Safety & Security Technologies
Comtech Telecommunications Corp.

June 3, 2020

Annette Walton & Nancy Storant, Buyer(s)
State Purchasing Bureau
1526 K Street, Suite 130
Lincoln, NE 68508

Subject: RFP 6264 Z1 Next Generation 911 Emergency Services IP Network (ESInet) and Next Generation Core Services (NGCS) – Option C File Upload List

Dear Ms. Walton and Ms. Storant,

NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc. (hereinafter referred to as "Comtech")[1] submits the following files as part of its RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C package:

1. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 1 of 14: "Corporate Overview"
2. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 2 of 14 "Technical Approach"
3. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 3 of 14: "Cover Letter"
4. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 4 of 14: "Form A"
5. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 5 of 14: "Attachment C"
6. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 6 of 14: "RFP for Contractual Services Form"
7. NxGnCo (Comtech) 6264 Z1 Cost Proposal Option C ESInet and NGCS File 7 of 14: "Cost Proposal"
8. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 8 of 14: "RFP Sections II-IV"
9. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 9 of 14: "LightEdge Omaha DC Slick"
10. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 10 of 14: "SEC 10-K FY2019"
11. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 11 of 14: "Proprietary Information"
12. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 12 of 14: "Certificate of Public Convenience and Necessity"
13. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 13 of 14: "Certificate of Good Standing"

[1] NextGen Communications, Inc. is a wholly owned subsidiary of TeleCommunication Systems, Inc. TeleCommunication Systems, Inc. is a wholly owned subsidiary of Comtech Telecommunications Corp.

14. RFP 6264 Z1 NxGnCo (Comtech) Proposal 2 Option C File 14 of 14: “Incident Escalation Chart”

Sincerely,

Comtech Team

NG911 ESInet and NGCS

RFP/Solicitation # RFP 6264 Z1

Corporate Overview – Option C

June 3, 2020

Submitted to:
Annette Walton & Nancy Storant, Buyer(s)
Next Generation 911 Emergency Services IP Network (ESInet) and Next Generation Core Services (NGCS)
State Purchasing Bureau
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Notices

TeleCommunication Systems, Inc. is a wholly owned subsidiary of Comtech Telecommunications Corp. This proposal is being submitted by TeleCommunication Systems, Inc. or its service-providing affiliate (using the Comtech brand). Throughout this proposal, the Comtech Telecommunications Corp. (Comtech) parent company name may be referenced. However, TeleCommunication Systems, Inc. (or its service-providing affiliate) is generally the contracting entity for the delivery of Comtech's highly available Wireless E9-1-1, VoIP E9-1-1, VoWiFi E9-1-1 and NG9-1-1 i3 solutions and systems, and it is expected to be the contracting entity for the proposed system.

EMedia®, GEM9-1-1®, LivewirE9-1-1®, RAVE9-1-1®, VoIP Verify® and VoLTE9-1-1® are registered trademarks, and Intrepid9-1-1™ and LocatE9-1-1™ are trademarks of TeleCommunication Systems, Inc. in the U.S. and certain other countries.

All other brand names and product names used in this document are trademarks, registered trademarks, or service marks of their respective holders.

TeleCommunication Systems, Inc. holds more than 400 issued patents and has more than 100 patent applications pending worldwide. Its patents cover a broad spectrum of technologies, including wireless data, text and voice telecommunications, location-based services, GIS/mapping, intercarrier messaging, secure communications, public safety/E9-1-1, and mobile navigation.

Nasdaq GS: CMTL

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Acronyms

Acronym	Definition
ATM	Asynchronous Transfer Mode
BCF	Border Control Function
BIOS	Basic Input/Output System
CCB	Configuration Control Board
CHE	Call Handling Equipment
CJIS	Criminal Justice Information Services
CM	Configuration Management
DoD	Department of Defense
DPI	Deep Packet Inspection
E911	Enhanced 911
ECRF	Emergency Call Routing Function
ECS	Emergency Communication Systems
EIDD	Emergency Incident Data Document
ENP	Emergency Number Professional
ESInet	Emergency Services Internet Protocol
FCC	Federal Communications Commission
FISMA	Federal Information Security Management Act
GIS	Geographic Information System
GSEC	GIAC Security Essentials Certification
GUI	Graphical User Interface
HCH	Hosted Call Handling
ICE	Industry Collaboration Events
IMS	Integrated Master Schedule
ISO	International Standards Organization
IT	Information Technology
ITSM	Information Technology Service Management
LDB	Location Database
LNG	Legacy Network Gateway
LPG	Legacy PSAP Gateway
LSRG	Legacy Selective Router Gateway
LVF	Location Validation Function
MPLS	Multi-Protocol Label Switching

Acronym	Definition
MPP	Master Project Plan
MSRP	Message Session Relay Protocol
NCTCOG	North Central Texas Council of Governments
NENA	National Emergency Number Association
NG911	Next Generation 911
NGCS	Next Generation Core Services
NOC	Network Operations Center
NSOC	Network Security Operations Center
OARnet	Ohio's Academic Resources Network
OSP	Originating Service Provider
PKI	Public Key Infrastructure
PM	Project Manager
PMP	Project Management Professional
POC	Point of Contact
PRF	Policy Routing Function
PSAP	Public Safety Answering Point
QA	Quality Assurance
RFAI	Request for Assistance Interface
SAPEE	Spirent's Scalable Application Playback Emulation Environment
SI	Spatial Interface
SLA	Service Level Agreement
SME	Subject Matter Expert
SOC	Security Operations Center
SOCC	State of Ohio Computing Center
SQL	Structured Query Language
SR	Selective Router
TCC	Text Control Center
UAT	User Acceptance Test
VCRM	Verification Cross-Reference Matrix
WAN	Wide Area Network
WBS	Work Breakdown Structure

1. Corporate Overview [RFP VI A 1]

The Corporate Overview section of the Technical Proposal should consist of the following subdivisions:

1.1. Bidder Identification and Information [RFP VI A 1a]

The bidder should provide the full company or corporate name, address of the company's headquarters, entity organization (corporation, partnership, proprietorship), state in which the bidder is incorporated or otherwise organized to do business, year in which the bidder first organized to do business and whether the name and form of organization has changed since first organized.

Table 1. Identification and Information

Comtech Identification and Information	
Full Company or Corporate Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.
Company's Headquarters Address:	275 West Street, Annapolis, MD 21401
Entity Organization:	Corporation
State Incorporated:	Maryland
Year First Organized:	2008
Name Change:	The name and form of organization have not changed.

1.2. Financial Statements [RFP VI A 1b]

The bidder should provide financial statements applicable to the firm. If publicly held, the bidder should provide a copy of the corporation's most recent audited financial reports and statements, and the name, address, and telephone number of the fiscally responsible representative of the bidder's financial or banking organization.

Comtech is a publicly traded company and, as such, has included a copy of its most recently filed 10-K audited financial statements for FY2019 ending July 31, 2019 as *File 10*. Within the 10-K, you will find an independent report from the registered public accounting firm Deloitte & Touche, LLP.

The contact information for our banking organization's fiscally responsible representative is included below.

Table 2. Banking Organization Contact Information

Banking Organization Contact Information	
Name	Stuart Berman, Senior Vice President
Address	Citibank N.A. 730 Veterans Memorial Highway Hauppauge, NY 11788
Email	stuart.n.berman@citi.com
Telephone #	631.265.3430

If the bidder is not a publicly held corporation, either the reports and statements required of a publicly held corporation, or a description of the organization, including size, longevity, client base, areas of specialization and expertise, and any other pertinent information, should be submitted in such a manner that proposal evaluators may reasonably formulate a determination about the stability and financial strength of the organization. Additionally, a non-publicly held firm should provide a banking reference.

This is not applicable.

The bidder must disclose any and all judgments, pending or expected litigation, or other real or potential financial reversals, which might materially affect the viability or stability of the organization, or state that no such condition is known to exist.

Comtech has nothing to report at this time.

The State may elect to use a third party to conduct credit checks as part of the corporate overview evaluation.

Understood.

1.3. Change of Ownership [RFP VI A 1c]

If any change in ownership or control of the company is anticipated during the twelve (12) months following the proposal due date, the bidder should describe the circumstances of such change and indicate when the change will likely occur. Any change of ownership to an awarded bidder(s) will require notification to the State.

Comtech has nothing to report at this time.

1.4. Office Location [RFP VI A 1d]

The bidder's office location responsible for performance pursuant to an award of a contract with the State of Nebraska should be identified.

Comtech's office location responsible for performance is 100 Technology Center Drive, Stoughton, MA 02072.

1.5. Relationships with the State [RFP VI A 1e]

The bidder should describe any dealings with the State over the previous five (5 years. If the organization, its predecessor, or any Party named in the bidder's proposal response has contracted with the State, the bidder should identify the contract number(s) and/or any other information available to identify such contract(s). If no such contracts exist, so declare.

Comtech does not have any contracts with the state of Nebraska. However, we do have contracts with several of the PSAPs. These are as follows:

- North Central Region, which consists of the following counties: Keya Paha, Brown, Rock, Cherry and Boyd-Holt. Each has a Solacom Guardian geo-diverse solution.
- Sheridan County will be joining the North Central Region later this year.
- East Central Nebraska MSRP Text to 911 circuit connectivity. East Central Nebraska is comprised of the following eight PSAPs that collectively total 22 call-taking positions:
    1. Boone County Sheriff's Department
    2. Butler County Sheriff's Office
    3. Hall County

4. Merrick County Sheriff's Office
5. Nance County Sheriff's Office
6. Columbus Police Dept
7. Polk County Sheriff's Office
8. Saunders County Dispatch

1.6. Bidder's Employee Relations to State [RFP VI A 1f]

If any Party named in the bidder's proposal response is or was an employee of the State within the past five (5) months, identify the individual(s) by name, State agency with whom employed, job title or position held with the State, and separation date. If no such relationship exists or has existed, so declare.

If any employee of any agency of the State of Nebraska is employed by the bidder or is a subcontractor to the bidder, as of the due date for proposal submission, identify all such persons by name, position held with the bidder, and position held with the State (including job title and agency). Describe the responsibilities of such persons within the proposing organization. If, after review of this information by the State, it is determined that a conflict of interest exists or may exist, the bidder may be disqualified from further consideration in this proposal. If no such relationship exists, so declare.

Comtech does not have any party named in our proposal response that is or was an employee of the state of Nebraska within the past five months. Furthermore, there are no state of Nebraska employees associated with this proposal submission.

1.7. Contract Performance [RFP VI A 1g]

If the bidder or any proposed subcontractor has had a contract terminated for default during the past five (5) years, all such instances must be described as required below. Termination for default is defined as a notice to stop performance delivery due to the bidder's non-performance or poor performance, and the issue was either not litigated due to inaction on the part of the bidder or litigated and such litigation determined the bidder to be in default.

Comtech has nothing to report regarding the solution being offered.

It is mandatory that the bidder submit full details of all termination for default experienced during the past five (5)) years, including the other Party's name, address, and telephone number. The response to this section must present the bidder's position on the matter. The State will evaluate the facts and will score the bidder's proposal accordingly. If no such termination for default has been experienced by the bidder in the past five (5) years, so declare.

Comtech has nothing to report regarding the solution being offered.

If at any time during the past five (5) years, the bidder has had a contract terminated for convenience, non-performance, non-allocation of funds, or any other reason, describe fully all circumstances surrounding such termination, including the name and address of the other contracting Party.

Comtech has nothing to report regarding the solution being offered.

1.8. Summary of Bidder's Corporate Experience [RFP VI A 1h]

The bidder should provide a summary matrix listing the previous projects similar to this solicitation in size, scope, and complexity. The State will use no more than three (3) narrative project descriptions submitted by the bidder during its evaluation of the proposal.

The bidder should address the following:

v. Provide narrative descriptions to highlight the similarities between the bidder's experience and this solicitation. Provide the number of ESInet and NGCS solutions implemented by the bidder that are in production today and lessons learned throughout the project that will be applied to the deployment of the Nebraska ESInet and NGCS solution. These descriptions should include:

a) The time period of the project;

b) The scheduled and actual completion dates;

c) The bidder's responsibilities;

d) For reference purposes, contracting entity name, contact name, contact title, contact email address, and contact telephone number. The Commission may request that references authorize a site visit and the opportunity to review event logs.); and

e) Each project description should identify whether the work was performed as the prime Contractor or as a subcontractor. If a bidder performed as the prime Contractor, the description should provide the originally scheduled completion date and budget, as well as the actual (or currently planned) completion date and actual (or currently planned) budget.

As a prime contractor, Comtech has implemented six Emergency Services IP Network (ESInet) and Next Generation Core Services (NGCS) solutions that are in production today; as a subcontractor, Comtech has delivered solution support for an additional five solutions that are in production. However, we have observed other prime contractors tasked with implementing NENA i3 implementations have delivered Request for Assistance Interface (RFAI) solutions as an interim phase until they're able to complete i3 interoperability. Interoperability testing and functional element performance are key items to address prior to beginning implementation in a production environment. The lessons learned throughout the projects are as follows:

- Communication – Clearly defined roles and responsibilities, plus frequent communication with and between all parties (Contracting Office, Public Safety Answering Point [PSAP], Competitive Local Exchange Carrier [CLEC], Originating Service Provider [OSP], Prime and subcontractors) to ensure a cooperative, collaborative and committed focus on maintaining current levels of service and implementing the proposed new service in a non-disruptive manner.
- Planning – A well-defined schedule that incorporates all project milestones and interdependencies, with commitments from all stakeholders (prime, subcontractor, service providers, customer).
- Coordination – Establishing integrated project teams of multidisciplinary personnel from across the project to ensure that well-defined objectives and milestones are established and measurable while providing visibility to ensure all parties are informed and can fully participate in any required decision points

The Comtech project team being proposed to deliver the NENA i3-compliant Nebraska NGCS and ESInet services has delivered similar services for statewide solutions. This team has demonstrated, and remains committed to quality performance, teamwork, and customer satisfaction.

Table 3. Comtech's Corporate Experience #1

Project Name:	Commonwealth of Massachusetts	
Time Period of the Project:	2014-present	
Comtech's Responsibilities:	The proposed Comtech management and technical leadership team committed as key personnel for this Nebraska project, include key staff members who have successfully implemented and operated the Commonwealth of Massachusetts NGCS, ESInet, and hosted call-handling systems, including a statewide Text to 9-1-1 implementation. This system includes 250-plus PSAPs, more than 800 call-handling positions, three geo-diverse data centers, and a dual Multi-Protocol Label Switching (MPLS) backbone that provides network diversity. This system serves 6.7 million citizens with an average annual call volume of 3.2 million. Initiated in 2014 and now in its five-year option period, the Commonwealth of Massachusetts NG9-1-1 System is the largest National Emergency Number Association (NENA) i3 end-to-end fully integrated NGCS, ESInet, logging and recording, and hosted call-handling system in the United States. This level of experience and commitment of skilled resources that provides all functional elements (Emergency Call Routing Function [ECRF], ECRP, Border Control Function [BCF], Policy Routing Function [PRF], Location Validation Function [LVF], Logging) is unparalleled. Our non-native experience that forms an integral part of this solution (not merely lab-tested) includes: DDTi – ECRF and LVF; Equature – logging; Call Works – call handling; RapidSOS – supplemental data; Carbyne – video/supplemental data; and Oracle – BCF.	
Similarities to this Solicitation:	This project covers the full breadth of systems engineering, integration, operations and maintenance that demonstrate our team's full capability to deliver a quality Next Generation 911 (NG911) project, plus our corporate commitment to the public safety mission and its standardized and compliant approach to system and service delivery.	
Reference		
Contracting Entity Name:	Commonwealth of Massachusetts, State 911 Department	
Contact Name:		
Contact Email Address:		
Contact Telephone Number:		
Work Performed as Prime:	☒Yes ☐No	
	Originally Scheduled Completion Date:	August 2014 - August 2019
	Original Budget:	Approximate total contract value: $100 million
	Actual Completion Date:	Base contract completed August 2019; currently performing on a five-year extension for continued operations and maintenance.

	Actual Budget:	Approximate total contract value: $100 million
Work Performed as Subcontractor:	☐Yes ☒No	

Table 4. Comtech's Corporate Experience #2

Project Name:	**Morgan County/State of Ohio NG911 Pilot**
Time Period of the Project:	2013-present
Comtech's Responsibilities:	In 2013, a pilot project was begun for implementing and maintaining the first NENA i3 standards-based system in the state of Ohio; it was designed to serve multiple Ohio counties with the State of Ohio Computing Center (SOCC) in Columbus as the core location, the state of Ohio's Academic Resources Network (OARnet) as the wide area network (WAN), and multiple carriers responsible for last-mile connectivity to reach participating jurisdictions over diverse routes. The project was led by Morgan County, with support from the state of Ohio's 9-1-1 department. The NGCS geospatially routes SOCC-aggregated traffic to 13 PSAPs in six Ohio counties that possess 27 call-handling positions. The pilot deployment includes all NENA i3 functional elements (ECRF, LVF, ESRP, PRF, BCF, logging), plus a transitional location database (LDB). Originally planned to be one of several Ohio pilot projects, it was the only one successfully launched and operated. The Comtech NG9-1-1 Pilot is a successful proof-of-concept design for Ohio's anticipated statewide system, which is currently in an initial procurement phase. Ohio's Morgan County NG911 pilot was specifically designed to demonstrate a NG911 solution that is scalable for statewide deployment, one with a capacity well in excess of five million calls per year. With active participation from the state of Ohio, these six pilot-county jurisdictions are utilizing the SOCC and OARnet, both of which will be integral components once the state of Ohio deploys an NG911 system statewide. The NGCS, ESInet and NG911 call-handling solutions fully support the delivery of integrated Text to 911 via the Message Session Relay Protocol (MSRP). Although the scope of this pilot does not currently include connectivity to a Text Control Center (TCC), the solution was designed and engineered to be scalable for such a statewide deployment. In addition, Comtech has a complete suite of Text to 911 solutions that was made available to all Ohio jurisdictions. This deployed solution possesses system-monitoring and outage-reporting capabilities that are scalable beyond the six pilot counties, with the capacity to handle more than five million calls per year, as are the Network and Security Operations Center (NSOC) and its related trouble ticket system. A plan has been in place since the inception of the project to expand the scope as more jurisdictions are brought onboard. The Comtech team has established and continues to evolve a pre-integration environment (test bed) that proves invaluable for change and release control, with evaluation and recommendations based upon today's requirements as well as those of the future. Geographic Information System (GIS) was one of the first endeavors to be addressed, with Comtech's team performing due diligence and coordinating

	with each jurisdiction's GIS department to ensure accurate records, proper maintenance, and a thorough review and discrepancy analysis for implementing data corrections. The geospatial routing of calls is of particular focus in this environment and has greatly enhanced the accuracy and timeliness of information provided to first responders. With the state of Ohio being serviced by multiple providers who were independently contracted by each respective jurisdiction, this pilot project has proven to be a comprehensive and collaborative implementation project that validates the importance of standards adherence and the benefits of NENA i3 compliance. Our non-native experience that has been implemented in the solution (not just lab tested) includes: DDTi – ECRF and LVF; Equature – Logging; WestTel – ESRP, PRF and call handling; and Oracle – BCF.	
Similarities to this Solicitation:	This project covers the full breadth of systems engineering, integration, operations and maintenance that demonstrate our team's full capability to deliver a quality NG911 project, plus our corporate commitment to the public safety mission and its standardized and compliant approach to system and service delivery.	
Reference		
Contracting Entity Name:	Morgan County 911	
Contact Name:		
Contact Email Address:		
Contact Telephone Number:		
Work Performed as Prime:	☒Yes ☐No	
	Originally Scheduled Completion Date:	July 2014
	Original Budget:	$5 million
	Actual Completion Date:	July 2014, annual O&M extensions through June 2020
	Actual Budget:	Approximate total contract value: $3 million
Work Performed as Subcontractor:	☐Yes ☒No	

Table 5. Comtech's Corporate Experience #3

Project Name:	NCT9-1-1	
Time Period of the Project:	Live since July 2013	
Comtech's Responsibilities:	North Central Texas Emergency Communications District (NCT9-1-1) is a voluntary organization of, by and for local governments, serving 13 counties in the Dallas-Fort Worth metropolitan area. Thirteen counties participate in the Enhanced 9-1-1 (E9-1-1) program, which provides services to 43 PSAPs. Comtech provides ESInet and NG911 network systems and services, including Legacy Network Gateways (LNGs), Legacy Selective Router Gateways (LSRGs), and Legacy PSAP Gateway (LPG). Comtech also provides the network connectivity, managing a MPLS core network and its connectivity to the PSAPs. Comtech's call-routing solution interfaces with NCT9-1-1's GeoComm GIS-based ECRF and GIS services. Comtech provides 24x7 Network Operations Center (NOC) services to NCT9-1-1 and its PSAPs.	
Similarities to this Solicitation:	This project covers the full breadth of systems engineering, integration, operations and maintenance that demonstrate our team's full capability to deliver a quality NG911 project, plus our corporate commitment to the public safety mission and its standardized and compliant approach to system and service delivery.	
Reference		
Contracting Entity Name:	North Central Texas Emergency Communications District (NCT9-1-1)	
Contact Name:		
Contact Email Address:		
Contact Telephone Number:		
Work Performed as Prime:	☒Yes ☐No	
	Originally Scheduled Completion Date:	September 14, 2012
	Original Budget:	$1.4 million
	Actual Completion Date:	September 14, 2012
	Actual Budget:	$1.368 million
Work Performed as Subcontractor:	☐Yes ☒No	

vi. Contractor and subcontractor(s) experience should be listed separately. Narrative descriptions submitted for subcontractors should be specifically identified as subcontractor projects.

Not applicable.

vii. If the work was performed as a subcontractor, the narrative description should identify the same information as requested for the Contractors above. In addition, subcontractors should identify what share of contract costs, project responsibilities, and time period were performed as a subcontractor.

Not applicable.

1.9. Summary of Bidder's Proposed Personnel/Management Approach [RFP VI A 1i]

The bidder should present a detailed description of its proposed approach to the management of the project.

The bidder should identify the specific professionals who will work on the State's project if their company is awarded the contract resulting from this solicitation. The names and titles of the team proposed for assignment to the State project should be identified in full, with a description of the team leadership, interface and support functions, and reporting relationships. The primary work assigned to each person should also be identified. Project managers assigned to the project shall be certified Project Management Professionals (PMP) and are highly encouraged to possess the Emergency Number Professional (ENP) certification.

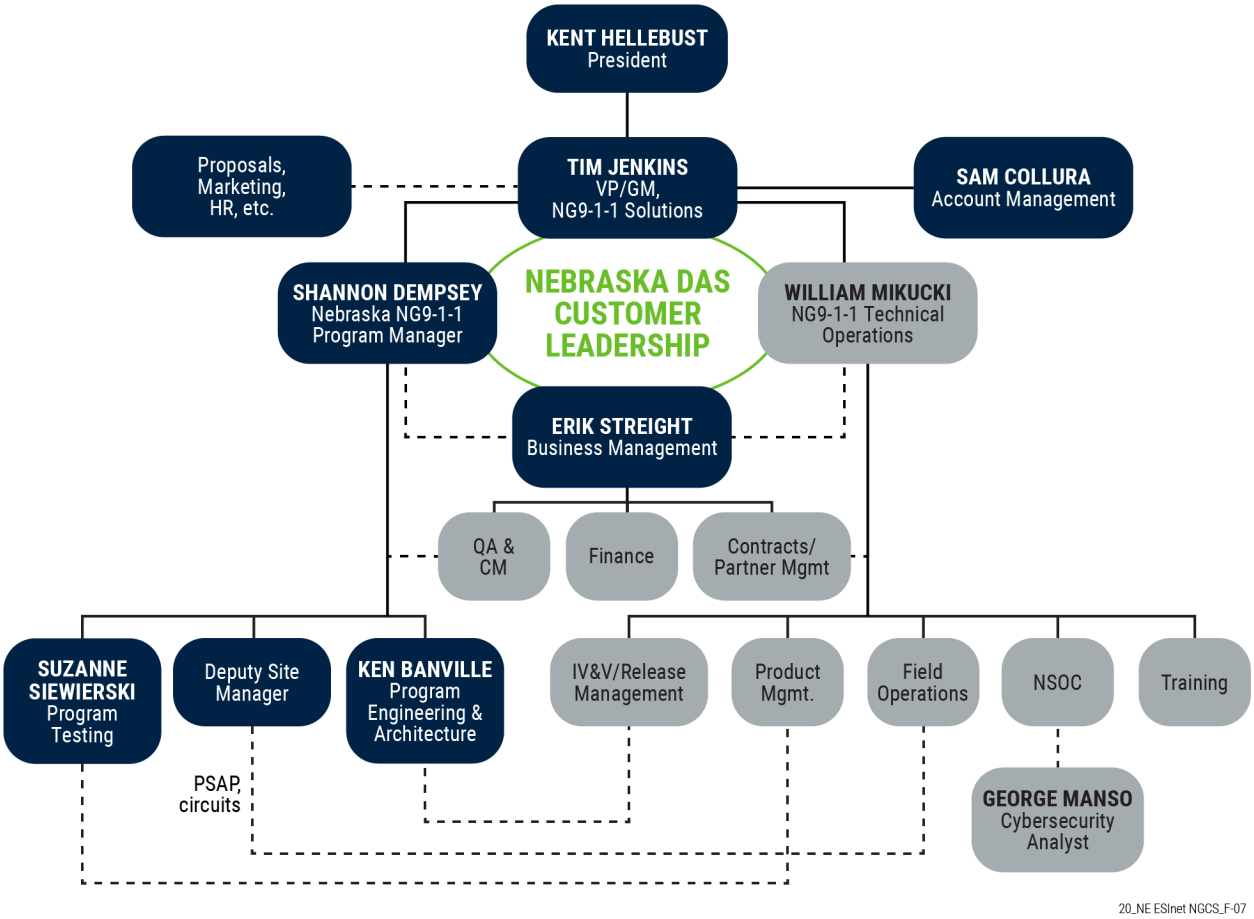

Figure 1. Comtech's Organizational Chart

Description of the Team Leadership:

The Nebraska NG911 Project/Program Manager (PM) will be primarily responsible for overseeing the project from initiation through to acceptance testing, and its subsequent transition to operation and maintenance. Resumes for additional key personnel are included below. These employees are part of the Comtech NG911 service team and are supported by additional staff members and Subject Matter Experts (SMEs). Every employee is dedicated 100 percent to the Comtech NGCS service, but their time may be shared across multiple customers.

The Comtech Nebraska project team will be composed of the following functions:

- **Account Manager –** The account manager is primarily focused on helping to achieve customer goals and advocating within Comtech on the customer's behalf. This person handles account renewals and channels new product and service offerings to our customers.
- **Project/Program Manager (PM) –** The PM will be responsible for oversight, program management, staff supervision, and status reporting. This person will be the SPOC and the first path of escalation for the Commission, its jurisdictions, and associated PSAPs. The PM will work directly with the Commission and its jurisdictions to finalize a conversion plan that best fits the needs of key stakeholders and drives toward successful, on-time cutovers of PSAPs to the NG911 system.
- **Engineering –** This engineering department is solely dedicated to our NG911 business. The engineering group is comprised of staff members with direct experience in key subject matter areas (networking, computing systems, storage, SIP call processing, and legacy carrier routing), as well as possessing intimate knowledge of our vendors' components as they apply directly to a NENA-compliant NG911 system. Engineering will be responsible for all aspects of designing, integrating and testing solution elements that will integrate the state of Nebraska's data centers, designated PSAPs, and legacy PSAP gateways. Engineering is also responsible for equipment staging (where PSAP configurations are configured and tested before shipment to the PSAPs), change/configuration management, and system security design and implementation.
- **Business Management –** Comtech has a staff dedicated to interfacing with the strategic partners, carriers and telecommunications service providers necessary to implement an end-to-end NG911 system. This group's responsibilities include establishing the required performance, service delivery, interconnection agreements, and circuit orders/scheduling, while also overseeing the service providers during provisioning, testing and turn-up. Following cutover, this team will ensure that these service providers are achieving applicable SLAs and managing and reporting on incidents, as required by the contract.
- **Implementation and Testing –** Based upon the selection and participation of Nebraska counties, field technicians and installers will be responsible for up-front site surveys to determine PSAP facility requirements, the installation of the suite of call-handling equipment, and pre-cutover/cutover onsite testing during PSAP migration to the NG911 system.
- **Training –** The training coordinator will work with Nebraska's designated training lead, and with training content developers (OEMs and Comtech's in-house instructional systems designers), to finalize the curriculum and content of the proposed training regimen. During training, the training coordinator will manage the training schedule, address customer satisfaction and feedback regarding training courses, and ensure that the instructors and materials being presented meet the state of Nebraska's training objectives.

- **Managed Network Services –** Post-conversion, Comtech will provide system monitoring, maintenance, incident management and reporting, and service (help) desk services from our NG911 operations organization. This organization includes a 24x7x365 NSOC with all the tools required to monitor and manage all components of the Nebraska NG911 system.
- **Field Operations –** Comtech maintains a pool of field technicians to support both project implementation and deployment, as well as post-conversion for operations and maintenance (both preventative and corrective action). In the post-conversion operations and maintenance phase, field technicians act as an extension of the NSOC for local onsite activities. This team is comprised of qualified personnel knowledgeable and trained on the NG911 system, and they are fully aware of the urgency required to maintain and adhere to SLA performance criteria.

Table 6. Key Personnel

Name	Title	Support Functions	Reporting Relationship
Shannon Dempsey	Nebraska NG911 PM	• Assigned and fully authorized Comtech executive • Overall management of team performance • Customer satisfaction • Executive outreach to OEMs and partners for their total commitment to the contract	• Reports directly to Comtech's Vice President/General Manager of NG911 Solutions • Will have the decision-making authority and assigned staff and partner support to ensure that skilled resources are available and assigned to the project for the duration of the project • SPOC and the first path of escalation for the state of Nebraska, its jurisdictions, and associated PSAPs • Works directly with the state of Nebraska and its jurisdictions to finalize a conversion plan that best fits the needs of key stakeholders and drives toward successful, on-time cutovers of PSAPs to the NG911 system
Sam Collura	Account Management	• Executive sales and sales management for North American wireless carriers, public safety, cable MSO, and enterprises.	• Reporting to the Global Commercial Sales VP • Responsible for the commercial sales of Comtech's public safety and commercial offerings

			• This sales coverage includes secure wireless and VoIP Enhanced 911 services; NG911; text messaging; carrier software, cyber intelligence; location-based services infrastructure, and mobile applications using precise location for wireless devices.
William Mikucki	Vice President, Technical Operations	• Responsible for the design and testing of the Massachusetts NG911 system that serves 250-plus PSAPs and a population of more than 6.7 million • Directs the design and testing of the NG911 solutions for the state of Ohio's six-county pilot program and the St. Louis County, Missouri, NG911 system, which was designed to support 21 PSAPs and a population in excess of one million • Creates system engineering processes to effectively and efficiently deliver solutions and products	• Overall responsibility for the design and management of all engineering and operations resources • Management responsibility for the NSOC
Ken Banville	Nebraska Program Engineering and Architecture	• Experienced in large multi-vendor environments • Experienced in the configuration and deployment of cloud services • Responsible for design review and enhancement identification to maintain NENA i3 standards for the Massachusetts NG911 system. This included advocating more advanced technologies to support the third data center.	• Leader and mentor of network and systems engineers • Expert in engineering process management from design through implementation and support
George Manso	Cybersecurity Analyst	• Functions as the principal security officer supporting the Commonwealth of Massachusetts NG911	• Principal cybersecurity architect supporting network, systems, and security design and integration.

		deployment, operations and maintenance	

Our project management professional (PMP)-certified program managers and NENA Emergency Number Professional (ENP)-certified solution architects and systems engineers have decades of experience in telephony, unified communications, and PSAP implementation projects. Comtech and our partners for NG911 solutions have proven past performance, actively participate in NENA Industry Collaboration Events (ICE), NENA Emergency Incident Data Document (EIDD) Conveyance Working Group, NG911 PSAP Working Group, and others.

Comtech Nebraska NG9-1-1 Program/Project Manager (PM)

Comtech is proposing Shannon Dempsey, as the Nebraska NG911 PM. Shannon has 13 years of industry and customer experience, and subject matter expertise, whose presence will ensure the successful delivery of ESInet and NGCS to the state of Nebraska and its citizens. As the Comtech PM, Shannon reports directly to Comtech's Vice President/General Manager of NG911 Solutions and will have the decision-making authority and assigned staff and partner support to ensure that skilled resources are available and assigned to the project for the duration of the project.

The Nebraska PM is responsible for:

- Oversight of the delivery of Comtech NG911 as-a-Service (NG911aaS) for the statewide NGCS and ESInet.
- Ensuring fulfillment of the transition and deployment plans, which includes Nebraska PSAP adoption to the statewide project, plus contract expansion to adjacent counties and neighboring states.
- Managing the successful completion of all tasks in the assigned program area to include design, integration, testing, deployment and operations, plus the achievement of financial and operational objectives.

The PM has extensive knowledge of and experience with operations and/or the installation of 911 and Emergency Communication Systems (ECS). The PM is responsible for implementing systems that include data centers, MPLS networks, 911 call handling systems, and call handling equipment (CHE) implementation to PSAPs.

General Requirements:

- Supervises assigned technical and administrative staff—including subordinate supervisors—and performs personnel actions including hiring and performance evaluation.
- Reviews project plans and proposals and then identifies project responsibilities by determining the phases and elements of the project. Develops an IMS and Work Breakdown Structure (WBS) for all aspects of the project.

- Coordinates the procurement of subcontractor activities and manages compliance and the quality of subcontractor deliverables and finances.
- Develops, reviews and approves plans, data deliverables, schedules, subcontractor agreements and other program documents.
- Prepares and provides various reports and technical reviews to senior management, as requested.

Project Management Approach

Comtech's PM will align and coordinate with a designated State project lead and will personally attend significant project events, including the installation of the core system and any optional capabilities purchased, during intervals throughout system testing, and when the system goes live.

Across all phases of the project, the Comtech PM will provide project coordination, task oversight and milestone completion, while also conducting project meetings and providing schedule updates and progress reports. The Comtech PM prepares and maintains a Master Project Plan (MPP) that is reviewed with management and used to manage all phases of the program. The MPP also ensures project compliance in order to deliver the highest levels of performance, teamwork and customer satisfaction. The primary responsibilities of the PM include:

- Acting as the primary customer contact for the State during the project life cycle.
- Acting as the primary point of contact (POC) for all Comtech personnel and subcontractors during the project life cycle.
- Attending all project meetings, which include:

- Project kickoff meeting
- Weekly project meetings, as scheduled by the State
- Ad-hoc meetings, as scheduled by the State

- Providing coordination between State personnel and the Comtech team for the compilation of configuration and integration details for all NG911 subsystems
- Coordinating and assigning key project tasks with State employees and PSAP personnel (where necessary).
- Participating in all aspects of project planning and execution, which include:

- Subcontractor/Comtech resource planning and assignments
- Lab-staging activities
- Site sequencing for deployment/cutover

- Managing project activities in accordance with the approved master schedule.

- Coordinating the development of required project documentation.
- Coordinating site access for the Comtech project team.
- Building consensus between Comtech and the State, such as:

- Acting as liaison with originating service providers (OSPs), State personnel, and other relevant stakeholders throughout the state of Nebraska.
- Collaborating with State personnel to ensure that systems requirements and participating agencies' needs are met in all phases of the project.

Kickoff Meeting

The Comtech PM will conduct a kickoff meeting with the State, to be held onsite at a mutually agreeable location within 10 business days following contract execution. The Comtech PM will coordinate with State personnel to ensure the content of the meeting meets the State's expectations. At a minimum, the kickoff meeting will include:

- A review of the technical solution and the preliminary MPP
- Program organization, with an introduction of key project personnel from both Comtech and the State
- Roles and responsibilities, with the identification of external project stakeholders critical to the project's success
- Critical milestones
- Deliverables
- Communication
- Identifying staging and storage areas
- Site access requirements
- Survey planning

Following the kickoff meeting, Comtech will make any necessary adjustments to the documents that were presented during the meeting. Electronic meeting minutes will be submitted to all participants. Comtech will deliver a detailed Project Schedule/Integrated Master Schedule (IMS) within 10 business days following this kickoff.

Weekly Project Meetings

The Comtech PM will coordinate and conduct weekly project meetings with designated state and local PSAP personnel during the project life cycle. Prior to each meeting, Comtech will electronically send to all participants a Project Status Report (in Microsoft Office format) that details:

- Work completed during the two weeks prior to the meeting

- Work planned for the upcoming two weeks
- Project status in relation to the project schedule
- Upcoming milestones
- Material procurement status
- Deliverable status
- Action item status
- Open issues and punch-list items
- Estimated date of completion
- Closed issues, with details of resolution

The Comtech PM will present the project status report during the weekly meeting, which will include whatever information is required of the State to complete tasks. A submission date will be agreed to during the meeting and tracked as an open action item. Electronic meeting minutes will be submitted to all participants after each meeting.

Ad hoc Conference Calls

During the project life cycle, the Comtech PM will convene conference calls with State personnel to discuss current status, review action items, and address project-related issues. The Comtech PM will provide a conference bridge with dial-in instructions for the call. Electronic meeting minutes will be submitted to all participants within a specified period after each call.

Monthly Status Report

The Comtech PM will provide monthly status reports, to be delivered on an agreed-upon day after the end of each month. These reports will contain the following project-related details:

- Work completed during the previous month
- Work planned for the upcoming month
- Project status in relation to the project schedule
- Upcoming milestones
- Material procurement status
- Deliverable status
- Action item status
- Open issues
- Closed issues, with details of resolution

Project Review Check Point

Once per quarter, the Comtech PM and the account team will provide a full onsite update for the State. This presentation will include a report on project status, lessons learned, and an updated project schedule.

Project Management Tools and Processes

Comtech brings a full suite of project management tools and processes that have been proven effective across projects with similar requirements. These processes and tools provide the following elements:

- A repeatable set of processes for use by project managers and technical leads to ensure operational efficiency and overall quality performance.
- Best practices and lessons learned from previous programs. Our standardized processes incorporate those best practices and lessons learned to enhance efficiency.
- A common foundation and knowledge repository for Comtech and subcontractor use, creating a common baseline for knowledge sharing and employee and subcontractor training.
- Standards and tools tailored to the requirements of the Nebraska NG911 project, so that all technical activities are relevant, efficient and optimized.
- A framework for maintaining and continuously improving the standards and project management tools to ensure quality assurance (QA) in all areas.
- Integration between tools (management, program, and technical) and standards for monitoring and reporting to guarantee effective management of this complex, multidisciplinary project.

The Comtech team, led by the PM, will use the tools and processes listed in Table 7. Post-award, the PM will ensure understanding of project governance among the various stakeholders and update/ tailor these approaches to the needs of the Nebraska NG911 project. Comtech will ask the State to identify the individuals who should have web portal access privileges and, once established, we will conduct an overview of this access, use and common activities. Comtech's portal will be a repository for project-related deliverables, status and plans.

Table 7. Tools and Processes

Project Phase	Highlighted Tool/Process	Benefits
All	Collaboration tools - Slack, Microsoft Teams, Click up; as well as other web-based applications to store, organize, share, and access information	• Real-time posting of project deliverables for review and approval, accessible on a permissions basis by customer and Comtech personnel. It will include open issues and real-time punch list. • Monthly posting of operational reports on system performance, ticket status/statistics, etc. • Accessible to the Commissions and PSAPs, with email notifications of document postings and updates
	Weekly Project Status Review	• Regular forum to report on project status and address outstanding issues • Predetermined stakeholder attendance to ensure all are informed
	IMS	• Maintains status on overall project health and progress • Maps major project milestones • Identifies risk to critical-path items • Prioritizes tasks to ensure interdependencies are being met
	Verification Cross-Reference Matrix (VCRM) –decomposition of Nebraska requirements – with source mode of verification (e.g., document, test, inspect)	• Ensures understanding of requirements post-award (reviewed with the Commission) • Informs test and acceptance process
Planning and Engineering	Weekly Configuration Control Board (CCB) (sample Change Request Form) • Review/approval of changes or updates to configuration baseline impactful to the Commission and/or PSAPs • Overview of release schedule and testing	• Cross-functional attendance (Comtech engineering, release management, and Configuration Management [CM]) to keep everyone informed • Customer concurrence/approval required
	Site Deployment Tracker (where applicable) • Hosted on Comtech's portal, updated daily ▪ Customized to relevant milestones for Nebraska personnel to view key dependencies and status	• Design of tracker will be a joint effort with Comtech and Nebraska personnel • Multi-tab tracker will be customized from existing tool used for other production NG911 projects (>300 PSAPs)

Integration, Test and Deployment	Monthly Status Reports – Key system performance metrics will be posted to Comtech's portal • Incident reports with root cause analysis, as required • Customer access to Remedy ticketing system	• Customer access to relevant system performance and incident reports • Real-time access to Remedy to track incident reporting and resolution
	Recurring Operations Caucus meetings consisting of: • Open Remedy ticket reviews • Service Level Agreement (SLA) performance reports • Review of outstanding operations action items	• Allows customer stakeholders to review key operational metrics with Comtech • Facilitates continuous improvement in service delivery

The bidder should provide resumes for all personnel proposed to work on the project. The State will consider the resumes as a key indicator of the bidder's understanding of the skill mixes required to carry out the requirements of the solicitation in addition to assessing the experience of specific individuals.

Resumes should not be longer than three (3) pages. Resumes should include, at a minimum, academic background and degrees, professional certifications, understanding of the process, and at least three (3) references (name, address, and telephone number) who can attest to the competence and skill level of the individual. Any changes in proposed personnel shall only be implemented after written approval from the State.

While we have identified the individuals whom we expect will be assigned to the project contemplated by this proposal, we reserve the right to change such personnel at any time at our discretion. We agree to use reasonable efforts to promptly notify the State of any material change in any key Comtech personnel who may be assigned to the project from time to time. Comtech will obtain written approval from State prior to any changes in personnel.

Shannon Dempsey will be the Nebraska NG911 Project Manager.

SHANNON DEMPSEY (COMTECH) –NEBRASKA NG9-1-1 PROJECT MANAGER	
EXPERIENCE AND SKILL SUMMARY	
• NG911 program and partner management for core services, ESInet and carrier migration • Quality Assurance and Process Improvement, working closely with testing and engineering Subject Matter Experts (SMEs) • Certified SCRUM product owner • Training for both end-users and train- the-trainer	
COMPARABLE COMPLETED PROJECTS	
Project Title:	Commonwealth of Massachusetts NG911
Company Name:	Commonwealth of Massachusetts, State 911 Department
Client Contact Information:	

Project Description:	Engineer, furnish, install, test and maintain a turnkey NG911 platform for deployment within the Commonwealth of Massachusetts, replacing the legacy E911 telephony platform with a NENA i3-ready call-handling solution. This project includes network switching at redundant data centers, primary and backup PSAPs, and administrative Internet Protocol (IP)-based Private Branch Exchange (PBX) systems. Onsite supervision and management of the installation of the primary and backup data centers as well as 250-plus PSAP locations across the Commonwealth of Massachusetts, enabling a NENA i3-compliant NG911 end-to-end services architecture including the replacement of existing the CPE call-handling solution, the design and deployment of NGCS in three geo-diverse data centers, and the provision of two fully redundant and diverse routed ESInet Wide Area Network (WAN).
Role/Responsibility:	Program manager for the operation and maintenance of the end-to-end Next Generation Core Services (NGCS), ESInet, and hosted call handling. Implemented a Text to 911 service for statewide deployment and was actively involved in the curriculum development and training program for more than 5,200 911 call takers.

EDUCATION/TRAINING/CERTIFICATIONS

- B.A. Psychology and Mathematics, University of Vermont (Burlington)
- Certificate in American Sign Language and Deaf Studies: interpreting
- C+ Computer programming
- DoD security clearance

EMPLOYMENT HISTORY

Comtech Telecommunications Corp., NG911 division of Westwood, MA

Program Manager, May 2018 – Present

- Primary point of contact responsible for oversight, program management, staff supervision, and status reporting
- Conducts program reviews with all partners and customer personnel
- Works directly with the Massachusetts State 911 department and PSAP management across the Commonwealth to ensure compliance with all project requirements.
- Supports and responds to all requests for service to include moves, additions and changes
- Provides regular reporting and project status, tracks and presents monthly program metrics, and makes recommendations for areas of improvement
- Works closely with all program partners to review project performance, project planning, product roadmap, and resource assignments

General Dynamics Information Technology, Inc.

Project and Training Manager, September 2014 – May 2018

- Project manager for implementing Text to 911 in Massachusetts
- Primary interface between GDIT and the Massachusetts State 9-1-1 Department (S911D) for all training-related matters
- Managed the creation of curriculum and job aids for Massachusetts Next Generation PSAP call takers and PSAP administrators with instructional design SME's, partners and S911D
- Managed training of more than 5,200 911 call takers across five Massachusetts training centers
- Received an overall satisfaction score of 90 percent from student surveys

General Dynamics Information Technology, Inc.

Product Program Manager, October 2011 – September 2014

- Primary point of contact and interface for all managerial and technical matters with Government Program Office (GPO)
- Managed and took responsibility for the successful completion of all tasks in the assigned program area including technical work, financial activities, and business development activities
- Directed program activities to meet client and organization work objectives, serving as liaison with clients to coordinate activities, negotiate tasks, and solve problems
- Ensured the quality of program products, services and deliverables, including participation in reviews, audits and site visits
- Reviewed future project requirements and developed strategies and processes for future work to ensure compliance with corporate and International Standards Organization (ISO) standards

General Dynamics Information Technology, Inc.

Project Manager, 2006 – October 2011

- Served as the point of contact for members of the company's internal team as well as all U.S. Air Force customer orders
- Developed and maintained strong working relationships with OEMs/vendors, team members and customers
- Initiated project kickoff meetings and managed project setup
- Coordinated the management of all work performed on tasks under the contract, including tasks assigned to subcontractors/vendors and team members, to ensure that contract requirements and deliverables were met
- Oversaw requests made by the project's financial analyst and worked with the finance group to meet budgets and milestones
- Identified ongoing opportunities for process improvement and collaborated with the team to implement these changes
- Led the product project closeout, which included customer acceptance and the approval of project deliverables

REFERENCES

Name:	Brian Smith Software Architect, GDIT	**Email Address:**	brian.smith@gdit.com	**Telephone:**	401.845.3662
Name:	Peter Joo Director Engineering, GDIT	**Email Address:**	peter.joo@gdit.com	**Telephone:**	781.589.3186
Name:		**Email Address:**		**Telephone:**	

William Mikucki is Comtech's vice president of technical operations.

WILLIAM MIKUCKI (COMTECH) – VICE PRESIDENT, TECHNICAL OPERATIONS	
EXPERIENCE AND SKILL SUMMARY	
• Responsible for the design and testing of the Massachusetts NG911 system, which serves 250-plus PSAPs and more than 6.7 million people. • Oversaw the transition of the Massachusetts project from legacy E911 to NG911, eliminating selective routers (SRs) and non-NG911 call-handling infrastructure, and into its Operations and Maintenance phase of the NG911 system, where Comtech provides end-to-end system management. • Directing the design and testing of the St. Louis County, Mo., NG911 system, which serves 21 PSAPs and more than one million people. • Former Deputy Commander, U.S. Air Force, 375th Communications Squadron, responsible for personnel and daily operations of 352 airmen, civilians and contractors in a squadron that represented a $52 million Information Technology (IT) enterprise and providing command, control, communications, and computer support/services to more than 15,000 command, operational, and installation customers.	
COMPARABLE COMPLETED PROJECTS	
Project Title:	Commonwealth of Massachusetts NG911
Company Name:	Commonwealth of Massachusetts, State 911 Department
Client Contact Information:	
Project Description:	Engineer, furnish, install, test and maintain a turnkey NG911 platform for deployment within the Commonwealth of Massachusetts, replacing the legacy SR and E911 telephony platforms with a NENA i3 NGCS, ESInet, and hosted call handling (HCH) solution. The system uses geospatially routing core at redundant data centers to HCH services presenting 911 calls to 291 primary, secondary and private PSAPs over a statewide ESInet. Management of the installation of 298 PSAP locations across the Commonwealth of Massachusetts, enabling a NENA i3-compliant NG911 end-to-end services including the replacement of existing the CHE call-handling solution with HCH, transitioned off of SRs with three geo-diverse data centers, and two fully redundant and diverse routed ESInet WANs.
Role/Responsibility:	Director of Engineering, Operations, and Program Management
Project Title:	St. Louis County Next Generation 9-1-1 Emergency Communications System
Company Name:	St. Louis County, Missouri
Client Contact Information:	
Project Description:	Comtech is leading the engineering, design, and test completion for the comprehensive modernization of the St. Louis County, Missouri, 911 system and infrastructure, enabling a NENA i3-compliant NG911 end-to-end services architecture including the replacement of existing CHE at 22 PSAPs with a hosted call-handling solution, the design and deployment of NGCS in two geo-diverse data centers, and the provision of two fully redundant and diverse routed ESInet WAN.
Role/Responsibility:	Director of Engineering, Operations, and Program Management
EDUCATION/TRAINING/CERTIFICATIONS	

- B.S., Mathematics and Computer Science, University of Illinois, 1993
- M.S., Computer Information Systems – Security, Boston University, 2015

EMPLOYMENT HISTORY

Comtech Telecommunications Corp., NG911 division of Westwood, Mass.

Vice President, Technical Operations, 2019-Present

General Dynamics Information Technology, Inc., NG911 business unit of Westwood, Mass.

Director of Engineering, Operations, and Program Manager, 2015-2019

Leads three teams of IT engineers focused on systems engineering, configuration management, and the staging of NG911 systems. Leads state and local solutions engineering organization of 32 engineers in 16 distinct disciplines.

- Completed the design and testing of the Massachusetts NG911 system, which serves 250-plus PSAPs and more than 6.7 million people.
- Directing the design and testing of the St. Louis County, Mo., NG911 system, which serves 20-plus PSAPs and more than one million people.
- Provided technical program and task development, plus execution by the engineering organization, to complete the customer's requirements.
- Created system engineering processes to effectively and efficiently deliver solutions and products.

Directs a 24x7x365 NSOC operating, securing, protecting, and maintaining NG911 systems across the United States. Guides the design and implementation of systems and services in support of the operations organization. Ensures the "No 9-1-1 Call is Lost" culture is firmly engrained in the operations teams. Directs the NG911 field team for accomplishing the onsite diagnostics and repair of PSAP components.

Invited to assume program management responsibilities in April 2018 for the $120M statewide NG911 system, in additional to directorial responsibilities. Built strong customer relationships that enabled the extension of the contract for five years and $100M within the first six months. Optimized processes to implement and bill Move/Add/Change requests for the customer, ensuring customer satisfaction and revenue growth. Additionally assumed program director responsibilities, with supervisory duties over multiple program managers.

General Dynamics Information Technology, Inc.

Senior Manager/Manager, Information Systems, 2010-2015

Recruited, trained and led a technical team of 41 IT engineers in 12 disciplines to design and implement a large military customer's cyber and boundary defense system. Directly managed 22 technical specialists in multiple locations and oversaw recruiting, utilization, goals, training, and policy implementation of the team while providing technical guidance and approval for architecture and security engineering changes within the system.

- Ensured compliance with the Federal Information Security Management Act (FISMA) in defense of 350,000 systems at more than 100 locations worldwide, providing an advanced worldwide cyber security perimeter that protected clients' IT infrastructure.
- Directed a team of 12 to build a $25 million cyber security modernization effort that implemented deep packet inspection, an application-aware firewall, and packet forensics into an existing customer's security infrastructure, thereby shielding 182 sites globally.
- Provided technical program and task development and execution for a matrixed organization to complete customer requirements, utilizing developed processes to effectively and efficiently deliver systems engineering plans and programs.

United States Air Force Reserve

Major/Deputy Commander, 375th Communications Squadron, 2002-2015

- Infrastructure and Systems Operations: Responsible for IT operational and security activities of 252 personnel assigned to defending a $52 million enterprise while providing command, control, communications, and cyber-defense capabilities to more than 15,000 systems. Directed and established command direction for performance, engineering, operational availability, information/system security, and configuration control for cyber weapon platforms and networks.
- Innovative Technology and Leadership: Built the cyber security organization involved in defending the largest Air Force base networks, with a focus on vulnerability management, threat analysis, boundary defense, and infrastructure hardening. Revamped the emergency communications management plan, which enabled an improved response to base-wide emergencies and threats against the cyber infrastructure. Implemented an 802.1x infrastructure based upon Public Key Infrastructure (PKI) credentials. Designed, managed and developed architecture to create a vulnerability management system that controlled more than 300 systems administrators in the defense of 10,000 computer systems.
- Distinctions and Results: Named Air Mobility Command Information Dominance (IT Security) Officer of the Year for 2010. Named 375th Communications Group Officer of the Year for 2009. Directed and completed a $12 million infrastructure upgrade program that enabled IP telephony, network segregation, and port security infrastructure. Managed and executed a $3 million security software development program. Received a rating of Excellent in four different security and IT inspections.

REFERENCES

Name:		**Email Address:**		**Telephone:**	
Name:	Ed Hudson VP/GM, GDIT Public Safety Network Solutions	**Email Address:**	edhudjr@gmail.com	**Telephone:**	781.789.3439
Name:	Brian Harrington VP/GM, iNet Technology Sector	**Email Address:**	bharrington.capecod@gmail.com	**Telephone:**	781.801.0900

Kenneth Banville will be responsible for Nebraska program engineering and architecture.

KENNETH BANVILLE (COMTECH) – NEBRASKA PROGRAM ENGINEERING AND ARCHITECTURE	
EXPERIENCE AND SKILL SUMMARY	

• Leader and mentor of network and systems engineers
• Expert in engineering process management, from design through to implementation and support.
• Experienced with large, multi-vendor environments
• Expert in systems analysis, with a focus on identifying the enhancement potential of existing systems and applications.
• Strategic business planning
• Strong oral and written communications skills
• Experienced in the configuration and deployment of cloud deployments (Amazon Web Services)
• Experienced in the configuration and deployment of multi-vendor hardware:
  ▪ Compute – Desktop, midrange and server-class systems from IBM, Dell, HP, Micro-systems.
  ▪ Hyperconverged – Nutanix
  ▪ Networking – PIX, ASA, and Palo Alto firewalls, fiber channel switching, various IP routers and switches
  ▪ Storage systems – Pillar Data Systems, NetApp, EMC VNX series
• Experienced in configuration and deployment of multi-vendor software and operating systems:
  ▪ Operating Systems – AIX (3.2-5.3), Solaris (7-10), RedHat Linux (Fedora, Server 4 through 7), HP-UX, Windows NT through Server 2019, SCO, NCR sysV, DOS (1-6)
  ▪ Databases – MySQL, Sybase, Informix, BerkleyDB, Oracle, MS-Access, MSSQL
  ▪ Misc. Software – Citrix Veritas Netbackup, Apache, SunOne web server, subversion, Kickstart, Jumpstart, MS Office (and related applications), 4690 GSA/SSA, ADT Security Systems, Tivoli Software Distribution Manager, BMC Patrol, SSH, GCC compiler, Visual Age C++ compilers, iforls license server, NetIQ App Manager, VAS (Quest Authentication Services), Nominum DNS Services.
• Experience with Programming Languages:
• Current – Terraform, Ansible.
• Historic – Korn Shell Scripting, PHP Scripting, C Programming, Basic, Fortran, Cobol, Pascal	

COMPARABLE COMPLETED PROJECTS	
Project Title:	Commonwealth of Massachusetts NG911
Company Name:	Commonwealth of Massachusetts, State 911 Department
Client Contact Information:	
Project Description:	Engineer, furnish, install, test and maintain a turnkey NG911 platform for deployment within the Commonwealth of Massachusetts, replacing the legacy SR and E911 telephony platforms with a NENA i3 NGCS, ESInet, and HCH solution. The system uses a geospatially routing core at redundant data centers, with HCH services presenting 911 calls to 291 primary, secondary and private PSAPs over a statewide ESInet. Managed the installation of 298 PSAP locations across the Commonwealth of Massachusetts, enabling a NENA i3-compliant NG911 with end-to-end services that included the replacement of the existing CHE call-handling solution with HCH, transitioned away from SRs to three geo-diverse data centers, and two fully redundant and diversely routed ESInet WANs.

Role/Responsibility:	Senior Systems Engineer – Responsible for the design, review and enhancement identification to maintain alignment of the solution with the NENA i3 standards. This included the selection of more advanced technologies when the third data center was introduced, plus the development of an analytics system. Also served the lead role in utilizing the Massachusetts-based model to develop the next version of Comtech's hosted NG911 solution.

EDUCATION/TRAINING/CERTIFICATIONS

- Active DoD Top Secret security clearance
- GCIH Silver: GIAC Certified Incident Handler (ID: 20668)
- GSEC Silver: GIAC Security Essentials Certification (ID: 31763)
- Bachelor of Business Administration, University of Phoenix
- Associate of Information Technology, Western International University
- Certificate in Computer Systems Specialist, Northeastern University

EMPLOYMENT HISTORY

Comtech Telecommunications Corp., NG911 division of Westwood, MA

Sr. Systems Architect, April 2019-Present

Responsible for identifying requirements, determining solutions, and providing the architectural design for the development and deployment of a NG9-1-1 solution to operate as a Comtech-owned cloud service. This effort includes leading a team of senior engineers in the development of the core operational infrastructure, the SIP signaling networks, the NG911 location and routing elements, and systems management components.

- Utilize DEVOPS automation tools such as Terraform and Ansible to deploy cloud-based services within a nationwide cloud architecture.
- Architect a central NSOC capable of monitoring and managing multiple customer deployments within a single management infrastructure while adhering to the strictest operational and security standards.
- Develop and design a business and technical case for a full cloud-based as-a-service NG911 NGCS model.
- Provide the management team with design, costing and statistical data to assist in pricing analysis and business case development.
- Provide guidance to management, engineering and operations teams for the adoption of new architectures.
- Develop architectural models for both isolated and multi-tenant customer NG911 call processing solutions by utilizing the latest industry standards.
- Design a data analytics system utilizing logging data from all call-processing and system-logging data, allowing for enhanced system and call-processing reporting and anomaly detection.
- Develop a segregated testing environment capable of supporting the testing of multiple NG911 customers
- Design and deploy a company-wide, customer-focused Security Operations Center (SOC) with supporting governance, policies and procedures.

General Dynamics Information Technology, Inc.

Systems Architect, 2016-April 2019

Responsible for identifying requirements, determining solutions, and providing the architectural design for the development and deployment of a NG911 solution to operate as a GDIT-owned as-a-service. This effort included leading a team of senior engineers in the development of the core operational infrastructure, the SIP signaling networks, the NG911 location and routing elements, and the systems management components.

Additional responsibilities included acting as the assistant product manager to determine which services were to be part of the solution product catalog, working with the sales team to change the marketing structure from solution provider to service provider, and assisting the finance team in developing a service-based cost model.

- Architected a central NSOC capable of monitoring and managing multiple customer deployments within a single management infrastructure while adhering to the strictest operational and security standards.
- Provided the management team with design, costing and statistical data to assist in pricing analyses and business case development.
- Provided guidance to engineering and operations teams for adopting new architectures.
- Developed architectural models for both isolated and multi-tenant customer NG911 call processing solutions by utilizing the latest industry standards.

General Dynamics Information Technology, Inc.

Sr. Principal Engineer, 2009-2016

- Storage design and migration at 22 locations
- Produce architectural design VMware virtual infrastructure to replace an existing physical environment.
- Act as Linux design and integration engineer for migrating an existing Arcsight installation from RHEL 4.7 to new servers running RHEL 5.7 while maintain existing file systems and data.
- Technical lead for the integration and implementation from Nominum CNS to Nominum Vantio caching name services across 18 worldwide sites.
- Performed de-installation and installation functions of a new NETIQ app manager and analysis center for monitoring hardware and services across 18 worldwide sites.
- Technical lead to design, code and implement an asset management database and web front end using PHP and MySQL.
- Technical lead for designing and implementing patch management and sustainment for all Unix systems.
- Oversee and participate with lab maintenance for a 300-system developmental lab environment.
- Developed customized RHEL 4.7 deployment DVD with a pre-installed base product suite that required minimal user intervention for production rollout.
- Developed, documented and deployed migration process for moving Arcsight servers from Windows to Linux environments while maintaining existing data.
- Performed the design and implementation of a plug-and-test product evaluation lab utilizing NetApp storage, VMware on HP blades, plus Cisco network switches.
- Developed and executed DNS evaluation test plan against Infoblox DNS and Bluecat DNS appliances.

REFERENCES

Name:	Frank Loulourgas President, FOTIS Networks	**Email Address:**	frank.loulourgas@fotisnetwroks.com	**Telephone:**	617.780.9406
Name:	Daniel Hagan President, Hagan Consulting	**Email Address:**	daniel.hagan@hagan-consulting.com	**Telephone:**	540.445.1776
Name:	Kathy Lambrecht Program Sr. Manager, GDIT Defense Division	**Email Address:**	Katharine.Lambrecht@gdit.com	**Telephone:**	781.400.7529

George Manso will serve as the Nebraska cybersecurity analyst.

GEORGE MANSO (COMTECH) – NEBRASKA CYBERSECURITY ANALYST	
EXPERIENCE AND SKILL SUMMARY	
• Design and implementation of secure systems that meet the varying needs of federal, civil, military, and commercial security standards • Extensive experience as an advanced security practitioner • Skilled in risk management framework and remediation	
COMPARABLE COMPLETED PROJECTS	
Project Title:	Commonwealth of Massachusetts NG911
Company Name:	Commonwealth of Massachusetts, State 911 Department
Client Contact Information:	
Project Description:	Engineer, furnish, install, test and maintain a turnkey NG911 platform for deployment within the Commonwealth of Massachusetts, replacing the legacy SR and E911 telephony platforms with a NENA i3 NGCS, ESInet, and HCH solution. The system uses a geospatially routing core at redundant data centers, with HCH services presenting 911 calls to 291 primary, secondary and private PSAPs over a statewide ESInet. Managed the installation of 298 PSAP locations across the Commonwealth of Massachusetts, enabling a NENA i3-compliant NG911 with end-to-end services that included the replacement of the existing CHE call-handling solution with HCH, transitioned away from SRs to three geo-diverse data centers, and two fully redundant and diversely routed ESInet WANs.
Role/Responsibility:	Principal cybersecurity architect supporting network, systems, and security design and integration. Functions as the principal security officer supporting the Commonwealth of Massachusetts NG911 deployment, operations and maintenance.
EDUCATION/TRAINING/CERTIFICATIONS	
• B.S., Information Technology, Bryant University, Smithfield, R.I. • CompTIA Advanced Security Practitioner • ITIL Foundation • MCITP Server Administration • MCTS Server	
EMPLOYMENT HISTORY	
Comtech Telecommunications Corp./FOTIS ***Principal Cybersecurity Architect and IT Security Officer, September 2014-Present*** • Design implementation and maintenance of an NG911 cybersecurity threat detection, prevention and mitigation program. • Supporting multiple NG911 programs including the Commonwealth of Massachusetts, Fairfax County, Va., Charles County, Md., and multiple counties within the state of Ohio. • Routinely involved in analysis, assessment and prevention techniques. • Continuous review and evaluation of OEM products and security standards for compliance with NENA, Criminal Justice Information Services (CJIS), and other industry security requirements.	

GEORGE MANSO (COMTECH) – NEBRASKA CYBERSECURITY ANALYST

General Dynamics Information Technology, Inc./FOTIS

Principal Security Engineer, 2007-2014

- Led and supported major DoD programs for accreditation and authorization using the NIST Risk Management Framework.
- Established authority-to-operate credentials using cybersecurity design elements.
- Active directory architecture focused on new deployments and disaster recovery.

REFERENCES

Name:	Dave McCarthy GDIT Director Facility Security	**Email Address:**	david.mccarthy@gdit.com	**Telephone:**	781.400.7498
Name:	Kathy Lambrecht Program Sr. Manager, GDIT Defense Division	**Email Address:**	Katharine.Lambrecht@gdit.com	**Telephone:**	781.400.7529
Name:	Jeff Modica Tyto Athene Director of Engineering	**Email Address:**	jeff.modica@gotyto.com	**Telephone:**	617.429.3045

1.10. Subcontractors [RFP VI A 1j]

If the bidder intends to subcontract any part of its performance hereunder, the bidder should provide:

i. name, address, and telephone number of the subcontractor(s);

ii. specific tasks for each subcontractor(s);

iii. percentage of performance hours intended for each subcontract; and

iv. total percentage of subcontractor(s) performance hours.

Table 8. Subcontractors

Subcontractors	
Digital Data Technologies, Inc. (DDTi)	
Address:	2323 W. Fifth Avenue, Suite 210, Columbus, OH 43204
Telephone Number:	614.429.3384
Tasks:	Software service for ECRF, LVF, LDB, Spatial Interface (SI)
% of Performance Hours:	<5%
Total % of Subcontractor performance hours:	~ 15%
Equature, Inc.	
Address:	3900 NW 12th Street, Suite 100, Lincoln, NE 68521
Telephone Number:	858.768.2183
Tasks:	Software and appliance for i3 Logging
% of Performance Hours:	<5%
Total % of Subcontractor performance hours:	~ 20%
Inteliquent, Inc.	
Address:	550 West Adams Street, Suite 900, Chicago, IL 60661
Telephone Number:	720.590.6933
Tasks:	Service provider aggregation
% of Performance Hours:	<5%
Total % of Subcontractor performance hours:	~ 30%
Global Blue DVBE, Inc.	
Address:	5930 Price Ave., McCelellan, CA 95652-2402
Telephone Number:	916.704.0131
Tasks:	Smart hands operations and maintenance support
% of Performance Hours	<10%
Total % of Subcontractor performance hours:	~ 35%

NG911 ESInet and NGCS

RFP/Solicitation # RFP 6264 Z1

Technical Approach – Option C

June 3, 2020

Submitted to:
Annette Walton & Nancy Storant, Buyer(s)
Next Generation 911 Emergency Services IP Network (ESInet) and Next Generation Core Services (NGCS)
State Purchasing Bureau
1526 K Street, Suite 130
Lincoln, NE 68508
402-471-6500
as.materielpurchasing@nebraska.gov

Prepared by:
Sam Collura
VP, North America Commercial Sales
NextGen Communications, Inc.
d/b/a Maryland TeleCommunication Systems, Inc.
2401 Elliott Avenue, Suite 200
Seattle, WA 98121-3311
404.229.3143
sam.collura@comtechtel.com
www.comtech911.com

Notices

TeleCommunication Systems, Inc. is a wholly owned subsidiary of Comtech Telecommunications Corp. This proposal is being submitted by TeleCommunication Systems, Inc. or its service-providing affiliate (using the Comtech brand). Throughout this proposal, the Comtech Telecommunications Corp. (Comtech) parent company name may be referenced. However, TeleCommunication Systems, Inc. (or its service-providing affiliate) is generally the contracting entity for the delivery of Comtech's highly available Wireless E9-1-1, VoIP E9-1-1, VoWiFi E9-1-1 and NG9-1-1 i3 solutions and systems, and it is expected to be the contracting entity for the proposed system.

EMedia®, GEM9-1-1®, LivewirE9-1-1®, RAVE9-1-1®, VoIP Verify® and VoLTE9-1-1® are registered trademarks, and Intrepid9-1-1™ and LocatE9-1-1™ are trademarks of TeleCommunication Systems, Inc. in the U.S. and certain other countries.

All other brand names and product names used in this document are trademarks, registered trademarks, or service marks of their respective holders.

TeleCommunication Systems, Inc. holds more than 400 issued patents and has more than 100 patent applications pending worldwide. Its patents cover a broad spectrum of technologies, including wireless data, text and voice telecommunications, location-based services, GIS/mapping, intercarrier messaging, secure communications, public safety/E9-1-1, and mobile navigation.

Nasdaq GS: CMTL

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Acronyms

Acronym	Definition
CHE	Call Handling Equipment
DDP	Discovery, Preliminary Design, and Planning
EFIS&T	Engineer, Furnish, Install, Secure, and Test
ESInet	Emergency Services Internet Protocol Network
IMS	Integrated Master Schedule
IP	Internet Protocol
IPT	Integrated Product Team
ISO	International Standards Organization
ITIL	Information Technology Infrastructure Library
NENA	National Emergency Number Association
NG911	Next Generation 911
NGCS	Next Generation Core Services

Acronym	Definition
NMS	Network Management System
NSOC	Network Security and Operations Center
OSP	Originating Service Provider
PIDF-LO	Presence Information Data Format - Location Object
PMP	Project Management Plan
PSAP	Public Safety Answering Point
QoS	Quality of Service
SIP	Session Initiation Protocol
SLA	Service Level Agreements
SME	Subject Matter Expert
SOW	Statement of Work
SS7	Signaling System 7
TDM	Time Division Multiplexing

1. Technical Approach [RFP VI A 2]

The technical approach section of the Technical Proposal should consist of the following subsections:

1.1. Understanding of the Project Requirements [RFP VI A 2a]

a. Understanding of the project requirements;

Comtech Response:

Comtech understands the primary project goals include:

- Establishment of a National Emergency Number Association (NENA) i3-compliant statewide Next Generation 911 (NG911) solution that includes an Emergency Services Internet Protocol Network (ESInet) and Next Generation Core Services (NGCS).
- The contracted vendor will provide an ESInet/NGCS service on behalf of the state of Nebraska.
- The ESInet will connect directly to two call-handling equipment (CHE) hosts located in each of the seven regional systems, which encompass 68 Public Safety Answering Points (PSAPs).
- All regions will connect to the NG911 ESInet/NGCS within calendar year 2023.
- Geospatial routing is desired; however, if a short-term transitional routing schema is required, the Commission prefers its provider to take the quickest possible production path.
- Provision of an ESInet solution capable of interfacing with neighboring state and regional NG911 Internet Protocol (IP) networks.

1.2. Proposed Development Approach [RFP VI A 2]

b. Proposed development approach;

Comtech Response:

<u>Phased Development Approach</u>

The state of Nebraska NGCS and ESInet service will be implemented in a series of phases, with intermediate milestones and deliverables as follows:

- Phase 1 – Discovery, Preliminary Design, and Planning (DDP)
- Phase 2 – Detailed Systems and Process Design
- Phase 3 – System Construction/Build-and-Test Requirements
- Phase 4 – Production Readiness and System Deployment to Production
- Phase 5 – Managed Network Services

Comtech will turn up the Nebraska NGCS and the ESInet service, testing the entire system prior to initiating any cutover activities. We will coordinate OSP transition in a logical fashion that ensures there is no service interruption or disruption at the PSAPs. This process is generally accomplished by having OSPs establish connectivity to our aggregation service while maintaining their existing service. Subsequent OSP migration needs to be balanced to ensure that OSPs are not put into a risk element. The proposed aggregation service is designed to strike a balance between convenience and expedience as OSPs migrate to their preferred interconnectivity based upon Session Initiation Protocol (SIP) that features a full NENA i3-compliant NG911 interface (including Presence Information Data Format - Location Object [PIDF-LO]). During the initial outreach, we will strongly encourage OSPs to interconnect via SIP, with a full NG911 session interface. OSPs that are ready to interconnect via SIP will do so at the BCFs, deployed as part of the aggregation services. If an OSP insists that we define a Time Division Multiplexing (TDM)/Signaling System 7 (SS7) interconnection option, we would consider doing so upon consultation with the Commission, and once all possible alternatives for interconnecting via SIP/NG911 have been exhausted.

Disciplined Engineering Process

Throughout the project lifecycle, Comtech employs a disciplined engineering process that routinely evaluates industry standards, solution compliance, and overall system performance. Comtech test, validation and deployment activities that are an integral part of Phase 3 and Phase 4 signal the onset of our monitoring, reporting, and real-time event updates associated with our 24x7x365 Network Security and Operations Center (NSOC) operational support and proactive awareness. This strategic early involvement of the NSOC, encompassing Tier I through Tier III technical and engineering support, is involved from the earliest project stages and ensures that no significant learning curve is required to manage a system's operation and maintenance. The NSOC has well-defined processes, procedures and work instructions for all facets of support and maintenance, based upon Information Technology Infrastructure Library (ITIL) principles and industry best practices. All NSOC procedural documentation is maintained in a digital library, with online access for all staff members plus a limited number of hard copies available for reference. All documentation updates go through a review and approval process, and the latest approved documents are available online. Comtech ensures that all NSOC staff are trained on our NGCS and ESInet architectural and operational standards.

The NSOC will provide timely responses and replies to the Commission while coordinating the team's responses to maintenance, service and customer service actions. The NSOC team is involved from the onset of testing and is familiar with the system as it has been deployed, understands the Service Level Agreements (SLAs), and is trained in the Network Management System (NMS) to understand alarm notifications, the generation of alarms, and their severity, assignment and urgency in relation to maintaining the quality of service (QoS), response and resolution times, plus the appropriate escalation procedures based upon SLA requirements.

For the duration of the contract, Comtech will provide the Commission with monthly reports on actual network availability, which will include scheduled and routine maintenance activities. Throughout the solution, all equipment will comply with applicable industry standards.

Third-Party Mitigation

Comtech partners with third parties to broaden our expertise and subject-matter discipline, which further enhances our solution. Identifying and managing potential risk is an integral part of Comtech's development, implementation, operational, logistical and managerial processes. We strive to consistently and effectively identify, manage and mitigate potential difficulties, using a risk management approach that combines our disciplined and proven processes with the expertise and experience of our team's Subject Matter Experts (SMEs).

In previous project deployments with these partners, we have ensured their commitment to customer requirements through the flow-down processes included in our subcontractor agreements.

Comtech recognizes that change and uncertainty are major drivers of risk, and we use a highly effective risk-reduction technique for activities that have the potential to cause significant changes, or when a great deal of flexibility is anticipated. In these instances, we generally develop an incremental work breakdown approach consisting of short-duration tasks that more easily provide discrete, known deliverables. By breaking work into smaller components, any difficulty is identified more quickly and becomes easier to mitigate, with less potential for negative impact.

Our closed-loop system continually collects and uses metrics and event data to identify and track possible problem areas and mitigation options. Every member of the Comtech NGCS and ESInet service team is responsible for supporting the identification, documentation, assessment and resolution of risk. Effective risk management allows for early identification of any difficulties that, despite mitigating actions, may need further attention or require escalation. This process is discussed further in our configuration management and control process program, our release management program, and our diligent test program.

The Comtech Nebraska service team has directly relevant experience in delivering NG911 and E911 solutions, as do our core partners, who have been part of our service delivery team since 2013; this includes working with Comtech on projects at both state and county levels while using standardized tools and processes for consistent project, change, and risk management. Our team and its experience enhance our capabilities to surmount any difficulties and provide a direct benefit to the state of Nebraska's NG911 solution.

As an International Standards Organization (ISO) 9001:2015/TL 9000:2016–certified supplier, we use the seven-step methodology depicted in Figure 1 for risk management and mitigation. At each step, risks are qualified, reviewed and updated using a variety of review and management techniques at every working level. These include: Integrated Product Team (IPT) forums; SME reviews; informal day-to-day staff interactions; risk identification checklists; analyses of assumptions, decision drivers, similar/like processes, and change requests; solution

validation of Statement of Work (SOW) requirements; and proof-of-concept or prototype testing.

We analyze the schedule and budget implications of all identified risks. We coordinate risk management with the customer, regardless of the source.

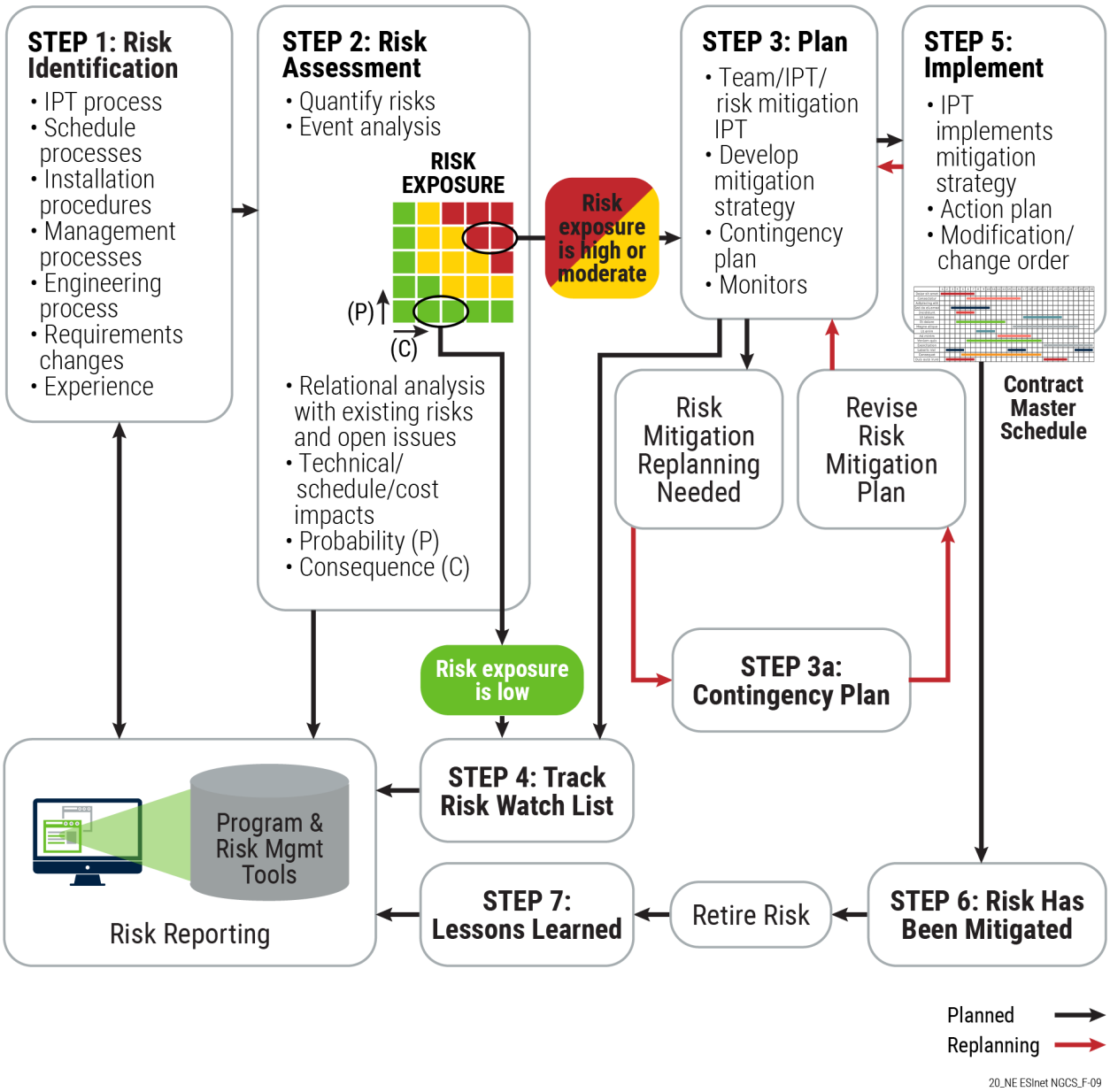

Figure 1. Risk Management Process Flow

<u>Monitoring and Reporting Network Performance</u>

Comtech employs a disciplined engineering process that routinely evaluates industry standards, solution compliance, and overall system performance. These Comtech test, validation and

deployment activities that are part of Phases 3 and 4 signal the onset of our monitoring, reporting and real-time event updates associated with our 24x7x365 NSOC operational support and proactive awareness. This strategic early involvement of the NSOC, encompassing Tier I through Tier III technical and engineering support, is involved from the earliest project stages and ensures that no significant learning curve is required to manage the system's operations and maintenance. The NSOC team is involved from the onset of testing and is familiar with the system as it has been deployed, understands the SLA, and is trained in the NMS to understand alarm notifications, the generation of alarms, and their severity, assignment and urgency in relation to maintaining the quality of service, response and resolution times, plus the appropriate escalation procedures based upon SLA requirements.

For the duration of the contract, Comtech will provide the Commission monthly reports on actual network availability to the , which will include scheduled and routine maintenance activities. The NSOC uses SolarWinds to provide network availability reports; these reports include Network Performance Monitor, VoIP and Network Quality Manager IP SLA, and NetFlow Traffic Analyzer modules.

1.3. Attachment C - Technical Requirements Option A, B, and/or C [RFP VI A 2c]

c.	*Attachment C - Technical Requirements Option A, B, and/or C;*

Comtech Response:

Comtech's completed Attachment C for Option C is included as a separate attachment (see *File 5*) and in its native format.

1.4. Proposed High-Level Project Plan [RFP VI A 2d]

d.	*Proposed high-level project plan*

Comtech Response:

Comtech has fully documented our implementation plan using a five-phase approach, which has been developed from our vast experience in deploying NG911 for other customers. This approach leverages our unparalleled experience in engineering and the program management of complex projects that possess critical security requirements and risk sensitivity for E911 and NG911 installations.

Throughout this phased approach, Comtech will provide engineering and project management where we will communicate regularly with all stakeholders and subcontractor management principals, while also continuously identifying and mitigating risks in order to successfully implement the system. Comtech will abide by the negotiated schedule, validate all functional requirements, and work with the Commission and its regions regarding concurrence and approvals for each phase of the project.

The Comtech team will Engineer, Furnish, Install, Secure, and Test (EFIS&T) and implement a

complete NGCS solution—based upon the NENA i3 standard—for the state of Nebraska. To accomplish this task, Comtech has created a high-level notional Integrated Master Schedule (IMS) (see *File 11*), dividing the project's overall implementation into the five phases as described below. Upon contract award, the IMS will be updated to reflect actual dates.

The state of Nebraska's NGCS and ESInet service will be implemented in a series of phases, with intermediate milestones and deliverables as follows:

- Phase 1 – DDP
- Phase 2 – Detailed Systems and Process Design
- Phase 3 – System Construction/Build and Test Requirements
- Phase 4 – Production Readiness and System Deployment to Production
- Phase 5 – Managed Network Services

Immediately upon contract award, Comtech will work with the Commission to schedule a kickoff meeting and to mutually establish an agenda that addresses key aspects of the program. At this meeting, Comtech will present our preliminary project management plan (PMP), which includes our design solution, project plan, schedule, and all other elements of this critically important deliverable. This meeting will serve as a formal introduction between Comtech key personnel, partner representatives, Nebraska leadership, and stakeholders. Of utmost importance to Comtech is to establish a close partnership with the Nebraska project team and all stakeholders, as well as to ensure that objectives, requirements, milestones and expectations are met with the highest degree of customer satisfaction.

The following activities span the duration of the project and account for the coordination, customer interaction, oversight, management, risk mitigation, and tracking of all program tasks. This includes requirements analysis, interface design and documentation, the conducting of engineering design reviews, and all necessary test plan and procedure modifications.

All deliverables within Phase 1 and Phase 2, plus the breakdown of activities required to be completed for each, are shown in our IMS as found in *File 11*. The status of these deliverables and tasks will be shared with the Commission on a regular basis to ensure compliance and adherence to the schedule.

1.5. Schedule for the Lifecycle of this Project [RFP VI A 2e]

e. Schedule for the lifecycle of this project; and

Comtech Response:

Comtech's IMS includes ongoing operations, maintenance, and customer service support for the lifecycle of the contract. As standards evolve, we recognize the contract may need to be reworked to accommodate this evolution, or certainly a discussion with the Commission regarding the prospect of adjusting the contract accordingly. As part of our response to *Attachment C, NGCS Optional Services* we have identified several newer technology initiatives

for the Commission's consideration. We understand these proposed elements do not cover all options the Commission may consider as a result of ongoing executive briefings or industry events. Regardless of the inclusion of any such options, Comtech will continue to maintain a current schedule throughout the lifecycle of the project. The Comtech account manager will ensure the continuity of service, support, and communication with the Commission for as long as the contract is in force.

1.6. Cost Proposal [RFP VI A 2f]

f.	*Cost Proposal*

Comtech Response:

Comtech's completed Cost Proposal is included as a separate attachment and in its native format.

Kent Hellebust
President, Safety & Security Technologies
Comtech Telecommunications Corp.
Phone: 206.792.2446

June 3, 2020

Annette Walton/Nancy Storant, Buyer(s)
State Purchasing Bureau
1526 K Street, Suite 130
Lincoln, NE 68508

Subject: RFP 6264 Z1 Next Generation 911 Emergency Services IP Network (ESInet) and Next Generation Core Services (NGCS) – Option C Response

Dear Ms. Walton and Ms. Storant,

NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc. (hereinafter referred to as "Comtech")[1] commends the state of Nebraska in its commitment to the transition and operation of a Next Generation 911 (NG911) service to meet your citizens' public safety needs. Comtech is pleased to submit this National Emergency Number Association (NENA) i3-compliant Option C proposal in response to the above-referenced Request for Proposal (RFP). Enclosed with this cover letter, Comtech submits all requested information in the technical proposal, the cost proposal, and the proprietary information package, each of which are separate files as instructed by the RFP. Our priced offer is on an all or none basis.

Furthermore, Comtech acknowledges receipt of Addenda 1, 2, 3, 4, 5, 6, 7 and 8 as issued by the state of Nebraska Public Service Commission ("Commission").

Executive Summary

Comtech is focused on delivering Next Generation Core Services (NGCS) solutions, and we are the only provider to achieve live production services in six states, including Massachusetts, Iowa and Washington. Comtech and its partners are passionate about adhering to industry standards and participating in the evolution of NENA i3 standards-based solutions to accommodate the needs of the public safety community. This commitment is clearly illustrated by Comtech's purchase of the Massachusetts-based NG911 business division of General Dynamics in 2019 and our April 2019 contract-extension award to provide the Commonwealth of Massachusetts with large-scale, standards-based NG911 services for another five years. We are proposing these same industry-leading services for the state of Nebraska.

[1] NextGen Communications, Inc. is a wholly owned subsidiary of TeleCommunication Systems, Inc. TeleCommunication Systems, Inc. is a wholly owned subsidiary of Comtech Telecommunications Corp.

Kent Hellebust
President, Safety & Security Technologies
Comtech Telecommunications Corp.
Phone: 206.792.2446

Comtech delivers a disciplined, standards-based approach to planning, designing, implementing, managing, monitoring, and maintaining NGCS to support our NENA NG911 vision. Our solution is fully aligned with the Commission's objectives and has the adaptability to expand and adopt future NENA goals.

Comtech has extensive public safety experience and coverage in the state of Nebraska. In 2019, we supported network carriers by routing more than 400,000 calls statewide. We currently have 47 active Text to 911 deployments, with four in process. Comtech also provides call handling to Nebraska's north-central region.

Comtech has selected a group of partners for the Nebraska project whose capabilities exceed the requirements of this RFP. Our partners include Digital Data Technologies, Inc. (DDTi), Inteliquent, and Global Blue DVBE, a veteran-owned a veteran-owned business network of certified Nebraska field support personnel.

This offer includes:

- Aggregation of all incoming Originating Service Provider (OSP) traffic by converting it to Session Initiation Protocol (SIP) traffic, as necessary, plus full packet inspection to ensure optimal security. This element of our solution will allow for the rapid retirement of existing Selective Routers (SRs).
- A fully functional and deployed Location Database (LDB) that has been operational in Massachusetts since 2015. This critical component ensures that the most authoritative location data is used for geospatial routing. Importantly, there would be no need for Nebraska's OSPs to have their own Location Information Server (LIS) or for an interim IP Selective Router (IPSR). Jurisdictions can migrate to geospatial routing at their own pace without having to create a separate track. Also, for those OSPs that presently have a LIS, our solution offers a seamless transition to NG911.
- A state-of-the art Emergency Services IP Network (ESInet) that will interconnect all seven regional hubs. Our design maximizes redundancy and reliability with a fully meshed network that uses diverse routing and provides situational awareness where further diversity is cost-prohibitive. Our i3-compliant ESInet will carry 911 traffic and additional inputs authorized by the Commission to conform with its security requirements.
- Cybersecurity built-in from design through all phases of implementation and operation. Our robust cybersecurity practices apply principles learned over many years to ensure that the state of Nebraska solution incorporates industry best-practices.

Kent Hellebust
President, Safety & Security Technologies
Comtech Telecommunications Corp.
Phone: 206.792.2446

- Extensive knowledge of industry standards and the ability to manage a disciplined program that establishes interfaces to facilitate functional interoperability for bi-directional intrastate call transfers.

Unparalleled Integration Experience

Comtech maintains a Pre-Integration Environment (PIE) Laboratory where our partners' equipment and software are deployed to support an active test environment. We test new software and functionality in our lab—both as individual systems and applications, and within the end-to-end solution—to ensure superior performance, reliability and functionality. Only after this testing is performed is new software made available to our customers for deployment.

Accelerated Migration Path

Comtech is highly motivated to assist the Commission in replacing its legacy 911 elements and their associated fees. Comtech does not sell legacy Automatic Location Information (ALI), SR, nor Centralized Automated Message Accounting (CAMA) trunk services; consequently, we have no conflict of interest in eliminating these costs. We are fully committed to completing the migration to NG911 in the shortest possible time:

- Comtech has unmatched experience deploying DDTi's NENA i3-compliant LDB. This critical component underpins geospatial routing and allows for full ALI replacement across all jurisdictions, while providing for varying states of readiness.
- Comtech has extensive experience working with multiple carriers to ensure a smooth transition, from the use of SRs to direct connections with NGCS core locations.
- Comtech has the subject matter expertise and disciplined processes to deliver diverse routes between its sites and all ESInet points of presence.
- Comtech's comprehensive approach, from design to operation and maintenance, is fully resourced and capable of delivering results for the Commission beginning on Day One.

Reduced Call Transfers

By using the polygons and policies determined through a collaborative process with local jurisdictions, Comtech's geospatial routing will reduce the need for call transfers. Since the Comtech solution uses the most authoritative location available, transfers will be further reduced with improvements in location accuracy automatically. Examples of improvements include returning accurate wireless call location faster by eliminating legacy-based ALI queries and the use of location clearing houses. We have considerable experience in reducing call

Kent Hellebust
President, Safety & Security Technologies
Comtech Telecommunications Corp.
Phone: 206.792.2446

transfers in one of our other large-scale statewide deployments, and we will apply those lessons learned to achieve similar results in Nebraska.

The Comtech team prides itself on its commitment to customer satisfaction and flexibility. We fully believe that one model does not fit every scenario and that each deployment has its unique aspects. As such, we look forward to working with the Commission to make *your* NG911 vision a reality.

All contact regarding this RFP submission should be directed to:

Sam Collura
Vice President, N. America Commercial Sales
Comtech Telecommunications Corp.
2401 Elliott Avenue, Suite 200
Seattle, WA 98121-3311
sam.collura@comtechtel.com
404.229.3143

Sincerely,

Kent A. Hellebust

Kent Hellebust

Form A
Bidder Proposal Point of Contact
Request for Proposal Number 6264 Z1

Form A should be completed and submitted with each response to this solicitation. This is intended to provide the State with information on the bidder's name and address, and the specific person(s) who are responsible for preparation of the bidder's response.

Preparation of Response Contact Information	
Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.
Bidder Address:	2401 Elliott Avenue, Suite 200 Seattle, WA 98121-3311
Contact Person & Title:	Sam Collura, VP, North America Commercial Sales
E-mail Address:	sam.collura@comtechtel.com
Telephone Number (Office):	404.229.3143
Telephone Number (Cellular):	404.229.3143
Fax Number:	206.792.2001

Each bidder should also designate a specific contact person who will be responsible for responding to the State if any clarifications of the bidder's response should become necessary. This will also be the person who the State contacts to set up a presentation/demonstration, if required.

Communication with the State Contact Information	
Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.
Bidder Address:	2401 Elliott Avenue, Suite 200 Seattle, WA 98121-3311
Contact Person & Title:	Sam Collura, VP, North America Commercial Sales
E-mail Address:	sam.collura@comtechtel.com
Telephone Number (Office):	404.229.3143
Telephone Number (Cellular):	404.229.3143
Fax Number:	206.792.2001

NG911 ESInet and NGCS

RFP/Solicitation # RFP 6264 Z1

Attachment C, Option C

June 3, 2020

Submitted to:
Annette Walton & Nancy Storant, Buyer(s)
Next Generation 911 Emergency Services IP Network (ESInet) and Next Generation Core Services (NGCS)
State Purchasing Bureau
1526 K Street, Suite 130
Lincoln, NE 68508
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as.materielpurchasing@nebraska.gov

Prepared by:
Sam Collura
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Acronym

Acronym	Definition
AES	Advanced Encryption Standard
ACLs	Access Control Lists
ADR	Additional Data Repository
ALI	Automatic Location Information
ANI	Automatic Number Identification
APCO	Association of Public Safety Communications Officials
API	Application Program Interface
ASC	Application Session Controller
ATAS	Advanced temporal analysis system
B2BUA	Back-to-Back User Agent
BC	Business Continuity
BCF	Border Control Function
BE	Best Effort
BFD	Bi-Directional Forward Detection
BGP	Border Gateway Protocol
CAD	Computer Aided Dispatch
CAS	call-associated signaling
CBQoS	Class-Based Quality of Service
CCB	Configuration Control Board
CDR	Call Detail Record
CHE	Call-Handling Equipment
CJIS	Criminal Justice Information Services
CLDXF	Civic Location Data Exchange Format
CLEC	Competitive Local Exchange Carriers
CM	Configuration Management
CoMA	Commonwealth of Massachusetts
CPA	Certified Public Accountant
CPU	Central Processing Unit
CSA	Cloud Security Alliance
CSRIC	Communications Security, Reliability and Interoperability
DBMS	Database Management System
DDoS	Distributed Denial of Service
DHS	Department of Homeland Security
DiffServ	Differentiated Services
DMZ	Demilitarized Zone
DNS	Domain Name Server

Acronym	Definition
DoD	Department of Defense
DR	Disaster Recovery
DSCP	Differentiated Services Code Points
E911	Enhanced 911
ECaTS	Emergency Call Tracking System
ECRF	Emergency Call Routing Function
ECRIT	Emergency Context Resolution with Internet Technologies
EF	Expedited Forwarding
EHS	Environmental Health and Safety
EIDD	Emergency Incident Data Document
EMS	Emergency Medical Service
ERB	Engineering Review Board
ESB	Emergency Service Boundary
ESInet	Emergency Services IP Network
ESME	Emergency Services Message Engine
ESN	Emergency Service Number
ESRP	Emergency Services Routing Proxy
ESZ	Emergency Service Zone
FCAPS	Fault, Configuration, Accounting, Performance, Security
FCC	Federal Communications Commission
FoCR	Function of Code R
GAAP	Generally Accepted Accounting Principles
GIAC	Global Information Assurance Certified
GIS	Geographic Information System
GUI	Graphical User Interfaces
HCH	Hosted Call Handling
HELD	HTTP Enabled Location Delivery
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
ICA	Interconnection Carrier Agreement
ICD	Interface Control Document
ICE	Industry Collaboration Events
ID	Identification

Acronym	Definition
IDPS	Intrusion Detection & Prevention System
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IIS	Internet Information Services
IITE	Integrated Information Technology Environment
ILEC	Incumbent Local Exchange Carrier
IMS	Integrated Master Schedule
IP	Internet Protocol
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
IRS	Internal Revenue Service
ISDN	Integrated Services Digital Network
ISMS	Information Security Management System
ISO	International Standards Organization
ISP	Internet Service Provider
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITSM	Information Technology Service Management
IV&V	independent verification and validation
KBD	Knowledgebase Development
KPIs	Key Performance Indicators
LAN	Local Area Network
LART	Log Analysis and Retrieval Tool
LDB	Location Database
LEC	Local Exchange Carrier
LIF	Location Interwork Function
LIS	Location Information Server
LNG	Legacy Network Gateway
LNP	Local Number Portability
LoST	Location-to-Service Translation
LSRG	Legacy Selective Router Gateway
LTE	Long Term Evolution
LVF	Location Validation Function
MCS	MSAG Conversion Service
MIS	Management Information System

Acronym	Definition
ML	Machine Learning
MLTS	Multi-Line Telephone System
MOS	Mean Opinion Score
MPC	Mobile Positioning Center
MPLS	Multi-Protocol Label Switching
MPP	Master Project Plan
MSAG	Master Street Address Guide
MSC	Mobile Switching Center
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
NAT	Network Address Translation
NBAR	Network-Based Application Recognition
NCAS	non-call-associated signaling
NENA	National Emergency Number Association
NG	Next Generation
NG911	Next Generation 911
NG911aaS	NG911 as-a-Service
NGCS	Next Generation Core Services
NGFW	Next Generation Firewall
NG-SEC	Next Generation 9-1-1 Security
NIF	NG911-specific Internetwork Function
NIST	National Institute of Standards and Technology
NMS	Network Management System
NOC	Network Operations Center
NORS	Network Outage Reporting System
NPAC	Number Portability Administration Center
NRF	No Record Found
NSOC	Network and Security Operations Center
NTP	Network Time Protocol
OCOM	Oracle's Communication and Operations Manager
OEM	Original Equipment Manufacturer
OSPF	Open Shortest Path First
OSP	Originating Service Provider
pANI	Pseudo ANI
PCA	PSAP Credentialing Authority
PCAPs	Packet Captures
PHB	Per Hop Behavior

Acronym	Definition
PIDF-LO	Presence Information Data Format - Location Object
PIE	Pre-Integration Environment
PIF	Protocol Interworking Function
PIM	Protocol Independent Multicast
PKI	Public Key Infrastructure
PM	Project Manager
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PMO	Program Management Office
POAM	Plan of Action and Milestones
POCs	Points of Contact
POPs	Points of Presence
POTS	Plain Old Telephone Service
PRF	Policy Routing Function
PRI	Primary Rate Interface
PSALI	Private Switch ALI
PSAP	Public Safety Answering Point
PSTN	Public Switched Telephone Network
QA	Quality Assurance
QC	Quality Control
QMS	Quality Management System
QoS	Quality of Service
RCE	Remote Command Execution
RDP	Remote Desktop Protocol
RFID	Radio Frequency Identification
RFP	Request for Proposal
RMF	Risk Management Framework
RSA	Rivest-Shamir-Adleman
RTCP	Real-Time Control Protocol
RTP	Real-Time Protocol
RTT	Real-Time Text
S911D	State 911 Department
SBC	Session Border Controller
SCTP	Stream Control Transmission Protocol
SDLC	System Development Life Cycle
SDO	Standards Development Organization
SDP	Session Description Protocol
SD-WAN	Software-Defined Wide Area Network

Acronym	Definition
SFTP	SSH File Transfer Protocol
SI	Spatial Interface
SIEM	Security Information Event Management
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SLAM	Service Level Agreement Metrics
SME	Subject Matter Expert
SMS	Short Message Service
SNMP	Simple Network Management Protocol
SOC	Security Operations Center
SOC	Service Organization Control
SOI	Service Order Input
SOP	Standard Operating Procedure
SPL	Session Plugin Language
SQL	Structured Query Language
SRS	Session Recorder Server
SS7	Signaling System 7
SSAE	Statement on Standards for Attestation Engagements
SSP	System Security Plan
SUT	System Under Test
TCC	Text Control Center
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
TDoS	Telephony Denial of Service
TFOPA	Task Force on Optimal PSAP Architecture
TLS	Transport Layer Security
TMN	Telecommunications Management Network
TN	Telephone Number
TSP	Telephone Service Provider
UAC	User Agent Client
UAS	User Agent Server
UBAD	User Behavior Anomaly Detection
UDP	User Datagram Protocol
U-NAPTR	URI-enabled Naming Authority Pointer
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
US-CERT	United States Computer Emergency Readiness Team

Acronym	Definition
VCRM	Verification Cross-Reference Matrix
VLAN	Virtual Local Area Network
VM	Virtual Machine
VoIP	Voice over Internet Protocol

Acronym	Definition
VPC	VoIP Positioning Center
VPD	Virtual Private Desktop
VPN	Virtual Private Network
WAN	Wide Area Network

Attachment "C"
Option C Revision One
Technical Requirements
Public Service Commission ESInet
Request for Proposal Number 6264 Z1

Bidders are instructed to complete a Matrix for Emergency Services Internet Protocol (IP) network (ESInet). Bidders are required to describe in detail how bidder's proposed solution meets the conformance specification outlined within each Requirement. The matrix is used to document and evaluate bidder's response to the requirements.

The matrix should indicate how the bidder intends to comply with the requirement and the effort required to achieve that compliance. It is not sufficient for the bidder to simply state that it intends to meet the requirements of the RFP. PSC will consider any such response to the requirements in this RFP to be non-responsive and the bid may be rejected. The narrative should provide The Public Service Commission (PSC) with sufficient information to differentiate the bidder's business solution from other bidders' solutions. Bidder shall not refer to other sections as a response. Even if the response is an exact duplicate of a previous response, the details shall be provided in the same paragraph as the requirement. Bidder shall not include pricing information in the description and shall not refer the reader to pricing.

The bidder must ensure that the original requirement identifier and requirement description are maintained in the matrix as provided by PSC. Failure to maintain these elements may render the bid non-responsive and result in for rejection of the bidder.

The bidder's response to each of the below requirements shall include an indication on the level of compliance that can be met. (Complies, Complies Partially, Complies with Future Capability, Does Not Comply) Bidder shall respond by placing an "X" in only **one** checkbox per requirement. Failure to complete this process properly will be treated the same as "Does Not Comply," and may result in the rejection of the response form.

- Complies: Bidder's proposal complies with the RFP requirements and the products/services are included in the base price, are currently developed, generally available, and successfully deployed. Responding with "Complies" or "Complies with Future Capability" shall mean the bidder's solution meets or exceeds the requirement regardless of any comments included as additional information.

- Complies Partially: Bidder's proposal addresses the RFP requirements through another method that currently is developed and available for implementation (i.e., shall be generally available), or the solution complies with some, but not all of the requirements. Bidder is responsible for clearly explaining how the proposed solution does not fully comply.

- Complies with Future Capability: The RFP requirements will be met with a capability delivered at a future date. This response shall include a calendar quarter and year in which the requirement will be met with a generally available product or service at no additional cost.

- Does Not Comply: Bidder's proposal does not/cannot meet the specific RFP requirement.

Attachment "C"
Option C Revision One
Technical Requirements
Public Service Commission ESInet
Request for Proposal Number 6264 Z1

Req Identifier	Requirement Description				
GEN-1	**General Requirements - Bidder Vision of NG911** The Commission is issuing this RFP for the purpose of selecting a qualified bidder that understands and can clearly demonstrate alignment with the industry's evolution to NENA i3 -compliant ESInet and NGCS solutions. Describe bidder's vision of NG911 and how bidder's vision aligns with NENA's i3 standard, bidder's approach to monitoring and supporting evolving standards and the bidder's level of involvement in standards development and Industry Collaboration Events (ICE).	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: Comtech's Next Generation 911 (NG911) as-a-Service (NG911aaS) has been designed, built, and maintained for compliance with the latest National Emergency Number Association (NENA) i3 standards that leverage industry-leading technologies including public cloud and big-data analytics. In considering the NG911 ecosystem, Comtech is among the select few that have delivered a statewide end-to-end Next Generation Core Service (NGCS), Emergency Services IP Network (ESInet), Geographic Information System (GIS), and hosted call-handling (HCH) solution. We have done this not only as a prime contractor and integrator, but also by providing NENA i3 functional elements, a database, and a cybersecurity solution to ensure optimal operational performance and interoperability through transitional services to achieve end-state architectures. Comtech's vision of NG911 is an evolving, fully functional system that is accessible anytime, anywhere, from any device, and with a foundation based upon NENA standards and the requirements of 911 jurisdictions. Comtech provides a disciplined, standards-based systems engineering approach to architecting, designing, implementing, securing, managing, monitoring, and maintaining NGCS, ESInet and HCH solutions to enable the realization of NENA's NG911 vision and advance beyond it. Comtech's NG911aaS is a proven solution that uses geospatial call routing to its maximum feasible extent. All 911 payloads (voice, text, video, etc.) delivered to Comtech NGCS, regardless of language or physical capabilities, are routed to the most authoritative Public Safety Answering Point (PSAP) and available for public safety personnel to respond. We work with all industry-leading public safety partners to integrate devices, sensors, metadata, and information from connected human and non-human sources in order to enhance and expedite public safety's response to all emergency needs for the geographical area being served. A disciplined and sound engineering, testing, validation, and management solution is of paramount importance to ensure the high reliability and availability necessary for the most significant of public safety networks. Equally important, though, is our ongoing attention and commitment to innovation in continually improving the functionality, quality, and efficiency of providing critical information and forensics to call takers and PSAP personnel. To this end, Comtech is actively involved in the development of the *NENA STA-010.3*, as well as parallel updates to NENA standards. Comtech works with partners and conducts independent interoperability tests to evaluate Original Equipment Manufacturer (OEM) development and product compatibility. This involvement enables Comtech to leverage a realistic adoption and implementation plan to accommodate future updates that are independent of individual vendor processes. Given that NENA, Association of Public-Safety Communications Officials (APCO), and other Standards Development Organization (SDO) standards are in a continuous state of update, refinement and replacement, Comtech anticipates working with our customers on an ongoing basis to establish goals for adopting new NG911 standards and capabilities that may become the basis for future standards, as they are incorporated within products from NG911 vendors, suppliers and partners.				

	Comtech believes maintaining standards compliance is imperative to ensuring and enabling support for full NG911 migration and the ever-advancing end-state solution. This process includes inherent support for a wide array of existing and future technologies and services delivered within and outside of the ESInet, including video. This approach becomes even more important as interfaces extend beyond local, regional and state jurisdictions to include interoperability and cooperation with regional and national agencies. Comtech operates multiple testing labs where solutions, including equipment and software from our industry partners, are deployed to support an active analytical environment. We test new software and functionality in these labs—both as components, subsystems, and within the end-to-end solution—to ensure performance, reliability and functionality. Only after system engineering testing is performed are new software, hardware, services, and solutions recommended to our customers for piloting or production deployment. Comtech and our NG911 solution partners have proven past performance, actively participate in NENA Industry Collaboration Events (ICE), NENA Emergency Incident Data Document (EIDD) Conveyance Working Group, NG911 PSAP Working Group, and others. Our experienced team has continually been at the forefront of the country's NG911 migration. In Comtech's Massachusetts deployment, we demonstrated the efficacy and capability of NENA's full vision of i3, using only geospatial routing of all 911 payloads while decommissioning the legacy selective routers and Automatic Location Information (ALI) databases. Comtech converted 291 PSAPs from Enhanced 911 (E911) to NG911 NGCS/ESInet/HCH capabilities in less than one year, at times converting as many as nine PSAPs in a single week. Comtech's focus on implementing our vision in alignment with NENA's vision made the Massachusetts transition to NG911 possible. Comtech recommends a similar NGCS and ESInet approach for Nebraska.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
GEN-2	**Proprietary Solutions and Standards** 1. Describe any use of proprietary standards, interfaces, or protocols in bidder's proposed solution. 2. Describe any patented technology in the proposed solution, who owns the patent and describe any licensing arrangements. Disclose any technological limitations, in the response.	X			
	Bidder Response: Comtech's NG911aaS does not utilize any proprietary standards, interfaces, or protocols. Comtech does not include or impose any technological limitations.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
GEN-3	**System and Network Architecture** The Commission is seeking a Public Safety Grade Next Generation 911 System. System and network architecture, including the design and deployment of interface functions and security measures, shall comply with current NENA i3 requirements as established in NENA-STA-010.2-2016, NENA Detailed Functional and Interface Standards for the NENA i3 Solution. Describe how the solution meets or exceeds the requirements in Section V.D.1.b. of the RFP.	X			

Bidder Response:

Comtech's NG911aaS delivers a NENA i3-compliant public safety grade NG911 system that meets or exceeds the requirements of reliability, availability, and security.

Comtech's NG911aaS hybrid physical/cloud architecture provides geodiverse data centers for reliability and call quality coupled with cloud flexibility, redundancy and capacity. Comtech'sNG911aaS possesses the highest degree of resiliency, reliability, redundancy, and service availability. Comtech's proposed NG911aaS meets the required Mean Time Between Failure (MTBF) of 0.99999, as recommended in *NENA-INF-016.2-2018, Section 2.10.1*., ensuring that our service provides 99.999 percent reliability. This is a highly redundant system and provides NG911 capability that is designed and deployed to interconnect the various Nebraska regions. Comtech's NGCS service converts to NG911 core functionality without interrupting any existing legacy functions and provides seamless ingress and egress to and from the legacy network. Comtech's NGCS service distributes these incoming services across multiple gateways and accepts calls from all classes of service. The NG911 core functionality allows Voice over Internet Protocol (VoIP), wireless, Incumbent Local Exchange Carriers (ILECs), Competitive Local Exchange Carriers (CLECs), and future media providers to connect directly to the ESInet. The maintenance and sustainment of the data centers is managed out of a dedicated Network and Security Operations Center (NSOC), which is staffed with 24x7x365 help desk personnel and technical support engineers.

Comtech's proposed ESInet is a state-of-the-art, i3-compliant network, designed to maximize redundancy and reliability with a fully meshed network that uses available diverse routing and provides situational awareness where further diversity is cost-prohibitive. Our ESInet will carry 911 traffic and additional services authorized by the Commission that conform to the agency's security requirements.

Comtech employs a disciplined network management and monitoring system that provides for real-time situational awareness and ensures notifications are generated and received in a timely fashion. In addition, as alarms are triggered, the Comtech NSOC will initiate corrective/preventative measures to ensure system reliability and availability. As part of Comtech's operational model we employ an established quality, change management and configuration control process that ensures standardized methods and procedures are used for the efficient and prompt handling of all changes to the NG911aaS information technology (IT) infrastructure, which therefore minimizes the number and impact of any related incidents. These processes apply to all aspects of the project including, without limitation, the data centers, the cloud services, and the network. Change and configuration control processes adhere to an IT Infrastructure Library (ITIL) framework to improve service, manage changes, and maintain configuration control and minimize downtime. Comtech employs ITIL principles in all our project frameworks for design, service transition, service operation, and maintenance.

Comtech's disciplined approach—combined with the ability to recover from component failure, a failed system upgrade, operator error, or some other scheduled or unscheduled system interruption—guarantees a rapid Mean Time to Repair (MTTR) and ensures 99.999 percent availability so that downtime does not exceed five minutes per year, as recommended in *NENA-INF-016.2-2018, Section 2.10.1.*

Security is a key ingredient of Comtech's core competency and experience in all relationships with its NG911, state, local, federal, and defense businesses. To ensure the highest level of cybersecurity, Comtech's NG911 security architecture fully incorporates and complies with NENA security

	recommendations, Communications Security, Reliability and Interoperability Council (CSRIC) best practices, National Institute of Standards and Technology (NIST) security framework, Federal Communications Commission (FCC) security guidelines, and Comtech operational best-practices. This defense-in-depth strategy uses a layered approach to secure the solution, including physical security (e.g., site diversity, power redundancy, physical access), network security (e.g., security zones, packet scanning, Distributed Denial of Service (DDoS) protection), server and application security (e.g., log management and review, patching, backup and restoration plans), and host security (e.g., anti-malware/virus and encryption). Comtech's NG911aaS exceeds the recommendations of *NENA-INF-015.1-2016, Section 3.2*, including the following: • Rivest–Shamir–Adleman (RSA)-based public-key authentication for mutual authentication • Active Directory and Okta for centralized authorization, multi-factor authentication, and single sign-on • Advanced Encryption Standard (AES)-based encryption for confidentiality • Secure Hash Algorithm (SHA)-based digital hashing for integrity protection • Digital signature for non-repudiation. Comtech's proposed NG911aaS meets the Commission's requirements by using geo-diverse redundant components and systems, ensuring system resiliency and 99.999 percent availability, thereby delivering a NENA i3-compliant public safety grade NG911 system.

Any additional documentation can be inserted here:

GEN-4	**General Requirements – Capacity- Initial Design and Deployment** The bidder's initial design and deployment of the ESInet and NGCS elements, including all components and physical network segments, shall provide capacity that will support current and planned ESInet traffic and usage that occurs as a result of data sharing in, and between, all participating PSAPs, the Commission, and designated support agencies. Additionally, the system and network design shall allow for 50 percent traffic and usage growth for the life of the contract. All current and potential core functions and applications shall be considered, e.g., call-handling systems, CAD, logging, GIS data, streaming media, real-time text (RTT), IP traffic, traffic management systems, communications systems, and incident management systems. Describe how bidder's solution will meet or exceed the above requirements.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: Comtech's proposed NG911aaS provides the capacity to support current and planned Nebraska NGCS and ESInet requirements. Comtech utilizes fiber networks, which allow for large bandwidths and the ability to increase bandwidth as new requirements are identified. Comtech also uses enterprise- and carrier-grade devices that possess the capacity to meet any demand. Comtech's NGCS and ESInet services are designed and implemented to support a nationwide level of 911 activity. As shown in *Comtech Confidential Figure 1*, Comtech's ESInet service is a high-capacity and redundant dual Multi-Protocol Label Switching (MPLS) infrastructure. This approach maximizes routing diversity, fiber utilization, and carrier diversity. Comtech's services will easily allow for growth over time to accommodate more than 50 percent of existing traffic volume over the term of the contract. Today, Comtech's service easily meets the bandwidth and processing capacity of the 911 payload including Real-Time Text (RTT), call handling, logging, management, and GIS media requirements of Nebraska. As for potential applications, once defined they can utilize the ESInet for connectivity. Quality of Service (QoS) is a standard implementation, ensuring that real-time synchronous communications (i.e., voice 911 payloads) receive priority over non-911 traffic types. Comtech looks forward to detailed discussions regarding future applications of services for Nebraska.				

Any additional documentation can be inserted here:

Figure 1. ESInet MPLS Mesh (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
GEN-5	**Capacity - Scalable Deployment** As the Commission migrates toward a fully compliant NG911 environment, additional PSAP functions will transition to the systems and network. The bidder's systems and network solution shall be designed and deployed in a way that is easily scalable, with the capability to grow in both capacity and coverage without disruption in service. Describe in detail how the solution meets or exceeds the above requirements.	X			
	Bidder Response: The Comtech NG911aaS (NGCS, ESInet, as well as select value-added options) is a hosted internet protocol (IP)-enabled 911 call and data processing service, including hardware, software and legacy ALI access components, designed to support all current VoIP, wireless and wireline 911 calls being answered within the state of Nebraska's PSAPs. Comtech's NG911aaS is scalable to support future NG911 IP features, advancements, and requirements. Comtech understands the Commission's intention to participate in a future national ESInet and that the adopted solution should be compliant with consensus standards of industry associations, regulatory bodies, carriers and vendors. As these standards continue to evolve and mature, Comtech remains committed to maintaining NENA i3 compliance in an agile process. Scalability is provided by using industry engineering and design best practices, as well as by incorporating state-of-the-art hardware and software solutions with inherent scaling abilities that do not require forklift upgrades. This scalability is inherent to the design, regardless of any phased system rollouts. Network-level devices are chosen based upon the overall capacity of the device for current use and expansion. The design then considers the fit that devices and applications will play in the overall architectural design to ensure the same levels of scalability and growth potential exist on an end-to-end basis; this eliminates any potential for forklift upgrades as service demand increases. Comtech NSOC monitoring efforts, can help determine when and where any appropriate increase in services should be applied.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SEC 1	**Security - Cybersecurity** For the purposes of this RFP, cybersecurity (security) is considered to be the established systems and processes focused on protecting computers, networks, programs, and data from unintended or unauthorized access, modification, or destruction. **Security Requirements and Standards** The security requirements established in applicable standards listed in Section V.D.1. Table 1 of the RFP apply equally to all elements of the system requested in this RFP, including but not limited to components located in the following building types: 1. Data centers; 2. Network-housing structures; and, 3. Regeneration sites and other buildings housing any element or device that is part of the overall system. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's cybersecurity program is based upon an International Standards Organization (ISO) 27001 framework, which focuses on secure system controls, processes and procedures designed to protect Comtech and customer information resources. Additional requirements, standards and guidance come from our customers and from industry organizations such as Cloud Security Alliance (CSA), NIST and NENA. Figure 2 depicts the high-level view of Comtech's cybersecurity program methodology. Comtech's NG911 components reside on a secure private network. All network segments are managed and controlled to protect connected systems and associated data. Technical controls are deployed layered and in depth; this design includes the firewalls, intrusion detection, session border controls, and monitoring for security and availability. Comtech's comprehensive physical security program includes centrally managed exterior and interior card access controls and video surveillance systems. Environmental controls include implementations of power, cooling and fire-control systems. Security operating procedures are documented for systems and specify detailed instructions for activities such as access control, asset management, system backup, and configuration management. Other operational security controls include patch, change/capacity, and technical vulnerability management. The information security teams at Comtech develop and maintain processes designed to continuously identify new risks, as well as monitor and respond to known security risks. These processes include risk assessments, security reviews, security audits/testing and vulnerability management. Technical controls such as threat detection and security monitoring also complement these processes. Comtech maintains an incident response team that, in partnership with our NSOC, will identify and respond to events within the operational environment, including customer notification. Notification methodology includes sending email to customer-identified stakeholders as well as initiating telephone calls to provide progress updates. This incident response process is documented and closely integrated with Comtech's overall disaster preparedness and				

	emergency response programs. Our security program ensures the security of all physical and logical components including data centers, PSAPs (up to the ESInet demarcation points), and all other in-scope system components.

Any additional documentation can be inserted here:

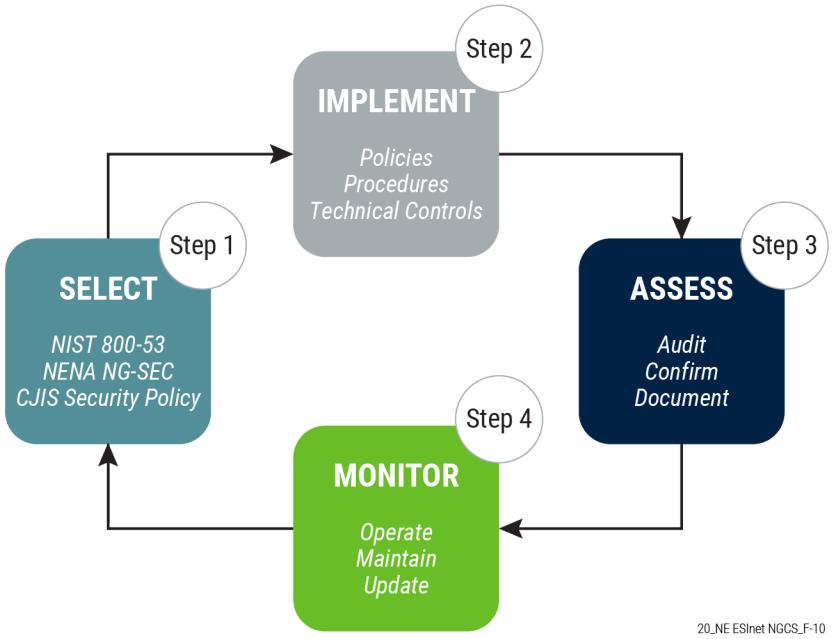

Figure 2. Comtech Cybersecurity Program Methodology

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SEC 2	**Security Plan** A comprehensive security plan is a critical component of the Nebraska's NG911 network solution. Describe the security plan, including the 1. mitigation; 2. monitoring; 3. alerting and incident-response processes; and 4. provide information on specific hardware components and software systems incorporated in the proposed security plan. The proposed solution's security plan is required to utilize the latest NENA specifications and incorporate the intentions of the Communications Security, Reliability and Interoperability Council (CSRIC) and Task Force on Optimal PSAP Architecture (TFOPA) best practices.	X			

Bidder Response:

Comtech's System Security Plan (SSP) complies with all stated network security function requirements. Comtech's services security controls are based upon the NIST Security Framework. Comtech's SSP addresses Nebraska security specifications, best practices and regulations, including those of NENA, NIST, Task Force on Optimal PSAP Architecture (TFOPA), and FCC's CSRIC. Comtech's SSP's posture follows the latest NENA specifications and incorporates CSRIC best practices when deploying network services. Security policies are always top-of-mind when designing and delivering services to data centers, PSAPs, ESInets, NGCS solutions, and any other components and enclaves connected to the solution.

The Comtech SSP is specifically structured for NGCS and ESInet services. The SSP provides an overview of system security requirements while describing the controls being put into place to meet those requirements. The SSP is developed in accordance with guidelines contained in *NIST Special Publication (SP) 800-18, Guide for Developing Security Plans for Information Technology Systems*, plus applicable risk-mitigation guidance and standards. Security requirements and controls are drawn from the *NIST 800-53, Information Security Management System* (ISMS), for which the Comtech Safety & Security Technologies group is certified. The SSP provides a high-level summary (by control family) as to how NGCS and ESInet services comply with the security controls articulated in *NIST 800-53*. The SSP details the degree to which Comtech's NGCS and ESInet services conform to security controls as well as the way those controls are implemented.

1. Mitigation
Comtech services are structured within the Comtech security strategy to protect information assets in an integrated and proactive manner. Security information event management and intrusion detection/prevention elements are distributed throughout our computing infrastructure. These security platforms provide capture, deep packet inspection, analysis, and the reporting of malicious and anomalous activity, thereby allowing Comtech's NSOC to focus on high-risk events for investigation and mitigation. Internet-facing assets are protected by Next Generation Firewalls (NGFWs) and DDoS mitigation services. The Comtech SSP applies mitigation controls to guard against vulnerabilities, intrusions, and issues that may result due to natural disasters. Each control registers the security posture selected by Comtech and documents the policies, processes, and artifacts validating the controls.

2. Monitoring
Comtech's SSP defines the security controls that implement continuous monitoring and security operations monitoring. Comtech's NSOC provides 24x7x365 security monitoring, performed by security analysts and supported by SANS Institute Global Information Assurance Certified (GIAC) security engineers. The SSP defines the NSOC's responsibility for threat policies and process enforcement, threat detection and prevention, security incident

	management, security auditing and logging, vulnerability management, and security incident forensic analysis. Additionally, the SSP describes continuous monitoring controls that define the auditing and validation of the SSP and associated security documents. **3. Alerting and Incident Response** Comtech's SSP defines security controls for alerting in the NGCS and ESInet services, including controls on notifications of physical access alerts, security alerts and advisories, and intrusion alerts. Furthermore, the SSP contains security controls required for incident reporting and response. These security controls define the policies, processes, and artifacts that validate the controls. **4. Hardware components and software systems** Comtech's SSP for NGCS and ESInet services contains security control for the lifecycle management of hardware components and the detection, tracking, and remediation/mitigation of security vulnerabilities in the software. Comtech's ESInet systems are categorized as operational in several states; the SSP is based upon existing systems as well as designs for future deployments. Specific details, such as security hardware, have been abstracted to protect the confidentiality of sensitive information. Comtech's security team is available to discuss those details, as needed. Figure 3 depicts Comtech cybersecurity program components. *Comtech Confidential Figure 4* depicts the proposed security architecture. Untrusted Security Zone devices (servers and other applications) are co-located with a security appliance and/or are monitored as a licensed endpoint. Untrusted Security Zone devices include the switches, firewalls, and servers in the NG911 environment.

Any additional documentation can be inserted here:

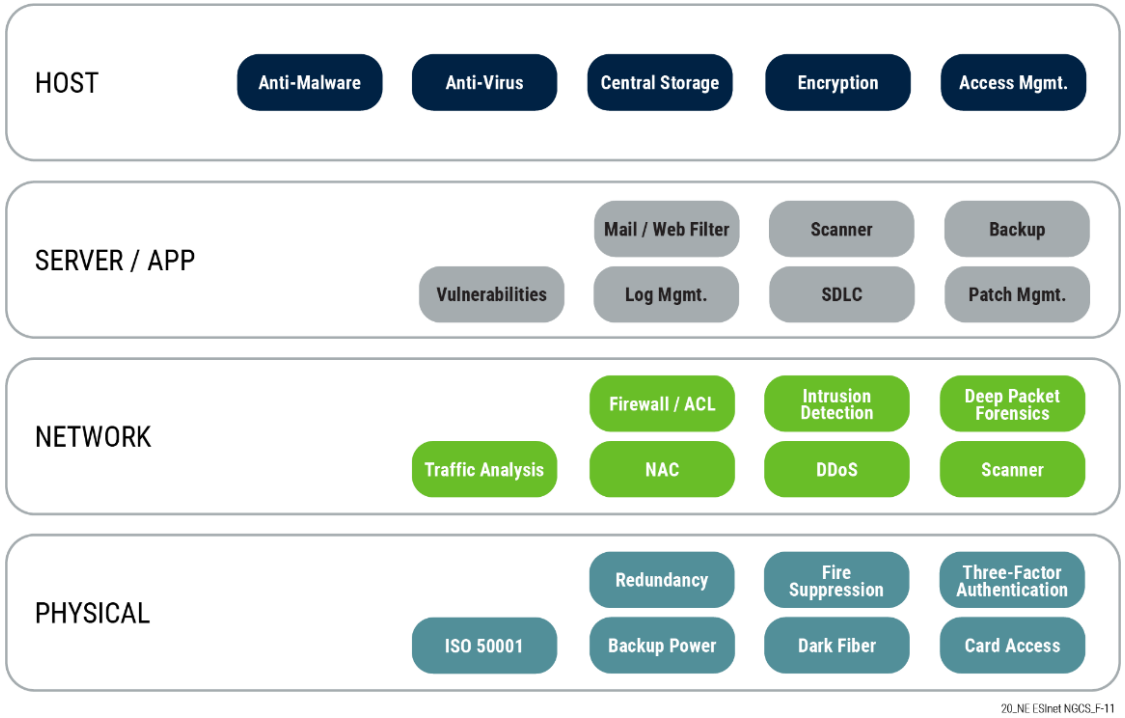

Figure 3. Defense-in-Depth Design

Figure 4. Border Control Function (BCF)-Specific Network Security Zones (Comtech Confidential)

SEC 3	**Security Compliance Matrix** Describe how the proposed solution addresses compliance in each of the following categories in NENA 75-502, NENA NG-SEC Audit Checklist.

Category
1. Senior Management Statement

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2. Acceptable Use Policy
3. Authentication/Password Policy
4. Data Protection
5. Exception Request/Risk Assessment
6. Hiring Practices
7. Incident Response
8. Information Classification and Protection
9. Physical Security
10. Compliance Audits & Reviews
11. Network/Firewall/Remote Access
12. Security Enhancement Technical Upgrade
13. Technical Solutions Standards
14. Wireless Security

Bidder Detailed Response:

Comtech complies with all aspects of *NENA 75-501* as determined by the results of *NENA 75-502*, which includes each of the 14 categories listed above. A compliance summary of each category is shown below.

1. Senior Management Statement
Comtech maintains a SSP for Comtech's NG911aaS including a Senior Management Statement as governed by Next Generation 9-1-1 Security (*NG-SEC) 75-501*. The SSP designates those individuals responsible for security management and also documents the security goals and objectives of Comtech's NG911aaS solution.

2. Acceptable Use Policy
Comtech maintains an Acceptable Use Policy for Comtech's NG911aaS solution that is compliant with *NG-SEC 75-501*. Any misuse of Public Safety and Emergency Services assets in the NG911aaS solution is reported to the designated management for investigation and further action.

3. Authentication/Password Policy
Comtech maintains an Authentication Policy that complies with or exceeds all requirements in *NG-SEC 75-501*, in addition to *NIST SP 800-53*. This Authentication Policy governs all aspects of authentication, including the use of passwords and passphrases, security around authenticators, use of multifactor authentication, and the handling of credentials within the environment.

4. Data Protection
Comtech maintains a Security Assessment Policy that complies with or exceeds all requirements in *NG-SEC 75-501 Data Protection*, in addition to *NIST SP 800-53*. Comtech performs annual self-assessments of security as well as third-party assessments every two years.

In addition to the Security Assessment Policy, Comtech implements a network design that complies with *NG-SEC 75-501 Data Protection*. The Comtech NG911aaS solution has the following functions:

- Logs all activity within the solution
- Only allows access to the service at controlled points of entry
- Has limited ingress/egress points controlled by full security boundaries and documented in Interface Control Documents (ICDs)
- Aligns its solution with data security boundaries across the system segments and achieves proper boundary control between each segment

In addition to the above, Comtech maintains an Access Control Policy governing concepts of account creation, least privilege, and role-based access control. The Access Control Policy outlines how permissions are granted and ensures that only authorized individuals are only granted access to the systems.
In accordance with the remaining requirements of *NG-SEC 75-501 Data Protection*, Comtech hardens all systems to an industry-standard for technical security controls. All systems are security hardened against attack and include or exceed all *NG-SEC 75-501* requirements for technical security within data protection parameters.

5. Exception Request/Risk Assessment
Comtech maintains a Risk Management Policy that complies with or exceeds all requirements in *NG-SEC 75-501*, in addition to *NIST SP 800-53*. Comtech utilizes an established risk-management process based upon NIST Risk Management Framework (RMF) and Department of Defense (DoD) risk-management programs for the NG911aaS system. All identified vulnerabilities are cataloged, documented, and assigned a risk score in consonance with United States Computer Emergency Readiness Team (US-CERT) standards.

Once scored, vulnerabilities are managed in accordance with Risk Management Policy priorities and timelines. Critical vulnerabilities receive top priority and speedy mitigation by the Comtech security and engineering teams. All vulnerabilities are documented with a Plan of Action and Milestones (POAM), including a status report and a timeline for remediation.

6. Hiring Practices
Comtech maintains a Hiring Practice Policy that applies to all employees and contractors of Comtech and the NG911aaS solution.

7. Incident Response
Comtech maintains both an Incident Response Plan and a Business Continuity (BC)/Disaster Recovery (DR) plan that complies with or exceeds all requirements in *NG-SEC 75-501*, in addition to *NIST SP 800-53*.

8. Information Classification and Protection
Comtech maintains an Information Classification and Protection policy that complies with or exceeds all requirements in *NG-SEC 75-501*, in addition to *NIST SP 800-53*. These associated procedures ensure all data is classified as "sensitive" upon ingress until reviewed for proper classification based upon actual content. Additional procedures ensure proper transport methods, encryption, and data destruction relative to the classification of the data at hand.

9. Physical Security
Comtech maintains a Physical Security Policy that complies with or exceeds all requirements in *NG-SEC 75-501*, in addition to *NIST SP 800-53*. Comtech ensures all employees and contractors receive annual security awareness training. All Comtech facilities have security and access-control systems to ensure only authorized individuals can access the areas that house Comtech equipment. Any workstations or other equipment connected to, or capable of accessing, Comtech's systems are housed in secured, access-controlled areas.

10. Compliance Audits & Reviews

Comtech performs annual internal security audits, and any vulnerabilities subsequently discovered are documented within POAMs and labeled for corrective action. Comtech also utilizes independent third-party auditors every three years.

11. Network/Firewall/Remote Access
Comtech maintains a Remote Access Policy that complies with or exceeds all requirements in *NG-SEC 75-501*, in addition to *NIST SP 800-53*. All external communications run through a NGFW, Intrusion Detection & Prevention Systems (IDPS), proxies, probes, and/or a Session Border Controller (SBC) to protect the edge. Remote access is allowed only to those who possess the authority to connect to the systems, and then only by connecting through a Virtual Private Network (VPN). The network employs IDPS services through the deployed NGFWs. All access and system activity are logged and reviewed on a regular basis.

12. Security Enhancement Technical Upgrade
Comtech maintains a Security Enhancement Technical Upgrade policy that complies with or exceeds all requirements in *NG-SEC 75-501*, in addition to *NIST SP 800-53*. Comtech maintains a real-time security posture analysis and regularly reviews the systems and networks for operational and security deficiencies; these are remediated as needed. Our network and its systems are designed with multiple paths and redundant connections to ensure full operational redundancy.

13. Technical Solutions Standards
Comtech maintains strict technical standards on all elements of the NG911aaS solution. Comtech utilizes system engineering methodology, an Engineering Review Board (ERB), and a Configuration Control Board (CCB) (which includes customer participation) to ensure compliance against engineering, security, and industry standards. Policies and best practices are adhered to during all phases of the service design, test, development, deployment, and administration. Data from these two boards is archived for historic product review and disaster recovery purposes, with no time limit for retention.

14. Wireless Security
Comtech does not currently maintain a policy for NG911aaS regarding the utilization of wireless or Bluetooth technology. Comtech does not utilize WIFI, Bluetooth, or similar technologies in its delivery or operation of the NG911aaS solution.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SEC 4	**Predictive Analysis and Monitoring** Describe solution's capabilities to provide predictive analysis and modeling to combat security threats.	X			

Bidder Response:

Comtech currently employs the following data science predictive analysis and modeling methods:

- Analytic Knowledgebase Development (KBD): Provides machine learning (ML) classification and prediction of success for all Hypertext Transfer Protocol (HTTP) conversations and responses. KBD uses ensemble predictive algorithms to compute the probability of attack success, based upon thousands of analytically decomposed attributes of attack-and-response conversations. Data scientists define these as "features." KBD uses a learning engine to identify both attack attempt and attack success attributes, creates ML model(s), and then computes the statistical probability of attack success on each new HTTP conversation and/or outbound HTTP response. This detection product runs 24x7x365 and is fully automated.
- User behavior anomaly detection (UBAD): UBAD provides ML detection of outlier log source messages by using a learning engine that analyzes "security action" log messages from a user/administrator and classifies anomalous actions based upon security severity. UBAD currently uses custom log parsers to normalize log messages as inputs, with the plan that it will use all log parsers in 2020. UBAD frequently catches the following incidents: crypto miners, geographic anomalies (e.g., login attempts / successes, VPN connections, duplicate user-credential connections), rogue administrator actions (e.g., punched holes in firewalls, inbound remote desktop protocol (RDP) connections that cause policy or access changes, encrypted outbound connections with large data transfers), and more. UBAD runs 24x7x365 in production, while 2020 upgrades will include new datatypes and custom tuning capabilities.
- Structured Query Language (SQL) injection detectors: We have three SQL injection detectors in production that use ML and heuristic methods to detect successful SQL injection attacks and SQL attack progression. While these all use independent models, each statistically predicts the probability of success and the confidence of future success. These detectors operate on the data science batch analytics platform and run hourly 24x7x365. Hourly batches excel at catching successful attacks and progressions that are often overlooked in real-time systems.

Improvements to Comtech's data science are being evaluated with the following pilots:

- Advanced temporal analysis system (ATAS): ATAS models and detects long-running campaigns and attacks. Learning and modeling the temporal patterns of activity, ATAS detects malicious variances to those patterns and produces plots for simplified Security Operations Center (SOC) analyst review.
- Log message baselining: Log message baselining learns "normal" message volumes and IDs, and it identifies any anomalies to the hosts. This analysis uses a learning engine and statistical analysis to "pop a flare" on highly unusual activities, provides temporal analysis, and prioritizes analysis based upon security impact. It is anticipated this service will go into full production in 2020.
- Analytic threat hunting: Analytic threat hunting uses unsupervised and semi-supervised classifiers to analyze attacks that are similar to but significantly different from known attacks. These attacks are clustered into highly similar (99 percent or greater) clusters (groups) and allow

	security analysts and researchers to efficiently review those clusters. Each cluster may include just a few attacks or potentially thousands of activities that can take place in a matter of minutes. • Remote command execution (RCE) detection: We are currently piloting remote command execution detectors that target Apache Struts techniques and other RCE methods, such as web shells and escape vulnerabilities. These detectors share genomes from the SQL batch analytic detectors, which is described above, and extend those models to this critical class of attacks. • Customer modeling: Customer modeling provides for the classification of asset types and purposes while also allowing collaborative filtering analyses for improving coverage/threat detection and predictively identifying vulnerabilities or weaknesses. Customer modeling currently uses several algorithms plus matrix factorization, regularization, and stochastic gradient descent to optimize customer experience and security value.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SEC 5	**Credentialing Process** Solution shall provide a process so that devices and carriers outside the IP network shall not have credentials, per NENA-STA-010.2-2016. Provide details regarding how the solution ensures that devices and carriers outside the IP network are not provided credentials.	X			
	Bidder Response: Only those users (both devices and carriers) determined to have valid business reasons for accessing the NGCS or the ESInet will be granted access. Anyone outside the scope of the NGCS or ESInet will not be issued credentials nor be granted access to any elements. This policy is supported by processes defined within *Comtech Access Control Policy (ISO 27001, 9.1.1) and Comtech Access to Networks and Network Services (ISO 27001, 9.1.2)*.				

Any additional documentation can be inserted here:

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		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SEC 6	**Third-Party Security Audits** Bidder shall allow for annual third-party security audits at the request and cost of the Commission. Describe bidder's current process for third party security audits.	X			
	Bidder Response: The Commission may audit directly or have a third-party perform its audit compliance. Comtech will participate in compliance audits arranged by the Commission, presuming these audits will not degrade the required level of service. Comtech will include the Commission's audit requirements in our audit program schedule, which currently includes Comtech internal and external audit engagements as well as those of interested parties, such as our customers. In preparation, Comtech will scope applicable systems and access methods to facilitate the Commission's audit requirements.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SEC 7	**Physical Security** All structures outside the Commission's control that will house components of the ESInet and NGCS shall have security and access-control systems that ensure that only duly authorized individuals can access the areas housing the Commission's systems and network equipment. Any workstations or other equipment connected to, or capable of accessing, the ESInet and NGCS systems shall be housed in secured, access-controlled areas. Any devices, power distribution, and cross-connect panels feeding the cages or rooms housing the Commission's systems similarly shall be protected. Identify any elements that are not under the direct control of the bidder, and a description of the building's security and access-control systems shall be provided.	X			
	Bidder Response: Comtech utilizes a hybrid cloud/physical infrastructure deployment. For our physical components, Comtech's comprehensive physical security program includes centrally managed exterior and interior card access controls and video surveillance systems. Environmental controls include implementations of power, cooling, moisture detection, and fire-control systems. For the cloud-based components Comtech has outsourced the infrastructure for the NG911aaS platform to an industry-leading cloud provider. The utilization of a public cloud solution offers Comtech the flexibility to react to changing industry and technical requirements and trends much faster than with traditional in-house data center management. Comtech utilizes multiple cloud platform regions and multiple availability zones within each region to ensure redundancy and high availability of the NG911 services. Comtech regularly reviews our vendors' level of compliance to the standards we require. The cloud vendor Systems and Organization Controls reports are renewed on an annual basis and are vetted by our security organization to ensure we continuously exceed the security requirements of our customers. Comtech does not own or maintain any of the hardware elements located within the cloud provider's data centers; we operate under a shared security responsibility model, where the cloud provider is responsible for protecting the hardware, software, networking, and facilities that operate their Cloud services infrastructure and run the services offered. Comtech's share of the responsibility is to secure the applications and services we utilize to provide the NG911 call processing, monitoring and alerting services. This is inclusive of the operating systems, the applications, and the network accessibility to said services. All solutions that operate within the cloud platform adhere to strict security protocols set by Comtech. These protocols include both data-at-rest and data-in-transit encryption, both internally between security enclaves as well as for any external communications. Production servers and customer-facing applications and services are physically and logically separated from Comtech's corporate IT systems. The management and operation of production services are managed by the Comtech NG911 NSOC and engineering teams.				

Any additional documentation can be inserted here:

Attachment "C"
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	General Requirements – **Network Operations Center (NOC)/Security Operations Center (SOC)**	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 1	**Centralized NOC/SOC** All services and components deployed and interconnected as part of the solution shall be monitored 24 hours a day, 7 days a week, 365 days a year (24 x 7 x 365) by a centralized Network Operations Center (NOC) and Security Operations Center (SOC). These functions may be in separate buildings or combined in a single building located in the continental United States.	X			
	NOC/SOC Interoperability Contractor shall have the ability to communicate, troubleshoot and connect with other vendors NOCs should there be a different ESInet and NGCS provider. In addition, the Contractor shall interface with the NOCs that support the regions throughout the state. This shall include ebonding of the ticket systems to support transparency throughout the troubleshooting process.	X			
	NOC/SOC Operations Model Provide documentation including organizational structure and procedures that describe bidder's 1. NOC/SOC operations model, 2. Continuity Of Operations Plan (COOP), 3. problem and change management systems, 4. reporting systems, 5. escalation plan, and 6. conformance with best practices (Information Technology Infrastructure Library (ITIL) or equivalent methodology)) for service-delivery management. The Contractor shall confirm the requirement compliance of any interconnected network utilized by the Contractor not previously identified to the Commission.	X			
	Bidder Response: **<u>Centralized NOC/SOC</u>** At the core of Comtech's NG911aaS is Comtech's NSOC facility in Boston, and its Network Operations Center (NOC) in Seattle. Comtech operates both centers to monitor all Comtech and customer systems 24x7x365. The Comtech NSOC and NOC utilize centralized management and monitoring systems that enable situational awareness across both centers. While using a centralized system, Comtech's NSOC and NOC's geographical separation enables its high availability/business continuity plan to handle any situation. **<u>NOC/SOC Interoperability</u>** Comtech's operations centers utilize multiple tools to work with partners and third-party vendors of emergency service solutions. Comtech utilizes communication capabilities (telephone, email, and Slack) along with Information Technology Service Management (ITSM) tools for all operational interfaces with external operations centers. Comtech will interconnect with Nebraska's regional operational providers for incident and problem management, using tools deemed acceptable to the third party in question. If the external operation center is capable, Comtech will build an e-bonded connection with the third party's ITSM system.				

NOC/SOC Operations Model

Comtech operations centers utilize ITIL/ITSM principles and methodologies to operate NG911 systems and services for Comtech customers. Comtech support operational policies and procedures utilizing a suite of tools. Comtech uses BMC Remedy ITSM for event, incident, problem, defect, and service request management. Comtech uses SolarWinds as the basis for its enterprise management platform. Comtech additionally uses a set of element management and diagnostic tools to provide complete situational awareness and management of the components and subsystems that comprise Comtech's NG911 systems and services.

Comtech's operations centers receive events via the automated monitoring of systems alerts, or else manually whenever a customer contacts Comtech via any number of communication methods (toll-free calling, Slack, or Portal). Once an event is evaluated, the NSOC/NOC follows proper incident management processes for resolution thru three tiers of technical support. The Comtech operations centers manage all escalations to partner/OEM/service provider resources and or management personnel. Notifications of ticket status are sent to designated customer personnel. The operational goal is to resolve an incident in the shortest possible time and at the lowest tier of technical support. This notification process is maintained throughout the life cycle of the ticket. State and local jurisdiction personnel who possess viewing permissions will have 24x7x365 remote access to view and track tickets in real time within the Remedy system, as well as being able to view incident reports. Comtech will establish NGCS and ESInet monitoring for Nebraska as part of the user acceptance test process during Phase 4 of the program plan.

Comtech will hold weekly operational meetings with state and regional operations leaders, where incidents and statuses are reviewed. Metrics and trend analyses are reported monthly. These operational reviews will be led by the operations manager, with the overall responsibility for either the NSOC or the NOC. Comtech has a formal process for the opening, tracking and resolution of trouble tickets, along with a well-defined troubleshooting methodology that conforms to industry best practices. The Comtech Remedy ITSM system includes a module that incorporates all vendor and partner information. This information includes contact details, emergency procedures, service providers, operating areas, and so on. Each partner Comtech selects understands the system's technical performance requirements and is integrated into our problem/defect resolution process, to include coordinating with the customer to ensure acceptance prior to a ticket being closed. Comtech will work with each service provider to understand their ticketing system and determine the best method for sharing information to achieve real-time situational awareness. Each of Comtech's subcontractors is governed by a combination subcontractor agreement, mutual work agreement processes, incident escalation procedures, and Service Level Agreement (SLA) compliance. Through the combination of trouble ticket, peer coordination, and recurring communications, Comtech will ensure that all ticket information is complete, accurate and timely.

The NSOC uses and integrates multiple network and event management tools and modules for monitoring, alerting and notifications. Alerts can be configured to initiate trouble tickets by sending a notification to our Remedy trouble ticketing system. Remedy is configured to send notifications to technical, management, plus operational and jurisdictional resources, based upon the severity of the incident and time intervals. All our partners are included in this incident management process and are integrated into the escalation and resolution activity. If a defect is identified, our problem and change management process defines and supports the necessary steps for corrective action to include the root cause analysis, suggested remediation, convening the CCB to review and approve recommended changes, the pre-release process to evaluate the impact of the change, and finally, coordinating the appropriate maintenance/change window to implement and document the change in the configuration management baseline. These actions, coupled with Comtech's extensive experience in proactively managing and monitoring NG911 data centers, provides a comprehensive approach backed by real-world experience.

Continuity of Operations Plan
Comtech Operations maintains a Continuity of Operations Plan (COOP). The primary feature of this plan involves the presence of the integrated dual operations centers, which are geographically separated. Both operations centers keep in continuous contact through a situational awareness tool (Slack) and a centralized enterprise management system. If one of the centers experiences any sort of disaster (weather, natural, fire, etc.), the other center can cover 100 percent of the required services. This redundancy provides the time necessary to restore the impacted center, or to relocate the impacted center's staff to a COOP site maintained in Phoenix, Ariz.

Problem and Change Management Systems
Comtech Operations utilizes the full suite of BMC's Remedy ITSM tool, including Incident, Problem, Defect, Asset, Configuration, Change, and Release Management modules. Comtech Operations identifies service problems based upon multiple incidents for the same component/service, or based upon multiple components/services with the same symptoms. If the root cause of an incident or problem requires new application programming by an OEM or Comtech partner, a defect report will be opened and all incidents/problems will be related to that defect. Once a potential solution for a defect is identified, the combination of Configuration and Change Policies, Standard Processes, CCBs for system/service wide and customer-specific services, and associated archive and reporting services provided in the Comtech portal are applied to validate, test, and release the candidate change into the system/service, thereby resolving the defect and its associated incidents and problems.

Reporting Systems
Comtech Operations generates an impressive amount of fault, configuration, accounting, performance, and security data, which is stored in a data lake. Internally, Comtech Operations uses this data lake to create reports for the analysis and improvement of services. Customers receive reports based upon the contents of the data lake as required by the contract and within the agreed-upon time frame, which is typically monthly. Comtech will deliver to the Commission a Service Level Agreement Metrics (SLAM) report to ensure that all performance criteria are being tracked and managed in compliance with contractual requirements. *A sample Comtech Confidential SLAM report is included in File 11*.

Escalation Plan
Comtech Operations will provide an escalation plan to the Commission's operations and regional operations organizations. This escalation plan will include contact information, in the event an escalation is required. Comtech Operations uses the following guidelines for escalating incidents. These guidelines are designed to ensure that escalation will occur within the specified timeframes. Comtech's NSOC escalates the incident when any of the following is true:

- The on-duty Operations staff cannot resolve the incident
- Incident severity is such that the immediate involvement of Tier II or Tier III staff is required
- A customer asks for the incident to be escalated
- The escalation time limit based upon the Severity Level has been reached

The primary responsibility for driving an incident to resolution lies with the NSOC. Additional resolution support will be provided by the points of escalation, as well as by the Comtech Program Manager. If requested, Comtech NSOC will also escalate the incident to Operations management.

Conformance with Best Practices
Comtech Operations utilizes an ITIL services model as its basis for all operational policy and processes. Comtech will confirm the requirement compliance of any interconnected network utilized by the contractor not previously identified to the Commission.

Any additional documentation can be inserted here:

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NOC/ SOC 2	**NOC/SOC - Remote Connectivity Required** Contractor shall provide any network connectivity required to support Contractor's NOC/SOC services. Describe any remote connectivity required by the solution including, but not limited to, Virtual Private Network (VPN), phone-home connection, and tech support remote access.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: Comtech's NG911aaS includes connectivity required to support our NOC/SOC services. Comtech utilizes in-band management in a Virtual Local Area Network (VLAN) and may deploy long-term evolution (LTE) out-of-band management connectivity. All connections are encrypted and protected. Additionally, Virtual Private Desktop (VPD) access or VPN access with two-factor authentication for management and customer-based access to services or management is provided. Comtech does not use Public Switched Telephone Network (PSTN)-based designs for management access.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 3	**NOC/SOC - Network Security Monitoring and Management** **Security Management Solution** The bidder's security management solution shall control access to network resources in accordance with public safety network security best practices such as NIST, NENA and the FCC to prevent sabotage, service interruption (intentional or unintentional) and the compromise of sensitive information. Security management shall comply with security- and data-integrity standards listed in Section V.D.1. Table 1 in the RFP, to monitor users logging into network resources and to refuse access to those who enter inappropriate access codes. The proposed IP network and systems shall support standard security policies that may include the use of firewall rules, Access -Control Lists (ACLs), Virtual Local-Area Networks (VLANs), VPNs, and Transport Layer Security (TLS) protocols to control network traffic and access. The systems shall support the use of software to detect and mitigate viruses, malware, and other attack vectors. Describe how the solution meets or exceeds the above requirement.	X			
	Bidder Response: The solution will adhere to NIST, NENA and the FCC public safety network security best practices. Comtech agrees to comply with all applicable security requirements listed in Request for Proposal (RFP) Section V.D.1. Table 1. The proposed system adheres to *NENA 75-001 (NG-SEC Standard).* Our Security Information and Event Management (SIEM) systems use software, analytics and expert services to assess, detect and block threats to applications and systems; the system support standard security policies including the use of firewall rules, Access Control Lists (ACLs), VLANs, VPNs, and Transport Layer Security (TLS) protocols to control network traffic and access. This architecture drives security visibility, threat detection, and the speedy resolution of security events. Comtech focuses on the threats most relevant to public safety and critical infrastructure systems by defending each application and infrastructure layer against attacks. NSOC security analysts investigate alerts and detect suspicious activity such as unauthorized access and the exposure or modification of accounts, controls or configurations. Additional controls include firewalls, VLANs, intrusion detection, session border controls, and the encryption of data, whether in transit or at rest.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 4	**NOC/SOC - Connected Systems Compliance** Any system that connects to an IP network shall be required to comply with listed standards in Table 1, including security standards, and demonstrate compliance through an initial and recurring audit. **Security Reports and Recommendations** Contractor shall provide, within 30 days of the end of each calendar month, security summary reports and recommended improvements on a monthly basis (at a minimum), including incidents and incident response; building, facility, and network access reports, including failed attempts; and updates or changes to security systems and software. All related data shall be retained for the period of the contract and provided to the Commission electronically at the end of the contract. Describe how the solution meets or exceeds the above requirement.	X			
	Bidder Response: Comtech agrees to comply with all applicable security requirements listed in Table 1. The proposed system adheres to *NENA 75-001 (NG-SEC Standard).* Comtech will provide monthly reports in the services portal. Reports are inclusive of incidents and incident response; building, facility, and network access reports, including failed attempts; and updates or changes to security systems and software and any changes. This information will be collected through both automated detection and physical records. All data will be placed into the Comtech data lake, and all reporting will be created from the sum of all data for each type of requested report. Updates or changes to security systems and software will be accomplished thru a change management process and will be documented in the associated reporting and archiving. These reporting and change management archives will be maintained for the term of the contract. An example of the level of reporting maintained by Comtech is the implementation of physical controls into all cabinets. Personnel who require access to an equipment cabinet will employ a radio frequency identification (RFID) device to provide identity and permission for access; otherwise they will be required to contact the NSOC/NOC, which will record this event. All cabinets are monitored with video, which is constantly visible to the NSOC/NOC. These measures exceed the requirements in *NENA 75-001*.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 5	**NOC/SOC – Connected Systems Compliance Support for Similar Solutions** Provide details concerning how bidder provides security monitoring and management for similarly deployed production solution. Provide details, including drawings, which explain how the proposed solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech provides similar solutions for the Commonwealth of Massachusetts (CoMA) and the state of Washington. While the CoMA State 911 Department (S911D) system includes HCH in addition to NGCS and ESInet solutions, it is identical in overall design to the NG911aaS proposed for Nebraska. The CoMA S911D engaged a third-party security assessment firm to evaluate Comtech's implementation. This security firm performed penetration testing from external and PSAP facilities. All external attempts were unsuccessful, while internal attempts only succeeded once the overall network security policy was suspended to accommodate application testing. Comtech uses a "defense-in-depth" security and monitoring architecture; this results in deployments that provide end-to-end security services, encryption, PSAP Credentialing Authority (PCA), and other cybersecurity functionalities and services. *Comtech Confidential Figure 5* depicts the defense-in-depth security architecture that serves as the baseline for the Nebraska design. This defense-in-depth approach provides complete end-to-end security, from the ingress to the data center through the NGCS, the ESInet and to the PSAP and dispatch centers. Comtech considers cyber security to be a vital, underlying element for any solution or service we provide. Comtech services include compliance to *NENA 75-001, NENA 04-503*, and Criminal Justice Information Services (CJIS), as well as significant elements of *NIST 800-53*. These controls are inclusive of the operating environment and the interfaces of the NG911 system. While in operation, security monitoring and remediation is an integral aspect of the NGCS. Alongside real-time traffic analysis, passive solutions monitor each system to identify any anomalies in the security of the service. In addition to this real-time review and prevention, Comtech performs annual security audits utilizing the *NENA 75-502 Security Audit checklist* and key elements of the NIST Cybersecurity Framework to ensure continued adherence to and the highest level of security and protection. These security controls and mechanisms discover and mitigate exploits and ensure that risks and vulnerabilities are sufficiently adjudicated before a breach can occur.				

Any additional documentation can be inserted here:

Figure 5. Proposed Security Architecture (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 6	**NOC/SOC - Physical Access Monitoring and Management** Contractor shall track and log all physical access to structures housing IP network components serving the Commission or have the capability to obtain access logs for structures not under immediate control of the bidder. Reports may be requested and shall be made available for review upon request. All related data shall be retained for the period of the contract and provided to the Commission electronically at the end of the contract. Provide a detailed explanation of bidder's processes and procedures for logging physical access to ESInet /NGCS components, and how the bidder's solution generates the required reports.	X			
	Bidder Response: Comtech utilizes cabinet-level physical security. Individuals who access an equipment cabinet will employ an RFID device (whether in dongle or ID format) to provide their identity and reveal their level of permission for access. The system records all access, and these logs are stored within the Comtech data lake. All cabinets are monitored with video, which is constantly visible to the NSOC/NOC; these recordings are also stored in the data lake. If a customer representative or some third-party requires access, a call to the NSOC and the verification of their identity (including video) is required. The NSOC will manually log their entry in the data lake and unlock the cabinet remotely. Comtech can produce monthly reports for subsequent retrieval within the services portal, or the customer can request an ad-hoc report to be created and posted in the portal. All reports are generated from data contained within the Comtech data lake. All data is retained for the duration of the contract, and upon its conclusion we can provide the Commission with the entirety of data collected over the life of the contract.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 7	**NOC/SOC - Incident Management System** The bidder's incident management system shall log all support requests, both from users and those automatically generated. 1. Provide examples of monthly reports detailing tickets opened, pending, resolved, and closed. 2. Provide a matrix outlining Service Impact Levels in a detailed response, to include notification times and response times.	X			
	Bidder Response: The NSOC uses and integrates multiple network and event management tools and modules for monitoring, alerting and notifications. Alerts can be configured to initiate trouble tickets by sending a notification to our Remedy trouble ticketing system. Incident tickets can also be created manually by the NSOC help desk. Remedy is configured to send notifications to technical, management, operational, and jurisdictional resources based upon the severity of the incident and time intervals. All Comtech partners are included in this incident management process and are integrated into the escalation and resolution actions. Comtech has applied the incident classifications of Severity Levels 1–4 as part of our internal tracking and escalation tool. Additionally, our instance of Remedy ITSM includes SLA time frames and an escalation protocol to ensure all required parties are kept apprised of the status. Comtech understands the interpretation of incident severity levels and will verify and confirm with the Commission as to each incident's severity. Comtech will employ all necessary resources to take proper steps and precautions, ensuring that actions within our control are implemented. If there is a situation where a resolution time is in jeopardy, Comtech will communicate with the Commission to ensure that all actions and possible workarounds are reviewed, while also making decisions that have the greatest potential benefit to the Nebraska NG911 system. Comtech will provide monthly reports that clearly document our SLA performance. SLA performance measurements map the severity level of any incident against impact, response time, credit and/or fees, and enforcement. This report is designed to provide a framework of input for monthly reporting SLAM. *A sample Comtech Confidential SLAM report that captures the RFP SLAs is provided in File 11*. Figure 6 illustrates Comtech's severity level tracking and escalation process.				

Any additional documentation can be inserted here:

Attachment "C"
Option C Revision One
Technical Requirements
Public Service Commission ESInet
Request for Proposal Number 6264 Z1

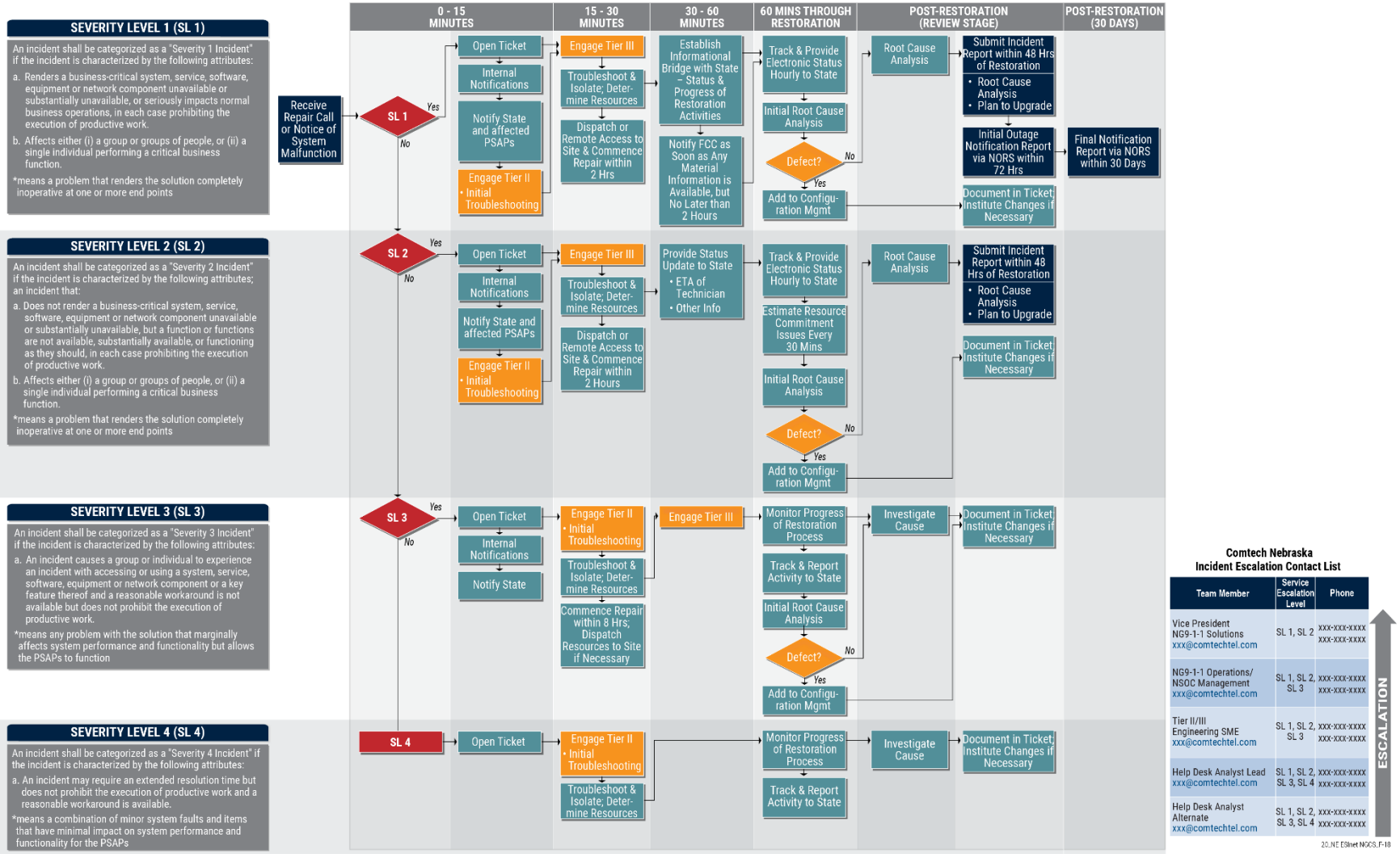


Figure 6. Incident Escalation Chart

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 8	**NOC/SOC - Change Management System** **Change Management Review System** Describe bidder's change management system and the ability to provide the Commission's program manager and designated PSAP representatives with the ability to review proposed change requests and the client approval process. The Contractor shall provide monthly reports detailing change tickets opened, pending, resolved, and closed.	X			
	Bidder Response: Comtech's change management process strictly controls the testing, release, and installation of any changes to hardware, software, or system. The process begins with the identification of a change. Change can be driven by contract modification, a service request, defect remediation, a lifecycle refresh, a system enhancement, or operational optimization. The change begins with the submission of a change request form. Upon approval by engineering management, the change will be tested in the Pre-Integration Environment (PIE) laboratory. Engineering will review and forward the change request once this change has been test-validated. The change request is reviewed by change management and presented for CCB review. The CCB is made up of members of the customer community (Commission's program manager and designated PSAP representatives), Comtech partners, and Comtech functional leads for engineering, operations, quality control, configuration control, release management, security, and program management. CCB proceedings are documented in a charter. All CCB decisions are documented in control forms. Upon CCB authorization to proceed, the change is presented to the release manager, who will implement the change in a pre-integration offline environment for complete testing and verification. Pending successful evaluation, the release manager notifies the CCB and, upon final approval, schedules a maintenance window and provides notification to all parties. Prior to the final configuration change, the pre-release configuration is saved in the event a back-out is required. Upon the successful release upgrade, functional tests are conducted to ensure expected results are achieved and no adverse effects have been experienced. Finally, the operations team accepts the changed system from the release manager, presuming the tests are successful.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 9	**NOC/SOC - Change Management System** **Change Management Tools** Provide detailed descriptions of any other tools bidder intends to use to provide access to the change management system, such as web portals and client software.	X			
	Bidder Response: The Commission will have access via a secure connection to the Comtech portal, which will contain real-time status data of Nebraska NG911 services dashboard, NG911 services reports, service tickets, and services documentation. Additionally, change window notifications, pre-window, start, and end notices will be sent out using Comtech's mass notification services. The Commission, state operations, regional operations, and PSAP operations personnel will be able to opt in for email, voice calls, and text notifications of releases.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 10	**NOC/SOC – Change Management System** **Change Testing and Training Environment** A non-production ESInet replica /NGCS replica, test lab, or similar system shall be established to test, and exercise proposed upgrades, third-party interfaces, and applications prior to release in live production. This system also could be leveraged for training purposes. Provide detailed descriptions of how the solution satisfies this function in the change management process.	X			
	Bidder Response: As a service provider of critical communications systems, we test a wide variety of NG911 products in our i3 solutions interoperability lab (i.e., PIE Lab). Consistent with the requirement "to test, and exercise proposed upgrades, third-party interfaces, and applications prior to release in live production," Comtech uses its PIE Lab to evaluate OEM products, compare performance levels, and demonstrate integrated functionality. These functions are performed on an ongoing basis and are tightly integrated with our configuration and change management processes. It is conceivable the lab environment could be used for training; however, the very nature of a lab suggests that variations in configuration and functional may be present, and training would exist more as an ad-hoc event. Should the Commission desire a Nebraska-exclusive change management, testing, and training environment for the Nebraska NGCS and ESInet, Comtech will work with the Commission to understand the overall concept of operations, which would include the audience for training, the operations and maintenance of a Nebraska change management environment, as well as a change testing and training environment.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 11	**NOC/SOC – Change Management System** **Change Management Process** 1. Outline bidder's proposed change management process. The ITIL change management standard methods and procedures are preferred. 2. Include a description of the process for notifying the Commission and affected PSAPs. Notification shall be made no less than ten (10) business days in advance of the change, except in emergency situations, in which case notification shall be provided immediately. 3. Include explanation of solution's Fault, Configuration, Accounting, Performance, and Security (FCAPS) procedures. 4. Provide a detailed explanation describing how the proposed solution meets or exceeds the requirements for the ITIL and FCAPS processes.	X			

Bidder Response:

Comtech has a robust independent verification and validation (IV&V) and release management process, operated by dedicated technical and engineering personnel who evaluate, test and analyze all hardware and software releases—and their patches—for operational impact, functional performance, and i3 compliance. This activity is tightly integrated with the configuration management and control process. Beyond the technical verification and validation processes produced by the release management team, there is a well-defined configuration control process that will include Commission-delegated participants on a CCB for review and approval before any releases are delivered to the production environment. The CCB is comprised of Comtech, OEM, and customer members. Operational assessment is performed using the Comtech PIE Lab for testing patches and upgrades prior to their rollout, which eliminates any potential maintenance issues.

Change and configuration control processes adhere to an ITIL framework to improve service, manage changes, and maintain configuration control to minimize downtime. Comtech employs ITIL principles in our framework for design, service transition, service operations, and maintenance across our projects.

Regardless of the derivation of the change, whether initiated by a customer, by internal Comtech personnel, or by subcontractors or partners, the change control process is applied if any of the following are affected:

- Interchangeability or interoperability
- Form, fit, function, or interface
- Security
- Items tracked within the configuration baseline

This process pertains to the entire Integrated Information Technology Environment (IITE) being designed, built and maintained pursuant to the Nebraska NGCS ESInet contract and any subcontracts issued under its auspices.

All hardware and software within the Nebraska NG911 IITE are subject to this process. This process ensures that:

- Changes are made in a manner that minimizes the impact on operations and security.
- Changes are made in a manner that minimizes the risk of system instability.
- Changes are communicated to all stakeholders in a way that ensures understanding with adequate (no less than 10 days) notification.

	• Changes are only implemented in the full production environment after the appropriate testing has occurred in a dedicated development/Quality Assurance (QA) environment, and with proper authorization. This process implements the operational policy requirement that both an ERB and a CCB use as the method of reviewing, prioritizing, evaluating, and adjudicating proposed changes to established configuration management (CM) baselines for the Nebraska NG911 IITE. Comtech Operations utilizes SolarWinds for most of the network management and monitoring-and-availability reports; these include Network Performance Monitor, VoIP and Network Quality Manager IP SLA, and NetFlow Traffic Analyzer modules. Additionally the NSOC provides 24x7x365 security monitoring by SANS Institute GIAC security analysts by using multiple industry-leading technologies. This facility is responsible for threat policies and process enforcement, threat detection and prevention, security incident management, security auditing and logging, vulnerability management, and security incident forensic analysis. Comtech complements the SolarWinds Network Management System (NMS) with a NIST RMF-based cybersecurity program for all customers. A NIST RMF is widely accepted as the most in-depth security framework currently available and is ideal for mission-critical systems. Comtech layers additional requirements, standards, and guidance from NENA, CJIS, and other industry organizations on top of NIST RMF to further tailor the cybersecurity program for emergency-call networks. Through the integration of multiple monitoring and management tools in support of a well-defined and disciplined change management process we can provide timely situation awareness, notifications, escalations and provide exceptional incident, and change management and control. Over the past six years, Comtech has continually developed and matured our network management platform, not just for compliance with Telecommunications Network Management (TMN) fault, configuration, accounting, performance, security (FCAPS) requirements, but also to incorporate operational insight and experience that takes into consideration a customer's unique requirements as well as industry standard offerings. By tightly integrating all the software tools with partner monitoring and alerting systems, we have achieved end-to-end visibility of Comtech's NG911aaS. This visibility, coupled with our well-defined and disciplined NSOC practice, ensures that we are cognizant of all performance parameters. When incorporated with our configuration and change management practice, we provide an NSOC service and a change management practice that is intended to identify and minimize any risk to the NGCS and ESInet operational environments. Realizing that human factors can sometimes result in unintended consequences, Comtech blends our technology integration with operational procedures, using the Comtech mass notification system to provide notice of scheduled changes at least 10 days in advance. Comtech will work with the Commission to ensure that the proper points of contact are identified, and we will periodically review and update that contact information and/or a distribution list, as necessary.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 12	**NOC/SOC - Network Management System** **System and Network Management Software** Software packages are widely available for capturing, analyzing, and reporting the network's health based on the Simple Network Management Protocol (SNMP) traffic it receives. Provide the name and description of the management software that will be implemented including all functional modules associated with it (e.g., reporting, backup, and IP address management).	X			
	Bidder Response: Comtech Operations uses SolarWinds to provide network availability reporting; this includes Network Performance Monitor, VoIP and Network Quality Manager IP SLA, and NetFlow Traffic Analyzer modules. Access to SolarWinds NMS reports is accomplished through the Comtech portal, which is permissions-based providing the necessary authorization for personnel access. For the duration of the contract, Comtech will provide the Commission with monthly reports on actual network availability. These reports will include a listing of scheduled and routine maintenance activities.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 13	**NOC/SOC – Network Management System** **NMIS Interworking with Elements and Services** Provide a detailed explanation and associated drawings explaining how the proposed solution interworks with all of the various elements and services of the proposed systems and network elements.	X			
	Bidder Response: Comtech's management systems utilize three primary methods to manage and monitor the system. The first method is Simple Network Management Protocol (SNMP) polling and trapping. Comtech uses SNMP version 3 as its default, but if the manufacturer does not support this version, the SNMP version 2 is used. The polling queries for metrics from every device on a five-minute interval, unless the metric requires a lesser time interval. Comtech's management system also receives SNMP traps from devices for diagnostic use. All polling and trap information is stored in a database used to provide system-wide situational status. The second method involves the collecting and parsing of component logs. The management system sends alerts based upon logging information. Finally, Comtech's management system uses probes deployed throughout the system and its network. These probes collect and report on key performance indicators (KPIs), for example, jitter and packet loss. The network management system creates alerts based upon the probe information. Comtech uses all three methods to provide a complete system status and alert methodology. *Comtech Confidential Figure 7* depicts Comtech's NMS data flow.				

Any additional documentation can be inserted here:

Figure 7. NMS Data Flow (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 14	**NOC/SOC - Network Event Logging** **System and Network Event Logging and Reporting** The network management system shall capture real-time and historical tracking of network and system events, as well as event resolution of the IP network and attached systems. This is for logging errors and statistical information related to the health of the network and attached systems. Events shall include, but are not limited to, hardware (power, processor, interface cards, ports), software (operating system errors, database errors, application errors and failures), network (Quality of Service (QoS), Mean Opinion Score (MOS), jitter, latency, and packet loss)). The events recorded in this section are not related to the event logging of 911 requests for service as part of NGCS Option B requirement NGCS 13 Event Logging. Describe how the solution meets or exceeds the above requirement.	X			
	Bidder Response: Comtech's management systems capture all of the following required logging and statistical information: Hardware (power, processor, interface cards, ports), software (operating system errors, database errors, application errors and failures), network (QoS), Mean Opinion Score (MOS), jitter, latency, and packet loss. All data is collected in SNMP queries, logs and probes and is stored in databases as well as in the Comtech data lake. The data from all devices is used for real-time event and alarm management, as well as to provide performance metrics.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 15	**NOC/SOC - Network Event Logging** **Management System Interface to Incident Management System** This system should be part of, or interfaced with, the bidder's incident management system, or contain cross-reference abilities. Contractor shall maintain historical information for the term of the contract and provide copies of the data to the Commission on request, and at the end of the contract. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's enterprise management system (SolarWinds) has a direct application program interface (API) connection to Comtech's ITSM (Remedy). Each SolarWinds record identification (ID) is placed in a field of each Remedy incident, which allows for cross-reference capability. Databases for SolarWinds and Remedy are backed up for historical recording and can be provided at the conclusion of the contract period, or they may be offered upon each annual milestone to make sure the data is deliverable in a supportable data volume method. All relative logs and probe data stored in the Comtech data lake will be provided as well.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 16	**NOC/SOC - Network Event Logging Interfacing Between Solutions** Provide a detailed explanation and associated drawings explaining bidder's processes, tools, and procedures for interfacing with the bidder's monitoring solutions.	X			
	Bidder Response: Comtech utilizes a standards-based logging solution that ties back into different aspects of our monitoring systems. The real-time monitoring and alerting systems utilize SNMP interfaces that are readily available on most modern systems. For analytics and greater in-depth monitoring, we employ system and network event logs. These logs interface via standard syslog http, Windows event log feeds into a central data lake; they are retained for the life of the contract in their raw form. Data is then normalized into a data structure that can be attached to various monitoring and analytics tools wherever the data is needed by the application function. *Comtech Confidential Figure 8 depicts the logging flow.*				

Any additional documentation can be inserted here:

Figure 8. Logging Flow (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 17	**NOC/SOC - Access to Technical Staff** 1. Detail the procedures by which bidder communicates with technical personnel from participating subcontractors, the Commission, and the participating PSAPs. 2. Specify the level of assistance required from such technical personnel to resolve service-related issues.	X			
	Bidder Response: Comtech uses communication tools (Slack) for direct communication with all sub-contractor operational organizations, as well as to Comtech operations and engineering personnel. Comtech provides two methods whereby external organizations have access to engineering personnel. First, escalation will occur within the operational organization. Second, a request can come from the Comtech program manager to engage an engineering caucus, where the engineering team will discuss topics of customer interest with the appropriate parties. Comtech accomplishes most customer service requests though the use of Tier I and Tier II personnel. If the required assistance is more complex, Tier III or higher personnel will be engaged. Customers can always escalate the issue further, if they deem the resolution unsatisfactory.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 18	**NOC/SOC - Notification** Specify how the bidder's NOC informs the Commission and the affected PSAPs or their designees of problems with the network, scheduled service and maintenance outages, and upgrades. Include all methods of notification used. Notifications for scheduled maintenance or outages shall be made no less than ten (10) business days in advance, except for emergency situations in which case, notification will be given immediately. Tickets related to the services delivered to subcontractors shall be forwarded automatically. Notification shall be provided via multiple communications means to the Commission and applicable PSAPs. Entities requiring notification may change, depending on the alarm or incident. Provide a detailed explanation explaining how the solution meets or exceeds the above requirements, including the methods of communications used.	X			
	Bidder Response: Comtech has multiple methods and procedures to address notification. Comtech automatically notifies Commission members, regional personnel and PSAP personnel whenever incident tickets are created. The type of notification is based upon the severity of the issue and what the customer may desire. Email and text messaging are the preferred methods of communication for incident tickets, ticket updates, and ticket closures. This process includes tickets opened and assigned to subcontractors. Remedy will contain the list of individuals to be notified, based upon their location, and this list can be modified by calling the NSOC/NOC as personnel changes occur within the organization. Comtech has an established maintenance schedule that will be communicated to the Commission, to regional personnel, and to PSAP personnel. Email reminders will be sent 10 business days in advance of a maintenance event. If an emergency maintenance event is required, Comtech NSOC/NOC will utilize the mass notification system to provide the Commission, regional personnel, and PSAP personnel with a notice via whatever form of communication (email, text message, and/or voice) that group may elect. Comtech release activities are scheduled based upon the approval of the CCB. The release manager emails schedules and status reports on a regular basis to satisfy the Commission's requirements.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 19	**NOC/SOC - Executive Dashboard** Contractor shall provide a web-based executive dashboard or similar tool, providing near real-time visibility of network status displayed geographically with service impact levels color-coded. Open ticket status shall be available to users through this dashboard. Describe how the solution meets or exceeds the above requirement.	X			
	Bidder Response: Nebraska-designated personnel will have access via a secure connection to the Comtech portal, which will contain the near-real-time status of Nebraska's NG911 services dashboard, NG911 services reports, service tickets, and services documentation. The Comtech monitoring system supports all standard interfaces such as SNMP, syslog, and other direct-query methods. The Commission and all authorized PSAP personnel will have the ability to view the KPIs such as bandwidth utilization, latency, jitter, packet loss, MOS reports, and open ticket status. Comtech's NG911 services dashboard will display network status geographically with color-coded service impact levels.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 20	**NOC/SOC - Escalation Procedures** 1. Outline a detailed regional-level escalation process to be used during incidents that affect service, particularly those that result in critical service outages. 2. Describe how discrepancies in the perception of service level agreement (SLA) incident levels may be escalated and addressed. These procedures shall be maintained and accessible via an online portal. This escalation notification process shall be integrated with the notification processes described above, based on the problem reported.	X			
	Bidder Response: The Comtech escalation process for regional organizations consists of having the right to request a manager call-back when talking to the NSOC/NOC, and possessing point-of-contact details to be able to reach the NSOC/NOC manager, Comtech's Director of Operations, the VP of Technical Operations, and the General Manager. Whenever a region may feel the need to escalate an incident more quickly than via the standard process, contacting members of this escalation tree is the process. The Commission and all associated organizations will be assigned a program manager acting as customer advocate for the Commission regarding whatever SLA incident perceptions need to be addressed. Additionally, the Commission has portal access to the discrepancies module in the ITSM system, through which the Commission can open a discrepancy report and tie it to an incident/problem ticket number.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 21	**NOC/SOC -Statement on Standards for Attestation Engagement Number 16** Bidder shall demonstrate compliance with the Statement on Standards for Attestation Engagements Number 16 (SSAE 16). The applicable report from an SSAE 16 engagement is the Service Organization Controls 1 (SOC 1) report. 1. If bidder is proposing services, provide a detailed explanation of how bidder has complied with SSAE 16 for similar solutions, and how this would be implemented with the Commission's NG911 implementation. 2. Provide with the detailed explanation and graphical representation explaining how the solution meets or exceeds the above requirement.		X		
	Bidder Response: **<u>Statement on Standards for Attestation Engagements Number 16 (SSAE 16)</u>** Comtech conforms with SSAE 16 principles; however, Comtech does not perform a SSAE 16 SOC 1 audit. Comtech follows Generally Accepted Accounting Principles (GAAP) for preparing financial statements and for developing internal controls, which are audited annually by Deloitte and Touche, a third-party auditor. Additionally, Comtech provides solutions and services to various departments of the federal government and is audited regularly by those departments. Comtech continues to evaluate customer requirements and may, in the future, add SSAE 18 audits. Comtech utilizes service providers that offer SSAE 16 SOC 1 reports. The current provider of facilities is LightEdge which has successfully completed Type 2 SOC 1, Type 2 SOC 2, and SOC 3 examinations by an independent third-party certified public accountant (CPA) firm. These exams included the co-location process. *LightEdge's Omaha data center datasheet is included as File 9.*				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NOC/ SOC 22	**NOC / SOC - Configuration Backup and Restoration** 1. The bidder shall deploy and provide detailed descriptions of bidder and any subcontractors' capabilities to automatically or routinely back up configuration data and define the conditions under which the configuration of network elements, such as routers or switches, will be restored, and the process that will be used. A reporting process shall confirm regularly scheduled (e.g., monthly, quarterly) backup and restoration, and provide sufficient details on backup and restoration activity. 2. Describe the bidder's abilities to perform on-demand backups, such as at the end of a successful configuration change. A reporting process shall confirm on-demand backup and restoration and provide sufficient details on backup and restoration activity. 3. Describe bidder's COOP as it applies to the NGCS and delivery of 911 traffic via IP network to the respective host locations. 4. Provide a detailed explanation and any associated drawings explaining how the proposed processes and procedures provide the ability to manage these configuration backup and restoration processes in a manner that has no negative impact on the total Commission ESInet and NGCS solution.	X			
	Bidder Response: Comtech deploys two methods for configuration backup and restoration. For all appliances, routers, switches, and other devices, SolarWinds performs a nightly backup of the configuration, and these files are stored in the SolarWinds database for 30 days (see *Figure 9*). At the time of a network device/appliance failure, Tier II technicians will push the last running configuration to the replacement device, once it has been installed. SolarWinds reports on the success and failure of backups. For Virtual Machine (VM) server-based components, Comtech deploys a Nakivo backup system to interact with the Operating System (OS) to ensure there are no operational impacts during backups. Nakivo reports on the success or failure of backups for NSOC/NOC actions. Nakivo also provides VM verification by testing restorations without having to restore the VM into the system. Using the tools described in this response, Comtech Operations can execute a backup of appliances or VM servers on demand. The Comtech release manager's release checklists include the steps on how to execute a backup before a release as well as how to create a backup following release of a change. If the release fails and is backed out, the initial backup is used for backout steps. Comtech maintains two separate MPLS backbones to the NGCS facilities, each operated by a separate service provider. This communication diversity provides the continuity of operations required for NSOC/NOC operational connections to all subsystems and components of the NGCS as it delivers 911 payloads to PSAPs. Comtech backup solutions are tested to ensure there is no impact to operational systems. These backup systems are configured for slow and steady backups, using low resources (processor percentage, input/output throughput, etc.). Comtech's keen focus on systems engineering ensures that current customer and Nebraska's 911 payloads are delivered every time.				

Any additional documentation can be inserted here:

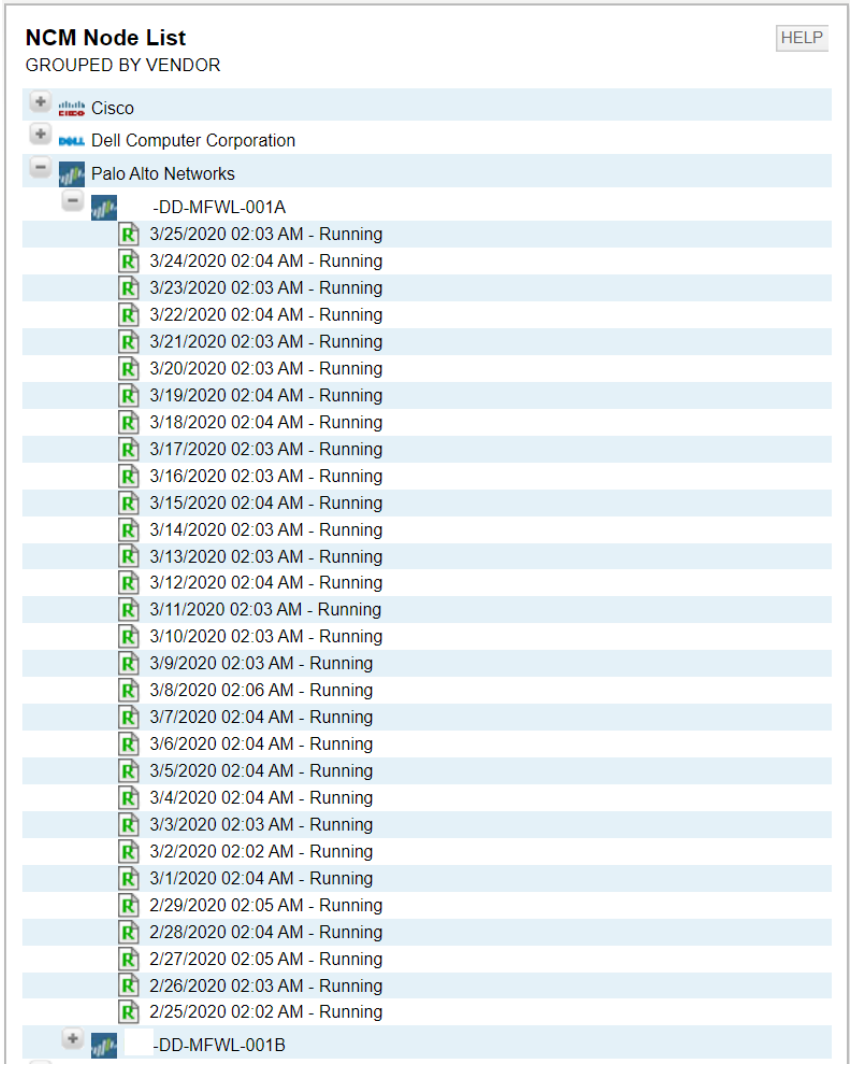


Figure 9. NCM Mode List Example

NOC/ SOC 23	**NOC/SOC - Third-Party Management** The Commission is seeking the optimum value provided by best-of-class products and services integrated as part of the total IP network solution. This may present a situation where no single manufacturer or supplier can provide a public safety-grade, unified NOC/SOC accountable for all components, products, and services that comprise the Commission's total IP network solution. Consequently, the Commission may find it beneficial to have a third party provide that overarching NOC/SOC service. A third-party NOC/SOC provider may be responsible for functioning as an umbrella for monitoring all of the Contractor's products and services, including collaboration with the Contractor's NOC/SOC. To facilitate that capability, the third-party NOC/SOC shall have a view into all elements that are under SLAs. Bidder's NOC/SOC NMIS and/or incident-tracking tools shall have the ability to perform eBonding, which enables bidirectional data synchronization. 2. Provide a detailed narrative discussing bidders experience in providing access to third-party NOC/SOC, overarching support as well as for each of the requirements in Third-Party NOC/SOC Support below.				
	Bidder Response: Comtech will support the provision of a SNMP Version 3 interface, plus a syslog interface and the e-bonding of the incident management system with a third-party NOC/SOC, as selected by the Commission. At present, Comtech does not have a maintenance customer who has found our service unacceptable and was therefore compelled to hire a third party to provide operations service. Comtech has significant experience as a prime contractor and in establishing similar interfaces with subcontracted service providers and partners. Comtech has gone beyond the simple SNMP traps and schemas as well as logging, demanding specific enhancements that ensure operational excellence in our NG911 systems. Comtech will apply our significant experience in the interconnection of operational systems, should the Commission request it. Comtech's ITSM system includes a change management module. Comtech will e-bond the change management model to the third parties' ITSM system. Comtech will support the third party in change management in accordance with the third parties' policies, provided they do not violate Comtech's change management policy. Comtech will support the Commission-selected third-party management vendor in coordinating and managing trouble tickets to their ultimate resolution, including those of subcontractors and partners within the Comtech service sector. Comtech will complete its trouble ticket report management for the services Comtech provides to the Commission, and data for these reports—they may be daily, weekly, monthly, quarterly or yearly—will be available to the third-party management provider through the e-bonded link. Comtech will support these notification processes for the third-party management vendor and its suppliers, as well as for any other entities so designated by the Commission.				

	Comtech will provide system alarm access in the form of SNMP or syslog data directly to the third party management vendor. Comtech has extensive experience and processes for interworking with multiple public safety data system suppliers including CHE vendors, TCC Provider(s), Local Exchange Carriers (LECs), and cellular carriers.

1. In support of the Commission's consideration of such an option, bidder shall indicate the compliance level of experience in providing access to third-party NOC/SOC overarching support, as related to the requirements identified in the table below.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
Change management processes	X			
Coordinating and managing trouble tickets to resolution from bidder and multiple suppliers.	X			
Trouble ticket report management (reports may be daily, weekly, monthly, quarterly, or yearly).	X			
Notification processes for bidder and suppliers, and any other entities or people designated by the Commission.	X			
System alarm access in the form of SNMP or syslog data.	X			
Experience and processes for interworking of multiple public safety data system suppliers.	X			

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 1	**General Operations - Service Level Agreements** **System Capacities and Performance** 1. Provide capacity levels of each element of the IP Network This may be in terms of busy-hour calls, network bandwidth, or any other applicable measure. The proposed solution shall be capable of handling current and planned IP traffic and usage plus 50 percent capacity growth over the term of the contract. 2. Specify lead times required to increase capacities on each element of the IP network.	X			

Bidder Response:

<u>Capacity</u>

Each NGCS functional element is equipped with redundant network interfaces that possess a speed of 1 Gigabits per second (Gbps) or (see *Comtech Confidential Figure 10*). Circuits to each edge location (whether regional handoff or PSAP) are sized to greater than 150 percent of the projected bandwidth required over the life of the contract. A 911 call is transmitted in a synchronous Real-Time Protocol (RTP) using the G.711 encoding/decoding format. With RTP and G.711, a 911 call uses no more than 128 Kilobits per second (Kbps) in each direction (full duplex). The default regional connection is provided over two 10 Megabits per second (Mbps) full duplex circuits. As a result, the region could take 156 simultaneous 911 calls, a volume that exceeds the current system's capacity and number of answering positions. Other planned traffic (Session Initiation Protocol [SIP], Message Session Relay Protocol [MSRP], Hypertext Transfer Protocol Secure [HTTPS] for Presence Information Data Format - Location Object [PIDF-LO]) are asynchronous traffic types that may use the bandwidth in lower-ranked QoS queues.

All NGCS service components (BCF, Emergency Services Routing Proxy [ESRP], Media Services Controller [MSVC], and Legacy Network Gateway [LNG]) have carrier-grade capacities capable of serving populations of 30 million under published worst-case, non-disaster loads. Each element has licensing that allows the system to exceed simultaneous sessions, and thus it can grow dynamically as the state's population increases. Comtech is proposing licensing greater than 200 percent of Commission's requirements at each location to process all calls. Comtech constantly monitors this usage and will engage with the Commission should the load exceed 70 percent of available simultaneous sessions. The remaining components (Location Database [LDB], Emergency Call Routing Function [ECRF], Location Validation Function [LVF]) are web-based systems that run on virtual server platforms with redundant load balancers. Current capacity exceeds 250 percent of the expected requirements for these services in Nebraska. These systems can be "spun up" in near-real-time to provide additional web services and/or virtual machines for adding to the load balancers.

<u>Lead Time</u>

Comtech will measure and monitor bandwidth usage and will work with the Commission (whenever circuits reach 70 percent real time utilization) to obtain approval to increase circuits to the next bandwidth tier (20 Mbps), can be accomplished within 90 days of approval. All components can grow with additional licenses to maintain this higher capacity.

Any additional documentation can be inserted here:

Figure 10. Interface Bandwidth (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 2	**Service Level Agreements - System Performance** **Network Latency** Specify the guaranteed maximum latency across the backbone network under a full-load condition, and include how that information will be gathered, calculated and provided to the Commission and the affected PSAPs.	X			
	Bidder Response: Comtech's solution guarantees a maximum round-trip latency of 100ms within its ESInet and NGCS. Latency is tracked via network probes that monitor 100 percent of call-control and media messaging while they reside within the Comtech solution. Additionally, synthetic monitoring is performed on key network links to ensure that latency is within the proper parameters, even in the absence of call traffic.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 3	**Service Level Agreements - System Performance** **Point of Presence (POP) to POP** Specify the guaranteed maximum latency from interconnection facility to interconnection facility, and include how that information will be gathered, calculated and provided to the Commission and the affected PSAPs.	X			
	Bidder Response: Comtech's solution guarantees a maximum round-trip latency of 80ms between interconnection facilities. Latency is tracked using network probes that monitor 100 percent of call-control and media traffic while they reside within the Comtech solution. Additionally, synthetic monitoring is performed on key network links to ensure that latency is within the proper parameters, even in the absence of call traffic.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 4	**Service Level Agreements - System Performance** **POP to Endpoints** Specify the guaranteed maximum latency from interconnection facilities to the network interface device located at the entrance to the hosts' premises, and include how that information will be gathered, calculated and provided to the Commission and the affected PSAPs.	X			
	Bidder Response: Comtech's solution guarantees a maximum round-trip latency of 80ms between each interconnect facility and the network interface device (NID) location at the regional hand-offs. Latency is tracked using network probes that monitor 100 percent of call-control and media traffic while they reside within the Comtech solution. Additionally, synthetic monitoring is performed on key network links to ensure that latency is within the proper parameters, even in the absence of call traffic.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 5	**Service Level Agreements - System Performance** **Mean Opinion Score (MOS)** Bidder shall guarantee, in the response, a consistent MOS of 4.0 or better across all network links transporting media streams from interconnection facilities to the network interface device located at the entrance to the hosts' premises, and include how that information will be gathered, calculated and provided to the Commission and affected PSAPs monthly or as requested. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's audio quality monitoring solution provides comprehensive monitoring through multiple voice communications probes that continuously sample voice traffic at multiple points within the points of presence (POPs) to the demarcation point inside each region. Comtech guarantees the system will be provisioned to support a consistent MOS of 4.0 or better. Comtech's solution monitors 100 percent of calls between those points. The probes continuously analyze call data and provide real-time MOS output through Oracle's Communication and Operations Manager (OCOM). OCOM provides details on call signaling and call quality that is monitored by the NSOC on a 24x7x365 basis. Comtech observes operational MOS values that typically range between 4.1 (satisfied) and 4.3 (very satisfied). OCOM's data is preserved within Comtech's data lake, which allows for long-term analysis and reporting on NG911 call processing for the Commission, as well as to authorized regional and PSAP users.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 6	**Service Level Agreements - System Performance** **Packet Loss** Specify the guaranteed maximum end-to-end packet loss across the network. This specification also shall include any loss characteristics associated with another carrier's network or any applicable wireless links, including how that information will be gathered, calculated and provided to the Commission and affected PSAPs monthly or as requested.	X			
	Bidder Response: Comtech's solution guarantees maximum end-to-end packet loss of less than 0.5 percent per month within the Comtech-controlled network demarks. Packet loss is tracked by using network probes that monitor 100 percent of call-control and media traffic while they reside within the Comtech solution. Additionally, synthetic monitoring is performed by tapping key network links and using a Network Performance Monitoring (NPM) system to ensure any packet loss is quickly identified and remediated.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 7	**Service Level Agreements - System Performance** **Network Latency** Specify the guaranteed maximum end-to-end network latency across the network. This specification also shall include any latency associated with another carrier's network or any applicable wireless links, including how that information will be gathered, calculated and provided to the Commission and affected PSAPs monthly or as requested.	X			
	Bidder Response: Comtech's solution guarantees a maximum round-trip latency of 100ms, edge-to-edge, within the Comtech-controlled network. Latency is tracked using network probes that monitor 100 percent of call-control and media traffic while they reside within the Comtech solution. Additionally, synthetic monitoring is performed on key network links to ensure that latency is within the proper parameters, even in the absence of call traffic.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 8	**Service Level Agreements - System Performance** **Jitter** Specify the guaranteed maximum end-to-end jitter across the network. This specification also shall include any jitter characteristics associated with another carrier's network or any applicable wireless links, including how that information will be gathered, calculated and provided to the Commission and affected PSAPs monthly or as requested.	X			
	Bidder Response: Comtech's solution guarantees a maximum end-to-end jitter of 20ms across the Comtech-controlled network. Jitter is tracked using network probes that monitor 100 percent of call-control and media traffic while they reside within the Comtech solution. Additionally, synthetic monitoring is performed on key network links to ensure that latency is within the proper parameters, even in the absence of call traffic.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 9	**Service Level Agreements - System Performance** **Network Traffic Convergence** Specify convergence protocols and the estimated or guaranteed network convergence time (less than 54 ms) of IP traffic at any point within the proposed solution, including how convergence information will be gathered, calculated and provided to the Commission and affected PSAPs monthly or as requested.			X	
	Bidder Response: Comtech's routing protocol design ensures that all Layer 3 devices that run dynamic routing protocols will quickly and reliably converge in the event of a device failure or a loss of upstream connectivity. The main routing protocols used in Comtech's design are Border Gateway Protocol (BGP) and Open Shortest Path First (OSPF), with specifically configured timers, features and parameters to ensure the fastest possible convergence of routing topology within the architecture. Additionally, this high-availability design of network components ensures that multiple copies of the routing table are maintained on redundant devices to minimize the amount of convergence required in the event of a failure or outage. Comtech's Layer 2 design minimizes convergence time by limiting the use of a spanning-tree in favor of link aggregation mechanisms for multi-homed devices. Estimated or guaranteed network convergence time will vary depending upon specific components, failover scenarios, and conditions. For example, convergence within an OSPF area configured with "Fast Hellos" and "Non-stop Forwarding" will be much faster than BGP convergence over the ESInet; this is due to the nature of link-state protocols. Comtech measures convergence time by testing every plausible failure scenario and using the longest overall convergence time of the system, rather than the convergence time of individual network components or segments. Our tests are conducted by using phone call simulators, and time is measured from the moment of the outage until existing call communications are properly re-established. Most tested failure scenarios result in sub-second convergence. Reports will be generated monthly (or as requested) from our NMS and/or NPM and will list all outages and losses of connectivity that have occurred during that period. These reports can be used to calculate overall convergence times for the entire system. Convergence times for individual network segments or high-availability device pairs can be delivered by analyzing correlated log data for a more granular view of any event. Comtech's design converges on the ESInet in hundreds of milliseconds, based upon customer BGP and Bi-directional Forward Detection (BFD) timers, since there are no existing affordable standards-based technologies for Wide Area Networks (WANs). A Software-Defined Wide Area Network (SD-WAN) potentially presents an ESInet circuit impact of 54ms or less, but that does not change routing protocol convergence times. Comtech continues to evaluate technologies that can reduce possible interruptions and against which any disaster can be reduced or protected. If the Commission did not intend to connect the SLA to routing protocol convergence, Comtech meets this requirement by utilizing redundant systems to eliminate disruptions by single points of failure.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 10	**Service Level Agreements - System Performance** **Mean Time to Repair (MTTR)** Specify the MTTR characteristics of the proposed solution. These specifications shall reflect the end-to-end solution, as well as components or subsystems that are subject to failure. Include how MTTR information will be gathered, calculated and provided to the Commission and affected PSAPs.	X			
	Bidder Response: MTTR of a failed hardware component is measured through our NMS/trouble ticketing system. Comtech's solution is designed and operated to achieve a two-hour MTTR for critical components. The network has been designed with redundancy in its core systems to ensure uptime in the event of a component failure. Furthermore, the network design involves no single point of failure. In addition to monitoring and reporting at the component level, circuit-level statistics are monitored, managed, and reported on via the NMS.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 11	**Service Level Agreements - System Performance** **Mean Time Between Failures (MTBF)** Specify the MTBF characteristics of the proposed solution. These specifications shall reflect the end-to-end solution, as well as components or subsystems that are subject to failure. Include how MTBF information will be gathered, calculated and provided to the Commission and affected PSAPs.	X			
	Bidder Response: Comtech design engineers calculated the NG911 system's overall system availability based upon MTBF numbers provided by OEMs. To ensure the availability of the NG911 system exceeds 99.999 percent, the design has implemented parallel configuration of every function element to overcome a MTBF for a particular component which is less than five-nines. Using the classic system availability formulas (serial and parallel), Comtech engineers the end-to-end service value. Once operational, Comtech will track any failures through its incident management system and its enterprise management system reports. Comtech uses the failure information in these selfsame system-available formulas to ensure that operational experience meets or exceeds design calculations. For the Commonwealth of Massachusetts NG911 system, the most recent 60-day system availability rating for the operational system was 99.99977 percent; this was for a system that supports 250-plus PSAPs and serves 6.7 million citizens with an average annual call volume of 3.2 million.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 12	**Service Level Agreements - System Performance** **Network Reliability** Network reliability is defined as the ability for system end-points to effectively communicate with each other, and all associated data and information is exchanged in usable formats. An IP-based network looks at reliability as an overall redundancy design, rather than component by component. Specify in the response the overall reliability service level of the IP network, including all bidder-provided components and facilities.	X			
	Bidder Response: Comtech solutions, both NGCS and ESInet, are engineered to exceed the five nines (99.999 percent) carrier-grade standard of reliability. Comtech designs its systems for continuous 911 transaction processing, and we achieve this high-performance capability, along with optimal reliability, through the intelligent use of a highly redundant system architecture.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 13	**Service Level Agreements - System Performance** **Network Availability** 1. Specify the service level offered as a percentage of time when the service is available, and the maximum period of total outage before remedies are activated. Availability is defined as MTBF/(MTBF+MTTR). 2. Include how system availability information will be gathered, calculated and provided to the Commission and affected PSAPs.	X			
	Bidder Response: Comtech solutions, both NGCS and ESInet, are engineered to exceed the five nines (99.999 percent) carrier-grade standard of availability. Availability information is collected based upon our NMS metrics in combination with incident management tickets from all sources. Availability is calculated monthly and reported to the Commission and affected PSAPs via standardized report forms on an agreed-upon schedule.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 14	**Service Level Agreements - System Performance** **End-of-Support Equipment** Contractor shall proactively replace, at Contractor's expense, any hardware that has reached end of support (EOS) no later than 90 calendar days prior to the manufacturer's EOS date. All equipment must be new and of current manufacture, not refurbished. Describe your procedures for End-of-Support Equipment.	X			
	Bidder Response: Comtech has an established end-of-life, manufacturer-discontinued, end-of-support process whereby we are kept notified by OEMs regarding any change of support plans and recommended changes. This information is reviewed by technical subject matter experts (SMEs) and evaluated for risk analysis and assessment. To maintain solution integrity and compliance, Comtech also employs a rigorous testing and evaluation process. Any changes that are required due to a manufacturer's change of support is addressed through our standard CCB process.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 15	**Service Level Agreements –** **SLAs for Incident Management** The Commission requires the Contractor to establish processes and procedures for supporting a NOC/SOC that can rapidly triage and manage reported network incidents. Bidder shall develop an ITIL compliant severity-level scale that includes levels one through four, with level one being the most severe incident. The top two levels shall capture all incidents affecting the level of service of one or more end-points. Include a description of incident severity-level attributes, including response and resolution times for each severity level, and how response and resolution times are measured.	X			
	Bidder Response: Comtech has applied the incident classifications of Severity Levels 1–4 as part of our internal tracking and escalation tool. Additionally, our instance of Remedy ITSM includes SLA time frames and an escalation protocol to ensure all required parties are kept apprised of the status. Comtech understands the interpretation of incident severity levels and will verify and confirm with the Commission as to each incident's severity. Comtech will employ all necessary resources to take proper steps and precautions, ensuring that actions within our control are implemented. If there is a situation where a resolution time is in jeopardy, Comtech will communicate with the Commission to ensure that all actions and possible workarounds are reviewed, while also making decisions that have the greatest potential benefit to the Nebraska NG911 system. Figure 11 illustrates Comtech's severity level tracking and escalation process. Within this chart, we have included partial contact information (final information will be provided upon award) to ensure no erroneous contact is made to the Comtech NSOC tasked with supporting critical NG911 customers.				

Any additional documentation can be inserted here

Attachment "C"
Option C Revision One
Technical Requirements
Public Service Commission ESInet
Request for Proposal Number 6264 Z1

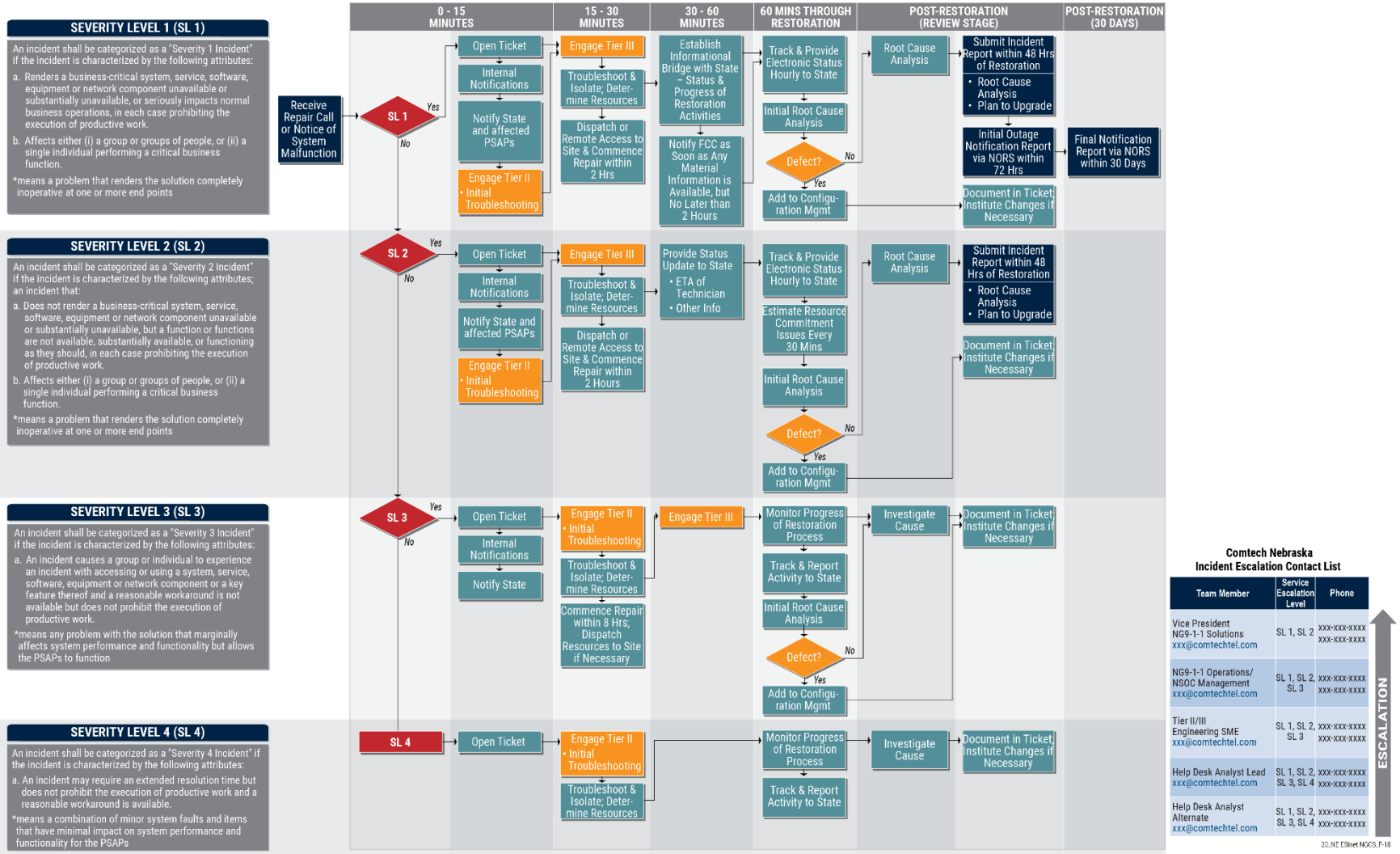


Figure 11. Incident Escalation Chart

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 16	**Service Level Agreements –** **Outage Notification and Reason for Outage (RFO) Report** **Outage Summary and Lessons Learned** Provide a summary of FCC reportable outage situations that interrupted 911 service to bidder's clients over the past three years, where 911 calls were not delivered or not delivered to the appropriate PSAP as a result of the issue. The response shall include the deployment type (legacy, ESInet, and NGCS), month, year, duration, number of PSAPs or population impacted, number of PSAPs or population served by the impacted system, impacted system, and lessons learned from each outage. **Regulatory Compliance** Contractor shall comply with all applicable local, state, and federal outage and notification rules throughout the term of the contract.	X			
	Bidder Response: Comtech has included a summary of FCC reportable outage situations for the last three years in *Comtech Confidential File 11*. In some instances, outages occurred outside of Comtech's span of control for NGCS and, therefore, an exact accounting of the number of people impacted is unknown. Additionally, Comtech has a Regulatory Affairs office to ensure compliance with all applicable local, state, and FCC notification rules.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 17	**Service Level Agreements –** **Outage Notification and Reason for Outage (RFO) Report** **Outage Notification** Contractor shall notify the Commission and affected PSAPs within a maximum 30 minutes of discovering an event or outage that may impact 911 services. All events that meet criteria for local, state, or federal reporting shall also be completed by the Contractor. At the time of initial notification, the Contractor shall convey all available information that may be useful in mitigating the effects of the event or outage, as well as a name, telephone number, ticket or reference number, and email address at which the service provider can be reached for follow-up. The Contractor is responsible for coordinating data gathering, troubleshooting and reporting on behalf of subcontractors. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Depending upon the severity of the incident, Comtech's standard operating procedure (SOP) is to provide a customer notification within a five- to 30-minute time frame, where the five-minute threshold is associated with a higher priority or more severe incident. During this initial notification time, Comtech provides the information that was gathered during initial triage and the planned next steps, which includes escalations for both management awareness and additional subject matter expertise. The Comtech NSOC team, which includes our subcontractor partners, are well versed in this communication and diligence protocol. The Comtech NSOC is the primary point of contact and will ensure that all associated information regarding the incident is captured, documented, and communicated to include details of the event or outage, as well as a name, telephone number, ticket or reference number, email address, and phone number where the service provider can be reached.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 18	**Service Level Agreements –** **Outage Notification and Reason for Outage (RFO) Report** **Status Updates** The Contractor shall communicate any updated status information to the Commission and affected PSAPs no later than two hours after the initial contact, and at intervals no greater than two hours thereafter until normal 911 service is restored. This information shall include the nature of the outage, the best-known cause, the geographic scope of the outage, the estimated time for repairs, and any other information that may be useful to the management of the affected operations. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Status updates are provided at regular intervals, depending upon the nature and severity of the incident or event. As depicted in our incident escalation chart, the standard procedure for providing updates, escalating to the next highest tier, and dispatching personnel is incorporated into our SOPs. Status updates will be provided no later than two hours after the initial contact and will continue at two-hour intervals until service is restored. With Severity Level 1 and Level 2 scenarios, these notification updates are provided every hour. Comtech will initiate a conference bridge and send this notification (the bridge phone number, a brief explanation of the problem, and the scheduled time of the conference bridge) to key Nebraska personnel, partners, state representatives, and technical SMEs. Comtech will also identify the management lead for this effort who will discuss the situational awareness, details of the triage, and what troubleshooting steps have taken place. This conference bridge will remain open until the incident/problem has been resolved, the root cause is identified, and corrective actions are understood to have fixed the issue. The Comtech NSOC is the primary point of contact and will ensure that all associated information regarding the incident is captured, documented, and communicated to include the nature of the outage, the best-known cause, the geographic scope of the outage, the estimated time for repairs, and any other information that may be useful to managers of the affected operations.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 19	**Service Level Agreements –** **Outage Notification and Reason for Outage (RFO) Report** **Reason For Outage (RFO) Reporting** Following the restoration of normal 911 service, Contractor shall provide a preliminary RFO report to the Commission and affected PSAPs no later than three (3) calendar days after discovering the outage. An in-depth RFO report, including a detailed root-cause analysis, shall be provided to the Commission and affected PSAPs no later than ten (10) calendar days after discovering an outage. 1. Describe how bidder will comply with the notification and reporting requirements above. 2. Describe the NOC/SOC tools and techniques at bidder's disposal to ensure that bidder's various subcontractor perform troubleshooting and post-event analysis and provide associated reports.	X			
	Bidder Response: Upon the restoral of normal 911 services, Comtech updates the incident trouble ticket with details from the initial issue report through to subsequent investigations that include the root cause analysis and preventative measure recommendations. Within three calendar days, the Commission and the affected PSAP(s) will be provided with an initial root cause analysis, and subsequent in-depth findings to be provided no later than 10 days following discovery of the outage. Utilizing NMS tools and network appliance probes, Comtech can monitor all end-points and view and review perturbations in network traffic. This information is available to and shared with engineering SMEs and OEMs to assist them in troubleshooting and service restoration. All corrective actions are documented as part of the incident ticket, and this information is reviewed as part of the ticket closure process. The Comtech Remedy ITSM system includes a module that incorporates all vendor and partner information. This information includes contact details, emergency procedures, the names of service providers, operating areas, and so on. Each partner Comtech selects understands the system's technical performance requirements and is integrated into our problem/defect resolution process, which includes coordinating with the customer to ensure acceptance prior to a ticket being closed. Comtech will work with each service provider to understand their ticketing system and determine the best method for sharing information to achieve real-time situational awareness. Through the combination of trouble ticket issuance, peer coordination, and recurring communications, Comtech will ensure that all ticket information is complete, accurate and timely.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 20	**Service Level Agreements –** **Outage Notification and Reason for Outage (RFO) Report** **PSAP Notifications** Outage notifications and follow-up analysis of outages are a critical element to understanding overall system health and preventing future service interruptions. Having awareness of issues that exist in a neighboring PSAP provides valuable insight into potential issues that may begin impacting another PSAP's operations. The Commission' is seeking an outage notification service that allows for each PSAP to elect the outage notification types and PSAPs for which it will receive outage notifications, outage updates and RFO reports. A web portal for authorized users to select/deselect outage notifications is required. Provide a detailed description of how bidder will support such an outage notification service.	X			
	Bidder Response: Comtech uses and integrates with Rave Mobile Safety for internal notifications and will make this service available as an option for PSAPs that elect the outage notification. Access to this service is provided through a web portal on a permissions basis. If this optional notification process is selected, user training will be provided.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 21	**Service Level Agreements –** **Media Contact** 1. Contractor shall provide a 24 x 7 spokesperson who will be available for media contact regarding ANY outage of 911 service due to any failure of 911 call delivery to the Commission's host equipment and to the affected PSAPs. **Government & Regulatory Contact** 2. Contractor shall provide a 24 x 7 representative who will be available for government and regulatory contact regarding ANY outage of 911 service due to any failure of 911 call delivery to the Commission's host equipment and to the affected PSAPs Describe bidder's experience in providing both a Media Contact and Government & Regulatory Contact for similar contracts.	X			
	Bidder Response: Comtech's experience with a media contact requires an authoritative leader who is knowledgeable about the current event(s), is authorized to speak on behalf of the company, and can commit to corrective measures. Since any outage of 911 services is a critical issue, it is imperative that awareness and its proper response is a top priority, where resources and the company's commitment is assigned with the utmost urgency. This level of contact is assigned to senior executive leadership. Similarly, government and regulatory contact is assigned to senior leadership from our Regulatory Affairs Department to ensure that all reporting, accounting, and communications is compliant with all local, state, and FCC requirements. Contact information for both representatives will be provided upon contract award.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 22	**Service Level Agreements –** **SLA Violations** An SLA violation shall have occurred whenever: A. The Contractor fails to meet any single performance level; or, B. The average of any single performance item over the preceding two-month period fails to meet the service level stated in response to requirements SLA 1 through SLA 22. Contractor shall deliver an SLA violations report to the Commission on a monthly basis. **SLA Reporting** Provide a detailed description of how bidder measures and reports incidents, including immediate notifications and regularly scheduled reports. SLA results shall be delivered to the Commission on the 10th business day of the month. The report shall include all performance items identified in the bidder's proposal and documented in contract negotiations.	X			
	Bidder Response: Comtech understands the importance of SLA performance and adherence. Comtech's Remedy ITSM includes SLA time frames and our NSOC incident management process includes an escalation protocol to ensure all required parties are kept apprised of the status. Comtech will provide monthly reports that clearly document SLA performance. SLA performance measurements map the severity levels of any incident against its impact, response time, credit and/or fees, and enforcement. The Comtech NG911 Project/Program Manager (PM) will submit a monthly SLAM report. This report will be tailored to ensure that all performance items identified in our proposal, as well as documented negotiations, are captured and reported. As indicated above, the SLAM report will be delivered on the 10th business day of the month. *A sample Comtech Confidential SLAM report is included in File 11.*				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SLA 23	**Service Level Agreements –** **SLA Violation Financial Remedies** Contractor shall provide financial remedies to the Commission for each event in which service levels are not maintained. The Commission requires that all of the Contractor's network facilities, devices, and services will be measured on a rolling, 12-month calendar. Failure to meet SLAs shall be measured per service-affecting outage. Financial remedies shall be assessed for failure to meet SLAs. For service-affecting incidents, a 10 percent (10%) discount shall be accessed against the Monthly Recurring Charge (MRC) applicable to the source of the failure, whenever the initial period of resolution is exceeded. If the resolution period length of time doubles, then the discount shall increase to 20 percent of the MRC. If the resolution period length of time quadruples the initial period, then 50 percent of the MRC shall be assessed. The amount related to the damages is to be credited to the invoice for the month immediately following the violation. Bidder shall include how uptime information will be gathered, analyzed and provided to the Commission.	X			
	Bidder Response: Comtech uses a monthly SLAM report to report on SLA performance. This report will be submitted on a recurring basis for review with the Commission to ensure that all performance metrics for network facilities, devices, and services are in accordance with SLAs. Details within each SLA include the date of occurrence, the incident severity level, the trouble ticket number, the total number of events, the total number of incidents, each event's response time, the related SLA response requirement, a response credit (if applicable), a description of the incident, the cause of the incident, what relief is being proposed, and any penalty and/or fee. Uptime information is gathered via NMS monitoring, which reports on all component- and circuit-level performance and statistics. All systems are deployed with multiple power supplies that are fed through separate uninterruptable power supply (UPS) and generator backup circuits. In addition, all communications paths to the systems are redundant within the system, where separate paths lead back to separate network connections. Cloud-based components are operated in separate regions and in separate availability zones within each region, which ensures uninterrupted uptime of those components. Network paths from the data center to the cloud provider include servers with at least two direct-connect paths to the cloud infrastructure per data center. Comtech routinely conducts operational caucuses with our customers to communicate and review trends, high-priority activities, planning, and action tracking, which will include uptime analysis. This will be a standing process for the life of the contract.				

Any additional documentation can be inserted here

Operational Scenarios
Safeguards shall be established to minimize the impact of human or system error. Describe bidder's risk-mitigation and issue-resolution strategies for the following hypothetical scenarios:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
GEN SCEN 1	**Scenario 1** At 0300 hours, a series of SBC alarms previously unseen by the NOC staff on duty begin to increase in volume and frequency. At 0330, multiple critical alarms are received. At 0345, a few PSAPs start reporting garbled audio while others report an inability to obtain location information. At 0600, some PSAPs are reporting that they have not received a call in the last 15 minutes.	X			

Bidder Response:

At 0300 hours, a series of SBC alarms previously unseen by the NOC staff on duty begin to increase in volume and frequency.
As the first alarms appear on the SolarWinds event monitoring screen, the NSOC staff initially determines the severity and criticality of the type of alarm generated by the BCF. This is the first step in the triage process. Component isolation is the next priority. Once these factors are known, a Remedy incident trouble ticket is promptly opened at a severity level appropriate to the triage results and its findings. In this case, the problem will be classified as a Severity Level 4 incident, according to the escalation matrix shown in *Figure 12 below.* The determination of this severity level is consistent with the NSOC process, "How to Determine 911 Severity." As additional information becomes known or as mitigation measures are implemented, the initial severity level could be adjusted upward or closed out. Severity Level 4 is further confirmed because the SNMP traps are indicating the trouble is confined to a single component of a high-availability pair, and consequently user services are not impacted.

The logs, alerts types, and frequency will continue to be closely monitored. While the monitoring system will automatically poll the devices at specified intervals, the process can be manually invoked as an alternate to waiting for the polling cycle to complete. This process results in obtaining potentially critical information more quickly while trying to triage an issue.

Polling from the monitoring console is manually invoked to capture the most recent data and establish trending patterns more quickly. Trending data is inspected to ensure benchmark performance metrics are within established thresholds. Monitoring of call quality is performed continuously using the Oracle SIP call flow tools. Call-flow behavior is inspected for alternate or default routing, which could occur in advance of an alert, alarm, or other system issue as the result of a two- to five-minute polling cycle. Latency, jitter, packet loss, and MOS metrics are routinely inspected during active calls to ensure the system is stable and operating properly.

Isolation of the problem continues by executing the next stage of the triage process. Basic appliance health statistics will be compared to baseline measurements. Component processor utilization and memory consumed as a function of the total are reviewed to determine the state of the device at a moment in time. Contractual metrics for packet loss, latency, and jitter statistics are reviewed against observed threshold metrics for each element.

At 0330, multiple critical alarms are received.
More in-depth fault isolation techniques continue to determine if the issues and alerts are related to the initial inbound call session to the next hop, and outbound calls to the LNG or the bi-direction connections from the SIP trunk calling. The overall health and proper operation of the secondary BCF will be analyzed to ensure it is ready to assume 100 percent of the system call flow traffic, if necessary. The multitude of alarms are triaged; based upon the results of the findings, the severity of the ticket will be upgraded to Severity Level 2. The remedy ticket is then updated to reflect the updated information.

From the system summary map, a Tier I NSOC help-desk technician can easily determine the supporting network elements and perform a basic inspection of the devices to continue to isolate the failing devices. These inspections confirm proper router, switch, server central processing unit (CPU), memory utilization, and interface conditions that rule out the network as a possible cause of the problems.

	Among the metrics being reviewed—such as average response time and packet loss—call sessions initiated compared to sessions requested (SIP invites to the BCF compared to invites outbound from the BCF to the next hop device) are measured to determine if inbound calls to the BCF are rejected. Using the monitoring toolset, the Tier I NSOC help-desk technician will drill down into the health of the device believed to be causing the alerts. The Universal Device Poller Status page provides SIP session information, including rejected messages. Combined with SIP call-flow monitor details, if this information indicates a displayed 5XX message during the invite from the LNG, the BCF is rejecting calls. If calls are rejected from the BCF, the NSOC technician will manually (yet gracefully) failover the primary BCF component of the high-availability pair to the secondary device. This procedure may not be necessary, though, because the BCF can perform continuous health checks and automatically failover to the secondary high-availability component. The failed component is placed into a maintenance mode so that no additional alarms are generated. The Tier I NSOC technician will ask the target PSAPs to initiate a series of test calls to ensure that the failover is successful and active and that calls are not being affected. The Tier I resource will also monitor the sessions to ensure proper and continuous operation. During the triage and troubleshooting process, the NSOC will ask PSAPs to initiate test calls to better understand the user experience. The trouble ticket will be updated to reflect the mitigation steps and the success of those actions. **At 0345, a few PSAPs start to report garbled audio, while other PSAPs report an inability to obtain location information.** Several PSAPs are reporting garbled audio, while others report an inability to obtain location information. Since some of the PSAPs are reporting the absence of location information from the transmitted call payload, a Remedy ticket will be immediately opened with a classification of Severity Level 2. Comtech will initiate a conference bridge and send this notification (the bridge phone number, a brief explanation of the problem, and the scheduled time of the conference bridge) to key Nebraska personnel, partners, state representatives, and technical SMEs. Comtech will also identify the management lead for this effort who will discuss the situational awareness, details of the triage, and what troubleshooting steps have taken place. This conference bridge will remain open until the incident/problem has been resolved, the root cause is identified, and corrective actions are understood to have fixed the issue. While the loss of location information could be caused by a failing BCF, there are more likely target components to triage and fault-isolate the issue. All the protocols associated with the Severity Level 2 classification assigned to this incident will be executed. Commission representatives and affected regions and/or PSAPs are immediately notified of the issues and the proposed actions. Automated incident trouble tickets are generated and texted or e-mailed to designated recipients. As previously described, these actions also include establishing a conference bridge with the Commission, affected PSAPs, project partners, and Comtech Tier III engineering and executive leadership to provide real-time communication, status, and resolution progress. Call routing is dependent on a caller ID (telephone number) and civic location information associated with the number. A Policy Routing Function (PRF) is designed into the system architecture as a safeguard to avoid dropping a 911 call, when civic location or caller telephone number information is not available. Wireline SIP calls transmitted without location information will be default routed to a designated call center, which is a preset route defined by a PRF and inserted by the ESRP. Upon delivery of the call to the call center, the call taker will direct the transfer of the call to the PSAP location verbally specified by the caller. The NSOC Tier I technician observes several calls have been default routed to the call center, which is a condition that appears as a direct transferred call flow to a PSAP without location information. This could be caused by the absence of proper civic or geodetic location information in the SIP packet header, which is required for geospatial routing. The call taker notes there is an absence of an inbound caller ID or a 10-digit callback number (CBN), which was delivered to the NG911 system by the selective router. This condition is identified by inspecting the first Invite header in the call flow from

	the LNG to the BCF. While this condition existed for a single call, this is not the source of the problem because other calls are shown to be default routing, according to the call flow monitor. A 10-digit caller ID must be included in the 911 call Invite with an inbound wireline call; otherwise, the ESRP cannot perform a location search in the civic address LDB. When a null value is returned from the LDB to the ESRP as a result of the absence of caller ID (i.e., no search criteria), the PRF value that contains the routing information for the default call center is inserted as the desired endpoint path and then forwarded to the next hop. The ESRP generates an error message—no record found (NRF)—which can be viewed on the system monitor. The default-routed call will be delivered to the call center designated by the default route coded from the PRF. The call taker at the default PSAP will obtain the location of the emergency from the 911 caller and manually route the call to the appropriate PSAP. Test calls will be requested by the Tier I help desk technicians for initiation at the target PSAPs to help validate this finding and further isolate the problem. Wireless test calls are directed to the call center and successfully transferred to the desired PSAP, accompanied by location information. This scenario rules out wireless calls and purposefully blocking a caller ID by the caller. The problem persists for wireline callers. Communication is essential and is continuously performed to ensure the proper resources are updated with the latest information. This is accomplished on the open conference call and via Remedy ticket updates, e-mails, and text messages as new information arises. An internal routing failure will cause a call to default route without its accompanying location information. In this scenario, the first invite with a wireline 911 call contains only a 10-digit callback number, since the call was sent to the default PSAP call center. The initial steps involve gathering data points for all components responsible for the call's routing. An inspection of the components is conducted. The ESRP, LDB, and ECRF log files are inspected for errors at the precise time the call was initiated. Test calls are once again initiated with target PSAPs to rule out the possibility of an ALI discrepancy issue. The test call default routes to the designated call center. Since the ESRP did not return a valid civic location from the LDB or did not return the corresponding correct PSAP routing Uniform Resource Identifier (URI) from the ECRF, and the call was default routed, the partner responsible for the component failure would be advised of the failure, and an immediate investigation would be requested. Call trace data, time of the call, and log files are sent to the partners along with the request. A series of test calls would be initiated by a target PSAP to try to replicate and validate the problem. Again, the call is delivered to the desired PSAP without its location information. Once the component causing the undesired behavior is identified, it would be removed from the available load balancer pool (i.e., taken offline) of components capable of performing this routing action. In this case, the device would be removed from the load balancer pool and would no longer be called on for location or routing information. The Remedy trouble ticket is updated, and a ticket would be opened with the appropriate partner for a root cause analysis of the system failure. A series of test calls would be initiated by the PSAPs involved to verify that the problem is resolved. As a matter of policy, an inbound wireless or VoIP call will be sent to a mobile call center and manually transferred to a PSAP based upon the caller communicating the location of the emergency to the call center. Both call types will be delivered to an appropriate PSAP minus its location information. The call taker at the appropriate PSAP will be notified by the transferring PSAP call taker that the call was destined for another location. The PSAP call taker will notify the Tier I help desk technician about the missing location information. Since no other PSAPs are contacting the NSOC to advise they are answering calls from their alternates, the root cause of the issue will most likely require the determination of where calls are being dropped within the system.

BCF troubleshooting will occur in parallel with the execution of the Severity Level 2 protocol, and Packet Captures (PCAPs) between the ingress side of the BCF and the LNG and the egress side of the BCF to the next hop device will be recorded during sustained calls. Two-way RTP packets from both sides of the RTP packet transmissions will be analyzed for signal clarity and garbled audio. The PCAP results show normal RTP inbound from transmissions from the LNG into the BCF. The RTP outbound from the BCF shows evidence of dropping audio, with a latency rate greater than one second in the direction of the next hop. This observation is noted on multiple sustained audio streams. Several target PSAPs experiencing these audio problems are contacted and instructed to execute several test calls to confirm the situation. Additional PCAPs are recorded between the BCF and the next hop. These traces show evidence of malformed audio signals from the BCF in the direction of the next hop in the call path, and call takers are reporting choppy and garbled audio throughout the period of the test calls. The Tier I help desk technician will remotely log into either BCF in the high-availability pair (in the event the primary is unreachable) and execute the command *'notify berpd force'*, which will gracefully failover the primary unit to the secondary unit. Active as well as new calls will begin to seamlessly traverse the path with the secondary BCF. Additional PCAPs are recorded between the operational secondary BCF and the next hop. The audio signals appear to be normal. Additional PCAPs are recorded between the BCF and the next hop and requesting test calls from the PSAP in parallel. Test call feedback from the PSAPs confirm that isolating the BCF from the call path has eliminated the audio issues. A service request ticket is opened for the replacement of the BCF and the ticket number is added to the initial Remedy ticket, which is then updated and closed.

At 0600, some PSAPs are reporting they have not received a call in the last 15 minutes.

Based upon what is known about the direct-connected NG911 system architecture, carrier and selective router segments of the call path are eliminated. This removes a potential element of failure from the architecture and triage process while trying to diagnose connectivity issues. While dual geographically diverse connections are highly recommended from the regions to the PSAPs, several within a region may be connected through a single path. This happens to include the primary and alternate PSAPs.

- *System design notes* – An issue of this magnitude, resulting from a failure within the highly available NG911 system, would cause the NSOC monitoring tools to send alarms and alerts. SIP option pings are enabled between the BCF and Application Session Controller (ASC). One device sends continuous pings to the destination node, which listens and replies to the sender as a continuous health check measure. If a return ping is interrupted, the sending component sends SNMP traps to the monitoring device that contain messages about the trouble. Additional trouble reports should send messages to the system monitor as well. No SNMP traps from the routing elements have been sent to the monitoring tools.
- *There are no system elements directly shared between two PSAPs* – A PSAP does not share hardware components with adjacent PSAPs. Therefore, a router or switch failure at one PSAP location would not impact a router or switch in another site. However, the PSAPs do share certain data center infrastructure elements such as routers, switches, and servers.
- *Monitoring tools are operational and are not sending alerts* – If any indication of call- or routing failures were sent to the NSOC, notices would be sent to the affected PSAPs within roughly five minutes after the first notice of trouble from the monitoring tools. In this case, the PSAPs have not previously been notified of any trouble by the NSOC related to this issue, and no alerts have been sent to the monitoring tools.
- *Calls were not observed to default or alternate route* – If calls were default- or alternate routed, PSAPs receiving those calls would be communicating a notification to the PSAPs where the calls were intended to be delivered. The PSAPs would then call the NSOC to report the problem.
  - A series of test calls are initiated at the target PSAPs that have been reporting no calls delivered over a certain time. The BCF's Graphical User Interfaces (GUIs) are examined to ensure the calls are traversing inbound and connecting to the first point into each NG911 data center.

There could be multiple explanations for several PSAPs not receiving calls in an NG911 high-availability environment.

- There is no call activity; however, this is not likely at a busy PSAP.
- Monitoring or connectivity system failures. Not likely, because the monitoring system has a mirrored instance at each data center and appears to be sending non-critical messages.
- Routing failure. Not likely, because alerts would be expected to be displayed.
- Test calls sent to these PSAPs are entering the system and are visible in the BCF GUI. The call flow monitor shows the call setup through to each device up to the WAN routers. Representatives join the conference call previously established. The OEM is informed about the incident, and they quickly try to isolate the issue.
- PSAP connectivity issues resulting from PSAP infrastructure issues could cause call delivery problems.

For the purpose of this scenario, it is assumed that these PSAPs typically receive many calls within a 15-minute period around the clock. No other reports provided by PSAP call takers have been provided to the NSOC except for the PSAPs noted in the above scenario, where some PSAPs have not received any calls within the previous 15 minutes.

The following triage process would be initiated by NSOC personnel upon receiving notification from the PSAPs:

- Test calls would be initiated at all PSAPs that report an absence of calling activity by attempting 911 wireline calls from their PSAP Plain Old Telephone Service (POTS) administrative lines. The same is requested from the PSAP for outbound calls:
  - The system is searched for these inbound calls to the system.
  - Node monitors and alerts tracked to isolate any issues are not showing any evidence of trouble.
  - Call-path components outside of the NG911 system are suspected to be the source of the trouble as a result of the no-alert status of the monitoring tools.
  - Calls are shown to be delivered to the next hop once they enter the system.
  - The PSAP's calls takers are not reporting any incoming call activity from these test calls.
- Test calls are initiated at several PSAPs seen to be receiving a normal number of 911 calls during this time period, which attempts to validate the magnitude of the issue:
  - The system will be searched for these calls inbound to the system.
  - Node monitors and alerts are tracked to isolate any issues.
  - Calls are shown to be delivered to the next hop once they enter the system.
  - The PSAP's calls takers are reporting incoming call activity from the test calls.
- The incident will be classified as Severity Level 1 in the trouble ticket, based upon the user and multi-PSAP impact. The determination of the severity level is consistent with the current NSOC process, *"How to Determine 911 Severity" (Section 1.2, "Catastrophic Event")"* and the associated communication, reporting, and response protocols. As additional information becomes known, the severity level can be adjusted downward as mitigation measures are implemented, and as conditions warrant.
- A series of text messages and e-mails are sent out to a predefined list of partners, engineers, customer representatives, and senior leaders. The NSOC manager or designee leads the call, coordinates the discussion with the partners and engineers, and updates the trouble ticket. The NSOC manager also provides status updates and requests trouble isolation data, as well as aggregating and providing additional information to the team, as it becomes available.
- The local carriers and central office representatives join the conference call.

	• A partner provides a report that construction workers have severed a major fiber feed that serves the region. • After some analysis of the infrastructure beyond the boundary of the NG911 system, the central serving office of each PSAP reporting no call delivery is determined to be affected by the disruption of the infrastructure. • The central office representatives dispatch a repair crew to the incident site to restore connectivity. The NSOC confirms restoration of service with the Commission and affected PSAP(s), documents the restoration steps that were taken, and closes the ticket in Remedy. Remedy emails the close-out status to all stakeholders.

Any additional documentation can be inserted here

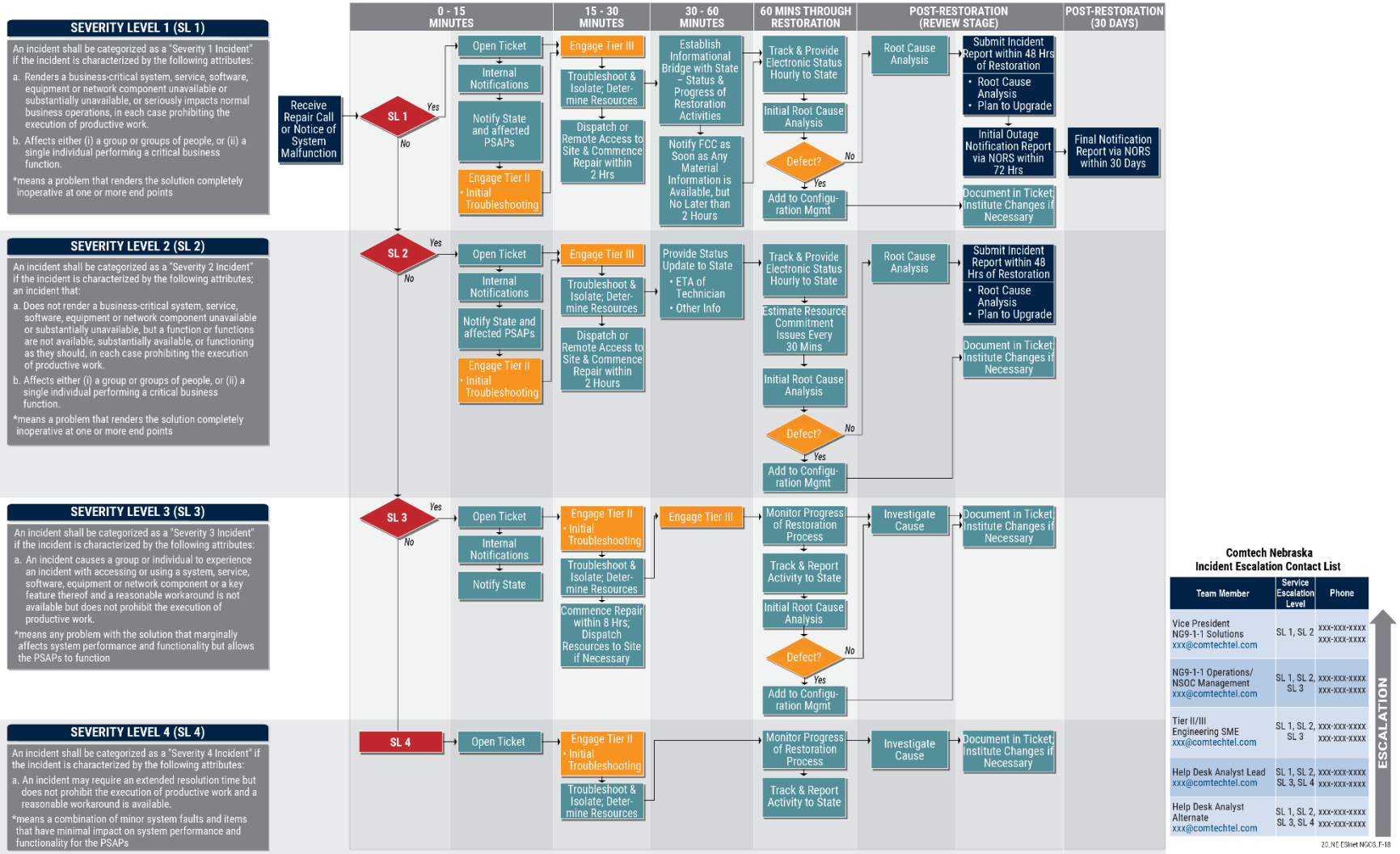


Figure 12. Incident Escalation Chart

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
GEN SCEN 2	**Scenario 2** All originating service providers in the state are connected directly via Signaling System Number 7 (SS7) protocol to the bidder's LNGs that serve the PSAPs in Nebraska, as well as others outside the Commission's footprint. Each LNG consistently processes about 10,000 calls per day, but each is capable of processing in excess of 100,000 calls per day. One of the LNGs experiences a catastrophic failure and is unable to process any calls. In a review of the prior day's logs, it is found that the two surviving LNGs only are processing 2,000 calls each.	X			
	Bidder Response: Comtech NSOC personnel, in coordination with Originating Service Provider (OSP), will analyze the 2,000 calls that were processed by each LNG and look for patterns: • Are there any specific OSPs that are not sending their usual call volume to the functional LNG? • Are there any specific Mobile Switching Centers (MSCs) within an OSP that are sending less than normal volume to the LNG? Comtech would reach out to the OSPs to verify if the geo-redundant connectivity is truly in place and functional, or if there is any missing provisioning on the OSP device that prevents the calls from being routed to the functional LNG. Comtech will also query the OSPs to see if there are any alarms related to call-processing failures on their nodes. The aim would be to identify why call volume has dropped considerably, and what corrective action is required to make sure all calls are successfully routing to the available LNG. During the process of researching the reasons for the decrease in call volume in the LNG, and while gathering information from OSPs and/or PSAPs, Comtech constantly assesses whether a 911 impairment has occurred as a result of an LNG failure. As soon as the available information concludes that an impairment had occurred (or is still happening), the Comtech NSOC would immediately send out an initial Severity Level 1 outage notification to the distribution list the customer provided to Comtech. Within the context of an outage and given the significant drop in call volume compared to what was processed the previous day, the Comtech NSOC would reasonably conclude this outage is also FCC-reportable. The NSOC would open an FCC Network Outage Reporting System (NORS) report and provide the FCC report number in the subsequent update to the customer. The Comtech NSOC would continue to send out hourly updates until the outage is resolved. The most likely cause of this issue is a failure in the OSP's network ingressing into the Legacy Selective Router Gateway (LSRG). In this scenario, Comtech would work cooperatively with the OSP to determine the root cause of the issues and restore operations and connectivity in the most expedient manner possible. The NSOC confirms restoration of service with the Commission, documents the restoration steps that were taken, and closes the ticket in Remedy. Remedy emails the close-out status to all stakeholders.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
GEN SCEN 3	**Scenario 3** As part of normal data-maintenance procedures, the bidder has uploaded six minor recent changes. The bidder's Quality Assurance/Quality Integrity (QA/QI) process provides a discrepancy report detailing 15,000 errors resulting from the updated file.	X			

Bidder Response:

Comtech's solution partner—Digital Data Technologies, Inc. (DDTi)—deploys DataManager, which serves as the Spatial Interface (SI) that provides the interface for provisioning updated GIS data to the ECRF/LVF. The Quality Control (QC)/Quality Assurance (QA) processes in DataManager are designed to detect GIS data errors and, based upon the configured, halt the publishing process prior to updating the ECRF/LVF database. This will prevent any GIS errors from affecting call routing.

For every data submission, the system will send notifications when data was received, when a job was started, when a job was finished, and if the job was successfully published. Any detected errors can block publishing and generate an e-mail notification to the defined end user(s). The detailed QC/QA reports and GIS change reports can be reviewed by the jurisdiction's GIS professionals to determine what corrective action is necessary before GIS data is resubmitted.

While the DataManager is designed to catch errors before they impact the ECRF, it is possible for GIS errors to be published. If this happens, the errors will be detected as part of the LVF validation process for the LDB records. These are handled through the normal LDB discrepancy workflow that is part of the LDB website.

If the jurisdiction's GIS professionals are uncertain regarding the accuracy of information as detailed in the provided reports or messages, Comtech and DDTi support professionals are available to provide consultation and assist in remediation.

Review of QC Processes for Submitted GIS Updates

Stage 1: Data Import Service

The data import service can detect several fundamental data issues. If there is an issue with spatial validity, the process can be set to either skip the record or stop the import process. Schema changes will be detected in the import process, and the process will be stopped for this layer. If the file name or type has been changed, the import job will not complete. In all three scenarios, an e-mail notification will be sent. The Data Import Service can be configured to generate a customized change report for the Road layer. While this will not affect the status of the job, it does provide an audit trail of the specific data changes for the layer with both the new and old values for the changed fields.

Stage 2: DataManager QC

The service will perform various QCs on the Road layer, including some customizable domain checks. ECRF data updating can be contingent based upon the result of the QCs. An administrative user can establish publishing rules that will block the update based upon the layer, the QC severity, and the absolute or relative number of errors for the layer. Here are some examples for Road data changes that could cause 15,000 errors:

- The Road could be spatially moved out of the coverage area for the dataset.
- The Street Name field can be empty.
- Address ranges can overlap to cause multiple matches in the ECRF.

	• Specific fields used in ECRF matching can be altered, where the new values do not belong to the allowable domain of the field. For example, the STS field has been changed to "Hghway" – which is not a valid value. More crucially, the Area fields can be checked against an allowable domain. Any of these individual QCs can be set up to block the Road data from publishing. If the data is blocked from publishing, e-mail notifications will be sent to the list of authorized recipients. For auditing purposes, the DataManager database keeps historical records based upon a unique ID. This makes it possible to see the exact evolution of the record through time. It can also help to ease the process of rolling back the database to an earlier state, if necessary. *Step 3: LVF Validation* If the GIS data has been published to the ECRF/LVF, the detected errors will be reported by utilizing the following categories: • Critical errors – The query is outside of the authoritative limits of the ECRF. • High errors – The ECRF has not determined any possible matching database records for this address. If the address has valid area values, a default route can be returned (for example, if the address has a valid Master Street Address Guide (MSAG) community, the call can be default-routed based upon the value of the MSAG community). • Medium errors – There are multiple match candidates and more than one possible routing result. The ECRF will select one of the possible routing results. • Low errors – There are multiple match candidates, but they all have the same call-routing values.

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
GEN SCEN 4	**Scenario 4** At 0700, the NOC has received an alarm reporting loss of connectivity for a single path to Host A. At 0705, the NOC contacts Host A to confirm the loss of connectivity. The PSAP has found that the link lights are off, but the system appears to be operational. At 0725, the redundant link appears to be bouncing for Host A. At 0900, the PSAP is reporting a decrease in typical call volume.	X			

Bidder Response:

At 0700, the NOC has received an alarm reporting a loss of connectivity for a single path to Host A.

Comtech's monitoring system automatically generates a Remedy ticket when a loss of connectivity is detected. This type of alarm would be classified as Severity Level 2. The alarm informs the NSOC which piece of equipment is reporting a loss of connectivity. Notifications are simultaneously disseminated to all on-duty personnel. In addition, Remedy automatically sends text alerts to key personnel, including Comtech management and Commission leadership. This alert occurs immediately upon ticket generation; an update is sent 30 minutes later, and then every 60 minutes until the incident is resolved. NSOC personnel contact the PSAP to confirm operational status.

At 0705, the NOC contacts Host A to confirm the loss of connectivity. The PSAP discovered that the link lights are off, but the system appears to be operational.

NSOC personnel have contacted the PSAP to investigate its operational status and subsequently confirm a loss of connectivity. Although NSOC personnel know which piece of equipment is reporting this loss of connectivity, they initiate a series of troubleshooting questions regarding connectivity and system performance. NSOC asks if the PSAP is still receiving calls, if the application is working as expected, if it is exhibiting sluggish behavior, or if anything else is different. NSOC personnel inquire about any exigent circumstances at the PSAP that may have generated the alarm (i.e., an unscheduled facility electrical outage, an equipment reboot, etc.). NSOC personnel instruct PSAP personnel to visually inspect their workstation equipment. If accessible, NSOC personnel ask the PSAP to visually assess the malfunctioning network equipment. The PSAP reports that the link lights are off, but their system appears to be operational. After accessing the PSAP's redundant routers, an NSOC Tier II technician confirms that 911 traffic is traveling on the redundant path. Since the PSAP remains operational on this redundant link, this incident remains Severity Level 2. The NSOC begins to investigate a presumed circuit outage, reaching out to the primary circuit's carrier. The NSOC opens a ticket with the circuit provider.

At 0725, the redundant link appears to be bouncing for Host A.

Bouncing of the redundant link for Host A generates additional alarms and Remedy tickets for the affected PSAP. Since the primary link is down and the redundant link is bouncing, the NSOC raises the incident to Severity Level 1 and communicates with the affected PSAP and its alternate before rolling traffic to the alternate. The NSOC performs test calls with the alternate PSAP to confirm that traffic is being received. The NSOC contacts the carrier of the redundant circuit and opens a ticket. Carriers tickets are immediately escalated via the carrier chain of command. Conference bridges are established to troubleshoot and begin remediation. Automated updates are sent to key personnel at 0730 and 0830.

At 0900, the PSAP is reporting a decrease in its typical call volume.

The affected PSAP would not receive any 911 calls once traffic has been directed to its alternate. The NSOC will continue to monitor the status of circuits and troubleshoot the situation with the carrier. The NSOC continues to monitor the alternate PSAP to ensure traffic is flowing normally. Traffic will remain redirected, and the conference bridge remains open until the primary and alternate circuits are restored. Automated updates are sent to key

	personnel at 0930, and every 60 minutes thereafter until the incident is resolved. Once the circuits are restored, the NSOC will restore traffic to the original PSAP. The NSOC performs test calls with the original PSAP once traffic is restored. The NSOC confirms its restoration of service with the PSAP and the Commission, documents the restoration steps that were taken, and closes the ticket in Remedy. Remedy emails the close-out status to all stakeholders.

	Project Management and Ongoing Client Management Services **Project Management Methodology** 1. Describe bidder's project management methodology and support structure. 2. Describe the daily, weekly, and monthly interactions during the migration. 3. Include a proposed high-level project plan. 4. Include a schedule for the through implementation of this project.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
PM 1		X			

Bidder Response:

Comtech is proposing Shannon Dempsey to be the Nebraska NG911 PM. Shannon has 13 years of industry and customer experience, as well as substantial subject matter expertise, and her presence will ensure the successful delivery of ESInet and NGCS to the state of Nebraska and its citizens. As the Comtech PM, Shannon reports directly to Comtech's Vice President/General Manager of NG911 Solutions and will have the decision-making authority and assigned staff and partner support to ensure that skilled resources are available and assigned to the project for the duration of the project. Comtech's PM will be onsite during significant project events, including the installation of the core system and any optional capabilities that were purchased, during intervals throughout system testing, and when the system goes live. Across all phases of the project, the Comtech PM will provide project coordination, task oversight and milestone completion, while also conducting project meetings and providing schedule updates and progress reports. The Comtech PM prepares and maintains a Master Project Plan (MPP) that is reviewed with management and used to manage all phases of the program. The MPP also ensures project compliance to deliver the highest levels of performance, teamwork and customer satisfaction. The primary responsibilities of the PM include:

- Acting as the primary customer contact for Nebraska during the project life cycle.
- Acting as the primary point of contact (POC) for all Comtech personnel and subcontractors during the project life cycle.
- Attending all project meetings, which include:
  - Project kickoff meeting
  - Weekly project meetings, as scheduled by the Commission
  - Ad-hoc meetings, as scheduled by the Commission
- Providing coordination between Commission personnel and the Comtech team for the compilation of configuration/integration details for all NG911 sub-systems
- Coordinating and assigning key project tasks with Commission personnel and PSAP personnel (where necessary).
- Participating in all aspects of project planning/execution, which include:
  - Subcontractor/Comtech resource planning/assignments
  - Lab staging activities
  - Site sequencing for deployment/cutover
- Managing project activities in accordance with the approved MPP.
- Coordinating the development of required project documentation.
- Coordinating site access for the Comtech project team.
- Building consensus between Comtech and the Commission, such as:
  - Acting as liaison with OSPs, Commission personnel, and other relevant stakeholders throughout the state of Nebraska.

	– Collaborating with Commission personnel to ensure that system requirements and participating agencies' needs are met in all phases of the project. The Comtech PM will conduct a kickoff meeting with the Nebraska project designee(s), to be held onsite at a pre-designated location within 10 business days following contract execution. The Comtech PM will coordinate with Commission personnel to ensure the content of the meeting meets their expectations. At a minimum, the kickoff meeting will include: • A review of the technical solution and the preliminary MPP • Program Organization – The introduction of key project personnel from both Comtech and the Commission • Roles and Responsibilities – The identification of external project stakeholders critical to the project's success • Critical milestones • Deliverables • Communication • Staging/storage areas • Site access requirements • Survey planning Following the kickoff meeting, Comtech will make any necessary adjustments to the documents that were presented during the meeting. Electronic meeting minutes will be submitted to all participants. Comtech will deliver a detailed Project Schedule/Integrated Master Schedule (IMS) within 10 days following this kickoff. Please refer to *Comtech Confidential File 11* for the draft IMS. **Weekly Project Meetings** The Comtech PM will coordinate and conduct weekly project meetings with Commission personnel during the project life cycle. Prior to each meeting, Comtech will electronically send to all participants a Project Status Report (Microsoft Office format) detailing: • Work completed during the two weeks prior to the meeting • Work planned for the upcoming two weeks • Project status in relation to the MPP • Upcoming milestones • Material procurement status • Deliverable status • Action item status • Open issues/punch list items • Estimated date of completion • Closed issues, with details of resolution

The Comtech PM will present the project status report during the weekly meeting, which will include whatever information is required of the state of Nebraska to complete its assigned tasks. A submission date will be agreed to during the meeting and tracked as an open action item. Electronic meeting minutes will be submitted to all participants after each meeting.

Ad hoc Conference Calls

During the project life cycle, the Comtech PM will convene conference calls with Commission personnel to discuss the current status of the project, review action items, and address project-related issues. The Comtech PM will provide a conference bridge with dial-in instructions for the call. Electronic meeting minutes will be submitted to all participants within a specified period after each call.

Monthly Status Report

The Comtech PM will provide monthly status reports, to be delivered on an agreed-upon day after the end of each month. These reports will contain the following project-related details:

- Work completed during the previous month
- Work planned for the upcoming month
- Project status in relation to the MPP
- Upcoming milestones
- Material procurement status
- Deliverable status
- Action item status
- Open issues
- Closed issues, with details of resolution

Project Review Check Point

Once per quarter, the Comtech PM and the account team will provide a full onsite update with the Commission's designee(s). This presentation will include a report on project status, lessons learned, and an updated MPP.

Comtech is proposing a five-phase implementation plan, where each phase is addressed in the IMS. The IMS starts with the initial milestone of Contract Award and subsequent kickoff meeting, and it proceeds through all Design, Deployment, Integration, and Test tasks required to deliver a NENA i3–compliant NGCS and ESInet project. The tasks for PSAP integration are included; however, the prioritization of PSAP scheduling will be coordinated with the Commission's designee(s).

As one of the largest NG911 systems integrators in the United States, Comtech's capabilities and expertise include complex program management, security management, network management, transition planning, quality management, risk management, and other skill sets that are crucial to a project of this scale and scope. The Comtech Program Management Office (PMO) will provide direction for all functional areas of the program. Through the program's vision, mission and objectives, the success factors of the program involve teamwork and the ability to solve problems and institutionalize solutions. This process includes ensuring that all resources are available to accomplish each milestone requirement.

Comtech's program management approach is in accordance with our MPP, our Quality Management System (QMS), and our Environmental Health and Safety (EHS) procedures. The program management approach is based upon a core team of key personnel and teammates, led by Comtech's NG911 PM.

The Comtech team's management framework is based upon industry best practices and includes ISO 9001:2015/TL 9000:2016–registered processes. These processes are documented in our QMS and provide a foundation for effective project management to:

- Improve overall project performance
- Ensure that projects are delivered on time and within budget
- Reduce project risk
- Enhance quality
- Improve inter- and intra-project communication
- Establish a consistent standard that everyone can follow
- Complement standard System Development Life Cycle (SDLC) methodologies

Project management for the Nebraska NG911 program will be tightly integrated with the Project Management Institute (PMI) Project Management Body of Knowledge (PMBOK) life cycle management methodology. Figure 13 provides a high-level overview of how each phase aligns with the state of Nebraska's NG911 project and PMBOK.

Project Management Tools and Processes

Comtech brings a full suite of project management tools and processes that have been proven effective across projects, with requirements we believe parallel the Nebraska NG911 requirements. These processes and tools provide the following elements:

- A repeatable set of processes for use by project managers and technical leads to ensure operational efficiency and overall quality performance.
- Best practices and lessons learned from previous programs. Our standardized processes incorporate those best practices and lessons learned to enhance efficiency.
- A common foundation and knowledge repository for Comtech and subcontractor use, creating a common baseline for knowledge sharing and employee and subcontractor training.
- Standards and tools tailored to the requirements of the Nebraska NG911 project, so that all technical activities are relevant, efficient, and optimized.
- A framework for maintaining and continuously improving the standards and project management tools to ensure QA in all areas.
- Integration between tools (management, program, and technical) and standards for monitoring and reporting to guarantee effective management of this complex, multidisciplinary project.

The Comtech team, led by the PM, will use the tools and processes listed in Table 1. Post-award, an understanding of project governance among the various stakeholders will allow Comtech to tailor these approaches to the needs of the Nebraska NG911 project. Comtech will ask the Commission to identify the individuals who should have web portal access privileges and, once established, we will conduct an overview of that portal access, use, and common activities. The Comtech portal is a repository for project-related deliverables, status and plans.

Table 1. Tools and Processes

Project Phase	Highlighted Tool/Process	Benefits
All	Collaboration tools– Slack, Microsoft Teams, Click up; as well as other web-based applications to store, organize, share, and access information	• Real-time posting of project deliverables for review and approval, accessible on a permissions basis by customer and Comtech personnel. It will include open issues and a real-time punch list. • Monthly posting of operational reports on system performance, ticket status/statistics, etc. • Accessible to the Commissions and PSAPs, with email notifications of document postings and updates
	Weekly Project Status Review	• Regular forum to report on project status and address outstanding issues • Predetermined stakeholder attendance to ensure all are informed
	IMS	• Maintains status on overall project health and progress • Maps major project milestones • Identifies risk to critical-path items • Prioritizes tasks to ensure interdependencies are being met
	Verification Cross-Reference Matrix (VCRM) decomposition of Nebraska requirements – with source mode of verification (e.g., document, test, inspect)	• Ensures understanding of requirements post-award (reviewed with the Commission) • Informs test and acceptance process
Planning and Engineering	Weekly CCB (sample Change Request Form) • Review/approval of changes or updates to configuration baseline impactful to the Commission and/or PSAPs • Overview of release schedule and testing	• Cross-functional attendance (Comtech engineering, release management, and CM) to keep everyone informed • Customer concurrence/approval required
	Site Deployment Tracker (where applicable) • Hosted on Comtech's portal, updated daily – Customized to relevant milestones for Nebraska personnel to view key dependencies and status	• Design of tracker will be a joint effort with Comtech and Nebraska personnel • Multi-tab tracker will be customized from existing tool used for other production NG911 projects (>300 PSAPs)
Integration, Test and Deployment	Monthly Status Reports – Key systems performance metrics will be posted to Comtech's portal • Incident reports with root cause analysis, as required • Customer access to Remedy ticketing system	• Customer access to relevant system performance and incident reports • Real-time access to Remedy to track incident reporting and resolution

		Recurring Operations meetings consisting of: • Open Remedy ticket reviews • SLA performance reports • Review of outstanding operations action items	• Allows customer stakeholders to review key operational metrics with Comtech • Facilitates continuous improvement in service delivery

Any additional documentation can be inserted here:

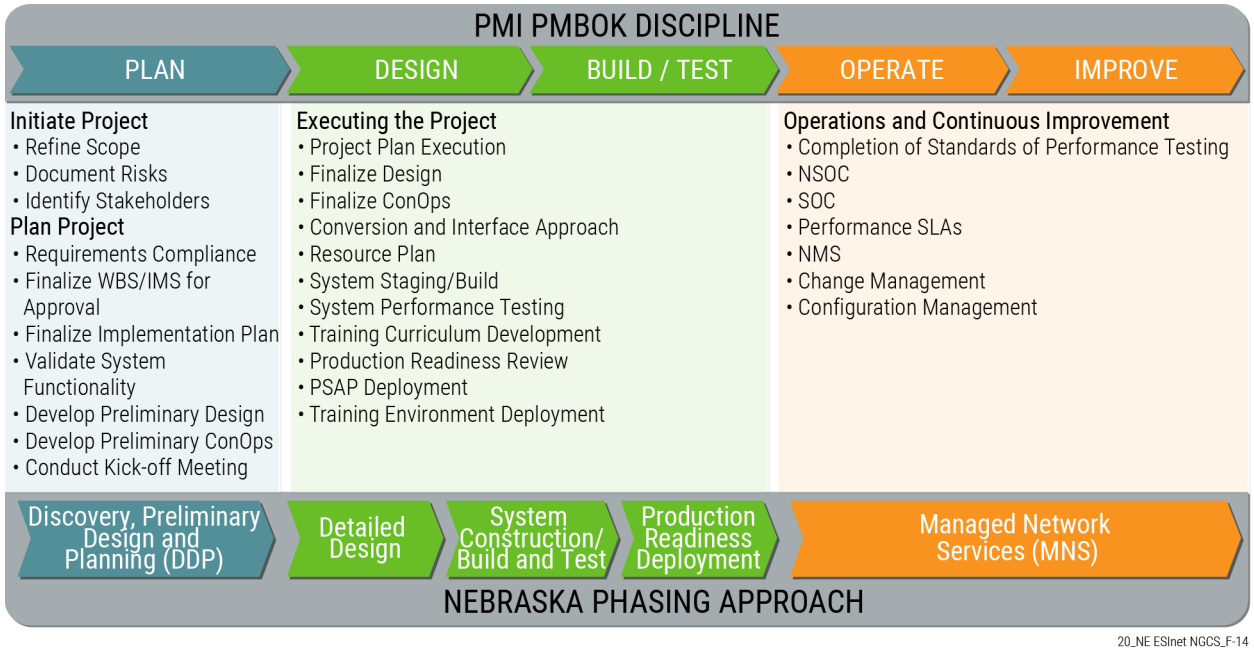


Figure 13. SDLC Management Approach

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
PM 2	**Project Management and Ongoing Client Management Services** **Post-Deployment Client Management** Describe the post-deployment client management service, including client management reports, executive briefings and the fielding of ad hoc support requests.	X			
	Bidder Response: Following system acceptance, Comtech will provide support and maintenance for the Nebraska NGCS and ESInet. Comtech NSOC involvement begins with testing, validation and deployment activities that are part of Phase 3 and Phase 4. Monitoring, reporting and real-time event updates are associated with Comtech's 24x7x365 NSOC operational support and proactive awareness. This strategic early involvement of the NSOC includes Tier I – III technical and engineering support and ensures that no learning curve is required to manage the operation and maintenance of the NG911 system. The NSOC has well-defined processes, procedures and work instructions for all facets of support and maintenance, based upon ITIL principles and industry best practices. For the duration of the contract, the Comtech PM will provide monthly reports to the Commission, which will include scheduled and routine maintenance activities, technology and standards updates, and other areas of importance to the Commission. Network performance reports will be provided by the Comtech NSOC using SolarWinds to provide network availability reports; these include Network Performance Monitor, VoIP and Network Quality Manager IP SLA, and NetFlow Traffic Analyzer modules. It is understood that the PSAPs and the dispatch centers have onsite technical support staff, but their responsibilities will be limited to routine maintenance as prescribed by Comtech. These support and maintenance functions are initiated with the opening of a trouble ticket. The exact process will be detailed in the state of Nebraska's Customer Service Guide that will be delivered following contract award. All trouble tickets will be opened with the Comtech NSOC. Comtech will employ fully qualified and trained support technicians on all aspects of our NGCS and ESInet deployment for the state of Nebraska's data centers, as well as the service points at PSAPs and dispatch centers. Comtech's ongoing operations and maintenance service utilize locally assigned technicians. Support and maintenance will be inclusive of remote diagnostics; upgrades and enhancements will be aimed at always achieving the efficient operation of the NG911 system and for providing safe services. Support services include a toll-free number for reporting service issues, an e-mail address to contact the NSOC support team, and remote diagnostic capabilities. All contact information (including escalation procedures) will be documented and provided in the customer service guide. Comtech employs a disciplined engineering process that routinely evaluates industry standards, solution compliance, and overall system performance throughout the lifecycle of the contract and will provide executive briefings and ad-hoc support requests that includes key information to aid in strategic planning and ensuring the NGCS and ESInet maintain compliance performance, and conformance with evolving NENA standards.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
TRN 1	**General Requirements – Training** **Comprehensive Training** Contractor shall provide comprehensive training to designated Commission representatives responsible for varying layers of network/system monitoring and system maintenance. Describe bidder's training program for system implementation and ongoing operation and maintenance, including but not limited to the following topics: 1. user-configurable elements; 2. NOC/SOC procedures; 3. escalations; 4. trouble reporting; 5. help desk portal; 6. executive dashboard; and, 7. service monitoring tools. Training shall be available at the user level and delivered to the PSC and each region (up to 10) and also the train-the-trainer level (up to 25 individuals).	X			
	Bidder Response: Comtech provides user and administrator training for the lifetime of the project. Comtech will conduct on-site training, at the time of installation and supplement with subsequent webinar sessions to ensure all users are fully trained, as needed. The training coordinator will work with the Commission's designated training lead, and with training content developers (OEMs and Comtech in-house instructional systems designers), to finalize the curriculum and content of the proposed training to include: 1. User-configurable elements 2. NSOC procedures 3. Escalations 4. Trouble reporting 5. Help desk portal 6. Executive dashboard 7. Service monitoring tools 8. Nominal administrative tasks and basic techniques relative to any new features or enhancements. Training courses are planned for up to 10 students and run between four and eight hours per session, depending on final curriculum. During training, the training coordinator will manage the training schedule, address customer satisfaction and feedback regarding training courses, and ensure that the instructors and materials being presented meet the state of Nebraska's training objectives. Training allocation has been made to provide the following: • Supervisor and Administrative training • End-user training • Train-the-trainer can be provided				

	Training will be provided to the Public Service Commission (PSC) and each region (up to 10), and train-the-trainer can be provided for up to 25 individuals.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
TRN 2	**General Requirements – Training Attendees and Curriculum** 1. Describe the number and types of attendees required to attend training, training curriculum, number of training attendees included in the proposed price, and the duration of the training program per attendee (expressed in hours per day and number of days), as well as the location of the training and whether such training is available online or onsite. Preference is given to training that can be conducted in an onsite setting for attendees. 2. Provide Examples of the proposed training plans. 3. Provide a sample of the training materials to be used. Training classes shall be recorded for future reference and training of new Commission and PSAP employees.	X			

Bidder Response:

Training attendees typically include systems administrators, PSAP technical staff, OSPs, and other stakeholders interested in learning how the solution is configured. The change management process is covered during the training, so it is useful for end-users and administrators to attend and become familiar with day-to-day operational support models. Comtech will provide a combination of onsite and web-based training. Comtech plans to train multiple regional hosts each week to introduce policy routing functions. This training typically takes four to eight hours per session. Comtech will also provide follow-up documentation and templates for the change management processes discussed during training, as well as user guides and other helpful documentation.

Comtech's training coordinator will work with the Commission to finalize a training plan that includes curriculum, content, and corresponding materials for the course(s). Courses are designed for systems administrators, management personnel, and PSAP and dispatch center personnel consisting of end-user training and supervisor/administrator training. Students will be grouped in pairs and practice using the system's features in a simulated call-taking setup. The final course module allows students to review specific topics and ask the trainer to demonstrate procedures relevant to their operating environment.

Here is a sample of training topics covered:

- **Comtech web portal** - access and use
- **NSOC contact and interface** – Training on Comtech's trouble reporting process, SOP, and portal access. Once a region has been tested and goes live on the NG911 system, we provide the NOC PSAP SOP and answer any questions as a refresher.
- **PRF policy store** – Comtech provides a document that describes the options available for the local jurisdictions to document their alternative routing plans and answers any specific questions they may have.
- **NGCS workflows and reports** – This training will cover NGCS element workflows as well as the NG911 services dashboard.
- **LDB workflows and reports** –Training will cover:
  - LDB overview
  - Data processing and location validation

Separate web-based sessions are provided for local jurisdictions and OSPs and will include user guides. Comtech includes change-management processes specific to each training section, as well as our user guides and/or SOPs. Training classes will be recorded for future reference and training of new Commission and PSAP personnel.

	A Comtech Confidential sample training plan is included in File 11.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SRAR 1	**General Requirements – Service, Repair and Advance Replacement** The Commission shall not be responsible for the replacement and maintenance of hardware and software required to provide the NGCS or ESInet connectivity provided as part of the bidder's solution. The Contractor shall resolve all faults or malfunctions at no additional cost to the Commission. **Support Maintenance** 1. Describe in detail bidder's 24 x 7 x 365 maintenance support for the life of the contract. 2. Describe bidder's understanding of public safety maintenance windows and associated notification processes. 3. Describe bidder's problem resolution and change management processes, the supporting systems, and adherence to best practices, such as those described in the ITIL version 3 or most current version.	X			

Bidder Response:

<u>24x7x365 Maintenance Support for the Life of the Contract</u>

Support maintenance is integrated as part of Comtech network operations; it is managed by the NSOC. The NSOC has well-defined processes, procedures, and work instructions for all facets of support and maintenance, based upon ITIL principles and industry best practices. All NSOC procedural documentation is maintained in a digital library, with online access for all staff members plus a limited number of hard copies available for reference. All documentation updates go through a review-and-approval process, and the latest approved documents are available online. Comtech ensures that all NSOC staff members are trained in our NGCS architecture and operational standards. The NSOC will provide timely responses and replies as they coordinate the team's responses to maintenance, service, and customer service actions. The NSOC team will have been involved since the onset of testing and is familiar with the system as deployed, understands the SLA, and is skilled in the NMS for understanding alarm notifications, the generation of alarms, severity levels, assignments, and the urgency related to maintaining the QoS, response and resolution times, plus the escalation procedures based upon SLA requirements. The *Comtech Confidential* draft maintenance plan is included in *File 11*. The draft maintenance plan provides detailed steps and processes. Comtech will work with the Commission to modify or tailor those elements, as required.

For the duration of the contract, Comtech will provide monthly reports on actual network availability to the Commission, which will include scheduled and routine maintenance activities. The NSOC uses SolarWinds to provide network availability reports; these include Network Performance Monitor, VoIP and Network Quality Manager IP SLA, and NetFlow Traffic Analyzer modules. It is understood that the PSAPs and the dispatch centers have onsite technical support staff, but their responsibilities will be limited to routine maintenance as prescribed by Comtech. This support and maintenance is initiated with the opening of a trouble ticket. The exact process will be detailed in the state of Nebraska's Customer Service Guide, which will be delivered following contract award. All trouble tickets will be opened with the 24x7x365 Comtech NSOC. Comtech will employ fully qualified and trained technicians on all aspects of our NGCS deployment for the state of Nebraska. Our solution is based upon a plan to utilize locally assigned technicians. Support and maintenance will be inclusive of remote diagnostics; upgrades and enhancements will be aimed at always achieving the efficient operation of the system and for providing safe services. Support services include a toll-free number for reporting service issues, an email address to contact our support team, and remote diagnostic capabilities. All contact information (including escalation procedures) will be documented and provided in the customer service guide.

<u>Public Safety Maintenance Windows and Associated Notification Processes</u>

	Maintaining the Nebraska NGCS and ESInet is not just about technology support; it must also fully consider the timing impact on operations, organizational schedules, and overall risk mitigation. This is a fundamental shift from the maintenance approach generally adopted by carriers or OSPs, who prefer to work around "their" schedule as opposed to that of the customer. In our experience of supporting public safety organizations with E911 and NG911, every PSAP and 911 organization has their own demands and priorities. In some of Comtech's implementations, customers prefer maintenance to be performed mid-day and mid-week—when they have traditionally slow periods—to ensure minimal disruption to any activities. In the CoMA, the customer prefers maintenance work to be done during late night/early morning, mid-week hours. Upon arriving at a mutually agreeable schedule, maintenance windows will be coordinated and adhered to in order to minimize any disruption. Since Comtech has its own NSOC and employees who perform service and maintenance tasks, we can schedule work based upon our customers' requirements, with the flexibility to accommodate urgent requests and/or reprioritize as required. The NSOC owns the preventative maintenance process by using preventative maintenance checklists, break/fix repair actions, updates to the configuration baseline, upgrades, and patches in accordance with approved change control processes, plus continuous monitoring and customer communication. Regardless of the action or activity, an incident ticket is generated for all maintenance and support requests. Comtech has implemented an incident ticket categorization process into our Remedy system. Comtech routinely conducts operations meetings with our customers to communicate and review trends, high-priority activities, planning, and action tracking. This will be a standing process for the life of the contract. For all maintenance activities and notifications, Comtech requires our underlying service providers to adhere to a notification process for any maintenance activity they may perform. We understand that "upstream" actions can have an unanticipated impact, and that advance notice and communication is needed to prevent any negative impact. <u>Problem Resolution and Change Management Processes</u> The NSOC uses and integrates multiple network and event management tools and modules for monitoring, alerting and notifications. Alerts can be configured to initiate trouble tickets by sending a notification to our Remedy trouble ticketing system. Remedy is configured to send notifications to technical, management, operational, and jurisdictional resources based upon the severity of the incident and time intervals. All our partners are included in this incident management process and are integrated into the escalation and resolution actions. If a defect is identified, our problem and change management process defines and supports the necessary steps for corrective action to include the root cause analysis, suggested remediation, convening the CCB to review and approve recommended changes, the pre-release process to evaluate the impact of the change, and finally, coordinating the appropriate maintenance/change window to implement and document the change in the configuration management baseline. These actions, coupled with Comtech's extensive experience in proactively managing and monitoring NG911 data centers, provides a comprehensive approach backed by real-world experience. A trusted partner who is experienced in managing and sustaining the transition in a time-sensitive period becomes a key factor for success. Interoperability, risk management, operational enablement, life cycle support, customer service, and training will be critical to a successful transformation. Our rigorous, multi-tiered engineering, operations, and service end-to-end life cycle approach—as well as our NSOC processes and documentation—are based upon ITIL quality practices.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SRP 1	**General Requirements – Software Release Policy** **Scheduled Releases** **Frequency of Scheduled Releases** 1. Describe the frequency of scheduled software releases, the feature release testing process, and the decision-making processes involved in deciding what features and defect resolutions to include in a scheduled release. 2. Include a current roadmap of feature updates and additions with projected release by quarter and year.	X			

Bidder Response:

Following service delivery and operation, Comtech utilizes our change management process for any software updates. Software-specific changes are typically created by a partner, a subcontractor, or a service supplier. This development is initially tested in the appropriate partner's development lab. Once the software change has passed its internal development testing, the software change is delivered and processed through Comtech's change control process.

Comtech's change management process strictly controls the testing, release and installation of any changes to the system, regardless of whether it is a hardware or a software change. The process typically begins with the identification of a change item and the submission of a change request form. The change request is then reviewed and presented for CCB review. The CCB is made up of members of the customer community, Comtech partners, and Comtech functional leads for engineering, operations, quality control, configuration control, release management, and program management. All CCB decisions are documented in control forms. Upon CCB authorization to proceed, the change is presented to the release manager, who will implement the change in a pre-integration offline environment for complete testing and verification. Pending successful evaluation, the release manager notifies the CCB and, upon final approval, schedules a maintenance window and provides notification to all parties. Prior to the final configuration change, the pre-release configuration is saved in the event a back-out is required. Upon the successful release upgrade, functional tests are conducted to ensure expected results are achieved and no adverse effects have been experienced.

Any software defects that are identified during pre-integration testing, or after implementation, are tracked and managed in Comtech's internal ticketing system until the defect has been resolved. An example of our partner Software Release Policy for DDTi is explained below:

DDTi follows the scrum process for developing and releasing software.

- Requirements and bugs are created and maintained by the product owner in a product backlog file. Cross-functional product teams that include software developers and testers, plus implementation and service engineers, operate in three-week sprints to produce a releasable product. The software is tested during the sprint in the form of unit tests and regression tests, and it must pass all tests to be released.
- At the end of the sprint, the software is deployed to an internal DDTi environment for additional load- and performance testing. Software that passes all tests in the internal DDTi environment will be considered for release to the integration testing environment.
- DDTi will follow the procedures outlined by the CCB to have its software approved for release into the integration environment. This includes detailed test plans, implementation plans, and release notes. Integration testing is performed with all other call-flow components during this stage. If the software passes all these tests, it will be considered for a production release.
- The process for updating call-flow components in production involves tight integration between DDTi and Comtech engineers. Call-flow components are put into maintenance mode and removed from the pool of load-balanced services for updating, one at a time. Smoke tests are performed on the services before they are returned to the call flow. During this process, both teams are monitoring the telemetry to

	ensure there is no loss of service. DDTi and Comtech have performed more than 150 updates to production systems over the past five years. Comtech NGCS roadmap items are included in *Comtech Confidential Table 2* below.

Any additional documentation can be inserted here:

Table 2. Comtech NGCS Roadmap Items (Comtech Confidential)

SRP 2	**General Requirements – Software Release Policy** **Maintenance Releases** Describe the frequency of defect-resolution software releases, as well as the decision-making processes involved in selecting which software defects to fix.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: Defects are an incorrect behavior of NG911 systems or components that requires software code modification for corrective action. Given our rigorous development and pre-integration testing, we expect the frequency of software defects to be low. In our experience, most software defects are related to call handling. Comtech works with critical manufacturers to implement mitigation steps (workarounds) while manufacturers identify a corrective patch or upgraded version of the component. If a defect is identified, our problem and change management process defines and supports the necessary steps for corrective action to include the root cause analysis, suggested remediation, convening the CCB to review and approve recommended changes, the pre-release process to evaluate the impact of the change, and finally, coordinating the appropriate maintenance/change window to implement and document the change in the configuration management baseline. These actions, coupled with Comtech's extensive experience in proactively managing and monitoring NG911 data centers, provides a comprehensive approach backed by real-world experience.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SRP 3	**General Requirements – Software Release Policy** **Test Environment** Prior to install of new releases, bidder shall explain how Contractor replicates the production environment for software release testing to provide assurances that future software releases will not negatively impact PSAP operations.	X			
	Bidder Response: Comtech maintains a lab environment that emulates its production environment. Comtech utilizes this lab for evaluation and interoperability testing of all new releases, patches, or updates. This is an industry-standard IV&V platform that facilitates the central management of patching for all systems within the NG911 environment. Upon release, patches are analyzed and tested in the development environment prior to being deployed into the production environment. All patches are manually reviewed and approved to minimize any operational impact to the NG911 system while maintaining security risk awareness. As with the endpoint security platform, utilizing a central patch repository enhances our security posture by allowing endpoints to receive their patches internally, as opposed to downloading them from an external source.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SRP 4	**General Requirements – Software Release Policy** **Access to Defect Tracking System** Contractor shall provide the Commission with access to the Contractor's defect tracking system for the Commission to track the progress of defect resolutions. **Software Defect Tracking Process** Provide a detailed description of the software defect tracking process and describe how bidder will provide training for no more than ten (10) Commission staff prior to Final Acceptance Testing.	X			

Bidder Response:

Any software defects that are identified during pre-integration testing or after implementation are tracked and managed in Comtech's internal ticketing system until the defect has been resolved. Commission access to this defect tracking is granted on a permission-based policy to view any updates to the ticket status. As part of the final QA/QC tasks, the delegated commission members are invited to participate in the QA/QC review. Training of these commission members will be performed via a hands-on approach, with SMEs leading the training prior to the Final Acceptance Training, which is planned to coincide with what is referred to as Staging tests.

- Staging tests verify the initial construction of equipment and software elements.
- System Under Test (SUT) - This test procedure provides the definition of the test environment (a.k.a., the test rig). The test environment is defined as all system/subsystem(s)/component(s) required to connect to the SUT to execute, measure and report on SUT compliance with the requirements. Finally, the test procedure captures all artifacts, logs and observations, and it will be filled out during each test event.
  - Upon the completion of staging acceptance testing, the NGCS and ESInet are ready for connectivity and the integration of internal and external components.
  - Comtech will obtain Commission approval of the completion of staging acceptance testing.
  - Functional acceptance testing does not begin until the Commission approves staging acceptance testing.
- Requirements and bugs are created and maintained by the product owner in a product backlog file. Cross-functional product teams that include software developers and testers, plus implementation and service engineers, operate in three-week sprints to produce a releasable product. The software is tested during the sprint in the form of unit tests and regression tests, and it must pass all tests to be released.
- At the end of the sprint, the software is deployed to an internal developer's environment for additional load- and performance testing. Software that passes all tests in the internal developer's environment will be considered for release to the integration testing environment.
- Software providers follow the procedures outlined by the CCB to have the software approved for release into the integration environment. This includes detailed test plans, implementation plans, and release notes. Integration testing is performed with the other call flow components during this stage. If the software passes all these tests, then it will be considered for a production release.
- The process for updating call flow components in production involves tight integration between software providers and Comtech engineers. Call-flow components are put into maintenance mode and removed from the pool of load-balanced services for updating, one at a time. Smoke tests are performed on the services before they are returned to the call flow. During this process, both teams are monitoring the telemetry to ensure there is no loss of service. This process has been employed to perform more than 150 updates to production systems over the past five years.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SRP 5	**General Requirements – Software Release Policy** **Software Defect Aging** Describe how service-affecting software defects are aged. If minor problems (from the Contractor's perspective) are not identified and resolved immediately, these minor problems can become major or critical problems. Describe in detail how/when this minor problem gets scheduled or automatically escalated, and the feedback mechanism in place for keeping the Commission informed.	X			
	Bidder Response: Comtech will conduct mutually agreeable quarterly meetings with our customers to communicate and review trends, high-priority activities, planning, and action tracking. This will be a standing process for the life of the contract. As part of this process, Comtech will maintain the current list and priority of all known software defects. This list will be reviewed and verified with the Commission, the software provider, and any other required stakeholders.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
DOC 1	**General Requirements – Documentation** The Contractor shall provide the Commission with all pertinent documentation for the ESInet and/or NGCS connectivity provided as part of the Contractor's solution as implemented, No more than 30 days after completion of the network construction, and update the Commission as configurations change over the term of the contract. The required documentation shall include the following: **1.** Detailed project plan; **2.** Escalation procedures; **3.** Circuit identification; **4.** Single points of failure; **5.** Network path diversity drawings into each PSAP; **6.** Network path diversity drawings into each non-PSAP site or structure housing any element or device that is part of the overall system; **7.** PSAP backroom as-built drawings; **8.** PSAP demarcation point drawings; and, **9.** All user interface training and reference materials. **Network As-Built Documentation** Upon implementation, Contractor shall provide a network or solution diagram that clearly depicts the Contractor's solution as implemented. The Contractor shall provide all documentation in agreed-upon electronic format via a Contractor-hosted web portal. Please describe how bidder's solution meets or exceeds this requirement.	X			
	Bidder Response: All pertinent Comtech NG911aaS documentation will be made available in Comtech's web portal, a repository for project-related deliverables, status and plans. Comtech will ask the Commission to identify the individuals who should have web portal access privileges and, once established, we will conduct an overview of portal access, usage, and common activities. Comtech will provide the above-referenced documentation no more than 30 days after ESInet construction is complete. As configurations change during the contract term, updated documentation will be posted to Comtech's web portal. As-built network / solution diagram(s) will also be posted to Comtech's web portal for the Commission's review and feedback.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 1	**Emergency Services IP Network (ESInet)** **Diversity** The network shall be designed with diverse entrances (e.g., east-west entrances) into specified buildings that are part of the ESInet. This requirement shall apply to the core network sites, including data centers and PSAPs specified in Attachment A - PSAP Host End-Point Locations, Equipment List and Selective Router Locations. Primary and redundant links shall not share common routes, trenches, or poles. If last-mile facility or building construction is required, bidder shall so indicate. If this is not possible at a given location, indicate how bidder intends to provide redundant and resilient connectivity to that location. Describe how bidder's solution meets or exceeds the above requirement.	X			

Bidder Response:

Comtech's proposed ESInet is a state-of-the-art, i3-compliant network, designed to maximize redundancy and reliability with a fully meshed network that uses available diverse routing. The core of Comtech's "Five Nines" ESInet solution is embodied in two diverse MPLS networks. Two separate MPLS providers will be deployed, and Comtech will ensure the existence of complete physical and logical path diversity between them. The resulting private WAN is isolated from the global Internet. This isolation is a key intentional component of Comtech's ESInet reliability since it removes exposure to Internet-based attacks. Where fiber is available, it is the preferred option. Wired circuits are preferred over wireless. All circuits will exhibit an Ethernet handoff, regardless of the native circuit signaling. Comtech's proposed design incorporates a composite set of connectivity services that meets the performance requirements called out in the RFP.

Comtech's ESInet solution consists of an MPLS mesh that connects multiple NGCS cores located in geographically separate facilities. This design utilizes diverse carriers and diverse paths for redundancy to provide service to all regions. Each PSAP has a highly available PSAP gateway solution that provides component-level redundancy for connecting to both ESInet MPLS WAN circuits. Devices at both the NGCS data centers and at the regions are deployed in a high availability configuration using various technologies. In the event of a device failure, dynamic routing protocols (i.e., BGP or OSPF) are used for route convergence. In addition, BFD is used to provide fast-forwarding path detection failure for all routing protocols.

Each Comtech NGCS core is comprised of a hybrid cloud-POP hardware solution. Each region will have diverse paths to multiple POPs. The two regional connections will be supplied by different providers, and data will traverse physically separate paths from the region to termination points at the POPs. Wherever possible, path diversity will start at the regional demarcation point. The circuits will utilize physically separate routing devices at each region, and traffic will be transitioned between the circuits and associated equipment utilizing open standard dynamic routing protocols. Comtech may also elect to perform its best-path selection via more advanced technologies such as a SD-WAN solution.

All data centers and regions are connected to the ESInet through two physically diverse and logically separate connections, thereby ensuring system resilience, reliability, and security. Comtech's design offers exceptional flexibility by leveraging diverse carriers, technologies, and network facilities in place today within Nebraska, as well as planned expansions and consolidations. Comtech has the subject matter expertise and disciplined processes to identify diverse routes between its sites and the ESInet POP.

Comtech Confidential Figure 14 depicts Comtech's ESInet MPLS Mesh.

Any additional documentation can be inserted here:

Figure 14. ESInet MPLS Mesh (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 2	**Emergency Services IP Network (ESInet)** **Network Design** Bidder shall design the physical network using the most robust facilities available. Use of fiber-optics is the preferred method for connectivity due to available capacity (bandwidth) and increased reliability. Given the amount of fiber-optic facilities and interconnections between the fiber-optic networks in Nebraska, the ESInet design should include as much fiber as possible, not only on the transport side but on the access side as well. Describe the design of proposed network with specific details on connectivity.	X			
	Bidder Response: Comtech understands and agrees with the utilization of fiber-optic communications, and we shall design the networks accordingly. Comtech's ESInet solution consists of an MPLS mesh that connects multiple NGCS cores located in geographically separate facilities. This design utilizes diverse carriers and diverse paths for redundancy to provide service to all regions. Each PSAP has a highly available PSAP gateway solution that provides component-level redundancy for connecting to both ESInet MPLS WAN circuits. Devices at both the NGCS data centers and at the regions are deployed in a high availability configuration using various technologies. In the event of a device failure, dynamic routing protocols (i.e., BGP or OSPF) are used for route convergence. In addition, BFD is used to provide fast-forwarding path detection failure for all routing protocols. Each NGCS core is comprised of a hybrid cloud-POP hardware solution. Each region will have diverse paths to multiple POPs. The two regional connections will be supplied by different providers, and data will traverse physically separate paths from the region to termination points at the POPs. Wherever possible, path diversity will start at the regional demarcation point. The circuits will utilize physically separate routing devices at each region, and traffic will be transitioned between the circuits and associated equipment utilizing open standard dynamic routing protocols. Comtech may also elect to perform its best-path selection via more advanced technologies such as a SD-WAN solution. All data centers and regions are connected to the ESInet through two physically diverse and logically separate connections, thereby ensuring system resilience, reliability, and security. Comtech's design offers exceptional flexibility by leveraging diverse carriers, technologies, and network facilities in place today within Nebraska, as well as planned expansions and consolidations. Comtech has the subject matter expertise and disciplined processes to identify diverse routes between its sites and the ESInet POP.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 3	**Emergency Services IP Network (ESInet)** **No Single Points of Failure** The mission-critical ESInet shall be designed with no single points of failure. All equipment shall include redundant processors and power supplies and be supported by an uninterruptible power supply (UPS) system and alternate power source in a properly conditioned environment. Describe how the solution meets or exceeds the above requirement.	X			
	Bidder Response: Comtech's experience in providing highly available and resilient statewide NGCS and ESInet services includes the deployment of redundant applications and equipment, with the physical diversity of network paths included—wherever possible—at PSAPs and at redundant and geographically separated NGCS data center cores. System availability is maintained by having a level of redundancy that eliminates single points of failure throughout the NG911 system, as well as keeping a certain number of spare devices handy to replace any faulty components along the call path. In case of manufacturer defects, Comtech works with critical manufacturers to implement mitigation steps (workarounds) while manufacturers identify a corrective patch or upgraded version of the component. These corrective actions are always implemented using Comtech's robust change management process. Comtech's NG911aaS provides high availability, no single point of failure, and 99.999 percent reliability. Comtech NGCS are deployed in three distinct geographical locations with redundant Internet Service Provider (ISP) links. Comtech's ESInet service utilizes diverse carriers and diverse paths for redundancy to provide service to all PSAPs. Devices at both the NGCS data centers and at the PSAPs are deployed in a high availability configuration using various technologies. In the event of a device failure, dynamic routing protocols (i.e., BGP or OSPF) are used for route convergence. In addition, BFD is used to provide fast-forwarding path detection failure for all routing protocols. All systems are deployed with multiple power supplies that are fed through separate UPS and generator backup circuits. In addition, all communications paths to the systems are redundant within the system with separate paths back to separate network connections. Cloud-based components are operated in separate regions, and in separate availability zones within each region, to ensure the uptime of those components. Network paths from the data center to the cloud provider includes servers with at least two direct-connect paths to the cloud infrastructure per data center. Comtech will provide a thorough engineering analysis of the finalized NGCS and ESInet design. Network availability details of specific routes, end-points, and selected systems are all part of the final design approval process. The final Comtech NG911 system implementation plan will involve performing a thorough engineering analysis, plus documentation and the calculation of NGCS and ESInet network availability.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 4	**Emergency Services IP Network (ESInet)** **IPv4 and IPv6 Support** All network equipment shall be new and of current manufacture at the time of implementation. All servers, systems, routers, switches, and other network equipment shall support IPv4 and IpPv6 and have the capability to run dual protocol stacks. Describe how the solution meets or exceeds the above requirement.	X			
	Bidder Response: The IP network infrastructure to be deployed will consist of new and current manufactured goods, capable of both Internet Protocol version 4 (IPv4) and Internet Protocol version 6 (IPv6) support (i.e., dual protocol stacks). Underlying core IP network transport is of carrier-grade/class. All servers, system, routers, switches, and other equipment will be new and of current manufactured goods, and will support IPv4and IPv6. Support for dual-stack protocols will be included on the network hardware. IP addressing schemes will be developed and distributed as part of the ESInet design phase.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 5	**Emergency Services IP Network (ESInet)** **Open Standards** Open standards-based protocols shall be used, and the use of proprietary routing protocols is prohibited. **Resiliency** Resiliency, or fast failover, may be achieved through the use of the Bidirectional Forwarding Detection (BFD) protocol as defined in IETF Request for Comments (RFC) 5880 and RFC 5881, or other standards-based, non-proprietary methods. Describe how the bidder's solution will achieve resiliency.	X			
	Bidder Response: The networking infrastructure supports BFD protocol, including *RFC 5880* (echo and demand mode not supported) and *RFC 5881* (fully compliant). BFD will detect failures for fast failover in the proposed network, ensuring resiliency and operational efficacy when one of the dual paths becomes impaired. Comtech will utilize BFD with BGP and/or OSPF from both the call-handling equipment to the Comtech core, and on the Comtech MPLS network. Comtech currently deploys BFD to achieve sub-second convergence. Upon contract award, Comtech will provide deployment details as part of its network engineering documentation effort.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 6	**Emergency Services IP Network (ESInet)** **Multicast Routing and Switching** Routers and switches must support multicast routing and switching. The applicable base protocols are Internet Group Management Protocol (IGMP) and Protocol Independent Multicast (PIM). Describe how the solution meets or exceeds the above requirement.	X			
	Bidder Response: The underlying Cisco Networks equipment (routers/switches) provides multicast support that includes Internet Group Management Protocol (IGMP) and Protocol Independent Multicast (PIM) protocols, among other available protocols.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 7	**Emergency Services IP Network (ESInet)** **Quality of Service (QoS)** The network equipment shall support Quality of Service (QoS) marking for prioritizing traffic in the network using the Differentiated Services Code Point (DSCP) protocol. While the network can change DSCP values through rules, the values typically are set by the system or functional element that originates the traffic. Network routers and switches shall not be configured in such a manner as to change DSCP values set by originating functional elements. Describe how the solution meets or exceeds the above requirement.	X			

Bidder Response:

Comtech's end-to-end QoS strategy leverages modular QoS to properly identify and classify traffic types, to apply or reapply Differentiated Services Code Points (DSCP) markings, and to prioritize traffic flows by applying policing and shaping policies as well as determining low-latency or class-based weighted fair queuing for each traffic classification.

When entering the network, traffic is analyzed as close to the source as possible, and traffic types are classified and marked or re-marked with the appropriate DSCP values. Traffic identification is performed by DSCP, ACLs, Network-Based Application Recognition (NBAR), or a combination of these parameters.

DSCP markings and adequate bandwidth is preserved as traffic traverses the Local Area Network (LAN). At the network's edge, egress traffic destined for the ESInet is re-marked as needed and assigned guaranteed bandwidth—or a percentage of total bandwidth—as required by each traffic class. Media traffic utilizing RTP is put into a priority queue and marked with an Expedited Forwarding (EF) DSCP tag. The bandwidth for RTP is guaranteed, and low-latency queuing is applied. Signaling, which matches the SIP protocol, is also placed in its own class of service and allocated a percentage of bandwidth to ensure SIP packets are prioritized during periods of network congestion. Classes are also defined for mission-critical traffic, which includes mapping and location services, control and routing protocol traffic, and other applications that are vital to call path and related NG911 functionality. A default class is defined for all traffic that is to be treated as 'Best Effort' (BE).

Comtech's QoS model is built on a Differentiated Services (DiffServ) Architecture *(RFC 2475)* to control per-hop behavior (PHB) at each network node to provide end-to-end QoS. Comtech's design utilizes EF PHBs, Assured Forwarding PHBs, and Default PHBs. Class-selector PHBs are configured, as required, to achieve backwards compatibility when interfacing with older systems.

Comtech's solution is fully compliant with this RFP's QoS marking requirements. QoS markings will be based upon the NENA i3 solution, as outlined in Table 3.

The Comtech team will work in close partnership with the Commission to develop an approved final network design that includes all necessary QoS settings.

Any additional documentation can be inserted here:

Table 3. QoS Markings

DSCP	Use	PHB
1	Routine Traffic	Default
5	911 Signaling	AF12
9	911 Text Media	AF12

13	911 Audio Media	EF
17	911 Video Media	AF11
21	911 Non-human-initiated Call	AF21
25	Intra ESInet Events	AF21
29	Intra ESInet Other 911 Traffic	AF22

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 8	**Emergency Services IP Network (ESInet)** **ESInet Properties** The proposed ESInet shall be private, robust, scalable, secure, diverse, redundant, sustainable, and self-healing. Bidder shall propose a network solution for all host sites listed in Attachment A - PSAP Host End-Point Locations and any future identified regions throughout the term of the contract. Describe how the proposed system meets each of these individual requirements.	X			
	Bidder Response: Comtech's ESInet solution is based entirely on private circuits. The ESInet includes redundant sites and network circuits to provide services to each location. The network is robust and redundant due to the use of diverse MPLS providers, circuits, and sites. All ESInet connections are routed using dynamic routing protocols that ensure the network self-heals around any circuit or site outage. Use of dynamic routing and redundant links also allows Comtech to migrate traffic to new circuits as they are provisioned, permitting the ESInet to be sustained through circuit and site evolutions over time. All traffic within the ESInet is encapsulated in IPsec tunnels to ensure data security and integrity even from the participating MPLS providers. Selection of diverse circuits to each site includes the selection of physically diverse network paths as well as physically diverse circuit entry points into each site's termination facility. *Comtech Confidential Figure 15* depicts Comtech's ESInet MPLS Mesh.				

Any additional documentation can be inserted here:

Figure 15. ESInet MPLS Mesh (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
	Emergency Services IP Network (ESInet) **Special Construction** Bidder is responsible for any fees incurred through system commissioning, construction permits, make-ready costs, and other subcontracted activity. **Use of Existing Network Assets** There is already a microwave network in place that may be used as a backup network, as well as other local and state-owned network assets that may be suitable for inclusion in the ESInet. The final network design may make use of any of these facilities that are determined by the bidder to be suitable for inclusion in the ESInet. The bidder may support the router configuration necessary to make use of these facilities. **Network Design Documentation** Provide a network or solution diagram that clearly depicts the bidder's proposed transitional and end-state designs for the ESInet.	X			
ESI 9	Bidder Response: Comtech's price proposal includes fees associated with the design, build out, and operation of the ESInet. Comtech welcomes the Commission's input on potential secondary and tertiary network options for augmenting the ESInet. The ESInet architecture includes support for multiple paths and QoS prioritization of traffic during failback to secondary and tertiary paths. Comtech's ESInet solution has successfully operated PSAP sites via satellite, LTE modem, and IPsec VPN over the public Internet via cable modem during various events that required non-traditional connectivity, such as building closures due to fire or renovation, and the operation of mobile PSAP equipment in the field during special events and emergencies. *Comtech Confidential Figure 16 depicts the beginning of transition, with Comtech's Aggregation service interconnected to Nebraska selective routers and Comtech's NGCS service connected to at least one Nebraska region. In this state, all calls from the selective routers are destined for the ESInet-connected region, while all other 911 calls continue to connect from the selective routers to the non-ESInet PSAPs/regions.* *Comtech Confidential Figure 17 depicts the full transition. All Nebraska regions are connected to the ESInet, all OSPs are directly connected to Comtech Aggregation services, and selective routers are no longer used to deliver 911 calls.*				

Any additional documentation can be inserted here:

Figure 16. Comtech's Proposed Transitional ESInet Design (Comtech Confidential)

Figure 17. Comtech's Proposed End-State ESInet Design (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 10	**Emergency Services IP Network (ESInet)** **Provide Network to Network Interface with Other IP Networks** Contractor shall provide an ESInet solution capable of interfacing with neighboring state and regional NG911 IP networks as they are established, and capable of transferring voice and data between PSAPs. Describe how the solution will meet these requirements.	X			
	Bidder Response: Comtech's i3-compliant ESInet is fully capable of interconnecting with other external i3-compliant ESInets. Comtech will work with the Commission and surrounding states to establish mutual interconnection agreements with adjoining ESInet entities in support of emerging requirements. Comtech will work to obtain coverage data for adjoining ECRF/LVF systems to establish connectivity between them. Nebraska coverage data can be provided to any surrounding state that wishes to operate in the same Location-to-Service Translation (LoST) tree as the Nebraska system. Comtech will support a transition to a National Forest Guide, should one become available during the contract period. Call transfers between adjoining ESInets are of interest to regions and PSAPs along the Nebraska border. These transfers will require established paths and agreement on fully qualified URIs. Comtech's ESInet service supports call transfers between Nebraska's PSAPs and legacy/NG911 PSAPs that are connected to an external NG911 ESInet. Call transfer mechanisms are triggered by a PSAP's specific CHE. This trigger may be a 10-digit number, a directed SIP URI, a SIP REFER URI, a star (*) code, or some other PSAP equipment mechanism, depending on whether the call-handling system is legacy E911 or NG911. We recommend that the Commission should contract Comtech to deliver IP voice circuits to the adjoining ESInet core. Alternatively, the Commission can collaborate with the adjoining state(s) to provide circuits. In addition, the external ESInet must have conference-aware user agents. In the absence of these configuration items, calls can be transferred over PSTN, but no location can be provided. If a call is being transferred between two NG911 PSAPs, several pieces of data could be transferred to the receiving PSAP, including: • Caller's Number • NG Location • NENA Call ID • NENA Incident ID • Initiating PSAP's identity				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
ESI 11	**Emergency Services IP Network (ESInet)** **Provide Network to Network Interface with Other IP Networks** **Connecting to Other IP Networks** At such time as neighboring ESInets and NGCS systems are able to interconnect and exchange traffic, Contractor shall establish such connections and provide routing and security to allow traffic to be exchanged with neighboring ESInets and NGCS systems, regardless of the respective vendors of those systems. Describe how the solution meets or exceeds the above requirement.	X			
	Bidder Response: Comtech's NG911aaS is fully IP-based, and it is deployed with networks based upon open standards protocol. The proposed service follows NENA i3 and has lab-proven capabilities to interconnect to ESInets at state and regional levels. Based upon Comtech experience no state level customer with NG911 capabilities has invested in the circuit infrastructure to interconnect to a neighboring state. Comtech will ensure secure interoperability between surrounding entities and the Nebraska NG911 system.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 1	**Next Generation Core Services Elements (NGCS)** Provide a network or solution diagram that clearly depicts the bidder's proposed transitional and end state for the Commission's ESInet and NGCS, taking into account the hosts and PSAPs listed in Attachment A - PSAP Host End-Point Locations. The following functional elements and services be included: a. Originating Service Provider (OSP) Connectivity; b. Legacy Network Gateway (LNG); c. Border Control Function (BCF); d. Emergency Services Routing Proxy (ESRP); e. Policy Routing Function (PRF); f. Emergency Call Routing Function (ECRF); g. Location Validation Function (LVF); h. Spatial Interface (SI); i. Location Database (LDB); j. Discrepancy Reporting; k. Logging and Recording; l. Time Server; m. Alarm Integration; and, n Message Session Relay Protocol (MSRP). **Originating Service Provider (OSP) Connectivity** **Due Authorization** Bidder shall possess a certificate of public necessity to operate as a telecommunications provider in the state of Nebraska. The Contractor shall provide a copy of current certificate of public necessity prior to award of contract. **Identification of Service Providers Connected to the Legacy Selective Router** Contractor shall be responsible for identifying and for connecting all wireline, wireless, Voice over IP (VoIP), telematics, and other third-party service providers currently connected to the existing legacy selective router. Contractor shall be responsible for updating this information quarterly for the term of the contract. Bidder shall identify each service provider that will be utilized by Contractor..	X			
	Bidder Response: Comtech's solution uses a NENA i3-compliant design to provide 911 services ingress and delivery that is geospatially routed to Nebraska's regional hosts and its PSAPs, delivered over a private and secure ESInet. *Comtech Confidential Figure 18* shows the system architecture of Comtech's NG911 ESInet and NGCS solutions while depicting specific NENA system components. *Comtech Confidential Figure 18* illustrates the routing of a specific call through the NGCS and the ESInet for delivery to a NG911, legacy, or hosted region. Call origination from the carriers **(1)**, the Text Control Centers (TCCs) **(4)**, through the legacy selective routers **(2)** (during transition) is shown in the low numbers on the left side of the diagram. Regardless of their source, all calls will ingress the Aggregator **(3)** and proceed to the NGCS through the BCF **(5)**, which serves as a security boundary for both voice and data. From the BCF, all calls are passed to i3-compliant web services **(6)**/**(7)**, which				

	invoke NENA functional elements designed to determine a caller's location **(8)**/**(9)**/**(10)**/**(11)** and then geospatially route the call based upon the caller's location **(12)** and Nebraska's call-routing policies **(13)**. Once routed, calls are delivered **(14)** over the ESInet to the target Regional gateway (NG911 or Legacy) **(15)**/**(16),** for call presentation to the PSAPs. **Discrepancy Reporting** Comtech uses a discrepancy process to notify PSAPs of invalid results while allowing new data to upload, performing re-validation until the data meets acceptable criteria as agreed upon with the Commission. **Discrepancy Process** Unlike legacy systems, civic addresses in NG911 are pre-validated against the LVF. If a civic address submitted by a service provider fails LVF validation, a discrepancy is created in the LDB and a workflow is initiated to resolve this issue. LVF validation can fail for one of three reasons: a. The address submitted by the service provider is invalid. b. The address was incorrectly translated into the NG911 format by the MSAG Conversion Service (MCS). c. The address is missing from the GIS data (i.e., it is not in the LVF). When a record fails LVF validation, it is initially assigned to either the service provider that owns the record (based upon the telephone number [TN]), or to the GIS user(s) responsible for the authoritative GIS data. Users are expected to review the reasons for LVF validation failure and either make a fix to the data or reassign the discrepancy to another group. **Logging and Recording** Comtech's i3 logger collects call events from all i3 functional elements in the NG911 system. These events include an HTTP-Enabled Location Delivery (HELD) queries and responses, LoST queries and responses, and routing decisions. All i3 logger information is retained in redundant cloud-based enclaves and can be queried through an i3 logger web interface by the legacy call-handling system (if capable) for the legacy call detail record (CDR). Access to the legacy system's CDR is unique to each legacy PSAP system. If the legacy system is capable, Comtech will offer to build an interface to ingest legacy CDRs from legacy PSAP systems. **Time Servers** Comtech deploys two physical Stratum 1 time servers into each point of the POP locations, which act as the central time resources for all systems operating in the NGCS and on the ESInet. **Alarm Integration** Comtech supports the transport of Automated Secure Alarm Protocol (ASAP) over the ESInet to a PSAP's Computer Aided Dispatch (CAD) system. To ensure the security of the NGCS system, Comtech will require an optional security boundary and security audit of the PSAP before allowing ASAP to transit the ESInet to a PSAP's CAD. At this time, Comtech has not had a customer's PSAP implement ASAP. Comtech is fully confident that the ASAP protocol, since it is based upon IP, will easily transit the ESInet to PSAPs. **Originating Service Provider (OSP) Connectivity Due Authorization** Comtech understands this requirement and will provide a copy of current certificate of public necessity prior to award of contract. **Identification of Service Providers Connected to the Legacy Selective Router**

	Comtech understands this requirement and will identify and connect all wireline, wireless, VoIP, telematics, and other third-party service providers currently connected to the existing legacy selective router. Comtech will update this information quarterly over the term of the contract, or until all such connections to the legacy selective router have been terminated. Comtech will identify all service providers utilized.

Any additional documentation can be inserted here

Figure 18. Comtech's Proposed NG911 System (Comtech Confidential)

NGCS 2	**Next Generation Core Services Elements (NGCS)** **Interconnection and Commercial Agreements, and Trunking** **Originating Service Provider (OSP) Connectivity** Contractor shall be responsible for negotiating interconnection or commercial agreements, and for data and network connection arrangements with each service provider identified in requirement NGCS 1. Interconnection or commercial agreements shall cover subjects including, but not limited to, split rate centers and cell sectors, tandem-to-tandem connections to legacy selective routers and NGCS, Local Number Portability (LNP), National Number Portability (NNP), and Function of Code R (FoCR). Describe the process and provide timelines for meeting the requirements of this section, as well as the expected process for resolution of disputes.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: Comtech understands this requirement and will be responsible for negotiating agreements with every identified service provider. The process will include the following: • Provisioning each POI with the gateway functionality necessary to convert incoming 911 traffic, delivered as negotiated with each OSP, to the NENA i3-conforming SIP. • Routing SIP traffic to the geo-redundant NGCS locations. • Providing bi-directional transfer capabilities with legacy selective routers, as required, during the transition period. • Negotiating Interconnection Agreements (ICAs) including, but not limited to, split rate centers and cell sectors, tandem-to-tandem connections to legacy selective routers and NGCS, Local Number Portability (LNP), National Number Portability (NNP), and Function of Code R (FoCR). • Serving as the point of contact accepting responsibility for day-to-day coordination with the carriers, which includes circuit orders and tracking, issuance of Letters of Agency (LOAs), order issues resolution, and the "facilities" testing of T1s, DS0s and so on, during the interconnection on-boarding process. This process will commence upon contract award and is expected to finish within 12 months.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 3	**Next Generation Core Services Elements (NGCS)** **Originating Service Provider (OSP) Connectivity** **Management of OSP Connectivity** Contractor shall be responsible for managing moves, adds, changes, and deletions of the connections from the OSPs to the Contractor's systems for the term of the contract. Contractor shall allow for both Time-Division Multiplexing (TDM) and IP ingress to the network, proactively monitor these connections, and work with the respective service providers to resolve problems as they arise. Describe the process and provide timelines for meeting these requirements.	X			
	Bidder Response: Comtech understands this requirement and will be responsible for managing connections from the OSPs to the Comtech NG911 system for the term of the contract. Comtech will manage and coordinate with the carriers and the Commission for the test and turn-up of the ingress network prior to each instance where live traffic is re-routed for the first time. Comtech will manage and monitor any changes to the carriers' initial configurations, such as the deployment and decommissioning of switches, added network capacity, or configuration changes, as required. The system will allow both Time-Division Multiplexing (TDM) and IP traffic ingress. This process will commence upon contract award and is planned to be completed within 12 months.				

Any additional documentation can be inserted here

NGCS 4	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **LNG Description** The LNG is a signaling and media interconnection point between callers in legacy call-originating networks, i.e., Enhanced 911 (E911), and the NENA NG911 i3 architecture. The LNG shall log all calls it receives and processes and shall permit the uploading of daily log files to a network monitoring and management system for analysis. The LNG shall allow for ad hoc uploads of log files for troubleshooting and incident response. All call activity on both the legacy side (TDM) and the IP side of the LNG shall be logged. The LNG shall have Intrusion Detection System (IDS)/ Intrusion Prevention System (IPS) functionality to detect and mitigate Distributed Denial of Services (DDoS) attacks from both the TDM side and the IP side. Describe how the solution meets or exceeds the above requirements.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: The Comtech NGCS service includes a complete LNG functional element provided by the Aggregation service. This Aggregation service includes the comprehensive logging of both Signaling System 7 (SS7) messaging and SIP messaging to fully document all call-control activities. These logs are integrated into the NENA i3 Logging Service, where supported by the NENA standards. Logs are delivered continuously to both the NENA i3 Logging Service and to troubleshooting and data analytics tools. Daily and ad-hoc delivery can both be performed as desired to support the Commission's requirements. OSPs that are IP-connected can be redirected or otherwise load-balanced for those connections between the switching center SBC and the POP BCF by using BGP and load-balancing mechanisms deployed at the POPs. Connectivity between the SBCs and BCFs, while IP-based, is provided by private circuits that eliminate exposure to IP-based DDoS attacks from the global Internet. The security boundary at the edge of the private circuits includes state-of-the-art NGFWs, which include denial of service detection and protection at each site. Each LNG site uses Ribbon (formerly Sonus) GSX appliances that include state-of-the-art, carrier-grade intrusion detection on the TDM and SIP sides of the LNG. Mitigating the impact of Telephony Denial of Service (TDoS) incidents presents unique challenges in the space of emergency call services. There are currently no standardized TDoS mitigation mechanisms that can guarantee the successful identification and delivery of all legitimate 911 calls while filtering out illegitimate calls. The implementation of STIR/SHAKEN by carriers as mandated by the TRACED Act is underway. Comtech is continually monitoring developments in the TDoS mitigation space and expects the deployment of STIR/SHAKEN to be a significant factor. Comtech will work with the Commission to implement mutually agreeable mitigation techniques as they become available. Customers have engaged with Comtech to explore TDoS mitigation techniques such as rate-limiting and other threshold-value-based methods. Potential mitigation strategies include options such as: • Automatic Number Identification (ANI) Management – (wholesale trunks) If 2500 calls with the same ANI are detected per hour and the average call duration is 12s or less, it will be blacklisted. Any further attempts will be 503'd for 30 days unless a manual removal is requested and approved. • Randomizer – Internal analytics identify suspected fraudulent originating numbers based upon high-volume originating caller ID thresholds. Calls are redirected to an intercept message that requires the caller to enter a specific two-digit number to proceed, or else the call is terminated. • Invalid Number Plan Area (NPA) Blocking – An ANI lookup is used to determine if an originating NPA is valid; if invalid, the call is rejected (but with exceptions for government numbers and international calls).				

	• ANI Blocking – Comtech complies with all Do Not Originate requests from U.S. telecom and will also block vetted and confirmed fraudulent calling numbers on a case-by-case basis (calling numbers of Internal Revenue Service [IRS], Department of Homeland Security [DHS], etc.). • Automatic Call Gapping – The Service Control Point can indicate that a called number is in a congestion state for a specific time frame. During this time frame, any new attempts to this called number are rejected. It is not possible to identify a value that will eliminate all false positives that are intrinsic to such techniques. Customers therefore typically elect not to implement these mitigations rather than risk the possibility of dropping a legitimate 911 call.

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 5	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** Contractor shall provide redundant, resilient LNGs with legacy selective router gateway (LSRG) functionality to allow the legacy selective routers to transfer calls with Automatic Number Identification (ANI) and Automatic Location Identification (ALI) information to deployed NGCS and vice versa. Legacy functionality and components shall be in place and operational during the NG911 transitional phase until all 911 authorities and PSAPs served by the legacy selective router have completed the transition. Describe the steps bidder will take to meet the transition timelines and minimize overlapping network costs.	X			
	Bidder Response: The Comtech solution includes a combination LNG and 911 Aggregation service to address transitional elements from selective routers and E911 PSAPs to NGCS/ESInet/NG911 PSAPs. As a transitional element, Comtech will provide an LNG service for as long as the state of Nebraska requires the ingress of traditional telephony 911 calls. Comtech's goal is to transition as quickly as possible, reducing Nebraska's traditional selective router and database costs. At the beginning of the program, Comtech's standard implementation plan for aggregation services will establish LNG services (formerly LSRG) to the selective routers in Nebraska. These connections are transitional. The LNG service will only be required in the interim as PSAPs are converted to the Comtech NGCS/ESInet services. Additionally, these LNG services are required as OSPs move 911 trunks from the selective router to direct legacy TDM connections to Comtech's Aggregation service. For the OSPs, LNG services are also transitional and will be discontinued as OSPs convert Integrated Services Digital Network (ISDN)/ SS7 911 transmission to SIP/RTP transmission. Comtech's Aggregation service's LNG provides a bi-directional bridge between existing 911 call OSPs/selective routers and NGCS/ESInet, using SS7/ISDN-to-SIP/RTP conversion. Comtech's aggregation services are outside the ESInet, utilize POIs, switching centers, enter the NGCS at the BCF, to enable the proper routing of 911 calls from OSPs to PSAPs, based upon ECRF (could be converted ALI) and Nebraska ESRP/PRF overrides. It is understood that all PSAPs may not be immediately ready for geospatial routing and will require some transition time. Comtech will work with the Commission to prioritize those PSAPs and regions that are ready to migrate away from the selective routers.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 6	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Previous Work on Similar Solutions** 1. Explain how bidder has worked with legacy OSPs with similar solutions on similar projects. 2. Submit specific plans for working with established legacy 911 service providers in Nebraska.	X			
	Bidder Response: Comtech will ask the Commission to designate Comtech as the 911 service provider for the state; upon this designation, Comtech will initiate and enter into ICAs with the various service providers. This will allow and require the OSPs to support the transition from legacy 911 to the NGCS. Our most successful transition, in circumstances similar to this, occurred in the Commonwealth of Massachusetts, where Comtech and Verizon coordinated and supported the transition that converted more than 250 PSAPs, typically cutting over five or six PSAPs per week.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 7	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Traffic Engineering Process** Describe the process that will be utilized to analyze the current trunk engineering for 911 traffic, and to validate any applicable trunk rebalancing for public-safety grade service.	X			
	Bidder Response: Comtech's Aggregation, NGCS, and ESInet services exceed the capacity currently required, or at 150 percent of current usage, as well as multiple redundant interconnect points. Through the process of signing an ICA, encourage OSPs to provide significant and redundant trunking to the Aggregation service. While these OSPs may choose to follow Comtech's recommendations, or not, they are nonetheless required under FCC regulations to provide appropriate trunking, capacity and redundancy. Comtech will ensure the Commission fully understands the capacities and location of OSP interconnections. Comtech logs call volume and trunk utilization by the OSPs. Comtech will also ensure the Commission is notified when trunk capacity reaches 70 percent utilization and will make recommendations to OSPs on their applicable trunk rebalancing for public-safety grade service.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 8	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Location Information** The LNG shall obtain location information to define, create, populate and send the correct Presence Information Data Format Location Object (PIDF-LO) parameter to the correct ESRP or terminating PSAP, as described within NENA-STA-010.2-2016. Describe how the solution meets or exceeds the above requirements.	X			

Bidder Response:

Comtech is at the forefront of the migration from legacy E911 to NG911, implementing many of the most complex and largest end-to-end NENA i3 projects awarded to date. We have met the challenges of integrating legacy elements with transitional ones, with NG911, and with high-quality components to optimize what is available in the market today, to include multiple transitional call-handling solutions. We fully understand the complexities of migrating carrier connections to achieve non-service-affecting cutovers and improved situational awareness. A key to Comtech's execution of the transition and migration period from legacy E911 is the correct use of location services between carriers, service providers, and the state of Nebraska.

A Location Information Server (LIS) is the responsibility of the OSP. However, in Comtech's experience, the OSPs are not yet ready to provide a LIS. Comtech implements a NENA-compliant transitional LDB to provide the same service within the NGCS, which allows OSPs to process Service Order Input (SOI) records directly within the NGCS.

To successfully replace a legacy ALI system with an LDB, a mechanism is provided whereby the service providers can update location information in the LDB. During the transition to NG911, and to aid 911 authorities in receiving cooperation from the service providers, this LDB system includes a SOI processing function that is similar to existing SOI processing. This means that service providers need not change their existing processes to support the i3 system. A translation mechanism is provided to convert SOI records into the appropriate Civic Location Data Exchange Format (CLDXF) format for comparison against the LVF, and for subsequent use in PIDF-LO documents for call delivery to the Comtech NGCS for call routing and presentation. Service providers can submit their SOI files for processing via a secure agreed-upon method.

The LDB fully supports private switch ALI (PSALI) records. Each PSALI customer is added to the LDB as a service provider, and each requires its own unique NENA Identification (ID). PSALI customers can maintain their records using legacy SOI files, or by using the LDB Manager website directly. Blocking ranges can be employed to limit the scope of TNs where a PSALI customer can create a record. All records added by PSALI customers will be in the CLDXF format (they will be translated to CLDXF format if provisioned using legacy SOI processes), and LVF validation will be performed.

All calls presented by the aggregator LNG will include PIDF-LO, either by reference or by value, in the SIP headers. PIDF-LO data is available to any ESRP or CHE that processes the call, and it is fully compliant with all *NENA STA-10.2-2016* call-processing standards.

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 10	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Protocol Conversion** **External Interfaces** The LNG external interfaces shall comply with NENA-STA-010.2-2016, requirements SLA 1-23, and other applicable standards and requirements. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech is at the forefront of deploying and operating NENA-compliant LNG interfaces with all OSPs. Comtech's prior experience in operating LNGs at the state and county levels has been successful due to our embrace of standards-compliant solutions that maximize interoperability. The LNG interface implements *NENA-STA-010.2-2016* Location Interwork Function (LIF), NG911 Specific Interwork Function (NIF), and Protocol Interworking Function (PIF) interfaces. In the Commonwealth of Massachusetts NG911 system, Comtech's LNG services have completely replaced the legacy selective routers and has convinced forward-leading OSPs to convert from legacy Telcordia interfaces to SIP/RTP protocols over IP interfaces to deliver 911 payloads. Furthermore, Comtech is currently undergoing a testing regimen with two cellular OSPs to deliver i3-compliant 911 payloads with geocoding for interaction with new LIS services being provided by these OSPs. Comtech participates in industry working groups and conferences, allowing us to be up to date on the evolution of standards and requirements, as well as providing feedback from our experience in implementing large-scale NG911 systems. This cooperative effort helps these bodies improve the standards and guidance for the industry as a whole.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 11	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Baudot Code Transcoding** The bidder's BCF solution shall support transcoding of Baudot tones to real-time text (RTT), as described in IETF RFC 4103. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's BCF solution is capable of RTT/Baudot transcoding. At this time, Comtech has not interfaced with a PSAP that operates equipment capable of supporting RTT, nor one with an actual RTT service, so Comtech has no operational experience in this regard. When a Nebraska PSAP shows the capability of accepting RTT, Comtech's service will be able to translate back and forth with all the non-RTT PSAPs				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 12	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Callback Number** The LNG shall support obtaining the callback number associated with any pseudo ANI data that does not include the callback number. This may require the Contractor to obtain the callback number from the wireless or VoIP provider and may include additional recurring and non-recurring costs that are independent of this RFP. The Contractor shall be responsible for all recurring and non-recurring costs associated with this requirement. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: When a person dials 911 from a wireless device, such as a mobile phone, the call is delivered to the Comtech aggregator LNG. The LNG can interface with the LDB and its Emergency Services Message Engine (ESME) service, which is configured with redundant connections to Mobile Positioning Center (MPCs)/VoIP Positioning Centers (VPCs) to obtain the callback number associated with the pseudo ANI (pANI). The LNG constructs a HELD query, and sends it to the LDB. Based upon information in the HELD query to the LDB, which has its ESME service, it constructs an E2 query to request information from the MPC/VPC. The E2 response will contain the CBN among other details, such as location. The LDB must be properly provisioned with pANI steering data. This steering data includes pANI information relevant to the OSP. This steering data is configured by using the LDB Manager web interface. This element therefore meets the Commission's requirement. Comtech understands it is responsible for E2 services as part of the NGCS service.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 13	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Event Logging** The LNG shall facilitate logging of all significant events and 911 calls received and processed. Each call log shall contain all relevant parameters defined in Section 5.13.3 of NENA-STA-010.2-2016. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's LNG solution complies with i3 logging as specified in *NENA STA-010.2-2016*.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 14	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Extraction of Log Files** All LNG log files shall be capable of being extracted in near real-time and shall be in a format suitable for importing into a spreadsheet or word-processing program. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's LNG solution logs are included in our centralized log processing system. This centralized log system includes the ability to export data in near-real-time in a .CSV text format, which is suitable for usage in spreadsheets, word processing, and other customizable analysis tools. The Comtech LNG also logs all events in real-time to the i3 logger. This logger provides an interface to generate reports and to export information to Microsoft Word or Excel. LNG CDRs are generated at the completion of each call and are available on a per-call basis.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 15	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **High-Availability Design** The LNG solution shall be deployed in a high-availability design to meet public safety-grade resiliency and redundancy requirements, Section V.D.1.b. (General Requirements – Technical – Public Safety Grade). Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: For each component in the NGCS service, Comtech selects the best option that meets the technical requirements and integration capabilities for the designed solution. In general terms, the equipment has more than 200,000 hours of MTBF. This MTBF rate, coupled with the redundancy of the design, allows the solution to be highly resistant to failures. At a minimum, at least one physical device of each functional element must be available to maintain services. All physical equipment in the critical path are deployed and maintained in at least N+1 redundancy. These physical data centers are fully redundant, and each contains at least N+1 redundancy for all physical equipment involved in providing services. In addition to selecting quality components with a high MTBF, Comtech uses a "spares and repair" strategy that minimizes MTTR. Critical spares are stored locally onsite or in strategically located depots to optimize repair time of critical components. The inherent redundancy of the design architecture—redundant components at each site in combination with fully redundant sites—combined with the MTBF and MTTR of critical components ensures that the Comtech NGCS service has both a reliability and availability of 99.999 percent per year.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 16	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Legacy Selective Router Gateway (LSRG) Functionality** The LSRG functionality shall support selective transfer, commonly referred to as "star code" transfers, made by legacy PSAPs for calls destined for the NextGen911 PSAPs or to neighboring legacy PSAPs outside of the ESInet. Describe how bidder's LNG solution provides for LSRG functionality.	X			
	Bidder Response: The Comtech LNG solution allows for dialing through to the legacy network (via LNG and LSRG functional elements) to reach PSAPs not included on the ESInet, as well as ESInet-to-ESInet connectivity for neighboring jurisdictions. Outbound dialing requests may be formatted as seven-digit numbers, 10-digit numbers, star codes, or pound codes. Comtech will work with the Commission to ensure that all necessary outside agencies may be reached efficiently. All outbound dialing and/or conference requests include the ANI within the dial, so that the receiving PSAP can retrieve ALI. To provide full location functionality on a call being transferred outside the ESInet, connectivity to the LSRGs is required. Given the cost of maintaining multiple inter-tandem trunks, most jurisdictions opt for transfers to take place through a traditional digital telephone line, an ISDN primary rate interface (PRI) line, or directly to the transferred-to PSAP. The decision to use a PRI line is typically made, with the expectation that surrounding regions are also on the path to NG911, which will eventually enable direct IP-to-IP communication and avoid the high cost of inter-tandem trunks.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 17	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Proposed LNG Locations** Provide the proposed locations for hosting the primary LNGs for the NextGen911 system, including the data center tier level for the host sites.	X			
	Bidder Response: The following proposed LNG locations are *Comtech Confidential.*				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 18	**Next Generation Core Services Elements (NGCS)** **Legacy Network Gateway (LNG)** **Charges for Dual Service** The bidder shall be responsible for meeting the timelines outlined above in requirement NGCS 2 and 3. If the transition from the legacy selective routers to NGCS exceeds the committed timeline, and is attributable to the acts or omissions of the Contractor, the Contractor will accept responsibility for financial support of the legacy network until such time as the full transition is complete. Describe how bidder's solution meets this requirement.	X			
	Bidder Response: At the beginning of the program, Comtech's standard implementation plan for aggregation services will establish LNG services (formerly LSRG) to the selective routers in Nebraska. These connections are transitional. The LNG service will only be required for an interim period as PSAPs are converted to the Comtech NGCS/ESInet services. Additionally, the LNG services are required as OSPs move 911 trunks from the selective router to direct legacy TDM or IP connections to Comtech's aggregation services. For the OSPs, LNG services are also transitional and will be discontinued as OSPs convert ISDN/ SS7 911 transmission to SIP/RTP transmission. Immediately upon contract award, Comtech will work with the Commission (via a discovery process) to ensure that all OSPs are notified through official channels that Comtech is the state of Nebraska's designated 911 service provider and is expected to establish interconnection agreements with each of the service providers to provide clear guidance and direction for supporting the transition in the time frames agreed upon. Comtech will review the project schedule and its performance with the Commission on a weekly basis, thereby ensuring that all planned schedule dates are being met, or that work-around and/or corrective measures are being put into place so that the committed transition time frame is achieved.				

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 19	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **BCF Description** The BCF shall provide logical network security functions between external networks and the ESInet, and between the ESInet and PSAP networks. The BCF is responsible for numerous functions, including the following: a. Border firewall; b. VPN; c. IDS/IPS; d. Session Border Control (SBC); e. Opening and closing of pinholes; f. Limiting access to critical components through the use of VLANs; g. Call admission control; h. Media transcoding; i. Signaling protocol normalization and interworking; j. Network Address Translation (NAT); k. Codec negotiation; l. Support for QoS and priority markings; and, m. Media proxy. Provide details, including drawings, describing how the proposed BCF meets or exceeds all functions listed above and the requirements described in NENA-STA-010.2-2016, as well as additional firewall requirements described in NENA 04-503, NENA-INF-015.1-2016, and NENA 75-001, or the next subsequent version of the NENA documents listed that are publicly available at the proposal release date.	X			
	Bidder Response: In Comtech's i3- compliant architecture, the BCF is the first functional element for inbound traffic and the last functional element for outbound traffic. The BCF provides the connectivity point between the NG911 ESInet/NGCS and any other externally connected networks, and it serves as the primary ingress and egress for any IP/SIP call-related signaling and media, as well as for NG911 applications traffic. The BCF hosts two subcomponents—the SBC and the NGFW—providing edge border IP/SIP-level security and policy for both the NGCS and the ESInet. BCF components are connected to multiple network VLANs for the purpose of limiting access to critical components. As part of a defense-in-depth design, Comtech uses firewalls at various points along the network to allow for a more advanced cybersecurity solution, as opposed to situations where only the BCF's NGFW are used. This NGFW component is utilized to create IPSec-VPN tunnels for all connectivity; these include connectivity from data center to data center, from data center to PSAP(s), and from data center to partner provider. All communications points pass through the NGFW's built-in IDS/IPS solution to identify both potential threats and normal communications flows. This defense-in-depth model enables Comtech to provide a fine-tuned level of security that allows only the required communications between systems on a ports-and-protocols level, while adjusting for those pinhole-level security aspects.				

	Comtech's solution will use IPv4 *RFC 1918* private addressing, as well as NAT, to meet the cybersecurity and routing protocol design standards and best practices found in Internet Engineering Task Force (IETF) and NENA. Using these best practices and recommendations ensures that no SIP or RTP transport issues will be encountered. The ESInet will use globally routed IP addressing when routing to the appropriate external agencies, but private *RFC 1918* addresses when routing to internal endpoints. As part of Comtech's NGCS and ESInet services, the BCF offers advanced Class-Based Quality of Service (CBQoS) suitable for marking, recognizing and transporting emergency call services traffic, as well as guaranteeing the highest relative priority to the points of demarcation into the NGCS core. Comtech leverages Inteliquent services as a component of the LNG. Inteliquent also maintains a BCF for incoming call traffic, and it is at that level where the call admission control and the media transcoding occur. The Comtech SBC component of the BCF secures all voice and media traffic that enters the ESInet from Inteliquent. With this aggregation in all call flows, ingress traffic will enter the data center as IP and will be routed to the BCF. The SBC will perform the necessary SIP and media proxies and required back-to-back user agent (B2BUA) functionality, as well as negotiation. *Comtech Confidential Figure 19* depicts the proposed security architecture. Untrusted Security Zone devices (servers and other applications) are co-located with a security appliance and/or are monitored as a licensed endpoint. Untrusted Security Zone devices include the switches, firewalls, and servers in the NG911 environment.

Any additional documentation can be inserted here

Figure 19. BCF-Specific Network Security Zones (Comtech Confidential)

	Next Generation Core Services Elements (NGCS) **Border Control Function (BCF)** **High-Availability Design** The BCF solution shall be deployed in a manner to achieve 99.999 percent availability. Describe how the solution meets or exceeds the above requirements.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
NGCS 20	Bidder Response: Comtech's NGCS service provides high availability, no single point of failure, and 99.999 percent reliability. The NGCS service is deployed in two distinct geographical locations with redundant ISP links. Comtech's ESInet service utilizes diverse carriers and diverse paths for redundancy to provide service to all PSAPs. Devices at each of the NGCS data centers are deployed in a high availability configuration using various technologies. Dynamic routing protocols (i.e., BGP or OSPF) are used for route convergence in the event of a device failure. In addition, BFD is used to provide fast-forwarding path detection failure for all routing protocols. Inclusive in this overall model are the BCF components, which are deployed in active/active pairs at each of the two geographically dispersed data center locations. Each individual BCF can handle the full call capacity for Nebraska, if required. This allows Comtech to take any individual component out of service for maintenance without affecting the delivery of service.				

Any additional documentation can be inserted here

	Next Generation Core Services Elements (NGCS) **Border Control Function (BCF)** **Auditing of System Log Files** Management of the BCF shall include continuous auditing of the system log files for anomalies, and processes for responding to and managing security incidents. Describe how the solution meets or exceeds the above requirements.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
NGCS 21	Bidder Response: Comtech's logging solutions collect data from all systems to include security auditing, operational system logs, and CDRs. All logging is performed on a centralized, off-system logging solution that is used to distribute those logs to various analytical systems for analysis. Security audit and system log data is processed into a central SIEM. The SIEM facilitates the centralization of all monitoring and response activities of security- and network-related events and anomalies.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 22	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **Silence Suppression Detection** The BCF shall be capable of detecting when silence suppression is present in the 911 call and of disabling silence suppression if it is detected in the call. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: The Comtech BCF features a Session Plugin Language (SPL) that can be configured as a plug-in to augment the SBC configuration. One of the capabilities of the SPL is to manipulate the Session Description Protocol (SDP) during the call-setup phase. If call signaling is received with the *silenceSuppression* attribute parameter value, and if *silenceSuppEnable* is set to 'on' in the SDP, the SPL script would attempt to re-signal the INVITE with the *silenceSuppression* attribute parameter value to 'off' in order for the calling party to not stop RTP in the event of perceived silence.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 23	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **SIP Call Mediation** The BCF shall mediate all incoming 911 calls from VoIP providers to Session Initiation Protocol (SIP) calls and should be done in accordance with NENA-STA-010.2-2016. Any specific variations or non-compliance with this requirement shall be identified and documented below. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: The Comtech SBC component of the BCF provides the necessary SIP proxy and required B2BUA functionality that enables the NENA-required call mediation. The BCF performs topology hiding, anchors the media, and acts as the User Agent Server (UAS) for the ingress SIP dialog. On the egress side, the BCF acts as a User Agent Client (UAC) to create a new transaction for the egress dialog; it accomplishes this by sending an INVITE populated with a Route header field pointing to the ESRP, with Via and Contact header fields pointing to itself, and with an SDP offer.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 24	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **Event Logging** The BCF shall provide the functionality to maintain logs of all 911 sessions and all additional BCF logging and recording requirements, as specified in NENA-STA-010.2-2016. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: The Comtech BCF implements the Session Recording Client as defined by SIPREC (*RFC 7866*). The BCF also supports sending SIPREC metadata (*RFC 7865*). It generates a SIPREC metadata *LogEventinclude* the *CallIdURN* and *IncidentURN* for the emergency call being recorded in the SIPREC INVITE it generates, as well as when generating an associated SIPREC metadata *LogEvent*. Each emergency call results in a separate recording session. More than one recording session may be logged for a single call. The BCF implements Real-Time Control Protocol (RTCP) on the recording session. The clock time is sent to the Session Recorder Server (SRS), which allows for the media synchronization of multiple media streams upon playback. The BCF supports the provisioning of SIPREC, allowing it to be enabled or disabled on each of the session routers, as desired.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 25	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **NAT/NAPT Detection and Mediation** Provide details on how the proposed Session Border Control (SBC) will recognize that a Network Address Translation (NAT) or Network Address and Port Translation (NAPT) has been performed on Open Systems Interconnection (OSI) Layer 3, but not above, and correct the signaling message for SIP.	X			
	Bidder Response: The Comtech BCF supports various configurations of "natting" on the remote end of the phone call. There are various methods within the platform for efficiently dealing with Network Address Translation (NAT). The most prominently employed method is dynamic NAT traversal, which learns the behavior of the NAT and adjusts the timers to account for port changes based upon this behavior.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 26	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **IPv4/IPv6 Interworking** Provide details on how the proposed SBC shall enable interworking between networks utilizing IPv4 and IPv6 through the use of dual stacks, selectable for each SBC interface, based on NENA-STA-010.2-2016. All valid IPv4 addresses and parameters shall be translated to/from the equivalent IPv6 values.	X			
	Bidder Response: The Comtech BCF is designed with a dual stack architecture, which allows for the interworking between IPv4 and IPv6 networks and does so at the network interface level. Each interface supports either IPv4 or IPv6 format notation for IP address, netmask and gateway entries. The BCF supports an interwork function between IPv4 and IPv6 in either direction. The configuration steps needed to create an interface for IPv4 or IPv6 are as follows: • First, the physical interface is defined with a name, a port number, and a slot. • The network interface is created by referencing the named physical interface and assigning an IP address, a netmask and a gateway by using IPv4 or IPv6 notation. • The realm (for example Carrier or ESRP) is then created that references the appropriate network interface to be used. • Local policies are then created for each realm to define a policy attribute that contains the next hop in either an IPv4 or an IPv6 notation.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 27	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **SIP Support Over Multiple Protocols** Provide details on how the proposed SBC shall support SIP over the following protocols: 1. Transmission Control Protocol (TCP), 2. User Datagram Protocol (UDP), 3. Transport Layer Security over TCP (TLS-over-TCP), and 4. Stream Control Transmission Protocol (SCTP). Protocols supported shall be selectable for each SBC interface to external systems. These transport layer protocols are generated and terminated at each interface to external systems.	X			
	Bidder Response: The Comtech BCF includes configurations at the SIP interface level that defines which protocol, IP address and port to use for SIP signaling. Each SIP interface can be configured independently with a transport protocol of Transmission Control Protocol (TCP), User Datagram Protocol (UDP), TLS-over-TCP or Stream Control Transmission Protocol (SCTP). The BCF facilitates the interworking of these protocols. A call received on a SIP interface over TCP can be sent out via some other interface, over UDP for example. TCP – This is a Layer-3 protocol that provides reliable stream delivery and a virtual connection service to applications through the use of sequenced acknowledgement with the retransmission of packets, when necessary. UDP – This is a Layer-3 protocol that provides a simple message service for transaction-oriented services. Each UDP header carries both a source port identifier and a destination port identifier, which allows high-level protocols to target specific applications and services among hosts. TLS-over-TCP – This is a Layer-3 protocol that provides encrypted SIP signaling over TCP. TLS requires additional configuration steps, including the creation of certificates and the configuration of a TLS profile. Once established, the TLS profile is applied against a SIP interface to result in encrypted SIP signaling for traffic using that interface. The BCF performs the interworking needed to accept carrier-based UDP traffic on one interface (for example), and send it through the ESInet to the CHE in an encrypted manner. SCTP – This is a Layer-4 protocol that provides acknowledged, error-free, non-duplicated transfers of messages by using checksums, sequence numbers, and a selective retransmission mechanism.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 28	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **Packet Prioritization Based on Session Type** Provide details on how the proposed SBC shall be capable of populating the Layer 3 headers, based on call/session type (e.g., 911 calls) in order to facilitate priority routing of the packets.	X			
	Bidder Response: Comtech's end-to-end QoS strategy leverages modular QoS to properly identify and classify traffic types, apply or reapply DSCP markings, and prioritize traffic flows by applying policing and shaping policies, as well as determining low-latency or class-based weighted fair queuing for each traffic classification. When entering the network, traffic is analyzed as close to the source as possible, and traffic types are classified and marked (or re-marked) with the appropriate DSCP values. Traffic identification is performed by DSCP, ACLs, NBAR, or a combination of these parameters. Traffic shaping is part of Comtech's overall QoS portfolio. Shaping features thus employed include minimum bandwidth guarantees for the highest priority traffic classes, as well as bandwidth maximums for lesser priority classes. Classification is based upon any or all NBAR, DSCP markings, IP addresses, and TCP or UDP ports, as necessary. DSCP markings and adequate bandwidth is preserved as traffic traverses the LAN. At the network's edge, egress traffic destined for the ESInet is re-marked as needed and assigned guaranteed bandwidth, or a percentage of total bandwidth, as required by each traffic class. Media traffic utilizing RTP is put into a priority queue and marked with an EF DSCP tag. The bandwidth for RTP is guaranteed, and low-latency queuing is applied. Signaling, which matches the SIP protocol, is also placed in its own class of service and allocated a percentage of bandwidth to ensure SIP packets are prioritized during periods of network congestion. Classes are also defined for mission-critical traffic, which includes mapping and location services, control and routing protocol traffic, and other applications that are vital to call path and related NG911 functions. A default class is defined for all traffic that is to be treated as BE. As part of Comtech's NGCS and ESInet services, the BCF includes advanced CBQoS suitable for marking, recognizing and transporting emergency call services traffic, as well as guaranteeing the highest relative priority to the points of demarcation into the NGCS core.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 29	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **Encryption of Unencrypted Calls** Provide details on how the proposed SBC supports encryption for calls that are not protected entering the ESInet, based on NENA-STA-010.2-2016.	X			
	Bidder Response: The Comtech BCF supports TLS for SIP, which protects user and network privacy by providing authentication and guaranteeing the communications integrity between the BCF and other next-hop devices in the ESInet. Calls received "in the clear" by the BCF can be encrypted by applying a TLS profile against the SIP interface configuration for each next-hop device. The TLS configuration process begins by creating a certificate record configuration and generating or obtaining certificates. The TLS profile is created by storing the certificate and all supported TLS versions. The TLS profile is applied against each of the SIP interfaces, defining the transport protocol as TLS for those interfaces. When the BCF negotiates on TLS, it starts with the highest TLS version and works its way down until it finds a compatible version and cipher that works for the other side. The BCF supports multiple TLS operational modes. The first of these is where the connection is set up and torn down for each call. The second is where the TLS connection is persistent and is only torn down upon timer expiration or loss of connectivity. The BCF supports Online Certificate Status Protocol to validate a certificate against a Public Key Infrastructure (PKI), if required.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 30	**Next Generation Core Services Elements (NGCS)** **Border Control Function (BCF)** **BCF Elements** 1. Provide details, including drawings, describing the different BCF elements that the proposed solution comprises. 2. As part of the details, identify all of the elements and/or interfaces to be provided by the Commission and/or PSAPs to the bidder.	X			
	Bidder Response: Comtech's i3-compliant BCF is the first functional element for inbound traffic and the last functional element for outbound traffic. The BCF provides the connectivity point between the NG911 ESInet/NGCS and any externally connected networks, and it serves as the primary ingress and egress for any IP/SIP call-related signaling and media, as well as for NG911 applications traffic. The BCF hosts two subcomponents—the SBC and a set of NGFW—to provide edge border IP/SIP-level security and policies for both the NGCS and the ESInet. These NGFWs are separate to ensure there is no traffic interaction between the ESInet and the public internet, further enhancing baseline security. BCF components are connected to multiple VLANs for the purpose of limiting access to critical components. The primary ingress/egress into/out of the NGCS/ESInet occurs through the BCF components within the data centers, and there is nothing the Commission needs to provide for these elements. Comtech will also provide the same BCF structure at each regional facility, albeit smaller models. For legacy facilities there will be LPGs to convert traffic between IP and legacy systems. For NG regions, the Commission will need to provide an RJ-45 IP network connection into the region's network for the ingress/egress connectivity for the BCF. For legacy regions, the Commission will need to provide both a serial interface (ALI) and a TDM (T1, CAMA) interface into the region's CHE for the ingress/egress connectivity for the BCF. *Comtech Confidential Figure 20* depicts the BCF components and interfaces at the data center level.				

Any additional documentation can be inserted here:

Figure 20. Interface and BCF Elements (Comtech Confidential)

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 31	**Next Generation Core Services Elements (NGCS)** **Emergency Service Routing Proxy (ESRP) and Policy Routing Function (PRF)** **ESRP Description** The ESRP routes a call to the next hop. It also evaluates the originating policy rules set for the queue the call arrives on, extracts the location of the caller from the SIP signaling, queries the Emergency Call Routing Function (ECRF) for the nominal next-hop route, evaluates the route based on policy rules and queue states of the downstream entity queues, and then forwards the call to the resulting next hop. Bidder's proposed ESRP must meet or exceed NENA-STA-010.2-2016. Describe how the proposed solution meets or exceeds the standards.	X			
	Bidder Response: The ESRP functional element is the call-processing and initial call-routing service in NENA's i3 architecture. The Comtech ESRP is a SIP routing proxy that fundamentally routes calls to the next hop. The ESRP maintains interfaces to a provisioned LIS or transitional LDB services against which HELD queries are performed to determine location-by-value or location-by-reference. The ESRP passes on the location via the LoST interface to the ECRF, which determines the next hop in routing a call to the requested service. The ECRF performs the mapping of the location information and service to determine the appropriate PSAP URI where the call should be delivered. Using the returned PSAP URI, the ESRP then applies a policy from the PRF to determine the appropriate routing URI while considering factors such as time of day, PSAP state, etc. The ESRP maintains an i3-compliant logging interface for every transaction and message that is received and sent on to its call interfaces. Each query against and response received from the LIS/LDB and ECRF are logged, along with the routing decision once policy rules are applied. Comtech's ESRP is deployed on virtualized servers in a high availability cluster configuration.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 32	**Next Generation Core Services Elements (NGCS)** **Emergency Service Routing Proxy (ESRP) and Policy Routing Function (PRF)** **Transition to Geospatial Routing** Bidder understands that all PSAPs and regions may not be ready for geospatial routing on day one of operations and shall provide tabular routing services, also known as Internet Protocol Selective Routing (IPSR), until such time as PSAPs and regions are ready for geospatial routing. In bidder's separate cost proposal response, indicate the pricing difference between tabular and geospatial routing. Describe the process for transitioning each PSAP or region from tabular routing to geospatial routing as PSAP's becomes ready and the manner in which the solution provides for routing by both means simultaneously.	X			
	Bidder Response: The Comtech LDB will be implemented on Day One to replace the legacy ALI system. The LDB is flexible in that it can fully support both legacy and NG911 processes. The LDB allows records to be both MSAG-validated (prior to translation from legacy address to CLDXF address) and LVF-validated. If MSAG validation is turned on, each record that is valid will be assigned to the appropriate Emergency Service Number (ESN) from the MSAG (where the MSAG is stored in the MCS). When the ESRP queries the LDB for location, it will receive both a CLDXF-compliant PIDF-LO as well as a legacy ESN in the response, and it can use either element for routing the call. In a typical call flow for a PSAP that does not yet have GIS in the ECRF, the ESRP will query the LDB for location. From the LDB response it will use the location to query the ECRF. Since GIS is not yet present in the ECRF for this location, the ECRF will respond with something like the following: *<errors source="dev-dem-ecrf.ddti.net" xmlns="urn:ietf:params:xml:ns:lost1">* * <notFound message="Unable to find coverage for the specified location." xml:lang="en" />* *</errors>* The ESRP will then fall back to using the ESN it received from the LDB to route the call to the appropriate PSAP.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 33	**Next Generation Core Services Elements (NGCS)** **Emergency Service Routing Proxy (ESRP) and Policy Routing Function (PRF)** **Policy Routing Function (PRF) Description** The PRF is a required function of the ESRP. The ESRP interacts with the PRF to determine the next hop of a call or event. Before the ESRP sends the call to the next hop, it first queries the PRF to check the status of the next hop to determine if a unique routing rule or policy is in place that would direct the call to another location. The destination of the next hop is typically a queue. The PRF monitors the downstream queues of ESRPs for active understanding of the entity's queue status. Describe how the solution meets or exceeds the standards.	X			
	Bidder Response: In Comtech's current standard configuration, the PRF is a tabular database that is co-resident in our virtualized infrastructure with the ESRP. The PRF is managed by authorized users to provide modifications to end-point location determination SIP-URI as specified by the geospatial queries to the ECRF. These modifications are affected through the manipulation of rules within the PRF policy store. The PRF solution utilizes all methods described in *Section 4.3.1, Policy Store Web Service, in NENA-STA-010.2 (originally 08-003).* The PRF is used to determine potential emergency call routes. A query/response interaction with a provisioned ECRF is a minimal action resulting from a rule that governs the call's origin. The PRF makes routing decisions based upon factors that include class of service, time of day, media type, and ranges of numbers. Additional rules the PRF can apply govern call termination and can include a routing decision based upon knowledge that a specific downstream ESRP is busy (call queue full), or that a specific PSAP is offline.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 34	**Next Generation Core Services Elements (NGCS)** **Emergency Service Routing Proxy (ESRP) and Policy Routing Function (PRF)** **PRF Policy Store and User Interface** The PRF shall allow defining of policy rules for distributing a wide range of calls in an efficient manner. 1. Describe the solution's Policy Store and the PSAP's ability to effect changes to the PRF. 2. Describe the user interface, role-based authentication, the ability of each PSAP or region to manage PSAP's own policy rules, and the types of policy rules available at the time of proposal submission, as well as those on the product roadmap. Roadmap items must include an estimated time of feature availability.	X			
	Bidder Response: Rule maintenance is accomplished through a configuration tool that allows authorized users to maintain policy rules associated with an individual PSAP and its policy name. As modifications are made to the policy store, changes become effective and routing changes are implemented at the designated start time. Accordingly, PRF rules can be applied in near-real-time. Another condition for route modification that is unique to Comtech's solution involves the awareness of an active SIP session based upon packet inspection; this allows policy rules to be applied based upon SIP headers. In all cases, the PRF modifies the "intended" next hop location, but it does not change the GIS routing or service boundaries. This allows changes to be administratively based without involving GIS authorities, reduces the possibility of creating a systemic erroneous change, is easily placed and removed, and does not change GIS location validation. There are two types of user interfaces available for modifying the PRF. One is via a GUI application that runs on the administrative server and can be remotely accessed using RAdmin Viewer; this is a secure application used for remote monitoring of servers/PCs. The other is a Web application accessible via a standard web browser, as specified by *NENA 08-003.* The following Comtech PRF roadmap statement is *Comtech Confidential.*				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 35	**Next Generation Core Services Elements (NGCS)** **Emergency Service Routing Proxy (ESRP) and Policy Routing Function (PRF)** **Next-Hop Queues** A next-hop queue may be a Uniform Resource Identifier (URI) that routes the call to an interactive multimedia response system (as described in IETF RFC 4240) that plays an announcement (in the media negotiated by the caller) and potentially accepts responses via Dual-Tone Multi-Frequency (DTMF) signaling or other interaction protocols. Describe how the bidder's solution implements next-hop queueing.	X			
	Bidder Response: The Comtech ESRP and PRF may select a next-hop destination that is a URI. The routing of a call to a specified URI could include an interactive system, but such a system is beyond the scope of ESRP/PRF functionality. The function of the ESRP is to route a call to the next hop. Routing to an interactive response system or playing an announcement is possible; we furthermore note it may be desirable for some jurisdictions to place calls into such a system instead of providing alternate routing to a different PSAP.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 36	**Next Generation Core Services Elements (NGCS)** **Emergency Service Routing Proxy (ESRP) and Policy Routing Function (PRF)** **High-Availability Design** The ESRP/PRF solution shall be designed with resiliency and redundancy to provide a minimum of 99.999 percent availability. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's NGCS service provides high availability, no single point of failure, and 99.999 percent reliability. The NGCS service is deployed in two distinct geographical locations with redundant ISP links. Comtech's ESInet service utilizes diverse carriers and diverse paths for redundancy to provide service to all PSAPs. Devices at each of the NGCS data centers are deployed in a high availability configuration using various technologies. Dynamic routing protocols (i.e., BGP or OSPF) are used for route convergence in the event of a device failure. In addition, BFD is used to provide fast-forwarding path detection failure for all routing protocols. Inclusive in this overall model are the ESRP and PRF components, which are deployed in active/passive pairs at each of the two geographically dispersed data center locations. Each individual ESRP/PRF can handle the full call capacity for Nebraska, if needed. This allows Comtech to take any individual component out of service for maintenance without affecting the delivery of service.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 37	**Next Generation Core Services Elements (NGCS)** **Emergency Service Routing Proxy (ESRP) and Policy Routing Function (PRF)** **Keep-Alive Signaling Between Elements** Provide an explanation of how the proposed ESRPs use the SIP "options" transactions for maintaining "keep -alive" signaling between ESRPs, LNGs, Legacy PSAP Gateways (LPGs) and session recording services.	X			
	Bidder Response: The ESRP application supports the SIP OPTIONS health check heartbeat as it is directed toward downstream entities (such as PSAPs) to determine availability or "keep alive" status-checking. In the event there is no response to the SIP OPTION, a ring-no-answer result, or any 4xx, 5xx, or 6xx error received from the PSAP, the NGCS will apply PRF to determine an alternate call destination, presuming one has been provisioned for these scenarios.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 38	**Next Generation Core Services Elements (NGCS)** **Emergency Service Routing Proxy (ESRP) and Policy Routing Function (PRF** **TCP/TLS Implementation** The upstream interface on the proposed non-originating ESRPs shall implement Transmission Control Protocol/Transmission Layer Security (TCP/TLS), but shall be capable of fallback to UDP, as described in NENA-STA-010.2-2016. Stream Control Transmission Protocol (SCTP) support is optional. The ESRP shall maintain persistent TCP and TLS connections to the downstream ESRPs or User Agents (UA) that it serves. Provide detailed documentation describing how the non-originating ESRP interface supports TCP/TLS with fallback to UDP.	X			
	Bidder Response: The Comtech ESRP supports (at minimum) the following interfaces for upstream/downstream communication: • A SIP call interface over UDP, TCP, or TCP/TLS. • A LoST interface for a provisioned ECRF. It maintains a persistent TCP/TLS connection with the ECRF and is provisioned with the credentials for the ECRF. • A HELD de-reference interface for a provisioned LIS or TCC. It maintains a persistent TCP/TLS connection with the LIS or TCC and is provisioned with the credentials for the LIS or TCC.				

Any additional documentation can be inserted here:

NGCS 39	**Next Generation Core Services Elements (NGCS)** **NENA Compliance Chart** Provide a description of how the proposed ESRPs meet or exceed all functional requirements below as defined in NENA-STA-010.2-2016, which are listed below.				

Bidder Response:

The Comtech ESRP and PRF is responsible for call routing and policy implementation for NG911 applications per NENA i3. The ESRP is the i3 replacement for legacy selective router technology. It interfaces easily with other LNGs and or ESRPs as well as additional ESRP implementations, and it can receive and parse PIDF-LO—both civic and geospatial— and by value or by reference per the NENA i3 standard. If the location information is not received embedded in the SIP message header upon receipt, it can perform a HELD query to a LIS/LDB per the NENA i3 standard. The Comtech ESRP supports location query steering-based PRF rules.

Key benefits include the following:

- Exceeds the NENA i3 standard for NG911 call routing.
- Has automatic failover to a redundant backup with no manual intervention, no A/B switching, and no hot standby.
- Bridges the gap from legacy analog (PSTN) with high-quality conversion of call data to IP.
- Routes based upon spatial as well as tabular data.
- Offers a highly available, load-balanced and fault-tolerant system.
- Saves costs by incorporating a non-blocking low latency conference bridge.

<u>Rules-Based Routing Proxy</u>
The Comtech ESRP provides B2BUA functionality and identifies the "next hop" for a call toward the optimal queue of call takers. The Comtech ESRP uses incoming call policies (part of the PRF) to determine the call treatment. The From/P-asserted-identity, or the source IP address, can be used to trigger a specific policy. This policy determines whether the calls should be routed directly (via a pre-configured route) or per NENA i3 (LIS/ECRF queries). More specifically for i3, the ESRP supports receiving caller location both by value in an incoming call SIP INVITE as well as by reference. When receiving a location by reference, the ESRP can dereference the location using HELD. In both cases, based upon instructions in the PRF, the ESRP can override this location by performing a HELD query to a predetermined LIS/LDB. Furthermore, the LNG subsystem supports performing HELD queries to a LIS. In this case, the incoming call PRF specifies the HELD query destination. This allows for the support of HELD query "steering" in a similar way as "ALI steering" was supported.

Once a call and its associated location is received, the ESRP, as instructed by the PRF, will use the caller's location to perform a LoST routing query to the ECRF. The ECRF returns a URI that identifies the primary PSAP. The ESRP then uses the URI and the PRF to send the call to the correct primary PSAP. The PRF is also used to identify alternate routes to the primary PSAP, if necessary.

The Comtech ESRP supports both TCP and UDP for SIP. For an ingress call, this selection is automatic based upon the method chosen by the sender to maximize interoperability. Upon egress, this selection is done in the PRF (outgoing call policies). When location (PIDF-LO) must be sent, TCP is automatically selected due to the packet size involved in sending PIDF-LO.

The flexibility in sending or not sending PIDF-LO is required when routing administrative calls or initiating transfers to non-i3 end-points such as PBXs. The service PRF is divided in two sections; incoming call policies and outgoing call policies. Incoming call policies can be triggered by using:

- Incoming SIP: URI
- Origination IP address
- SIP To field
- Media type (Voice or MSRP)

The ESRP supports receiving and routing inbound SIP INVITEs from the PSAPs and providing "administrative" call treatment to these calls.

Overview Section 5.2.1.1
Comply. The proposed ESRP will act as an originating ESRP. As such it evaluates an incoming call policy, which instructs it to perform an ECRF query to obtain a routing destination in the form of a URI. Using the URI, it then evaluates a routing policy.

Call Queueing Section 5.2.1.2
Comply. The Comtech ESRP implements a queue of 1 when acting as an originating ESRP. This approach allows the terminating PSAP to provide the queuing mechanism and specific call processing such as returning voice messages to the caller. The originating ESRP, using these routing policies, can restrict the amount of simultaneous calls sent to a given PSAP, in which case an alternate route specific to the targeted PSAP is given by the routing policies. The ESRP can respond to a call from an entity not in its policy with a 404 error.

Queue State Event Package Section 5.2.1.3
Comply. The Comtech ESRP implements a queue of 1 as stated in the NENA document and as such, does not implement a Queue State Event Package.

De-queue Registration Event Package Section 5.2.1.
Comply. The Comtech ESRP implements a queue of 1 as stated in the NENA document. As such, it does not implement a de-queue registration event package.

Policy Routing Function Section 5.2.1.5
Comply. The Comtech ESRP provides policy rules that allow for LoST queries to be performed so that a next-hop route can be evaluated. These policies also allow for a default route to be defined as well as overflow conditions, routing priorities and load sharing across end-points.

ESRP Notify Event Package Section 5.2.1.6
Complies with Future Capability. The ESRP PRF does not currently allow a Notify action. The Notify event package is expected to change significantly in *STA-010.3,* which is Version 3 of the NENA Standard for Next Generation 911 . It is currently available for public review and comment, but has not yet been ratified. As a result, Comtech has decided to wait for Version 3 to be ratified before implementing.

INVITE Transaction Processing Section 5.2.1.7
Comply. The ESRP can evaluate an incoming call policy, which instructs it to perform an ECRF routing query using the LoST protocol to obtain a routing destination in the form of a URI. Using the URI, it then evaluates a routing policy. To perform the LoST query, the caller's location is required. The ESRP can obtain a caller's location in the following manners:

- Directly from the SIP INVITE when the location is received by value.

	• By a dereferencing query using the HELD protocol when the location is received by reference in the SIP INVITE • By a HELD query to a pre-configured LIS. BYE Transaction Processing Section 5.2.1.8 Comply. The Comtech ESRP processes BYEs as per *RFC 3261* (SIP). CANCEL Transaction Processing Section 5.2.1.9 Comply. The Comtech ESRP processes CANCEL as per *RFC 3261*. OPTIONS Transaction Processing Section 5.2.1.10 Comply. The Comtech ESRP processes OPTIONS transactions per *RFC 3261*. It can periodically send OPTIONS when a routing policy is configured to use *RFC 3263* (SIP: Locating SIP Servers). Upstream Call Interface Section 5.2.2.1 Comply. As an originating ESRP, the Comtech ESRP supports all the minimal methods and headers as defined in *Section 4.1.1*. It supports INVITE, REFER, BYE, OPTIONS, CANCEL, ACK, MESSAGE, INFO. Downstream Call Interface Section 5.2.2.2 Partially Comply. All SIP methods described in 5.2.2.2 are supported, except for UPDATE and PRACK. The specified Call-Info (NENA CallId and NENA IncidentId), Via and History-Info headers are also supported as well as Priority and Geolocation-Routing and Geolocation. Finally, SIP-over-UDP and TCP are supported. ECRF Interface Section 5.2.2.3 Comply. The Comtech ESRP implements a LoST interface towards a (provisioned) ECRF and can use the specified Uniform Resource Names (URNs). Location Information Server (LIS) Dereference Interface Section 5.2.2.4 Partially Comply. The Comtech ESRP implements HELD dereferencing interfaces. The SIP Presence Event Package is not supported, and in Comtech's experience, is not being used by any LIS. Comtech will re-evaluate its stance should a LIS vendor implement this capability. Additional Data Interfaces Section 5.2.2.5 Complies with Future Capability. As an originating ESRP, the Comtech ESRP does not currently support receiving nor forwarding references to Additional Data Repositories (ADRs). To Comtech's knowledge none has been deployed that uses the mechanism described in the *STA-010.2* standard. The mechanism and its underlying protocol and payload are expected to change significantly with *STA-010.3*. Comtech will evaluate this situation once *STA-010.3* is ratified. ESRP, PSAP, Call-Taker State Notification and Subscriptions Section 5.2.2.6 Complies with Future Capability. The Comtech ESRP PRF does not currently allow a Notify action. The Notify event package is expected to change significantly in *STA-010.3,* and Comtech has decided to wait before implementing it. Time Interface Section 5.2.2.7

	Comply. The Comtech ESRP uses Network Time Protocol (NTP) to synchronize the servers' clocks. <u>Logging Interface Section 5.2.2.8</u> Partially Comply. The Comtech ESRP provides detailed logs based upon the *STA-010.1 Event Logging* specifications. Several extensions to the Event Logging specifications were done to ensure complete viewing of the call processing. The Comtech version of i3 logging is supported by Management Information System (MIS) vendors, as well as recorder companies. Comtech is working on the *STA-010.3* logging interface which is expected to supplant 10.2 at some future point. <u>Data Structures Section 5.2.3</u> Complies with Future Capability. The Comtech ESRP implements a queue of 1 as stated in the NENA document and as such, does not implement a Queue State Event Package. The data structures for Additional Data are changing significantly with *STA-010.3,* and they will be evaluated once the *STA-010.3* is ratified. <u>Policy Elements Section 5.2.4</u> Complies with Future Capability. The Comtech ESRP implements a queue of 1, as stated in *STA-010.2* and as such, does not implement a Queue State and Dequeue Registration Event Package. For Element State, significant changes are expected in *STA-010.3* and will be integrated into the ESRP once *STA-010.3* is ratified. <u>Provisioning Section 5.2.5</u> Comply. The Comtech ESRP is provided with GUI allowing to provision amongst other things: • Incoming routing policies; • Outgoing route policies; • Links to LIS(s) that can be used; • Links to ECRF(s) it uses; • Links to Logging service it uses; • Mappings from 10-digit PSAP telephone numbers to URIs as well as URI to 10-digit numbers; • The URI of a default route PSAP that takes calls when a route cannot be determined.

Any additional documentation can be inserted here:

	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
Overview Section 5.2.1.1	X			
Call Queueing Section 5.2.1.2	X			
Queue State Event Package Section 5.2.1.3	X			
De-queue Registration Event Package Section 5.2.1.	X			

Policy Routing Function Section 5.2.1.5	X			
ESRP Notify Event Package Section 5.2.1.6			X	
INVITE Transaction Processing Section 5.2.1.7	X			
BYE Transaction Processing Section 5.2.1.8	X			
CANCEL Transaction Processing Section 5.2.1.9	X			
OPTIONS Transaction Processing Section 5.2.1.10	X			
Upstream Call Interface Section 5.2.2.1	X			
Downstream Call Interface Section 5.2.2.2		X		
ECRF Interface Section 5.2.2.3	X			
Location Information Server (LIS) Dereference Interface Section 5.2.2.4		X		
Additional Data Interfaces Section 5.2.2.5			X	
ESRP, PSAP, Call-Taker State Notification and Subscriptions Section 5.2.2.6			X	
Time Interface Section 5.2.2.7	X			
Logging Interface Section 5.2.2.8		X		
Data Structures Section 5.2.3			X	
Policy Elements Section 5.2.4			X	
Provisioning Section 5.2.5	X			

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 40	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** Describe how the ECRF interfaces with other ECRF solutions which may interface with the bidder's solution. Awarded Contractor shall coordinate with other ECRF solution providers to ensure interoperability between the respective solutions.	X			

Bidder Response:

The Comtech ECRF/LVF solution comes through a partnership with DDTi. The Comtech ECRF/LVF maintains both civic and geodetic coverage information. This information is used to determine who should answer a specific query. At a minimum, the Comtech ECRF/LVF must be provisioned with coverage information for geographic areas where it is authoritative. For example, civic coverage may contain an entry that it is authoritative for any LoST civic profile query where A1 = "NE". The geodetic coverage, in the form of one or more polygons, may contain an entry that covers the entire state of Nebraska and indicates that this ECRF/LVF is authoritative for any query to fall within these polygons.

Coverage data can also be added for areas where this ECRF/LVF is not authoritative. For these coverage entries, an app string will be added to tell the ECRF/LVF what other LoST Server (ECRF) it needs to contact to receive an authoritative answer. For example, if a bordering state (Iowa, perhaps) has a deployed ECRF/LVF in the form of a polygon that represents the geographic area where the Iowa ECRF/LVF is authoritative, it can be added to the coverage data for the Nebraska ECRF/LVF. If the Nebraska ECRF/LVF receives a query that falls inside the Iowa coverage polygon, the Nebraska ECRF/LVF can recursively query the Iowa ECRF/LVF for an authoritative response. This assumes there is a direct network connection between the Nebraska and Iowa ECRF/LVF servers. If no such direct connection exists, the National Forest Guide may be queried. The National Forest Guide would contain coverage data for both Nebraska and Iowa and have connectivity to each state. Comtech will provide the necessary coverage data to the organization responsible to maintaining the National Forest Guide.

If a National Forest Guide is unavailable, Comtech will work with surrounding regions and states to obtain coverage data for their ECRF/LVF systems and attempt to establish connectivity between them. Comtech will also provide Nebraska coverage data to any surrounding region or state that wishes to operate in the same LoST tree as the Nebraska system.

Initially, in the absence of a National Forest Guide, the Nebraska coverage data for the civic profile may look something like this:

A5	A4	A3	A2	A1	Country	Is Local	App String
			DOUGLAS COUNTY	NE	US	True	
			SAUNDERS COUNTY	NE	US	True	
			BUTLER COUNTY	NE	US	True	
				IA	US	False	ecrf.iowa.gov

				SD	US	False	ecrf.southdakota.gov

The "App String" represents the URI-enabled Naming Authority Pointer (U-NAPTR) record to resolve to another ECRF/LVF system. In this table, we see that any LoST query received where A2 is either "DOUGLAS COUNTY", "SAUNDERS COUNTY" or "BUTLER COUNTY" (and A1 = "NE" and Country = "US") is handled by the Nebraska ECRF/LVF. If a query is received where A1 is "IA", a recursive query would be issued to the ECRF/LVF resolved by "ecrf.iowa.gov".

Once the National Forest Guide is operational, this coverage data may change to look something like this:

A5	A4	A3	A2	A1	Country	Is Local	App String
			DOUGLAS COUNTY	NE	US	True	
			SAUNDERS COUNTY	NE	US	True	
			BUTLER COUNTY	NE	US	True	
				IA	US	False	lost.fcc.gov
				SD	US	False	lost.fcc.gov

In this case, all queries that have the state (A1) equal to "IA" or "SD" are routed to the National Forest Guide. Civic coverage need not be defined simply by the use of A1, A2 and Country, as it can be broken down into smaller coverage regions using other fields to support regional or county level ECRF/LVF deployments. These tables are merely for illustration purposes and do not necessarily represent how a production configuration would appear. A similar process would be used for geodetic coverage.

When interfacing with other ECRF/LVF systems, including the National Forest Guide, strict adherence to the LoST protocol as defined in *RFC 5222* is required to ensure proper integration.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 41	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **ECRF Description** The ECRF shall be designed according to NENA-STA-010.2-2016 and be implemented using diverse, reliable and secure IP connections. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: All systems within the Comtech solution are designed with multiple networks paths over secured communications channels. For external communications, this includes separate entry points and separate circuit paths for each connection. Internal networks utilize separate switches with redundant power that operates on diverse power sources. The Comtech ECRF solution comes through a partnership with DDTi. DDTi strongly supports the NENA i3 and other relevant standards. The company has been actively involved with the development of many of these standards, as well as interoperability testing at many of the NENA ICE events. The Comtech ECRF/LVF complies with the following standards: • NENA-STA-010.2-2016 compliant • RFC 5222 LoST protocol • RFC 4848 for LoST server name resolution • RFC 5031 for service names and format • RFCs 4119, 5139, and 5491 for location formats • RFC 5582 (informative) for LoST architecture .				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 42	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **High-Availability Design** Bidder shall supply an ECRF function that meets a minimum of 99.999 percent availability. Describe how the solution meets or exceeds the above requirements**.**	X			
	Bidder Response: Comtech's NGCS service provides high availability, no single point of failure, and 99.999 percent reliability. The NGCS service is deployed in two distinct geographical locations with redundant ISP links. Comtech's ESInet service utilizes diverse carriers and diverse paths for redundancy to provide service to all PSAPs. Devices at each of the NGCS data centers are deployed in a high availability configuration, using various technologies. Dynamic routing protocols (i.e., BGP or OSPF) are used for route convergence in the event of a device failure. In addition, BFD is used to provide fast-forwarding path detection failure for all routing protocols. The ECRF/LVF system runs in a high-availability architecture to achieve the required five-nines up-time metric. Four instances of the ECRF/LVF are deployed per data center, running behind load-balancing hardware. Each instance runs on its own VM, utilizing its own replica database instances. These load balancers perform a health check against each instance, once per second, and they will automatically pull an unhealthy element from the pool and raise a system alert, where applicable. A single instance of each element has sufficient capacity to run the entire system, should there be multiple simultaneous element failures.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 43	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **Accessibility by Outside Functional Elements** Contractors providing an ECRF shall ensure that it is accessible from outside the ESInet and that the ECRF permits querying by an IP client/endpoint, an LNG, an ESRP in a next-generation emergency services network, or by some combination of these functions. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Additional, non-call path, ECRF/LVF instances (two per data center) are deployed into the Demilitarized Zone (DMZ), and accessible from outside the ESInet. These instances are protected by firewalls, so any required access must be granted to third parties.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 44	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **Accessibility Inside the ESInet** Contractor shall provide an ECRF accessible inside an ESInet, which shall permit querying from any PSAP (or future entity authorized to connect to the ESInet) inside the ESInet. ECRFs provided by other entities may have their own policies regarding who may query them. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Access control to the ECRF/LVF instances within the ESInet is controlled by firewalls and other security measures. All other ESInet elements that need to access the ECRF/LVF will be granted access.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 45	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **Origination Network ECRF** An origination network may use an ECRF, or a similar function within its own network, to determine an appropriate route—equivalent to what would be determined by the authoritative ECRF—to the correct ESInet for the emergency call. Describe the functionality of such an ECRF equivalent and document where this functional element resides within the proposed solution.	X			
	Bidder Response: The functionality of such an ECRF equivalent would involve returning a valid routable location for calls within the originating network. If the situation arose where an external ECRF was preferred for final route selection, the best way to allow this and maintain adherence to the standards, would be to provide access to the external ECRF through the DMZ in Comtech's solution. A policy would need to be created to resolve any potential conflicts. For example, if the incoming call met defined criteria, then the ESRP would determine the appropriate route by using the external ECRF equivalent instead of the ECRF/LVF that is part of the state of Nebraska's NGCS. Since determining an appropriate route should be governed by the authoritative ECRF, originating networks that have their own ECRF equivalent and serve citizens within Nebraska would ideally use a LIS to embed the caller's location in the SIP-header, thereby allowing the state of Nebraska's ECRF to return the authoritative route. A Forest Guide would ensure that when multiple ECRFs exist, a call is routed to the authoritative ECRF for each location, and to its respective ESInet/NGCS for final route determination. Comtech's standards-based solution would be fully interoperable with a standards-based Forest Guide. In the absence of a Forest Guide, Nebraska jurisdictions could also choose to share GIS data with neighboring jurisdictions to avoid routing errors associated with mismatched boundaries.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 46	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **Routing Query Interface** The ECRF shall support a routing query interface that can be used by an endpoint, ESRP or PSAP to request location-based routing information from the ECRF. Additionally, it shall support both iterative and recursive queries to external ECRF sources. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: The ECRF/LVF is fully compliant with *NENA-STA-010.2-2016* and *RFC 5222*, providing the LoST query interface to any functional element capable of performing a LoST query. The ECRF/LVF can also be configured to perform recursive queries to other ECRF/LVF servers for locations where it is non-authoritative. Alternatively, it can return the URI to the authoritative ECRF/LVF, allowing any LoST client to perform iterative queries. The ECRF/LVF must share authoritative coverage areas (both civic and geodetic) for this feature to be enabled.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 47	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **LoST Protocol Support** The ECRF shall interface with the Location-to-Service Translation (LoST) protocol (as described in IETF RFC 5222) and support LoST queries via the ESRP, PSAP CHE, or any other permitted IP host. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's ECRF/LVF complies with the *RFC 5222 LoST Protocol*, and additionally complies with other relevant standards: • NENA-STA-010.2-2016 • RFC 4848 for LoST server name resolution • RFC 5031 for service names and format • RFCs 4119, 5139, and 5491 for location formats • RFC 5582 (informative) for LoST architecture The ECRF/LVF also implements requirements that are specific to NENA i3, including: • Configurable service names, for services beyond those specified in RFC 5031 • Logging of LoST queries and responses to an i3-compatible logging service • Discovery of additional data associated with a location. The ECRF/LVF allows queries from any functional element capable of performing an RFC 5222-compliant LoST request, as permitted by other security elements, such as firewalls.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 48	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **Query Rate-Limiting** The proposed ECRF shall allow for rate-limiting queries from sources other than the proposed ESRP(s), and provide logging of all connections, connection attempts, and LoST transactions. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech typically uses a Domain Name Server (DNS) solution to have call flow-related queries (LNG, ESRP, etc.) sent to a certain group of ECRF/LVF instances, and non-call flow-related queries (such as the LDB performing a full revalidation) sent to a different group of ECRF/LVF instances. Rate-limiting techniques may be applied, but we have found the described approach works best. All LoST connections, queries and responses are logged to debug log files plus a centralized logging database. Additionally, LoST queries and responses can also be logged to a NENA-compliant i3 logger. A utility tool called the Log Analysis and Retrieval Tool (LART) can be provided to mine logging data from the database logging stores, as needed. Figure 21 shows a log file search that uses the LART tool. Figure 22 shows a search for a query/response pair from the database store that uses the LART tool.				

Any additional documentation can be inserted here:

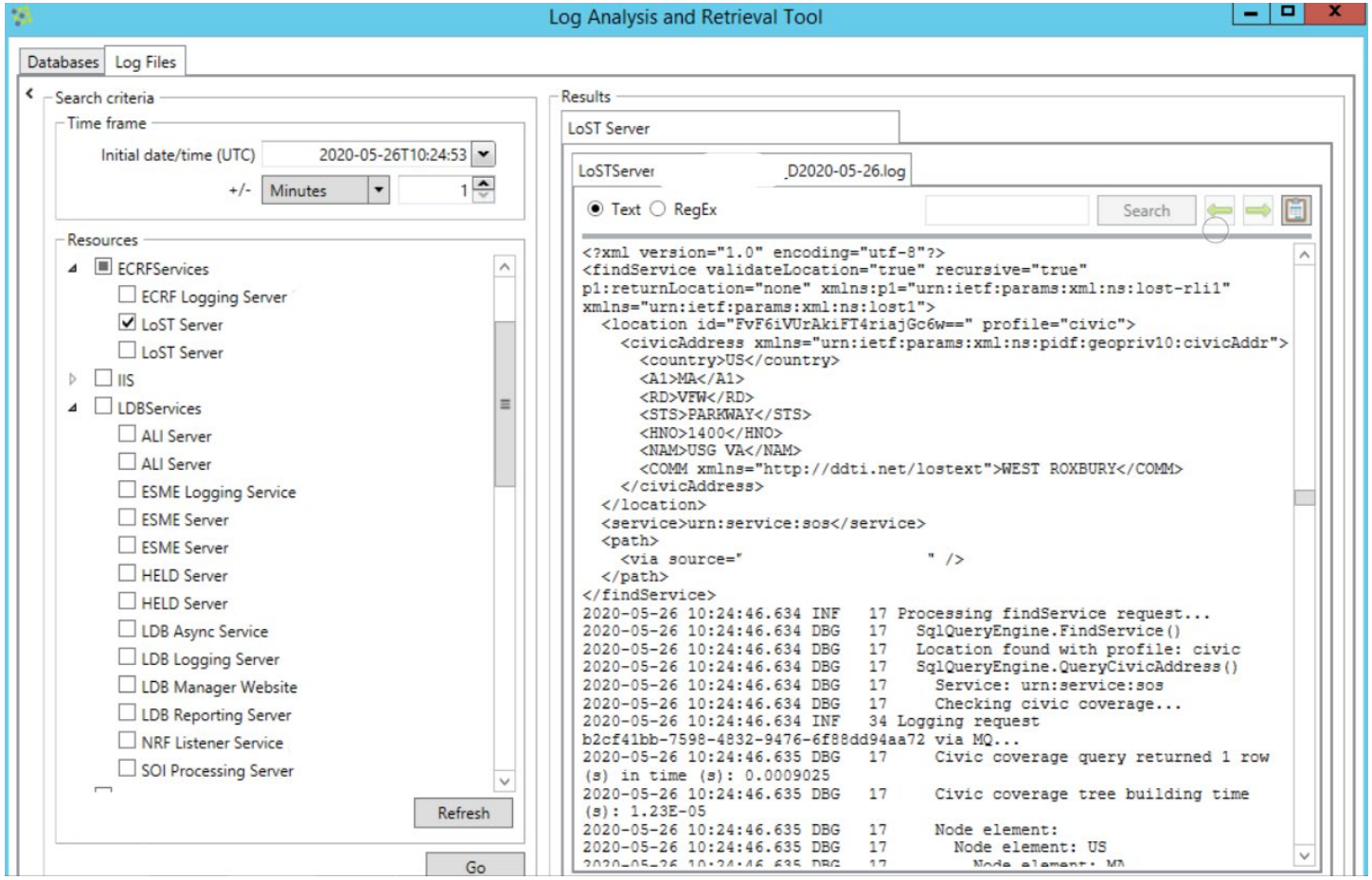


Figure 21. Log File Search using LART Tool

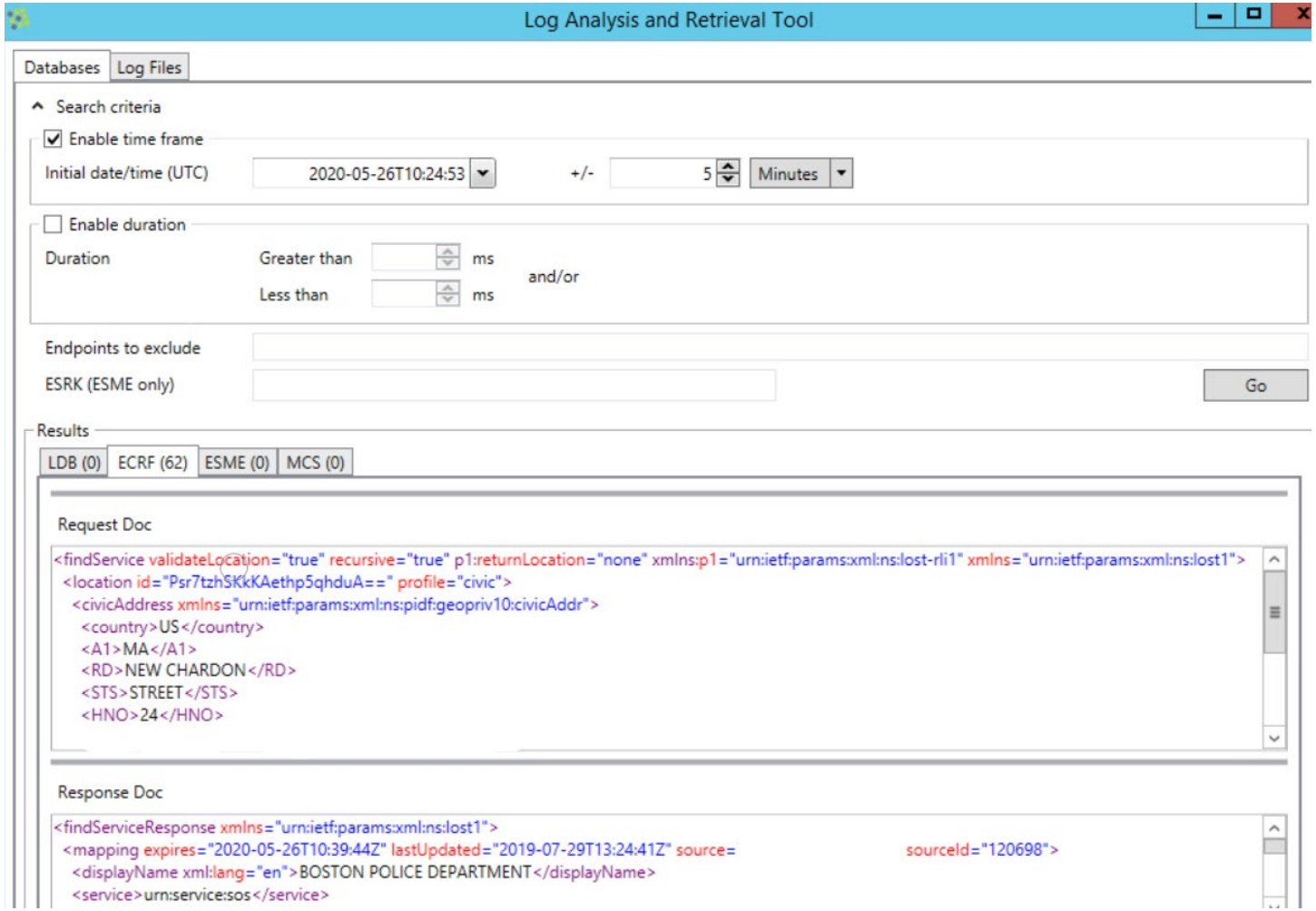


Figure 22. Query/Response Pair Search from Database Store using LART tool

	Next Generation Core Services Elements (NGCS) **Emergency Call Routing Function (ECRF)** **Supported Functions** The ECRF shall support each of the following items. Describe how the solution meets or exceeds each of the requirements below:	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
NGCS 49	Bidder Response: **Logging of all connections, connection attempts, data updates, ECRF query results, and LoST transactions** Multiple levels of logging are implemented by the ECRF/LVF to capture all relevant information. All connections and connection attempts are recorded by the logging mechanisms built into Microsoft Internet Information Services (IIS). All LoST queries and responses are logged both to the i3 event logging service and to an independent centralized ECRF logging database. Debug logging can also be enabled on the ECRF with minimal impact, and this method provides more specific detail regarding query processing. GIS data updates are all logged by DDTi's DataManager, and a history of recent GIS edits are stored for every GIS feature. **Location error identification** The ECRF is provisioned by DataManager, which acts as the SI. All errors in the GIS are identified in DataManager before they can be published to the ECRF. DataManager can block the publishing of GIS data to the ECRF based upon publishing thresholds that are tied to the severity and volume of any errors found. For example, a gap in the service polygons is likely to be confirmed as a critical error, and DataManager will block the publishing of this error to the ECRF until remediation has occurred. All identified errors are published back to the GIS group responsible for maintaining the data so that remediation work can be performed before the data is resubmitted. **Updates from the SI in near-real-time with no degradation of LoST services** DataManager provides an interface for provisioning updated GIS data to the ECRF/LVF. Upon receipt of updated GIS data, DataManager performs a substantial amount of QC checks to avoid provisioning the ECRF/LVF with bad data. The time it takes to run these checks will vary based upon the number of changes in the GIS data. Once QC has completed its checks, actual provisioning of the GIS data to the live ECRF/LVF instances is relatively quick (typically within minutes). The DataManager and ECRF/LVF system uses a concept of master and replica databases. The master database is not used in live call flow and is where any intensive processing takes place, such as the QC workflows. When an update is committed to the master database by DataManager, it is replicated using the RDBMS native replication process to each of the live call flow ECRF/LVF database instances. This happens in the background and has little or no impact on the ECRF/LVF query performance. **Routing of calls based upon geographic coordinates, geodetic shapes, and civic addresses** The ECRF/LVF fully supports both civic and geodetic profiles. During the transition phase, the LDB will provide all location data, either directly or indirectly (via an E2 connection). For wireline calls, the LDB will contain a valid LVF and a CLDXF-compliant address location. For wireless, the LDB				

	will contain a shell record and will attempt to obtain more granular location data over E2 from the MPC. Location data from the MPC will consist of a point and a confidence radius. This location data is converted by the LDB into a circle that can be used by the ECRF for determining call routing. For VoIP, the LDB may contain either a civic address location or a shell record. If it is a shell record, the LDB will attempt to query the VoIP Positioning Center (VPC) for a more granular location. For VoIP, the E2-provided location could be geodetic or civic, or both. If the VPC provides a civic address location, it will be in the legacy MSAG format, so the LDB will utilize the MCS to convert the location into a CLDXF-compliant PIDF-LO. The ECRF/LVF also supports all other geodetic shapes as specified by *RFC 5222* (point, polygon, circle, ellipse and arcband), but only "circle" is currently used in active deployments. **Utilization of common GIS boundaries, including, but not limited to, PSAP, law enforcement, fire, and emergency medical services (EMS)** Different service polygons can be used to represent different service request types (such as police, fire, and EMS), represented by the service URN in the LoST query. The Comtech ECRF/LVF fully supports the service-naming conventions defined in *RFC 5031*, including the top-level services and sub-services defined therein. Support for services defined in the future is provided via configuration updates. Service substitutions are also supported and may be configured to return a mapping for an alternate service, if the desired service is not available for the queried location. For example, if the ECRF receives a query for *urn:service.sos.physician*, but no physician service polygon is defined for that location, the ECRF can be configured to respond with a mapping for another service, such as *urn:service.sos*. **Permitting of LoST queries for find a service request association with each layer** Different polygon layers can be used to represent different service request types (such as police, fire, and EMS), represented by the service URN in the LoST query. At a minimum, a layer that represents the top level urn:service.sos is required. **Compliance with NENA 02-010 and NENA 02-014** *NENA 02-010 (now NENA STA-015.10-2018)* is a legacy standard and has been superseded by *NENA-STA-006.1.1-2020 (NENA Standard for NG9-1-1 GIS Data Model)* and *NENA-STA-004.1-2014 (NENA Next Generation United States Civic Location Data Exchange Format CLDXF)*. The ECRF/LVF fully complies with these new standards. *NENA 02-014* is also a legacy standard. For example, it requires an Emergency Service Zone (ESZ) layer, which has no role in an NG911 deployment. **Dynamic updates to GIS without disrupting the ECRF** The Comtech ECRF/LVF supports dynamic override service polygons. This feature allows authorized users to draw polygons on a map display and specify a new call route for any calls that fall within that polygon. **Validation of GIS updates before they are provisioned into the ECRF** DataManager, which acts as the SI, provides the interface for provisioning updated GIS data to the ECRF/LVF. Upon the receipt of updated GIS data, DataManager performs a substantial amount of QC checks to avoid provisioning the ECRF/LVF with bad data. The time it takes to run these checks will vary based upon the number of changes in the GIS data. Once QC has completed its checks, the actual provisioning of GIS data to the live ECRF/LVF instances is relatively quick. More extensive detail on this data validation is provided in the SI section of this response.

Attachment "C"
Option C Revision One
Technical Requirements
Public Service Commission ESInet
Request for Proposal Number 6264 Z1

Any additional documentation can be inserted here:

	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
Logging of all connections, connection attempts, data updates, ECRF query results, and LoST transactions	X			
Location error identification.	X			
Updates from the SI in near real-time with no degradation of LoST services	X			
Routing of calls based on geographic coordinates, geodetic shapes, and civic addresses	X			
Utilization of common GIS boundaries, including, but not limited to, PSAP, law enforcement, fire and emergency medical services (EMS).	X			
Permitting of LoST queries for find service request association with each layer.	X			
Compliance with NENA 02-010 and NENA 02-014.	X			
Dynamic updates to GIS without disruption of the ECRF.	X			
Validation of GIS updates before they are provisioned into the ECRF.	X			

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 50	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **User Interface and Provisioning** Define bidder's method for: 1. provisioning the ECRF; 2. updating the ECRF (including the frequency of updates); 3. validating data provisioning; 4. performing error logging; 5. performing gap and overlap analysis; and 6. supporting LoST queries from ESRPs, the PSAP CHE, and other authorized hosts within the ESInet. 7. Provide a clear description of the functionality of the ECRF; list features and capabilities; 8. describe the error handling, default mechanisms, and logging; and 9. provide an overview of deployment recommendations to achieve 99.999 percent reliability.	X			
	Bidder Response: **Provisioning the ECRF, updating the ECRF (including the frequency of updates), and validating data provisioning** The GIS data provisioned to the ECRF/LVF can be updated as often as the Commission may desire. These updates should take place at least weekly, although daily updates are optimal. Provisioning of the ECRF/LVF is accomplished using the DataManager product. Comtech will work with each jurisdiction that is providing GIS data to determine an automated process for receiving data updates. This is typically accomplished by the secure transfer of a file-based GIS format, such as an Esri file geodatabase. Multiple layers of testing are performed whenever new GIS is received. Initial tests will check layer availability, and subsequent tests evaluate its completeness. For example, the DataManager system will test new GIS data to ensure required fields are complete prior to loading. The following screenshot shows an email report for a successful load of new GIS data into the system (note, at this stage, nothing has been published to the ECRF/LVF).				

```
Results for Spatial Data Import to Mass:[redacted]

Import Layer:  Address_Points -> Addresses (SkipOnErrors=True, AllowMultiGeometry=False, BlankOutUnmappedFields=False, PartialDatasetDetection=True (diff of 10% or 300000 records
triggers partial), AliasRecordsCheck=False (ExpectedCount=-1, DeviationPercent=-1), CommitFrequency=1000, DataTable=False, ChangeReport=False (ReportName=ChangeReport,
ChangeTypes=AMD, NewPrefix=NEW_, OldPrefix=OLD_, EmailReport=False, ReportDir=), 26 fields).
Source file:  'D:\DDTI\Data Import Server\Drops\FDB\MassAddresses\EXPORT_PRODUCT.gdb [Address_Points], ID=131693296691009529'.

Target validation SUCCEEDED
Source validation SUCCEEDED

+++++ IMPORT STARTED
3382642 source records to import
2387 source records ADDED
1125 source records UPDATED
544 records DELETED from the target
+++++ IMPORT DONE

Import SUCCEEDED
Process FINISHED normally

Files have been moved to 'D:\DDTI\Data Import Server\Data\FileGeodatabase\Finished\131693296691009529-EXPORT_PRODUCT.gdb'
```

The load process performs a change detection against the data that currently exists in DataManager, and only processes records that have changed.

If minimum data requirements are not met (e.g., expected layers are missing from the source data, duplicate unique IDs are present, or spatial inconsistencies such as invalid geometry or multi-part features are detected), email notifications will be sent that identify these errors. As a result, processes can be placed on hold until corrections are made, and remediated data is uploaded.

The following screenshot is a sample email report that shows a failed update of an address point layer (the errors shown are for duplicate IDs in the unique ID field). This report only indicates the update could not be processed; this is not a report for actual spatial quality errors in the data, which occurs following a successful update.

SDI: Incomplete Import for Address_Points

SDI_Errors.txt
2 KB

Results for Spatial Data Import to Mass:

Import Layer: Address_Points -> Addresses (SkipOnErrors=True, AllowMultiGeometry=False, BlankOutUnmappedFields=False, PartialDatasetDetection=True (diff of 10% or 300000 records triggers partial), AliasRecordsCheck=False (ExpectedCount=-1, DeviationPercent=-1), CommitFrequency=1000, DataTable=False, ChangeReport=False (ReportName=ChangeReport, ChangeTypes=AMD, NewPrefix=NEW_, OldPrefix=OLD_, EmailReport=False, ReportDir=), 26 fields).
Source file: 'D:\DDTI\Data Import Server\Drops\FDB\MassAddresses\EXPORT_PRODUCT.gdb [Address_Points], ID=131462546880251231'.

Target validation SUCCEEDED
Source validation SUCCEEDED

+++++ IMPORT STARTED
3361125 source records to import
+++++ IMPORT DONE WITH ERRORS

Import FAILED
Process FAILED with errors
Review the attached file for error details.

Files have been moved to 'D:\DDTI\Data Import Server\Data\FileGeodatabase\Incomplete\131462546880251231-EXPORT_PRODUCT.gdb'

SDI_Errors (003).txt - Notepad

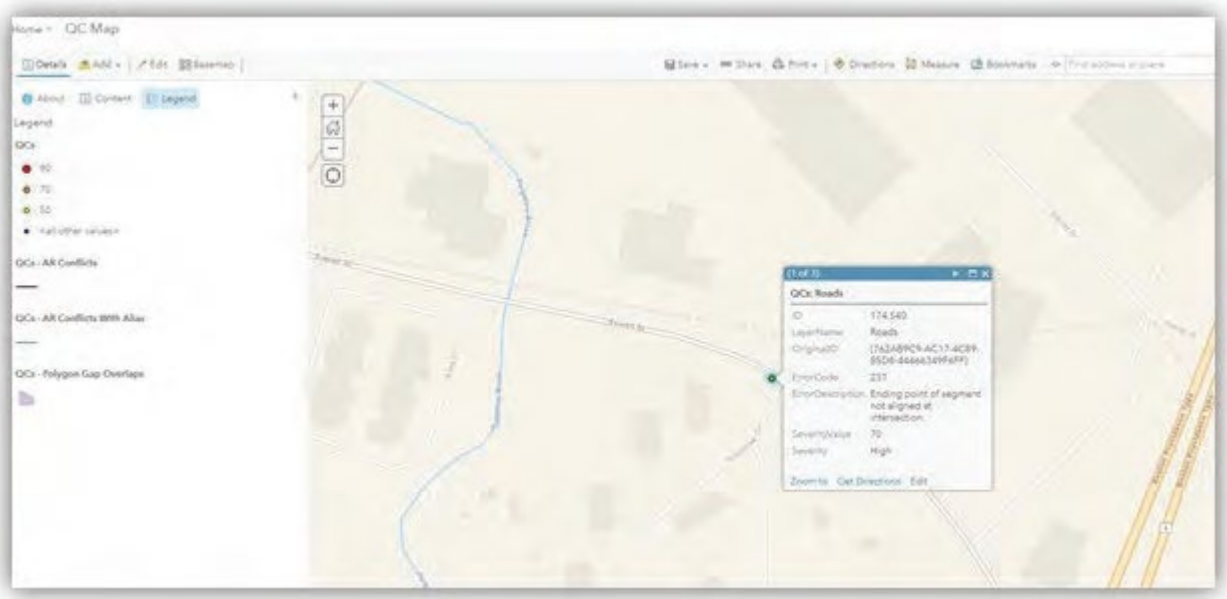
File Edit Format View Help

```
20 IMPORT ERRORS ------------------------------
    DUPLICATE UIDs in target: 1402104 maps to FIDs 2864811, 2864830
    DUPLICATE UIDs in target: 1423776 maps to FIDs 2864810, 2864821
    DUPLICATE UIDs in target: 1971725 maps to FIDs 2866869, 2866870
    DUPLICATE UIDs in target: 2405427 maps to FIDs 2865818, 2865824
    DUPLICATE UIDs in target: 2606355 maps to FIDs 2865816, 2865873
    DUPLICATE UIDs in target: 2607370 maps to FIDs 2865814, 2865823
    DUPLICATE UIDs in target: 2631211 maps to FIDs 2877983, 2877993
    DUPLICATE UIDs in target: 2765674 maps to FIDs 2862857, 2862865
    DUPLICATE UIDs in target: 2765732 maps to FIDs 2862856, 2862862
    DUPLICATE UIDs in target: 2896488 maps to FIDs 2862858, 2862866
    DUPLICATE UIDs in target: 2903400 maps to FIDs 2862861, 2862867
    DUPLICATE UIDs in target: 3117602 maps to FIDs 2865821, 2865825
    DUPLICATE UIDs in target: 3138520 maps to FIDs 2865820, 2865874
    DUPLICATE UIDs in target: 3265236 maps to FIDs 2865813, 2865822
    DUPLICATE UIDs in target: 3500779 maps to FIDs 2858849, 2858898
    DUPLICATE UIDs in target: 3591581 maps to FIDs 2859801, 2859804
    DUPLICATE UIDs in target: 3592818 maps to FIDs 2859802, 2859806
    DUPLICATE UIDs in target: 3593485 maps to FIDs 2859803, 2859805
    DUPLICATE UIDs in target: 65069 maps to FIDs 2864808, 2864826
```

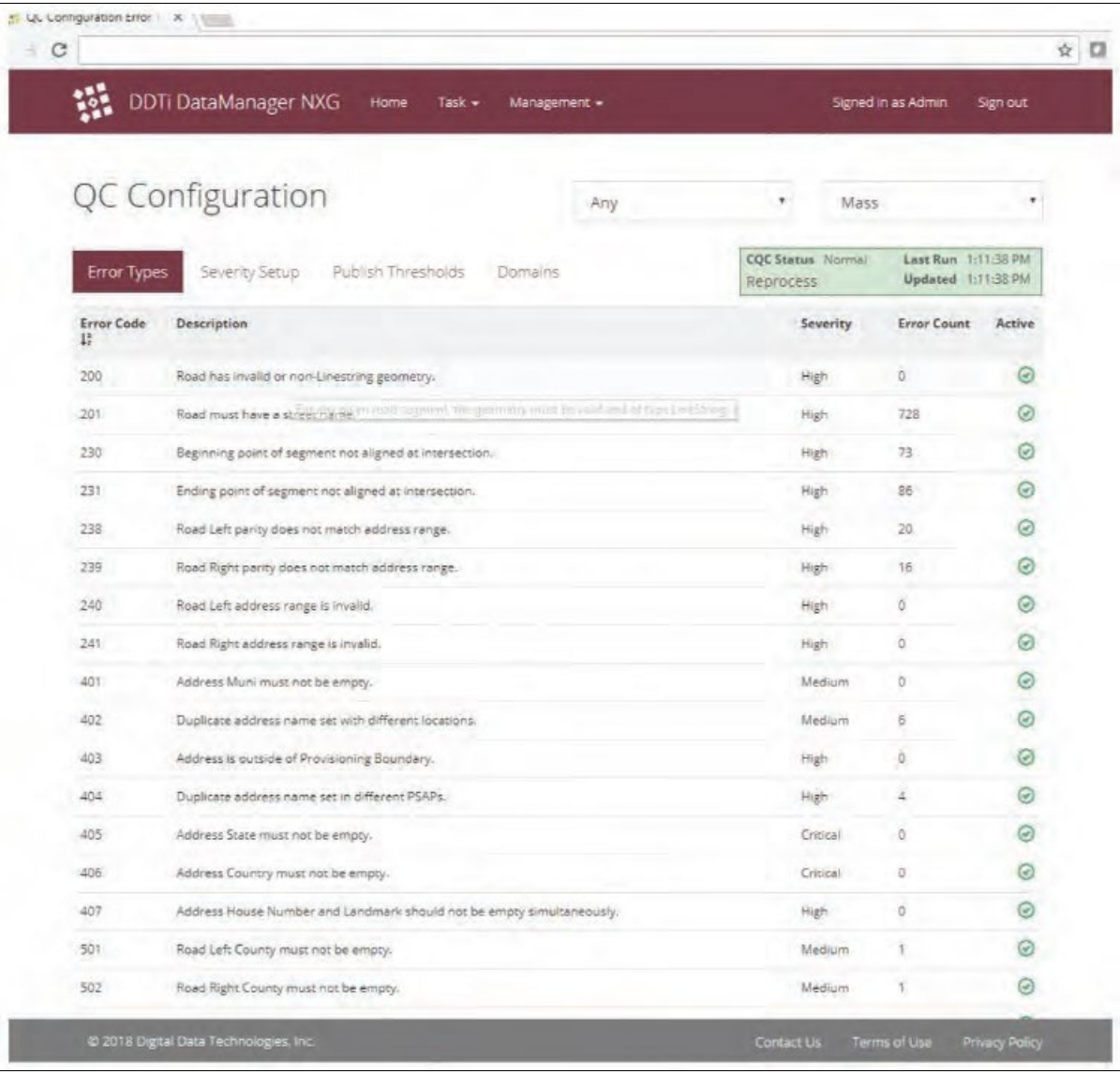
If the data passes the import checks, it will be loaded into DataManager where more granular and spatial quality controls are performed. If there are any discrepancies, this process updates the QC tables.

Data that passes QC can then be provisioned in near-real time to other systems within the network, including the ECRF/LVF. Customized publishing of data can also occur for use in other systems, such a CAD or a PSA Tactical Map Display.

Any errors found within the data are published as an Esri ArcGIS web service feature layer (although the errors can also be sent to the county in a file-based format), which allows GIS users to add this layer to ArcMap to provide real-time context to the location and nature of the errors. The following screenshot shows a sample quality control error layer displayed in ArcGIS Online.



A web interface is provided within the solution that allows authorized users to configure GIS QC checks, set quality control thresholds, and view reports on QC metrics. The following screenshot shows the QC configuration page of the DataManager web interface.



Error Code	Description	Severity	Error Count	Active
200	Road has invalid or non-Linestring geometry.	High	0	✓
201	Road must have a street name.	High	728	✓
230	Beginning point of segment not aligned at intersection.	High	73	✓
231	Ending point of segment not aligned at intersection.	High	86	✓
238	Road Left parity does not match address range.	High	20	✓
239	Road Right parity does not match address range.	High	16	✓
240	Road Left address range is invalid.	High	0	✓
241	Road Right address range is invalid.	High	0	✓
401	Address Muni must not be empty.	Medium	0	✓
402	Duplicate address name set with different locations.	Medium	6	✓
403	Address is outside of Provisioning Boundary.	High	0	✓
404	Duplicate address name set in different PSAPs.	High	4	✓
405	Address State must not be empty.	Critical	0	✓
406	Address Country must not be empty.	Critical	0	✓
407	Address House Number and Landmark should not be empty simultaneously.	High	0	✓
501	Road Left County must not be empty.	Medium	1	✓
502	Road Right County must not be empty.	Medium	1	✓

	Each jurisdiction will have its own set of layers within DataManager, and there will also be one aggregated statewide dataset. When changes occur to a jurisdictional GIS layer, and those changes pass the QC checks, they will be pushed to the aggregated statewide dataset where additional QC checks are run (something might not be an error at the local dataset level but could be an error at the aggregated dataset level, such as a duplicate address). The DataManager system will attempt to publish GIS data updates to the target ECRF/LVF systems, based upon existing publishing rules. Publishing rules are configured within the QC configuration. For example, if there are gaps or overlaps in the datasets and a zero tolerance for gaps and overlaps has been agreed upon, the data will not be published to the ECRF. Any errors, along with their locations, will be sent to the appropriate entity, and resolution must be achieved and data resent to the system upon remediation. **Performing error logging** Multiple levels of logging are implemented by the ECRF/LVF to capture all relevant information. All connections and connection attempts are recorded by the logging mechanisms built into IIS. All LoST queries and responses are logged both to the i3 event logging service and to an independent centralized ECRF logging database. Debug logging can also be enabled on the ECRF with minimal impact, which provides more specific detail regarding query processing. Additionally, informational and error messages can be written to other tools, such as DataDog or Seq. **Performing gap and overlap analysis** As part of the GIS data provisioning process, the DataManager product performs checks on polygon layers for gaps and overlaps. Typically, publishing thresholds are set to block a polygon layer from being published to the ECRF/LVF if it contains a gap or overlap. The following screenshot shows a sample QC report from the DataManager interface, highlighting the gap and overlap QC checks.

605	Service Boundary	Service boundary override service URN must not be empty.	Critical	0	
608	Service Boundary	Service boundary display name must not be empty.	Medium	0	
619	Service Boundary	Service boundary has one or more invalid URIs.	Critical	0	
620	Service Boundary	Service boundary SIP URI must start with sip: or sips:.	Critical	0	
621	Service Boundary	Service boundary SIP URI is not a known URI.	Critical	0	
622	Service Boundary	Service boundary SIP URI is missing.	Critical	0	
630	Service Boundary	Service boundary overlaps another.	Critical	0	
640	Service Boundary	Service boundary extends beyond Provisioning Boundary.	Critical	0	
650	Service Boundary	Gap in service boundary layer.	Critical	0	
680	Service Boundary	SQL geography is not valid.	Critical	0	
700	Address	Not a registered value for Address MSAG Community.	Medium	0	
701	Address	Not a registered value for Address PRD.	Medium	0	
702	Address	Not a registered value for Address POD.	Medium	2	
703	Address	Not a registered value for Address STS.	Medium	2	

47 Total Records Previous 1 2 3 Next 20

Additionally, as with point-and-line QC errors, polygon errors can be shared back to the appropriate GIS authority as a map layer, either file-based or as a web service.

Supporting LoST queries from ESRPs, the PSAP CHE, and other authorized hosts within the ESInet

The ECRF/LVF supports all query and response types defined in the LoST protocol *RFC 5222*. The ECRF/LVF allows access to the LoST interface with firewall rules, preventing unauthorized access.

Providing a clear description of the functionality of the ECRF, with list features and capabilities

The ECRF/LVF system utilizes a Microsoft SQL Server backend, and it employs Microsoft IIS for the http(s) interface. A master ECRF/LVF receives GIS data updates from DataManager. These updates are then replicated to each ECRF/LVF instance, each of which use their own replica of the

	database. Any failure in the master database would have no impact on the replica databases, allowing each ECRF/LVF instance to continue to be fully functional (although no GIS data updates would process until the master database is back online). The Comtech ECRF/LVF is a fully standards-compliant LoST Server as defined by RFC 5222. The LoST protocol also provides extension points for errors, warnings, and location validation. The Comtech ECRF/LVF already includes several such extensions used to better characterize the quality of the response, and we anticipate that similar or equivalent extensions will be standardized by NENA at some future point. Additionally, there is a standards-track draft "*draft-ietf-ecrit-similar-location*" extension to LoST that will allow a LoST server to respond with suggested locations whenever the location used in the *findService* query is invalid or incomplete. This feature has been implemented in the Comtech ECRF/LVF and can be used by the Comtech LDB to provide users with assistance in resolving discrepancies. **Describing the error handling, default mechanisms, and logging** The Comtech ECRF/LVF is designed to answer queries with the most useful possible response for the given query parameter, and it takes full advantage of the errors and warnings defined for the LoST protocol, when needed. If the location in the query is malformed in such a way that it cannot be understood, the server will return a descriptive error message that documents the problem to its best possible determination. If a civic location is correctly formed but is simply invalid, meaning that it cannot be uniquely resolved to a specific GIS feature, there are several possible outcomes depending on how much of the location is considered valid. It is possible that the query may still return correct call-routing information, multiple sets of call-routing information (if the location is ambiguous), or default call-routing information accompanied by a warning. Multiple levels of logging are implemented by the ECRF/LVF to capture all relevant information. All connections and connection attempts are recorded by the logging mechanisms that are built into IIS. All LoST queries and responses are logged both to the i3 event logging service and to an independent centralized ECRF logging database. Debug logging can also be enabled on the ECRF with minimal impact and provides more specific detail regarding query processing. **Providing an overview of deployment recommendations to achieve 99.999 percent reliability** The ECRF/LVF system runs in a high-availability architecture to achieve the required five-nines up-time metric. Typically, two to four instances of the ECRF/LVF are deployed per data center, running behind load-balancing hardware. Each instance runs on its own VM or container, utilizing its own replica database instances. These load balancers perform a health check against each instance, once per second, and they will automatically pull an unhealthy element from the pool and raise a system alert. A single instance of each element has sufficient capacity to run the entire system, should there be multiple simultaneous failures of elements.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 51	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **Hierarchical Integration with Other ECRFs** The ESInet will be part of an overall hierarchical plan that includes interconnectivity to other regions and ECRFs. Provide details regarding bidder's vision for how this interconnection will include replicas of ECRF/LVF at different levels of the hierarchy, as well as access/origination networks.	X			
	Bidder Response: Comtech will deploy an ECRF/LVF system that is authoritative for the state and any other jurisdictions that become part of the project. Once neighboring state-level ECRF/LVFs are provisioned, tabular and spatial authoritative coverage regions will be provided to each state-level ECRF/LVF vendor so their state-level ECRF/LVF can be provisioned with this information. The state-level neighboring ECRF/LVFs will also need to provide coverage data for provisioning in the Nebraska ECRF/LVF. IP connectivity will need to be established between each neighboring state-level ECRF/LVF and the Nebraska ECRF/LVF defined for this project to allow recursion between the systems, based upon the authoritative coverage data. For example, for civic address locations the Nebraska ECRF/LVF might be considered authoritative for: A1 = NE and Country = US. The Nebraska ECRF/LVF would then be provisioned for recursively sending civic address queries to the neighboring state-level ECRF/LVF where A1 = SD (for example). A similar process is required for geodetic queries. A polygon will be loaded into the Nebraska ECRF/LVF that defines the geographic area where it is authoritative. This same polygon will be provided to the neighboring state-level ECRF/LVFs. If a neighboring state-level ECRF/LVF receives a geodetic query that falls inside that polygon, it will know to recursively send the query to the Nebraska ECRF/LVF for the authoritative answer (or, using an iterative approach, it will respond to the query with the application string of the Nebraska ECRF/LVF so the client can directly query it). This approach will create a multi-state LoST tree and can be used until a National Forest Guide is available to create a LoST tree hierarchy.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 52	**Next Generation Core Services Elements (NGCS)** **Emergency Call Routing Function (ECRF)** **Forest Guide** Provide explanations of any tradeoffs between aggregations of data at higher-level ECRFs versus the use of Forest Guides (as defined in NENA-INF-009.1-2014) to refer requests between ECRFs that possess different levels of data. As part of that explanation, provide details on how the appropriate ECRF/LVF data will be managed and provisioned for use in overload and backup routing scenarios in the current environment, and any dependencies that might impact provisioning.	X			

Bidder Response:

The LoST protocol is designed for servers to be organized in hierarchical trees, and for queries to automatically navigate the tree structure until the authoritative server for the queried location is reached. The tree structure of the LoST system allows GIS data to be maintained in any number of independent, authoritative datasets for different regions, each with its own logical ECRF/LVF node. These nodes may or may not reside on the same physical servers as other ECRF/LVF nodes. Forest guides are LoST servers that facilitate navigation between trees in the LoST hierarchy, but they are not sufficiently authoritative to answer queries on their own and are not provisioned with data other than coverage regions of the root nodes.

The LoST hierarchy is built as a collection of LoST trees, each represented by a root node that is authoritative for one or more areas designated by coverage regions. Each root node publicizes its coverage regions via forest guides. Each root node may optionally delegate some or all of its authority to one or more lower-level child nodes. This delegation is also expressed using coverage regions that are narrower in scope than those representing the entire root node. These smaller coverage regions must be shared between a parent and its child but are not distributed to forest guides. Each child node, in turn, may further delegate authority to children of its own.

There is no requirement that a root node ECRF/LVF should be authoritative for a specific size or scope of area, although it is generally suggested that root nodes are on the scale of a country or a state. This provides individual jurisdictions with the flexibility to determine how to deploy ECRF/LVF services. Deployment can be in cooperation with other ECRF/LVFs in an existing tree structure, or a new root node can be declared. Smaller jurisdictions that are prepared to move forward earlier than others in their region may initially deploy an ECRF/LVF as a root node, but they expect to have that node moved under a larger parent in the future. This methodology will affect the coverage regions represented in forest guides, and to a lesser effect how often a forest guide is needed to allow a query to navigate the LoST hierarchy.

The question of GIS data aggregation does not directly determine whether a node is a root node or a child node, but rather determines whether a given area is represented by one logical ECRF node or many (which may or may not fall under a common parent). In either case, the LoST protocol is designed to work seamlessly. There are some tradeoffs, however, between aggregation or non-aggregation.

The aggregation of independently maintained datasets requires an extra level of error checking, may present challenges in obtaining a consistent level of quality throughout the dataset, and requires the data aggregator to deal with any boundary/edge issues in order to present a single, usable set of data to the ECRF/LVF. Placing individual datasets into their own ECRF/LVF nodes requires coverage regions to be created that accurately describe the areas where each node is authoritative, but it furthermore establishes a more direct line of responsibility and isolates any GIS issues so they cannot block updates to data contained in other nodes.

Comtech recommends data aggregation be used if the combined data represents a contiguous area of similar quality, presuming the aggregator can be treated as the authoritative source of that data and is effective in correcting errors in the data. If these conditions are not met, it may make more sense to keep the datasets isolated.

	A logical ECRF/LVF node can essentially be hosted with as many replicas and at any locations the responsible authority wishes. Smaller nodes may be able to take advantage of the performance benefits of distributed computing when placed on separate physical hosts, but they incur virtually no penalty when co-hosted versus the same data combined into a single dataset. Every ECRF/LVF query must be answered with a service mapping from the authoritative logical node. ECRF/LVFs that are not authoritative for a queried location can answer using cached mappings in some cases, but they cannot independently generate a result where the authoritative node cannot be reached. Furthermore, because the expiration time of cached mappings is typically very short (literally within minutes), it is unlikely that non-authoritative servers will be of any substantial benefit in the event the authoritative node fails. There is no mechanism for one logical ECRF/LVF node to "take over" for another. The requirement to have reliability and high availability of the ECRF/LVF service should not be a factor in decisions regarding the aggregation of data. Instead, every logical node should simply be deployed in a geo-diverse manner while using as many replicas as needed to obtain both the desired performance and level of reliability. Some or all replicas could conceivably be hosted on common hardware with other logical ECRF/LVF nodes. The provisioning of all replicas of a logical node must be identical but remains completely independent (aside from shared resources such as disk space) of provisioning for any other nodes that happen to be hosted in the same location.

Any additional documentation can be inserted here:

NGCS 53	**Next Generation Core Services Elements (NGCS)** **Location Validation Function (LVF)** An LVF is a LoST protocol server where civic location information for every call originating endpoint is validated against the SI-provisioned GIS data Describe how the LVF solution interfaces with other LVF solutions which may interface with bidder's solution. Contractor shall coordinate with other LVF solution providers to ensure interoperability between the respective solutions.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: The LoST protocol does not currently provide a manner to separate LVF queries from ECRF queries. These queries are identical, except that an LVF will always have the optional "*validateLocation*" flag set to true, whereas an ECRF query may set this flag to either true or false. There is no mechanism to conclusively identify the intent of the LoST query (ECRF or LVF). Given this, there are no specific ECRF servers and LVF servers, only a LoST (ECRF/LVF) server. All ECRF/LVF server instances are provisioned identically and simultaneously. However, different instances of the ECRF/LVF servers can be used by different elements to separate out call-routing queries from validation queries. This is easily accomplished through DNS. Given this situation, each ECRF/LVF or LoST server within the Nebraska solution can be made part of a larger LoST tree system by instituting interconnection agreements and the appropriate networking between the nodes. Presuming all nodes will strictly adhere to *RFC 5222* and any other applicable standards, interfaces with other ECRF/LVF instances can be accomplished.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 54	**Next Generation Core Services Elements (NGCS)** **Location Validation Function (LVF)** **LVF Description** The SI is responsible for provisioning and updating the information used for location validation in the LVF, which shall contain a standardized interface to the SI. Describe how the LVF solution meets the above requirements**.**	X			
	Bidder Response: As the Comtech ECRF/LVF system is deployed as a series of LoST servers, where each instance is identical, the provisioning of the LVF and ECRF are the same. Each LoST server is a provisioning target of the SI. As of *NENA-STA-010.2-2016*, there is still not an implementable standard for the SI. As such, the current interface between the SI and ECRF/LVF is web services.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 55	**Next Generation Core Services Elements (NGCS)** **Location Validation Function (LVF)** **Location Validation** The LVF shall be available to validate civic locations at the time a wireline device is ordered— e.g., Service Order Interface (SOI) validation—when a nomadic device is connected to the network, and when a PSAP or other authorized entity makes a civic location validation request. The LIS/LDB shall be allowed to periodically revalidate the civic location information against the GIS data contained within the LVF. Describe how the solution meets or exceeds the above requirements.	X			

Bidder Response:

Location validation prior to the use of that location in an emergency call is one of the fundamental principles within NG911. The Comtech ECRF/LVF is designed to be deployed as a highly available service that can run without interruption. The ECRF/LVF will be available for validating locations that fit the civic location profile as described in *RFC 5222*. The use of location validation prior to the use of that location in an emergency call is one of the fundamental principles in NG911.

The ECRF/LVF will be accessible to all endpoints within the ESInet and trusted networks, as well as made publicly accessible via the internet. This is necessary both for call routing and so that any device or location server can pre-validate civic locations.

SOI records do not fit the civic location profile required for LoST queries, and they contain data that does not follow CLDXF standards. To ensure that SOI records can be directly validated by a compliant ECRF/LVF, a LDB must be used to first convert (with the use of the NENA-defined MCS) the SOI data to a CLDXF-compliant PIDF-LO.

Although the ECRF/LVF itself cannot initiate the revalidation of civic locations contained within the LDB or any other location server (it can only respond when queried), the periodic revalidation of all civic location records is expected and the ECRF/LVF will be sized with sufficient capacity to handle such ongoing revalidation activity.

The Comtech ECRF/LVF is fully compliant with *RFC 5222*, supporting the optional "*validateLocation*" attribute of a LoST query. Additionally, the ECRF/LVF has been extended to include the Emergency Context Resolution with Internet Technologies (ECRIT) Similar and Complete Location standard, allowing additional useful information to be passed back to clients who make validation queries.

The LDB has three different mechanisms for revalidation:

- A full revalidation runs as a scheduled job to periodically revalidate every civic address record in the LDB against the GIS, using an LVF query.
- A discrepancy revalidation runs more frequently and revalidates LDB records that were previously flagged as being LVF-invalid.
- A targeted revalidation runs when GIS data in the ECRF/LVF system has been updated, and it revalidates civic address records in the LDB that may have been affected by specific changes to the GIS data.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 56	**Next Generation Core Services Elements (NGCS)** **Location Validation Function (LVF)** **High-Availability Design** The LVF shall support all functionality as defined in NENA-STA-010.2-2016, shall be designed with resiliency and redundancy to provide a minimum of 99.999 percent availability, and shall be provisioned with the same data as the ECRF. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's NGCS service provides high availability, no single point of failure, and 99.999 percent reliability. The NGCS service is deployed in two distinct geographical locations with redundant ISP links. The Comtech ESInet service utilizes diverse carriers and diverse paths for redundancy to provide service to all PSAPs. Devices at each of the NGCS data centers are deployed in ahigh availability configuration using various technologies. Dynamic routing protocols (i.e., BGP or OSPF) are used for route convergence in the event of a device failure. In addition, BFD is used to provide fast-forwarding path detection failure for all routing protocols. As previously described, the ECRF/LVF system is deployed as a series of LoST servers, where each server is identical regardless of its primary function (whether live call-flow routing or civic address validation). The ECRF/LVF system runs in a high-availability architecture to achieve the required five-nines up-time metric. Typically, two to four instances of the ECRF/LVF are deployed per data center, running behind load-balancing hardware. Each instance runs on its own VM, utilizing its own replica database instances. These load balancers perform a health check against each instance, once per second, and they will automatically pull an unhealthy element from the pool and raise a system alert. A single instance of each element has sufficient capacity to run the entire system, should there be multiple simultaneous failures of elements.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 57	**Next Generation Core Services Elements (NGCS)** **Location Validation Function (LVF)** **Public-Facing LVF** Outline options for a public-facing LVF provisioned for use by service providers outside the ESInet.	X			
	Bidder Response: Location validation prior to using that location in an emergency call is one of the fundamental principles in NG911. This means that location validation must be available to all devices and service providers via a public interface. Because the ECRF/LVF is a critical functional element, used both within and external to the ESInet, separate internal and external ECRF/LVF replicas will be deployed for each logical node. Internal ECRF/LVF replicas will be deployed within the ESInet and will only receive queries that originate internally or from other trusted ESInets. External ECRF/LVF replicas will be deployed within a DMZ and will handle all queries that originate from untrusted networks and the public Internet. If all external ECRF/LVF replicas are attacked or compromised, the internal replicas will still be available to service internal validation and calls from trusted networks. Both internal and external ECRF/LVF servers are critical to performing location validation and placing 911 calls in a NG911 environment, and both tiers will be deployed in highly available and redundant configurations.				

Any additional documentation can be inserted here:

	Next Generation Core Services Elements (NGCS) **Location Validation Function (LVF)** **User Interface and Security** Describe the functionality of the proposed LVF solution in sufficient detail to address the requirements outlined in NENA-STA-010.2-2016, with particular attention to: 1. the arrangement of the proposed components; 2. user interface and features; 3. and security aspects.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 58		X			

Bidder Response:

Comtech's ECRF/LVF is a scalable LoST server that adheres to IETF and NENA standards and provides both call-routing and location validation functions. The ECRF/LVF is hosted within IIS, and it connects to a Microsoft SQL Server backend database. This solution leverages numerous Microsoft technologies to provide reliable, highly available, and highly performant service. Hosting the service within IIS also provides timely access to security updates and a rich set of options related to security and management (LoST is transported over HTTP and HTTP-over-TLS).

The LoST protocol is specified in *RFC 5222*, and the ECRF/LVF implementation was designed for strict compliance with that specification to ensure its proper functionality and interoperability with LoST clients, as well as with other ECRF/LVFs. Several related specifications are referenced directly or indirectly by *RFC 5222*, with which the ECRF/LVF also complies. These include:

- RFC 4848 for LoST server name resolution.
- RFC 5031 for service names and format.
- RFCs 4119, 5139, and 5491 for location formats.
- RFC 5582 (informative) for LoST architecture.

The ECRF/LVF also implements requirements that are specific to NENA i3, including:

- Configurable service names, for services beyond those specified in RFC 5031.
- The logging of LoST queries and responses to an i3-compatible logging service.
- The discovery of additional data associated with a location.

As part of Comtech's and DDTi's commitment to standards compliance, DDTi has tested its ECRF/LVF with other vendors at the five most recent NENA ICE events. Comtech and DDTi also participate regularly in NG911 standards development processes, with attention to those standards that affect the LoST protocol and the ECRF/LVF.

The design of the ECRF/LVF allows for flexible hosting options, including multiple replicas. To achieve the availability and reliability needed for NG911, multiple ECRF/LVF replicas will be deployed, each on data center-grade hardware that possesses redundant network connectivity. Redundant load balancers will serve as reverse proxies for all incoming queries, and HTTPS requests will be secured with TLS according to industry best practices.

	Because the ECRF/LVF is a critical functional element used both within the ESInet and by validation and calls originating external to the ESInet, separate internal and external ECRF/LVF replicas will be deployed for each logical node. Internal ECRF/LVF replicas will be deployed within the ESInet and will only receive queries that originate internally or from other trusted ESInets. External ECRF/LVF replicas will be deployed within a DMZ and will handle all queries that originate from untrusted networks and the public Internet. This process helps minimize the security risk associated with operating a service that must be accessible via the public Internet, and it allows internal functionality to continue unimpeded, even if all externally facing replicas are under are attack. Specifications for the ECRF/LVF do not include a traditional user interface. The specified point of interaction for location validation is the LoST query interface, which is an XML-based query/response mechanism that uses HTTP. While the results of a LoST query are human-readable, normally a third-party application is responsible for generating the query and presenting the results to a user. The DDTi LDB Manager website is an example of such an application, as it allows users to enter a location, test its validity, and visualize the results. A user interface is provided for DataManager, the SI, which provides full insight into the GIS data within the ECRF/LVF.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 59	**Next Generation Core Services Elements (NGCS)** **Spatial Interface (SI)** **SI Description** The SI is responsible for provisioning and updating authoritative GIS data to the ECRF, the LVF, the map viewer, the PSAP tactical map display, CAD systems, and similar applications that consume GIS data. GIS data provisioned by the SI shall undergo data-quality and data-integrity checks to ensure that the data complies with all applicable requirements of NENA 02-010, NENA 02-014, and Attachment B of NENA-STA-010.2-2016. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: *NENA 02-010* and *NENA 02-014* are mostly legacy standards and are superseded by NG911 standards, including *NENA-REQ-002.1-2016*, *NENA-STA-005.1.1- 2017* and *NENA-STA-006.1-2018*. Adherence to these updated standards and data models is preferred. *NENA Next Generation 9-1-1 Data Management Requirements (NENA-REQ-002.1, Section 3.3)* states: "It is expected that 9-1-1 Authorities will perform Quality Assurance/Quality Control (QA/QC) processes listed above prior to provisioning the data into the SI thus minimizing the errors and resolution timeframe for the provisioning process." Some issues that could be reported back to the 911 authority from the SI include the following: • Invalid geometry • Gap/overlap • Duplicate attribute as defined by the SI system • Mandatory field(s) missing or mismatched data types • Address range issues on centerline • General provisioning failure to SI or ECRF/LVF • Malformed URI There are many more data QC checks that should be performed, and with different data QC gateways the GIS department(s) and 911 authority have the flexibility to identity errors at a much earlier stage than the SI. GIS data QCs occur at multiple stages. The process starts before data is provisioned, and it is recommended that the MSAG and ALI are rigorously synchronized to the NG911 authoritative GIS layers that will be used for call routing before procurement or implementation of a NG911 system occurs. After this is complete, it is important that an iterative QC occurs each time data is submitted to the system. Between the time a GIS departments data is submitted and before the data is provisioned to the ECRF and LVF, there are two gateways where error trapping can occur; this provides flexibility in QC configurations and allows for critical errors to be identified as early as possible in the replication process.				

For a GIS department that is responsible for maintaining the authoritative GIS data for the service area being provisioned, and along with a 911 Authority, it will have the choice of which QC errors should stop publishing to the ECRF and LVF so the error(s) can be corrected and data re-submitted to the system as soon as possible.

The first data gate is the Data Importing Service. Once successful, it then passes the data to a secondary QC process (DataManager) where, if any discrepancies exist, a QC file will be updated. QCs are returned to a subscribing GIS group, who then become responsible for fixing the data.

The Data Importing Service recognizes and reports general errors from each GIS layer and analyzes and reports on issues with the following factors:

- Data file names
- NG911 schema constraints
- Primary Key inconsistencies
- Unique ID
- Allowable <Null> values
- Default Values
- Spatial Reference Identifier
- Partial dataset detection (configurable)
- Records which break spatial validity rules
- Records that containing multi-part features
- Data type incompatibility
- Alias record duplication

The value of these QCs allows the GIS provider to halt processing and replication before data is entered into DataManager; the subscriber group will then be notified at the earliest possible stage.

At the second data gate (the DataManager product), each QC is assigned a severity level per layer: critical, high, medium, and low. For each layer, publishing criteria can be set for each of these levels. Restrictions can be set based upon the absolute number of errors at that severity level, or based upon a percentile level. Examples of commonly reported errors are shown below

Layer	Error Description	Severity
Emergency Service Boundaries	Gap in service boundary layer.	Critical
Emergency Service Boundaries	Service boundary has one or more invalid URIs.	Critical
Emergency Service Boundaries	Service boundary overlaps another.	Critical
Emergency Service Boundaries	Service boundary override service URN must not be empty.	Critical
Emergency Service Boundaries	Service boundary SIP URI is missing.	Critical

Emergency Service Boundaries	Service boundary SIP URI is not a known URI.	Critical
Emergency Service Boundaries	Service boundary SIP URI must start with sip: or sips:.	Critical
Roads	Road has invalid or non-Linestring geometry.	Critical
Roads	Road has multi-part geometry	Critical
Roads	Beginning point of segment not aligned at intersection.	High
Roads	Ending point of segment not aligned at intersection.	High
Roads	Road Left address range is invalid.	High
Roads	Road Left parity does not match address range.	High
Roads	Road must have a street name.	High
Roads	Road Right address range is invalid.	High
Roads	Road Right parity does not match address range.	High
Addresses	Address Muni must not be empty.	Medium
Addresses	Duplicate address name set with different locations.	Medium
Addresses	Not a registered value for Address Community.	Medium
Addresses	Not a registered value for Address POD.	Medium
Addresses	Not a registered value for Address PRD.	Medium
Emergency Service Boundaries	Service boundary display name must not be empty.	Medium
Roads	Not a registered value for Road Left Community.	Medium
Roads	Not a registered value for Road POD.	Medium
Roads	Not a registered value for Road PRD.	Medium
Roads	Not a registered value for Road Right Community.	Medium
Roads	Road Left County must not be empty.	Medium
Roads	Road Left Muni must not be empty.	Medium
Roads	Road Left State must not be empty.	Medium
Roads	Road Right County must not be empty.	Medium
Roads	Road Right Muni must not be empty.	Medium
Roads	Road Right State must not be empty.	Medium

	Upon achieving successful QC, data from DataManager can be confidently provisioned to any downstream element that consumes the authoritative GIS data, including a PSAP map display, CAD, or other ECRFs.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 60	**Next Generation Core Services Elements (NGCS)** **Spatial Interface (SI)** **Web Feature Service and Updates** The SI shall convert the GIS data into the format (data structure and projection) used by the ECRF and LVF, in real-time or near real-time, using a web feature service. The SI shall be able to provision and perform incremental updates, in near real-time, to the ECRF, LVF, the map viewer service, the PSAP tactical map display and similar applications that consume GIS data. Describe how the solution meets or exceeds the above requirements.	X			

Bidder Response:

Data Publishing
There are several processes for updating data to internal and external systems. The first is the update process to the primary data sources, which consist of the ECRF database(s), the Esri server database(s), and the creation of Esri file formats for possible external distribution. In addition, there are administrative controls to manage and report on the process from the DataManager website. Finally, there are several potential methods that can be used for data distribution beyond these ECRF and Esri databases.

Data Update Overview

ECRF/LVF database(s) Updates
The DataManager publishing mechanism operates by detecting changes made to data held within the DataManager (through the Data Import process, or by editors directly), determining the resulting differences as compared to the current ECRF/LVF database, and then executing SQL transactions to bring the ECRF/LVF database up to date. All change comparison operations that involve ECRF/LVF data are performed on the ECRF/LVF master database, which is not used in LoST query processing. All operational ECRF/LVFs use local replica databases to answer queries. This means the change comparison portion of the ECRF/LVF updates cannot impact live LoST services. The update portion of the process uses SQL transactions specifically designed to minimize the impact to concurrent queries used to answer LoST requests. This minimizes the impact on individual ECRF/LVF replicas when the update transactions are applied. All guaranteed service levels are maintained during an ECRF/LVF data update.

ESRI Server(s) Updates for Tactical Map Display
Existing map datasets are exported from DataManager. These are then migrated to the Esri server to be processed. First, the new Roads and Addresses data is used to update the locator data that is used by the Esri geocoding service. If the Esri server is providing a map tile service, the new data set is compared to the previous version. These are then compared to detect which map tiles need to be updated. Once the map tiles have been updated at the master server, the new tiles are copied to any additional Esri servers that are providing a map tile service. Finally, the reference data is updated for the next iteration of updates and data comparisons.

Custom Export Files
When publishing is initiated within DataManager, it can also generate custom exports in standard Esri file formats or non-spatial formats. These can be used for legacy systems or to distribute the data for systems outside of the NG911 system.

	Administration The DataManager website provides a secure process for administrative users to manage their data publishing rules, determine which QCs are performed on the data, control QC and Publishing jobs, and obtain status reports that relate to QC and publishing. *Publishing Rules* Publishing rules can be set up for any layer that will be published. Each QC has an assigned severity level and based on these, an administrative user can create rules that will allow or disallow automated publishing of the data. There are two types of rules: 1. An absolute rule that is based on the total number of errors for a specific severity for a specific layer. For example, the fire service polygon may be blocked for publishing with a count of critical errors > 0 (or any positive integer). 2. A rule based upon the percentage of records with errors at a specific severity level. For example, the Roads layer may be blocked from publishing when the percentile of records with medium severity errors is > 10 percent. *QC Tests* An authorized administrative user can establish whether the QC test will be performed by turning the QC on or off, and that user can set the severity level of a QC process (i.e., the severity level used in publishing rules). *Monitoring and Control* The status of any QC or publishing jobs is reported on the DataManager website. In addition, the last successful job(s) completed are also reported. QC and publishing jobs can be started and stopped from the DataManager website. **Data Distribution** There are several methods that can be used to either distribute the GIS data directly or provide access to the data via services. ECRF database(s) are tightly coupled to the DataManager, so data is directly provided to the ECRF via the publishing processes. Further data access can be provided by the Esri server(s). This can include map tile services, web feature services, and other Esri methods, as required. For data users outside of the NG911 system, spatial or non-spatial files can be made available via SSH File Transfer Protocol (SFTP). For example, the Roads can be used to generate a MSAG 3.1 file for distribution to Telephone Service Provider (TSP) entities for use in their phone databases.

Any additional documentation can be inserted here:

	Next Generation Core Services Elements (NGCS) **Spatial Interface (SI)** **Data Provisioning and Validation** Describe the functionality of the proposed SI solution in sufficient detail to explain the validation of GIS data and data updates prior to provisioning into the ECRF and LVF, along with the means of real-time or near real-time provisioning of incremental updates to the GIS data provisioned to the ECRF and LVF.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 61		X			

Bidder Response:

DataManager (SI)
There are four core areas of functionality for the DataManager Service: Data Quality Control, Data Publishing, System and Data Reporting, and Administrative Control.

Data Quality Control

- DataManager includes a QC process that runs continuously and evaluates updates as they are incorporated into the core database. The output of these checks is one or more (depending on the QC checks that are used) QC error layers in the DataManager system.
- Users can directly view QC error layers by using the Data Maintenance Service user interface, and/or the QC error layers can also be exported to Esri file-based formats. In addition, an Esri server layer can be used to distribute the QC error data (although this would require the appropriate Esri licensing).
- QC checks can be assigned to several different classifications: geocoding, standards, internal consistencies, and external consistencies (if any). These checks include most of the tests that were used during the data quality control and synchronization phases, as previously described.

Data Publishing

- The Data Publishing function transforms, formats, and exports the data from the core database into files or other databases based upon the client's needs. The publishing of data can be restricted based upon errors detected during the QC process. Individual QCs are assigned to a customizable severity level, and individual thresholds can be configured for each severity level and GIS layer. These thresholds can be based upon either the absolute count of errors or the relative rate of errors in the layer. If any of the QC error thresholds are violated, the publishing process will be blocked. It is also possible for an administrator to configure a given publishing task to ignore these QC error thresholds, if needed.
- Data publishing tasks can be initiated on demand, scheduled as a one-time publishing, scheduled as a reoccurring publishing, or triggered automatically by any changes that follow the completion of QC checks.
- A database layer can be set up to be published to multiple user-defined export files. Each of these exports can be customized in a limited way. The specific fields for export can be designated, and the output field name and format can be configured.
- Data Publishing will directly update the master ECRF database. Additional ECRF databases will be updated via replication from the master ECRF database.

System and Data Reporting

- QC error summary counts are available via the DataManager website, as well as detailed counts by error type/description.

	• Change report summaries and counts are available on a pre-scheduled basis. • Publishing failures (due to excessive QC errors, for example) can be configured to generate email notifications. • The system contains all the historical data, along with a time stamp and a user ID for any changes. *Administrative Control* • The DataManager website provides a secure administrative interface. • Administrators can configure quality control and data publishing from the website. • Administrators can also control users, permissions, and display options. • Administrators can request a rollback to a previous database state, if necessary.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 62	**Next Generation Core Services Elements (NGCS)** **Spatial Interface (SI)** **Use of the Commission's GIS Data Model** 1. Describe how the bidder's solution will use the Commission's GIS data model (Attachment D) without modification to the schema. 2. Define bidder's processes and methods to receive and incorporate the updated SI datasets. 3. Describe bidder's proposed workflow for receiving GIS updates from regions to allow for a smooth transition. 4. Describe all security and monitoring aspects, and any additional features supported by the proposed SI.	X			

Bidder Response:

The Comtech ECRF/LVF, LDB and MCS solution has been built from the ground up as a NENA i3 solution. The Commission's GIS data model is closely aligned with the NG911 GIS data model and can therefore be used directly in our solution without modification.

Comtech will work directly with each region to determine the best method to receive data updates. Typically, this involves some sort of secure and automated file transfer, but other mechanisms are available as well (such as database replication).

The DataManager system offers two possible solutions for the workflow. It can either process each jurisdiction's data in complete isolation, and then publish each dataset to individual ECRF/LVF instances (each of which would share each other's authoritative coverage information and allow them to do recursive queries amongst themselves), or else DataManager can aggregate each jurisdiction's dataset into a statewide dataset.

This process was initially designed to minimize any impact on local GIS data structures and normal maintenance procedures; it is illustrated in Figure 23 below.

The workflow process from local jurisdictions and progressing to the ECRF/LVF dataset is integrated with the following processes:

<u>The Local Data Editing Environment</u>
This is where the local jurisdiction(s) edit and maintain their GIS data that will eventually populate the ECRF database. There are several options for services in this category. Each local jurisdiction can pick the option that best fits their needs and existing processes. In addition, it is possible to mix the options within the jurisdiction by layer. For example, the Road layer could be maintained by one local agency and the emergency service boundary (ESB) layers could be maintained by a different agency. Each of these agencies can pick the option that best suites them. The basic requirement is that a given local GIS layer can only be maintained via one option.

<u>Data Submission</u>
This service facilitates the submission of data updates for the GIS layers by local jurisdictions. There are several options that can be selected and, as with the data editing options, this can be customized down to the local GIS layer level. In addition, non-GIS data (MSAG and ALI data, for example) can be submitted via SFTP.

Data Import Services

The Data Import Service consists of five core areas of functionality: Data Update Monitoring, Data Schema Verification, Data Transformation, Data Coalescence, and Regional Data Updating. There is an instance configured for each local data provider. The only client requirement for the Data Import service is a valid email account for error reporting and job status reporting.

- *Data Update Monitoring*
  - The Data Import Service monitors a configured destination location for the data submission process. If an update is detected, the Data Import processes will automatically start.

- *Data Schema Verification*
  - The submitted data is checked against the configured local schema and verified that the data transformation can be applied.
  - If there are any schema issues or specific record issues, these will be reported to the local data provider via email. The email will include detailed information concerning the specific errors.
    - A schema issue is usually caused by a change in the submitted data fields. For example, if a field name has been changed, then the configured data transformation may no longer be valid.
    - Individual record issues are usually caused by specific data values. For example, if a submitted record contains a non-integer value in an integer target field, then a data conversion issue will exist for the individual record. Additionally, invalid geometry is also checked and would be reported for any individual records that show invalid geometry.

- *Data Transformation*
  - The submitted data is transformed to the ECRF data set schema using the configured transformation(s).

- *Data Coalescence*
  - The set of the most current transformed local datasets are coalesced to form the NG911 Map data set for updating the DataManager database. This coalescence transformation may include some topological-based transformations, depending on its configuration. Beyond that, this functionality is, at its core, a union operation.

- *Regional Data Updating*
  - The current ECRF dataset is compared to the current DataManager dataset. Changes in the two datasets are detected and are classified as "delete," "add," or "modify." The ECRF dataset is modified based upon the changes detected above.

DataManager Software

The DataManager software is tied to the ECRF dataset. Each ECRF dataset will have its own instance of the DataManager service (it is expected there will be one instance for this project). There are three main functions the DataManager performs. First, it is the primary data quality control engine for the ECRF. In addition, quality control results will be prepared and served back through one of the data discrepancy reporting options. The DataManager service has the export transforms that will be necessary for exporting the data to the ECRF dataset and for other customized exports (for example, the mapping application in the dispatch centers). Next is the publishing function, which will verify that the data meets the quality constraints (customizable) for publishing data to the ECRF and other systems (if applicable). It will then perform the necessary transformations and export the data. Finally, there is an administrative website that will enable registered users to control these functions and view reports on the system.

	Next Generation Services This will consist of two independent services: the ECRF/LVF service and the LDB service. The ECRF database will have the current ECRF dataset and will provide the LVF query service. The LDB will have the NG911 phone data. It will initiate LVF queries and store LDB discrepancies (i.e., phone records that have discrepancies from the LVF query). The LDB website provides the functionality for managing discrepancies, including assigning them to different groups for resolution and auditing. GIS Data Discrepancy Reporting There are several options for reporting discrepancies. Most of the services will provide website access to the discrepancies. In addition, these discrepancies can be exported into various formats so that the local user can access them in their Data Editing environments. Alternatively, if discrepancies have a spatial component, they can be provided as an Esri data service.

Any additional documentation can be inserted here:

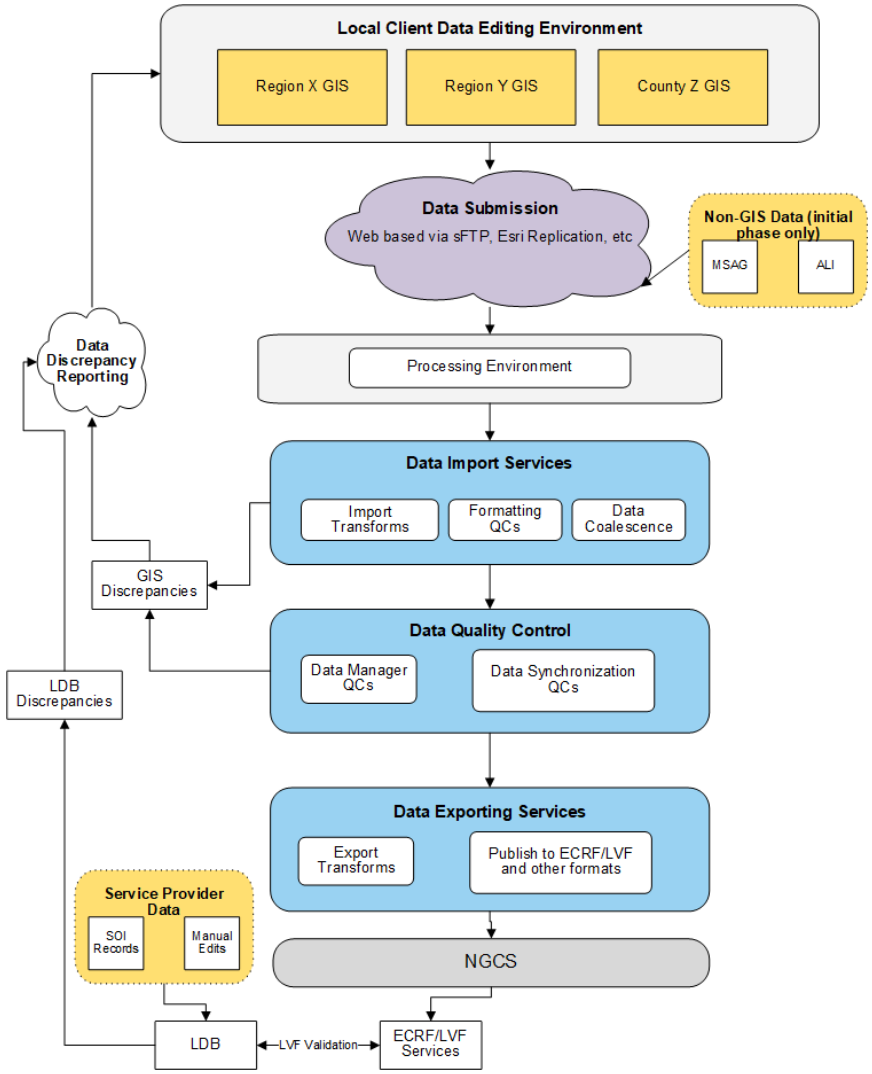


Figure 23. GIS Data Workflow Process

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 63	**Next Generation Core Services Elements (NGCS)** **Location Database (LDB)** Describe how the solution interfaces with other LDB solutions which may participate in or interface with bidder's solution. Contractor shall coordinate with other LDB solution providers to ensure interoperability between the respective solutions. Also explain how the proposed solution would deal with multiple ALI/MSAG databases and the locations where ALI steering may be in place.	X			
	Bidder Response: The LDB can interface with any neighboring ESInets, but it is unlikely to need to interface directly with other LDB solutions. If a call originates in Nebraska and is transferred over the state line to some other NENA i3-compliant ESInet, the location dereference Uniform Resource Locator (URL) will travel with the transfer as part of the SIP header. The CHE in the adjacent state can use this dereference URL to obtain the caller's location directly from the Nebraska LDB, without the need to query any LDB inside their own state. For example, a wireless call placed from Iowa could be handled by a cell tower in Nebraska. This call would likely hit an LNG in Nebraska that will, in turn, query the Nebraska LDB. Once at the Nebraska ESRP, one of two things can happen. The ESRP will dereference the location from the Nebraska LDB. If the LDB is only able to return a cell tower location at this point, the call will be routed to a Nebraska PSAP. From there, the PSAP can transfer the call to the Iowa PSAP. This transfer will include the location dereference URL the Iowa PSAP can use to get updated location information from the Nebraska LDB. Alternatively, if the Nebraska LDB can return the actual caller's location to the Nebraska ESRP, the ESRP can route the call directly to the Iowa ESInet (to either the Iowa ESRP or directly to the appropriate Iowa PSAP). If sent to the Iowa ESRP, it can use the dereference URL to request an updated location from the Nebraska LDB and use that to determine to which Iowa PSAP the call should be sent (using the Iowa ECRF). If a neighboring state is still operating a legacy system, or if it is not fully NENA i3-compliant, other mechanisms can be put in place, such as a legacy-style FoCR. In this situation, pANI records in the Nebraska LDB are shared with the neighboring state provisioning into their ALI database. Conversely, the neighboring state will share their pANI records for provisioning into the Nebraska LDB. For these scenarios, the LDB legacy ALI service will be configured to permit ALI query steering from neighboring states. For example, assume Iowa is using a legacy ALI system that has been loaded with all the Nebraska pANI records that point, or steer, to the LDB legacy ALI service in Nebraska. If a wireless call processed by a Nebraska cell tower is transferred to a legacy PSAP in Iowa, this PSAP can perform a standard ALI query to the Iowa ALI database. This ALI database will find the pANI record and steer the query to the Nebraska LDB legacy ALI service, which will respond with the caller's location in legacy format. The format returned from the Nebraska legacy ALI service can be formatted to match the ALI layout used by Iowa. Interoperability with multiple legacy ALI systems outside of Nebraska is possible with this solution.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 64	**Next Generation Core Services Elements (NGCS)** **Location Database (LDB)** **LDB Description** A LDB serves as both a legacy ALI database and as a LIS in an i3-compliant NG911 environment. The LDB retains all of the current information, functionality, and interfaces of today's ALI, but also can utilize the new protocols required in an NG911 deployment. The LDB supports the protocols for legacy ALI query and ALI query service, the protocols required to obtain information for wireless calls by querying the mobile positioning center (MPC) or Gateway Mobile Location Center (GMLC), and the protocols required for i3 location information retrieval and conveyance, such as HTTP-Enabled Location Delivery (HELD) or other proprietary protocols. Describe the functionality of the proposed LDB, including additional features and capabilities, error handling, FoCR capabilities, logging and deployment recommendations in detail to address the requirements outlined, with particular attention to the arrangement of the proposed components, user interface, and features, and security aspects.				
		X			

Bidder Response:

For an LDB to function correctly and allow interoperability between legacy and NG911 formats, a MCS is needed (as defined in *NENA-STA-010.2-216*). An MCS is included as part of this response.

MCS Overview
The MCS is designed to bridge the gap between legacy (ALI/MSAG) and NG911 (PIDF-LO/CLDXF) data schemas and formats. An MCS is a required functional element, if interoperability is required between legacy and NG911 data.

In circumstances where the legacy ALI database is wholly replaced by a transitional LDB, the MCS is used by the SOI process to convert the legacy address records submitted by the service providers to the NG911 CLDXF format. The LDB stores all records in CLDXF format and is therefore closely aligned with the data in the ECRF/LVF. Additionally, the MCS is used to convert dynamically received address data that is received over an E2 connection (typically for VoIP). The E2 will return address data in a legacy format, which needs to be converted to a CLDXF-compliant PIDF-LO before being sent to the ECRF for call-routing instructions.

If legacy CHE exists in the deployment, the MCS will also be used to provide legacy ALI services to this CHE.

Without the MCS, location data associated with each call will not be aligned with the GIS data that is in the ECRF/LVF, since this data is required to be in the NG911 GIS Data Model (which is closely aligned with CLDXF, and very different from legacy ALI/MSAG data models). Failure to align call-location data with ECRF/LVF data will result in significant negative call-routing issues.

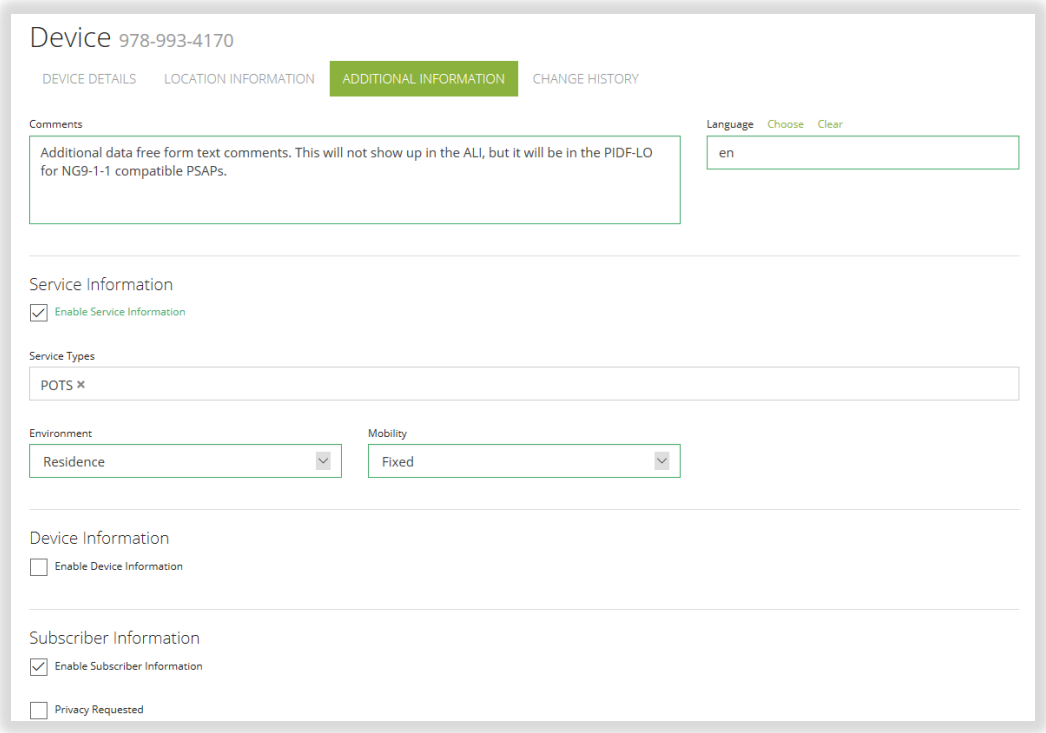
	Additionally, the MCS can provide translation services to gateway elements when calls must be transferred with location between legacy and NG PSAPs. **LDB Overview** To overcome the problems of legacy ALI systems, NENA recommends the use of the LIF, within the LNG, utilizing an internal location database with steering data, as needed. This database is often referred to as an LDB (*NENA-INF-008.2-2014*). The LIF is a part of the LNG, although it can be physically separated. An LDB serves as both a legacy ALI database and as a LIS in an i3 NG911 environment, and it is included in this response to fully replace the existing ALI database and enable a smooth transition to NG911. The LDB can provide the same functionality as a legacy ALI database, but it also provides i3 processes and interfaces. A single statewide LDB would provide numerous advantages over the current ALI database system(s), including: • All location records that contain a civic address are pre-validated against the LVF, ensuring that at the time of a 911 call they will be properly routed. LDB response times are measured in milliseconds, not seconds (although for wireless and nomadic VoIP, the LDB must still communicate with MPC/VPC, which will introduce some delay). • Service providers would not have to change their workflows, since the LDB supports legacy SOI provisioning interfaces. Service providers can continue to send their records in this legacy format, and the MCS will be used to convert the record into the NG911 data model before provisioning the data into the LDB. This means that legacy service providers can continue "business as usual" without having to change their existing processes. • All data would be stored in native NG911 formats. • At the state level, a legacy MSAG can still be created for service providers that wish to use it. The MSAG is generated from data in the ECRF/LVF, and it is converted into a legacy format using the MCS. **Shall support all relevant sections of NENA 02-010, 02-011, 02-015, 04-005, 08-501 and 08-502 related to ALI Database Management System (DBMS).** *NENA 02-010 Standard Data Formats for 9-1-1 Data Exchange & GIS Mapping* The LDB meets, and in many cases exceeds, all relevant requirements of *NENA 02-010*. The LDB supports SOI processing of files in the 2.1 and 4.0 exchange formats. Support for version 3.0 is not implemented, since it is not commonly used within the industry. The GIS data model is not directly relevant to the LDB. *NENA 02-011 NENA Data Standards for Local Exchange Carriers, ALI Service providers & 9-1-1 Jurisdictions* The LDB meets, and in many cases exceeds, all relevant requirements of *NENA 02-011*. *NENA 02-015 Standard for Reporting and Resolving ANI/ALI Discrepancies and No Records Found for Wireline, Wireless and VoIP Technologies*

	The LDB meets, and in many cases exceeds, all relevant requirements of *NENA 02-015*. All NRF reports are automatically generated for service providers, and the LDB Manager web interface provides a full NRF workflow. Location discrepancies (such as those reported by a PSAP) are tracked in the standard ticketing system. *NENA 04-005 NENA ALI Query Service (AQS) Standard* The LDB stores location data in a format compliant with NG911 data models. This means an intermediate process is required to convert this data for legacy ALI. If an AQS is required, an MCS is used to convert the CLDXF-compliant PIDF-LO from the LDB back into the NENA ALI 4.0 format. At this time, the AQS is not fully supported but it can be, if required. It is recommended that CHE use the NG911 HELD protocol, wherever possible. Legacy ALI interfaces do not support the same rich data format as HELD. If all CHE can support the HELD protocol, there is no need for an AQS to be deployed. Standard legacy ALI is fully supported. *NENA 08-501 NENA Technical Information Document on the Network Interface to IP Capable PSAP* The entire LDB is built to communicate over IP networks, and it fully supports both IPv4 and IPv6. Legacy ALI queries can be supported over a TCP/IP connection, and the HELD interface also runs over a TCP/IP connection. The LDB also supports additional data when using the HELD protocol. The latest standards are used for this, which supersede the information in this document. *NENA 08-502 NENA Generic E9-1-1 Requirements Technical Information Document* The LDB supports section 2.6.2, with the exception that the location information is LVF-validated rather than MSAG-validated. The LDB provides callback information as described in section 2.6.3, providing the callback information is available from the MPC/VPC. The LDB supports section 2.7.2 in that it will store static location data, as well as steer E2+ queries, as appropriate, for nomadic location data, such as wireless and nomadic VoIP. The LDB can process SOI files from service providers in either the NENA 2.1 or NENA 4.0 formats, as described in section 2.7.2.1. A full range of error and validation checks are performed on each file, and each record and its errors are returned to the service provider for resolution. LVF-generated discrepancies are returned to whichever GIS group is responsible for the data in the ECRF/LVF. LNP is fully supported by using the Unlock and Migrate process, and Number Portability Administration Center (NPAC) databases are queried to verify TN ownership to ensure the accuracy of the database. The LDB supports section 2.7.2.2, offering both legacy and i3 interfaces for location queries. An NG911-compliant CHE can use the HELD interface, whereas legacy systems can perform a legacy ALI dip. The ability to steer queries to other databases is supported, as described in section 2.7.2.3, but it requires the full cooperation of other database providers. The LDB includes a full ESME subsystem, allowing it to communicate over E2/E2+ to positioning centers for wireless and nomadic VoIP.

	The LDB can be deployed in a multiple node system, allowing it to achieve 99.999 percent availability as described in section 2.7.2.5. The LDB meets the requirements of section 2.7.2.6, since most queries for static records take 100ms or less. Queries to outside systems (such as an MPC/VPC) may take longer and are beyond the control of the LDB. The LDB supports data provisioning as described in sections 2.8.2.1 and 2.8.2.2, using either standard SOI-type file processing or a web interface. **Shall be capable of assuming the role of a location DBMS as defined in NENA-INF-008.2-2013, NENA NG9 1-1 Transition Plan Considerations.** The LDB was developed to provide all the relevant transitional database functionality as defined in *Section 11.5 of the NG9-1-1 Transition Plan Considerations* document. Unlike other solutions on the market, our LDB was built from the ground up as an LDB, not an ALI database system subsequently repurposed as an LDB. **Shall support NENA standards J-036, E2, E2+, non-call-associated signaling (NCAS) and call-associated signaling (CAS).** The LDB, in conjunction with the ESME, can provide all the necessary processing to handle legacy wireless and nomadic VoIP calls. In a typical scenario, each pANI record within the LDB is assigned to an E2 connection (E2 steering). The ESME sub-system maintains all E2 connections to the appropriate MPC or VPC. When a pANI query is presented to the LDB, it determines which E2 connection it needs to use, and passes a query onto the ESME. The ESME, which has dual IP connections to each MCP or VPC, performs the actual E2 (or E2+) query to the appropriate positioning center, and then passes the response back to the LDB. In the case where the E2+ response contains an address (which often occurs with nomadic VoIP), a further call is placed to the MCS to convert this address from a legacy format to the PIDF-LO equivalent. **Shall be able to provide LIS functionality and interfaces as defined in NENA-STA-010.2-2016.** The LDB supports all LIS functionality and interfaces as defined in *NENA-STA-010.2-2016*. Specifically, the LDB supports the HELD protocol, as specified in *NENA-STA-010.2-2016*, and detailed in *RFC 5985*, and in HELD location dereference *RFC 6753*. **Shall be able to seamlessly interact with a NENA i3-compliant ECRF, as described in NENA-STA-010.2-2016.** The LDB, as part of data provisioning, uses the LoST protocol to validate all civic address data against the ECRF/LVF. All civic address locations that return invalid elements will generate a discrepancy and enter the LDB discrepancy workflow system. In terms of call flow, the LDB and ECRF act independently. The ESRP will issue a dereference HELD query to the LDB and await a response. Once this response is received, the location will be sent by the ESRP as a LoST query to the ECRF. **Shall be able to dereference a location by reference, as defined in NENA-STA-010.2-2016.** The LDB supports both GET and POST location dereference queries using the HELD protocol. The initial query will need to take place by value, with the initial response including the location dereference URL. Future location requests can use the location dereference URL to retrieve updated location information.

Shall be able to dereference requests for additional information, as defined in NENA-STA-010.2-2016.
Both location-by-value and location-by-reference queries include additional data in the response. The LDB currently supports the ECRIT additional data standard (*RFC 7852*), which includes most of the additional data structure defined in *NENA-STA-010.2-2016* (such as ProviderInfo and ServiceInfo).

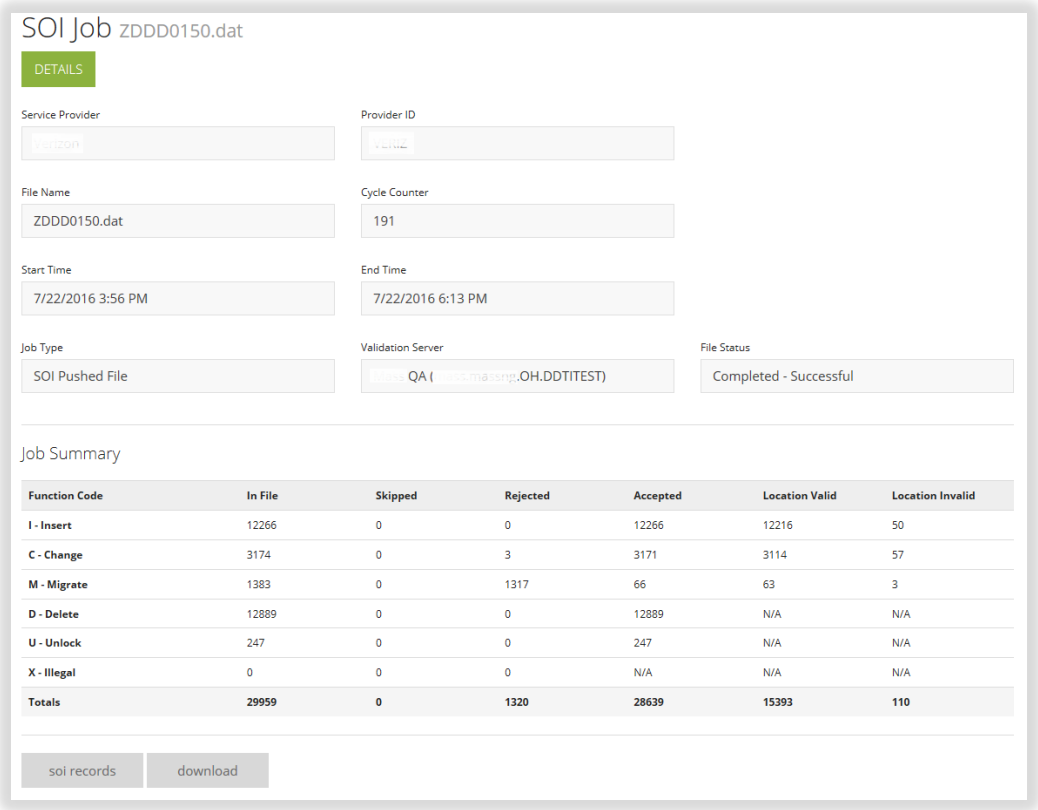
The following screenshot shows the LDB Manager web interface for a Device Additional Data.



Shall be able to interface simultaneously with multiple wireless callers.
The LDB supports legacy wireless location delivery using an ESME connected to one or more MPCs. Each multi-threaded ESME instance can handle multiple simultaneous queries, with the ability to handle hundreds of wireless calls per second.

Shall be able to interface simultaneously with multiple remote ALI databases.

	Presuming the remote ALI database provider can provide steering data (in some agreed-upon mechanism, such as FoCR), the LDB is able to steer queries to remote ALI databases. The MCS is used to convert legacy ALI responses from the remote ALI database into PIDF-LO. Additionally, the LDB can be provisioned with pANI from neighboring ALI databases, allowing it to perform E2 queries to retrieve location information for calls that have been transferred into Nebraska. Data-sharing agreements must be in place with neighboring ALI database providers to allow for the sharing of these records. A legacy ALI interface can also be provided, allowing the legacy ALI database to perform queries for data that is contained within the LDB. The MCS will be used to convert LDB PIDF-LO data into the legacy ALI 4.0 format, which can then be formatted into other legacy ALI formats. **Shall automatically detect, import and validate customer records (SOI records).** To successfully replace a legacy ALI system with an LDB, a mechanism must be provided to the service providers to update the location information in the LDB. During the transition to i3, and to aid 911 authorities in gaining cooperation from the service providers, the LDB system includes a SOI processing function that is similar to existing SOI processing. This means that the service providers do not have to change their existing processes to support the i3 system (an MCS is provided to convert SOI records into the appropriate CLDXF format for comparing against the LVF). Service providers can submit their SOI files for processing via some agreed-upon, secure method. Asynchronous backend server processes are run to process the SOI files. Multiple SOI processing agents can be configured on a single database, allowing multiple SOI files to be processed at the same time. Unlike SOI processing for E911 ALI databases, each SOI record must be validated against the GIS, by way of an LVF, prior to the record being committed to the database and being made available for HELD queries. This ensures the civic address location provided by the service provider can be mapped, and thus routed and plotted. If a record fails its validation, the service provider is notified (various notification mechanisms exist, including via an error report). The group responsible for the GIS map data can also be notified, so the map data can be checked for accuracy. The following screenshot shows the details of a SOI job.



SOI Job ZDDD0150.dat

DETAILS

Service Provider: verizon

Provider ID: [illegible]

File Name: ZDDD0150.dat

Cycle Counter: 191

Start Time: 7/22/2016 3:56 PM

End Time: 7/22/2016 6:13 PM

Job Type: SOI Pushed File

Validation Server: [illegible] QA ([illegible].OH.DDTITEST)

File Status: Completed - Successful

Job Summary

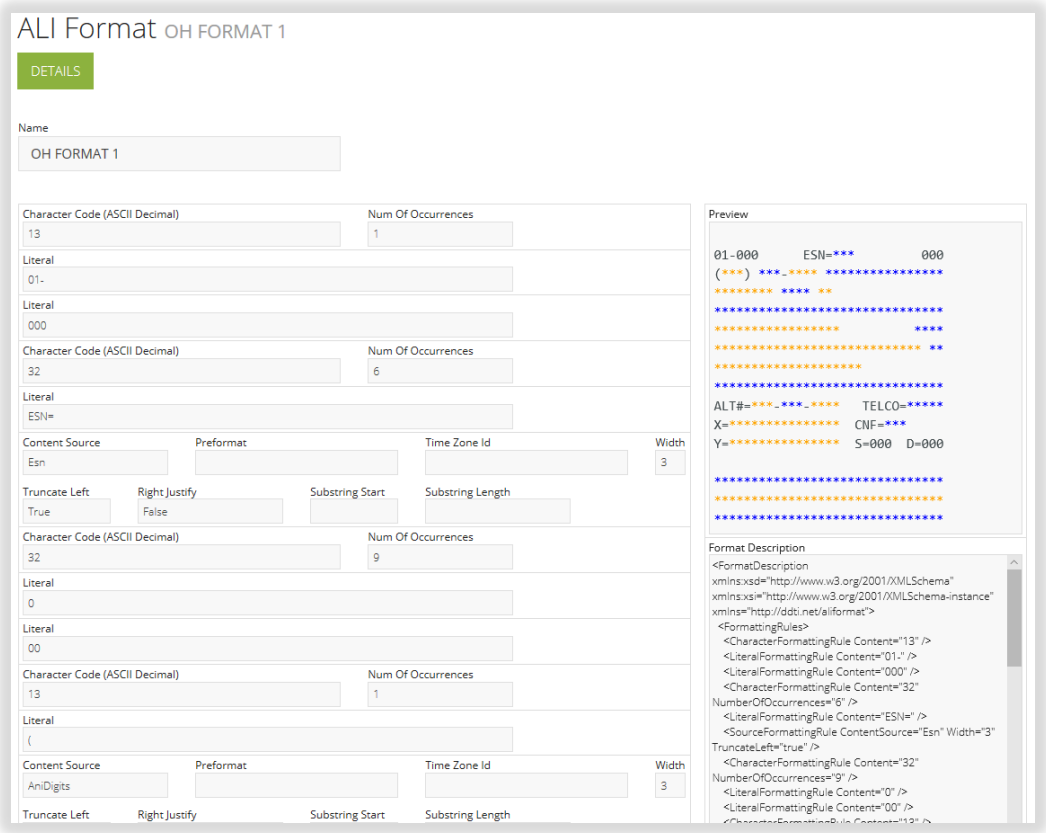
Function Code	In File	Skipped	Rejected	Accepted	Location Valid	Location Invalid
I - Insert	12266	0	0	12266	12216	50
C - Change	3174	0	3	3171	3114	57
M - Migrate	1383	0	1317	66	63	3
D - Delete	12889	0	0	12889	N/A	N/A
U - Unlock	247	0	0	247	N/A	N/A
X - Illegal	0	0	0	N/A	N/A	N/A
Totals	**29959**	**0**	**1320**	**28639**	**15393**	**110**

soi records | download

Each SOI record can be reviewed individually as well. Rejected records can be directly edited within the LDB Manager web interface, or a new and correct SOI record could be submitted.

The scheduled, periodic revalidation of existing LDB records will also be performed by the system. This process checks all LDB records that have previously been flagged as LVF-valid and submits a new LVF query to verify that each record is still valid. Records that fail validation will be flagged in the LDB as invalid, but they will still be returned in HELD queries for a configurable period (by default, this is 30 days). This offers the service provider or the GIS department sufficient time to investigate and resolve the issue.

	The LDB utilizes a web-based interface that grants access to the backend location database for authorized personnel. From this web interface, users with the appropriate permissions can schedule reports and run data extracts. Key functionality of the web interface includes: • Role-based security that restricts users to what they can do and what data they can see. For example, a service provider will only be allowed to view their location records and job reports from SOI jobs they have submitted. • The ability to query data by telephone number and address. • The ability to modify location records and validate those changes against the LVF in real time. • The ability to view reports. The workflow for resolving data discrepancies for records that have failed LVF validation (for example, if, after review, the service provider has determined that the location data is correct, the discrepancy can be routed to the appropriate GIS department for resolution). Users can be defined and managed via the LDB web interface. Users will have permission-based access to their subscriber data and be able to schedule daily data extracts. **Shall have the ability to be used simultaneously by both NG911-capable and E911 capable PSAPs.** The LDB provides both legacy and NG911 location interfaces. To support NG911-capable PSAPs, a HELD interface is provided. To support legacy PSAPs, a legacy ALI interface is provided, and location data within the LDB is converted into legacy formats using the MCS. The HELD interface can support hundreds of queries per second. The legacy ALI interface requires the legacy CHE to maintain one or more TCP/IP connections. Each CHE instance must initiate and maintain the connection to the LDB legacy ALI interface. Each individual TCP/IP connection can handle one legacy ALI query per position at a time. This is a limitation of the legacy interface, not of the LDB. **Shall allow different PSAPs to use different ALI formats based on individual needs.** It is expected that NG911-capable PSAPs will not use ALI, and they should be capable of consuming data provided in the HELD response. Data provided in this way cannot be reformatted into different formats, since it is controlled by a well-defined XML schema. For legacy PSAPs that use the legacy ALI interface, the response can be formatted on a PSAP-by-PSAP basis. The following screenshot shows the ALI formatting page.



Shall utilize LVFs to validate civic addresses.
As civic address data is provisioned into the LDB (either through SOI or by manual input using the web interface), it is validated against the LVF. If the civic address is submitted via SOI, it is converted from its legacy MSAG format to the LVF-compatible CLDXF format before being validated by the LVF. If a civic address fails validation, it is placed into the discrepancy workflow process for resolution.

Discrepancies are marked with a severity that is determined from the response from the LVF. A civic address that fails to return a mapping will be flagged as critical, allowing these types of discrepancies to be worked first.

	Shall support PIDF-LO location data formatting as defined in NENA-STA-010.2-2016. The CLDXF standard describes the PIDF-LO format for the United States. This standard is strictly observed in both the LDB and ECRF/LVF systems. To support legacy processes (to convert between PIDF-LO in the CLDXF format and legacy ALI) an MCS is used. The MCS is included as part of this response. All GIS data within the ECRF/LVF will be in the CLDXF format. As a result of this, the civic address data stored within the LDB must also be in this format, otherwise it would fail LVF validation. If SOI is used to provision civic address data into the LDB, it undergoes a transformation from its legacy format to CLDXF during file processing, resulting in a CLDXF-compliant civic address in the LDB. Additionally, if civic address data is provided from a MPC/VPC during call flow (such as with a nomadic VoIP call), it is converted during the call flow by the LDB from the legacy format into CLDXF-compliant PIDF-LO (using the MCS). **Shall periodically reevaluate the location information using LVF functions within the system.** A backend server process runs continuously against the LDB database. This backend process is configured to periodically perform revalidation tasks. It is typically configured to revalidate open discrepancies with a frequency similar to that where the GIS data is updated in the ECRF/LVF. Additionally, full database revalidation is typically configured to run weekly or monthly. The LDB has three different mechanisms for revalidation: • A full revalidation runs as a scheduled job to periodically revalidate every civic address record in the LDB against the GIS, using an LVF query. • A discrepancy revalidation runs more frequently and revalidates civic address records that were previously flagged as being LVF-invalid. • A targeted revalidation runs when GIS data in the ECRF/LVF system has been updated, and it revalidates civic address records in the LDB that may have been affected by specific changes to the GIS data. **Shall be able to communicate with NG911 functional elements using the SIP and HELD protocols.** The LDB provides full support of the HELD protocol, secured with TLS. The LDB can accept HELD queries from all authorized NG911 core elements, as well as dereference requests from NG911-capable CHE that is performing a "re-bid." The LDB does not have a SIP interface at this time, since none of the other functional elements offered in this solution can request a location using SIP SUBSCRIBE/NOTIFY. In general, the industry seems to have standardized on the HELD protocol. If any client exists that is capable of SIP SUBSCRIBE/NOTIFY for location, support can be added to a future release of the LDB. **Shall be able to provide a PIDF-LO based on both the wireless and VoIP E2 response.** The LDB converts E2/E2+ responses to PIDF-LO. In the case of wireless E2, the Position Result, which contains latitude/longitude coordinates, as well as an uncertainty designation, is converted to a GML circle in the PIDF-LO response, and the E2 confidence is also included in the PIDF-LO. In the case of a E2+ response that includes a civic address (in a legacy format), the legacy address is converted into a CLDXF-compliant PIDF-LO using the MCS.

	Since the HELD protocol can support multiple locations per response, the LDB is able to provide all location data received in the E2/E2+ response. Additionally, the shell record location can also be included, if appropriate. **Shall be able to dereference additional data requests.** The LDB can also act as an ADR as defined in *NENA-STA-010.2*. When responding to a location request, either by value or by reference, the LDB will include available additional data blocks inside the <provided-by> element of the PIDF-LO. These additional data blocks conform to the *IETF ECRIT Additional Data Related to an Emergency Call* standard, and may include: • Data Provider Information • Service Information • Device Information • Owner/Subscriber Information • Comments Clients can retrieve additional data by performing a dereference query to the LDB using the URI received in the initial location response. **Shall consistently respond to all requests within 400 milliseconds (ms).** Average query latency is less than 50ms for data stored locally within the LDB. If data must be retrieved from other systems, response times will vary and are dependent on the remote system (such as a remote ALI database, RapidSOS or an MPC/VPC). The HELD protocol supports a parameter in the query to tell the LDB how long the query client is willing to wait for a response. This is a useful feature, particularly for legacy wireless calls. In this scenario, the LNG may initiate a query to the LDB, with a maximum wait time of three seconds. The LDB will, via the ESME, query the remote MPC. After three seconds, the LDB will respond with the best data it has available. At this point, it is possible that the MPC was only able to return Phase I location data. However, by the time the call reaches the ESRP, and the ESRP performs a dereference request, the ESME may have received Phase II wireless data; consequently, the LDB will then respond to the ESRP with this updated information.

Any additional documentation can be inserted here:

The LDB shall meet the following requirements:	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
Shall support all relevant sections of NENA 02-010, 02-011, 02-015, 04-005, 08-501 and 08-502 related to ALI Database Management System (DBMS).	X			
Shall be capable of assuming the role of a location DBMS as defined in NENA-INF-008.2-2013, NENA NG9 1-1 Transition Plan Considerations.	X			
Shall support NENA standards J-036, E2, E2+, non-call-associated signaling (NCAS) and call-associated signaling (CAS).	X			

Shall be able to provide LIS functionality and interfaces as defined in NENA-STA-010.2-2016	X			
Shall be able to seamlessly interact with a NENA i3-compliant ECRF, as described in NENA-STA-010.2-2016.	X			
Shall be able to dereference a location by reference, as defined in NENA-STA-010.2-2016.	X			
Shall be able to dereference requests for additional information, as defined in NENA-STA-010.2-2016.	X			
Shall be able to interface simultaneously with multiple wireless callers.	X			
Shall be able to interface simultaneously with multiple remote ALI databases.	X			
Shall automatically detect, import and validate customer records (SOI records).	X			
Shall have the ability to be used simultaneously by both NG911-capable and E911 capable PSAPs.	X			
Shall allow different PSAPs to use different ALI formats based on individual needs.	X			
Shall utilize LVFs to validate civic addresses.	X			
Shall support PIDF-LO location data formatting as defined in NENA-STA-010.2-2016.	X			
Shall periodically reevaluate the location information using LVF functions within the system.	X			
Shall be able to communicate with NG911 functional elements using the SIP and HELD protocols.	X			
Shall be able to provide a PIDF-LO based on both the wireless and VoIP E2 response.	X			
Shall be able to dereference additional data requests.	X			
Shall consistently respond to all requests within 400 milliseconds (ms).	X			

NGCS 65	**Next Generation Core Services Elements (NGCS)** **Location Database (LDB)** **Integration of Multi-Line Telephone System Data** The LDB shall support the Integration of Multi-Line Telephone System (MLTS) databases. As part of this migration, Contractor shall be responsible for migrating records from the current MLTS databases to the LDB. Provide details on the database migration process and the user interface for management of these MLTS data records.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: The LDB offers full support for PSALI. Each PSALI customer must have its own registered NENA ID, since this information is used to uniquely identify and securely partition their data within the LDB. PSALI customers will be given access to the LDB Manager web interface, allowing them full read-and-write access to their records. Additionally, the LDB can be configured with blocking ranges, restricting the access to a specific range of TNs where the PSALI customer can create new device records. Each PSALI customer can manage their records in the LDB by either a SOI process (if their Multi-Line Telephone System [MLTS] supports the generation of these files) or by direct editing via the LDB Manager web interface.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 66	**Next Generation Core Services Elements (NGCS)** **Discrepancy Reporting** 1. Provide details regarding the proposed solution's report functions for notifying PSAPs any time a discrepancy is detected concerning the BCF, ESRP, PRF, ECRF, LVF, and SI. As part of the detail, explain how a report will be sent for the purpose of reporting the discrepancy to multiple responding PSAPs, as determined by the Commission. Discrepancy reporting is outlined in Section 4.7 of NENA-STA-010.2-2016. 2. Describe the functionality of the proposed discrepancy reporting function in sufficient detail to address the requirements outlined, with particular attention to the user interface and features, and the security aspects.	X			

Bidder Response:

A critical phase of the Nebraska migration, which can be done concurrently with the re-routing of circuits, involves building the correct routing data based upon local 911 authoritative GIS data. Prior to the migration of each PSAP, GIS data from the PSAP jurisdictions is loaded into the NGCS SI and validated against QA/QC processes that verify its completeness, its topographical integrity, and its accuracy against road center lines and address points. Once the GIS data is validated, it is loaded into the ECRF/LVF for use in call routing and location validation. Comtech uses a discrepancy process to notify PSAPs of invalid results while allowing new data to upload, performing re-validation until the data meets acceptable criteria agreed upon with Nebraska.

<u>Discrepancy Process</u>
Unlike legacy systems, civic addresses in NG911 are pre-validated against the LVF. If a civic address submitted by a service provider fails LVF validation, a discrepancy is created in the LDB and a workflow is initiated to resolve this issue. LVF validation can fail for one of three reasons:
a. The address submitted by the service provider is invalid.
b. The address was incorrectly translated into the NG911 format by the MCS.
c. The address is missing from the GIS data (i.e., it is not in the LVF).

When a record fails LVF validation, it is initially assigned to either the service provider that owns the record (based upon the TN), or to the GIS user(s) responsible for the authoritative GIS data. Users are expected to review the reasons for LVF validation failure and either make a fix to the data or else reassign the discrepancy to another group.

For example, a discrepancy might be assigned to a service provider, who, upon review, decides that the address is valid; they will subsequently assign the discrepancy to the GIS user(s) responsible for the GIS data in the LVF. The service provider must add comments to the discrepancy to help the GIS user resolve this discrepancy. If the GIS user can fix the data, that effort will be reflected in the LVF, the record will become valid, and the discrepancy will be closed. If service providers and GIS users cannot agree on how the data should be fixed, the discrepancy can be assigned to a Discrepancy Arbitrator user for resolution.

The LDB utilizes a web-based interface that grants access to the backend location database to authorized users. From this web interface, users with the appropriate permissions can schedule reports and run data extracts.

Key functionality of the web interface includes:

	• Role-based security that restricting users to what they can do and what data they can see. For example, a service provider will only be allowed to view their location records and job reports from SOI jobs they have submitted. • The ability to query data by telephone number and address. • The ability to modify location records and validate those changes against the LVF in real time. • The ability to view reports. Automated functional element discrepancy reporting from the BCF, the ESRP, and the PRF currently in *NENA STA-010.2-2016* have not been defined. Comtech will work toward the adoption of full discrepancy reporting functionality at some future point, once the advancement of the *NENA STA-010* document defines the standard.

Any additional documentation can be inserted here:

NGCS 67	**Next Generation Core Services Elements (NGCS)** **Event Logging and Management Information System (MIS)** PSAPs may have a variety of logging recorders capable of recording SIP traffic and associated media. PSAPs will use the Emergency Call Tracking System (ECaTS) for call logging and capture event details. The Commission will gather statistical data from PSAPs through ECaTS. Describe how the solution interfaces with logging recorders and ECaTS.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
		X			
	Bidder Response: Comtech's solution provides i3-compliant logging over a web interface to any i3-compliant logging service, including Emergency Call Tracking System (ECaTS). Comtech's functional elements will log call events (e.g. location query, location response, LoST query, LoST response, route) and provide these details to the logging service, or to ECaTS, through the web interface. This data is provided in near-real-time at each step along the call path. Comtech's functional elements will log call events (e.g., location query, location response, LoST query, LoST response) and provide these details to the logging service through the web interface.				

Any additional documentation can be inserted here

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 68	**Next Generation Core Services Elements (NGCS)** **Event Logging and Management Information System (MIS)** **Event Logging Description** Extensive logging of NG911related events, transactions, media, and operations is required. All log entries shall be accurately time-stamped. Logging must include all elements in the call flow including logging of NG911related events within ESInets, the NGCS, the PSAP, and related operations, and is a standardized function used throughout ESInets, NG911 functional elements, and PSAPs. Logged events include ingress and egress to an ESInet, ingress, and egress to a PSAP, all steps involved in call processing, and processing of all forms of media. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: The Comtech MIS solution collects and integrates real-time call and system performance data from multiple sources and functional elements, including i3 logging, CDRs, and system probes. One of these sources is OCOM, which provides details on call signaling and call quality. We also use web services to collect call records from various NGCS functional elements including, but not limited to, the BCF, the ESRP, and the ECRF as well as being able to collect CDRs from the CHE systems. Also, while the Comtech solution provides basic call-center reporting metrics, the solution also provides for additional reporting metrics specific to NG911 that allow for the monitoring of the overall performance of the NGCS and the performance of individual services and functional elements within the NGCS. The call-handling and agent-related metrics are also specific to NG911 and provide a level of detail beyond whatever standard call-center reporting currently supports.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 69	**Next Generation Core Services Elements (NGCS)** **Event Logging and Management Information System (MIS)** **Integration with Call-Handling Equipment** 1. Describe how bidder's event-logging solution may integrate with the each PSAP's call-handling equipment, to provide a complete, end-to-end view of a call. 2. Describe how the Commission can gain access to information in the event-logging solution. 3. Describe the requirements of the PSAP's call-handling equipment, software license agreements, and interfaces required to support integration with the bidder's event-logging solution.	X			
	Bidder Response: The Comtech event-logging and MIS solution, native to Comtech's NGCS, collects and integrates real-time call- and system-performance data from multiple sources and functional elements, including i3 logging, CDRs, system logs and network probes. Comtech's MIS dashboard is a comprehensive reporting and analytics solution that allows users who possess the proper system access privileges to report on, analyze and monitor the health of their NG911 system. The solution collects call details, system, and network information from multiple NGCS functional elements and integrates this information into a normalized data structure to present a cohesive picture. Data that is collected allows Comtech's MIS solution to provide an end-to-end view of calls being processed through the network and its systems. For example, one of these sources is OCOM, which provides details on call signaling and call quality. Comtech also uses an i3 interface or syslog redirection to collect call records from various NGCS functional elements including the BCF, the ESRP and the ECRF, as well as region- and PSAP-specific CHE systems. Comtech's MIS tools and data processing capabilities enable us to process data from multiple CHEs. As regions and PSAPs are brought online with Comtech's NCGS solution, Comtech's event logging solution allows for integration of the CHE equipment by utilizing a NENA i3-compliant interface to receive data. CHE and CDR payload data are captured using Comtech's data pipelines, which feed the data lake for analysis and reporting to the MIS dashboard. To ensure the reliable capture of data, Comtech's data pipelines exhibit built-in redundancy during each phase of the process. Data is shipped from the CHE to Comtech's data lake, where the raw data is stored, analyzed, and then used to generate reports for key performance parameters. This data transfer is delivered using a secure connection; if that connection is down, the data is saved locally until the connection is restored. Upon the restoration of the connection, any local data is shipped to the data lake, along with all new data. Data within the data lake is encrypted at rest and stored in a redundant manner. Once processing is complete, end-to-end call data is available via the MIS dashboard. This web-enabled dashboard utilizes role-based access controls to limit the data availability to only such data as is relative to whichever user is connecting to the system. The NGCS requires that the regional/PSAP CHE should be able to provide an i3 feed into the logging system, with no additional licensing required. Integration into a third-party solution, such as ECaTS, is made available through i3 logging interfaces that are established between Comtech and ECaTS, with no additional requirements for the region/PSAPs. Comtech's event logging and MIS solution is the key to analyzing, monitoring, and reporting on NG911 call processing for the Commission, as well as regional and PSAP system and service managers.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 70	**Next Generation Core Services Elements (NGCS)** **Event Logging and Management Information System (MIS)** **Access to Event Logging Data** 1. Describe how the PSAPs and the Commission will gain access via role-based authentication to the event-logging solution data and run statistical and other MIS reports. The PSAP is the custodian of such data for purposes of the Nebraska Public Records Statutes, Neb. Rev. Stat. §§ 84-712 to 84 712.09. The PSAP is responsible for maintaining such data pursuant to the PSAP record-retention schedule applicable to such data as provided in the Nebraska Public Record Statutes, Neb. Rev. Stat. §§ 84 1201 to 84 1229. The state is implementing the ECaTS MIS solution statewide. Upon deployment, the Contractor shall coordinate with ECaTS, the state, and the PSAPs to deliver event logging data to the ECaTS solution. An existing data-sharing agreement (DSA) between the state and the PSAPs governs what data the state may access along with notifications of records requests. This DSA will govern data collected by the NGCS and ESInet provider whether that data is delivered to ECaTS or directly to the state or PSAPs. 2. Describe the reports, MIS tools, and performance metrics made available to each PSAP, the user interface for retrieving or receiving reports, role-based authentication to limit access to data and reports, and the ability to customize reports based on individual PSAP needs. These reports may be used as a basis for changes to bandwidth and capacity. The required reports and metrics will include, but is not limited to: a. Timing b. Call-delivery time c. Call-processing time between elements d. Volumes e. Call volumes by call type f. Alternate-routed calls g. Text-to-911 h. All NGCS element usage volumes i. Bandwidth/trunk utilization j. Calls per trunk k. Trunk utilization l. Circuit utilization	X			
	Bidder Response: Comtech understands the Commission currently uses ECaTS, and we are very familiar with their product and its capabilities. Although the provided data-sharing agreement (DSA) is not directly applicable to the NGCS/ESInet services, Comtech understands the Commission's intent and can comply with data ownership and sharing provisions. Comtech has interconnected for data sharing with ECaTS in our existing NGCS customer base. In addition, the Comtech NGCS service provides an MIS service reporting on all aspects of the NGCS systems and functional elements.				

	The native Comtech NGGS service includes an MIS solution that provides basic reporting metrics as well as additional NG911-specific reporting metrics that enables customers to monitor overall NGCS performance and the performance of individual services and functional elements within the NGCS. These call-handling and agent-related metrics are also specific to NG911 and provide a level of detail beyond what standard call-center reporting currently supports. The Comtech MIS solution is accessible through a web-enabled dashboard utilizing role-based access controls. Through the web interface, various reports are made available for analytical and statistical insight. Integration into a third-party solution such as ECaTS is made available through i3 logging interfaces that are established between Comtech and ECaTS to transmit the raw data over an i3 interface. Accessibility to and retention of the data sent to ECaTS is the responsibility of ECaTS as declared in their agreements with the PSAPs. The Comtech MIS solution provides a set of core reports that are made available to the Commission and its PSAP representatives, limited to the rights of the user's role. These standard reports include: **1) Timing** a) ESRP response time b) Call-delivery time c) Call-processing time between elements d) Call answering times e) ESRP/ESME query time; differentiate by carrier, MPC, or destination database site f) Avg Duration Total By Carrier g) Avg Duration Total By CoS type **2) Volumes** a) Number of calls b) Number of Text to 911 messages c) Transfers d) Calls per hour e) Top busiest hour f) Alternate-routed calls g) All NGCS element usage volumes h) Calls per trunk i) Default route counts (route reason) j) List/count of default route reasons k) Call Counts By PSAP l) Total Alternate Routed - By Cause type m) Total Final Routed - By Cause type n) Total Default Routed - By Cause type o) Mobile Location at time of route i) Ph1/Coarse ii) Ph2/Fine iii) Other

	3) Utilization a) Bandwidth/trunk utilization b) Trunk utilization c) Circuit utilization **4) Additional i3 Reports** a) Alternate routes by reason b) Final routes c) List by carrier d) NRF by carrier e) Total ring to answer time f) PRF Overrides (ECRF to ESRP comparison) g) Total duration of call (i.e., caller experience) h) Count of calls not delivered to CHE i) By carrier – time to WPH2 j) Locations that never got to WPH2 k) Direct/Transfer These canned reports can be configured to report by location, by call type, or by (time) period. Additionally, custom reports may be negotiated and generated upon request. Any reports requested of or offered by ECaTS is outside of the responsibility of Comtech, other than to forward the required data available.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 71	**Next Generation Core Services Elements (NGCS)** **Event Logging and Management Information System (MIS)** **NENA Standards Compliance** The bidder's proposed logging solution shall meet the requirements set forth in NENA-STA-010.2-2016. **Third-Party Certification Fees** Bidder is responsible for any third-party certification fees. Describe how the solution meets or exceeds these above requirements.	X			
	Bidder Response: Comtech's NG911 aaS includes the Equature™ Logging Service, which conforms to *NENA-STA-01.2-2016*. Equature has participated in every NENA ICE event since the program's inception, and the Equature™ Logging Service has been shown to interoperate with every vendor who has participated. Adherence to this NENA standard ensures that Equature will fulfill its role in the NGCS and interoperate with other vendors' systems that may be deployed at the PSAPs. Furthermore, Comtech has worked with Equature to provide logging services for the Commonwealth of Massachusetts, St. Louis County, Missouri, and the state of Ohio's NG911 pilot. Independent of Comtech, Equature is currently supporting multiple Nebraska counties. Comtech agrees to be responsible for any third-party fees for certifications it seeks for the Equature platform or components thereof.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 72	**Next Generation Core Services Elements (NGCS)** **Network Time Protocol (NTP) and Time Source** Bidder's solution shall sync with existing time sources to maintain consistent time stamps across the network and systems. Describe how bidder's solution complies with this requirement.	X			
	Bidder Response: Comtech's NGCS service deploys with a minimum of three NENA-compliant GPS-equipped Stratum 1 master clocks, which are typically configured to maintain time with GPS and connections to Stratum 0 (zero) time services. If the Commission operates existing Stratum 1 servers, our clocks can also be configured to peer with them.				

Any additional documentation can be inserted here:

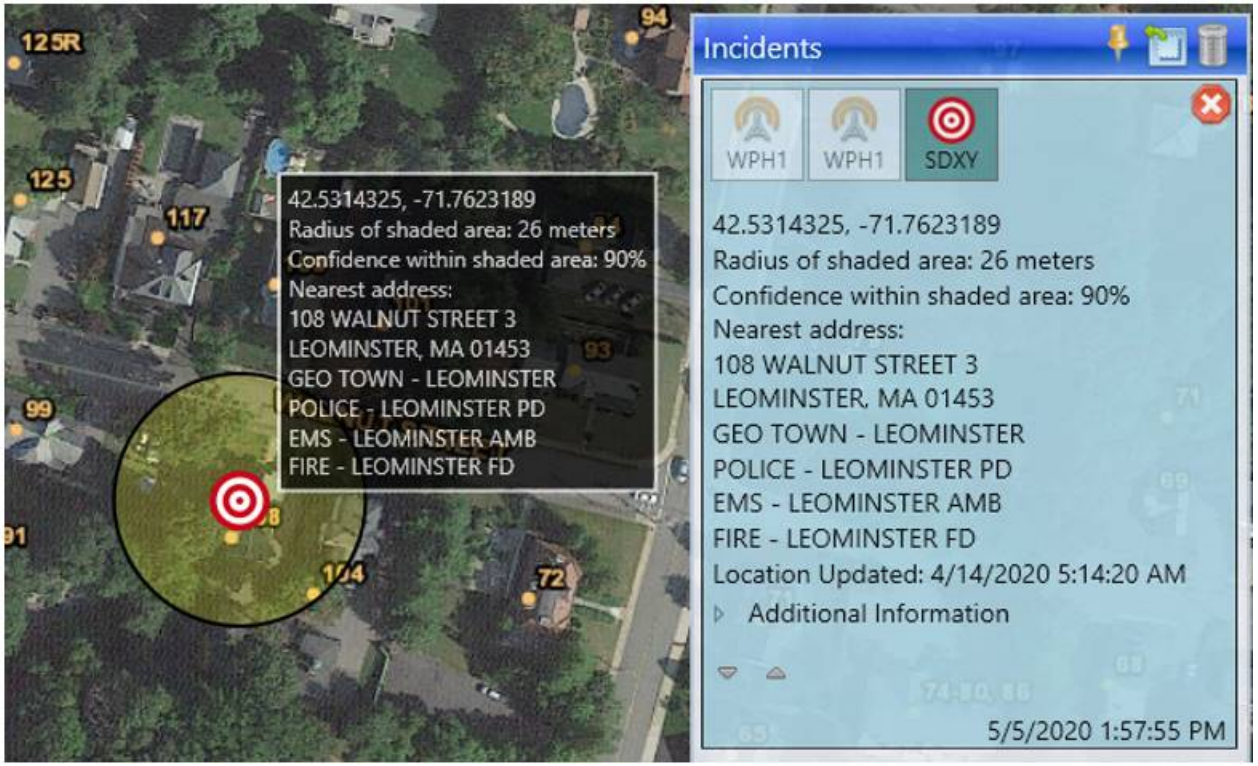
		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 73	**Next Generation Core Services Elements (NGCS)** **Network Time Protocol (NTP) and Time Source** **Master Clock Description** The bidder shall provide redundant, resilient network-attached Stratum 2 time sources ("master clocks") capable of supplying standard time to all systems, network devices, and functional elements that comprise the ESInet and the NGCS. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's NGCS service deploys a minimum of three NENA-compliant GPS-equipped Stratum 1 master clocks. These master clocks operate on the ESInet and are accessible to be queried by all components of the NGCS. To preserve the security and integrity of the time, NTP servers are configured to utilize authentication keys to ensure that the time being passed to the NTP clients is provided by a trusted source.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 74	**Next Generation Core Services Elements (NGCS)** **Network Time Protocol (NTP) and Time Source** **Accessibility by PSAP Equipment** The master clock time source(s) shall be accessible to the PSAPs for synchronizing call-handling systems and other related systems. All systems, network devices, and functional elements shall support the use of the NTP for maintaining system clock accuracy. Describe how the solution meets or exceeds the above requirements.	X			
	Bidder Response: Comtech's NGCS service deploys with a minimum of three NENA-compliant GPS-equipped Stratum 1 master clocks. These master clocks operate on the ESInet, and the necessary ports and protocols are opened to the PSAPs to allow PSAP components to query the master clocks for time synchronization. To preserve the security and integrity of the time, NTP servers are configured to utilize authentication keys to ensure that the time being passed to the NTP clients is provided by a trusted source.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 75	**Next Generation Core Services Elements (NGCS)** **NG911 Application Integration** Bidder shall describe other NG911 applications, additional data integrations, and personal safety applications that may be integrated with the NGCS solution. The bidder's system must be capable of integration with Additional Data Repositories (ADR), Identity-Searchable Additional Data Repositories (IS-ADR) or commercial third-party LIS, as described in NENA STA-010.2-2016, within two years of the deployment of the first PSAP. Describe how the solution will accomplish integration, information storage, and use/transmission of data to PSAP CHE.	X			
	Bidder Response: The LDB included in this proposal can act as an ADR out of the box, providing additional data in the HELD response in compliance with *IETF RFC 7852 Additional Data Related to an Emergency Call*. Additionally, the LDB can query the external RapidSOS ADR for additional location information for a wireless call. Further development may be needed to support other external ADRs as they become available, particularly if they do not support the HELD protocol. If the CHE is i3 ready, it should be able to receive PIDF-LO as part of the call payload (or issue a dereference request to the LDB for that information). The LDB will provide all the location information it can to the CHE. The following screenshot shows a tactical call-handling map display that has received a PIDF-LO from the LDB, showing three separate locations for a single call. The RapidSOS location is shown, with buttons available to switch to the wireless Phase I and wireless Phase II locations, if desired.				



Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 76	**Next Generation Core Services Elements (NGCS)** **Message Session Relay Protocol Text (MSRP) Integration** The PSAPs have deployed short messaging service (SMS)-to-911 service. 1. Describe the ability to integrate existing web-based and MSRP-integrated SMS-to-911 and Real-Time Text (RTT) services into the solution. 2. Explain whether the solution supports location-by-reference and/or location-by-value. This requirement is for the integration of text messaging with MSRP and not a requirement for procuring text services.	X			
	Bidder Response: 1) Comtech's NGCS service provides for both web-based and MSRP-integrated Text to 911 (SMS only) and RTT communications. For web-based solutions/services, the Comtech NGCS will allow a VPN connection from the provider contracted by the region/PSAP into the NGCS security boundary. The Comtech NGCS security boundary ensures the security of the IP traffic and then forwards the HTTP/HTTPS thru the ESInet to the regional location via a separate VPN tunnel (for security purposes). Once the web service traffic reaches the regional locations, it will be incumbent upon the regional organization to send the IP traffic to the PSAP's call-taking positions. For MSRP-integrated Text to 911, the text payload is received in the Comtech TCC and signaled to the Comtech NGCS' BCF to follow standard 911 payload routing as depicted in *Comtech Confidential Figure 24* to the regional NG911 gateway. The BCF at the regional sites will signal to the next hop SIP peer (which may be an SBC). Once SIP signaling is completed between the TCC and the regional's/PSAP's CHE, the MSRP media is established between the TCC and the CHE, using the NGCS/ESInet services as transport. For RTT, SIP signaling will originate from the OSP into the Comtech Aggregation BCF to follow the standard 911 payload routing as depicted in *Comtech Confidential Figure 24* to the Regional NextGen Gateway. The BCF at the regional sites will signal to the next-hop SIP peer (which may be an SBC). Once SIP signaling is completed between the OSP and the regional's/PSAP's CHE, voice and data media protocols are established between the OSP and the CHE, using the NGCS/ESInet services as transport. 2) Comtech's NGCS can support both location-by-reference and location-by-value, but Comtech prefers location-by-reference, when available. Comtech's TCC currently provides location-by-reference. Since Comtech provides the TCC, Aggregation, NGCS, ESInet services, all three methods of Text to 911 are covered by Comtech's NG911aaS.				

Any additional documentation can be inserted here:

Figure 24. Comtech's Proposed NG911 System (Comtech Confidential)

	Next Generation Core Services Elements (NGCS)	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
	1. Make-Busy Functionality Some PSAPs have a physical make-busy switch that can be activated in the event of an emergency evacuation. Bidder's solution shall support this functionality to all PSAPS.	X			
	2. Ringdown Functionality Bidders' solution shall support ringdown functionality, either through the call-handling system or through the NGCS.	X			
	3. Near-Simultaneous Transfer The solution shall support near-simultaneous conference and transfer capability, with up to at least 12 parties in the conference. This feature shall allow transfer or conference buttons to be programmed to automatically establish a conference with multiple parties. For instance, one button at a police department might establish a conference between the police, fire, and EMS PSAPs and the original caller, without having to add each additional party individually. Describe how bidder's solution meets or exceeds these requirements.	X			
NGCS 77	Bidder Response: Comtech's NGCS service will support the following functions: 1) **Make-Busy Functionality** – Comtech presumes the make-busy functionality physical button disconnects the physical TDM circuits from the PSAP to the 911 service provider, or between the CHE and the call-taking positions in the PSAP. When a PSAP activates the make-busy functionality, the signaling between the PSAP component (either on a TDM or a SIP level) will be prevented, and the upstream component will be aware of the failure (through the loss of circuits or the loss of a SIP peer). If it is TDM-based, the CHE or the Legacy Regional Gateway (LPG equivalent) will see the inability to reach the PSAP and will signal via SIP to the ESRP. The ESRP will engage alternate routing for the disabled PSAP to the designated failover PSAP. If the PSAP is SIP-based, the appropriate SIP 400 response code from the CHE or Legacy Regional Gateway (LPG equivalent) is provided. Upon receiving the SIP 400 code, the ESRP will engage alternate routing for the disabled PSAP to the designated failover PSAP. 2) **Ringdown Functionality** – Comtech presumes the ringdown functionality is either provided by the PSAP CHE to a call-taking position, or as requested in the NGCS to a non-CHE IP ringdown phone. If provided by the CHE, the NGCS will accept the SIP signaling of the CHE to establish a voice channel to the distance end of the ringdown "circuit." If not provided by CHE, Comtech has a PBX functional element in the NGCS that, in combination with optional phones, will provide a ringdown capability. 3) **Near-Simultaneous Transfer Functionality** – Comtech's NGCS contains bridging and PBX functional elements capable of near-simultaneous conferencing/transfer functionality. If the function is initiated from the CHE, it will be required to program URI compatibility with the NGCS functionality. If the CHE is incapable of this function, optional phones can be procured by the PSAP to provide this capability.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 78	**Next Generation Core Services Elements (NGCS)** **PSAP Interfaces and Backroom Equipment Requirements** **Support of PSAP Interfaces** Bidder's solution shall have the ability to support PSAP interfaces specified in NENA STA-010.2-2016, Section 4, including the following: a. SIP calls b. NGCS call delivery c. Web services d. All baseline media and multimedia (as described in NENA STA-010.2-2016, Section 4) e. NTP time services interface, accurate to 1 ms f. Transport layer security g. Discrepancy reporting Describe the functionality of the PSAP interfaces in detail to address the requirements outlined above, with particular attention to the user interface, additional features, and security aspects.	X			
	Bidder Response: Comtech's NGCS service provides *NENA STA-010.2-2016* compliant interfaces for PSAPs. *NENA STA-010.2-2016 Section 5.7* specifies the interfaces expected to be implemented by PSAPs for use by the NGCS. Section 4 of the standard specifies various interfaces of an NGCS. Comtech's solution complies with Section 4 and expects downstream PSAPs to comply with Section 5.7. As a rule, *NENA STA-010.2-2016* does not specify user interfaces; the NGCS provides service interfaces that are utilized by systems at the PSAP, rather than directly by a human user. For the purposes of *NENA STA-010.2-2016*, centrally hosted CHE are effectively a PSAP, not part of the NGCS. As such, Comtech does not specify human-user interfaces to the NGCS service interfaces as provided under *NENA STA-010.2-2016*. For example, SIP calls delivered via NGCS call-delivery mechanisms (including HELD/LoST web services for location processing and media or multimedia content delivery) are designed to be received and processed by a PSAP CHE. The PSAP CHE is responsible for presenting the call to a human operator and providing the human-user interface for use by call takers. Likewise, NTP and TLS are machine-to-machine interfaces without a direct human-user interface. Discrepancy reporting as specified in *NENA STA-010.2-2016* is also a machine-to-machine web service interface. Automated functional element discrepancy reporting currently in *NENA STA-010.2-2016* has not been fully defined. Comtech will work toward the future adoption of full discrepancy reporting functionality with the advancement of the *NENA STA-010* document. However, Comtech's solution does include discrepancy report functionality for the transitional LDB, which is directly usable by human users. This interface is not specified by *NENA STA-010.2-2106* but is provided as an easy way for location data maintainers (such as OSPs and PSALI operators) to perform maintenance on the LDB. All service interfaces offered to the PSAP by the NGCS are secured via NENA-standard security mechanisms to ensure data confidentiality and integrity.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 79	**Next Generation Core Services Elements (NGCS)** **PSAP Interfaces and Backroom Equipment Requirements** **Support of Call Handling Equipment (CHE) Platforms** 1. Provide a list of CHE platforms for which bidder has successfully implemented the interfaces listed above in a live production environment, noting any interfaces that have not yet been tested with each CHE vendor/model. 2. Where interfaces with CHE vendors/models have yet to be deployed and/or tested, please describe the integration testing process that the bidder will perform prior to acceptance testing of the solution. 3. Describe the physical interface handoff required at the PSAP CHE demarcation point.	X			

Bidder Response:

Comtech's NG911aaS has interconnected with and performed interoperability testing with each of the CHE vendors listed in *Comtech Confidential Table 4*. Any CHE solution that employs versions outside of this exhibit must either leverage an LPG or conduct interoperability testing with the Comtech lab prior to deployment.

Table 4. CHE Interoperability Testing (Comtech Confidential)

Comtech has not tested the following interfaces with one or more CHE providers:

- Subscribe/notify has not been tested with any of the CHE providers listed in Table 4
- RTT is currently not supported by most CHEs and has not been tested; however, Solacom has been tested for this interface
- TLS has not been implemented by any current customer's PSAP and thus has not been tested
- Discrepancy reporting will experience significant changes in the proposed *STA 10.3;* since CHE providers have not fully implemented *STA 10.2* discrepancy reporting, this has not been tested.

Comtech maintains a PIE lab and a connected PSAP laboratory for testing NGCS services as well as HCH equipment services. Comtech has used these labs to test against various Comtech ICDs, defining the interfaces between CHE and Comtech's NGCS service. These vendors can either provide CHE for our lab, or else Comtech will work with the CHE vendor to interconnect between the CHE lab and Comtech's labs. Comtech and the CHE vendor will review the VCRM plus the test plan, and its procedures, customizing the testing to whichever interfaces the CHE may provide. Testing will then be performed with all defects cataloged. Based upon the type and severity of any discovered defects, the PSAP or the region can decide to implement the interface in a production environment.

Comtech supports two configurations governed by ICDs. First is an LPG (regional) configuration, with a serial interface to accommodate ALI and at least two Telcordia Interface DS0s or a channelized DS1 with in-band signaling. Second is an NG PSAP (regional) gateway interface, with at least two 10/100/1000 Mbps interfaces where SIP, RTP, HTTP(S), and additional agreed-upon protocols will be interconnected.

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 80	**Next Generation Core Services Elements (NGCS)** **Transfer to 7/10-Digit Numbers** The bidder's solution shall be capable of transferring 911 calls to 7 or 10-digit numbers with the Calling Party Number (CPN). Describe how the solution meets or exceeds this requirement.	X			
	Bidder Response: Comtech's NGCS service supports call transfers between PSAPs that are both connected to the Nebraska ESInet, as well as to PSAPs connected to an external NG911 ESInet, whether the PSAPs are legacy or NG911. Call transfers are triggered by the PSAP's CHE. The specific trigger may be a seven- or 10-digit number, a star (*) code, or some other PSAP equipment mechanism, depending on the specific CHE. For transfers from Nebraska's ESInet PSAPs to external ESInet PSAPs, Comtech leverages Inteliquent services as a component of the LNG. Inteliquent will provide the PIF between the legacy selective routers and the BCF and LSRG to facilitate call transfers from a NG911 PSAP to legacy PSAPs. Inteliquent will also provide SBC-to-SBC connectivity for NG911-to-NG911 transfers. For transfers internal to the Nebraska ESInet, the transfer is sent from the local CHE back through Comtech's MSVC, which re-routes the call to the intended PSAP. At a minimum, in the case of transfers between legacy PSAPs, the initiating PSAP's LPG sends both the calling party's number and its location data to the destination PSAP's LPG, and the destination PSAP sends only the calling party's data to the CHE. In the case of a Legacy-to-NG911 transfer, since the call is being transferred to a NG911 PSAP, several additional pieces of data could also be transferred. This could include NENA Caller ID and NENA Incident ID information. For NG911-to-NG911 transfers, in addition to all the previously mentioned data, the transfer also includes NG911 location and the initiating PSAP's identity.				

Any additional documentation can be inserted here:

		Comply	Partially Comply	Complies with Future Capability	Does Not Comply
SVAL-1	**Service Validation** Throughout the life of the contract, upon request of the Commission, Bidder shall allow for network testing and validation by a third-party entity, to verify that the service(s) and/or solution(s) are in compliance with the contract's scope.	X			
	Bidder Response: Comtech understands the requirement and will support third-party network testing and validation upon the request of the Commission.				

OPTIONAL SERVICE

	Next Generation Core Services Elements (NGCS) **OPTIONAL SERVICES** **NG911 Applications and Alarm Integration** **Alarm Integration Description** NG911 provides for the capability to have alarm companies integrate directly with the ESInet and use the NGCS for routing of the alarm and associated data. Describe bidder's experience with integrating alarms, sensors, and other non-interactive call types with bidder's NGCS solution and include separate pricing.	Comply	Partially Comply	Complies with Future Capability	Does Not Comply
NGCS 81		X			
	Bidder Response: Comtech supports the transport of ASAP over the ESInet to PSAP's CAD system. To ensure the security of the NGCS system, Comtech will require an optional security boundary and security audit of the PSAP before allowing ASAP to transit the ESInet to a PSAP's CAD. At this time, Comtech has not had a customer PSAP implement ASAP. Comtech is 100 percent confident that the ASAP protocol based upon IP will be no issue to transit the ESInet to PSAPs. Comtech supports and can provide other non-interactive call types such as video, Text from 911, and smartphone applications. Comtech's partner, Carbyne, has a c-Live Universe Solution—a NG911 plugin for legacy platforms—that provides NG911 functionality to PSAPs that use legacy call-handling software. This product's features include industry-leading location capabilities, call-taker-controlled live video streaming, integration with smart city sensors, and Chat to 911 functionality. Another Comtech partner offering, provided by Rave Mobility, is Rave911 Chat. Rave911 Chat provides call takers with additional communications method of Text from 911. Text from 911 has been used to aide in the growing issue of dropped and abandoned mobile calls. Call takers have the ability to initiate a text communication with any mobile number, and no Smart911 safety profile is required. Other scenarios where this additional mode of communication has proven to be effective include hostage or domestic violence incidents.				

Any additional documentation can be inserted here:

REQUEST FOR PROPOSAL FOR CONTRACTUAL SERVICES FORM

By signing this Request for Proposal for Contractual Services form, the bidder guarantees compliance

CONTRACTOR MUST COMPLETE THE FOLLOWING

with the procedures stated in this Solicitation, and agrees to the terms and conditions unless otherwise indicated in writing and certifies that bidder maintains a drug free work place.

Per Nebraska's Transparency in Government Procurement Act, Neb. Rev Stat § 73-603 DAS is required to collect statistical information regarding the number of contracts awarded to Nebraska Contractors. This information is for statistical purposes only and will not be considered for contract award purposes.

_____ NEBRASKA CONTRACTOR AFFIDAVIT: Bidder hereby attests that bidder is a Nebraska Contractor. "Nebraska Contractor" shall mean any bidder who has maintained a bona fide place of business and at least one employee within this state for at least the six (6) months immediately preceding the posting date of this Solicitation.

_____ I hereby certify that I am a Resident disabled veteran or business located in a designated enterprise zone in accordance with Neb. Rev. Stat. § 73-107 and wish to have preference, if applicable, considered in the award of this contract.

_____ I hereby certify that I am a blind person licensed by the Commission for the Blind & Visually Impaired in accordance with Neb. Rev. Stat. §71-8611 and wish to have preference considered in the award of this contract.

FORM MUST BE SIGNED USING AN INDELIBLE METHOD OR BY DOCUSIGN

FIRM:	**NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.**
COMPLETE ADDRESS:	**2401 Elliott Avenue, Suite 200 Seattle, WA 98121-3311**
TELEPHONE NUMBER:	**206.792.2446**
FAX NUMBER:	**206.792.2001**
DATE:	**June 1, 2020**
SIGNATURE:	Kent A Hellebust
TYPED NAME & TITLE OF SIGNER:	**Kent Hellebust, President**

Instructions To Bidders

General

- All cells are locked except those allowing input (shaded green).
- **Do not attempt to edit formula cells**. Any attempt to edit a formula may cause bidder's entire response to be rejected.
- Tabs will contain cells for Non-Recurring Costs (NRC) and Monthly Recurring Charges (MRC).
- Follow the instructions for each Tab.
- Save as an Excel file and give it a unique name, using the following format: "**Company XYZ XXXX Z1 Cost Proposal Option C ESInet and NGCS**".
- Print the workbook (not just the worksheets) to verify content of each tab. Also, verify that all data can be seen in each cell.
- Include the saved Excel file when submitting the RFP response package to the Nebraska State Purchasing Bureau.
- If more rows are needed in each region, you can insert additional rows.
- Each sheet is divided into the 7 regions. Enter pricing information for each region based on bidders implementation plan.
- All PSAPs and regions may not be ready for geospatial routing on day one of operations and Bidder shall provide tabular routing services, also known as Internet Protocol Selective Routing (IPSR), until such time as PSAPs and regions are ready for geospatial routing. Be sure the cost proposal response indicates the pricing difference between tabular and geospatial routing.
- Include pricing for Optional NGCS services on the Optional Svc tab.

NRC Milestones

- Milestone Payments - NRC payments will be made as structured on the NRC Milestones Tab.As each region is completed on each tab, it is calculated into the total milestone. **Bidders should prepare their cost proposal to reflect the timeline submitted with Bidder's Implementation Plan.**

Summary Tab

- As the name implies, this tab contains the totals from the ESInet, **Legacy Network Gateway (LNG)**, **Border Control Function (BCF)**, **Emergency Services Routing Proxy and Policy Routing Function (ESRP & PRF)**, **Emergency Call Routing Function and Location Validation Function (ECRF & LVF)**, **Spatial Interface (SI)**, **Location Database (LDB)** and **Miscellaneous (MISC) tabs.**
- Enter the Bidder name and date in the designated cells. This information automatically populates the other tabs.
- All other cells are locked.

ESInet Tab

- Change the free form "Bidder Input" labels as needed and enter the pricing information **in each region** for Emergency Services IP Network services (hardware, software, connectivity, training, maintenance, etc.) for each region. Add rows for each region as needed.
- Enter the NRC in whole dollars and the **MRC in monthly per person amounts in cents**. The monthly amounts are automatically multiplied by the population of the region and by 12 months.

LNG Tab

- Change the free form "Bidder Input" labels as needed and enter the pricing information **in each region** for Legacy Network Gateway services (hardware, software, connectivity, training, maintenance, etc.). Add rows for each region as needed.
- Enter the NRC in whole dollars and the **MRC in monthly amounts per person amounts in cents**. The monthly amounts are automatically multiplied by 12 and the region's population.

BCF Tab

- Change the free form "Bidder Input" labels as needed and enter the pricing information **in each region** for Border Control Function services (hardware, software, connectivity, training, maintenance, etc.). Add rows for each region as needed.
- Enter the NRC in whole dollars and the **MRC in monthly amounts per person amounts in cents**. The monthly amounts are automatically multiplied by 12 and the Region's population.

ESRP & PRF Tab

- Change the free form "Bidder Input" labels as needed and enter the pricing information **in each region** for Emergency Services Routing Proxy and Policy Routing Function services (hardware, software, connectivity, training, maintenance, etc.). Add rows for each region as needed.
- Enter the NRC in whole dollars and the **MRC in monthly amounts per person amounts in cents**. The monthly amounts are automatically multiplied by 12 and the Region's population.

ECRF & LVF Tab

- Change the free form "Bidder Input" labels as needed and enter the pricing information **in each region** for Emergency Call Routing Function and Location Validation Function services (hardware, software, connectivity, training, maintenance, etc.). Add rows for each region as needed.
- Enter the NRC in whole dollars and the **MRC in monthly amounts per person amounts in cents**. The monthly amounts are automatically multiplied by 12 and the Region's population.

SI Tab

- Change the free form "Bidder Input" labels as needed and enter the pricing information for Spatial Interface services (hardware, software, training, maintenance, etc.). Add rows for each region as needed.
- Enter the NRC in whole dollars and the **MRC in monthly amounts per person amounts in cents**. The monthly amounts are automatically multiplied by 12 and the Region's population.

LDB Tab

- Change the free form "Bidder Input" labels as needed and enter the pricing information **in each region** for Location Database services (hardware, software, training, maintenance, etc.). Add rows for each region as needed.
- Enter the NRC in whole dollars and the **MRC in monthly amounts per person amounts in cents**. The monthly amounts are automatically multiplied by 12 and the Region's population.

MISC Tab

- Change the free form "Bidder Input" labels as needed and enter the pricing information **in each region** for Miscellaneous services that are not part of one of the above functional elements or that may not have been covered in the RFP but are required in order to complete the project. Add rows for each region as needed.

ESInet Milestones	
Milestone 1: **Region 1** regional host connection and testing acceptance	2431.71
Milestone 2: **Region 2** regional host connection and testing acceptance	5050.47
Milestone 3: **Region 3** regional host connection and testing acceptance	7482.18
Milestone 4: **Region 4** regional host connection and testing acceptance	374.11
Milestone 5: **Region 5** regional host connection and testing acceptance	1683.49
Milestone 6: **Region 6** regional host connection and testing acceptance	1122.33
Milestone 7: **Region 7** regional host connection and testing acceptance	561.16
TOTAL	18705.45

NGCS Milestones	
Milestone 1: **Region 1** deployments complete	763,038.04
Milestone 2: **Region 2** deployments complete	1,584,771.32
Milestone 3: **Region 3** deployments complete	2,347,809.35
Milestone 4: **Region 4** deployments complete	117,390.47
Milestone 5: **Region 5** deployments complete	528,257.11
Milestone 6: **Region 6** deployments complete	352,171.40
Milestone 7: **Region 7** deployments complete	176,085.71
TOTAL	5869523.40

6264 Z1 Cost Proposal Option C ESInet NGCS Revision One

Bidder Name	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.
Date (MM/DD/YYYY):	6/3/2020

Next Generation Core Services	**INITIAL CONTRACT PERIOD**														
	YEAR 1		**YEAR 2**		**YEAR 3**		**YEAR 4**		**YEAR 5**		**YEAR 6**	**YEAR 7**	**YEAR 8**	**YEAR 9**	**YEAR 10**
	NRC	**MRC[1]**	**NRC**	**MRC[1]**	**NRC**	**MRC[1]**	**NRC**	**MRC[1]**	**NRC**	**MRC[1]**	**MRC[1]**	**MRC[1]**	**MRC[1]**	**MRC[1]**	**MRC[1]**
ESInet	18,705.45	646,322.90	0.00	646,322.90	0.00	646,322.90	0.00	646,322.90	0.00	646,322.90	646,322.90	646,322.90	646,322.90	646,322.90	646,322.90
LNG	434,659.52	891,898.52	0.00	891,898.52	0.00	891,898.52	0.00	891,898.52	0.00	891,898.52	891,898.52	891,898.52	891,898.52	891,898.52	891,898.52
BCF	852,795.40	1,090,642.40	0.00	1,090,642.40	0.00	1,090,642.40	0.00	1,090,642.40	0.00	1,090,642.40	1,227,160.67	1,227,160.67	1,227,160.67	1,227,160.67	1,227,160.67
ESRP & PRF	1,328,091.93	648,638.02	0.00	648,638.02	0.00	648,638.02	0.00	648,638.02	0.00	648,638.02	861,127.62	861,127.62	861,127.62	861,127.62	861,127.62
ECRF & LVF	144,045.00	258,964.72	0.00	258,964.72	0.00	258,964.72	0.00	258,964.72	0.00	258,964.72	282,217.55	282,217.55	282,217.55	282,217.55	282,217.55
SI	0.00	227,450.04	0.00	227,450.04	0.00	227,450.04	0.00	227,450.04	0.00	227,450.04	227,450.04	227,450.04	227,450.04	227,450.04	227,450.04
LDB	144,045.00	287,084.12	0.00	287,084.12	0.00	287,084.12	0.00	287,084.12	0.00	287,084.12	310,131.32	310,131.32	310,131.32	310,131.32	310,131.32
MISC	2,965,886.55	1,847,923.59	0.00	1,974,499.07	0.00	2,026,412.47	0.00	2,080,348.77	0.00	2,135,503.70	2,930,523.30	2,990,308.48	3,050,161.40	3,113,005.31	3,177,488.47
Total	5,888,228.85	5,898,924.32	0.00	6,025,499.80	0.00	6,077,413.20	0.00	6,131,349.50	0.00	6,186,504.43	7,376,831.92	7,436,617.10	7,496,470.02	7,559,313.93	7,623,797.09

Project Totals	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Yearly Totals (NRC+MRC)	11,787,153.17	6,025,499.80	6,077,413.20	6,131,349.50	6,186,504.43	7,376,831.92	7,436,617.10	7,496,470.02	7,559,313.93	7,623,797.09
Initial Contract (5 Year NRC+MRC)	36,207,920.09									
+ Optional Year 6 (6 Year NRC+MRC)	43,584,752.01									
+ Optional Years 7 (7 Year NRC+MRC)	51,021,369.11									
+ Optional Years 8 (8 Year NRC+MRC)	58,517,839.12									
+ Optional Years 9 (9 Year NRC+MRC)	66,077,153.05									
+ Optional Years 10 (10 Year NRC+MRC)	73,700,950.14									

State Population	
	2019 Estimates
Region One - ~~SE~~ SC	259,183
Region Two - ~~SC~~ SE	512,126
Region Three - Metro	772,006
Region Four - NC	28,227
Region Five - EC	180,423
Region Six - NE	114,203
Region Seven - Metro West	63,100
Total Population	1,929,268

Bidder Name:	0
Date (MM/DD/YYYY):	1/0/1900

Emergency Services IP Network	**INITIAL CONTRACT PERIOD**														
	YEAR 1		**YEAR 2**		**YEAR 3**		**YEAR 4**		**YEAR 5**		**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
	NRC	**MRC[1]**	**NRC**	**MRC[1]**	**NRC**	**MRC[1]**	**NRC**	**MRC[1]**	**NRC**	**MRC[1]**	**MRC[1]**	**MRC[1]**	**MRC[1]**	**MRC[1]**	**MRC[1]**
Region One Milestone															
ESInet Service	2,431.7100	0.0270	0.0000	0.0270	0.0000	0.0270	0.0000	0.0270	0.0000	0.0270	0.0270	0.0270	0.0270	0.0270	0.0270
NRC/MRC REGION 1 TOTAL	2,431.7100	83,975.2920	0.0000	83,975.2920	0.0000	83,975.2920	0.0000	83,975.2920	0.0000	83,975.2920	83,975.2920	83,975.2920	83,975.2920	83,975.2920	83,975.2920
Region Two Milestone															
ESInet Service	5,050.4700	0.0284	0.0000	0.0284	0.0000	0.0284	0.0000	0.0284	0.0000	0.0284	0.0284	0.0284	0.0284	0.0284	0.0284
NRC/MRC REGION 2 TOTAL	5,050.4700	174,532.5408	0.0000	174,532.5408	0.0000	174,532.5408	0.0000	174,532.5408	0.0000	174,532.5408	174,532.5408	174,532.5408	174,532.5408	174,532.5408	174,532.5408
Region Three Milestone															
ESInet Service	7,482.1800	0.0279	0.0000	0.0279	0.0000	0.0279	0.0000	0.0279	0.0000	0.0279	0.0279	0.0279	0.0279	0.0279	0.0279
NRC/MRC REGION 3 TOTAL	7,482.1800	258,467.6088	0.0000	258,467.6088	0.0000	258,467.6088	0.0000	258,467.6088	0.0000	258,467.6088	258,467.6088	258,467.6088	258,467.6088	258,467.6088	258,467.6088
Region Four Milestone															
ESInet Service	374.1100	0.0382	0.0000	0.0382	0.0000	0.0382	0.0000	0.0382	0.0000	0.0382	0.0382	0.0382	0.0382	0.0382	0.0382
NRC/MRC REGION 4 TOTAL	374.1100	12,939.2568	0.0000	12,939.2568	0.0000	12,939.2568	0.0000	12,939.2568	0.0000	12,939.2568	12,939.2568	12,939.2568	12,939.2568	12,939.2568	12,939.2568
Region Five Milestone															
ESInet Service	1,683.4900	0.0269	0.0000	0.0269	0.0000	0.0269	0.0000	0.0269	0.0000	0.0269	0.0269	0.0269	0.0269	0.0269	0.0269
NRC/MRC REGION 5 TOTAL	1,683.4900	58,240.5444	0.0000	58,240.5444	0.0000	58,240.5444	0.0000	58,240.5444	0.0000	58,240.5444	58,240.5444	58,240.5444	58,240.5444	58,240.5444	58,240.5444
Region Six Milestone															
ESInet Service	1,122.3300	0.0283	0.0000	0.0283	0.0000	0.0283	0.0000	0.0283	0.0000	0.0283	0.0283	0.0283	0.0283	0.0283	0.0283
NRC/MRC REGION 6 TOTAL	1,122.3300	38,783.3388	0.0000	38,783.3388	0.0000	38,783.3388	0.0000	38,783.3388	0.0000	38,783.3388	38,783.3388	38,783.3388	38,783.3388	38,783.3388	38,783.3388
Region Seven Milestone															
ESInet Service	561.1600	0.0256	0.0000	0.0256	0.0000	0.0256	0.0000	0.0256	0.0000	0.0256	0.0256	0.0256	0.0256	0.0256	0.0256
NRC/MRC REGION 7 TOTAL	561.1600	19,384.3200	0.0000	19,384.3200	0.0000	19,384.3200	0.0000	19,384.3200	0.0000	19,384.3200	19,384.3200	19,384.3200	19,384.3200	19,384.3200	19,384.3200
ESInet Total	18,705.4500	646,322.9016	0.0000	646,322.9016	0.0000	646,322.9016	0.0000	646,322.9016	0.0000	646,322.9016	646,322.9016	646,322.9016	646,322.9016	646,322.9016	646,322.9016

Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.
Date (MM/DD/YYYY):	6/3/2020

Legacy Network Gateway	INITIAL CONTRACT PERIOD														
	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		Year 6	Year 7	Year 8	Year 9	Year 10
	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]
Region One Milestone															
LNG Service	56,505.7400	0.0373	0.0000	0.0373	0.0000	0.0373	0.0000	0.0373	0.0000	0.0373	0.0373	0.0373	0.0373	0.0373	0.0373
NRC/MRC Region 1 Total	56,505.7400	116,010.3108	0.0000	116,010.3108	0.0000	116,010.3108	0.0000	116,010.3108	0.0000	116,010.3108	116,010.3108	116,010.3108	116,010.3108	116,010.3108	116,010.3108
Region Two Milestone															
LNG Service	117,358.0700	0.0392	0.0000	0.0392	0.0000	0.0392	0.0000	0.0392	0.0000	0.0392	0.0392	0.0392	0.0392	0.0392	0.0392
NRC/MRC Region 2 Total	117,358.0700	240,904.0704	0.0000	240,904.0704	0.0000	240,904.0704	0.0000	240,904.0704	0.0000	240,904.0704	240,904.0704	240,904.0704	240,904.0704	240,904.0704	240,904.0704
Region Three Milestone															
LNG Service	173,863.8000	0.0385	0.0000	0.0385	0.0000	0.0385	0.0000	0.0385	0.0000	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385
NRC/MRC Region 3 Total	173,863.8000	356,666.7720	0.0000	356,666.7720	0.0000	356,666.7720	0.0000	356,666.7720	0.0000	356,666.7720	356,666.7720	356,666.7720	356,666.7720	356,666.7720	356,666.7720
Region Four Milestone															
LNG Service	8,693.1900	0.0526	0.0000	0.0526	0.0000	0.0526	0.0000	0.0526	0.0000	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526
NRC/MRC Region 4 Total	8,693.1900	17,816.8824	0.0000	17,816.8824	0.0000	17,816.8824	0.0000	17,816.8824	0.0000	17,816.8824	17,816.8824	17,816.8824	17,816.8824	17,816.8824	17,816.8824
Region Five Milestone															
LNG Service	39,119.3600	0.0371	0.0000	0.0371	0.0000	0.0371	0.0000	0.0371	0.0000	0.0371	0.0371	0.0371	0.0371	0.0371	0.0371
NRC/MRC Region 5 Total	39,119.3600	80,324.3196	0.0000	80,324.3196	0.0000	80,324.3196	0.0000	80,324.3196	0.0000	80,324.3196	80,324.3196	80,324.3196	80,324.3196	80,324.3196	80,324.3196
Region Six Milestone															
LNG Service	26,079.5700	0.0390	0.0000	0.0390	0.0000	0.0390	0.0000	0.0390	0.0000	0.0390	0.0390	0.0390	0.0390	0.0390	0.0390
NRC/MRC Region 6 Total	26,079.5700	53,447.0040	0.0000	53,447.0040	0.0000	53,447.0040	0.0000	53,447.0040	0.0000	53,447.0040	53,447.0040	53,447.0040	53,447.0040	53,447.0040	53,447.0040
Region Seven Milestone															
LNG Service	13,039.7900	0.0353	0.0000	0.0353	0.0000	0.0353	0.0000	0.0353	0.0000	0.0353	0.0353	0.0353	0.0353	0.0353	0.0353
NRC/MRC Region 7 Total	13,039.7900	26,729.1600	0.0000	26,729.1600	0.0000	26,729.1600	0.0000	26,729.1600	0.0000	26,729.1600	26,729.1600	26,729.1600	26,729.1600	26,729.1600	26,729.1600
LNG Total	**434,659.5200**	**891,898.5192**	**0.0000**	**891,898.5192**	**0.0000**	**891,898.5192**	**0.0000**	**891,898.5192**	**0.0000**	**891,898.5192**	**891,898.5192**	**891,898.5192**	**891,898.5192**	**891,898.5192**	**891,898.5192**

6264 Z1 Cost Proposal Option C ESInet NGCS Revision One

Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.														
Date (MM/DD/YYYY):	6/3/2020														
	INITIAL CONTRACT PERIOD														
Border Control Function	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		Year 6	Year 7	Year 8	Year 9	Year 10
	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]
Region One Milestone															
BCF Service	110,863.4000	0.0456	0.0000	0.0456	0.0000	0.0456	0.0000	0.0456	0.0000	0.0456	0.0513	0.0513	0.0513	0.0513	0.0513
NRC/MRC Region 1 Total	110,863.4000	141,824.9376	0.0000	141,824.9376	0.0000	141,824.9376	0.0000	141,824.9376	0.0000	141,824.9376	159,553.0548	159,553.0548	159,553.0548	159,553.0548	159,553.0548
Region Two Milestone															
BCF Service	230,254.7600	0.0479	0.0000	0.0479	0.0000	0.0479	0.0000	0.0479	0.0000	0.0479	0.0539	0.0539	0.0539	0.0539	0.0539
NRC/MRC Region 2 Total	230,254.7600	294,370.0248	0.0000	294,370.0248	0.0000	294,370.0248	0.0000	294,370.0248	0.0000	294,370.0248	331,243.0968	331,243.0968	331,243.0968	331,243.0968	331,243.0968
Region Three Milestone															
BCF Service	341,118.1600	0.0471	0.0000	0.0471	0.0000	0.0471	0.0000	0.0471	0.0000	0.0471	0.0530	0.0530	0.0530	0.0530	0.0530
NRC/MRC Region 3 Total	341,118.1600	436,337.7912	0.0000	436,337.7912	0.0000	436,337.7912	0.0000	436,337.7912	0.0000	436,337.7912	490,995.8160	490,995.8160	490,995.8160	490,995.8160	490,995.8160
Region Four Milestone															
BCF Service	17,055.9100	0.0644	0.0000	0.0644	0.0000	0.0644	0.0000	0.0644	0.0000	0.0644	0.0725	0.0725	0.0725	0.0725	0.0725
NRC/MRC Region 4 Total	17,055.9100	21,813.8256	0.0000	21,813.8256	0.0000	21,813.8256	0.0000	21,813.8256	0.0000	21,813.8256	24,557.4900	24,557.4900	24,557.4900	24,557.4900	24,557.4900
Region Five Milestone															
BCF Service	76,751.5900	0.0453	0.0000	0.0453	0.0000	0.0453	0.0000	0.0453	0.0000	0.0453	0.0510	0.0510	0.0510	0.0510	0.0510
NRC/MRC Region 5 Total	76,751.5900	98,077.9428	0.0000	98,077.9428	0.0000	98,077.9428	0.0000	98,077.9428	0.0000	98,077.9428	110,418.8760	110,418.8760	110,418.8760	110,418.8760	110,418.8760
Region Six Milestone															
BCF Service	51,167.7200	0.0478	0.0000	0.0478	0.0000	0.0478	0.0000	0.0478	0.0000	0.0478	0.0537	0.0537	0.0537	0.0537	0.0537
NRC/MRC Region 6 Total	51,167.7200	65,506.8408	0.0000	65,506.8408	0.0000	65,506.8408	0.0000	65,506.8408	0.0000	65,506.8408	73,592.4132	73,592.4132	73,592.4132	73,592.4132	73,592.4132
Region Seven Milestone															
BCF Service	25,583.8600	0.0432	0.0000	0.0432	0.0000	0.0432	0.0000	0.0432	0.0000	0.0432	0.0486	0.0486	0.0486	0.0486	0.0486
NRC/MRC Region 7 Total	25,583.8600	32,711.0400	0.0000	32,711.0400	0.0000	32,711.0400	0.0000	32,711.0400	0.0000	32,711.0400	36,799.9200	36,799.9200	36,799.9200	36,799.9200	36,799.9200
BCF Total	**852,795.4000**	**1,090,642.4028**	**0.0000**	**1,090,642.4028**	**0.0000**	**1,090,642.4028**	**0.0000**	**1,090,642.4028**	**0.0000**	**1,090,642.4028**	**1,227,160.6668**	**1,227,160.6668**	**1,227,160.6668**	**1,227,160.6668**	**1,227,160.6668**

6264 Z1 Cost Proposal Option C ESInet NGCS Revision One

Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.														
Date (MM/DD/YYYY):	6/3/2020														
Emergency Services Routing Proxy & Policy Routing Function	INITIAL CONTRACT PERIOD														
	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		Year 6	Year 7	Year 8	Year 9	Year 10
	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]
Region One Milestone															
ESRP & PRF Service	172,651.9500	0.0271	0.0000	0.0271	0.0000	0.0271	0.0000	0.0271	0.0000	0.0271	0.0360	0.0360	0.0360	0.0360	0.0360
NRC/MRC Region 1 Total	172,651.9500	84,286.3116	0.0000	84,286.3116	0.0000	84,286.3116	0.0000	84,286.3116	0.0000	84,286.3116	111,967.0560	111,967.0560	111,967.0560	111,967.0560	111,967.0560
Region Two Milestone															
ESRP & PRF Service	358,584.8200	0.0285	0.0000	0.0285	0.0000	0.0285	0.0000	0.0285	0.0000	0.0285	0.0378	0.0378	0.0378	0.0378	0.0378
NRC/MRC Region 2 Total	358,584.8200	175,147.0920	0.0000	175,147.0920	0.0000	175,147.0920	0.0000	175,147.0920	0.0000	175,147.0920	232,300.3536	232,300.3536	232,300.3536	232,300.3536	232,300.3536
Region Three Milestone															
ESRP & PRF Service	531,236.7700	0.0280	0.0000	0.0280	0.0000	0.0280	0.0000	0.0280	0.0000	0.0280	0.0372	0.0372	0.0372	0.0372	0.0372
NRC/MRC Region 3 Total	531,236.7700	259,394.0160	0.0000	259,394.0160	0.0000	259,394.0160	0.0000	259,394.0160	0.0000	259,394.0160	344,623.4784	344,623.4784	344,623.4784	344,623.4784	344,623.4784
Region Four Milestone															
ESRP & PRF Service	26,561.8400	0.0383	0.0000	0.0383	0.0000	0.0383	0.0000	0.0383	0.0000	0.0383	0.0509	0.0509	0.0509	0.0509	0.0509
NRC/MRC Region 4 Total	26,561.8400	12,973.1292	0.0000	12,973.1292	0.0000	12,973.1292	0.0000	12,973.1292	0.0000	12,973.1292	17,241.0516	17,241.0516	17,241.0516	17,241.0516	17,241.0516
Region Five Milestone															
ESRP & PRF Service	119,528.2700	0.0270	0.0000	0.0270	0.0000	0.0270	0.0000	0.0270	0.0000	0.0270	0.0358	0.0358	0.0358	0.0358	0.0358
NRC/MRC Region 5 Total	119,528.2700	58,457.0520	0.0000	58,457.0520	0.0000	58,457.0520	0.0000	58,457.0520	0.0000	58,457.0520	77,509.7208	77,509.7208	77,509.7208	77,509.7208	77,509.7208
Region Six Milestone															
ESRP & PRF Service	79,685.5200	0.0284	0.0000	0.0284	0.0000	0.0284	0.0000	0.0284	0.0000	0.0284	0.0377	0.0377	0.0377	0.0377	0.0377
NRC/MRC Region 6 Total	79,685.5200	38,920.3824	0.0000	38,920.3824	0.0000	38,920.3824	0.0000	38,920.3824	0.0000	38,920.3824	51,665.4372	51,665.4372	51,665.4372	51,665.4372	51,665.4372
Region Seven Milestone															
ESRP & PRF Service	39,842.7600	0.0257	0.0000	0.0257	0.0000	0.0257	0.0000	0.0257	0.0000	0.0257	0.0341	0.0341	0.0341	0.0341	0.0341
NRC/MRC Region 7 Total	39,842.7600	19,460.0400	0.0000	19,460.0400	0.0000	19,460.0400	0.0000	19,460.0400	0.0000	19,460.0400	25,820.5200	25,820.5200	25,820.5200	25,820.5200	25,820.5200
ESRP & PRF Total	**1,328,091.9300**	**648,638.0232**	**0.0000**	**648,638.0232**	**0.0000**	**648,638.0232**	**0.0000**	**648,638.0232**	**0.0000**	**648,638.0232**	**861,127.6176**	**861,127.6176**	**861,127.6176**	**861,127.6176**	**861,127.6176**

6264 Z1 Cost Proposal Option C ESInet NGCS Revision One

Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.														
Date (MM/DD/YYYY):	6/3/2020														
Emergency Call Routing Function & Location Validation Function	INITIAL CONTRACT PERIOD														
	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		Year 6	Year 7	Year 8	Year 9	Year 10
	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]
Region One Milestone															
ECRF & LVF Service	18,725.8500	0.0108	0.0000	0.0108	0.0000	0.0108	0.0000	0.0108	0.0000	0.0108	0.0118	0.0118	0.0118	0.0118	0.0118
NRC/MRC Region 1 Total	18,725.8500	33,590.1168	0.0000	33,590.1168	0.0000	33,590.1168	0.0000	33,590.1168	0.0000	33,590.1168	36,700.3128	36,700.3128	36,700.3128	36,700.3128	36,700.3128
Region Two Milestone															
ECRF & LVF Service	38,892.1500	0.0114	0.0000	0.0114	0.0000	0.0114	0.0000	0.0114	0.0000	0.0114	0.0124	0.0124	0.0124	0.0124	0.0124
NRC/MRC Region 2 Total	38,892.1500	70,058.8368	0.0000	70,058.8368	0.0000	70,058.8368	0.0000	70,058.8368	0.0000	70,058.8368	76,204.3488	76,204.3488	76,204.3488	76,204.3488	76,204.3488
Region Three Milestone															
ECRF & LVF Service	57,618.0000	0.0112	0.0000	0.0112	0.0000	0.0112	0.0000	0.0112	0.0000	0.0112	0.0122	0.0122	0.0122	0.0122	0.0122
NRC/MRC Region 3 Total	57,618.0000	103,757.6064	0.0000	103,757.6064	0.0000	103,757.6064	0.0000	103,757.6064	0.0000	103,757.6064	113,021.6784	113,021.6784	113,021.6784	113,021.6784	113,021.6784
Region Four Milestone															
ECRF & LVF Service	2,880.9000	0.0153	0.0000	0.0153	0.0000	0.0153	0.0000	0.0153	0.0000	0.0153	0.0166	0.0166	0.0166	0.0166	0.0166
NRC/MRC Region 4 Total	2,880.9000	5,182.4772	0.0000	5,182.4772	0.0000	5,182.4772	0.0000	5,182.4772	0.0000	5,182.4772	5,622.8184	5,622.8184	5,622.8184	5,622.8184	5,622.8184
Region Five Milestone															
ECRF & LVF Service	12,964.0500	0.0107	0.0000	0.0107	0.0000	0.0107	0.0000	0.0107	0.0000	0.0107	0.0117	0.0117	0.0117	0.0117	0.0117
NRC/MRC Region 5 Total	12,964.0500	23,166.3132	0.0000	23,166.3132	0.0000	23,166.3132	0.0000	23,166.3132	0.0000	23,166.3132	25,331.3892	25,331.3892	25,331.3892	25,331.3892	25,331.3892
Region Six Milestone															
ECRF & LVF Service	8,642.7000	0.0113	0.0000	0.0113	0.0000	0.0113	0.0000	0.0113	0.0000	0.0113	0.0123	0.0123	0.0123	0.0123	0.0123
NRC/MRC Region 6 Total	8,642.7000	15,485.9268	0.0000	15,485.9268	0.0000	15,485.9268	0.0000	15,485.9268	0.0000	15,485.9268	16,856.3628	16,856.3628	16,856.3628	16,856.3628	16,856.3628
Region Seven Milestone															
ECRF & LVF Service	4,321.3500	0.0102	0.0000	0.0102	0.0000	0.0102	0.0000	0.0102	0.0000	0.0102	0.0112	0.0112	0.0112	0.0112	0.0112
NRC/MRC Region 7 Total	4,321.3500	7,723.4400	0.0000	7,723.4400	0.0000	7,723.4400	0.0000	7,723.4400	0.0000	7,723.4400	8,480.6400	8,480.6400	8,480.6400	8,480.6400	8,480.6400
ECRF & LVF Total	**144,045.0000**	**258,964.7172**	**0.0000**	**258,964.7172**	**0.0000**	**258,964.7172**	**0.0000**	**258,964.7172**	**0.0000**	**258,964.7172**	**282,217.5504**	**282,217.5504**	**282,217.5504**	**282,217.5504**	**282,217.5504**

Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.														
Date (MM/DD/YYYY):	6/3/2020														
Spatial Interface	INITIAL CONTRACT PERIOD														
	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		Year 6	Year 7	Year 8	Year 9	Year 10
	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]
Region One Milestone															
SI Service	0.0000	0.0095	0.0000	0.0095	0.0000	0.0095	0.0000	0.0095	0.0000	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095
NRC/MRC Region 1 Total	0.0000	29,546.8620	0.0000	29,546.8620	0.0000	29,546.8620	0.0000	29,546.8620	0.0000	29,546.8620	29,546.8620	29,546.8620	29,546.8620	29,546.8620	29,546.8620
Region Two Milestone															
SI Service	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
NRC/MRC Region 2 Total	0.0000	61,455.1200	0.0000	61,455.1200	0.0000	61,455.1200	0.0000	61,455.1200	0.0000	61,455.1200	61,455.1200	61,455.1200	61,455.1200	61,455.1200	61,455.1200
Region Three Milestone															
SI Service	0.0000	0.0098	0.0000	0.0098	0.0000	0.0098	0.0000	0.0098	0.0000	0.0098	0.0098	0.0098	0.0098	0.0098	0.0098
NRC/MRC Region 3 Total	0.0000	90,787.9056	0.0000	90,787.9056	0.0000	90,787.9056	0.0000	90,787.9056	0.0000	90,787.9056	90,787.9056	90,787.9056	90,787.9056	90,787.9056	90,787.9056
Region Four Milestone															
SI Service	0.0000	0.0135	0.0000	0.0135	0.0000	0.0135	0.0000	0.0135	0.0000	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135
NRC/MRC Region 4 Total	0.0000	4,572.7740	0.0000	4,572.7740	0.0000	4,572.7740	0.0000	4,572.7740	0.0000	4,572.7740	4,572.7740	4,572.7740	4,572.7740	4,572.7740	4,572.7740
Region Five Milestone															
SI Service	0.0000	0.0095	0.0000	0.0095	0.0000	0.0095	0.0000	0.0095	0.0000	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095
NRC/MRC Region 5 Total	0.0000	20,568.2220	0.0000	20,568.2220	0.0000	20,568.2220	0.0000	20,568.2220	0.0000	20,568.2220	20,568.2220	20,568.2220	20,568.2220	20,568.2220	20,568.2220
Region Six Milestone															
SI Service	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
NRC/MRC Region 6 Total	0.0000	13,704.3600	0.0000	13,704.3600	0.0000	13,704.3600	0.0000	13,704.3600	0.0000	13,704.3600	13,704.3600	13,704.3600	13,704.3600	13,704.3600	13,704.3600
Region Seven Milestone															
SI Service	0.0000	0.0090	0.0000	0.0090	0.0000	0.0090	0.0000	0.0090	0.0000	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090
NRC/MRC Region 7 Total	0.0000	6,814.8000	0.0000	6,814.8000	0.0000	6,814.8000	0.0000	6,814.8000	0.0000	6,814.8000	6,814.8000	6,814.8000	6,814.8000	6,814.8000	6,814.8000
SI Total	**0.0000**	**227,450.0436**	**0.0000**	**227,450.0436**	**0.0000**	**227,450.0436**	**0.0000**	**227,450.0436**	**0.0000**	**227,450.0436**	**227,450.0436**	**227,450.0436**	**227,450.0436**	**227,450.0436**	**227,450.0436**

6264 Z1 Cost Proposal Option C ESInet NGCS Revision One

Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.														
Date (MM/DD/YYYY):	6/3/2020														
Location Database	INITIAL CONTRACT PERIOD														
	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		Year 6	Year 7	Year 8	Year 9	Year 10
	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]
Region One Milestone															
LDB Service	18,725.8500	0.0120	0.0000	0.0120	0.0000	0.0120	0.0000	0.0120	0.0000	0.0120	0.0130	0.0130	0.0130	0.0130	0.0130
NRC/MRC Region 1 Total	18,725.8500	37,320.9357	0.0000	37,320.9357	0.0000	37,320.9357	0.0000	37,320.9357	0.0000	37,320.9357	40,317.0717	40,317.0717	40,317.0717	40,317.0717	40,317.0717
Region Two Milestone															
LDB Service	38,892.1500	0.0126	0.0000	0.0126	0.0000	0.0126	0.0000	0.0126	0.0000	0.0126	0.0136	0.0136	0.0136	0.0136	0.0136
NRC/MRC Region 2 Total	38,892.1500	77,512.7125	0.0000	77,512.7125	0.0000	77,512.7125	0.0000	77,512.7125	0.0000	77,512.7125	83,735.4565	83,735.4565	83,735.4565	83,735.4565	83,735.4565
Region Three Milestone															
LDB Service	57,618.0000	0.0124	0.0000	0.0124	0.0000	0.0124	0.0000	0.0124	0.0000	0.0124	0.0134	0.0134	0.0134	0.0134	0.0134
NRC/MRC Region 3 Total	57,618.0000	114,833.6482	0.0000	114,833.6482	0.0000	114,833.6482	0.0000	114,833.6482	0.0000	114,833.6482	124,052.5282	124,052.5282	124,052.5282	124,052.5282	124,052.5282
Region Four Milestone															
LDB Service	2,880.9000	0.0170	0.0000	0.0170	0.0000	0.0170	0.0000	0.0170	0.0000	0.0170	0.0183	0.0183	0.0183	0.0183	0.0183
NRC/MRC Region 4 Total	2,880.9000	5,741.6824	0.0000	5,741.6824	0.0000	5,741.6824	0.0000	5,741.6824	0.0000	5,741.6824	6,202.6264	6,202.6264	6,202.6264	6,202.6264	6,202.6264
Region Five Milestone															
LDB Service	12,964.0500	0.0119	0.0000	0.0119	0.0000	0.0119	0.0000	0.0119	0.0000	0.0119	0.0129	0.0129	0.0129	0.0129	0.0129
NRC/MRC Region 5 Total	12,964.0500	25,837.5708	0.0000	25,837.5708	0.0000	25,837.5708	0.0000	25,837.5708	0.0000	25,837.5708	27,911.8188	27,911.8188	27,911.8188	27,911.8188	27,911.8188
Region Six Milestone															
LDB Service	8,642.7000	0.0126	0.0000	0.0126	0.0000	0.0126	0.0000	0.0126	0.0000	0.0126	0.0136	0.0136	0.0136	0.0136	0.0136
NRC/MRC Region 6 Total	8,642.7000	17,225.0472	0.0000	17,225.0472	0.0000	17,225.0472	0.0000	17,225.0472	0.0000	17,225.0472	18,607.8792	18,607.8792	18,607.8792	18,607.8792	18,607.8792
Region Seven Milestone															
LDB Service	4,321.3500	0.0114	0.0000	0.0114	0.0000	0.0114	0.0000	0.0114	0.0000	0.0114	0.0123	0.0123	0.0123	0.0123	0.0123
NRC/MRC Region 7 Total	4,321.3500	8,612.5236	0.0000	8,612.5236	0.0000	8,612.5236	0.0000	8,612.5236	0.0000	8,612.5236	9,303.9396	9,303.9396	9,303.9396	9,303.9396	9,303.9396
LDB Total	**144,045.0000**	**287,084.1204**	**0.0000**	**287,084.1204**	**0.0000**	**287,084.1204**	**0.0000**	**287,084.1204**	**0.0000**	**287,084.1204**	**310,131.3204**	**310,131.3204**	**310,131.3204**	**310,131.3204**	**310,131.3204**

Bidder Name:	NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.														
Date (MM/DD/YYYY):	6/3/2020														
Miscellaneous	INITIAL CONTRACT PERIOD														
	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		Year 6	Year 7	Year 8	Year 9	Year 10
	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]
Region One Milestone															
Professional Services including PM, Engineering, Operations, NSOC, Configuration, and Account Management	385,565.2500	0.0772	0.0000	0.0825	0.0000	0.0847	0.0000	0.0870	0.0000	0.0893	0.1225	0.1250	0.1275	0.1301	0.1328
NRC/MRC Region 1 Total	385,565.2500	240,107.1312	0.0000	256,591.1700	0.0000	263,433.6012	0.0000	270,587.0520	0.0000	277,740.5028	380,999.0100	388,774.5000	396,549.9900	404,636.4996	413,034.0288
Region Two Milestone															
Professional Services including PM, Engineering, Operations, NSOC, Configuration, and Account Management	800,789.3700	0.0812	0.0000	0.0867	0.0000	0.0890	0.0000	0.0914	0.0000	0.0938	0.1288	0.1314	0.1340	0.1368	0.1396
NRC/MRC Region 2 Total	800,789.3700	499,015.5744	0.0000	532,815.8904	0.0000	546,950.5680	0.0000	561,699.7968	0.0000	576,449.0256	791,541.9456	807,520.2768	823,498.6080	840,706.0416	857,913.4752
Region Three Milestone															
Professional Services including PM, Engineering, Operations, NSOC, Configuration, and Account Management	1,186,354.6200	0.0798	0.0000	0.0853	0.0000	0.0875	0.0000	0.0898	0.0000	0.0922	0.1265	0.1291	0.1317	0.1344	0.1372
NRC/MRC Region 3 Total	1,186,354.6200	739,272.9456	0.0000	790,225.3416	0.0000	810,606.3000	0.0000	831,913.6656	0.0000	854,147.4384	1,171,905.1080	1,195,991.6952	1,220,078.2824	1,245,091.2768	1,271,030.6784
Region Four Milestone															
Professional Services including PM, Engineering, Operations, NSOC, Configuration, and Account Management	59,317.7300	0.1091	0.0000	0.1166	0.0000	0.1197	0.0000	0.1229	0.0000	0.1261	0.1731	0.1765	0.1801	0.1838	0.1876
NRC/MRC Region 4 Total	59,317.7300	36,954.7884	0.0000	39,495.2184	0.0000	40,545.2628	0.0000	41,629.1796	0.0000	42,713.0964	58,633.1244	59,784.7860	61,004.1924	62,257.4712	63,544.6224
Region Five Milestone															
Professional Services including PM, Engineering, Operations, NSOC, Configuration, and Account Management	266,929.7900	0.0768	0.0000	0.0821	0.0000	0.0843	0.0000	0.0865	0.0000	0.0888	0.1218	0.1243	0.1268	0.1294	0.1321
NRC/MRC Region 5 Total	266,929.7900	166,277.8368	0.0000	177,752.7396	0.0000	182,515.9068	0.0000	187,279.0740	0.0000	192,258.7488	263,706.2568	269,118.9468	274,531.6368	280,160.8344	286,006.5396
Region Six Milestone															
Professional Services including PM, Engineering, Operations, NSOC, Configuration, and Account Management	177,953.1900	0.0809	0.0000	0.0864	0.0000	0.0887	0.0000	0.0911	0.0000	0.0935	0.1283	0.1309	0.1335	0.1363	0.1391
NRC/MRC Region 6 Total	177,953.1900	110,868.2724	0.0000	118,405.6704	0.0000	121,557.6732	0.0000	124,846.7196	0.0000	128,135.7660	175,826.9388	179,390.0724	182,953.2060	186,790.4268	190,627.6476
Region Seven Milestone															
Professional Services including PM, Engineering, Operations, NSOC, Configuration, and Account Management	88,976.6000	0.0732	0.0000	0.0782	0.0000	0.0803	0.0000	0.0824	0.0000	0.0846	0.1161	0.1185	0.1209	0.1233	0.1259
NRC/MRC Region 7 Total	88,976.6000	55,427.0400	0.0000	59,213.0400	0.0000	60,803.1600	0.0000	62,393.2800	0.0000	64,059.1200	87,910.9200	89,728.2000	91,545.4800	93,362.7600	95,331.4800
MISC Total	**2,965,888.5500**	**1,847,923.5888**	**0.0000**	**1,974,499.0704**	**0.0000**	**2,026,412.4720**	**0.0000**	**2,080,348.7676**	**0.0000**	**2,135,503.6980**	**2,930,523.3036**	**2,990,308.4772**	**3,050,161.3956**	**3,113,005.3104**	**3,177,488.4720**

Bidder Name: NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc.
Date (MM/DD/YYYY): 6/3/2020

Optional Svc for NGCS	INITIAL CONTRACT PERIOD														
	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		Year 6	Year 7	Year 8	Year 9	Year 10
	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	NRC	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]	MRC[1]
Region One Milestone															
Rave 911 License (per workstation)	4,954.9500	0.0000	0.0000	0.0016	0.0000	0.0016	0.0000	0.0016	0.0000	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
c-Live Video Workstation (per workstation, up to 100 workstations/seats)	6,936.9300	0.0000	0.0000	0.0023	0.0000	0.0024	0.0000	0.0025	0.0000	0.0026	0.0027	0.0028	0.0029	0.0030	0.0031
Senior Executive (per hour)	286.0000	0.0000	294.5800	0.0000	303.4200	0.0000	312.5200	0.0000	321.9000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Program Manager /Unit Lead (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect / SME (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Project Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Operations Lead Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Lead / Manager (per hour)	179.0000	0.0000	184.3700	0.0000	189.9000	0.0000	195.6000	0.0000	201.4700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Functional Lead / Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Database Administrator (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Consultant (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Release Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Lead/Manager (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Delivery Consultant (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Business Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Programmer/Developer (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jr Programmer/Developer (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
System Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Performance Expert (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality Assurance Manager (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Test Lead/Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tester (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electrician (per hour)	175.0000	0.0000	180.2500	0.0000	185.6600	0.0000	191.2300	0.0000	196.9700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NRC/MRC Region 1 Total	17,105.8800	0.0000	5,370.4200	12,129.7644	5,531.5400	12,440.7840	5,697.4900	12,751.8036	5,868.5000	13,062.8232	13,373.8428	13,684.8624	13,995.8820	14,306.9016	14,617.9212
Region Two Milestone															
Rave 911 License (per workstation)	4,954.9500	0.0000	0.0000	0.0008	0.0000	0.0008	0.0000	0.0008	0.0000	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
c-Live Video Workstation (per workstation, up to 100 workstations/seats)	6,936.9300	0.0000	0.0000	0.0011	0.0000	0.0011	0.0000	0.0011	0.0000	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Senior Executive (per hour)	286.0000	0.0000	294.5800	0.0000	303.4200	0.0000	312.5200	0.0000	321.9000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Program Manager /Unit Lead (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect / SME (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Project Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Operations Lead Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Lead / Manager (per hour)	179.0000	0.0000	184.3700	0.0000	189.9000	0.0000	195.6000	0.0000	201.4700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Functional Lead / Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Database Administrator (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Consultant (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Release Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Lead/Manager (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Delivery Consultant (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Business Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Programmer/Developer (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jr Programmer/Developer (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
System Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Performance Expert (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality Assurance Manager (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Test Lead/Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tester (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electrician (per hour)	175.0000	0.0000	180.2500	0.0000	185.6600	0.0000	191.2300	0.0000	196.9700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NRC/MRC Region 2 Total	17,105.8800	0.0000	5,370.4200	11,676.4728	5,531.5400	11,676.4728	5,697.4900	11,676.4728	5,868.5000	11,676.4728	11,676.4728	11,676.4728	11,676.4728	11,676.4728	11,676.4728
Region Three Milestone															
Rave 911 License (per workstation)	4,954.9500	0.0000	0.0000	0.0005	0.0000	0.0005	0.0000	0.0005	0.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
c-Live Video Workstation (per workstation, up to 100 workstations/seats)	6,936.9300	0.0000	0.0000	0.0007	0.0000	0.0007	0.0000	0.0007	0.0000	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
Senior Executive (per hour)	286.0000	0.0000	294.5800	0.0000	303.4200	0.0000	312.5200	0.0000	321.9000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Program Manager /Unit Lead (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect / SME (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Project Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Operations Lead Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Lead / Manager (per hour)	179.0000	0.0000	184.3700	0.0000	189.9000	0.0000	195.6000	0.0000	201.4700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Functional Lead / Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Database Administrator (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Consultant (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Release Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Lead/Manager (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Delivery Consultant (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Business Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Programmer/Developer (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jr Programmer/Developer (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
System Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Performance Expert (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality Assurance Manager (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Test Lead/Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tester (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electrician (per hour)	175.0000	0.0000	180.2500	0.0000	185.6600	0.0000	191.2300	0.0000	196.9700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NRC/MRC Region 3 Total	17,105.8800	0.0000	5,370.4200	11,116.8864	5,531.5400	11,116.8864	5,697.4900	11,116.8864	5,868.5000	11,116.8864	11,116.8864	11,116.8864	11,116.8864	11,116.8864	11,116.8864
Region Four Milestone															

Rave 911 License (per workstation)	4,954.9500	0.0000	0.0000	0.0150	0.0000	0.0155	0.0000	0.0160	0.0000	0.0165	0.0170	0.0175	0.0180	0.0185	0.0191
c-Live Video Workstation (per workstation, up to 100 workstations/seats)	6,936.9300	0.0000	0.0000	0.0211	0.0000	0.0217	0.0000	0.0224	0.0000	0.0231	0.0238	0.0245	0.0252	0.0260	0.0268
Senior Executive (per hour)	286.0000	0.0000	294.5800	0.0000	303.4200	0.0000	312.5200	0.0000	321.9000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Program Manager /Unit Lead (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect / SME (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Project Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Operations Lead Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Lead / Manager (per hour)	179.0000	0.0000	184.3700	0.0000	189.9000	0.0000	195.6000	0.0000	201.4700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Functional Lead / Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Database Administrator (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Consultant (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Release Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Lead/Manager (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Delivery Consultant (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Business Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Programmer/Developer (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jr Programmer/Developer (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
System Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Performance Expert (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality Assurance Manager (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Test Lead/Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tester (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electrician (per hour)	175.0000	0.0000	180.2500	0.0000	185.6600	0.0000	191.2300	0.0000	196.9700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NRC/MRC Region 4 Total	17,105.8800	0.0000	5,370.4200	12,227.9364	5,531.5400	12,600.5328	5,697.4900	13,007.0016	5,868.5000	13,413.4704	13,819.9392	14,226.4080	14,632.8768	15,073.2180	15,547.4316
Region Five Milestone															
Rave 911 License (per workstation)	4,954.9500	0.0000	0.0000	0.0024	0.0000	0.0025	0.0000	0.0026	0.0000	0.0027	0.0028	0.0029	0.0030	0.0031	0.0032
c-Live Video Workstation (per workstation, up to 100 workstations/seats)	6,936.9300	0.0000	0.0000	0.0033	0.0000	0.0034	0.0000	0.0035	0.0000	0.0036	0.0037	0.0038	0.0039	0.0040	0.0041
Senior Executive (per hour)	286.0000	0.0000	294.5800	0.0000	303.4200	0.0000	312.5200	0.0000	321.9000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Program Manager /Unit Lead (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect / SME (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Project Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Operations Lead Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Lead / Manager (per hour)	179.0000	0.0000	184.3700	0.0000	189.9000	0.0000	195.6000	0.0000	201.4700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Functional Lead / Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Database Administrator (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Consultant (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Release Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Lead/Manager (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Delivery Consultant (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Business Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Programmer/Developer (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jr Programmer/Developer (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
System Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Performance Expert (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality Assurance Manager (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Test Lead/Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tester (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electrician (per hour)	175.0000	0.0000	180.2500	0.0000	185.6600	0.0000	191.2300	0.0000	196.9700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NRC/MRC Region 5 Total	17,105.8800	0.0000	5,370.4200	12,340.9332	5,531.5400	12,773.9484	5,697.4900	13,206.9636	5,868.5000	13,639.9788	14,072.9940	14,506.0092	14,939.0244	15,372.0396	15,805.0548
Region Six Milestone															
Rave 911 License (per workstation)	4,954.9500	0.0000	0.0000	0.0037	0.0000	0.0038	0.0000	0.0039	0.0000	0.0040	0.0041	0.0042	0.0043	0.0044	0.0045
c-Live Video Workstation (per workstation, up to 100 workstations/seats)	6,936.9300	0.0000	0.0000	0.0053	0.0000	0.0055	0.0000	0.0057	0.0000	0.0059	0.0061	0.0063	0.0065	0.0067	0.0069
Senior Executive (per hour)	286.0000	0.0000	294.5800	0.0000	303.4200	0.0000	312.5200	0.0000	321.9000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Program Manager /Unit Lead (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect / SME (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Project Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Operations Lead Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Lead / Manager (per hour)	179.0000	0.0000	184.3700	0.0000	189.9000	0.0000	195.6000	0.0000	201.4700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Functional Lead / Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Database Administrator (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Consultant (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Release Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Lead/Manager (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Delivery Consultant (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Business Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Programmer/Developer (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jr Programmer/Developer (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
System Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Performance Expert (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality Assurance Manager (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Test Lead/Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tester (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electrician (per hour)	175.0000	0.0000	180.2500	0.0000	185.6600	0.0000	191.2300	0.0000	196.9700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NRC/MRC Region 6 Total	17,105.8800	0.0000	5,370.4200	12,333.9240	5,531.5400	12,745.0548	5,697.4900	13,156.1856	5,868.5000	13,567.3164	13,978.4472	14,389.5780	14,800.7088	15,211.8396	15,622.9704
Region Seven Milestone															
Rave 911 License (per workstation)	4,954.9500	0.0000	0.0000	0.0067	0.0000	0.0069	0.0000	0.0071	0.0000	0.0073	0.0075	0.0077	0.0079	0.0081	0.0083
c-Live Video Workstation (per workstation, up to 100 workstations/seats)	6,936.9300	0.0000	0.0000	0.0095	0.0000	0.0098	0.0000	0.0101	0.0000	0.0104	0.0107	0.0110	0.0113	0.0116	0.0119
Senior Executive (per hour)	286.0000	0.0000	294.5800	0.0000	303.4200	0.0000	312.5200	0.0000	321.9000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Program Manager /Unit Lead (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect / SME (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Project Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Operations Lead Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Lead / Manager (per hour)	179.0000	0.0000	184.3700	0.0000	189.9000	0.0000	195.6000	0.0000	201.4700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Functional Lead / Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Database Administrator (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technical Architect (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Integration Consultant (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Release Manager (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Lead/Manager (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Training Delivery Consultant (per hour)	121.0000	0.0000	124.6300	0.0000	128.3700	0.0000	132.2200	0.0000	136.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Business Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Programmer/Developer (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jr Programmer/Developer (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
System Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Performance Expert (per hour)	162.0000	0.0000	166.8600	0.0000	171.8700	0.0000	177.0300	0.0000	182.3400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality Assurance Manager (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Specialist (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Security Analyst (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Test Lead/Manager (per hour)	214.0000	0.0000	220.4200	0.0000	227.0300	0.0000	233.8400	0.0000	240.8600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tester (per hour)	186.0000	0.0000	191.5800	0.0000	197.3300	0.0000	203.2500	0.0000	209.3500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electrician (per hour)	175.0000	0.0000	180.2500	0.0000	185.6600	0.0000	191.2300	0.0000	196.9700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NRC/MRC Region 7 Total	17,105.8800	0.0000	5,370.4200	12,266.6400	5,531.5400	12,645.2400	5,697.4900	13,023.8400	5,868.5000	13,402.4400	13,781.0400	14,159.6400	14,538.2400	14,916.8400	15,295.4400
Opt. Svc NGCS Total	**119,741.1600**	**0.0000**	**37,592.9400**	**84,092.5572**	**38,720.7800**	**85,998.9192**	**39,882.4300**	**87,939.1536**	**41,079.5000**	**89,879.3880**	**91,819.6224**	**93,759.8568**	**95,700.0912**	**97,674.1980**	**99,682.1772**

NG911 ESInet and NGCS

RFP/Solicitation # RFP 6264 Z1

RFP Section II - Terms and Conditions, RFP Section III - Contractor Duties, RFP Section IV - Payment

June 3, 2020

Submitted to:
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Notices

TeleCommunication Systems, Inc. is a wholly owned subsidiary of Comtech Telecommunications Corp. This proposal is being submitted by TeleCommunication Systems, Inc. or its service-providing affiliate (using the Comtech brand). Throughout this proposal, the Comtech Telecommunications Corp. (Comtech) parent company name may be referenced. However, TeleCommunication Systems, Inc. (or its service-providing affiliate) is generally the contracting entity for the delivery of Comtech's highly available Wireless E9-1-1, VoIP E9-1-1, VoWiFi E9-1-1 and NG9-1-1 i3 solutions and systems, and it is expected to be the contracting entity for the proposed system.

EMedia®, GEM9-1-1®, LivewirE9-1-1®, RAVE9-1-1®, VoIP Verify® and VoLTE9-1-1® are registered trademarks, and Intrepid9-1-1™ and LocatE9-1-1™ are trademarks of TeleCommunication Systems, Inc. in the U.S. and certain other countries.

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TeleCommunication Systems, Inc. holds more than 400 issued patents and has more than 100 patent applications pending worldwide. Its patents cover a broad spectrum of technologies, including wireless data, text and voice telecommunications, location-based services, GIS/mapping, intercarrier messaging, secure communications, public safety/E9-1-1, and mobile navigation.

Nasdaq GS: CMTL

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1. Terms and Conditions [RFP II]

Bidders should complete Sections II through VI as part of their proposal. Bidders should read the Terms and Conditions and should initial either accept, reject, or reject and provide alternative language for each clause. The bidder should also provide an explanation of why the bidder rejected the clause or rejected the clause and provided alternate language. By signing the solicitation, bidder is agreeing to be legally bound by all the accepted terms and conditions, and any proposed alternative terms and conditions submitted with the proposal. The State reserves the right to negotiate rejected or proposed alternative language. If the State and bidder fail to agree on the final Terms and Conditions, the State reserves the right to reject the proposal. The State of Nebraska is soliciting proposals in response to this solicitation. The State of Nebraska reserves the right to reject proposals that attempt to substitute the bidder's commercial contracts and/or documents for this solicitation.

Bidders should submit with their proposal any license, user agreement, service level agreement, or similar documents that the bidder wants incorporated in the Contract. The State will not consider incorporation of any document not submitted with the bidder's proposal as the document will not have been included in the evaluation process. These documents shall be subject to negotiation and will be incorporated as addendums if agreed to by the Parties.

If a conflict or ambiguity arises after the Addendum to Contract Award have been negotiated and agreed to, the Addendum to Contract Award shall be interpreted as follows:

1. If only one Party has a particular clause then that clause shall control;
2. If both Parties have a similar clause, but the clauses do not conflict, the clauses shall be read together;
3. If both Parties have a similar clause, but the clauses conflict, the State's clause shall control.

A. GENERAL

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			Comtech is attaching its Master Sales Agreement (see *File 11*) for provision of hosted services. Comtech's hosted services are provided in accordance with terms and conditions similar to those attached, including but not limited to, limitation of liability, ownership, and statutory immunities, all of which Comtech expects to be included in any resulting contract.

The contract resulting from this solicitation shall incorporate the following documents:

1. Request for Proposal and Addenda;

2. Amendments to the solicitation;
3. Questions and Answers;
4. Bidder's proposal (Solicitation and properly submitted documents);
5. The executed Contract and Addendum One to Contract, if applicable; and,
6. Amendments/Addendums to the Contract.

These documents constitute the entirety of the contract.

Unless otherwise specifically stated in a future contract amendment, in case of any conflict between the incorporated documents, the documents shall govern in the following order of preference with number one (1) receiving preference over all other documents and with each lower numbered document having preference over any higher numbered document: 1) Amendment to the executed Contract with the most recent dated amendment having the highest priority, 2) executed Contract and any attached Addenda, 3) Amendments to solicitation and any Questions and Answers, 4) the original solicitation document and any Addenda, and 5) the bidder's submitted Proposal.

Any ambiguity or conflict in the contract discovered after its execution, not otherwise addressed herein, shall be resolved in accordance with the rules of contract interpretation as established in the State of Nebraska.

B. NOTIFICATION

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

Contractor and State shall identify the contract manager who shall serve as the point of contact for the executed contract.

Communications regarding the executed contract shall be in writing and shall be deemed to have been given if delivered personally or mailed, by U.S. Mail, postage prepaid, return receipt requested, to the parties at their respective addresses set forth below, or at such other addresses as may be specified in writing by either of the parties. All notices, requests, or communications shall be deemed effective upon personal delivery or five (5) calendar days following deposit in the mail.

Either party may change its address for notification purposes by giving notice of the change, and setting forth the new address and an effective date.

C. BUYER'S REPRESENTATIVE

The State reserves the right to appoint a Buyer's Representative to manage (or assist the Buyer in managing) the contract on behalf of the State. The Buyer's Representative will be appointed in writing, and the appointment document will specify the extent of the Buyer's Representative authority and responsibilities. If a Buyer's Representative is appointed, the Contractor will be provided a copy of the appointment document, and is required to cooperate accordingly with the Buyer's Representative. The Buyer's Representative has no authority to bind the State to a contract, amendment, addendum, or other change or addition to the contract.

D. GOVERNING LAW (Statutory)

Notwithstanding any other provision of this contract, or any amendment or addendum(s) entered into contemporaneously or at a later time, the parties understand and agree that, (1) the State of Nebraska is a sovereign state and its authority to contract is therefore subject to limitation by the State's Constitution, statutes, common law, and regulation; (2) this contract will be interpreted and enforced under the laws of the State of Nebraska; (3) any action to enforce the provisions of this agreement must be brought in the State of Nebraska per state law; (4) the person signing this contract on behalf of the State of Nebraska does not have the authority to waive the State's sovereign immunity, statutes, common law, or regulations; (5) the indemnity, limitation of liability, remedy, and other similar provisions of the final contract, if any, are entered into subject to the State's Constitution, statutes, common law, regulations, and sovereign immunity; and, (6) all terms and conditions of the final contract, including but not limited to the clauses concerning third party use, licenses, warranties, limitations of liability, governing law and venue, usage verification, indemnity, liability, remedy or other similar provisions of the final contract are entered into specifically subject to the State's Constitution, statutes, common law, regulations, and sovereign immunity.

The Parties must comply with all applicable local, state and federal laws, ordinances, rules, orders, and regulations.

E. BEGINNING OF WORK

The bidder shall not commence any billable work until a valid contract has been fully executed by the State and the awarded bidder. The awarded bidder will be notified in writing when work may begin.

F. AMENDMENT

This Contract may be amended in writing, within scope, upon the agreement of both parties.

G. CHANGE ORDERS OR SUBSTITUTIONS

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as edited below

The State and the Contractor, upon the written agreement, may make changes to the contract within the general scope of the solicitation. Changes may involve specifications, the quantity of work, or such other items as the State may find necessary or desirable. Corrections of any deliverable, service, or work required pursuant to the contract shall not be deemed a change. The Contractor may not claim forfeiture of the contract by reasons of such changes.

The Contractor shall prepare a written description of the work required due to the change and an itemized cost sheet for the change. Changes in work and the amount of compensation to be paid to the Contractor shall be determined in accordance with applicable unit prices if any, a pro-rated value, or through negotiations. The State shall not incur a price increase for changes that ~~should have been included in the Contractor's proposal, were foreseeable, or~~ result from difficulties with or failure of the Contractor's ~~proposal or~~ performance, provided that such difficulties with or failure of Contractor's performance are not outside of Contractor's span of control or a force majeure event.

No change shall be implemented by the Contractor until approved by the State, and the Contract is amended to reflect the change and associated costs, if any. If there is a dispute regarding the cost, but both parties agree that immediate implementation is necessary, the change may be implemented, and cost negotiations may continue with both Parties retaining all remedies under the contract and law.

In the event any product is discontinued or replaced upon mutual consent during the contract period or prior to delivery, the State reserves the right to amend the contract or purchase order to include the Contractor's alternate product (of same form, fit, and function) at the same price.

Contractor will not substitute any item that has been awarded without prior written approval of SPB

H. VENDOR PERFORMANCE REPORT(S)

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The State may document any instance(s) of products or services delivered or performed which exceed or fail to meet the terms of the purchase order, contract, and/or solicitation specifications. The State Purchasing Bureau may contact the Vendor regarding any such report. Vendor performance report(s) will become a part of the permanent record of the Vendor.

I. NOTICE OF POTENTIAL CONTRACTOR BREACH

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

If Contractor breaches the contract or anticipates breaching the contract, the Contractor shall immediately give written notice to the State. The notice shall explain the breach or potential breach, a proposed cure, and may include a request for a waiver of the breach if so desired. The State may, in its discretion, temporarily or permanently waive the breach. By granting a waiver, the State does not forfeit any rights or remedies to which the State is entitled by law or equity, or pursuant to the provisions of the contract. Failure to give immediate notice, however, may be grounds for denial of any request for a waiver of a breach.

J. BREACH

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as redlined.

Either Party may terminate the contract, in whole or in part, if the other Party breaches its duty to perform its obligations under the contract in a timely and proper manner. Termination requires written notice of default and a thirty (30) calendar day (or longer at the non-breaching Party's discretion considering the gravity and nature of the default) cure period. Said notice shall be delivered by Certified Mail, Return Receipt Requested, or in person with proof of delivery. ~~Allowing time to cure a failure or breach of contract does not waive the right to immediately terminate the contract for the same or different contract breach which may occur at a different time. In case of default of the Contractor, the State may contract the service from other sources and hold the Contractor responsible for any excess cost occasioned thereby. OR~~ In case of breach by the Contractor, the State may, after providing Contractor with notice of breach and allowing a minimum 30 day cure period, without unreasonable delay, make a good faith effort to make a reasonable purchase or contract to purchase goods in substitution of those due from the contractor. ~~The State may recover from the Contractor as damages the difference between the costs of covering the breach.~~ The non-breaching Party may recover such damages as awarded by a court of competent jurisdiction.~~Notwithstanding any clause to the contrary, the State may also recover the contract price together with any incidental or consequential damages defined in UCC Section 2-715, but less expenses saved in consequence of Contractor's breach.~~

The State's failure to make payment shall ~~not~~ be a breach, and the Contractor shall retain all available statutory remedies and protections, provided however, the Contractor shall not terminate the contract.

K. NON-WAIVER OF BREACH

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The acceptance of late performance with or without objection or reservation by a Party shall not waive any rights of the Party nor constitute a waiver of the requirement of timely performance of any obligations remaining to be performed.

L. SEVERABILITY

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

If any term or condition of the contract is declared by a court of competent jurisdiction to be illegal or in conflict with any law, the validity of the remaining terms and conditions shall not be affected, and the rights and obligations of the parties shall be construed and enforced as if the contract did not contain the provision held to be invalid or illegal.

M. INDEMNIFICATION

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as edited below.

1. GENERAL

The Contractor agrees to defend, indemnify, and hold harmless the State and its employees, volunteers, agents, and its elected and appointed officials ("the indemnified parties") from and against any and all third party claims, liens, demands, damages, liability, actions, causes of action, losses, judgments, costs, and expenses of every nature, including investigation costs and expenses, settlement costs, and attorney fees and expenses ("the claims"), sustained or asserted against the State for personal injury, death, or property loss or damage, arising out of, resulting from, or attributable to the willful misconduct, negligence, error, or omission of the Contractor, its employees, subcontractors, consultants, representatives, and agents, resulting from this contract, except to the extent such Contractor liability is attenuated by any action of the State which directly and proximately contributed to the claims.

2. INTELLECTUAL PROPERTY (Optional)

The Contractor agrees it will, at its sole cost and expense, defend, indemnify, and hold harmless the indemnified parties from and against any and all claims, to the extent such claims arise out of, result from, or are attributable to, the actual or alleged infringement or misappropriation of any patent, copyright, trade secret, trademark, or confidential information of any third party by the Contractor or its employees, subcontractors, consultants, representatives, and agents ("IP Claim"); provided, however, the State gives the Contractor prompt notice in writing of the claim. The Contractor may not settle any infringement claim that will affect the State's use of the Licensed Software without the State's prior written consent, which consent may be withheld for any reason. Notwithstanding the foregoing, the State indemnified parties shall not be entitled to any defense, indemnification or the like under this Section if any IP Claim arises out of (a) the combination, operation, or use of any services or deliverables (including, but not limited to, any Contractor Software) with non-Contractor equipment, devices, software, data, products or services if such infringement would have been avoided but for such combination, operation or use, (b) alteration of the services or deliverables (including, but not limited to, any Contractor Software) by someone other than Contractor or an authorized representative of Contractor, if such claim would have been avoided by the absence of such alteration, (c) any State indemnified parties or third party's unauthorized use, negligent use, or misuse of the services or deliverables, (d) designs, instructions, specifications, data, materials, content or any other intellectual property provided by the State indemnified parties, (e) use of other than the latest available version of the services or deliverables (including, but not limited to, any Contractor Software) made available to State indemnified parties, (f) another party's infringement by products or services that are comparable to the services or deliverables (including, but not limited to, any Contractor Software), or (g) Contractor's implementation of the State indemnified parties originated design or modification where infringement is due to such State indemnified parties specified design or modification.

If a judgment or settlement is obtained or reasonably anticipated against the State's use of any intellectual property for which the Contractor has indemnified the State, the Contractor shall, at the Contractor's sole cost and expense, promptly modify the item or items which were determined to be infringing, acquire a license or licenses on the State's behalf to

provide the necessary rights to the State to eliminate the infringement, or provide the State with a non-infringing substitute that provides the State the same functionality. At the State's election, the actual or anticipated judgment may be treated as a breach of warranty by the Contractor, and the State may receive the remedies provided under this solicitation.

3. PERSONNEL

The Contractor shall, at its expense, indemnify and hold harmless the indemnified parties from and against any claim with respect to withholding taxes, worker's compensation, employee benefits, or any other employment or similarly related claim, demand, liability, damage, or loss of any nature relating to any of the personnel, including subcontractor's and their employees, provided by the Contractor.

4. SELF-INSURANCE

The State of Nebraska is self-insured for any loss and purchases excess insurance coverage pursuant to Neb. Rev. Stat. § 81-8,239.01 (Reissue 2008). If there is a presumed loss under the provisions of this agreement, Contractor may file a claim with the Office of Risk Management pursuant to Neb. Rev. Stat. §§ 81-8,829 – 81-8,306 for review by the State Claims Board. The State retains all rights and immunities under the State Miscellaneous (§ 81-8,294), Tort (§ 81-8,209), and Contract Claim Acts (§ 81-8,302), as outlined in Neb. Rev. Stat. § 81-8,209 et seq. and under any other provisions of law and accepts liability under this agreement to the extent provided by law.

5. The Parties acknowledge that Attorney General for the State of Nebraska is required by statute to represent the legal interests of the State, and that any provision of this indemnity clause is subject to the statutory authority of the Attorney General. provided however, that Contractor's defense counsel will primarily lead the indemnified parties defense.

5.6. The State and Contractor acknowledge their intent that Contractor, in its providing any services hereunder, enjoy the same immunity from or limitation of liability and or indemnity from state or federal government entities as is available to the State, its agents or subcontractors in providing 911 services, under applicable law. The State will reasonably assist Contractor, at Contractor's expense, in obtaining the benefit of such immunity, or limitation, or indemnity, if necessary and available. To the fullest extent permitted by applicable law, the foregoing immunity, limitation of liability, and/or indemnity will apply regardless of any fault, negligence, strict liability or product liability of Contractor in connection with the provision and performance of any services hereunder.

N. ATTORNEY'S FEES

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as edited below.

In the event of any litigation, appeal, or other legal action to enforce any provision of the contract, the Parties agree that each Party shallto pay allits own expenses and costs of such action, as permitted by law and if ordered by the court, including attorney's fees and costs, if the other Party prevails.

O. PERFORMANCE BOND

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The Contractor maybe required to supply a bond executed by a corporation authorized to contract surety in the State of Nebraska, payable to the State of Nebraska, which shall be valid for the life of the contract to include any renewal and/or extension periods. The amount of the bond must be $500,000. The bond will guarantee that the Contractor will faithfully perform all requirements, terms and conditions of the contract. Failure to comply shall be grounds for forfeiture of bond as liquidated damages. Amount of forfeiture will be determined by the agency based on loss to the State. The bond will be returned when the contract has been satisfactorily completed as solely determined by the State, after termination or expiration of the contract.

P. ASSIGNMENT, SALE, OR MERGER

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

Either Party may assign the contract upon mutual written agreement of the other Party. Such agreement shall not be unreasonably withheld.

The Contractor retains the right to enter into a sale, merger, acquisition, internal reorganization, or similar transaction involving Contractor's business. Contractor agrees to cooperate with the State in executing amendments to the contract to allow for the transaction. If a third party or entity is involved in the transaction, the Contractor will remain responsible for performance of the contract until such time as the person or entity involved in the transaction agrees in writing to be contractually bound by this contract and perform all obligations of the contract.

Q. CONTRACTING WITH OTHER NEBRASKA POLITICAL SUB-DIVISIONS OF THE STATE OR ANOTHER STATE

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The Contractor may, but shall not be required to, allow agencies, as defined in Neb. Rev. Stat. §81-145, to use this contract. The terms and conditions, including price, of the contract may not be amended. The State shall not be contractually obligated or liable for any contract entered into pursuant to this clause. A

listing of Nebraska political subdivisions may be found at the website of the Nebraska Auditor of Public Accounts.

The Contractor may, but shall not be required to, allow other states, agencies or divisions of other states, or political subdivisions of other states to use this contract. The terms and conditions, including price, of this contract shall apply to any such contract, but may be amended upon mutual consent of the Parties. The State of Nebraska shall not be contractually or otherwise obligated or liable under any contract entered into pursuant to this clause. The State shall be notified if a contract is executed based upon this contract.

R. FORCE MAJEURE

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

Neither Party shall be liable for any costs or damages, or for default resulting from its inability to perform any of its obligations under the contract due to a natural or manmade event outside the control and not the fault of the affected Party ("Force Majeure Event"). The Party so affected shall immediately make a written request for relief to the other Party, and shall have the burden of proof to justify the request. The other Party may grant the relief requested; relief may not be unreasonably withheld. Labor disputes with the impacted Party's own employees will not be considered a Force Majeure Event.

S. CONFIDENTIALITY

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

All materials and information provided by the Parties or acquired by a Party on behalf of the other Party shall be regarded as confidential information. All materials and information provided or acquired shall be handled in accordance with federal and state law, and ethical standards. Should said confidentiality be breached by a Party, the Party shall notify the other Party immediately of said breach and take immediate corrective action.

It is incumbent upon the Parties to inform their officers and employees of the penalties for improper disclosure imposed by the Privacy Act of 1974, 5 U.S.C. 552a. Specifically, 5 U.S.C. 552a (i)(1), which is made applicable by 5 U.S.C. 552a (m)(1), provides that any officer or employee, who by virtue of his/her employment or official position has possession of or access to agency records which contain individually identifiable information, the disclosure of which is prohibited by the Privacy Act or regulations established thereunder, and who knowing that disclosure of the specific material is prohibited, willfully discloses the material in any manner to any person or agency not entitled to receive it, shall be guilty of a misdemeanor and fined not more than $5,000.

T. EARLY TERMINATION

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as edited below.

The contract may be terminated as follows:

1. The State and the Contractor, by mutual written agreement, may terminate the contract at any time.
2. The State, in its sole discretion, may terminate the contract for any reason upon thirty (30) calendar day's written notice to the Contractor. Such termination shall not relieve the Contractor of warranty or other service obligations incurred under the terms of the contract. In the event of termination the Contractor shall be entitled to payment, determined on a pro rata basis, for products or services satisfactorily performed or provided, and payment for all costs incurred for supplies and services.
3. The State may terminate the contract immediately for the following reasons:
   a. if directed to do so by statute;
   b. Contractor has made an assignment for the benefit of creditors, has admitted in writing its inability to pay debts as they mature, or has ceased operating in the normal course of business;
   c. a trustee or receiver of the Contractor or of any substantial part of the Contractor's assets has been appointed by a court;
   d. fraud, misappropriation, embezzlement, malfeasance, misfeasance, or illegal conduct pertaining to performance under the contract by its Contractor, its employees, officers, directors, or shareholders;
   e. an involuntary proceeding has been commenced by any Party against the Contractor under any one of the chapters of Title 11 of the United States Code and (i) the proceeding has been pending for at least sixty (60) calendar days; or (ii) the Contractor has consented, either expressly or by operation of law, to the entry of an order for relief; or (iii) the Contractor has been decreed or adjudged a debtor;
   f. a voluntary petition has been filed by the Contractor under any of the chapters of Title 11 of the United States Code;
   g. Contractor intentionally discloses confidential information;
   h. Contractor has or announces it will discontinue support of the deliverable; and,
   i. In the event funding is no longer available.

U. CONTRACT CLOSEOUT

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:

		KH	Accept language as edited below.

Upon contract closeout for any reason the Contractor shall within 30 calendar days, unless stated otherwise herein:

1. Transfer all completed or partially completed deliverables to the State;
2. ~~Transfer ownership and title to all completed or partially completed deliverables to the State~~ Provide copies of documents identified as project deliverables and incorporated into the contract;
3. Return to the State all information and data, unless the Contractor is permitted to keep the information or data by contract or rule of law. Contractor may retain one copy of any information or data as required to comply with applicable work product documentation standards or as are automatically retained in the course of Contractor's routine back up procedures;
4. Cooperate with any successor Contactor, person or entity in the assumption of any or all of the obligations of this contract;
5. Cooperate with any successor Contactor, person or entity with the transfer of State owned information or data related to this contract;
6. Return or vacate any state owned real or personal property; and,
7. Return all data in a mutually acceptable format and manner.

Nothing in this Section should be construed to require the Contractor to surrender intellectual property, real or personal property, or information or data owned by the Contractor for which the State has no legal claim.

2. Contractor Duties [RFP III]

A. INDEPENDENT CONTRACTOR/OBLIGATIONS

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

It is agreed that the Contractor is an independent contractor and that nothing contained herein is intended or should be construed as creating or establishing a relationship of employment, agency, or a partnership.

The Contractor is solely responsible for fulfilling the contract. The Contractor or the Contractor's representative shall be the sole point of contact regarding all contractual matters.

The Contractor shall secure, at its own expense, all personnel required to perform the services under the contract. The personnel the Contractor uses to fulfill the contract shall have no contractual or other legal relationship with the State; they shall not be considered employees of the State and shall not be entitled to any compensation, rights or benefits from the State, including but not limited to, tenure rights, medical and hospital care, sick and vacation leave, severance pay, or retirement benefits.

By-name personnel commitments made in the Contractor's proposal shall not be changed without the prior written approval of the State. Replacement of these personnel, if approved by the State, shall be with personnel of equal or greater ability and qualifications.

All personnel assigned by the Contractor to the contract shall be employees of the Contractor or a subcontractor, and shall be fully qualified to perform the work required herein. Personnel employed by the Contractor or a subcontractor to fulfill the terms of the contract shall remain under the sole direction and control of the Contractor or the subcontractor respectively.

With respect to its employees, the Contractor agrees to be solely responsible for the following:

1. Any and all pay, benefits, and employment taxes and/or other payroll withholding;
2. Any and all vehicles used by the Contractor's employees, including all insurance required by state law;
3. Damages incurred by Contractor's employees within the scope of their duties under the contract;
4. Maintaining Workers' Compensation and health insurance that complies with state and federal law and submitting any reports on such insurance to the extent required by governing law;
5. Determining the hours to be worked and the duties to be performed by the Contractor's employees; and,
6. All claims on behalf of any person arising out of employment or alleged employment (including without limit claims of discrimination alleged against the Contractor, its officers, agents, or subcontractors or subcontractor's employees).

If the Contractor intends to utilize any subcontractor, the subcontractor's level of effort, tasks, and time allocation should be clearly defined in the bidder's proposal. The Contractor shall agree that it will not utilize any subcontractors not specifically included in its proposal in the performance of the contract without the prior written authorization of the State.

The State reserves the right to require the Contractor to reassign or remove from the project any Contractor or subcontractor employee.

Contractor shall insure that the terms and conditions contained in any contract with a subcontractor does not conflict with the terms and conditions of this contract.

The Contractor shall include a similar provision, for the protection of the State, in the contract with any subcontractor engaged to perform work on this contract.

B. EMPLOYEE WORK ELIGIBILITY STATUS

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The Contractor is required and hereby agrees to use a federal immigration verification system to determine the work eligibility status of employees physically performing services within the State of Nebraska. A federal immigration verification system means the electronic verification of the work authorization program authorized by the Illegal Immigration Reform and Immigrant Responsibility Act of 1996, 8 U.S.C. 1324a, known as the E-Verify Program, or an equivalent federal program designated by the United States Department of Homeland Security or other federal agency authorized to verify the work eligibility status of an employee.

If the Contractor is an individual or sole proprietorship, the following applies:

1. The Contractor must complete the United States Citizenship Attestation Form, available on the Department of Administrative Services website at http://das.nebraska.gov/materiel/purchasing.html.
2. The completed United States Attestation Form should be submitted with the solicitation response.
3. If the Contractor indicates on such attestation form that he or she is a qualified alien, the Contractor agrees to provide the US Citizenship and Immigration Services documentation required to verify the Contractor's lawful presence in the United States using the Systematic Alien Verification for Entitlements (SAVE) Program.
4. The Contractor understands and agrees that lawful presence in the United States is required and the Contractor may be disqualified or the contract terminated if such lawful presence cannot be verified as required by Neb. Rev. Stat. §4-108.

C. COMPLIANCE WITH CIVIL RIGHTS LAWS AND EQUAL OPPORTUNITY EMPLOYMENT / NONDISCRIMINATION (Statutory)

The Contractor shall comply with all applicable local, state, and federal statutes and regulations regarding civil rights laws and equal opportunity employment. The Nebraska Fair Employment Practice Act prohibits Contractors of the State of Nebraska, and their subcontractors, from discriminating against any employee or applicant for employment, with respect to hire, tenure, terms, conditions, compensation, or privileges of employment because of race, color, religion, sex, disability, marital status, or national origin (Neb. Rev. Stat. §48-1101 to 48-1125). The Contractor guarantees compliance with the Nebraska Fair Employment Practice Act, and breach of this provision shall be regarded as a material breach of contract. The

Contractor shall insert a similar provision in all subcontracts for goods and services to be covered by any contract resulting from this solicitation.

D. COOPERATION WITH OTHER CONTRACTORS

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

Contractor may be required to work with or in close proximity to other contractors or individuals that may be working on same or different projects. The Contractor shall agree to cooperate with such other contractors or individuals, and shall not commit or permit any act which may interfere with the performance of work by any other contractor or individual. Contractor is not required to compromise Contractor's intellectual property or proprietary information unless expressly required to do so by this contract.

E. PERMITS, REGULATIONS, LAWS

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The contract price shall include the cost of all royalties, licenses, permits, and approvals, whether arising from patents, trademarks, copyrights or otherwise, that are in any way involved in the contract. The Contractor shall obtain and pay for all royalties, licenses, and permits, and approvals necessary for the execution of the contract. The Contractor must guarantee that it has the full legal right to the materials, supplies, equipment, software, and other items used to execute this contract .

F. OWNERSHIP OF INFORMATION AND DATA / DELIVERABLES

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Contractor is providing the State with a hosted service and Contractor maintains all right, title, and interest in and to the hosted service. The State is granted a right to use the hosted services during the term of the contract.

No ownership interest in any services or materials developed by Contractor shall pass to the State under this contract unless otherwise expressly stated in a statement of work. For greater certainty and without limiting the foregoing:

8.3.1 Title to any communications equipment and other hardware installed by Contractor in connection with the performance of any services will at all times remain with Contractor;

8.3.2 Title to all software and data provided by Contractor and used by the State or Contractor hereunder will remain at all times with Contractor and its licensors; and

8.3.3 The State acknowledges that all intellectual property rights in and to any software and data provided by Contractor and used by the State or Contractor hereunder are and will remain the property of Contractor and its licensors.

~~The State shall have the unlimited right to publish, duplicate, use, and disclose all information and data developed or obtained by the Contractor on behalf of the State pursuant to this contract .~~

~~The State shall own and hold exclusive title to any deliverable developed as a result of this contract. Contractor shall have no ownership interest or title, and shall not patent, license, or copyright, duplicate, transfer, sell, or exchange, the design, specifications, concept, or deliverable.~~

G. INSURANCE REQUIREMENTS

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as edited below.

The Contractor shall throughout the term of the contract maintain insurance as specified herein and provide the State a current Certificate of Insurance/Acord Form (COI) verifying the coverage. The Contractor shall not commence work on the contract until the insurance is in place. If Contractor subcontracts any portion of the Contract the Contractor must, throughout the term of the contract, either:

1. Provide equivalent insurance for each subcontractor and provide a COI verifying the coverage for the subcontractor;
2. Require each subcontractor to have equivalent insurance and provide written notice to the State that the Contractor has verified that each subcontractor has the required coverage; or,
3. Provide the State with copies of each subcontractor's Certificate of Insurance evidencing the required coverage.

The Contractor shall not allow any subcontractor to commence work until the subcontractor has equivalent insurance. The failure of the State to require a COI, or the failure of the Contractor to provide a COI or require subcontractor insurance shall not limit, relieve, or decrease the liability of the Contractor hereunder.

In the event that any policy written on a claims-made basis terminates or is canceled during the term of the contract or within one (1) year of termination or expiration of the contract, the contractor shall obtain an extended discovery or reporting period, or a new insurance policy, providing coverage required by this contract for the term of the contract and one (1) year following termination or expiration of the contract.

If by the terms of any insurance a mandatory deductible is required, or if the Contractor elects to increase the mandatory deductible amount, the Contractor shall be responsible for payment of the amount of the deductible in the event of a paid claim.

Notwithstanding any other clause in this Contract, the State may recover up to the liability limits of the insurance policies required herein.

1. WORKERS' COMPENSATION INSURANCE

   The Contractor shall take out and maintain during the life of this contract the statutory Workers' Compensation and Employer's Liability Insurance for all of the contactors' employees to be engaged in work on the project under this contract and, in case any such work is sublet, the Contractor shall require the subcontractor similarly to provide Worker's Compensation and Employer's Liability Insurance for all of the subcontractor's employees to be engaged in such work. This policy shall be written to meet the statutory requirements for the state in which the work is to be performed, including Occupational Disease. The policy shall include a waiver of subrogation in favor of the State. The COI shall contain the mandatory COI subrogation waiver language found hereinafter. The amounts of such insurance shall not be less than the limits stated hereinafter. For employees working in the State of Nebraska, the policy must be written by an entity authorized by the State of Nebraska Department of Insurance to write Workers' Compensation and Employer's Liability Insurance for Nebraska employees.

2. COMMERCIAL GENERAL LIABILITY INSURANCE AND COMMERCIAL AUTOMOBILE LIABILITY INSURANCE

   The Contractor shall take out and maintain during the life of this contract such Commercial General Liability Insurance and Commercial Automobile Liability Insurance as shall protect Contractor and any subcontractor performing work covered by this contract from claims for damages for bodily injury, including death, as well as from claims for property damage, which may arise from operations under this contract, whether such operation be by the Contractor or by any subcontractor or by anyone directly or indirectly employed by either of them, and the amounts of such insurance shall not be less than limits stated hereinafter.

   The Commercial General Liability Insurance shall be written on an occurrence basis, and provide Premises/Operations, Products/Completed Operations, Independent Contractors, Personal Injury, and Contractual Liability coverage. The policy shall include the State, and others as required by the contract documents, Additional Insured(s). This policy shall be primary, and any insurance or self-insurance carried by the State shall be considered secondary and non-contributory. The COI shall contain the mandatory COI liability waiver language found hereinafter. The Commercial Automobile Liability Insurance shall be written to cover all Owned, Non-owned, and Hired vehicles.

REQUIRED INSURANCE COVERAGE	
COMMERCIAL GENERAL LIABILITY	
General Aggregate	$2,000,000
Products/Completed Operations Aggregate	$2,000,000
Personal/Advertising Injury	$1,000,000 per occurrence
Bodily Injury/Property Damage	$1,000,000 per occurrence
Medical Payments	$10,000 any one person
Damage to Rented Premises (Fire)	$300,000 each occurrence
Contractual	Included
~~XCU Liability (Explosion, Collapse, and Underground Damage)~~	~~Included~~
Independent Contractors	Included
~~Abuse & Molestation~~	~~Included~~
If higher limits are required, the Umbrella/Excess Liability limits are allowed to satisfy the higher limit.	
WORKER'S COMPENSATION	
Employers Liability Limits	$500K/$500K/$500K
Statutory Limits- All States	Statutory - State of Nebraska

REQUIRED INSURANCE COVERAGE	
Voluntary Compensation	Statutory
COMMERCIAL AUTOMOBILE LIABILITY	
Bodily Injury/Property Damage	$1,000,000 combined single limit
Include All Owned, Hired & Non-Owned Automobile liability	Included
Motor Carrier Act Endorsement	Where Applicable
UMBRELLA/EXCESS LIABILITY	
Over Primary Insurance	
$2,000,000 per occurrence	
PROFESSIONAL LIABILITY	
All Other Professional Liability (Errors & Omissions)	$1,000,000 Per Claim / Aggregate
COMMERCIAL CRIME	
Crime/Employee Dishonesty Including 3rd Party Fidelity	$1,000,000
CYBER LIABILITY	
Breach of Privacy, Security Breach, Denial of Service, Remediation, Fines and Penalties	$10,000,000
MANDATORY COI SUBROGATION WAIVER LANGUAGE	
"Workers' Compensation policy shall include a waiver of subrogation in favor of the State of Nebraska."	
MANDATORY COI LIABILITY WAIVER LANGUAGE	
"Commercial General Liability & Commercial Automobile Liability policies shall name the State of Nebraska as an Additional Insured and the policies shall be primary and any insurance or self-insurance carried by the State shall be considered secondary and non-contributory as additionally insured."	

3. EVIDENCE OF COVERAGE

The Contractor shall furnish the Contract Manager, with a certificate of insurance coverage complying with the above requirements prior to beginning work at:

Public Service Commission
Attn: State 911 Director
PO Box 94927
Lincoln, NE 68509

These certificates or the cover sheet shall reference the RFP number, and the certificates shall include the name of the company, policy numbers, effective dates, dates of expiration, and amounts and types of coverage afforded. If the State is damaged by the failure of the Contractor to maintain such insurance, then the Contractor shall be responsible for all reasonable costs properly attributable thereto.

Reasonable notice of cancellation of any required insurance policy must be submitted to the contract manager as listed above when issued and a new coverage binder shall be submitted immediately to ensure no break in coverage.

4. DEVIATIONS

The insurance requirements are subject to limited negotiation. Negotiation typically includes, but is not necessarily limited to, the correct type of coverage, necessity for Workers' Compensation, and the type of automobile coverage carried by the Contractor.

H. ANTITRUST

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The Contractor hereby assigns to the State any and all claims for overcharges as to goods and/or services provided in connection with this contract resulting from antitrust violations which arise under antitrust laws of the United States and the antitrust laws of the State.

I. CONFLICT OF INTEREST

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

By submitting a proposal, bidder certifies that no relationship exists between the bidder and any person or entity which either is, or gives the appearance of, a conflict of interest related to this Request for Proposal or project.

Bidder further certifies that bidder will not employ any individual known by bidder to have a conflict of interest nor shall bidder take any action or acquire any interest, either directly or indirectly, which will conflict in any manner or degree with the performance of its contractual obligations hereunder or which creates an actual or appearance of conflict of interest.

If there is an actual or perceived conflict of interest, bidder shall provide with its proposal a full disclosure of the facts describing such actual or perceived conflict of interest and a proposed mitigation plan for consideration. The State will then consider such disclosure and proposed mitigation plan and either approve or reject as part of the overall bid evaluation.

J. STATE PROPERTY

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The Contractor shall be responsible for the proper care and custody of any State-owned property which is furnished for the Contractor's use during the performance of the contract. The Contractor shall reimburse the State for any loss or damage of such property; normal wear and tear is expected.

K. SITE RULES AND REGULATIONS

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The Contractor shall use its best efforts to ensure that its employees, agents, and subcontractors comply with site rules and regulations while on State or any government premises. If the Contractor must perform on-site work outside of the daily operational hours set forth by the State, it must make arrangements with the State or any government to ensure access to the facility and the equipment has been arranged. No additional payment will be made by the State on the basis of lack of access, unless the State fails to provide access as agreed to in writing between the State and the Contractor.

L. ADVERTISING

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as edited below.

Except to the extent required by law, t~~T~~he Contractor agrees not to refer to the contract award in advertising in such a manner as to state or imply that the company or its goods or services are endorsed or preferred by the State. Any publicity releases pertaining to the project shall not be issued without prior written approval from the State.

M. NEBRASKA TECHNOLOGY ACCESS STANDARDS (Statutory)

Contractor shall review the Nebraska Technology Access Standards, found at http://nitc.nebraska.gov/standards/2-201.html and ensure that products and/or services provided under the contract are in compliance or will comply with the applicable standards to the greatest degree possible. In the event such standards change during the Contractor's performance, the State may create an amendment to the contract to request the contract comply with the changed standard at a cost mutually acceptable to the parties.

N. DISASTER RECOVERY/BACK UP PLAN

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

The Contractor shall have a disaster recovery and back-up plan, of which a copy should be provided upon request to the State, which includes, but is not limited to equipment, personnel, facilities, and

transportation, in order to continue delivery of goods and services as specified under the specifications in the contract in the event of a disaster.

O. DRUG POLICY

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

Contractor certifies it maintains a drug free work place environment to ensure worker safety and workplace integrity. Contractor agrees to provide a copy of its drug free workplace policy at any time upon request by the State.

P. WARRANTY

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Contractor accepts the language as edited below. Contractor also expects to add exclusions from warranty and certain disclaimers that apply similar to the clauses for exclusions of warranty and disclaimers found in Contractor's Master Sales Agreement.

Despite any clause to the contrary, the Contractor represents and warrants that its services shall, at the time of acceptance and for a period of thirty (30) days thereafter, ~~hereunder shall~~ be performed by competent personnel and shall be of professional quality consistent with generally accepted industry standards for the performance of such services and shall comply in all material respects with the applicable specifications~~requirements~~ of this Agreement. If any services fail to conform to their applicable warranty set forth herein, and the State notifies Contractor of such nonconformance in writing within the applicable warranty period, the State's exclusive remedy and Contractor's entire liability shall be for Contractor, at its option, (a) to the extent reasonably possible, repair, revise, re-perform or replace the defective or non-conforming services to bring the same into compliance with their applicable warranty above; or (ii) in the event the remedy specified in (i) is not accomplished in a reasonable period of time or is not reasonably possible, refund to the State the pro-rated amount actually paid by the State to Contractor for the relevant defective or non-conforming services. Any replacement or re-performed Services provided will be warranted from the date of replacement or re-performance for thirty (30) days.~~For any breach of this warranty, the Contractor shall, for a period of ninety (90) calendar days from performance of the service, perform the services again, at no cost to the State, or if Contractor is unable to perform the services as warranted, Contractor shall reimburse the State all fees paid to Contractor for the unsatisfactory services. The rights and remedies of the parties under this warranty are in addition to any other rights and remedies of the parties provided by law or equity, including, without limitation actual~~

~~damages, and, as applicable and awarded under the law, to a prevailing party, reasonable attorneys' fees and costs.~~

3. Payment [RFP IV]

A. PROHIBITION AGAINST ADVANCE PAYMENT (Statutory)

Neb. Rev. Stat. §§81-2403 states, "[n]o goods or services shall be deemed to be received by an agency until all such goods or services are completely delivered and finally accepted by the agency." Notwithstanding the foregoing, payment under this contract shall be in accordance with the payment schedule contained in the RFP.

B. TAXES (Statutory)

The State is not required to pay taxes and assumes no such liability as a result of this solicitation. The Contractor may request a copy of the Nebraska Department of Revenue, Nebraska Resale or Exempt Sale Certificate for Sales Tax Exemption, Form 13 for their records. Any property tax payable on the Contractor's equipment which may be installed in a state-owned facility is the responsibility of the Contractor

C. INVOICES

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
KH			

Invoices for payments must be submitted by the Contractor to the agency requesting the services with sufficient detail to support payment. Public Service Commission State 911 Director 1200 N St. Lincoln, NE 68509. The terms and conditions included in the Contractor's invoice shall be deemed to be solely for the convenience of the parties. No terms or conditions of any such invoice shall be binding upon the State, and no action by the State, including without limitation the payment of any such invoice in whole or in part, shall be construed as binding or estopping the State with respect to any such term or condition, unless the invoice term or condition has been previously agreed to by the State as an amendment to the contract.

D. INSPECTION AND APPROVAL

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as edited below.

Final inspection and approval of all work required under the contract shall be performed by the designated State officials.

Upon reasonable notice to the Contractor, t~~T~~he State and/or its authorized representatives shall have the right to enter any premises where the Contractor or subcontractor duties under the contract are being

performed, and to inspect, monitor or otherwise evaluate the work being performed. All inspections and evaluations shall be at reasonable times and in a manner that will not unreasonably delay work.

E. PAYMENT (Statutory)

Payment will be made by the responsible agency in compliance with the State of Nebraska Prompt Payment Act (See Neb. Rev. Stat. §81-2403). The State may require the Contractor to accept payment by electronic means such as ACH deposit. In no event shall the State be responsible or liable to pay for any goods and services provided by the Contractor prior to the Effective Date of the contract, and the Contractor hereby waives any claim or cause of action for any such services. Notwithstanding the foregoing, payment shall be made in accordance with the payment schedule in the RFP, and such payment schedule shall include payment of the monthly recurring charge in advance at the beginning of the month.

F. LATE PAYMENT (Statutory)

The Contractor may charge the responsible agency interest for late payment in compliance with the State of Nebraska Prompt Payment Act (See Neb. Rev. Stat. §81-2401 through 81-2408).

G. SUBJECT TO FUNDING / FUNDING OUT CLAUSE FOR LOSS OF APPROPRIATIONS (Statutory)

The State's obligation to pay amounts due on the Contract for a fiscal years following the current fiscal year is contingent upon legislative appropriation of funds. Should said funds not be appropriated, the State may terminate the contract with respect to those payments for the fiscal year(s) for which such funds are not appropriated. The State will give the Contractor written notice thirty (30) calendar days prior to the effective date of termination. All obligations of the State to make payments after the termination date will cease. The Contractor shall be entitled to receive just and equitable compensation for any authorized work which has been satisfactorily completed, and any and all costs incurred for supplies and ~~as~~services as of the termination date. In no event shall the Contractor be paid for a loss of anticipated profit.

H. RIGHT TO AUDIT (First Paragraph is Statutory)

The State shall have the right to audit the Contractor's performance of this contract upon a thirty (30) calendar days' written notice. Contractor shall utilize generally accepted accounting principles, and shall maintain the accounting records, and other records and information relevant to the contract (Information) to enable the State to audit the contract. (Neb. Rev. Stat. §84-304 et seq.) The State may audit and the Contractor shall maintain, the Information during the term of the contract and for a period of five (5) years after the completion of this contract or until all issues or litigation are resolved, whichever is later. The Contractor shall make the Information available to the State at Contractor's place of business or a location acceptable to both Parties during normal business hours. If this is not practical or the Contractor so elects, the Contractor may provide electronic or paper copies of the Information. The State reserves the right to examine, make copies of, and take notes on any Information relevant to this contract, regardless of the form or the Information, how it is stored, or who possesses the Information. Under no circumstance will the Contractor be required to create or maintain documents not kept in the ordinary course of contractor's business operations, nor will contractor be required to disclose any information, including but not limited to product cost data, which is confidential or proprietary to contractor.

Accept (Initial)	Reject (Initial)	Reject & Provide Alternative within Solicitation Response (Initial)	NOTES/COMMENTS:
		KH	Accept language as edited below.

The Parties shall pay their own costs of the audit unless the audit finds a previously undisclosed overpayment by the State. If a previously undisclosed overpayment exceeds ~~one-half of one~~five percent (~~.~~5%) of the total contract billings, or if fraud, material misrepresentations, or non-performance is discovered on the part of the Contractor, the Contractor shall reimburse the State for the total costs of the audit. Overpayments and audit costs owed to the State shall be paid within ninety (90) days of written notice of the claim. The Contractor agrees to correct any material weaknesses or condition found as a result of the audit.

LIGHTEDGE OMAHA DATA CENTER

The leader in compliant cloud & colocation

With its central US location and proximity to LightEdge's other facilities, Omaha was a natural fit for expanding our reach. LightEdge's 20,000 sq. ft. facility is the most up-to-date, multi-tenant data center in Omaha.

Enabled by a wealth of high-speed connectivity options, power rates that are 20% below the national average, 1/3 of power generation coming from renewable sources, and tax incentives that flow directly to data center tenants, the city of Omaha and the State of Nebraska are serious technology partners. Sarpy County is also home to other major national data centers, such as Facebook, Yahoo, Fidelity, and Travelers.

ABOUT LIGHTEDGE

With over 20 years in business, LightEdge offers a full stack of best-in-class IT services to provide flexibility, security, and control for any stage of a customer's technology roadmap.

Our solutions include premier colocation across seven purpose-built data centers, industry-leading private Infrastructure as a Service (IaaS) and cloud platforms, and the top global security and compliance measures. Our owned and operated facilities, integrated disaster recovery solutions, and premium cloud choices make up a true Hybrid Solution Center.

BEST-IN-CLASS SOLUTIONS

- ☑ Compliance & Security
- ☑ Hosting & Cloud
- ☑ Colocation
- ☑ Business Continuity

SECURITY & COMPLIANCE EXPERTISE

- ISO 20000-1
- ISO 27001
- HIPAA
- HITRUST
- PCI DSS
- SOC
- NIST
- FISMA
- FedRAMP
- CJIS
- NERC-CIP

STATE-OF-THE-ART DATA CENTERS

- Des Moines I & II
- Kansas City
- Omaha
- Austin I & II
- Raleigh

LIGHTEDGE

OMAHA DATA CENTER FEATURES

PHYSICAL LOCATION

- Convenient access to I-80
- Quick drive to Kansas City and Des Moines
- Close proximity to Omaha Airport
- Focal point for long-haul & transcontinental fiber
- Ideal for locality & geo-diversity
- Low seismic risk & low tornado probability
- Outside 500-year flood plain
- Not in airport landing path

BUILDING & EXPANSION

- 20,000 sq. ft. facility built in 2010 & retrofit in 2017
- Hardened 10" pre-cast concrete structure
- Multi-zoned, dual interlocked, dry pipe sprinkler
- Very Early Smoke Detection Apparatus (VESDA)
- Rack, cage, and private suite options available
- Built to Tier III standards
- "Burn in" room to test & configure equipment
- Meeting space onsite

POWER

- Two separate utility feeds (2-1,500 KVA transformers)
- Redundant substations
- Generator Power (2N) 2-1.5 MW Cat Generators
  - o 36-hour run time fully loaded (3,300-gallon fuel tanks)
- Two battery rooms
- Two separate electrical rooms
  - o Each outfitted with (1) 750 KVA NXL Liebert UPS
    - Plumbed for two for a max 1.5MW

COOLING

- N+1 built-in redundancy
- 36-inch raised floors
- Liebert CRAH units in N+1 configuration
- Dual power fed HVAC units with Variable Speed Fans
- Humidity set point of 44

CONNECTIVITY

- Private fiber backbone connects all LightEdge facilities
- Redundant, carrier agnostic connectivity
- Cross-connects to full suite of cloud services
- Variety of LightEdge dark fiber & lit services
- Enterprise-class, multi-carrier bandwidth
- Redundant DWDM access to local Carrier Hotel

SECURITY

- Video surveillance at perimeter, throughout facility, and on each data center aisle with 90+ days archival
- Three levels of secure checkpoints throughout:
  - o Secure check-in with key card, pin & biometrics
  - o Multi-factor authentication in mantraps
  - o Additional biometrics & key card access for white floor space entry
- All data center cabinets have combo locks
- Each cage or private suite is secured with key card access and/or biometric controls
- Tridium Niagara AX Building Management System
  - o Centralized management of critical infrastructure equipment
  - o Ensures conformance with ASHRAE TC 9.9 standards for A1 environments
  - o Historical data available for trending

COMPLIANCE

- PCI DSS & HIPAA compliant
- SOC 1 Type II, SOC 2 Type II & SOC 3 audited
- ISO 20000-1 & ISO 27001 certified

UNPARALLELED SUPPORT

- 24/7/365 manned Network Operations Center
- Remote Technical Hands available
- 100% uptime guarantee and SLA

UNITED STATES SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 10-K

(Mark One)

☒ Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934

For the fiscal year ended July 31, 2019

☐ Transition Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934

Commission File Number: 0-7928

(Exact name of registrant as specified in its charter)

Delaware	**11-2139466**
(State or other jurisdiction of incorporation /organization)	(I.R.S. Employer Identification Number)
68 South Service Road, Suite 230, Melville, NY	**11747**
(Address of principal executive offices)	(Zip Code)

(631) 962-7000
(Registrant's telephone number, including area code)

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common Stock, par value $.10 per share	**CMTL**	**NASDAQ Stock Market LLC**
Series A Junior Participating Cumulative Preferred Stock, par value $0.10 per share		

Securities registered pursuant to Section 12(g) of the Act:
None
(Title of class)

Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act.
☒ Yes ☐ No

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 of Section 15(d) of the Act.
☐ Yes ☒ No

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days.
☒ Yes ☐ No

Indicate by check mark whether the registrant has submitted electronically and posted on its corporate Web site, if any, every Interactive Data file required to be submitted and posted pursuant to Rule 405 of Regulation S-T (§ 232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit and post such files).

☒ Yes ☐ No

Indicate by check mark if disclosure of delinquent filers pursuant to Item 405 of Regulation S-K (§ 229.405 of this chapter) is not contained herein, and will not be contained, to the best of registrant's knowledge, in definitive proxy or information statements incorporated by reference in Part III of this Form 10-K or any amendment to this Form 10-K. ☒

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, a smaller reporting company, or an emerging growth company. See the definitions of "large accelerated filer," "accelerated filer," "smaller reporting company," and "emerging growth company" in Rule 12b-2 of the Exchange Act.

Large accelerated filer	☐	Accelerated filer	☒	Emerging growth company	☐		
Non-accelerated filer	☐	Smaller reporting company	☐				

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Indicate by check mark whether registrant is a shell company (as defined in Rule 12b-2 of the Exchange Act).

☐ Yes ☒ No

The aggregate market value of the registrant's voting stock held by non-affiliates of the registrant, computed by reference to the closing sales price as quoted on the NASDAQ Global Select Market on January 31, 2019 was approximately $584,329,000.

The number of shares of the registrant's common stock outstanding on September 19, 2019 was 24,267,980.

DOCUMENTS INCORPORATED BY REFERENCE.

Certain portions of the document listed below have been incorporated by reference into the indicated Part of this Annual Report on Form 10-K:

Proxy Statement for 2019 Annual Meeting of Stockholders - Part III

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Note: As used in this Annual Report on Form 10-K, the terms "Comtech," "we," "us," "our" and "our Company" mean Comtech Telecommunications Corp. and its subsidiaries.

Note About Forward-Looking Statements

This Form 10-K contains "forward-looking statements," including statements concerning the future of our industry, product development, business strategy, continued acceptance of our products, market growth, and dependence on significant customers. These statements can be identified by the use of forward-looking terminology such as "may," "will," "should," "could," "would," "expect," "plan," "anticipate," "believe," "estimate," "predict," "potential," "continue," the negative of these terms, or other similar words or comparable terminology. All statements in this report, other than statements of historical fact, are forward-looking information. When considering forward-looking statements, you should keep in mind the risk factors and other cautionary statements included in this Form 10-K. However, the risks described in this Form 10-K are not the only risks that we face. Additional risks and uncertainties, not currently known to us or that do not currently appear to be material, may also materially adversely affect our business, financial condition and/or operating results in the future. We describe risks and uncertainties that could cause actual results and events to differ materially in *"Risk Factors"* (Part I, Item 1A of this Form 10-K), *"Management's Discussion and Analysis of Financial Condition and Results of Operations"* (Part II, Item 7 of this Form 10-K) and *"Quantitative and Qualitative Disclosures about Market Risk"* (Part II, Item 7A of this Form 10-K). We do not intend to update or revise publicly any forward-looking statements, whether because of new information, future events, or otherwise, except as required by law.

PART I
ITEM 1. BUSINESS

We are a leading provider of advanced communications solutions for both commercial and government customers worldwide. Our solutions fulfill our customers' needs for secure wireless communications in some of the most demanding environments, including those where traditional communications are unavailable or cost-prohibitive, and in mission-critical scenarios where performance is crucial. In recent years, we have benefited from an increase in market demand for global voice, video and data usage which has resulted in our Company growing.

As more fully described throughout this Form 10-K, fiscal 2019 was a successful year for Comtech. It was our fourth consecutive year of net sales growth and third consecutive year of Adjusted EBITDA (a Non-GAAP financial measure) growth. We achieved consolidated net sales of $671.8 million, consolidated net income of $25.0 million and Adjusted EBITDA of $93.5 million. We also generated $68.0 million of cash flows from operations. We completed two small acquisitions and finished the fiscal year with solid backlog. We are experiencing strong business momentum in each of our two operating segments and are confident that fiscal 2020 will be even better.

Our Business Outlook for Fiscal 2020 is discussed further in *Part II* - "*Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations - Business Outlook for Fiscal 2020.*" For a definition and explanation of Adjusted EBITDA, see *Part II* - "*Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations - Comparison of Fiscal 2019 and 2018 - Adjusted EBITDA.*"

Our Internet website is www.comtechtel.com and we make available on our website: our filings with the Securities and Exchange Commission ("SEC"), including annual reports, quarterly reports, current reports and any amendments to those filings. The reference to our website address does not constitute incorporation by reference of the information contained therein into this Form 10-K. We also use our website to disseminate other material information to our investors (on the Home Page and in the "Investor Relations" section). Among other things, we post on our website our press releases and information about our public conference calls (including the scheduled dates, times and the methods by which investors and others can listen to those calls), and we make available for replay webcasts of those calls and other presentations for a limited time.

We also use social media channels to communicate with customers and the public about our Company, our products, services and other issues, and we use social media and the Internet to communicate with investors, including information about our stockholder meetings. Information and updates about our Annual Meetings will continue to be posted on our website at www.comtechtel.com in the "Investor Relations" section.

Any materials filed with the SEC may be read and copied by the public at the SEC's Public Reference Room at 100 F Street, N.E., Washington, DC 20549. The public may obtain information on the operation of the Public Reference Room by calling the SEC at 1-800-SEC-0330.

We are incorporated in the state of Delaware and were founded in 1967.

Corporate Strategies

We intend to manage our business with the following principal corporate strategies:

- Seek leadership positions in markets where we can provide differentiated products and technology solutions;
- Identify and participate in emerging technologies that enhance or expand our product portfolio;
- Maximize responsiveness to our customers, including offering more integrated systems and solutions;
- Expand and further penetrate our diversified and balanced customer base; and
- Pursue acquisitions of complementary businesses and technologies.

Competitive Strengths

The successful execution of our principal corporate strategies is based on our competitive strengths, including the following:

(1) We Have Significant Exposure to Large, Growing End Markets

We believe we are well positioned to capitalize on some of the most significant technology trends occurring worldwide and that customers around the world will increasingly turn to us to fulfill their needs for secure wireless communications in some of the most demanding environments, including those where traditional communications are unavailable or cost-prohibitive, and in mission-critical scenarios where performance is crucial. These important technology trends include growth in global wireless penetration and consumption, the need for public safety agencies to seamlessly utilize precise location to connect individuals with first responders, global deployment of in-flight connectivity solutions, the rapidly expanding breadth of High Definition ("HD") and 4K broadcasting content and the need for governments to have more modern and mobile communications and transmission equipment to successfully complete mission-critical goals. We believe that all of these trends generate growth in global voice, video and data usage that, in turn, drives increased demand for the secure wireless communication solutions that we provide.

(2) We Believe We Are a Market Leader in the End-Markets That We Serve

Commercial Solutions Segment

Satellite Ground Station Technologies - We believe we are the leading provider of Single Channel per Carrier ("SCPC") satellite earth station modems, solid-state amplifiers and traveling wave tube amplifiers. Many of our key satellite earth station modems incorporate Turbo Product Code ("TPC") forward error correction technology and bandwidth compression technology which enables our customers to optimize their satellite networks by either reducing their satellite transponder lease costs or increasing data throughput. Our amplifier products are used to amplify signals carrying voice, video or data for air-to-satellite-to-ground communications and are vital to satellite communication applications such as traditional broadcast, direct-to-home ("DTH") broadcast and satellite newsgathering. We differentiate our amplifier product offerings by our ability to develop the most efficient size, weight and power profile. Certain of our amplifiers are AS-900 (an airborne quality standard) certified and when incorporated into an aircraft satellite communication system, can provide passengers with email, Internet access and video conferencing. We believe we are a leader in providing amplifiers for the growing in-flight connectivity market.

Public Safety and Location Technologies - We believe that we are a leader in public safety communication and location technologies used for routing 911 calls. We believe we have significant market share in the routing of U.S. wireless 911 calls, Voice over Internet Protocol ("VoIP") 911 calls and Text to 911 messaging. We believe we are one of two companies fulfilling the Federal Communications Commission ("FCC") requirements for Enhanced 911 ("E911") call-routing to public safety answering points ("PSAPs") for wireless and VoIP network operators. E911 refers to 911 calls for both wireline and wireless telephones that are enhanced to provide the caller's location information. We are focusing our marketing and research and development efforts to meet system standards for next generation 911 ("NG-911"), which refers to an Internet Protocol ("IP") based system that allows digital information (e.g., voice, photos, videos, text messages) to flow seamlessly from the public, through the 911 network and on to emergency responders. Our Short-Messaging Service ("SMS") Center software has been used by wireless carrier subscribers to send and receive text or data messages to and from wireless devices for almost two decades. Additionally, we offer Location Studio ™, a complete end-to-end location services platform for mobile carriers, application developers, public safety customers and enterprises.

Government Solutions Segment

Mission-Critical Technologies - We are a key supplier to large governments (particularly the U.S. government) and large prime contractors, for mission-critical technologies, primarily tactical satellite-based technology solutions, field support services and satellite component supply chain management. We are a prime contractor under several indefinite delivery, indefinite quantity ("IDIQ") defense contract vehicles or task orders, including the: (i) U.S. Army's Global Tactical Advanced Communications Systems ("GTACS") contract, (ii) U.S. Navy's Seaport Next Generation ("SeaPort-Nxg") contract, (iii) Complex Commercial SATCOM Solutions ("CS3") contract and (iv) Communications Electronics Command ("CECOM") Responsive Strategic Sourcing for Services ("RS3") contract with the U.S. Army Contracting Command - Aberdeen Proving Ground ("ACC-APG"). We provide field support sustainment services to the U.S. Army's AN/TSC-198 family of communication systems that are commonly referred to as "SNAP" (Secret Internet Protocol Router ("SIPR") and Non-secure Internet Protocol Router ("NIPR") Access Point) Very Small Aperture Terminals ("VSATs"). We also provide sustainment services for the U.S. Army's Blue Force Tracking-1 ("BFT-1") system. Our field support services include providing U.S. Department of Defense ("DoD") personnel with curriculum development and training services to support cybersecurity workforce development. Our satellite component supply chain management services include the procurement of space components, antenna systems and high reliability Electrical, Electronic and Electromechanical ("EEE") parts in support of mission-critical space programs.

High-Performance Transmission Technologies - We are a key supplier of troposcatter and radio frequency ("RF") solid-state, high-power amplifier and switching technologies. We have designed, manufactured and sold troposcatter systems (sometimes referred to as over-the-horizon microwave products and systems) for over fifty years and are one of the largest independent suppliers of solid-state, high-power microwave amplifiers, which reproduce signals with high power and are extremely complex and critical to the performance of the systems into which they are incorporated. Our adaptive troposcatter modem systems can operate at 100 megabits per second ("Mbps") and our Modular Tactical Transmission System ("MTTS") provides a high capacity, beyond-line-of-sight modular communications system designed for easy and rapid deployment. Many amplifier power and switching technologies are produced in-house by large companies; however, our expertise has created a cost-effective and technologically superior alternative to in-house sourcing. Some of the companies who have outsourced amplifier production to us include Rockwell Collins, Inc., Thales Group, European Aeronautic Defense and Space Company ("EADS"), Telephonics Corporation, Northrop Grumman Corporation, BAE Systems PLC and Raytheon Company. Our amplifiers are also used in oncology treatment systems that allow physicians to give cancer patients higher doses of radiation that are more closely focused on cancerous tissue, thereby minimizing damage to healthy tissue.

(3) We Believe We Provide Industry Leading Innovation, Capabilities and Solutions

We have established a leading position of technology innovation in our fields through internal and customer-funded research and development activities, which have yielded significant advances. Examples of our industry-leading innovation include:

Our Heights™ Networking Platform - Our Heights™ networking platform ("Heights") is the cornerstone of our current research and development efforts and is an increasing focus of our satellite earth station equipment sales and marketing efforts. Heights™ is an advanced networking platform that combines our most efficient waveforms, compression engines and the ability to provide dynamic bandwidth and power management to meet the demands of customers operating on traditional fixed satellite service systems ("FSS") while providing advantages for customers who plan to transition to high throughput satellite ("HTS") systems in the future. Heights™ is ideally suited for cellular backhaul, universal service obligation networks and other applications that require high performance in a hub-spoke environment. Heights™ solutions are designed to deliver the highest Internet Protocol bits per Hertz in its class.

Our Solacom Software Solutions - In fiscal 2019, we acquired Solacom Technologies, Inc. ("Solacom"), a leading provider of NG-911 solutions for public safety agencies. Solacom has developed a best-in-class call handling solution marketed under the Guardian brand name which provides an integrated text-to-and-from 911 solution on a unified platform. The solution provides a flexible user interface, is capable of adapting to varying customer environments and preferences, provides powerful call conferencing capabilities, enhanced reporting capabilities and offers geospatial 911 location call display directly from a customized map. Because of its advanced features, it allows us to offer an immediate upgrade path to existing and new customers and has expanded our presence in the public safety solutions market. We intend to continue to invest in product enhancements of the Guardian software including developing a cloud-based version so that we can offer software as a service (SaaS) type solutions to our public safety customers.

(4) We Have a Diverse Global Customer Base

We have established long-standing relationships with thousands of customers worldwide, including leading system and network suppliers in the global satellite (such as Intelsat), mobile cellular (such as Verizon Wireless), defense, broadcast and aerospace industries, as well as the U.S. federal government (such as the U.S. Army and Navy), U.S. state and local governments, and foreign governments. Our global commercial and government customers are increasingly seeking integrated solutions to meet their operational needs. We believe that our customers recognize our ability to develop improved technologies and to meet stringent program requirements.

Our ability to solve complex problems is well known and we believe we a have strong relationships with our customers. We hold prime positions on a number of key contracts and have had a long history of servicing key programs.

Business Segments

Fundamentally, we offer advanced secure wireless communication technologies with expertise in the satellite communications and cellular markets. We believe these markets are undergoing a period of significant growth and rapid technological change. We manage our business through two reportable operating segments: Commercial Solutions and Government Solutions. Our corporate senior management team supports the business segments by, among other things, actively seeking to exploit potential synergies that exist between the segments, including in areas such as manufacturing, technology, sales, marketing, customer support and finance.

The diagram below summarizes our key products, systems and services by our two reportable operating segments:

Commercial Solutions Segment Technologies (approximately 53.2% of fiscal 2019 net sales)		Government Solutions Segment Technologies (approximately 46.8% of fiscal 2019 net sales)	
Satellite Ground Station Technologies	**Public Safety and Location Technologies**	**Mission-Critical Technologies**	**High-Performance Transmission Technologies**
• Satellite ground station technologies such as single channel per carrier and Heights™ modems that facilitate the transmission of voice, video and data over satellite links • Solid-state and traveling wave tube amplifiers used to amplify signals from satellite ground stations	• Wireless/VoIP 911 service for network operators • NextGen 911 solutions • ESInet (Emergency Services IP Network) • Call Handling applications for PSAPs • Software and equipment for location-based and messaging infrastructure	• Tactical satellite-based communications, field support and end-to-end integration • Satellite-based mobile communications and tracking systems • Procurement of satellite-based space components, satellite-based antenna systems, and high reliability EEE parts	• Over-the-horizon microwave equipment that can transmit digitized voice, video and data over distances from 20 to 200 miles using the troposphere • Solid-state, high-power amplifiers designed for radar, electronic warfare, jamming, medical and aviation applications

Commercial Solutions Segment Representative Customers	Government Solutions Segment Representative Customers
Satellite systems integrators, wireless and other communication service providers and broadcasters Domestic and international defense customers, as well as U.S. and foreign governments, prime contractors and system suppliers such as L3Harris Technologies, Inc., General Dynamics Corporation, Raytheon Company and ViaSat, Inc. Satellite broadcasters, such as The DIRECTV Group and EchoStar Corporation End-customers also include Verizon Communications Inc., BT Group plc., China Mobile Limited, CenturyLink, Inc., Claro Argentina, Comcast Corporation, Intelsat, S.A., Speedcast International Limited, Nokia Corporation, SES S.A., Sprint Corporation and Qualcomm Incorporated	U.S. Army logistics community, the U.S. Army war-fighter community, foreign governments, the U.S. Navy, prime contractors to the U.S. Armed Forces and NATO Domestic and international defense customers, prime contractors and system suppliers such as Raytheon Company, The Boeing Company, Lockheed Martin Corporation, Telephonics® Corporation and Thales Group Medical equipment companies, such as Varian Medical Systems, Inc., and aviation industry system integrators such as Collins Aerospace (a subsidiary of United Technology Corporation) Foreign government customers in the Middle East, Europe, North Africa, Latin America and Asia Pacific and related prime contractors and systems integrators. Oil companies such as Shell Oil Company and PETRONAS

Financial information about our business segments, including net sales, operating income, Adjusted EBITDA (a Non-GAAP financial measure), total assets, and our operations outside the United States, is provided in *"Notes to Consolidated Financial Statements - Note (12) Segment Information"* included in *"Part II - Item 8. - Financial Statements and Supplementary Data."*

The markets and key technologies for each segment are further described below.

Commercial Solutions Segment

Overview

Our Commercial Solutions segment offers satellite ground station technologies (such as modems and amplifiers) and public safety and location technologies (such as 911 call routing and mapping solutions) to commercial customers and smaller government customers, such as state and local governments. This segment also serves certain large government customers (including the U.S. government) that have requirements for off-the-shelf commercial equipment.

Key Markets and Technology Solutions

Satellite Ground Station Technologies

We offer our customers one-stop-shopping for satellite ground station technologies including modems, amplifiers, converters and network software for customers who utilize satellite communications. Our products are used to modulate, demodulate and amplify signals, carry voice, video and/or data over networks and are vital to satellite communication applications, including air-to-ground communications, video broadcasting and the backhaul of cellular traffic. Our Commercial Solutions segment manufactures most of the satellite ground station equipment we sell to our customers including equipment sold by our Government Solutions segment.

We believe that the overall satellite ground station equipment industry will grow over the next few years. This growth is expected to occur as a result of widespread deployment and upgrades of ground-based systems, including satellite earth stations, as well as integration of high-performance amplifiers used for high-performance systems necessary to meet demand for high-performance applications of satellite communications technologies, such as satellite-based wireless backhaul, DTH, HD and 4K broadcasting and in-flight connectivity. We believe that Comtech is well positioned to capitalize on this demand through sales of our market leading satellite ground station technologies.

Examples of end-market applications that are driving demand for our satellite-based communication technologies include:

- ***Satellite-Based Cellular Backhaul.*** Demand for satellite-based cellular backhaul services is anticipated to grow rapidly as a result of the increased penetration of smart cellular phones and network upgrades to 3G and 4G in developing regions of the world. Ultimately, as 5G services are deployed, mobile data services will become more critical. As mobile data penetration expands and mobile data consumption increases, wireless carriers must invest in their mobile network infrastructure and businesses will require back-up communications. In developing regions of the world and in remote areas where terrestrial network infrastructure is lacking, wireless network operators often backhaul, or transport, their wireless data traffic using satellite-based networking technologies. Comtech is well positioned to serve the high-performance, high availability needs of satellite-based cellular backhaul through sales of our satellite modems including our Heights™ networking platform.

- ***New High Throughput Satellites.*** There are more than 100 new High Throughput Satellite ("HTS") payloads expected to launch over the next decade which we believe is expected to lead to increasingly complex satellite networks. As service providers work to offer connectivity to these high-speed, high-bandwidth satellites and expand their networks to handle the demand for new HTS applications, we believe our Heights™ networking platform will be incorporated into many new installations and necessary upgrades of equipment.

- ***High Definition and Ultra-High Definition Broadcasting.*** Reports indicate that in recent years, consumers have purchased millions of HD televisions and Ultra-High Definition or "4K" televisions. We believe this will require a significant amount of satellite bandwidth, which will require satellite service providers to upgrade equipment and find new ways to manage the cost and transmission efficiency of their networks. We believe that these requirements will drive increased demand for our satellite ground station technologies.

- ***In-Flight Connectivity.*** Consumer demand for anytime, anywhere connectivity is rapidly rising. As a result, airlines worldwide are deploying in-flight connectivity and entertainment systems. The deployment of in-flight connectivity and entertainment systems by airlines is creating opportunities for us to serve as a key supplier of amplifier components used for in-flight Ku-band connectivity systems. As airlines continue to move to offer higher speed satellite-based connectivity, we believe this market will experience solid demand over the next few years.

Public Safety and Location Technologies

We are a leading provider of public safety and location technologies. Our next generation solutions enable 911 call routing via cellular and over the Internet ("VoIP"). When someone places an emergency call, our technologies can identify the call as an emergency call, access the user's location information from the wireless network and route the call to the assigned public safety jurisdiction. Today, we provide public safety and location technologies to many U.S. telecommunication carriers, the largest of which is Verizon. In fiscal 2018, we signed a multi-year contract with Verizon to provide their 911 call routing via cellular service, which we believe led another customer, AT&T, to begin migration of their 911 call routing via cellular service to a competitor. Given the large market shares of those two carriers, we believe the largest portion of the market for 911 cellular call routing service is split approximately equally between us and our leading competitor.

In addition to 911 call routing, we provide systems integration, satellite and location infrastructure terminals, and linkage to NG-911 Emergency Services IP Networks ("ESInet"). In fiscal 2019, we expanded our product offerings by acquiring Solacom, a small innovative company that offers best-in-class 911 call handling solutions. We believe state and local governments have a need to upgrade existing call handling systems and upgrade old networks to more modern NG-911 systems, including 911 text messaging services, advanced data, real-time photos and other types of information sharing over IP networks.

As the U.S. adopts upgraded call handling and NG-911 solutions, we believe that other countries will do so as well. Our public safety and location technology solutions have been deployed since 2006 and are utilized by literally millions of people in more than 30 states, as well as in Australia. Many of our location technologies (such as mapping and text messaging) are embedded in our public safety and location technology offerings to help address mapping, routing and geolocations. The Federal Communications Commission ("FCC") has mandated that emergency services must incorporate certain location technology, like our own, which utilizes more precise location information. Our text messaging platforms are used by wireless carriers to provide SMS to their end-customers and are also used to communicate with 911 PSAPs through major network operators.

In order to maximize market growth opportunities, we are repositioning certain location technology solutions (previously called enterprise technology offerings) to increase our penetration into the public safety space. Although the market is competitive and the sales cycle is long, we believe demand for our public safety and location technologies are growing and customers are looking for more of an integrated solution. Our Location Studio™ platform allows customers, including public safety agencies, to build their own applications with end-customer functionality, such as maps, search, geocoding, routing and navigation, using their brand. We believe that customers are increasingly looking for an alternative to free mapping services that are subject to change by the provider and which meet their privacy and security requirements. As such, we are integrating OpenStreetMap technologies into our solution which will allow our customers to eliminate certain third-party content fees. Our location technology solution enables the determination of a cell phone's geospatial position in environments where traditional Global Positioning System ("GPS"), global navigation satellite systems and cellular technologies do not work well (such as office buildings). For our installed base of systems, we often provide ongoing operational support, including administration of system components, system optimization and configuration management. Maintenance services include tracking customer support issues, troubleshooting and developing and installing maintenance releases.

Government Solutions Segment

Overview

Our Government Solutions segment provides mission-critical technologies (such as tactical satellite-based networks and ongoing support for complicated communication networks) and high-performance transmission technologies (such as troposcatter systems and solid-state, high-power amplifiers) to large government end-users (including those of foreign countries), large international customers and domestic prime contractors.

Key Markets and Technology Solutions

Mission-Critical Technologies

With persistent threats from state and non-state actors, governments around the world are increasingly seeking ways to mitigate vulnerabilities using information and more reliable communication systems to increase decision-makers' situational awareness. In response this demand, we offer a variety of mission-critical technologies including the supply and field support of tactical satellite-based networks (including satellite modems, ruggedized routers and solid-state drives), sustainment services for the AN/TSC-198A SNAP (Secret Internet Protocol Router ("SIPR") and Non-classified Internet Protocol Router ("NIPR") Access Point), Very Small Aperture Terminals ("VSATs") and sustainment services for the U.S. Army's Blue Force Tracking-1 ("BFT-1") system. Many of our mission-critical technologies are part of integrated communication infrastructure systems such as the U.S. Military Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (also known as "C4ISR") systems and similar complicated networks for international governments.

We are recognized as an industry leader and global supplier of high reliability products. Our solutions include supply chain services such as the procurement of satellite-based space components, satellite-based antenna systems, and high reliability Electrical, Electronic and Electromechanical ("EEE") parts in support of critical National Aeronautics and Space Administration ("NASA") programs and for an international space agency. We also provide a variety of in-class and on-line training services to our customers to help them protect networks from cyber attacks.

High-Performance Transmission Technologies

We offer several unique high-performance transmission technologies that are used in sophisticated communication systems, such as electronic warfare, radar and identification friend or foe ("IFF"). As our customers push the envelope for mobility, speed and higher frequency, we believe that demand for high-performance transmission products will grow from current levels.

Our troposcatter technologies (sometimes referred to as over-the-horizon microwave systems) are extremely reliable and secure and are a cost-effective alternative and compliment to satellite communication as it does not require the leasing of expensive satellite transponder space with its attendant recurring costs. Our over-the-horizon microwave systems, which include our patented forward error correction technology, can transmit video and other broadband applications at throughputs of up to 100 Mbps. U.S. and foreign governments use our over-the-horizon microwave systems to, among other things, transmit radar tracking, run C4ISR applications and to connect remote border locations. Additionally, energy companies use our systems to enable communication links for offshore oil rigs and other remote locations, as well as for exploration activities. Our MTTS, the first truly modular, rapidly deployable transit case-based troposcatter system, has been purchased by the U.S. Army, incorporated into the SNAP family of products used by the U.S. military and designated the Tactical Transportable TROPO ("SNAP 3T") or AN/TRC 198(V3). Our newly introduced next generation troposcatter modems provide significant reductions in size, weight and power as compared to prior models and we believe these next generation modems will facilitate further market expansion.

Our solid-state, high-power amplifiers and related switching technologies are utilized in several critical applications including electronic warfare, communications, radar, IFF and medical applications such as oncology cancer treatment systems. In the electronic warfare marketplace, we support a variety of legacy systems and are participating in the ongoing migration to platforms that require smaller and lighter amplifiers. Our solutions increase the flexibility of systems by providing wider bandwidth capabilities to address communication needs. We also believe that the desire for increased situational awareness of the airspace may create increased opportunities for our radar and IFF products, which are used by government customers around the world. Our high power and highly reliable Gallium Nitride ("GaN") amplifier technology is increasingly used both to update existing radar systems for improved sensitivity and range as well as for new radar installations. In addition to technologies that enhance performance of primary radars, we also supply solutions for IFF systems that provide positive identification of radar targets.

Acquisitions

In the past several years we have acquired businesses and enabling technologies.

On February 23, 2016, we acquired TeleCommunication Systems Inc. ("TCS"), a leading provider of commercial solutions (such as public safety and location technologies) and government solutions (such as mission-critical technologies). The TCS acquisition had an aggregate purchase price for accounting purposes of $340.4 million (also referred to as the transaction equity value) and an enterprise value of $423.6 million. The TCS acquisition resulted in Comtech entering complementary markets and expanding our domestic and international commercial offerings. Our financial results for each of fiscal 2019, 2018 and 2017 include a full year of TCS operations and fiscal 2016 includes approximately five months of TCS operations.

On February 28, 2019, we completed our acquisition of Solacom, a leading provider of NG-911 solutions for public safety agencies. Although revenue contributions in fiscal 2019 were nominal, the acquisition of Solacom was a significant step in our strategy of enhancing our public safety and location technologies solutions and we believe that this acquisition will help us achieve our fiscal 2020 sales target. The Solacom acquisition had an aggregate purchase price for accounting purposes of $32.9 million.

On April 29, 2019, we acquired the state and local government NG-911 business from General Dynamics Information Technology, Inc. (the "GD NG-911 business") and at the same time announced a five-year contract award in excess of $100.0 million to develop, implement and operate a NG-911 emergency communications system for a Northeastern state. The contract began on August 4, 2019 (the start of our fiscal 2020). The acquisition strengthened Comtech's position in the growing NG-911 solutions market and we have fully integrated this business into our Commercial Solutions segment. Revenue contributions from this business in fiscal 2019 were nominal and we believe that this acquisition will help us achieve our fiscal 2020 sales target. The GD NG-911 business has a preliminary aggregate purchase price for accounting purposes of $10.0 million.

In order to position ourselves to take advantage of additional growth opportunities and meet our strategic objectives, we have followed, and will continue to follow, a disciplined approach in identifying, executing and capitalizing on acquisitions.

See "*Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations*" for further discussion of our recent acquisitions and ongoing acquisition efforts.

Sales, Marketing and Customer Support

Sales and marketing strategies include direct sales through sales, marketing and engineering personnel, indirect sales through independent representatives, value-added resellers, and sales through a combination of the foregoing. We devote resources to evaluating and responding to requests for proposals by governmental agencies around the world and, as needed, we employ the use of specialized consultants to develop our proposals and bids.

We intend to continue to expand international marketing efforts by engaging additional independent sales representatives, distributors and value-added resellers and by establishing additional foreign sales offices. In addition, we also leverage our relationships with larger companies (such as prime contractors to the U.S. government and large mobile wireless operators) to market our technology solutions.

We are pre-qualified as an approved vendor for certain government contracts. We collaborate in sales efforts under various arrangements with integrators. Our marketing efforts also include advertising, public relations, speaking engagements and attending and sponsoring industry conferences.

Our management, technical and marketing personnel establish and maintain relationships with customers. Our sales strategies include a commitment to providing ongoing customer support for our systems and equipment. This support involves providing direct access to engineering staff or trained technical representatives to resolve technical or operational issues.

Our products and services in many of our product lines have long sales cycles. Once a product is designed into a system, customers may be reluctant to change the incumbent supplier due to the extensive qualification process and potential redesign required in using alternative sources. In addition, in recent years, we have found that overall sales cycles for each of our product lines have significantly increased.

Sales by geography and customer type, as a percentage of related net sales, are as follows:

	Fiscal Years Ended July 31,								
	2019	2018	2017	2019	2018	2017	2019	2018	2017
	Commercial Solutions			Government Solutions			Consolidated		
U.S. government	19.2%	18.1%	15.1%	63.8%	62.2%	59.2%	40.1%	35.5%	32.7%
Domestic	53.9%	54.6%	54.4%	12.5%	14.9%	15.5%	34.5%	38.9%	38.9%
Total U.S.	73.1%	72.7%	69.5%	76.3%	77.1%	74.7%	74.6%	74.4%	71.6%
International	26.9%	27.3%	30.5%	23.7%	22.9%	25.3%	25.4%	25.6%	28.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Sales to U.S. government customers include sales to the U.S. Department of Defense ("DoD"), intelligence and civilian agencies, as well as sales directly to or through prime contractors.

Domestic sales include sales to commercial customers, as well as to U.S. state and local governments. Included in domestic sales, are sales to Verizon Communications Inc. ("Verizon"), which represented 10.0% of consolidated net sales for fiscal 2018. Except for the U.S. government, there were no customers that represented more than 10.0% of consolidated net sales during fiscal 2019 and 2017.

International sales for fiscal 2019, 2018 and 2017 (which include sales to U.S. domestic companies for inclusion in products that are sold to international customers) were $170.6 million, $145.8 million and $156.5 million, respectively. When we sell internationally, we denominate virtually all of our contracts in U.S. dollars. Some of our sales to international customers are paid for by letters of credit or on an open account. From time to time, some of our international customers may require us to provide performance guarantees.

Except for the U.S., no individual country (including sales to U.S. domestic companies for inclusion in products that are sold to a foreign country) represented more than 10% of consolidated net sales for fiscal 2019, 2018 and 2017.

Backlog

Our backlog as of July 31, 2019 was $683.0 million (of which $493.9 million was attributed to the Commercial Solutions segment and $189.1 million was attributed to the Government Solutions segment). We expect that a significant portion of the backlog as of July 31, 2019 will be recognized as sales during fiscal 2020.

At July 31, 2019, 65.6% of our backlog consisted of orders for use by U.S. commercial customers, 20.0% consisted of U.S. government contracts, subcontracts and government funded programs and 14.4% consisted of orders for use by international customers (including sales to U.S. domestic companies for inclusion in products that will be sold to international customers).

Our backlog is defined as orders (sometimes also referred to herein as bookings) that we believe to be firm. Backlog that is derived from U.S. government orders relates to U.S. government contracts that have been awarded, signed and funded. Backlog for our U.S. government customers also includes amounts appropriated by Congress and allotted to the contract by the procuring government agency. Our backlog does not include the value of options that may be exercised in the future on multi-year contracts, nor does it include the value of additional purchase orders that we may receive under indefinite delivery/indefinite quantity ("IDIQ") contracts or basic ordering agreements. In some cases, such as contracts received from large U.S. based telecommunication companies, our backlog is computed by multiplying the most recent month's contract or revenue by the months remaining under the existing long-term agreements, which we consider to be the best available information for anticipating revenue under those agreements. When we acquire a company with existing contracts, we only record bookings for those contracts that meet our definition. Almost all of the contracts in our backlog (including firm orders previously received from the U.S. government) are subject to modification, cancellation at the convenience of the customer or for default in the event that we are unable to perform under the contract.

A significant portion of the backlog from our U.S. commercial customers relates to large, multi-year contracts to provide state and local governments (and their agencies) with public safety and location solutions. Although the contracts themselves represent legal, binding obligations of these governments, funding is often subject to the approval of budgets (for example, on an annual or bi-annual basis). Although funding for these multi-year contracts are dependent on future budgets being approved, we include the full estimated value of these large, multi-year contracts in our backlog given the critical nature of the services being provided and the positive historical experience of our state and local government customers passing their respective budgets.

There can be no assurance that our backlog will result in actual revenue in any particular period, or at all, or that any contract included in backlog will be profitable. There is a higher degree of risk in this regard with respect to unfunded backlog. The actual receipt and timing of any revenue is subject to various contingencies, many of which are beyond our control. The actual recognition of revenue on contracts included in backlog may never occur or may change because a program schedule could change, the program could be canceled, a contract could be reduced, modified or terminated early, funding may not be included in future budgets, or an option that we had assumed would be exercised is not exercised.

Variations in backlog from time to time are attributable, in part, to changes in sales mix, the timing of contract proposals, the timing of contract awards, delivery schedules on specific contracts and new bookings obtained through acquisitions. A large majority of the solutions in our satellite ground station technologies product line operate under short lead times. Our Government Solutions segment backlog is highly influenced by the nature and timing of orders received from the U.S. government, which is subject to unpredictable funding, deployment and technology decisions. As a result, we believe our backlog and orders, at any point in time, are not necessarily indicative of the total sales anticipated for any future period.

Manufacturing and Service

Our manufacturing operations consist principally of the assembly and testing of electronic products that we design and build from purchased fabricated parts, printed circuits and electronic components. We consider our facilities to be well maintained and adequate for current and planned production requirements. All of our manufacturing facilities, including those that serve the military market, must comply with stringent customer specifications. We employ formal quality management programs and other training programs, including the International Standard Organization's quality procedure registration programs.

We operate a high-volume technology manufacturing center located in Tempe, Arizona. This manufacturing center is operated by our Commercial Solutions segment and can be utilized, in part, by our Government Solutions segment and by third-party commercial customers, including prime contractors to the U.S. government, who can outsource a portion of their product manufacturing to us. Increased usage of our high-volume technology manufacturing center allows us to secure volume discounts on key components, better control the quality of our manufacturing process and maximize the utilization of our manufacturing capacity.

Our ability to deliver products to customers on a timely basis is dependent, in part, upon the availability and timely delivery by subcontractors and suppliers (including, at times, the U.S. government) of the components and subsystems that we use in manufacturing our products. Electronic components and raw materials used in our products are generally obtained from independent suppliers. Some components are standard items and are available from several suppliers. Others are manufactured to our specifications by subcontractors. Although we obtain certain components and subsystems from a single source or a limited number of sources, we believe that most components and equipment are available from multiple sources. Certain U.S. government contracts may require us to incorporate government furnished parts into our products. Delays in receipt of such parts can adversely impact the timing of our performance on the related contracts.

Research and Development

We have established a leading technology position in our fields through internal and customer-funded research and development activities.

Internal research and development expenses are reported as research and development expenses for financial reporting purposes and were $56.4 million, $53.9 million and $54.3 million in fiscal 2019, 2018 and 2017, respectively, representing 8.4%, 9.4% and 9.9% of total consolidated net sales, respectively, for these periods. Customer-funded research and development activities relate to the adaptation of our basic technology to specialized customer requirements which is recoverable under contracts and is reflected in net sales with the related costs included in cost of sales. Certain of our government customers contract with us from time to time to conduct research on telecommunications software, equipment and systems. During fiscal 2019, 2018 and 2017, we were reimbursed by customers for such activities in the amounts of $14.7 million, $16.9 million and $27.1 million, respectively.

Intellectual Property

We rely upon trade secrets, technical know-how, continuing technological innovation and, with respect to certain technologies, patents to develop and maintain our competitive position. The products we sell require significant engineering design and manufacturing expertise. For these technological capabilities that are not protected by patents or licenses, we generally rely on the expertise of our employees and our learned experiences in both the design and manufacture of our products and the delivery of our services.

Some of our key Commercial Solutions segment technology is protected by patents that are significant to protecting our proprietary technology. We have been issued several U.S. patents relating to forward error correction technology that is utilized in our TPC-enabled satellite modems. Due to our market leadership position, we do not expect that upon expiration of these patents, our future results will be negatively impacted.

We have a portfolio of several hundred patents worldwide relating to wireless location services, text messaging, GPS ephemeris data, emergency public safety data routing, electronic commerce and other areas. To-date, our strategy has been to avoid offensive and defensive patent litigation and focus on building meaningful partnerships with other companies through direct licensing, cross licensing, and other forms of agreements. We do not believe that any single patent or group of patents, patent application or patent license agreement is material to the Company's operations.

We have filed additional patent applications for certain apparatus and processes we believe we have invented covering key features of the location services, wireless text alerts, SMS Center, mobile-originated data and E911 network software. There is no assurance that any patent application will result in a patent being issued by the U.S. Patent and Trademark Office or other patent offices, nor is there any guarantee that any issued patent will be valid and enforceable. Additionally, foreign patent rights may or may not be available or pursued in any technology area for which U.S. patent applications have been filed.

Almost all of the products and services we sell to the U.S. government include technology and other technical know-how that we have internally developed. In past instances where we have provided government-purpose rights, to our knowledge, the U.S. government has not exercised any of these rights. To the extent that we have provided or will provide government-purpose rights in the future, we believe that given the rapidly changing nature of our technology, our future success will depend primarily on the technical competence and creative skill of our personnel, rather than any contractual protection.

Competition

Our businesses are highly competitive and are characterized by rapid technological change. Some of our competitors are substantially larger, have significantly greater financial, marketing, research and development, technological and operating resources and broader product lines than we have. Other companies are developing new technologies and the shift towards open standards such as IP-based satellite networks will likely result in increased competition. A significant technological breakthrough by others, including new companies, our existing competitors and our customers, could have a material adverse effect on our business. Our future success depends on, among other things, our ability to keep pace with such changes and developments and to respond to the increasing variety of electronic equipment users and transmission technologies.

Some large defense-based companies, such as Northrop Grumman Corporation, have subsidiaries or divisions that compete against us in one or more business segments. In addition, new and potential competitors are always emerging. Certain of our customers, such as prime contractors who currently outsource their engineering and manufacturing requirements to us, have technological capabilities in our product areas and could choose to replace our products with products they develop. In some cases, we partner or team with companies (both large and mid-tier) to compete against other teams for large defense programs. In some cases, these same companies may be among our competitors.

Listed below, in alphabetical order, are some of our competitors in each of our two business segments:

Commercial Solutions - ACTIA Group, Advantech Wireless Network Co Ltd, Agilis Satcom, AnaCom, Inc., CalAmp Corp., Codan Limited, CPI International, Inc., Datum Systems, Inc., dB Control Corp. (a subsidiary of HEICO Corp.), 8x8 Inc., ENENSYS Technologies SA, ETM, Inc., Gilat Satellite Networks Ltd., Google Inc., Here Technologies, Honeywell Aerospace, Infinite Convergence Solutions, Inc., Intermap Technologies Corporation, Iridium Communications Inc., ITS Electronics Inc., KVH Industries Inc., LM Ericsson Telephone Company, L3Harris Technologies, Inc., Mission Microwave Technologies, LLC., Motorola Solutions, Inc., ND Satcom GmbH, Newtec, Nokia Networks (a subsidiary of Nokia Corporation), NovelSat, Novra Technologies, Inc., Orbcomm, Inc., Panasonic, Paradise Datacom LLC (a subsidiary of Teledyne Technologies, Inc.), Polarity, Inc., SatixFy Israel Ltd, SatPath Systems, Inc., Spacepath Communications Limited, Speedcast International Limited, ST Engineering iDirect, Inc., Telenav, Inc., TMD Technologies LLC., TomTom N.V., ViaSat Inc. and West Corporation.

Government Solutions - Aethercomm Inc., AMERGINT Technologies, Inc., CACI International Inc., CalAmp Corp., Cubic Corporation, dB Control Corp. (a subsidiary of HEICO Corp.), DXC Technology, Empower RF Systems, Inc., Envistacom, LLC., Escape Communications, Inc., General Dynamics Corporation, International Datacasting Corporation (a subsidiary of Novra Technologies, Inc.), Kratos Defense & Security Solutions, Inc., L3Harris Technologies, Inc., Mercury Systems, Inc., NeuStar, Inc., Northrop Grumman Corporation (including the former Orbital ATK, Inc.), Raytheon Company, Teledyne Technologies, Inc., The KEYW Holding Corporation, Ultra Electronics Holdings plc. and ViaSat Inc.

We believe that competition in all our markets is based primarily on technology innovation, product performance, reputation, delivery times, customer support and price. Due to our proprietary know-how, we believe we can develop, produce and deliver products and services on a cost-effective basis faster than many of our competitors.

Employees

At July 31, 2019, we had 2,013 employees (including temporary employees and contractors), 1,189 of whom were engaged in production and production support, 423 in research and development and other engineering support, and 401 in marketing and administrative functions. None of our U.S. based employees are represented by a labor union. We believe that our employee relations are good.

U.S. Government Contracts and Security Clearances

The U.S. government operates on an October-to-September fiscal year. Generally, in February of each year, the President of the United States presents to the U.S. Congress ("Congress") the proposed budget for the upcoming fiscal year and from February through September of each year, the appropriations and authorization committees of Congress review the President's budget proposals and establish the funding levels for the upcoming fiscal year. Once these levels are enacted into law, the Executive Office of the President administers the funds to the agencies. Thereafter, we can receive orders pursuant to sole-source or competitively awarded contracts, which we describe below.

The U.S. government may be unable to complete its budget process before the end of any given government fiscal year and when the fiscal budget is not approved in a timely manner, the U.S. government is required either to shut down or be funded pursuant to a so-called "continuing resolution" that authorizes agencies of the U.S. government to continue operations but does not authorize new spending initiatives, either of which could result in reduced or delayed orders or payments for products and services we provide.

Sole-source contracts are generally awarded to a single contractor without a formal competition when a single contractor is deemed to have an expertise or technology superior to that of competing contractors or when there is an urgent need by the U.S. government that cannot wait for a full competitive process. Potential suppliers compete informally through research and development and marketing efforts. Competitively-bid contracts are awarded based on a formal proposal evaluation established by the procuring agency and interested contractors prepare bids. Competitively-bid contracts are awarded after a formal bid and proposal competition among suppliers.

The U.S. government has a stated policy direction to reduce the number of sole-source contract awards across all procuring agencies. In addition, the U.S. government is increasing the use of multiple-award IDIQ contracts to increase its procurement options. IDIQ contracts allow the U.S. government to select a group of eligible contractors for the same program. When the government awards IDIQ contracts to multiple bidders under the same program, a company that has already competed to be selected as a participant in the program must subsequently compete for individual delivery orders. As a result of this U.S. government shift toward multiple award IDIQ contracts, we expect to face greater competition for future U.S. government contracts and, at the same time, greater opportunities for us to participate in program areas that we do not currently participate in.

As a U.S. government contractor and subcontractor, we are subject to a variety of rules and regulations, such as the Federal Acquisition Regulations ("FAR"). Individual agencies can also have acquisition regulations. For example, the Department of Defense implements the FAR through the Defense Federal Acquisition Regulation supplement (commonly known as "DFARs"). For all Federal government entities, the FAR regulates the phases of any product or service acquisition, including: acquisition planning, competition requirements, contractor qualifications, protection of source selection and vendor information, and acquisition procedures. In addition, the FAR addresses the allowability of supplier costs, while Cost Accounting Standards address how those costs can be allocated to contracts. The FAR also subjects suppliers to audits and other government reviews. These reviews cover issues such as cost, performance and accounting practices relating to our contracts. The government may challenge a supplier's costs and fees. Suppliers are also required to comply with the National Industrial Security Program Operating Manual which relates to requirements regarding classified materials and programs. Suppliers who do not comply with these various regulations may lose and/or become ineligible for facility security clearances and/or participation in classified programs.

Under firm fixed-price contracts, we perform for an agreed-upon price and we can derive benefits from cost savings, but bear the risk of cost overruns. Our cost-reimbursable type contracts typically provide for reimbursement of allowable costs incurred plus a negotiated fee. Cost-plus-incentive-fee orders typically provide for sharing with the U.S. government savings accrued from orders performed for less than the target costs and costs incurred in excess of targets up to a negotiated ceiling price (which is higher than the target cost), and for the supplier to carry the entire burden of costs exceeding the negotiated ceiling price.

In fiscal 2019, $269.2 million or 40.1% of our consolidated net sales were to the U.S. government (including sales to prime contractors to the U.S. government). Of this amount, firm fixed-price and cost-reimbursable type contracts (including fixed-fee, incentive-fee and time and material type contracts) accounted for approximately $188.0 million and $81.2 million, respectively.

Regulatory Matters

In addition to the rules and regulations that pertain to us as a U.S. government contractor and subcontractor, we are also subject to a variety of local, state and federal governmental regulations.

Our products that are incorporated into wireless communications systems must comply with various government regulations, including those of the FCC. Our manufacturing facilities, which may store, handle, emit, generate and dispose of hazardous substances that are used in the manufacture of our products, are subject to a variety of local, state and federal regulations, including those issued by the Environmental Protection Agency. Our products are also subject to European Union directives related to the recycling of electrical and electronic equipment.

Our international sales are subject to U.S. and foreign regulations such as the Arms Export Control Act, the International Emergency Economic Powers Act ("IEEPA"), the International Traffic in Arms Regulations ("ITAR"), the Export Administration Regulations ("EAR") and the trade sanctions laws and regulations administered by the U.S. Department of the Treasury's Office of Foreign Assets Control ("OFAC") as well as other applicable laws relating to trade, export controls and foreign corrupt practices, the violation of which could adversely affect our operations. We cannot be certain that we will be able to obtain necessary export licenses, and such failure would materially adversely affect our operations. If we are unable to receive appropriate export authorizations in the future, we may be prohibited from selling our products and services internationally, which may limit our sales and have a material adverse effect on our business, results of operations and financial condition. We must comply with all applicable export control laws and regulations of the U.S. and other countries. Certain of our products and systems may require licenses from U.S. government agencies for export from the U.S., and some of our products are not permitted to be exported. In addition, in certain cases, U.S. export controls also severely limit unlicensed technical discussions, such as discussions with any persons who are not U.S. citizens or permanent residents. As a result, in cases where we may need an export license, our ability to compete against a non-U.S. domiciled foreign company that may not be subject to the same U.S. laws may be materially adversely affected. In addition, we are subject to the Foreign Corrupt Practices Act ("FCPA") and other local laws that generally bar bribes or unreasonable gifts to foreign governments or officials. Violations of these laws or regulations could result in significant sanctions, including disgorgement of profits, fines, and criminal sanctions against us, our officers, our directors, or our employees, more onerous compliance requirements, more extensive debarments from export privileges or loss of authorizations needed to conduct aspects of our international business. A violation of any of the regulations enumerated above could materially adversely affect our business, financial condition and results of operations. Additionally, changes in regulatory requirements which could further restrict our ability to deliver services to our international customers, including the addition of a country to the list of sanctioned countries under the IEEPA or similar legislation could negatively impact our business.

In the past, we have self-reported violations of ITAR to the U.S. Department of State, Directorate of Defense Trade Controls ("DDTC") and had an ITAR compliance audit performed by an independent auditor at the request of the DDTC. Although the audit found no violations of ITAR, we committed to the DDTC that we would enhance and maintain certain policies and procedures and we have established a company-wide Office of Trade Compliance.

In October 2014, we disclosed to OFAC that we learned during a self-assessment of our export transactions that a shipment of modems sent to a Canadian customer by Comtech EF Data Corp. was incorporated into a communication system, the ultimate end user of which was the Sudan Civil Aviation Authority. The sales value of this equipment was approximately $288,000. At the time of shipment, OFAC regulations prohibited U.S. persons from doing business directly or indirectly with Sudan. In late 2015, OFAC issued an administrative subpoena seeking further information about the disclosed transaction. We have responded to the subpoena, including alerting OFAC to Comtech's repair of three modems for a customer in Lebanon who may have rerouted the modems from Lebanon to Sudan without the required U.S. licensing authorization. In September 2018, Comtech agreed to enter into a Tolling Agreement with OFAC, which extends the statute of limitations in this matter through December 31, 2019. The Tolling Agreement was shortly followed by a second administrative subpoena seeking additional information about the disclosed transaction. In December 2018, Comtech responded to a second administrative subpoena from OFAC, answering the questions it posed and providing all the documents it sought. U.S. sanctions with respect to Sudan were revoked in 2017. Consistent with the revocation of the Sudan Sanction Regulations ("SSR"), shipments to the Sudan Civil Aviation Authority by U.S. persons are now permissible. We are not able to predict whether OFAC will take any enforcement action against us in light of the recent revocation of the SSR. If OFAC determines that we have violated U.S. trade sanctions, civil and criminal penalties could apply, and we may suffer reputational harm. Even though we take precautions to avoid engaging in transactions that may violate U.S. trade sanctions, those measures may not be effective in every instance.

In May 2018, we were informed by the Office of Export Enforcement ("OEE") of the Department of Commerce ("DoC") that it was forwarding to the DoC's Office of Chief Counsel, the results of its audit of international shipments by Comtech Xicom Technology, Inc. for further review and possible determination of an administrative penalty. We fully cooperated with the OEE in their audit and, based on our self-assessment of the approximately 7,800 individual transactions audited, have determined that six (6) transactions may not have been fully in compliance with the EAR. These six (6) items, for which export licenses were not obtained, were either spares or repaired power amplifier subassembly components valued at less than $100,000 (in aggregate) and were shipped to Brazil, Italy, Russia, Thailand and the United Arab Emirates. The EAR provides an exception to the requirement to obtain an export license for the replacement of a defective or damaged component. During our self-assessment, we determined that we inadvertently did not obtain export licenses for the spares or had evidence of the return or destruction of the defective or damaged components necessary to authorize our use of the export license exception for the replacements. Since discovering this issue, we have implemented additional controls and procedures and have increased awareness of these specific export requirements throughout the Company to help avoid similar occurrences in the future. Administrative penalties under the EAR can range from a warning letter to a denial of export privileges. A civil monetary penalty not to exceed the amount set forth in the Export Administration Act ("EAA") may be imposed for each violation, and in the event that any provision of the EAR is continued by any other authority, the maximum monetary civil penalty for each violation shall be that provided by such other authority. Administrative penalties under the EAR are currently determined pursuant to the IEEPA, which can reach the greater of twice the amount of the transaction that is the basis of the violation or approximately $300,000 per violation. We have not recorded an accrual related to a possible administrative penalty and continue to work cooperatively with the OEE.

Our financial reporting, corporate governance, public disclosure and compliance practices are governed by laws such as the Sarbanes-Oxley Act of 2002, Dodd-Frank Act of 2010, and rules and regulations issued by the SEC. The SEC has adopted rules which require, among other things, public companies to conduct certain inquiries to determine whether or not Conflict Minerals (as that term is defined in the SEC rules) that are necessary to the functionality of their manufactured products or their product's production processes originated in a Covered Country (as that term is defined in the SEC rules) and ultimately file a report with the SEC. Conflict Minerals are widely used in many industries, including the telecommunications industry and almost all of our products include component parts purchased from third-party suppliers and we must rely heavily on information received from suppliers to determine the origin of those materials. We have implemented a due diligence program consistent with the Organization for Economic Co-operation and Development guidelines to collect information concerning the country of origin of Conflict Minerals and in that regard, have adopted a policy that requires our suppliers (both public and private) to commit to a code of conduct relating to the responsible sourcing of minerals and to establish a policy to reasonably assure that the products they manufacture do not contain Conflict Minerals that originated in a Covered Country. Efforts to comply with this SEC rule have resulted in additional costs to us and, we believe, to our suppliers. As such, the availability of raw materials used in our operations could be negatively impacted and/or raw material prices could increase. Further, if we are unable to certify that our products are conflict free, we may face challenges with our customers, which could place us at a competitive disadvantage and could harm our reputation.

Laws and regulations have been enacted that affect companies conducting business on the Internet, including the European General Data Protection Regulation ("GDPR"). The GDPR imposes certain privacy related requirements on companies that receive or process personal data of residents of the European Union that are currently different than those in the United States and include significant penalties for non-compliance. Similarly, there are several legislative proposals in the United States, at both the federal and state level, that could impose new obligations in areas affecting our business, such as liability for personal data protection. In addition, some countries are considering or have passed legislation implementing data protection requirements or requiring local storage and processing of data or similar requirements that could increase the cost and complexity of delivering our services. Our costs to comply with the GDPR as well any other similar laws and regulations that emerge may negatively impact our business.

ITEM 1A. RISK FACTORS

Forward-Looking Statements

The following describes major risks to our business and should be considered carefully. Any of these factors could significantly and negatively affect our business, prospects, financial condition, or operating results, which could cause the trading prices of our equity securities to decline. The risks described below are not the only risks we may face. Additional risks and uncertainties not presently known to us, or risks that we currently consider immaterial, could also negatively affect us.

Risks Related to our Business

Our fiscal 2020 business outlook is difficult to forecast and operating results are subject to significant fluctuations and are likely to be volatile.

Although we currently believe overall market conditions for our business are positive and that our business performance in fiscal 2020 will be better than fiscal 2019, there can be no assurance of such results. Our business outlook is difficult to forecast and backlog (sometimes referred to herein as orders or bookings), net sales and operating results may vary significantly from period to period due to a number of factors including: sales mix; fluctuating market demand; price competition; new product introductions by our competitors; changing customer partnering procurement strategies; fluctuations in foreign currency exchange rates; unexpected changes in the timing of delivery of components or subsystems; the financial performance and impact of acquisitions; new accounting standards; political instability; regulatory developments; changes in income tax rates or tax credits; the price and expected volatility of our stock (which will impact, among other items, the amount of stock-based compensation expense we may record); and general global economic conditions.

We have experienced, and will experience in the future, significant fluctuations in bookings, net sales and operating results from period to period. For example, a sudden change in global economic conditions could have an immediate impact on a large portion of our net sales, a large amount of which are derived from products such as satellite ground station technologies, amplifier products and mission-critical technologies that generally have short order and lead times. Similarly, sales of certain of our public safety and location technologies are subject to sudden changes in wireless carrier procurement strategies, including decisions to sole-source such solutions. As a result of any such conditions or changes, bookings and backlog related to these solutions are extremely sensitive to short-term fluctuations in customer demand.

In addition, a large portion of our Government Solutions segment's net sales are derived in part from large U.S. government programs or large foreign government opportunities that are subject to lengthy sales cycles (including funding requirements) and are therefore difficult to predict.

If global economic business and political conditions deteriorate as compared to the current environment, it could have a material adverse impact on our business outlook and our business, operating results and financial condition.

Although overall current market conditions are strong, many of the end-markets for our products and services have been significantly impacted in the past by adverse global economic conditions. For example, many of our international end-customers are in emerging and developing countries that are subject to sweeping economic and political changes. Many governments around the world are under pressure to reduce their spending. In recent years, global oil and natural gas prices have been volatile and significantly impaired the ability of certain of our government customers in the oil and gas producing regions of the world to invest in telecommunications products and infrastructure. Additionally, the relative strength of the U.S. dollar against many international currencies has negatively impacted the purchasing power for many of our international end-customers because virtually all of our sales are denominated in U.S. dollars. We generate significant sales from Brazil, Russia, India and China as well as other emerging and developing countries.

The business environment is currently stable; however, a sudden change could result in the immediate suppression of end-market demand for many of our products such as satellite ground station technologies and other short-lead time products. The timing, impact, severity and duration of these conditions are impossible to predict. In addition, many of our international customers (including our Middle Eastern and African customers) rely on European bank financing to procure funding for large systems, many of which include our equipment. We believe that European financing has been and continues to be difficult to obtain. Volatility of interest rates may cause our customers to be reluctant to spend funds required to purchase our equipment or projects could be postponed or canceled.

Currently, the United Kingdom ("U.K.") is attempting to negotiate an exit from the European Union, commonly referred to as "Brexit." Although we currently do not sell any significant amount of equipment in the U.K. or maintain large operations in the U.K., adverse consequences concerning Brexit could result in a deterioration in global economic conditions, instability in global financial markets, political uncertainty, volatility in currency exchange rates, or adverse changes in the cross-border agreements currently in place, any of which could have an adverse impact on our financial results in the future.

In the past, our overall business has not been immune from adverse economic conditions. If U.S. or global economic conditions deteriorate, or political conditions become unstable, or additional economic sanctions are imposed on some of our end-customers, it could adversely impact our business in a number of ways, including:

- Difficulty in forecasting our results of operations - It is difficult to accurately forecast our results of operations during periods of adverse conditions as we cannot predict the severity or the duration of such conditions or the impact it could have on our current and prospective customers. If our current or prospective customers materially postpone, reduce or even forgo purchases of our products and services to a greater extent than we anticipate, our business outlook will prove to be inaccurate.

- Additional reductions in telecommunications equipment and systems spending may occur - In the past, our businesses have been negatively affected by uncertain economic environments in the overall market and, more specifically, in the telecommunications sector. Our customers have reduced their budgets for spending on telecommunications equipment and systems and in some cases postponed or reduced the purchase of our products and systems. In the future, our customers may again reduce their spending on telecommunications equipment and systems which would negatively impact both of our operating segments. If this occurs, it would adversely affect our business outlook, net sales, profitability and the recoverability of our assets, including intangible assets such as goodwill.

- Our customers may not be able to obtain financing - Although many of our products are relatively inexpensive when compared to the total systems or networks that they are incorporated into, our sales are affected by our customers' ability to obtain the financing they may require to build out their total systems or networks and fund ongoing operations. Many of our emerging market customers obtain financing for network buildouts from European commercial banks and/or governments. Our customers' inability to obtain adequate financing would adversely affect our net sales. In addition, if the economic environment and lack of financing results in insolvencies for our customers, it would adversely impact the recoverability of our accounts receivable which would, in turn, adversely impact our results of operations.

We have incurred indebtedness under a Credit Facility and may not be able to service that debt in the future and we must maintain compliance with various covenants that impose restrictions on our business.

On October 31, 2018, we entered into a First Amended and Restated Credit Agreement (the "Credit Facility") with a syndicate of lenders, replacing our prior Credit Agreement dated as of February 23, 2016. The new Credit Facility, as amended, provides a senior secured loan facility of up to $550.0 million consisting of: (i) a revolving loan facility with a borrowing limit of $300.0 million; (ii) an accordion feature allowing us to borrow up to an additional $250.0 million; (iii) a $35.0 million letter of credit sublimit; and (iv) a swingline loan credit sublimit of $25.0 million. The obligations under the Credit Facility are secured by substantially all of our tangible and intangible assets.

As of July 31, 2019, the amount outstanding under our Credit Facility was $165.0 million, which is reflected in the non-current portion of long-term debt on our Consolidated Balance Sheet. At July 31, 2019, we also had $2.7 million of standby letters of credit outstanding under our Credit Facility related to guarantees of future performance on certain customer contracts.

The Credit Facility matures on October 31, 2023. If we do not have sufficient funds to repay our debt when due, it may be necessary to refinance our debt through additional debt or equity financings. If, at the time of any refinancing, prevailing interest rates or other factors result in higher interest rates on such refinancing, increases in interest expense could have a material adverse effect on our business, results of operations and financial condition.

Our Credit Facility contains various affirmative and negative covenants that may restrict our ability to, among other things, permit liens on our property, change the nature of our business, transact business with affiliates and/or merge or consolidate with any other person or sell or convey certain of our assets to any one person.

As of July 31, 2019, our Secured Leverage Ratio (as defined in the Credit Facility, as amended) was 1.74x trailing twelve month ("TTM") Consolidated EBITDA (as defined in the Credit Facility, as amended) compared to the maximum allowable Leverage Ratio of 3.75x TTM Consolidated EBITDA. Our Interest Expense Coverage Ratio as of July 31, 2019 was 12.05x TTM Adjusted EBITDA compared to the Minimum Interest Expense Coverage Ratio of 3.25x TTM Adjusted EBITDA.

Given our expected future business performance, we anticipate maintaining compliance with the terms and financial covenants in our Credit Facility for the foreseeable future. However, there can be no assurance that we will be able to meet such covenants. Our ability to comply with these provisions may be affected by events beyond our control. Failure to comply with these covenants could result in an event of default, which, if not cured or waived, could accelerate our repayment obligations. Our substantial debt obligations could impede, restrict or delay the implementation of our business strategy or prevent us from entering into transactions that would otherwise benefit our business. For example:

- we may be required to dedicate a substantial portion of our cash flows from operations to payments on our indebtedness, thereby reducing the availability of our cash flows for other purposes, including business development efforts, capital expenditures, dividends or strategic acquisitions;

- if we are not able to generate sufficient cash flows to meet our substantial debt service obligations or to fund our other liquidity needs, we may have to take actions such as selling assets or raising additional equity or reducing or delaying capital expenditures, strategic acquisitions, investments and joint ventures, or restructuring our debt;

- we may not be able to fund future working capital, capital investments and other business activities;

- we may not be able to pay dividends or make certain other distributions;

- we may become more vulnerable in the event of a downturn in our business or a worsening of general economic or industry-specific conditions; and

- our flexibility in planning for, or reacting to, changes in our business and industry may be limited, thereby placing us at a competitive disadvantage compared to our competitors that have less indebtedness.

Future acquisitions of companies and investments could prove difficult to integrate, disrupt our business, dilute stockholder value or adversely affect operating results or the market price of our common stock.

As we enter fiscal 2020, we are involved with acquisition efforts to acquire companies that have complimentary solution offerings. In addition, we expect to continue to evaluate other acquisitions and investments as part of our growth plans. Such efforts may not result in an acquisition or ultimately be beneficial to us.

Future acquisitions or investments may result in the use of significant amounts of cash, potentially dilutive issuances of equity securities, incurrence of large amounts of debt, increases to amortization expense and future write-offs of the acquired intangibles. Acquisitions and investments involve risks that include failing to:

- properly evaluate the technology;

- accurately forecast the financial impact of the transaction, including accounting charges and transaction expenses;

- integrate the technologies, products and services, research and development, sales and marketing, support and other operations;

- integrate and retain key management personnel and other key employees;

- retain and cross-sell to acquired customers; and

- combine potentially different corporate cultures.

Acquisitions and investments could also:

- divert management's attention away from the operation of our businesses;
- result in significant goodwill and intangibles write-offs in the event an acquisition or investment does not meet expectations; and
- increase expenses, including expenses of managing the growth of such acquired businesses.

There can be no assurance that any future acquisition or investment will be successful within the anticipated time frame, or at all, will be as valuable as the amount we eventually pay to acquire it, and will not adversely affect our business, results of operations or financial condition. In addition, if we consummate future acquisitions using our equity securities or securities convertible into our equity securities, existing stockholders may be diluted, which could have a material adverse effect on the market price of our common stock.

Our business is highly dependent on the budgetary decisions of our government customers, including the U.S. government (including prime contractors to the U.S. government), and changes in the U.S. government's fiscal policies or budgetary priorities may have a material adverse effect on our business, operating results and financial condition.

During our fiscal years ended July 31, 2019, 2018 and 2017, sales to the U.S. government (including sales to prime contractors to the U.S. government) were $269.2 million, $202.7 million and $180.0 million or 40.1%, 35.5% and 32.7% of our consolidated net sales, respectively. In addition, a large portion of our existing backlog consists of orders related to U.S. government contracts and our Business Outlook for Fiscal 2020 and beyond depends, in part, on significant new orders from the U.S. government, which undergoes extreme budgetary pressures from time to time.

We rely on particular levels of U.S. government spending on our communication solutions, and our receipt of future orders depends in large part on continued funding by the U.S. government for the programs in which we participate. These spending levels are not generally correlated with any specific economic cycle, but rather follow the cycle of general public policy and political support for this type of spending. Government contracts are conditioned upon the continuing availability of congressional appropriations and Congress's failure to appropriate funds, or Congress's actions to reduce or delay spending on, or reprioritize its spending away from, U.S. government programs which we participate in, could negatively affect our results of operations. Because many of the items we sell to the U.S. government are included in large programs realized over a period of several years, it is difficult, if not impossible, to determine specific amounts that are or will be appropriated for our products and services. As such, our assessments relating to the impact of changes in U.S. government spending may prove to be incorrect.

The federal debt limit continues to be actively debated as plans for long-term national fiscal policy are discussed. The outcome of these discussions could have a significant impact on defense spending broadly and programs we support in particular. The failure of Congress to approve future budgets and/or increase the debt ceiling of the U.S. on a timely basis could delay or result in the loss of contracts for the procurement of our products and services and we may be asked or required to continue to perform for some period of time on certain of our U.S. government contracts, even if the U.S. government is unable to make timely payments. A decrease in Department of Defense or Department of Homeland Security expenditures, the elimination or curtailment of a material program in which we are involved, or changes in payment patterns of our customers as a result of changes in U.S. government spending could have a material adverse effect on our business, results of operations and financial condition.

Ultimately, the U.S. government may be unable to timely complete its budget process or fully agree upon spending priorities. As such, it is possible that a shutdown of the U.S. government may occur, or interim budgets may be adopted. As such, we may experience delayed orders, delayed payments and declines in net sales, profitability and cash flows. We may experience related supply chain delays, disruptions or other problems associated with financial constraints faced by our suppliers and subcontractors. All of the aforementioned conditions and factors could, in the aggregate, have a material adverse effect on our business, results of operations and financial condition. Additionally, cost cutting, efficiency initiatives, reprioritization, other affordability analyses, and changes in budgetary priorities by our governmental customers, including the U.S. government, could adversely impact both of our operating segments. We are unable to predict the impact these or similar events could have on our business, financial position, results of operations or cash flows.

Our contracts with the U.S. government are subject to unique business, commercial and government audit risks.

We depend on the U.S. government for a significant portion of our revenues. Our contracts with the U.S. government are subject to unique business and commercial risks, including:

- unexpected contract or project terminations or suspensions;
- unpredictable order placements, reductions, accelerations, delays or cancellations;
- higher than expected final costs, particularly relating to software and hardware development, for work performed under contracts where we commit to specified deliveries for a fixed-price; and
- unpredictable cash collections of unbilled receivables that may be subject to acceptance of contract deliverables by the customer and contract close out procedures, including government audit and approval of final indirect rates.

Although we take steps to mitigate our risk with respect to contracts with the U.S. government, we may not be able to do so in every instance for any of the following reasons, among others:

- Our U.S. government contracts can easily be terminated by the U.S. government - Our U.S. government contracts can be terminated by the U.S. government for its convenience or upon an event of default by us. Termination for convenience provisions provide us with little to no recourse related to: our potential recovery of costs incurred or costs committed, potential settlement expenses and hypothetical profit on work completed prior to termination.
- Our U.S. government contracts are subject to funding by the U.S. Congress - Our U.S. government contracts are conditioned upon the continuing approval by Congress of the necessary funding. Congress usually appropriates funds for a given program on a fiscal year basis even though contract performance may take more than one year. Consequently, at the beginning of a major program, the contract may not be fully funded, and additional monies are normally committed to the contract only if, and when, appropriations are made by Congress for future fiscal years. Delays or changes in funding can impact the timing of awards or lead to changes in program content. We obtain certain of our U.S. government contracts through a competitive bidding process. There can be no assurance that we will win additional contracts or that actual contracts that are awarded will ultimately be profitable.
- We can be disqualified as a supplier to the U.S. government - As a supplier to the U.S. government, we must comply with numerous regulations, including those governing security, contracting practices and classified information. Failure to comply with these regulations and practices could result in fines being imposed against us or our suspension for a period of time from eligibility for bidding on, or for award of, new government contracts. If we are disqualified as a supplier to government agencies, we would lose most, if not all, of our U.S. government customers and revenues from sales of our products would decline significantly.

In addition, all of our U.S. government contracts can be audited by the Defense Contract Audit Agency ("DCAA") and other U.S. government agencies and we can be subject to penalties arising from post-award contract audits (sometimes referred to as a Truth in Negotiations Act or "TINA" audit) or cost audits in which the value of our contracts may be reduced. If costs are found to be improperly allocated to a specific contract, those costs will not be reimbursed, and any such costs already reimbursed would be required to be refunded. TCS has recently undergone audits by the DCAA for periods prior to Comtech's fiscal 2016 acquisition of TCS and the DCAA has informed us that it is proposing retroactive contracts adjustments that, if finalized and issued, would result in the need for us to provide a refund to the U.S. government of approximately $2.4 million. We disagree with the DCAA's assessment and would vigorously protest any adjustment. We have not recorded any reserve related to these audits but ultimately an adjustment may be issued. Although we record contract revenues based upon costs we expect to realize upon final audit, we cannot predict the outcome of any such future audits and adjustments, and we may be required to materially reduce our revenues or profits upon completion and final negotiation of audits. Negative audit findings could also result in termination of a contract, forfeiture of profits, suspension of payments, fines and suspension or debarment from U.S. government contracting or subcontracting for a period of time.

Our dependence on sales to international customers exposes us to unique business, commercial and export compliance audit risks.

Sales for use by international customers (including sales to U.S. companies for inclusion in products that will be sold to international customers) represented approximately 25.4%, 25.6% and 28.4% of our consolidated net sales for the fiscal years ended July 31, 2019, 2018 and 2017, respectively, and we expect that international sales will continue to be a significant portion of our consolidated net sales for the foreseeable future. These sales expose us to certain risks, including barriers to trade, fluctuations in foreign currency exchange rates (which may make our products less price-competitive), political and economic instability, exposure to public health epidemics, availability of suitable export financing, tariff regulations, and other U.S. and foreign regulations that may apply to the export of our products. Although we take steps to mitigate our risk with respect to international sales, we may not be able to do so in every instance for any of the following reasons, among others:

- We may not be able to continue to structure our international contracts to reduce risk - We attempt to reduce the risk of doing business in foreign countries by seeking subcontracts with large systems suppliers, contracts denominated in U.S. dollars, advance or milestone payments and irrevocable letters of credit in our favor. However, we may not be able to reduce the economic risk of doing business in foreign countries in all instances. In such cases, billed and unbilled receivables relating to international sales are subject to increased collectability risk and may result in significant write-offs, which could have a material adverse effect on our business, results of operations and financial condition. In addition, foreign defense contracts generally contain provisions relating to termination at the convenience of the government.

- We rely on a limited number of international sales agents - In some countries, we rely upon one or a small number of sales agents, exposing us to risks relating to our contracts with, and related performance of, those agents. We attempt to reduce our risk with respect to sales agents by establishing additional foreign sales offices where it is practical and by engaging, where practicable, more than one independent sales representative in a territory. It is our policy to require all sales agents to operate in compliance with applicable laws, rules and regulations. Violations of any of these laws, rules or regulations, and other business practices that are regarded as unethical, could interrupt the sales of our products and services, result in the cancellation of orders or the termination of customer relationships, and could damage our reputation, any of which developments could have a material adverse effect on our business, results of operations and financial condition.

- We currently price virtually all of our products in U.S. dollars - Today, virtually all of our sales are denominated in U.S. dollars. Over the last few years, the U.S. dollar has strengthened significantly against many international currencies. As such, many of our international customers experienced a drop in their purchasing power as it relates to their ability to purchase our products. To date, we have not materially changed our selling prices and have experienced lower sales volumes in certain cases. If the U.S. dollar strengthens from current levels against many international currencies, our customers may reduce their spending or postpone purchases of our products and services to a greater extent than we currently anticipate which could have a material adverse effect on our business, results of operations and financial condition.

- We must comply with all applicable export control laws and regulations of the U.S. and other countries - Certain of our products and systems may require licenses from U.S. government agencies for export from the U.S., and some of our products are not permitted to be exported. In addition, in certain cases, U.S. export controls also severely limit unlicensed technical discussions, such as discussions with any persons who are not U.S. citizens or permanent residents. As a result, in cases where we may need a license, our ability to compete against a non-U.S. domiciled foreign company that may not be subject to the same U.S. laws may be materially adversely affected. U.S. laws and regulations applicable to us include the Arms Export Control Act, the IEEPA, the ITAR, the EAR and the trade sanctions laws and regulations administered by the U.S. Treasury Department's OFAC.

- We must comply with the FCPA and similar laws elsewhere - We are subject to the FCPA and other foreign laws prohibiting corrupt payments to government officials, which generally bar bribes or unreasonable gifts to foreign governments or officials. Violations of these laws or regulations could result in significant sanctions, including disgorgement of profits, fines, criminal sanctions against us, our officers, our directors, or our employees, more onerous compliance requirements, more extensive debarments from export privileges or loss of authorizations needed to conduct aspects of our international business. A violation of any of the regulations enumerated above could materially adversely affect our business, financial condition and results of operations. Although we have implemented policies and procedures designed to ensure compliance with these laws and regulations, there can be no assurance that our employees, contractors, agents, or subsidiaries will not violate our policies. Additionally, changes in regulatory requirements which could restrict our ability to deliver services to our international customers, including the addition of a country to the list of sanctioned countries under the IEEPA or similar legislation could negatively impact our business. For the fiscal years ended July 31, 2019, 2018 and 2017, we have conducted virtually no business with states designated as sponsors of terrorism.

- We must maintain a company-wide Office of Trade Compliance - In the past, we have self-reported violations of ITAR to the DDTC and had an ITAR compliance audit performed by an independent auditor at the request of the DDTC. Although the audit found no violations of ITAR, we committed to the DDTC that we would enhance and maintain certain policies and procedures and we have established a company-wide Office of Trade Compliance.

  In October 2014, we disclosed to OFAC that we learned during a self-assessment of our export transactions that a shipment of modems sent to a Canadian customer by Comtech EF Data Corp. was incorporated into a communication system, the ultimate end user of which was the Sudan Civil Aviation Authority. The sales value of this equipment was approximately $288,000. At the time of shipment, OFAC regulations prohibited U.S. persons from doing business directly or indirectly with Sudan. In late 2015, OFAC issued an administrative subpoena seeking further information about the disclosed transaction. We have responded to the subpoena, including alerting OFAC to Comtech's repair of three modems for a customer in Lebanon who may have rerouted the modems from Lebanon to Sudan without the required U.S. licensing authorization. In September 2018, Comtech agreed to enter into a Tolling Agreement with OFAC, which extends the statute of limitations in this matter through December 31, 2019. The Tolling Agreement was shortly followed by a second administrative subpoena seeking additional information about the disclosed transaction. In December 2018, Comtech responded to a second administrative subpoena from OFAC, answering the questions it posed and providing all the documents it sought. U.S. sanctions with respect to Sudan were revoked in 2017. Consistent with the revocation of the SSR, shipments to the Sudan Civil Aviation Authority by U.S. persons are now permissible. We are not able to predict whether OFAC will take any enforcement action against us in light of the recent revocation of the SSR. If OFAC determines that we have violated U.S. trade sanctions, civil and criminal penalties could apply, and we may suffer reputational harm. Even though we take precautions to avoid engaging in transactions that may violate U.S. trade sanctions, those measures may not be effective in every instance.

  In May 2018, we were informed by the Office of Export Enforcement ("OEE") of the Department of Commerce ("DoC") that it was forwarding to the DoC's Office of Chief Counsel, the results of its audit of international shipments by Comtech Xicom Technology, Inc. for further review and possible determination of an administrative penalty. We fully cooperated with the OEE in their audit and, based on our self-assessment of the approximately 7,800 individual transactions audited, have determined that six (6) transactions may not have been fully in compliance with the EAR. These six (6) items, for which export licenses were not obtained, were either spares or repaired power amplifier subassembly components valued at less than $100,000 (in aggregate) and were shipped to Brazil, Italy, Russia, Thailand and the United Arab Emirates. The EAR provides an exception to the requirement to obtain an export license for the replacement of a defective or damaged component. During our self-assessment, we determined that we inadvertently did not obtain export licenses for the spares or have evidence of the return or destruction of the defective or damaged components necessary to authorize our use of the export license exception for the replacements. Since discovering this issue, we have implemented additional controls and procedures and have increased awareness of these specific export requirements throughout the Company to help avoid similar occurrences in the future. Administrative penalties under the EAR can range from a warning letter to a denial of export privileges. A civil monetary penalty not to exceed the amount set forth in the Export Administration Act ("EAA") may be imposed for each violation, and in the event that any provision of the EAR is continued by any other authority, the maximum monetary civil penalty for each violation shall be that provided by such other authority. Administrative penalties under the EAR are currently determined pursuant to the IEEPA, which can reach the greater of twice the amount of the transaction that is the basis of the violation or approximately $300,000 per violation. We have not recorded an accrual related to a possible administrative penalty and continue to work cooperatively with the OEE.

- We may be subject to future export compliance audits - We continue to implement policies and procedures to ensure that we comply with all applicable export control laws and regulations. We may be subjected to compliance audits in the future that may uncover improper or illegal activities that would subject us to material remediation costs, civil and criminal fines and/or penalties and/or an injunction. In addition, we could suffer serious reputational harm if allegations of impropriety were made against us. Each of these outcomes could, individually or in the aggregate, have a material adverse effect on our business, results of operations and financial condition. The absence of comparable restrictions on competitors in other countries may adversely affect our competitive position. In addition, in order to ship our products into and implement our services in some countries, the products must satisfy the technical requirements of that particular country. If we were unable to comply with such requirements with respect to a significant quantity of our products, our sales in those countries could be restricted, which could have a material adverse effect on our business, results of operations and financial condition.

- We may be affected by the future imposition of tariffs and trade restrictions - The current U.S. administration has signaled support for, and in some instances has taken action with respect to, major changes to certain trade policies, such as the imposition of additional tariffs on imported products, the withdrawal from or renegotiation of certain trade agreements and the imposition of certain export sanctions. Such changes could result in retaliatory actions by the United States' trade partners. For example, over the last several months, the U.S. has increased tariffs on certain imports from China, as well as on steel and aluminum products imported from various countries and imposed export sanctions on certain Chinese entities. In response, China, the European Union, and several other countries have imposed or proposed additional tariffs on certain exports from the U.S. Our inability to effectively manage the negative impacts of changing U.S. and foreign trade policies, including, in connection with our business with customers outside of the United States or with newly sanctioned entities could adversely affect our business and financial results.

Our investments in recorded goodwill and other intangible assets could be impaired as a result of future business conditions, a deterioration of the global economy or if we change our reporting unit structure.

As of July 31, 2019, goodwill recorded on our Consolidated Balance Sheet aggregated $310.5 million. Additionally, as of July 31, 2019, net intangibles recorded on our Consolidated Balance Sheet aggregated $261.9 million.

For purposes of reviewing impairment and the recoverability of goodwill and other intangible assets, our Government Solutions and Commercial Solutions segment each constitute a reporting unit and we must make various assumptions in determining their estimated fair values. Reporting units are defined by how our President and Chief Executive Officer ("CEO") manages the business, which includes resource allocation decisions. We may, in the future, change our management approach which in turn may change the way we define our reporting units, as such term is defined by Financial Accounting Standards Board ("FASB") Accounting Standards Codification ("ASC") 350 "*Intangibles - Goodwill and Other.*" A change to our management approach may require us to perform an interim goodwill impairment test and possibly record impairment charges in a future period.

In accordance with FASB ASC 350, we perform a goodwill impairment analysis at least annually (in the first fiscal quarter of each fiscal year), unless indicators of impairment exist in interim periods. If we fail the quantitative assessment of goodwill impairment ("quantitative assessment"), we would be required to recognize an impairment loss equal to the amount that a reporting unit's carrying value exceeded its fair value; however, any loss recognized should not exceed the total amount of goodwill allocated to that reporting unit.

On August 1, 2019 (the first day of our fiscal 2020), we performed our annual quantitative assessment and estimated the fair value of each of our reporting units using a combination of the income and market approaches. Based on our quantitative evaluation, we determined that our Commercial Solutions and Government Solutions reporting units had estimated fair values in excess of their carrying values of at least 29.0% and 122.2%, respectively, and concluded that our goodwill was not impaired and that neither of our two reporting units was at risk of failing the quantitative assessment. It is possible that, during fiscal 2020 or beyond, business conditions (both in the U.S. and internationally) could deteriorate from the current state, our current or prospective customers could materially postpone, reduce or even forgo purchases of our products and services to a greater extent than we currently anticipate, or our common stock price could decline. A significant decline in our customers' spending that is greater than we anticipate or a shift in funding priorities may also have a negative effect on future orders, sales, income and cash flows and we might be required to perform a quantitative assessment during fiscal 2020 or beyond. If assumed net sales and cash flow projections are not achieved in future periods or our common stock price significantly declines from current levels, our Commercial Solutions or Government Solutions reporting units could be at risk of failing the quantitative assessment and goodwill and intangibles assigned to the respective reporting units could be impaired.

In any event, we are required to perform the next annual goodwill impairment analysis on August 1, 2020 (the start of our fiscal 2021). If our assumptions and related estimates change in the future, or if we change our reporting unit structure or other events and circumstances change (e.g., a sustained decrease in the price of our common stock (considered on both absolute terms and relative to peers)), we may be required to record impairment charges when we perform these tests, or in other future periods. In addition to our impairment analysis of goodwill, we also review net intangibles with finite lives when an event occurs indicating the potential for impairment. We believe that the carrying values of our net intangibles were recoverable as of July 31, 2019. Any impairment charges that we may record in the future could be material to our results of operations and financial condition.

We could be negatively impacted by a systems failure, lack of or failure of a redundancy, security breach through cyber attack, cyber intrusion or otherwise, by other significant disruption of our IT networks or those we operate for certain customers, or third-party data center facilities, servers and related systems. If such occurs in some cases, we may have to reimburse our customers for damages that they may have incurred, pay contract penalties, or provide refunds.

Similar to all companies in our industry, we are under constant cyber attack and are subject to an ongoing risk of security breaches and disruptions of our IT networks and related systems, including third-party data center facilities, whether through actual breaches, cyber attacks or cyber intrusions via the Internet, malware, computer viruses, attachments to e-mails, persons inside our organization or persons with access to systems inside our organization. Actual security breaches or disruption, particularly through cyber attack or cyber intrusion, including by computer hackers, foreign governments and cyber terrorists, have increased in recent years and have become more complex. Our IT network and systems, as well as third-party data center facilities, have been and, we believe, continue to be under constant attack. We face an added risk of a security breach or other significant disruption to certain of our equipment used on some of our customer's IT networks and related systems which may involve managing and protecting information relating to public safety agencies, wireless carriers as well as national security and other sensitive government functions. Many of our systems have, or are required to have, system redundancies and back-up; in some cases, we may not have sufficient redundancy and/or redundancy and/or back-ups may fail. We may incur significant costs to prevent and respond to system failures, failure of redundancies, actual breaches, cyber attacks and other systems disruptions.

As a communications company, and particularly as a government contractor and a provider of public safety and location technologies (including 911 hosted systems), we face a heightened risk of a security breach or disruption from actual breaches, cyber attacks and other threats to gain unauthorized access to our and our customers' proprietary or classified information on our IT networks, third-party data center facilities and related systems and to certain of our equipment used on some of our customer's IT networks and related systems. These types of information and IT networks and related systems are critical to the operation of our business and essential to our ability to perform day-to-day operations, and, in some cases, are critical to the operations of certain of our customers. Although we make significant efforts to maintain the security and integrity of these types of information and IT networks and related systems, and we have implemented various measures to manage the risk of a security breach or disruption, there can be no assurance that our security efforts and measures will be effective or that actual security breaches or disruptions will not be successful or damaging. Even the most well protected information, networks, data centers, systems and facilities remain potentially vulnerable because security breaches, particularly cyber attacks and intrusions, and disruptions have occurred and will occur again in the future. Techniques used in such breaches and cyber attacks are constantly evolving and generally are not recognized until launched against a target, and in some cases are designed not to be detected and, in fact, may not be detected. In some cases, the resources of foreign governments may be behind such attacks. Accordingly, we may be unable to anticipate these techniques or to implement adequate security barriers or other preventative measures, and thus it is virtually impossible for us to entirely mitigate this risk.

A security breach or other significant disruption (including as a result of a lack of redundancy and/or failure of such redundancy) involving these types of information and IT networks and related systems could:

- Disrupt the proper functioning of these networks, data center facilities and systems and therefore our operations and/or those of certain of our customers;

- Result in the unauthorized access to, and destruction, loss, theft, misappropriation or release of proprietary, confidential, sensitive or otherwise valuable information of ours or our customers, including trade secrets, which others could use to compete against us or for disruptive, destructive or otherwise harmful purposes and outcomes;

- Compromise national security and other sensitive government functions;

- Require significant management attention and resources to remedy the damage that results;

- Make payments to our customers to reimburse them for damages, or pay them penalties or provide refunds; and

- Damage our reputation with our customers (particularly agencies of the U.S. government) and the public generally.

In addition, the cost of continually defending against cyber attacks and actual breaches has increased in recent years and future costs and any or all of the foregoing could have a material adverse effect on our business, results of operations and financial condition.

The measures we have implemented to secure information we collect and store or enable access to may be breached, which could cause us to breach agreements with our partners and expose us to potential investigation and penalties by authorities and potential claims for contract breach, product liability damages, credits, penalties or termination by persons whose information was disclosed.

We take reasonable steps to protect the security, integrity and confidentiality of the information we collect and store and to prevent unauthorized access to third-party data to which we enable access through our products, but there is no guarantee that inadvertent or unauthorized disclosure will not occur or that third parties will not gain unauthorized access despite our efforts. If such unauthorized disclosure or access does occur, we may be required to notify persons whose information was disclosed or accessed under existing and proposed laws. Because the techniques used to obtain unauthorized access, disable or degrade service, or sabotage systems change frequently and are often not recognized until launched against a target, we may be unable to anticipate these techniques or implement adequate preventative measures. We also may be subject to claims of breach of contract for such disclosure, investigation and penalties by regulatory authorities and potential claims by persons whose information was disclosed. If there is a security breach or if there is an inappropriate disclosure of any of these types of information, we could be exposed to investigations, litigation, fines and penalties. Remediation of and liability for loss or misappropriation of end user or employee personal information could have a material adverse effect on our business, results of operations and financial condition. Even if we were not held liable for such event, a security breach or inappropriate disclosure of personal, private or confidential information could harm our reputation and our relationships with current and potential customers and end users. Even the perception of a security risk could inhibit market acceptance of our products and services. We may be required to invest additional resources to protect against damage caused by any actual or perceived disruptions of our services. We may also be required to provide information about the location of an end user's mobile device to government authorities, which could result in public perception that we are providing the government with intelligence information and deter some end users from using our services. Any of these developments could have a material adverse effect on our business, results of operations and financial condition.

Our U.S. federal, state and foreign tax returns are subject to audit and a resulting tax assessment or settlement could have a material adverse effect on our business, results of operations and financial condition. Significant judgment is required in determining the provision for income taxes.

The final determination of tax examinations and any related litigation could be materially different than what is reflected in historical income tax provisions and accruals.

Our federal income tax returns for fiscal 2017 and 2018 are subject to potential future Internal Revenue Service ("IRS") audit. None of our state income tax returns prior to fiscal 2015 are subject to audit. TCS' federal income tax returns for tax year 2015 and the tax period from January 1, 2016 to February 23, 2016, the date we acquired TCS, are subject to potential future IRS audit. None of TCS' state income tax returns prior to calendar year 2014 are subject to audit. In addition to income tax audits, TCS is subject to ongoing state excise tax audits by the Washington State Department of Revenue. Although adjustments relating to past audits of our federal income tax returns were immaterial, a resulting tax assessment or settlement for other periods or other jurisdictions that may be selected for future audit could have a material adverse effect on our business, consolidated results of operations and financial condition.

We have significant operations in Arizona, Florida, California, Washington State, Maryland, New York and other locations which could be materially and adversely impacted in the event of a terrorist attack and government responses thereto or significant disruptions (including natural disasters) to our business.

Terrorist attacks, the U.S. and other governments' responses thereto, and threats of war could materially adversely impact our business, results of operations and financial condition. For example, our 911 hosted location-based services and satellite teleport services operations depend on our ability to maintain our computer and equipment and systems in effective working order, and to protect our systems against damage from fire, natural disaster, power loss, telecommunications failure, sabotage, unauthorized access to our system or similar events.

Although many of our mission-critical systems and equipment are designed with built-in redundancy and security, any unanticipated interruption or delay in our operations or breach of security could have a material adverse effect on our business, results of operations and financial condition. Our property and business interruption insurance may not be adequate to compensate us for any losses that may occur in the event of a terrorist attack, threat, system failure or a breach of security. Insurance may not be available to us at all or, if available, may not be available to us on commercially reasonable terms.

We operate a high-volume technology manufacturing center located in Tempe, Arizona. We expect intercompany manufacturing to increase from current levels in future periods and we intend to maximize the use of our high-volume technology manufacturing center by continuing to seek contracts with third parties to outsource a portion of their manufacturing to us. A terrorist attack or similar future event may disrupt our operations or those of our customers or suppliers and may affect the availability of materials needed to manufacture our products or the means to transport those materials to manufacturing facilities and finished products to customers. If a natural disaster or other business interruption occurred with respect to our high-volume technology manufacturing center, we do not have immediate access to other manufacturing facilities and, as a result, our business, results of operations and financial condition would be materially adversely affected.

We design and manufacture our over-the-horizon microwave equipment and systems in Florida, where major hurricanes have occurred in the past, and amplifiers in Santa Clara, California, an area close to major earthquake fault lines, and also manufacture amplifiers in Melville, New York, an area subject to hurricanes. Additionally, certain of our Commercial Solutions segment activities are conducted in Washington State which is also near a fault line. We maintain operations in Maryland near a U.S. Navy facility which is more prone to a terrorist attack. Our operations in these and other locations (such as in our high-volume technology manufacturing center located in Tempe, Arizona), could be subject to natural disasters or other significant disruptions, including hurricanes, tornadoes, typhoons, tsunamis, floods, earthquakes, fires, water shortages, other extreme weather conditions, medical epidemics, acts of terrorism, power shortages and blackouts, telecommunications failures, and other natural and man-made disasters or disruptions.

We cannot be sure that our systems will operate appropriately if we experience hardware or software failure, intentional disruptions of service by third parties, an act of God or an act of war. A failure in our systems could cause delays in transmitting data, and as a result we may lose customers or face litigation that could involve material costs and distract management from operating our business.

In the event of any such disaster or other disruption, we could experience disruptions or interruptions to our operations or the operations of our suppliers, distributors, resellers or customers; destruction of facilities; and/or loss of life, all of which could materially increase our costs and expenses and materially adversely affect our business, results of operations and financial condition.

We may be subject to environmental liabilities.

We engage in manufacturing and are subject to a variety of local, state and federal laws and regulations relating to the storage, discharge, handling, emission, generation, manufacture and disposal of toxic or other hazardous substances used to manufacture our products. We are also subject to the Restriction of Hazardous Substance ("RoHS") directive which restricts the use of lead, mercury and other substances in electrical and electronic products. The failure to comply with current or future environmental requirements could result in the imposition of substantial fines, suspension of production, alteration of our manufacturing processes or cessation of operations that could have a material adverse effect on our business, results of operations and financial condition. In addition, the handling, treatment or disposal of hazardous substances by us or our predecessors may have resulted, or could in the future result, in contamination requiring investigation or remediation, or lead to other liabilities, any of which could have a material adverse effect on our business, results of operations and financial condition.

The success of our business is dependent on compliance with FCC rules and regulations and similar foreign laws and regulations.

Many of our products are incorporated into wireless communications systems that must comply with various U.S. government regulations, including those of the FCC, as well as similar international laws and regulations. As a result, our business faces increased risks including the following:

- We must obtain various licenses from the FCC - We operate FCC licensed teleports that are subject to the Communications Act of 1934, as amended, or the FCC Act, and the rules and regulations of the FCC. We cannot guarantee that the FCC will grant renewals when our existing licenses expire, nor are we assured that the FCC will not adopt new or modified technical requirements that will require us to incur expenditures to modify or upgrade our equipment as a condition of retaining our licenses. We may, in the future, be required to seek FCC or other government approval if foreign ownership of our stock exceeds certain specified criteria. Failure to comply with these policies could result in an order to divest the offending foreign ownership, fines, denial of license renewal and/or license revocation proceedings against the licensee by the FCC, or denial of certain contracts from other U.S. government agencies.

- We are dependent on the allocation and availability of frequency spectrum - Adverse regulatory changes related to the allocation and availability of frequency spectrum and in the military standards and specifications that define the current satellite networking environment, could materially harm our business by: (i) restricting development efforts by us and our customers, (ii) making our current products less attractive or obsolete, or (iii) increasing the opportunity for additional competition. The increasing demand for wireless communications has exerted pressure on regulatory bodies worldwide to adopt new standards and reassign bandwidth for these products and services. The reduced number of available frequencies for other products and services and the time delays inherent in the government approval process of new products and services have caused, and may continue to cause, our customers to cancel, postpone or reschedule their installation of communications systems including their satellite, over-the-horizon microwave, or terrestrial line-of-sight microwave communication systems. This, in turn, could have a material adverse effect on our sales of products to our customers. Changes in, or our failure to comply with, applicable laws and regulations could materially adversely harm our business, results of operations, and financial condition.

- Our future growth is dependent, in part, on developing NG-911 compliant products - The FCC requires that certain location information be provided to network operators for public safety answering points when a subscriber makes a 911 call. Technical failures, greater regulation by federal, state or foreign governments or regulatory authorities, time delays or the significant costs associated with developing or installing improved location technology could slow down or stop the deployment of our mobile location products. If deployment of improved location technology is delayed, stopped or never occurs, market acceptance of our products and services may be materially adversely affected. Because we rely on some third-party location technology instead of developing all of the technology ourselves, we have little or no influence over its improvement. The technology employed with NG-911 services generally anticipates a migration to internet-protocol ("IP") based communication. Since many companies are proficient in IP-based communication protocols, the barriers to entry to providing NG-911 products and services are lower than exist for the traditional switch-based protocols. If we are unable to develop unique and proprietary solutions that are superior to and/or more cost effective than other market offers, our 911 business could get replaced by new market entrants, resulting in a material adverse effect on our business, results of operations and financial condition.

- Under the FCC's mandate, our 911 business is dependent on state and local governments - Under the FCC's mandate, wireless carriers are required to provide 911 services only if state and local governments request the service. As part of a state or local government's decision to request 911, they have the authority to develop cost recovery mechanisms. However, cost recovery is no longer a condition to wireless carriers' obligation to deploy the service. If state and local governments do not widely request that 911 services be provided or we become subject to significant pressures from wireless carriers with respect to pricing of 911 services, our 911 business would be harmed and future growth of our business would be reduced.

Regulation of the mobile communications industry and VoIP is evolving, and unfavorable changes or our failure to comply with existing and potential new legislation or regulations could harm our business and operating results.

As the mobile communications industry continues to evolve, we believe greater regulation by federal, state or foreign governments or regulatory authorities is likely and we face certain risks including:

- We must adhere to existing and potentially new privacy rules - We believe increased regulation is likely in the area of data privacy, and laws and regulations applying to the solicitation, collection, processing or use of personal or consumer information could affect our customers' ability to use and share data, potentially reducing our ability to utilize this information in the resale of certain of our products. In order for mobile location products and services to function properly, wireless carriers must locate their subscribers and store information on each subscriber's location. Although data regarding the location of the wireless user resides only on the wireless carrier's systems, users may not feel comfortable with the idea that the wireless carrier knows and can track their location. Carriers will need to obtain subscribers' permission to gather and use the subscribers' personal information, or they may not be able to provide customized mobile location services which those subscribers might otherwise desire. If subscribers view mobile location services as an annoyance or a threat to their privacy, that could reduce demand for our products and services and have a material adverse effect on our business, results of operations and financial condition.

  Recently, there has been a number of laws and regulations enacted that affect companies conducting business on the Internet, including the European General Data Protection Regulation ("GDPR"). The GDPR imposes certain privacy related requirements on companies that receive or process personal data of residents of the European Union that are currently different than those in the United States and include significant penalties for non-compliance. Similarly, there are a number of legislative proposals in the United States, at both the federal and state level, that could impose new obligations in areas affecting our business, such as liability for personal data protection. In addition, some countries are considering or have passed legislation implementing data protection requirements or requiring local storage and processing of data or similar requirements that could increase the cost and complexity of delivering our services. Our costs to comply with the GDPR as well any other similar laws and regulations that emerge may negatively impact our business.

- We may face increased compliance costs in connection with health and safety requirements for mobile devices - If wireless handsets pose health and safety risks, we may be subject to new regulations and demand for our products and services may decrease. Media reports have suggested that certain radio frequency emissions from wireless handsets may be linked to various health concerns, including cancer, and may interfere with various electronic medical devices, including hearing aids and pacemakers. Concerns over radio frequency emissions may have the effect of discouraging the use of wireless handsets, which would decrease demand for our services. In recent years, the FCC and foreign regulatory agencies have updated the guidelines and methods they use for evaluating radio frequency emissions from radio equipment, including wireless handsets. In addition, interest groups have requested that the FCC investigate claims that wireless technologies pose health concerns and cause interference with airbags, hearing aids and other medical devices. There also are some safety risks associated with the use of wireless handsets while driving. Concerns over these safety risks and the effect of any legislation that may be adopted in response to these risks could limit our ability to market and sell our products and services.

- The regulatory environment for VoIP services is developing - The FCC has determined that VoIP services are not subject to the same regulatory scheme as traditional wireline and wireless telephone services. If the regulatory environment for VoIP services evolves in a manner other than the way we anticipate, our 911 business would be significantly harmed and future growth of our business would be significantly reduced. For example, the regulatory scheme for wireless and wireline service providers requires those carriers to allow service providers such as us to have access to certain databases that make the delivery of a 911 call possible. No such requirements exist for VoIP service providers, so carriers could prevent us from continuing to provide VoIP 911 service by denying us access to the required databases.

All of our business activities are subject to rapid technological change, new entrants, the introduction of other distribution models and long development and testing periods each of which may harm our competitive position, render our product or service offerings obsolete and require us to continuously develop technology and/or obtain licensed technology in order to compete successfully.

We are engaged in business activities characterized by rapid technological change, evolving industry standards, frequent new product announcements and enhancements, and changing customer demands. The introduction of products and services or future industry standards embodying new technologies, such as multi-frequency time-division multiple access ("MF-TDMA") based technologies could render any of our products and services obsolete or non-competitive. The successful execution of our business strategy is contingent upon wireless network operators launching and maintaining mobile location services, our ability to maintain a technically skilled development and engineering team, our ability to create new network software products and adapt our existing products to rapidly changing technologies, industry standards and customer needs. As a result of the complexities inherent in our product offerings, new technologies may require long development and testing periods. Additionally, new products may not achieve market acceptance or our competitors could develop alternative technologies that gain broader market acceptance than our products. If we are unable to develop and introduce technologically advanced products that respond to evolving industry standards and customer needs, or if we are unable to complete the development and introduction of these products on a timely and cost effective basis, it could have a material adverse effect on our business, results of operations and financial condition or could result in our technology becoming obsolete.

New entrants seeking to gain market share by introducing new technology and new products may make it more difficult for us to sell our products and services and could create increased pricing pressure, reduced profit margins, increased sales and marketing expenses, or the loss of market share or expected market share, any of which could have a material adverse effect on our business, results of operations and financial condition. For example, many companies are developing new technologies and the shift towards open standards such as IP-based satellite networks will likely result in increased competition and some of our products may become commoditized. Our DoubleTalk® Carrier-in-Carrier® bandwidth compression technology is licensed by us from a third party that maintains patents associated with the technology. Other competitors have developed similar technologies and some may have also licensed parts or all of this compression technology.

Our Commercial Solutions segment provides various technologies that are utilized on mobile phones. Applications from competitors for location-based or text-based messaging platforms may be preloaded on mobile devices by original equipment manufacturers, or OEMs, or offered by OEMs directly. Increased competition from providers of location-based services which do not rely on a wireless carrier may result in fewer wireless carrier subscribers electing to purchase their wireless carrier's branded location-based services, which could harm our business and revenue. In addition, these location-based or text-based services may be offered for free or on a one-time fee basis, which could force us to reduce monthly subscription fees or migrate to a one-time fee model to remain competitive. We may also lose end users or face erosion in our average revenue per user if these competitors deliver their products without charge to the consumer by generating revenue from advertising or as part of other applications or services.

Our expected growth and our financial position depends on, among other things, our ability to keep pace with such changes and developments and to respond to the increasing variety of electronic equipment users and transmission technologies. We may not have the financial or technological resources to keep pace with such changes and developments or be successful in our research and development and we may not be able to identify and respond to technological improvements made by our competitors in a timely or cost-effective fashion. Any delays could result in increased costs of development or redirect resources from other projects. In addition, we cannot provide assurances that the markets for our products, systems, services or technologies will develop as we currently anticipate. The failure of our products, systems, services or technologies to gain market acceptance could significantly reduce our net sales and harm our business.

Our business is highly competitive, we are reliant upon the success of our partners, and some of our competitors have significantly greater resources than we do, which could result in a loss of customers, market share and/or market acceptance.

Our business is highly competitive. We will continue to invest in research and development for the introduction of new and enhanced products and services designed to improve capacity, data processing rates and features. We must also continue to develop new features and to improve functionality of our software. Research and development in our industry is complex, expensive and uncertain. We believe that we must continue to dedicate a significant amount of resources to research and development efforts to maintain our competitive position. If we continue to expend a significant amount of resources on research and development, but our efforts do not lead to the successful introduction of product and service enhancements that are competitive in the marketplace, our business, results of operations and financial condition could be materially adversely affected.

Several of our potential competitors are substantially larger than we are and have greater financial, technical and marketing resources than we do. In particular, larger competitors have certain advantages over us which could cause us to lose customers and impede our ability to attract new customers, including: larger bases of financial, technical, marketing, personnel and other resources; more established relationships with wireless carriers and government customers; more funds to deploy products and services; and the ability to lower prices (or not charge any price) of competitive products and services because they are selling larger volumes. Furthermore, we cannot be sure that our competitors will not develop competing products, systems, services or technologies that gain market acceptance in advance of our products, systems, services or technologies, or that our competitors will not develop new products, systems, services or technologies that cause our existing products, systems, services or technologies to become non-competitive or obsolete, which could adversely affect our results of operations.

Our Commercial Solutions segment provides public safety and location technologies to various state and local municipalities and to a large extent, we are reliant on the success of our wireless partners and distributors to meet our growth objectives. In some cases, our wireless partners may have different objectives, or our distributors may not be successful. For example, in fiscal 2019, AT&T informed us that it will move all 911 call routing solutions to a competitor in full by April 2020. We also began an evaluation and repositioning of certain of our location technology solutions within our Commercial Solutions segment in order to focus on providing higher margin solution offerings and increase our penetration into the public safety space. To date, we have ceased offering certain location technology solutions, have worked with customers to wind-down certain legacy contracts and have not renewed certain contracts. Going forward, we intend to continue to work with our partners and expand our direct and indirect sales and distribution channels in this area. If we are not successful in doing so, we may not be able to achieve our long-term business goals.

Contract cost growth on our firm fixed-price contracts, including most of our government contracts, cost reimbursable type contracts and other contracts that cannot be justified as an increase in contract value due from customers exposes us to reduced profitability and the potential loss of future business and other risks.

A substantial portion of our products and services are sold under firm fixed-price contracts. Firm fixed-price contracts inherently have more risk than flexibly priced contracts. This means that we bear the risk of unanticipated technological, manufacturing, supply or other problems, price increases or other increases in the cost of performance. Future events could result in either upward or downward adjustments to those estimates which could negatively impact our profitability. Operating margin is materially adversely affected when contract costs that cannot be billed to the customer are incurred. This cost growth can occur if initial estimates used for calculating the contract price were incorrect, or if estimates to complete increase. To a lesser extent, we provide products and services under cost reimbursable type contracts which carry the entire burden of costs exceeding a negotiated contract ceiling price.

The cost estimation process requires significant judgment and expertise. Reasons for cost growth may include unavailability and productivity of labor, the nature and complexity of the work to be performed, the effect of change orders, the availability of materials, the effect of any delays in performance, availability and timing of funding from the customer, natural disasters, and the inability to recover any claims included in the estimates to complete. A significant change in an estimate on one or more programs could have a material adverse effect on our business, results of operations and financial condition.

Ongoing compliance with the provisions of securities laws, related regulations and financial reporting standards could unexpectedly materially increase our costs and compliance related expenses.

Because we are a publicly traded company, we are required to comply with provisions of securities laws, related regulations and financial reporting standards. Because securities laws, related regulations and financial reporting standards pertaining to our business are relatively complex, our business faces increased risks including the following:

- <u>If we identify a material weakness in the future, our costs may unexpectedly increase</u> - Pursuant to Section 404 of the Sarbanes-Oxley Act of 2002 and related SEC rules, we are required to furnish a report of management's assessment of the effectiveness of our internal controls as part of our Annual Report on Form 10-K. Our independent registered public accountants are required to attest to and provide a separate opinion. To issue our report, we document our internal control design and the testing processes that support our evaluation and conclusion, and then we test and evaluate the results. There can be no assurance, however, that we will be able to remediate material weaknesses, if any, that may be identified in future periods, or maintain all of the controls necessary for continued compliance. There likewise can be no assurance that we will be able to retain sufficient skilled finance and accounting personnel, especially in light of the increased demand for such personnel among publicly traded companies.

- Stock-based compensation accounting standards could negatively impact our stock - Since our inception, we have used stock-based awards as a fundamental component of our employee compensation packages. We believe that stock-based awards directly motivate our employees to maximize long-term stockholder value and, through the use of long-term vesting, encourage employees to remain with us. We apply the provisions of ASC 718, "*Compensation - Stock Compensation,*" which requires us to record compensation expense in our statement of operations for employee and director stock-based awards using a fair value method. In the first quarter of fiscal 2018, we adopted FASB ASU No. 2016-09 which modified certain aspects of ASC 718, including the requirement to recognize excess tax benefits and shortfalls in the income statement. The ongoing application of this standard will have a significant effect on our reported earnings, and could adversely impact our ability to provide accurate guidance on our future reported financial results due to the variability of the factors used to estimate the value of stock-based awards (including long-term performance shares which are subject to the achievement of three-year goals which are based on several performance metrics). The ongoing application of this standard could impact the future value of our common stock and may result in greater stock price volatility. To the extent that this accounting standard makes it less attractive to grant stock-based awards to employees, we may incur increased compensation costs, change our equity compensation strategy or find it difficult to attract, retain and motivate employees, each of which could have a material adverse effect on our business, results of operations and financial condition.

Also the accounting rules and regulations that we must comply with are complex. Accounting rules and regulations are continually changing in ways that could materially impact our financial statements. As further discussed in *"Notes to Consolidated Financial Statements - Note (1) - Summary of Significant Accounting and Reporting Policies"* included in *"Part II - Item 8. - Financial Statements and Supplementary Data,"* included in this Annual Report on Form 10-K, we note the following:

- We must maintain compliance with new complex revenue recognition rules - On August 1, 2018 (our first quarter of fiscal 2019), we adopted ASU No. 2014-09 *"Revenue from Contracts with Customers (Topic 606),"* which replaces numerous requirements in U.S. GAAP, including industry specific requirements, and provides a single revenue recognition model for contracts with customers. The ASU applies to all open contracts existing as of August 1, 2018. We adopted this ASU using the modified retrospective method and there was no material impact on our business, results of operations and financial condition.

- We must maintain compliance with new complex lease accounting rules - In February 2016, the FASB issued ASU 2016-02, "*Leases (Topic 842),"* to revise existing lease accounting guidance. The update requires most leases to be recorded on the balance sheet as a lease liability, with a corresponding right-of-use asset. We adopted Topic 842 on August 1, 2019, the beginning of our first quarter of fiscal 2020. Except for recording a total right -of-use asset and corresponding lease liability on our Consolidated Balance Sheet, which amount approximates 4.0% of our total consolidated assets at July 31, 2019, our adoption of Topic 842 is not expected to have a material impact to our future statements of operations or cash flows. We continue to evaluate our adoption of this new standard, as well as our ongoing financial reporting disclosures requirements.

We must comply with these new rules on a go-forward basis. Because of the uncertainties of the estimates, judgments and assumptions associated with these new accounting standards, as well as with any future guidance or interpretations related to them, we may incur additional costs and cannot provide any assurances that we will be able to comply with such complex rules.

Our costs to comply with the aforementioned and other regulations continue to increase and we may have to add additional accounting staff, engage consultants or change our internal practices, standards and policies which could significantly increase our costs to comply with ongoing or future requirements. In addition, the NASDAQ Stock Market LLC ("NASDAQ") routinely changes its requirements for companies, such as us, that are listed on NASDAQ. These changes (and potential future changes) have increased and may increase our legal and financial compliance costs, including making it more difficult and more expensive for us to obtain director and officer liability insurance or maintain our current liability coverage. We believe that these new and proposed laws and regulations could make it more difficult for us to attract and retain qualified members of our Board of Directors, particularly to serve on our Audit Committee, and qualified executive officers.

Our backlog is subject to customer cancellation or modification and such cancellation could result in a decline in sales and increased provisions for excess and obsolete inventory.

We currently have a backlog of orders, mostly under contracts that our customers may modify or terminate. Almost all of the contracts in our backlog (including firm orders previously received from the U.S. government) are subject to cancellation at the convenience of the customer or for default in the event that we are unable to perform under the contract. A portion of our backlog is determined based on contracts received from our customers (such as the U.S. government and large wireless carriers) and in certain cases, is computed by multiplying the most recent month's contract or revenue by the months remaining under the existing long-term agreements, which we consider to be the best available information for anticipating revenue under those agreements. There can be no assurance that our backlog will result in actual revenue in any particular period, or at all, or that any contract included in backlog will be profitable. As such, there is a higher degree of risk in this regard with respect to backlog. The actual receipt and timing of any revenue is subject to various contingencies, many of which are beyond our control. The actual receipt of revenue on contracts included in backlog may never occur or may change because a program schedule could change, the program could be canceled, a contract could be reduced, modified or terminated early, or an option that we had assumed would be exercised is not exercised.

A significant portion of the backlog from our U.S. commercial customers relates to large, multi-year contracts to provide state and local governments (and their agencies) with public safety and location technology solutions. Although the contracts themselves represent legal, binding obligations of these governments, funding is often subject to the approval of budgets (for example, on an annual or bi-annual basis). Although funding for these multi-year contracts are dependent on future budgets being approved, we include the full estimated value of these large, multi-year contracts in our backlog given the critical nature of the services being provided and the positive historical experience of our state and local government customers passing their respective budgets.

We record a provision for excess and obsolete inventory based on historical and projected usage trends and other factors, including the consideration of the amount of backlog we have on hand at any particular point in time. If orders in our backlog are canceled or modified, our estimates of future product demand may prove to be inaccurate, in which case we may have understated the provision required for excess and obsolete inventory. In the future, if we determine that our inventory is overvalued, we will be required to recognize such costs in our financial statements at the time of such determination. Any such charges could be materially adverse to our results of operations and financial condition.

We face a number of risks relating to the expected growth of our business. Our business and operating results may be negatively impacted if we are unable to manage this growth.

These risks include:

- The loss of key technical and/or management personnel could adversely affect our business - Our future success depends on the continued contributions of key technical and management personnel. Many of our key and technical management personnel would be difficult to replace and are not subject to employment or non-competition agreements. We currently have research and development employees in areas that are located a great distance away from our U.S. headquarters and some work out of their respective homes. Managing remote product development operations is difficult and we may not be able to manage the employees in these remote centers successfully. Our expected growth and future success will depend, in large part, upon our ability to attract and retain highly qualified engineering, sales and marketing personnel. Competition for such personnel from other companies, academic institutions, government entities and other organizations is intense. Although we believe that we have been successful to-date in recruiting and retaining key personnel, we may not be successful in attracting and retaining the personnel we will need to grow and operate profitably. Also, the management skills that have been appropriate for us in the past may not continue to be appropriate if we grow and diversify.

- We may not be able to improve our processes and systems to keep pace with anticipated growth - The future growth of our business may place significant demands on our managerial, operational and financial resources. In order to manage that growth, we must be prepared to improve and expand our management, operational and financial systems and controls. We also need to continue to recruit and retain personnel and train and manage our employee base. We must carefully manage research and development capabilities and production and inventory levels to meet product demand, new product introductions and product and technology transitions. If we are not able to timely and effectively manage our growth and maintain the quality standards required by our existing and potential customers, it could have a material adverse effect on our business, results of operations and financial condition.

- Our markets are highly competitive and there can be no assurance that we can continue to compete effectively - The markets for our products are highly competitive. There can be no assurance that we will be able to continue to compete successfully on price or other terms, or that our competitors will not develop new technologies and products that are more effective than our own. We expect the Department of Defense's increased use of commercial off-the-shelf products and components in military equipment will encourage new competitors to enter the market. Also, although the implementation of advanced telecommunications services is in its early stages in many developing countries, we believe competition will continue to intensify as businesses and foreign governments realize the market potential of telecommunications services. Many of our competitors have financial, technical, marketing, sales and distribution resources greater than ours. Recently, we have seen increased requests for proposals from large wireless carriers for sole-source solutions and have responded to several such requests. In order to induce retention of existing customer contracts and obtain business on a sole-source basis, we may ultimately agree to adjust pricing on a retroactive basis. If our sole-source proposals are rejected in favor of a competitor's proposal, it could result in the termination of existing contracts, which could have a material adverse effect on our business, results of operations and financial condition.

- We may not be able to obtain sufficient components to meet expected demand - Our dependence on component availability, government furnished equipment, subcontractors and key suppliers, including the core manufacturing expertise of our high-volume technology manufacturing center located in Tempe, Arizona, exposes us to risk. Although we obtain certain components and subsystems from a single source or a limited number of sources, we believe that most components and subsystems are available from alternative suppliers and subcontractors. During the past year or so, and as a result of overall increased industry-wide demand, lead times for many components have increased. In addition, threats of or actual tariffs could limit our ability to obtain certain parts on a cost-effective basis, or at all. A significant interruption in the delivery of such items could have a material adverse effect on our business, results of operations and financial condition. In addition, if our high-volume technology manufacturing center located in Tempe, Arizona is unable to produce sufficient product or maintain quality, it could have a material adverse effect on our business, results of operations and financial condition.

- Our ability to maintain affordable credit insurance may become more difficult - In the normal course of our business, we purchase credit insurance to mitigate some of our domestic and international credit risk. Although credit insurance remains generally available, upon renewal, it may become more expensive to obtain or may not be available for existing or new customers in certain international markets and it might require higher deductibles than in the past. If we acquire a company with a different customer base, we may not be able to obtain credit insurance for those sales. As such, there can be no assurance that, in the future, we will be able to obtain credit insurance on a basis consistent with our past practices.

We rely upon various third-party companies and their technology to provide services to our customers and if we are unable to obtain such services at reasonable prices, or at all, our gross margins and our ability to provide the services of our wireless applications business could be materially adversely affected.

Risks from our reliance with these third parties include:

- The loss of mapping and third-party content - The wireless data services provided to our customers are dependent on real-time, continuous feeds from map data, points of interest data, traffic information, gas prices, theater, event and weather information from vendors and others. Any disruption of this third-party content from our satellite feeds or backup landline feeds or other disruption could result in delays in our subscribers' ability to receive information. We obtain this data that we sell to our customers from companies owned by current and potential competitors, who may act in a manner that is not in our best interest. If our suppliers of this data or content were to enter into exclusive relationships with other providers of location-based services or were to discontinue providing such information and we were unable to replace them cost effectively, or at all, our ability to provide the services of our wireless applications business would be materially adversely affected. Our gross margins may also be materially adversely affected if the cost of third-party data and content increases substantially.

- Third-party data centers or third-party networks may fail - Many products and services of our advanced communication solutions, in particular our public safety and location technology solutions, are provided through a combination of our servers, which we house at third-party data centers, and the networks of our wireless carrier partners. Certain of our data centers are currently hosted in cloud-based applications operated by third parties such as Amazon Web Services and Microsoft or third-party facilities located in Irvine, California, San Francisco, California, Dallas, Texas and Raleigh, North Carolina, and we may use others as required. We also use third-party data center facilities in the Phoenix, Arizona area to provide for disaster recovery. As such, our business relies to a significant degree on the efficient and uninterrupted operation of the third-party data centers we use. Network failures, disruptions or capacity constraints in our third-party data center facilities or in our servers maintained at their location could affect the performance of the products and services of our wireless applications and 911 business and harm our reputation and our revenue. The ability of our subscribers to receive critical location and business information requires timely and uninterrupted connections with our wireless network carriers. Any disruption from our satellite feeds or backup landline feeds could also result in delays in our subscribers' ability to receive information.

- We must integrate our technologies and routinely upgrade them - We may not be able to upgrade our location services platform to support certain advanced features and functionality without obtaining technology licenses from third parties. Obtaining these licenses may be costly and may delay the introduction of such features and functionality, and these licenses may not be available on commercially favorable terms, or at all. Problems and delays in development or delivery as a result of issues with respect to design, technology, licensing and patent rights, labor, learning curve assumptions, or materials and components could prevent us from achieving contractual obligations. In addition, our products cannot be tested and proven in all situations and are otherwise subject to unforeseen problems. The inability to offer advanced features or functionality, or a delay in our ability to upgrade our location-based services platform, may materially adversely affect demand for our products and services and, consequently, have a material adverse effect on our business, results of operations and financial condition.

- We rely upon "open-source" software - We have incorporated some types of open-source software into our products, allowing us to enhance certain solutions without incurring substantial additional research and development costs. Thus far, we have encountered no unanticipated material problems arising from our use of open-source software. However, as the use of open-source software becomes more widespread, certain open-source technology could become competitive with our proprietary technology, which could cause sales of our products to decline or force us to reduce the fees we charge for our products, which could have a material adverse effect on our business, results of operations and financial condition.

Indemnification provisions in our contracts could have a material adverse effect on our consolidated results of operations, financial position, or cash flows.

In the ordinary course of business, we include indemnification provisions in certain of our customer contracts. Pursuant to these agreements, we have agreed to indemnify, hold harmless and reimburse the indemnified party for losses suffered or incurred by the indemnified party, including but not limited to losses related to third-party intellectual property claims. Some customers seek indemnification under their contractual arrangements with the Company for claims and other costs associated with defending lawsuits alleging infringement of patents through their use of our products and services, and the use of our products and services in combination with products and services of other vendors.

In some cases, we have agreed to assume the defense of the case. In others, the Company will negotiate with these customers in good faith because the Company believes its technology does not infringe the cited patents or due to specific clauses within the customer contractual arrangements that may or may not give rise to an indemnification obligation. It is not possible to determine the maximum potential amount the Company may spend under these agreements due to the unique facts and circumstances involved in each particular agreement.

The Company's assessments related to indemnification provisions are based on estimates and assumptions that have been deemed reasonable by management, but that may prove to be incomplete or inaccurate, and unanticipated events and circumstances may occur that might cause the Company to change those estimates and assumptions. Therefore, it is possible that an unfavorable resolution of one or more of these matters could have a material adverse effect on the Company's consolidated financial statements in a future fiscal period.

We are, from time to time, and could become a party to additional litigation or subject to claims, including product liability claims, relating to our software, government investigations and other proceedings that could cause us to incur unanticipated expenses and otherwise have a material adverse effect on our business, results of operations and financial condition.

We are, from time to time, involved in commercial disputes and civil litigation relating to our businesses. Our agreements with customers may require us to indemnify such customers. Direct claims against us or claims against our customers may relate to defects in or non-conformance of our products, or our own acts of negligence and non-performance. Occasionally, we are called upon also to provide information in connection with litigation involving other parties or government investigations. Product liability and other forms of insurance are expensive and may not be available in the future. We cannot be sure that we will be able to maintain or obtain insurance coverage at acceptable costs or in sufficient amounts or that our insurer will not disclaim coverage as to a future claim. In many cases, we are unable to obtain insurance and are self-insured. Any such claim could have a material adverse effect on our business, results of operations and financial condition.

For example, a customer that purchased a TCS 911 call handling software solution in December 2014 (which was more than one year prior to our acquisition of TCS) (the "TCS Legacy Customer") informed us that it experienced several network outages and that it would seek indemnification for any claims made against it as a result of such outages. Settlement conversations were had with this customer for several months and a mutual agreement was not reached. In September 2019, this customer filed a lawsuit which has accused us of committing fraud because, among other things, we failed to provide them with supposedly promised redundancy. We vigorously contest that we violated any contractual obligations, much less committed fraud, and have submitted notification to our insurance carriers of the lawsuit for review and consideration of coverage for potential liability that may arise from this lawsuit. We are also reviewing with counsel our multiple counter claims against this TCS Legacy Customer. For additional information related to this lawsuit, see *"Notes to Consolidated Financial Statements - Note (13)(b) - Commitments and Contingencies - Legal Proceedings and Other Matters"* included in *"Part II - Item 8.- Financial Statements and Supplementary Data,"* included in this Annual Report on Form 10-K.

Because our software may contain defects or errors, and our hardware products may incorporate defective components, our sales could decrease if these defects or errors adversely affect our reputation or delay shipments of our products.

Products as complex as ours are likely to contain undetected errors or defects, especially when first introduced or when new versions are released. Our products may not be error or defect free after delivery to customers, which could damage our reputation, cause revenue losses, result in the rejection of our products or services, divert development resources and increase service and warranty costs, each of which could have a material adverse effect on our business, results of operations and financial condition.

Software products, such as our 911 call handling software solutions, must meet stringent customer technical requirements and we must satisfy our warranty obligations to our customers. TCS had a call handling software solution developed more than ten years ago and was licensed to customers prior to our acquisition of TCS. Older versions of this software solution remain deployed by certain end-customers. In fiscal 2016, AT&T, a distributor of this small TCS product line, informed us that they did not believe we met certain contractual specifications related to performance and usability of the software solution. During fiscal 2018, we entered into a full and final warranty settlement with AT&T, pursuant to which we issued thirty-six credits to AT&T of $0.2 million, which AT&T can apply on a monthly basis to purchases of solutions from us, beginning October 2017 through September 2020. For additional information related to this warranty settlement, see "*Notes to Consolidated Financial Statements - Note (6) - Accrued Expenses and Other Current Liabilities*" included in "*Part II - Item 8.- Financial Statements and Supplementary Data*," included in this Annual Report on Form 10-K. Our current accrued warranty obligations at July 31, 2019 include $4.0 million of warranty obligations for the legacy TCS 911 call handling software solution. Our warranty liability associated with this issue was determined based on a review of contractual obligations, estimates of costs to enhance the software and include the terms of settlement with AT&T. We believe our customer support plan, which includes an intention to continue to support end-customers in exchange for an annual customer support fee, has mitigated the negative reputational impact of this issue. In fiscal 2019, 2018 and 2017, sales related to the legacy TCS 911 call handling software solution were $6.6 million, $7.0 million and $5.5 million, respectively. A significant portion of such sales were derived from our relationship with AT&T. Sales in fiscal 2020 for this old product line are expected to decline to virtually zero. Ultimately, our estimated warranty costs for this product may not be sufficient.

Our hardware products are also subject to warranty obligations and integrate a wide variety of components from different vendors.

Protection of our intellectual property is limited and pursuing infringers of our patents and other intellectual property rights can be costly.

Our businesses rely, in large part, upon our proprietary scientific and engineering know-how and production techniques. We rely on a combination of patent, copyright, trademark, service mark, trade secret and unfair competition laws, restrictions in licensing agreements, confidentiality provisions and various other contractual provisions to protect our intellectual property and related proprietary rights, but these legal means provide only limited protection. Although a number of patents have been issued to us and we have obtained a number of other patents as a result of our acquisitions, we cannot assure you that our issued patents will be upheld if challenged by another party. Additionally, with respect to any patent applications which we have filed, we cannot assure you that any patents will be issued as a result of these applications.

The departure of any of our key management and technical personnel, the breach of their confidentiality and non-disclosure obligations to us or the failure to achieve our intellectual property objectives could have a material adverse effect on our business, results of operations and financial condition. Our ability to compete successfully and achieve future revenue growth will depend, in part, on our ability to protect our proprietary technology and operate without infringing upon the rights of others. We may fail to do so. In addition, the laws of certain countries in which our products are or may be sold may not protect our products or intellectual property rights to the same extent as the laws of the U.S.

Our ability to protect our intellectual property rights is also subject to the terms of future government contracts. We cannot assure you that the federal government will not demand greater intellectual property rights or restrict our ability to disseminate intellectual property. We are also a member of standards-setting organizations and have agreed to license some of our intellectual property to other members on fair and reasonable terms to the extent that the license is required to develop non-infringing products.

Pursuing infringers of our proprietary rights could result in significant litigation costs, and any failure to pursue infringers could result in our competitors utilizing our technology and offering similar products, potentially resulting in loss of a competitive advantage and decreased revenues. Despite our efforts to protect our proprietary rights, existing patent, copyright, trademark and trade secret laws afford only limited protection. In addition, the laws of some foreign countries do not protect our proprietary rights to the same extent as do the laws of the U.S. Protecting our know-how is difficult especially after our employees or those of our third-party contract service providers end their employment or engagement. Attempts may be made to copy or reverse-engineer aspects of our products or to obtain and use information that we regard as proprietary. Accordingly, we may not be able to prevent the misappropriation of our technology or prevent others from developing similar technology. Furthermore, policing the unauthorized use of our products is difficult and expensive. Litigation may be necessary in the future to enforce our intellectual property rights or to determine the validity and scope of the proprietary rights of others. The costs and diversion of resources could significantly harm our business. If we fail to protect our intellectual property, we may not receive any return on the resources expended to create the intellectual property or generate any competitive advantage based on it.

Third parties may claim we are infringing their intellectual property rights and we could be prevented from selling our products, or suffer significant litigation expense, even if these claims have no merit.

Our competitive position is driven in part by our intellectual property and other proprietary rights. Third parties, however, may claim that we, our products, operations or any products or technology we obtain from other parties are infringing their intellectual property rights, and we may be unaware of intellectual property rights of others that may impact some of our assets, technology and products. From time to time we receive letters from third parties who allege we are infringing their intellectual property and ask us to license such intellectual property. We review the merits of each such letter and respond as we deem appropriate.

From time to time our customers are parties to allegations of intellectual property infringement claims based on our customers' incorporation and use of our products and services, which may lead to demands from our customers for us to indemnify them for costs in defending those allegations. Any litigation regarding patents, trademarks, copyrights or intellectual property rights, even those without merit, and the related indemnification demands of our customers, can be costly and time consuming, and divert our management and key personnel from operating our business. The complexity of the technology involved, and inherent uncertainty and cost of intellectual property litigation increases our risks. If any third party has a meritorious or successful claim that we are infringing its intellectual property rights, we may be forced to change our products or enter into licensing arrangements with third parties, which may be costly or impractical. This also may require us to stop selling our products as currently engineered, which could harm our competitive position. We also may be subject to significant damages or injunctions that prevent the further development and sale of certain of our products or services and may result in a material loss of revenue.

From time to time, there have been claims challenging the ownership of open source software against companies that incorporate open source software into their products. As a result, we could be subject to suits by parties claiming ownership of what we believe to be open source software. Some open source licenses contain requirements that we make available source code for modifications or derivative works under the terms of a particular open source license or other license granting third parties certain rights of further use. If we combine our proprietary software products with open source software in a certain manner, we could under certain of the open source licenses, be required to release our proprietary source code. Open source license terms may be ambiguous and many of the risks associated with usage of open source software cannot be eliminated, and could if not properly addressed, negatively affect our business. If we were found to have inappropriately used open source software, we may be required to release our proprietary source code, re-engineer our products and client applications, discontinue the sale of our products or services in the event re-engineering cannot be accomplished on a timely basis or take other remedial action that may divert resources away from our development efforts, any of which could materially adversely affect our business, results of operations, and financial condition.

A change in our relationship with our large wireless carrier customers could have a material adverse effect.

Although we have a long history of providing services to many of our wireless carrier partners, a change in purchasing or procurement strategies by a wireless carrier partner could result in the loss of business from that partner. Additionally, from time to time, we routinely perform services without a multi-period contract while we negotiate new and extended contract terms and pricing. These negotiations are complex and may take long periods of time. Even when we successfully negotiate a multi-period contract, our wireless carrier contracts, such as the ones with Verizon which accounted for 9.1% of our sales in fiscal 2019, provide for terminations with notice and provide a mechanism for the wireless carrier to renegotiate lower fees and/or change services. Fee pressure from these carriers are constant and ongoing. Thus, even when we obtain a multi-period contract term, our revenues could be suddenly and materially reduced.

Competitors offer technology that has functionality similar to ours for free, under different business models. Competition from such free offerings may reduce our revenue and harm our business. If our wireless carrier partners can offer such technology to their subscribers for free, they may elect to cease their relationships with us, alter or reduce the manner or extent to which they market or offer our services or require us to substantially reduce our subscription fees or pursue other business strategies that may not prove successful for us and could have a material adverse effect on our business, results of operations and financial condition.

Potential future business combinations among wireless network operators could result in a loss of revenue for our business.

The telecommunications industry generally is currently undergoing a consolidation phase. For example, T-Mobile US, Inc. ("T-Mobile") and Sprint Corporation have announced a merger. We currently generate several million dollars of revenue from both of these companies and we are uncertain of the impact that this merger may have on us in the future. Many of our customers, specifically wireless carrier customers of our Commercial Solutions segment, have or may become the target of acquisitions. If the number of our customers is significantly reduced as a result of this consolidation trend, or if the resulting companies do not utilize our product offerings, our business, results of operations and financial condition could be materially adversely affected.

If our wireless carrier partners change the pricing and other terms by which they offer our products to their end-customers or do not continue to provide our services at all or renegotiate lower fees with us, our business, results of operations, and financial condition could be suddenly and materially adversely affected.

We generate a significant portion of our revenue from customers that are wireless carriers, such as Verizon which accounted for 9.1% of our revenues in fiscal 2019. In addition, a portion of our revenue is derived from subscription fees that we receive from our wireless carrier partners for end-users who subscribe to our service on a standalone basis or in a bundle with other services. Future revenue will depend on the pricing and quality of those services and subscriber demand for those services, which may vary by market, and the level of subscriber turnover experienced by our wireless carrier partners. If subscriber turnover increases more than we anticipate, our financial results could be materially adversely affected.

Poor performance in or disruptions of the services included in our advanced communication solutions could harm our reputation, delay market acceptance of our services and subject us to liabilities (including breach of contract claims brought by our customers and third-party damages claims brought by end-users). Our wireless carrier agreements and certain customers require us to meet specific requirements including operational uptime requirements or be subject to penalties.

If we are unable to meet contractual requirements with our wireless carrier partners, such as Verizon, they could terminate our agreements or we may be required to refund a portion of monthly subscriptions fees they have paid us.

Risks Related to our Common Stock

Our stock price is volatile.

The stock market in general and the stock prices of technology-based companies, in particular, experience extreme volatility that often is unrelated to the operating performance of any specific public company. The market price of our common stock has fluctuated significantly in the past and is likely to fluctuate significantly in the future as well. Factors that could have a significant impact on the market price of our stock include, among others:

- strategic transactions, such as acquisitions and divestures;
- our ability to successfully integrate and manage recent acquisitions;
- issuance of potentially dilutive equity or equity-type securities;
- issuance of debt;
- future announcements concerning us or our competitors;
- receipt or non-receipt of substantial orders for products and services;
- quality deficiencies in services or products;
- results of technological innovations;
- new commercial products;
- changes in recommendations of securities analysts;
- government regulations;
- changes in the status or outcome of government audits;
- proprietary rights or product or patent litigation;
- changes in U.S. government policies;
- changes in economic conditions generally, particularly in the telecommunications sector;
- changes in securities market conditions, generally;
- changes in the status of litigation and legal matters (including changes in the status of export matters);
- cyber attacks;
- energy blackouts;
- acts of terrorism or war;
- inflation or deflation; and
- rumors or allegations regarding our financial disclosures or practices.

Shortfalls in our sales or earnings in any given period relative to the levels expected by securities analysts could immediately, significantly and adversely affect the trading price of our common stock.

Future issuances of our shares of common stock could dilute a stockholder's ownership interest in Comtech and reduce the market price of our shares of common stock.

In the future, we may issue additional securities to raise capital. We may also acquire interests in other companies by using a combination of cash and our common stock or just our common stock. We may also issue securities convertible into our common stock. Any of these events may dilute a stockholder's ownership interest in Comtech and have an adverse impact on the price of our common stock.

Provisions in our corporate documents and Delaware law could delay or prevent a change in control of Comtech.

We have taken a number of actions that could have the effect of discouraging, delaying or preventing a merger or acquisition involving Comtech that our stockholders may consider favorable.

For example, we have a classified board and the employment contract with our President and CEO, and agreements with other of our executive officers, provide for substantial payments in certain circumstances or in the event of a change of control of Comtech. In the future, we may adopt a stockholder rights plan which could cause substantial dilution to a stockholder, and substantially increase the cost paid by a stockholder who attempts to acquire us on terms not approved by our Board of Directors.

In addition, we are subject to the provisions of Section 203 of the Delaware General Corporation Law, an anti-takeover law. In general, this statute provides that, except in certain limited circumstances, a corporation shall not engage in any "business combination" with an "interested stockholder" for a period of three years after the date of the transaction in which the person became an interested stockholder, unless the business combination is approved in a prescribed manner.

A "business combination" includes mergers, asset sales and other transactions resulting in a financial benefit to the interested stockholder. Subject to certain exceptions, for purposes of Section 203 of the Delaware General Corporation Law, an "interested stockholder" is a person who, together with affiliates, owns, or within three years did own, 15% or more of the corporation's voting stock. This provision could have the effect of delaying or preventing a change in control of Comtech.

A disruption in our dividend program could negatively impact our stock price.

We have paid quarterly dividends every quarter since September 2010.

Our ability to continue to pay quarterly dividends will depend on our ability to generate sufficient cash flows from operations in the future and maintain compliance with our Credit Facility, as amended. This ability may be subject to certain economic, financial, competitive and other factors that are beyond our control. Future dividends remain subject to compliance with financial covenants under the Company's Credit Facility, as amended, as well as Board approval. Our Board of Directors may, at its discretion, decrease the targeted annual dividend amount or entirely discontinue the payment of dividends at any time.

Additionally, our ability to declare and pay dividends and make other distributions with respect to our capital stock may also be restricted by the terms of our Credit Facility, as amended, and may be restricted by the terms of financing arrangements that we enter into in the future.

ITEM 1B. UNRESOLVED STAFF COMMENTS

None.

ITEM 2. PROPERTIES

Historically, we have not owned any material properties or facilities and have relied upon a strategy of leasing. The following table lists our primary leased facilities at July 31, 2019:

Location		Property Type	Square Footage	Lease Expiration
Commercial Solutions Segment				
Tempe, Arizona	(A)	Manufacturing and Engineering	152,000	February 2021
Seattle, Washington	(B)	Network Operations, R&D, Engineering and Sales	57,000	December 2022
Santa Clara, California	(C)	Manufacturing and Engineering	47,000	April 2026
Various facilities	(D)	Engineering and General Office	35,000	Various
Westwood, Massachusetts	(E)	Network Operations	19,000	March 2023
Lake Forest, California	(F)	R&D and Engineering	18,000	July 2023
Greenwood Village, Colorado	(F)	Network Operations	17,000	July 2020
Gatineau, Canada	(G)	Network Operations, R&D, Engineering, Sales and General Office	15,000	April 2023
Moscow, Idaho	(H)	Support, Engineering and Sales	13,000	February 2025
Annapolis, Maryland	(F)	Support, Engineering and Sales	11,000	July 2026
Fremont, California	(H)	Support, Engineering and Sales	10,000	April 2020
Germantown, Maryland	(I)	Engineering and General Office	6,000	May 2025
			400,000	
Government Solutions Segment				
Orlando, Florida	(J)	Manufacturing and Engineering	99,000	April 2026
Tampa, Florida	(J)	Manufacturing (Currently Vacated)	46,000	April 2020
Melville, New York	(K)	Manufacturing and Engineering	45,000	December 2021
Cypress, California	(F)	Support, Engineering and Sales	28,000	July 2025
Germantown, Maryland	(I)	Engineering and General Office	26,000	May 2025
Various facilities	(L)	Support, Engineering and Sales	14,000	Various
Richardson, Texas	(F)	R&D and Engineering	13,000	July 2020
Annapolis, Maryland	(F)	Support, Engineering and Sales	6,000	July 2026
			277,000	
Corporate				
Annapolis, Maryland	(F)	General Office and Common Areas	2,000	July 2026
Melville, New York	(M)	Corporate Headquarters and General Office	9,600	August 2027
			11,600	
Total Square Footage			688,600	

(A) Although primarily used for our satellite earth station product lines, which are part of the Commercial Solutions segment, both of our business segments utilize, from time to time, our high-volume technology manufacturing facilities located in Tempe, Arizona. These manufacturing facilities utilize state-of-the-art design and production techniques, including analog, digital and RF microwave production, hardware assembly and full service engineering. Our leases for these facilities expire from fiscal 2020 through fiscal 2021.

(B) Our office in Seattle, Washington is used primarily for servicing and hosting our wireless and VoIP E911 public safety support services.

(C) Our Commercial Solutions segment manufactures certain amplifiers in a leased manufacturing facility located in Santa Clara, California. Our Commercial Solutions segment also operates a small office in the United Kingdom with a lease that expires in October 2021.

(D) Our Commercial Solutions segment also leases an additional twelve facilities, three of which are located in the U.S. The U.S. facilities aggregate 7,000 square feet and are primarily utilized for engineering and general office use. Our Commercial Solutions segment also operates nine small offices in Brazil, Canada, China, India, Singapore, Australia and the United Kingdom, all of which aggregate 28,000 square feet and are primarily utilized for customer support, engineering and sales.

(E) Our Commercial Solutions segment maintains office space in Westwood, Massachusetts used primarily for servicing and hosting our wireless and VoIP E911 public safety support services.

(F) We have leases for facilities in Annapolis, Maryland; Lake Forest, California and Greenwood Village, Colorado used primarily for the design and development of our software-based systems and applications and network operations. Major manufacturing and engineering facilities for our Government Solutions segment include Orlando, Florida, Cypress, California and Richardson, Texas.

(G) Our Commercial Solutions segment maintains office space in Gatineau, Canada that is utilized for network operations, R&D, engineering and sales of our public safety and location technology solutions.

(H) Our offices in Moscow, Idaho and Fremont, California are primarily used for research and development, engineering and sales of our satellite earth station products.

(I) Our Government Solutions segment leases a 32,000 square foot facility located in Germantown, Maryland, which is primarily used to support the U.S. Army's BFT-1 sustainment activities and certain cyber training activities. Our Government Solutions segment occupies 26,000 feet of the facility with the remainder utilized by our Commercial Solutions segment.

(J) Our Government Solutions segment engineers and manufactures our over-the-horizon microwave systems and tactical-based satellite equipment in a leased facility in Orlando, Florida. This segment also leases a small office in North Africa. As part of our cost reduction initiatives in our Government Solutions segment, we migrated our manufacturing and engineering activities from our Tampa, Florida facility to our Orlando, Florida facility. As the lease on Tampa, Florida facility expires in fiscal 2020, we are seeking opportunities to sublease the space for the duration of the lease.

(K) Our Government Solutions segment manufactures certain of our solid-state, high-power amplifiers in a 45,000 square foot engineering and manufacturing facility on more than two acres of land in Melville, New York and an 8,000 square foot facility in Topsfield, Massachusetts. We lease the New York facility from a partnership controlled by our President and CEO. The lease provides for our use of the premises as they exist through December 2021 with an option to renew for an additional ten-year period. We have a right of first refusal in the event of a sale of the facility. Our Massachusetts lease is currently on a month-to-month basis.

(L) Our Government Solutions segment also leases an additional four facilities located in the U.S. that are primarily used for engineering, sales and software development. Of these facilities, we are currently subleasing 6,000 square foot of the Suwanee, GA facility through August 2020. Our leases for these facilities expire from fiscal 2021 through fiscal 2023.

(M) Our corporate headquarters are located in an office building complex in Melville, New York. The lease provides for our use of the premises through August 2027.

The terms for all of our leased facilities are generally for multi-year periods and we believe that we will be able to renew these leases or find comparable facilities elsewhere.

ITEM 3. LEGAL PROCEEDINGS

Information regarding legal proceedings is incorporated herein by reference to the "*Notes to Consolidated Financial Statements – Note (13)(b) - Commitments and Contingencies – Legal Proceedings and Other Matters*" included in "*Part II - Item 8.- Financial Statements and Supplementary Data,*" included in this Annual Report on Form 10-K.

ITEM 4. MINE SAFETY DISCLOSURES

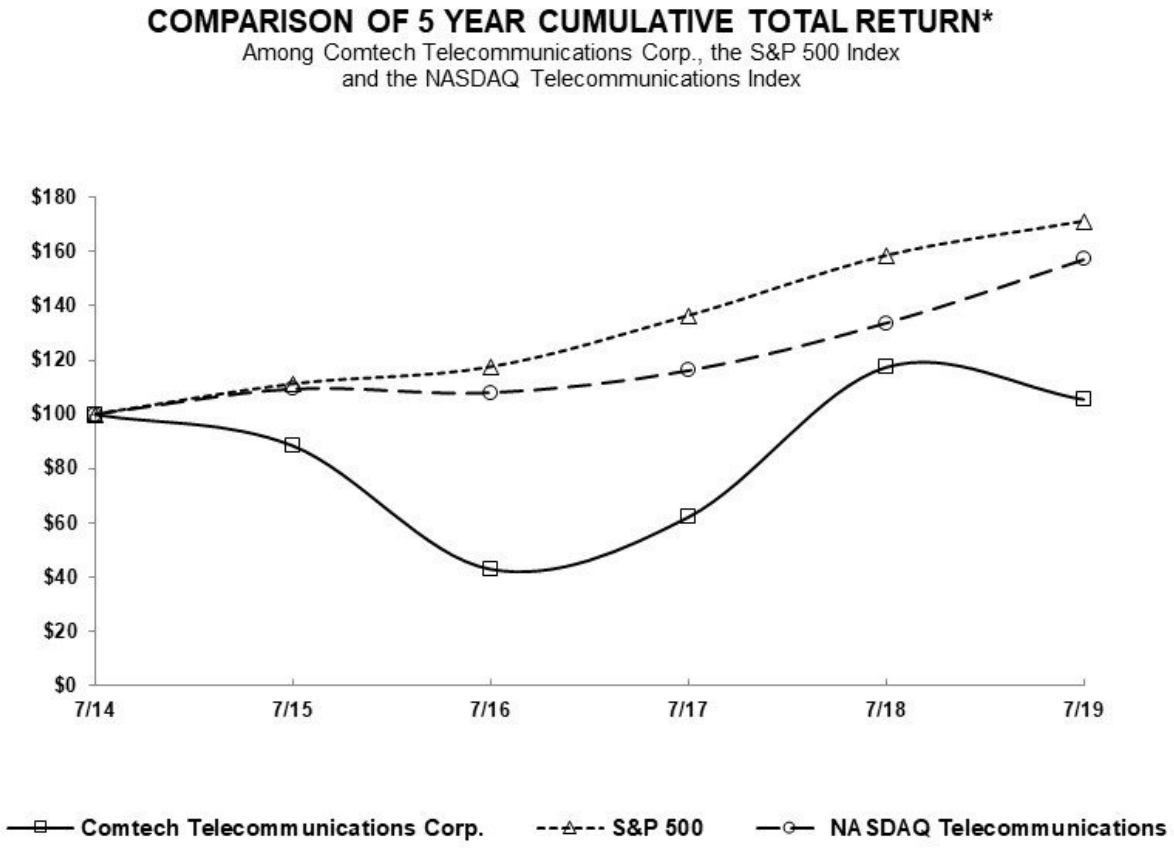
Not applicable.

PART II

ITEM 5. MARKET FOR REGISTRANT'S COMMON EQUITY, RELATED STOCKHOLDER MATTERS AND ISSUER PURCHASES OF EQUITY SECURITIES

Stock Performance Graph and Cumulative Total Return

The graph below compares the cumulative total stockholder return on our common stock with the cumulative total return on the S&P's 500 Index and the NASDAQ Telecommunications Index for each of the last five fiscal years ended July 31, assuming an investment of $100 at the beginning of such period and the reinvestment of any dividends. The comparisons in the graphs below are based upon historical data and are not indicative of, nor intended to forecast, future performance of our common stock.



Our common stock trades on the NASDAQ Stock Market LLC ("NASDAQ") under the symbol "CMTL."

The following table shows the quarterly range of the high and low sale prices for our common stock as reported by the NASDAQ. Such prices do not include retail markups, markdowns or commissions.

	Common Stock	
	High	Low
Fiscal Year Ended July 31, 2018		
First Quarter	$ 22.90	17.11
Second Quarter	23.90	19.30
Third Quarter	32.94	20.62
Fourth Quarter	35.38	29.36
Fiscal Year Ended July 31, 2019		
First Quarter	$ 36.94	27.15
Second Quarter	30.43	22.80
Third Quarter	27.50	20.94
Fourth Quarter	30.29	20.98

Dividends

Since September 2010, we have paid quarterly dividends. On September 26, 2018, December 6, 2018, March 6, 2019 and June 5, 2019, our Board of Directors declared a dividend of $0.10 per common share, which were paid on November 16, 2018, February 15, 2019, May 17, 2019 and August 16, 2019, respectively. On September 24, 2019, our Board of Directors declared a dividend of $0.10 per common share, payable on November 15, 2019 to stockholders of record at the close of business on October 16, 2019. The Board of Directors is currently targeting fiscal 2020 quarterly dividend payments of $0.10 per common share. Future dividends remain subject to compliance with financial covenants under our Credit Facility, as amended, as well as Board approval.

Recent Sales of Unregistered Securities

On February 28, 2019, in connection with the completion of our acquisition of Solacom Technologies Inc. ("Solacom") for cash and shares of our common stock, we issued 208,669 shares of common stock at a volume weighted average price of $26.86 per share. The shares of our common stock issued in connection with the acquisition were issued in reliance upon Section 3(a)(10) of the Securities Act of 1933, as amended, which exempts from the registration requirements any security that is issued in exchange for one or more bona fide outstanding securities where the terms and conditions of such issuance and exchange are approved, after a hearing upon the fairness of such terms and conditions at which all persons to whom it is proposed to issue securities in such exchange shall have the right to appear, by any court expressly authorized by law to grant such approval. The exchange of shares of Comtech's common stock as part of the total consideration for shares of Solacom was approved by the Superior Court of Canada, Province of Quebec, District of Montreal. See "*Notes to Consolidated Financial Statements - Note (2) - Acquisitions*" included in "*Part II - Item 8. - Financial Statements and Supplementary Data,*" included in this Annual Report on Form 10-K for further information concerning the acquisition.

Purchases of Equity Securities by the Issuer and Affiliated Purchasers

We did not repurchase any of our equity securities during the fiscal year ended July 31, 2019. As of July 31, 2019 and September 23, 2019, we were authorized to repurchase up to an additional $8.7 million of our common stock, pursuant to a $100.0 million stock repurchase program that was authorized by our Board of Directors. The $100.0 million stock repurchase program has no time restrictions and repurchases may be made in open-market or privately negotiated transactions and may be made pursuant to SEC Rule 10b5-1 trading plans.

Approximate Number of Equity Security Holders

As of September 19, 2019, there were approximately 824 holders of our common stock. Such number of record owners was determined from our stockholder records and does not include beneficial owners whose shares of our common stock are held in the name of various security holders, dealers and clearing agencies.

ITEM 6. SELECTED CONSOLIDATED FINANCIAL DATA

The following table shows selected historical consolidated financial data for our Company.

Detailed historical financial information is included in the audited consolidated financial statements for fiscal 2019, 2018 and 2017.

	Fiscal Years Ended July 31, (In thousands, except per share amounts)				
	2019	2018	2017	2016	2015
Consolidated Statement of Operations Data:					
Net sales	$ 671,797	570,589	550,368	411,004	307,289
Cost of sales	424,357	346,648	332,183	239,767	168,405
Gross profit	247,440	223,941	218,185	171,237	138,884
Expenses:					
Selling, general and administrative	128,639	113,922	116,080	94,932	62,680
Research and development	56,407	53,869	54,260	42,190	35,916
Amortization of intangibles	18,320	21,075	22,823	13,415	6,211
Settlement of intellectual property litigation	(3,204)	—	(12,020)	—	—
Acquisition plan expenses	5,871	—	—	21,276	—
	206,033	188,866	181,143	171,813	104,807
Operating income (loss)	41,407	35,075	37,042	(576)	34,077
Other expenses (income):					
Interest expense	9,245	10,195	11,629	7,750	479
Write-off of deferred financing costs	3,217	—	—	—	—
Interest (income) and other	35	254	(68)	(134)	(405)
Income (loss) before provision for (benefit from) income taxes	28,910	24,626	25,481	(8,192)	34,003
Provision for (benefit from) income taxes	3,869	(5,143)	9,654	(454)	10,758
Net income (loss)	$ 25,041	29,769	15,827	(7,738)	23,245
Net income (loss) per share:					
Basic	$ 1.04	1.25	0.68	(0.46)	1.43
Diluted	$ 1.03	1.24	0.67	(0.46)	1.42
Weighted average number of common shares outstanding – basic	24,124	23,825	23,433	16,972	16,203
Weighted average number of common and common equivalent shares outstanding – diluted	24,302	24,040	23,489	16,972	16,418

	Fiscal Years Ended July 31, (In thousands)				
	2019	2018	2017	2016	2015
Other Consolidated Operating Data:					
Backlog at period-end	$ 682,954	630,695	446,230	484,005	117,744
New orders	724,056	755,054	512,593	451,278	291,621
Research and development expenditures - internal and customer funded	71,086	70,793	81,310	59,622	45,144
Adjusted EBITDA	93,472	78,374	70,705	48,062	51,761

	As of July 31, (In thousands)				
	2019	2018	2017	2016	2015
Consolidated Balance Sheet Data:					
Total assets	$ 887,711	845,157	832,063	921,196	473,877
Working capital	134,967	114,477	96,833	119,493	236,419
Debt, including capital leases and other obligations	165,757	167,899	195,802	258,649	—
Other liabilities	18,822	4,117	2,655	4,105	3,633
Stockholders' equity	535,082	505,684	480,150	470,401	401,409

Non-GAAP Financial Data

This Annual Report on Form 10-K contains a Non-GAAP financial metric for the Company titled Adjusted EBITDA, which represents earnings (loss) before income taxes, interest (income) and other expense, write-off of deferred financing costs, interest expense, amortization of stock-based compensation, amortization of intangibles, depreciation expense, estimated contract settlement costs, settlement of intellectual property litigation, acquisition plan expenses, facility exit costs and strategic alternatives analysis expenses and other. In future periods, we expect to incur expenses similar to the aforementioned items and investors should not infer from our presentation of Adjusted EBITDA that these costs are unusual, infrequent or non-recurring. These items, while periodically affecting our results, may vary significantly from period to period and may have a disproportionate effect in a given period, thereby affecting the comparability of results.

Adjusted EBITDA is a Non-GAAP financial measure used by management in assessing Comtech's operating results. Although closely aligned, Comtech's definition of Adjusted EBITDA is different than the Consolidated EBITDA (as such term is defined in our Credit Facility, as amended) utilized for financial covenant calculations and also may differ from the definition of EBITDA or Adjusted EBITDA used by other companies and therefore, may not be comparable to similarly titled measures used by other companies. Our Adjusted EBITDA is also a measure frequently requested by Comtech's investors and analysts. We believe that investors and analysts may use Adjusted EBITDA, along with other information contained in our SEC filings, in assessing our performance and comparability of our results with other companies.

Non-GAAP financial measures have limitations as an analytical tool as they exclude the financial impact of transactions necessary to conduct our business, such as the granting of equity compensation awards, and are not intended to be an alternative to financial measures prepared in accordance with GAAP. Non-GAAP financial measures should be considered in addition to, and not as a substitute for or superior to, financial measures determined in accordance with GAAP. Investors are advised to carefully review the GAAP financial results that are disclosed in our SEC filings.

The following is a reconciliation of net income (loss), the most comparable GAAP measure, to Adjusted EBITDA:

	Fiscal Years Ended July 31, (In thousands)				
	2019	2018	2017	2016	2015
Adjusted EBITDA:					
Net income (loss)	$ 25,041	29,769	15,827	(7,738)	23,245
Provision for (benefit from) income taxes	3,869	(5,143)	9,654	(454)	10,758
Interest (income) and other	35	254	(68)	(134)	(405)
Write-off of deferred financing costs	3,217	—	—	—	—
Interest expense	9,245	10,195	11,629	7,750	479
Amortization of stock-based compensation	11,427	8,569	8,506	4,117	4,363
Amortization of intangibles	18,320	21,075	22,823	13,415	6,211
Depreciation	11,927	13,655	14,354	9,830	6,525
Estimated contract settlement costs	6,351	—	—	—	—
Settlement of intellectual property litigation	(3,204)	—	(12,020)	—	—
Acquisition plan expenses	5,871	—	—	21,276	—
Strategic alternatives analysis and other	—	—	—	—	585
Facility exit costs	1,373	—	—	—	—
Adjusted EBITDA	$ 93,472	78,374	70,705	48,062	51,761

ITEM 7. MANAGEMENT'S DISCUSSION AND ANALYSIS OF FINANCIAL CONDITION AND RESULTS OF OPERATIONS

Overview

We are a leading provider of advanced communications solutions for both commercial and government customers worldwide. Our solutions fulfill our customers' needs for secure wireless communications in some of the most demanding environments, including those where traditional communications are unavailable or cost-prohibitive, and in mission-critical and other scenarios where performance is crucial.

We manage our business through two reportable operating segments:

- Commercial Solutions - offers satellite ground station technologies (such as modems and amplifiers), public safety and location technologies (such as 911 call routing and mapping solutions) to commercial customers and smaller government customers, such as state and local governments. This segment also serves certain large government customers (including the U.S. government) that have requirements for off-the-shelf commercial equipment.

- Government Solutions - provides mission-critical technologies (such as tactical satellite-based networks and ongoing support for complicated communication networks) and high-performance transmission technologies (such as troposcatter systems and solid-state, high-power amplifiers) to large government end-users (including those of foreign countries), large international customers and domestic prime contractors.

In fiscal 2020, we have rebranded our operating segment product groups to better align with our end markets. Prior descriptions of these product lines were updated to reflect such changes.

Our Quarterly Financial Information
Quarterly and period-to-period sales and operating results may be significantly affected by either short-term or long-term contracts with our customers. In addition, our gross profit is affected by a variety of factors, including the mix of products, systems and services sold, production efficiencies, estimates of warranty expense, price competition and general economic conditions. Our gross profit may also be affected by the impact of any cumulative adjustments to contracts that are accounted for over time.

Our contracts with the U.S. government can be terminated for convenience by it at any time and orders are subject to unpredictable funding, deployment and technology decisions by the U.S. government. Some of these contracts are indefinite delivery/indefinite quantity ("IDIQ") contracts and, as such, the U.S. government is not obligated to purchase any equipment or services under these contracts. We have, in the past, experienced and we continue to expect significant fluctuations in sales and operating results from quarter-to-quarter and period-to-period. As such, comparisons between periods and our current results may not be indicative of a trend or future performance.

Critical Accounting Policies

We consider certain accounting policies to be critical due to the estimation process involved in each.

Revenue Recognition. On August 1, 2018, we adopted ASU No. 2014-09 "Revenue from Contracts with Customers (Topic 606)" or "ASC 606" applying the modified retrospective transition method. Except for new presentation or disclosure requirements, the impact of adoption was not material to our business, results of operations or financial condition. As a practical expedient, we adopted the new standard only for existing contracts as of August 1, 2018. All periods prior to August 1, 2018 will continue to be reported under the accounting standards in effect in those periods.

The core principle of ASC 606 is that revenue should be recorded in an amount that reflects the consideration to which we expect to be entitled in exchange for goods or services promised to customers. Under ASC 606, we follow a five-step model to: (1) identify the contract with our customer; (2) identify our performance obligations in our contract; (3) determine the transaction price for our contract; (4) allocate the transaction price to our performance obligations; and (5) recognize revenue using one of the following two methods:

- *Over time* - We recognize revenue using the over time method when there is a continuous transfer of control to the customer over the contractual period of performance. This generally occurs when we enter into a long-term contract relating to the design, development or manufacture of complex equipment or technology platforms to a buyer's specification (or to provide services related to the performance of such contracts). Continuous transfer of control is typically supported by contract clauses which allow our customers to unilaterally terminate a contract for convenience, pay for costs incurred plus a reasonable profit and take control of work-in-process. Revenue recognized over time is generally based on the extent of progress toward completion of the related performance obligations. The selection of the method to measure progress requires judgment and is based on the nature of the products or services provided. In certain instances, typically for firm fixed-price contracts, we use the cost-to-cost measure because it best depicts the transfer of control to the customer which occurs as we incur costs on our contracts. Under the cost-to-cost measure, the extent of progress toward completion is measured based on the ratio of costs incurred to date to the total estimated costs at completion, including warranty costs. Revenues, including estimated fees or profits, are recorded proportionally as costs are incurred. Costs to fulfill generally include direct labor, materials, subcontractor costs, other direct costs and an allocation of indirect costs. When these contracts are modified, the additional goods or services are generally not distinct from those already provided. As a result, these modifications form part of an existing contract and we must update the transaction price and our measure of progress for the single performance obligation and recognize a cumulative catch-up to revenue and gross profits.

  For over time contracts using a cost-to-cost measure of progress, we have an estimate at completion ("EAC") process in which management reviews the progress and execution of our performance obligations. This EAC process requires management judgment relative to assessing risks, estimating contract revenue and costs, and making assumptions for schedule and technical issues. Since certain contracts extend over a long period of time, the impact of revisions in revenue and or cost estimates during the progress of work may impact current period earnings through a cumulative adjustment. Additionally, if the EAC process indicates a loss, a provision is made for the total anticipated loss in the period that it becomes evident. Contract revenue and cost estimates for significant contracts are generally reviewed and reassessed at least quarterly.

The cost-to-cost method is principally used to account for contracts in our mission-critical technologies and high-performance transmission technologies product lines and, to a lesser extent, certain location-based and messaging infrastructure contracts in our public safety and location technologies product line. For service-based contracts in our public safety and location technologies product line we recognize revenue over time. These services are typically recognized as a series of services performed over the contract term using the straight-line method or based on our customers' actual usage of the networks and platforms which we provide.

- *Point in time* - When a performance obligation is not satisfied over time, we must record revenue using the point in time accounting method which generally results in revenue being recognized upon shipment or delivery of a promised good or service to a customer. This generally occurs when we enter into short term contracts or purchase orders where items are provided to customers with relatively quick turn-around times. Modifications to such contracts and or purchase orders, which typically provide for additional quantities or services, are accounted for as a new contract because the pricing for these additional quantities or services are based on standalone selling prices.

  Point in time accounting is principally applied to contracts in our satellite ground station technologies product line (which includes satellite modems, solid-state and traveling wave tube amplifiers) and certain contracts for our amplifiers in our high-performance transmission technologies product line. Point in time accounting is also applied to certain contracts in our mission-critical technologies product line. The contracts related to these product lines do not meet the requirements for over time revenue recognition because our customers cannot utilize the equipment for its intended purpose during any phase of our manufacturing process; customers do not simultaneously receive and or consume the benefits provided by our performance; customers do not control the asset (i.e., prior to delivery, customers cannot direct the use of the asset, sell or exchange the equipment, etc.); and, although many of our contracts have termination for convenience clauses and or an enforceable right to payment for performance completed to date, our performance creates an asset with an alternative use through the point of delivery.

  In determining that our equipment has alternative use, we considered the underlying manufacturing process for our products. In the early phases of manufacturing, raw materials and work in process (including subassemblies) consist of common parts that are highly fungible among many different types of products and customer applications. Finished products are either configured to our standard configuration or based on our customers' specifications. Finished products, whether built to our standard specification or to a customers' specification, can be sold to a variety of customers and across many different end use applications with minimal rework, if needed, and without incurring a significant economic loss.

When identifying a contract with our customer, we consider when it has approval and commitment from both parties, if the rights of the parties are identified, if the payment terms are identified, if it has commercial substance and if collectability is probable.

When identifying performance obligations, we consider whether there are multiple promises and how to account for them. In our contracts, multiple promises are separated if they are distinct, both individually and in the context of the contract. If multiple promises in a contract are highly interrelated or comprise a series of distinct services performed over time, they are combined into a single performance obligation. In some cases, we may also provide the customer with an additional service-type warranty, which we recognize as a separate performance obligation. Service-type warranties do not represent a significant portion of our consolidated net sales. When service-type warranties represent a separate performance obligation, the revenue is deferred and recognized ratably over the extended warranty period. Our contracts, from time-to-time, may also include options for additional goods and services. To date, these options have not represented material rights to the customer as the pricing for them reflects standalone selling prices. As a result, we do not consider options we offer to be performance obligations for which we must allocate a portion of the transaction price. In many cases, we provide assurance-type warranty coverage for some of our products for a period of at least one year from the date of delivery.

When identifying the transaction price, we typically utilize the contract's stated price as a starting point. The transaction price in certain arrangements may include estimated amounts of variable consideration, including award fees, incentive fees or other provisions that can either increase or decrease the transaction price. We estimate variable consideration as the amount to which we expect to be entitled, and we include estimated amounts in the transaction price to the extent it is probable that a significant reversal of cumulative revenue recognized will not occur when the estimation uncertainty is resolved. The estimation of this variable consideration and determination of whether to include estimated amounts in the transaction price are based largely on an assessment of our anticipated performance and all information (e.g., historical, current and forecasted) that is reasonably available to us.

When allocating the contract's transaction price, we consider each distinct performance obligation. For contracts with multiple performance obligations, we allocate the contract's transaction price to each performance obligation using our best estimate of the standalone selling price of each distinct good or service in the contract. We determine standalone selling price based on the price at which the performance obligation is sold separately. If the standalone selling price is not observable through past transactions, we estimate the standalone selling price taking into account available information such as market conditions, including geographic or regional specific factors, competitive positioning, internal costs, profit objectives and internally approved pricing guidelines related to the performance obligations.

Almost all of our contracts with customers are denominated in U.S. dollars and typically are either firm fixed-price or cost reimbursable type contracts (including fixed-fee, incentive-fee and time-and-material type contracts). In almost all of our contracts with customers, we are the principal in the arrangement and report revenue on a gross basis. Transaction prices for contracts with U.S. domestic and international customers are usually based on specific negotiations with each customer and in the case of the U.S. government, sometimes based on estimated or actual costs of providing the goods or services in accordance with applicable regulations.

The timing of revenue recognition, billings and collections results in receivables, unbilled receivables and contract liabilities on our Consolidated Balance Sheet. Under typical payment terms for our contracts accounted for over time, amounts are billed as work progresses in accordance with agreed-upon contractual terms, either at periodic intervals (e.g., monthly) or upon achievement of contractual milestones. For certain contracts with provisions that are intended to protect customers in the event we do not satisfy our performance obligations, billings occur subsequent to revenue recognition, resulting in what we have historically presented as unbilled receivables. Under ASC 606, unbilled receivables constitute contract assets. On large long term contracts, and for contracts with international customers that do not do business with us regularly, payment terms typically require advanced payments and deposits. Under ASC 606, payments received from customers in excess of revenue recognized to date results in a contract liability. These contract liabilities are not considered to represent a significant financing component of the contract because we believe these cash advances and deposits are generally used to meet working capital demands which can be higher in the earlier stages of a contract. Also, advanced payments and deposits provide us with some measure of assurance that the customer will perform on its obligations under the contract. Under the typical payment terms for our contracts accounted for at a point in time, costs are accumulated in inventory until the time of billing, which generally coincides with revenue recognition.

We recognize the incremental costs to obtain or fulfill a contract as an expense when incurred if the amortization period of the asset is one year or less. Incremental costs to obtain or fulfill contracts with an amortization period greater than one year were not material.

As commissions payable to our internal sales and marketing employees or contractors are contingent upon multiple factors, such commissions are not considered direct costs to obtain or fulfill a contract with a customer and are expensed as incurred in selling, general and administrative expenses on our Consolidated Statements of Operations. As for commissions payable to our third-party sales representatives related to large long-term contracts, we do consider these types of commissions both direct and incremental costs to obtain and fulfill such contracts. Therefore, such types of commissions are included in total estimated costs at completion for such contracts and expensed over time through cost of sales on our Consolidated Statements of Operations.

Remaining performance obligations represent the transaction price of firm orders for which work has not been performed as of the end of a fiscal period. Remaining performance obligations, which we refer to as backlog, exclude unexercised contract options and potential orders under indefinite delivery / indefinite quantity ("IDIQ") contracts.

Impairment of Goodwill and Other Intangible Assets. As of July 31, 2019, total goodwill recorded on our Consolidated Balance Sheet aggregated $310.5 million (of which $251.3 million relates to our Commercial Solutions segment and $59.2 million relates to our Government Solutions segment). Additionally, as of July 31, 2019, net intangibles recorded on our Consolidated Balance Sheet aggregated $261.9 million (of which $223.5 million relates to our Commercial Solutions segment and $38.4 million relates to our Government Solutions segment). Each of our two operating segments constitutes a reporting unit and we must make various assumptions in determining their estimated fair values.

In accordance with FASB ASC 350 "*Intangibles - Goodwill and Other,"* we perform a goodwill impairment analysis at least annually (in the first quarter of each fiscal year), unless indicators of impairment exist in interim periods. If we fail the quantitative assessment of goodwill impairment ("quantitative assessment"), we would be required to recognize an impairment loss equal to the amount that a reporting unit's carrying value exceeded its fair value; however, any loss recognized should not exceed the total amount of goodwill allocated to that reporting unit.

On August 1, 2019 (the first day of our fiscal 2020), we performed our annual quantitative assessment using market participant assumptions to determine if the fair value of each of our reporting units with goodwill exceeded its carrying value. In making this assessment, we considered, among other things, expectations of projected net sales and cash flows, assumptions impacting the weighted average cost of capital, trends in trading multiples of comparable companies, changes in our stock price and changes in the carrying values of our reporting units with goodwill. We also considered overall business conditions.

In performing the quantitative assessment, we estimated the fair value of each of our reporting units using a combination of the income and market approaches. The income approach, also known as the discounted cash flow ("DCF") method, utilizes the present value of cash flows to estimate fair value. The future cash flows for our reporting units were projected based on our estimates, at that time, of future revenues, operating income and other factors (such as working capital and capital expenditures). For purposes of conducting our impairment analysis, we assumed revenue growth rates and cash flow projections that are below our actual long-term expectations. The discount rates used in our DCF method were based on a weighted-average cost of capital ("WACC") determined from relevant market comparisons, adjusted upward for specific reporting unit risks (primarily the uncertainty of achieving projected operating cash flows). A terminal value growth rate was applied to the final year of the projected period, which reflects our estimate of stable, perpetual growth. We then calculated a present value of the respective cash flows for each reporting unit to arrive at an estimate of fair value under the income approach. Under the market approach, we estimated a fair value based on comparable companies' market multiples of revenues and earnings before interest, taxes, depreciation and amortization and factored in a control premium. Finally, we compared our estimates of fair values to our August 1, 2019 total public market capitalization and assessed implied control premiums based on our common stock price of $29.54 as of August 1, 2019.

Based on our quantitative evaluation, we determined that our Commercial Solutions and Government Solutions reporting units had estimated fair values in excess of their carrying values of at least 29.0% and 122.2%, respectively, and concluded that our goodwill was not impaired and that neither of our two reporting units was at risk of failing the quantitative assessment. It is possible that, during fiscal 2020 or beyond, business conditions (both in the U.S. and internationally) could deteriorate from the current state, our current or prospective customers could materially postpone, reduce or even forgo purchases of our products and services to a greater extent than we currently anticipate, or our common stock price could decline. A significant decline in our customers' spending that is greater than we anticipate or a shift in funding priorities may also have a negative effect on future orders, sales, income and cash flows and we might be required to perform a quantitative assessment during fiscal 2020 or beyond. If assumed net sales and cash flow projections are not achieved in future periods or our common stock price significantly declines from current levels, our Commercial Solutions and Government Solutions reporting units could be at risk of failing the quantitative assessment and goodwill and intangibles assigned to the respective reporting units could be impaired.

In any event, we are required to perform the next annual goodwill impairment analysis on August 1, 2020 (the start of our fiscal 2021). If our assumptions and related estimates change in the future, or if we change our reporting unit structure or other events and circumstances change (e.g., a sustained decrease in the price of our common stock (considered on both absolute terms and relative to peers)), we may be required to record impairment charges when we perform these tests, or in other future periods. In addition to our impairment analysis of goodwill, we also review net intangible assets with finite lives when an event occurs indicating the potential for impairment. We believe that the carrying values of our net intangible assets were recoverable as of July 31, 2019. Any impairment charges that we may record in the future could be material to our results of operations and financial condition.

Provision for Warranty Obligations. We provide warranty coverage for most of our products, including products under long-term contracts, for a period of at least one year from the date of shipment. We record a liability for estimated warranty expense based on historical claims, product failure rates and other factors. Costs associated with some of our warranties that are provided under long-term contracts are incorporated into our estimates of total contract costs. There exist inherent risks and uncertainties in estimating warranty expenses, particularly on larger or longer-term contracts. If we do not accurately estimate our warranty costs, any changes to our original estimates could be material to our results of operations and financial condition.

Accounting for Income Taxes. Our deferred tax assets and liabilities are determined based on temporary differences between financial reporting and tax bases of assets and liabilities, and applying enacted tax rates expected to be in effect for the year in which we expect the differences to reverse. Our provision for income taxes is based on domestic (including federal and state) and international statutory income tax rates in the tax jurisdictions where we operate, permanent differences between financial reporting and tax reporting and available credits and incentives. We recognize potential interest and penalties related to uncertain tax positions in income tax expense. The U.S. federal government is our most significant income tax jurisdiction.

Significant judgment is required in determining income tax provisions and tax positions. We may be challenged upon review by the applicable taxing authority and positions taken by us may not be sustained. We recognize all or a portion of the benefit of income tax positions only when we have made a determination that it is more likely than not that the tax position will be sustained upon examination, based upon the technical merits of the position and other factors. For tax positions that are determined as more likely than not to be sustained upon examination, the tax benefit recognized is the largest amount of benefit that is greater than 50% likely of being realized upon ultimate settlement. The development of valuation allowances for deferred tax assets and reserves for income tax positions requires consideration of timing and judgments about future taxable income, tax issues and potential outcomes, and are subjective critical estimates. A portion of our deferred tax assets consist of federal research and experimentation tax credit carryforwards, most of which was acquired in connection with our acquisition of TCS. No valuation allowance has been established on these deferred tax assets based on our evaluation that our ability to realize such assets has met the criteria of "more likely than not." We continuously evaluate additional facts representing positive and negative evidence in determining our ability to realize these deferred tax assets. In certain circumstances, the ultimate outcome of exposures and risks involves significant uncertainties. If actual outcomes differ materially from these estimates, they could have a material impact on our results of operations and financial condition.

On December 22, 2017, H.R.1, also known as the Tax Cuts and Jobs Act ("Tax Reform") was enacted in the U.S. Tax Reform significantly revised the U.S. tax code and lowered the amount of our current and future income tax expense primarily due to the reduction in the U.S. statutory income tax rate from 35.0% to 21.0%. This provision went into effect on January 1, 2018 and required us to remeasure our deferred tax assets and liabilities. During the fiscal year ended July 31, 2018, we remeasured our deferred tax assets and liabilities. The remeasurement was recorded pursuant to ASC 740 "Income Taxes" and SEC Staff Accounting Bulletin ("SAB") 118. All amounts recorded were based on available guidance on interpretation of Tax Reform and what we believed to be reasonable approaches to estimating its impact. See "*Notes to Consolidated Financial Statements - Note (10) - Income Taxes*" included in "*Part II - Item 8. - Financial Statements and Supplementary Data,*" included in this Annual Report on Form 10-K, for further information on the provisions of Tax Reform and its expected impact on our business.

Our federal income tax returns for fiscal 2017 and 2018 are subject to potential future IRS audit. None of our state income tax returns prior to fiscal 2015 are subject to audit. TCS's federal income tax returns for tax year 2015 and the tax period from January 1, 2016 to February 23, 2016, the date we acquired TCS, are subject to potential future IRS audit. None of TCS's state income tax returns prior to calendar year 2014 are subject to audit. Future tax assessments or settlements could have a material adverse effect on our consolidated results of operations and financial condition.

Research and Development Costs. We generally expense all research and development costs. Research and development expenses include payroll, employee benefits, stock-based compensation expense, and other personnel-related expenses associated with product development. Research and development expenses also include third-party development and programming costs. Costs incurred internally in researching and developing software to be sold are charged to expense until technological feasibility has been established for the software. Judgment is required in determining when technological feasibility of a product is established. Technological feasibility for our advanced communication software solutions is generally reached after all high-risk development issues have been resolved through coding and testing. Generally, this occurs shortly before the products are released to customers and when we are able to validate the marketability of such product. Once technological feasibility is established, all software costs are capitalized until the product is available for general release to customers. To date, capitalized internally developed software costs were not material.

Provisions for Excess and Obsolete Inventory. We record a provision for excess and obsolete inventory based on historical and projected usage trends. Other factors may also influence our provision, including decisions to exit a product line, technological change and new product development. These factors could result in a change in the amount of excess and obsolete inventory on hand. Additionally, our estimates of future product demand may prove to be inaccurate, in which case we may have understated or overstated the provision required for excess and obsolete inventory. In the future, if we determine that our inventory was overvalued, we would be required to recognize such costs in our financial statements at the time of such determination. Any such charge could be material to our results of operations and financial condition.

Allowance for Doubtful Accounts. We perform credit evaluations of our customers and adjust credit limits based upon customer payment history and current creditworthiness, as determined by our review of our customers' current credit information. Generally, we will require cash in advance or payment secured by irrevocable letters of credit before an order is accepted from an international customer that we do not do business with regularly. In addition, we seek to obtain insurance for certain domestic and international customers.

We monitor collections and payments from our customers and maintain an allowance for doubtful accounts based upon our historical experience and any specific customer collection issues that we have identified. In light of ongoing tight credit market conditions, we continue to see requests from our customers for higher credit limits and longer payment terms. Because of our strong cash position and the nominal amount of interest we are earning on our cash and cash equivalents, we have, on a limited basis, approved certain customer requests.

We continue to monitor our accounts receivable credit portfolio. Our overall credit losses have historically been within our expectations of the allowances established; however, we cannot guarantee that we will continue to experience the same credit loss rates that we have in the past. Measurement of credit losses requires consideration of historical loss experience, including the need to adjust for changing business conditions, and judgments about the probable effects of relevant observable data, including present economic conditions such as delinquency rates and the financial health of specific customers. Changes to the estimated allowance for doubtful accounts could be material to our results of operations and financial condition.

Results of Operations

The following table sets forth, for the periods indicated, certain income and expense items expressed as a percentage of our consolidated net sales:

	Fiscal Years Ended July 31,		
	2019	2018	2017
Gross margin	36.8 %	39.2%	39.6 %
Selling, general and administrative expenses	19.1 %	20.0%	21.1 %
Research and development expenses	8.4 %	9.4%	9.9 %
Settlement of intellectual property litigation	(0.5)%	—%	(2.2)%
Acquisition plan expenses	0.9 %	—%	— %
Amortization of intangibles	2.7 %	3.7%	4.1 %
Operating income	6.2 %	6.2%	6.7 %
Interest expense (income) and other	1.4 %	1.8%	2.1 %
Write-off of deferred financing costs	0.5 %	—%	— %
Income before provision for income taxes	4.3 %	4.3%	4.6 %
Net income	3.7 %	5.2%	2.9 %
Adjusted EBITDA (a Non-GAAP measure)	13.9 %	13.7%	12.8 %

For a definition and explanation of Adjusted EBITDA, see "*Item 6. Selected Consolidated Financial Data - Non-GAAP Financial Data*" and "*Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations - Comparison of Fiscal 2019 and 2018 - Adjusted EBITDA.*"

Business Outlook for Fiscal 2020

Fiscal 2019 exceeded our expectations, we finished the year with strong financial results across the board and generated consolidated:

- Net sales of $671.8 million;
- Operating income of $41.4 million;
- Net income of $25.0 million;
- Cash flows from operating activities of $68.0 million; and
- Adjusted EBITDA (a Non-GAAP financial measure discussed below) of $93.5 million.

We achieved a fiscal 2019 consolidated book-to-bill ratio (a measure defined as bookings divided by net sales) of 1.08 and ended the year with consolidated backlog of $683.0 million. Our backlog (sometimes referred to herein as orders or bookings) are more fully defined in *"Part I - Item 1. Business"* included in this Annual Report on Form 10-K and the total value of multi-year contracts that we have received is substantially higher than our reported backlog. As of July 31, 2019, our cash and cash equivalents were $45.6 million and our total debt outstanding (including capital leases and other obligations) was $165.8 million.

Anchored by our fiscal 2019 financial performance, we have strong backlog, lots of optimism and we have good business momentum. As such, we have established the following consolidated financial targets:

- Net sales are expected to be in a range of approximately $710.0 million to $730.0 million with year-over-year growth in both our Commercial Solutions and Government Solutions segments and the achievement of a consolidated book-to-bill ratio in excess of 1.0.

- Total depreciation expense is expected to approximate $13.0 million.

- Total amortization of intangible assets is expected to approximate $21.0 million.

- Total amortization of stock-based compensation expense is expected to range from approximately $12.0 million to $14.0 million.

- GAAP operating income, as a percentage of net sales, is expected to approximate 7.0% as compared to the 6.2% we achieved in fiscal 2019.

- Our interest expense rate (including amortization of deferred financing costs) is expected to approximate 4.6% with total interest expense of approximately $7.5 million in fiscal 2020. Our current cash borrowing rate is approximately 4.0%.

- Our effective income tax rate (excluding discrete tax items) is expected to approximate 23.0%.

- Adjusted EBITDA is expected to be in a range of approximately $98.0 million to $102.0 million or approximately 14.0%.

Like Comtech's business cycle for the past several years, our financial performance in the second half of fiscal 2020 is anticipated to be higher than the first half, with our first quarter of fiscal 2020 being the lowest in terms of consolidated net sales and Adjusted EBITDA. GAAP operating income in our first quarter of fiscal 2020 is expected to be lower than the $7.3 million we achieved during our first quarter in fiscal 2019, primarily due to incremental amortization of intangible assets associated with our fiscal 2019 acquisitions. In addition, in order to take advantage of additional growth opportunities and meet our strategic objectives, our GAAP operating income in the first quarter of fiscal 2020 is expected to reflect approximately $1.5 million of acquisition plan expenses for companies whose offerings are complementary to our business. Based on all of the aforementioned, we expect our first quarter consolidated net sales to approximate $168.0 million with Adjusted EBITDA at $18.1 million or slightly better than the $160.8 million of consolidated net sales and $18.0 million of Adjusted EBITDA we achieved in the first quarter of fiscal 2019. For the remaining quarters of fiscal 2020, we do expect consolidated net sales and Adjusted EBITDA to be better than the comparative quarters of fiscal 2019 with the fourth quarter being the peak quarter of the year. Regardless of timing, fiscal 2020 is expected to be a better year than fiscal 2019.

Except as discussed, the aforementioned fiscal 2020 financial targets do not include the impact of any acquisitions or the impact of any other expense we may incur in order to achieve our strategic objectives. Total acquisition plan expenses in fiscal 2020 may ultimately be higher than the $1.5 million we expect to incur in the first quarter of fiscal 2020. If order flow remains strong and we can achieve all of our fiscal 2020 business goals, it is possible that net sales and Adjusted EBITDA could be higher than our targeted amounts.

Our Business Outlook for Fiscal 2020 depends, in large part, on timely deliveries and the receipt of, and performance on, orders from our customers and could be adversely impacted if orders and/or deliveries are delayed, business conditions deteriorate, or our current or prospective customers materially postpone, reduce or even forgo purchases of our products and services. Additionally, we continue to evaluate cost reduction initiatives in our business, including in connection with the repositioning of our location technology solutions offerings. Our updated fiscal 2020 financial targets do not consider the financial impact of any additional future actions we may take in this regard.

On September 24, 2019, our Board of Directors declared a dividend of $0.10 per common share, payable on November 15, 2019 to stockholders of record at the close of business on October 16, 2019. Future dividends remain subject to compliance with financial covenants under our Credit Facility, as amended, as well as Board approval.

Additional information related to our Business Outlook for Fiscal 2020 and a definition and explanation of Adjusted EBITDA is included in the below section *"Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations - Comparison of Fiscal 2019 and 2018."*

Comparison of Fiscal 2019 and 2018

Net Sales. Consolidated net sales were $671.8 million and $570.6 million for fiscal 2019 and 2018, respectively, representing a significant increase of $101.2 million, or 17.7%. The significant period-over-period increase in net sales reflects higher net sales in both our Commercial and Government Solutions segments. Net sales by operating segment are discussed below.

Commercial Solutions

Net sales in our Commercial Solutions segment were $357.3 million for fiscal 2019, as compared to $345.1 million for fiscal 2018, an increase of $12.2 million, or 3.5%. Our Commercial Solutions segment represented 53.2% of consolidated net sales for fiscal 2019 as compared to 60.5% for fiscal 2018. As further discussed below, demand for our products appears strong and looking forward, we believe this segment will grow in fiscal 2020.

Bookings in our Commercial Solutions segment for fiscal 2019 were strong and our book-to-bill ratio (a measure defined as bookings divided by net sales) for this segment was 1.25. Period-to-period fluctuations in bookings is normal for this segment.

Net sales of our satellite ground station technologies during fiscal 2019 were slightly lower than fiscal 2018. In fiscal 2019, we experienced significant growth in sales to international customers as well as incremental demand from U.S. government customers. This strength was offset by order delays and lower sales for inflight communication amplifiers sold primarily to a U.S. domestic customer. Our Heights™ solutions continue to gain traction and both bookings and sales of these products were significantly higher than the amounts achieved in fiscal 2018. Based on the anticipated increase in the number of high-throughput satellites and low earth orbit and medium earth orbit satellites expected to be launched, and the migration of networks from 3G to 4G and ultimately 5G technologies in emerging countries, we believe that we are in the early stages of a multi-year period of growing demand for satellite ground station technologies which are used to backhaul cellular traffic. Sales to U.S. government customers in fiscal 2020 are also expected to remain strong with a small amount of year-to-year growth anticipated. As a result, we expect fiscal 2020 to be a year of net sales growth for our satellite earth station product line.

Net sales for fiscal 2019 of our public safety and location technology solutions were significantly higher as compared to the net sales we achieved in fiscal 2018. During fiscal 2019, we benefited from incremental sales to key wireless customers for 911 call routing and incremental sales to state and local agencies for our next-generation 911 products. The impact of the February 28, 2019 acquisition of Solacom on fiscal 2019 sales was nominal. Sales of our location technology solutions were significantly lower in fiscal 2019 as we repositioned this product line to focus on providing higher margin solutions offerings to our customers, ceased offering certain solutions and have not renewed certain contracts. Our public safety and location technology solutions have long sales cycles and are subject to difficult-to-predict changes in the overall procurement strategies of wireless carrier customers, but we believe we are positioned well. Overall market conditions remain favorable; as such, we expect fiscal 2020 to be another year of growth for our public safety and location technology solutions.

Bookings, sales and profitability in our Commercial Solutions segment can fluctuate from period-to-period due to many factors, including changes in the general business environment. As such, period-to-period comparisons of our results may not be indicative of a trend or future performance.

Government Solutions

Net sales in our Government Solutions segment were $314.5 million for fiscal 2019 as compared to $225.5 million for fiscal 2018, a significant increase of $89.0 million or 39.5%. Our Government Solutions segment represented 46.8% of consolidated net sales for fiscal 2019, as compared to 39.5% for fiscal 2018. As further discussed below, our business in fiscal 2019 was strong and demand for our products still appears robust. Looking forward, we believe that sales in our Government Solutions segment will be similar or slightly higher than the level we achieved in fiscal 2019 with the ultimate level largely determined by the timing of orders and sales.

Bookings in our Government Solutions segment for fiscal 2019 were solid and our book-to-bill ratio (a measure defined as bookings divided by net sales) in this segment for fiscal 2019 was 0.88. Period-to-period fluctuations in bookings is normal for this segment.

Net sales of our mission-critical technologies during fiscal 2019 were significantly higher as compared to fiscal 2018. Revenue growth during fiscal 2019 was driven by our successful execution on many key orders including: (i) over $78.0 million of orders to supply Manpack Satellite Terminals, networking equipment and other advanced VSAT products to the U.S. Army (which were booked pursuant to our $223.4 million Global Tactical Advanced Communication Systems ("GTACS") contract with the U.S. Army's PM Tactical Network, which has a remaining unfunded contract value of $45.5 million as of July 31, 2019); (ii) $41.4 million of orders to provide ongoing sustainment services to the U.S. Army for the AN/TSC-198A SNAP (Secret Internet Protocol Router ("SIPR") and Non-classified Internet Protocol Router ("NIPR") Access Point), Very Small Aperture Terminals ("VSATs"); (iii) $11.9 million of orders for cyber security training solutions; (iv) a $3.5 million follow-on satellite service order from a major national security solutions provider; and (v) $3.0 million of orders for antenna feeds to be incorporated into portable and inflatable 1.2-meter and 2.4-meter SATCOM terminals. In addition, we shipped $11.7 million of mobile satellite transceivers to support the U.S. Army's Blue Force Tracking-2 program (which we do not expect to repeat in fiscal 2020).

Net sales of our high-performance transmission technologies in fiscal 2019 were significantly higher than fiscal 2018 driven by increased deliveries in fiscal 2019 of troposcatter technologies (including our Modular Transportable Transmission System ("MTTS") troposcatter terminals to two foreign militaries) and an increase in both orders and sales of solid-state, high-power amplifiers and related switching technologies.

Bookings, sales and profitability in our Government Solutions segment can fluctuate dramatically from period-to-period due to many factors, including unpredictable funding, deployment and technology decisions by our U.S. and international government customers. As such, period-to-period comparisons of our results may not be indicative of a trend or future performance.

Geography and Customer Type

Sales by geography and customer type, as a percentage of related sales, for the fiscal years ended July 31, 2019 and 2018 are as follows:

	Fiscal Years Ended July 31,					
	2019	2018	2019	2018	2019	2018
	Commercial Solutions		Government Solutions		Consolidated	
U.S. government	19.2%	18.1%	63.8%	62.2%	40.1%	35.5%
Domestic	53.9%	54.6%	12.5%	14.9%	34.5%	38.9%
Total U.S.	73.1%	72.7%	76.3%	77.1%	74.6%	74.4%
International	26.9%	27.3%	23.7%	22.9%	25.4%	25.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Sales to U.S. government customers include sales to the U.S. Department of Defense ("DoD"), intelligence and civilian agencies, as well as sales directly to or through prime contractors.

Domestic sales include sales to commercial customers, as well as to U.S. state and local governments. Included in domestic sales, are sales to Verizon Communications Inc. ("Verizon"). Sales to Verizon were 10.0% of consolidated net sales for fiscal 2018.

International sales for fiscal 2019 and 2018 (which include sales to U.S. domestic companies for inclusion in products that are sold to international customers) were $170.6 million and $145.8 million, respectively. Except for the U.S., no individual country (including sales to U.S. domestic companies for inclusion in products that are sold to a foreign country) represented more than 10% of consolidated net sales for fiscal 2019 and 2018.

Gross Profit. Gross profit was $247.4 million and $223.9 million for fiscal 2019 and 2018, respectively. The increase of $23.5 million reflects higher sales in both of our segments, as discussed above.

Gross profit, as a percentage of consolidated net sales, for fiscal 2019 was 36.8% as compared to 39.2% for fiscal 2018. This decrease was almost entirely driven by product mix changes as a result of the significant year-to-year increase in net sales in our Government Solutions segment. This segment historically achieves lower gross margins than our Commercial Solutions segment. Gross profit in fiscal 2018 also reflects a benefit from a $0.7 million favorable warranty settlement and a $1.0 million favorable sales and use tax settlement, both of which are reflected in our unallocated segment. Gross profit, as a percentage of related segment net sales, is further discussed below.

Our Commercial Solutions segment's gross profit, as a percentage of related segment net sales, for fiscal 2019 declined in comparison to fiscal 2018. The decrease in gross profit percentage in fiscal 2019 primarily reflects changes in products and services mix, including a significant increase in fiscal 2019 net sales of our Heights™ solutions which currently have lower gross margins than our traditional satellite ground station technologies. Looking forward, we expect our gross profit as a percentage of this segment's net sales in fiscal 2020 to be slightly lower than the amount achieved in fiscal 2019, primarily due to anticipated mix changes, including higher sales of Heights™ solutions and the cessation of sales to AT&T for 911 wireless call routing.

Our Government Solutions segment's gross profit, as a percentage of related segment net sales, for fiscal 2019 declined slightly in comparison to fiscal 2018. In fiscal 2019, we completed shipments of relatively lower margin MT-2025 satellite transceivers to the U.S. Army. As noted above, we do not expect shipments of these transceivers in fiscal 2020. Based on the mix and anticipated timing of shipments and performance related to orders currently in our backlog and the mix and timing of expected new orders and related sales, gross profit for this segment, as a percentage of related segment net sales, for fiscal 2020 is expected to be similar or slightly lower than the level achieved in fiscal 2019.

Included in consolidated cost of sales for fiscal 2019 and 2018 are provisions for excess and obsolete inventory of $6.0 million and $5.6 million, respectively. As discussed in "*Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations - Critical Accounting Policies - Provisions for Excess and Obsolete Inventory,*" we regularly review our inventory and record a provision for excess and obsolete inventory based on historical and projected usage trends.

Because our consolidated gross profit, as a percentage of consolidated net sales, depends on the volume of sales, sales mix and related gross profit for each individual segment, it is inherently difficult to forecast. Nevertheless, based on expected bookings, expected timing of our performance on orders and the anticipated mix of net sales between our Commercial Solutions and Government Solutions segments, we currently expect our consolidated gross profit, as a percentage of consolidated net sales, for fiscal 2020 to be the same or slightly lower than the percentage we achieved in fiscal 2019.

Selling, General and Administrative Expenses. Selling, general and administrative expenses were $128.6 million and $113.9 million for fiscal 2019 and 2018, respectively, representing an increase of $14.7 million, or 12.9%. As a percentage of consolidated net sales, selling, general and administrative expenses were 19.1% and 20.0% for fiscal 2019 and 2018, respectively. The decrease, as a percentage of consolidated net sales, is primarily attributable to the significant increase in our consolidated net sales.

In fiscal 2019, we began a repositioning in our Commercial Solutions segment of certain of our location technology solutions (previously called enterprise technology solutions) to increase our penetration into the public safety space. In connection with this repositioning, we ceased offering certain solutions, have worked with customers to wind-down certain legacy contracts and have not renewed certain contracts; and in doing so, we incurred $6.4 million of estimated contract settlement costs that were recorded as selling, general and administrative expenses. Additionally, we took and continue to take steps to reduce our facility footprint and we incurred $1.4 million of facility exit costs in our Government Solutions segment. Excluding such costs, our selling, general and administrative expenses for fiscal 2019 would have been $120.8 million, or 18.0% of consolidated net sales.

Amortization of stock-based compensation expense recorded as selling, general and administrative expenses was $9.3 million in fiscal 2019 as compared to $6.9 million in fiscal 2018. Amortization in fiscal 2018 includes the benefit of a $0.4 million reversal of stock-based compensation expense related to certain performance shares previously expected to be earned. Amortization of stock-based compensation is not allocated to our two reportable operating segments.

Based on our current spending plans, we expect total fiscal 2020 selling, general and administrative expenses, in dollars, in fiscal 2020 to be higher and, as a percentage of consolidated net sales, to be slightly lower than the 19.1% recorded in fiscal 2019.

Research and Development Expenses. Research and development expenses were $56.4 million and $53.9 million for fiscal 2019 and 2018, respectively, representing an increase of $2.5 million, or 4.6%. As a percentage of consolidated net sales, research and development expenses were 8.4% and 9.4% for fiscal 2019 and 2018, respectively.

For fiscal 2019 and 2018, research and development expenses of $48.2 million and $46.0 million, respectively, related to our Commercial Solutions segment, and $7.2 million and $7.0 million, respectively, related to our Government Solutions segment. The remaining research and development expenses of $1.0 million and $0.9 million in fiscal 2019 and 2018, respectively, related to the amortization of stock-based compensation expense.

Whenever possible, we seek customer funding for research and development to adapt our products to specialized customer requirements. During fiscal 2019 and 2018, customers reimbursed us $14.7 million and $16.9 million, respectively, which is not reflected in the reported research and development expenses but is included in net sales with the related costs included in cost of sales.

We continue to invest in enhancements to existing products as well as in new products across almost all our product lines. Based on our current spending plans, we expect fiscal 2020 research and development expenses, in dollars, to be higher and, as a percentage of consolidated net sales, to be slightly lower than the 8.4% achieved in fiscal 2019.

Amortization of Intangibles. Amortization relating to intangible assets with finite lives was $18.3 million (of which $14.9 million was for the Commercial Solutions segment and $3.4 million was for the Government Solutions segment) for fiscal 2019 and $21.1 million (of which $17.7 million was for the Commercial Solutions segment and $3.4 million was for the Government Solutions segment) for fiscal 2018. The decrease from $21.1 million to $18.3 million was largely the result of certain intangible assets in our Commercial Solutions segment that became fully amortized in fiscal 2018.

Our Business Outlook for Fiscal 2020 assumes total annual amortization of intangible assets of approximately $21.0 million which reflects a full year's estimate of amortization of intangibles related to our fiscal 2019 acquisitions.

Settlement of Intellectual Property Litigation. In fiscal 2019, we recorded a $3.2 million benefit in our Unallocated segment as a result of a favorable ruling issued by the U.S. Court of Appeals for the Federal Circuit related to a legacy TCS intellectual property matter. There was no comparable adjustment in fiscal 2018.

Acquisition Plan Expenses. During fiscal 2019, we incurred $5.9 million of total acquisition plan expenses. These expenses are recorded in our Unallocated segment and primarily related to our fiscal 2019 acquisitions of Solacom and the GD NG-911 business, as discussed above.

In order to position ourselves to take advantage of additional growth opportunities and meet our strategic objectives, during the first quarter of fiscal 2020, we expect to incur approximately $1.5 million of acquisition plan expenses for companies whose solution offerings are complementary to our business. There is no certainty that our acquisition plan efforts will be successful and total acquisition plan expenses in the first quarter of fiscal 2020 may ultimately be higher.

Operating Income. Operating income for fiscal 2019 was $41.4 million as compared $35.1 million for fiscal 2018. Operating income by reportable segment is shown in the table below:

	Fiscal Years Ended July 31,							
	2019	2018	2019	2018	2019	2018	2019	2018
($ in millions)	Commercial Solutions		Government Solutions		Unallocated		Consolidated	
Operating income (loss)	$ 36.1	$ 40.8	$ 29.0	$ 11.0	$ (23.6)	$ (16.7)	$ 41.4	$ 35.1
Percentage of related net sales	10.1%	11.8%	9.2%	4.9%	NA	NA	6.2%	6.2%

The decrease in our Commercial Solutions segment's operating income for fiscal 2019, both in dollars and as a percentage of related segment net sales, was driven by the $6.4 million of estimated contract settlement costs, as discussed above. Excluding such charge, operating income in our Commercial Solutions segment for fiscal 2019 would have been $42.5 million, or 11.9% of related segment net sales which was slightly higher than the amount we achieved in fiscal 2018. Looking forward, given expected sales and product mix assumptions, as discussed above, we expect fiscal 2020 operating income, both in dollars and as a percentage of related segment net sales, to be slightly higher than the 11.9% achieved in fiscal 2019.

The significant increase in our Government Solutions segment's operating income for fiscal 2019, both in dollars and as a percentage of related segment net sales, was primarily due to significantly higher net sales in this segment, offset in part by $1.4 million of facility exit costs, as discussed above. Excluding such costs, operating income in our Government Solutions segment for fiscal 2019 would have been $30.4 million, or 9.7% of related segment net sales, which was significantly higher than the amount we achieved in fiscal 2018. Looking forward, given expected sales and product mix assumptions, as discussed above, we expect fiscal 2020 operating income, in dollars, to be comparable to the amount achieved in fiscal 2019, and as a percentage of related segment net sales, to be slightly lower than the 9.2% achieved in fiscal 2019.

The increase in unallocated expenses in fiscal 2019 as compared to fiscal 2018 is primarily due to increased business and sales activity, acquisition plan expenses and an increase in amortization of stock-based compensation, offset in part by the benefit related to a legacy TCS intellectual property matter, as discussed above. In addition, unallocated operating expenses for fiscal 2018 include the benefit of the warranty settlement and the sales and use tax settlement, as discussed above. Amortization of stock-based compensation was $11.4 million and $8.6 million, respectively, for fiscal 2019 and 2018. Amortization of stock-based compensation for fiscal 2018 reflects a reversal of $0.4 million of stock-based compensation expense related to certain performance shares that were previously expected to be earned.

Excluding net costs of $10.5 million, consisting of $6.4 million of estimated contract settlement costs, $1.4 million of facility exit costs, $5.9 million of acquisition plan expenses and a $3.2 million benefit related to a legacy TCS intellectual property matter (all of which are discussed above), consolidated operating income for fiscal 2019 would have been $51.8 million, or 7.7% of consolidated net sales. Excluding the aforementioned $1.7 million of favorable adjustments in fiscal 2018, consolidated operating income for fiscal 2018 would have been $33.4 million, or 5.9% of consolidated net sales. The increase from 5.9% to 7.7% reflects the benefit of incremental sales growth and changes in overall spending, as discussed above.

Our Business Outlook for Fiscal 2020 assumes, similar to the prior three fiscal years, that we will continue to pay certain annual non-equity incentive awards in the form of fully-vested share units. Amortization of stock-based compensation can fluctuate from period-to-period based on the type and timing of stock-based awards, estimated forfeitures and the achievement of applicable performance goals. If we do not achieve our fiscal 2020 business goals, amortization of stock-based compensation expense would be lower than our current expected fiscal 2020 range.

Looking forward, unallocated operating expenses in fiscal 2020 are expected to be higher than the $23.6 million incurred in fiscal 2019. The increase in unallocated expenses is expected to be driven by: (i) increased amortization of stock-based compensation (which is not allocated to our two reportable segments) which, in fiscal 2020, is expected to range from $12.0 million to $14.0 million; (ii) increased compensation costs, including incremental costs for additional personnel to support our anticipated growth; (iii) the absence of a $3.2 million benefit from the aforementioned legacy TCS intellectual property matter; and (iv) other increased spending as a result of increased business activity assumed in fiscal 2020.

Overall, our fiscal 2020 GAAP consolidated operating income (in dollars) is anticipated to be higher than the $41.4 million we achieved in fiscal 2019, and as a percentage of consolidated net sales, to approximate 7.0% as compared to the 6.2% we achieved in fiscal 2019. Total GAAP consolidated operating income in fiscal 2020 could be further impacted by additional acquisition plan expenses other than the estimated $1.5 million anticipated to be incurred during the first quarter of fiscal 2020.

Interest Expense and Other. Interest expense was $9.2 million and $10.2 million for fiscal 2019 and 2018, respectively. Our effective interest rate (including amortization of deferred financing costs) in fiscal 2019 was approximately 5.3%. Our current cash borrowing rate (which excludes the amortization of deferred financing costs) approximates 4.0%.

Based on the type, terms, amount of outstanding debt (including capital leases and other obligations) and current interest rates, our effective interest rate (including amortization of deferred financing costs) in fiscal 2020 is anticipated to approximate 4.6%. Total interest expense in fiscal 2020 is expected to approximate $7.5 million.

Write-off of Deferred Financing Costs. In connection with the establishment of our new Credit Facility in fiscal 2019, we wrote-off $3.2 million of deferred financing costs which primarily related to the term loan portion of our prior credit facility. See "*Notes to Consolidated Financial Statements - Note (8) - Credit Facility*" included in "*Part II - Item 8. - Financial Statements and Supplementary Data,*" included in this Annual Report on Form 10-K, for further information. There was no comparable charge in fiscal 2018.

Interest (Income) and Other. Interest (income) and other for both fiscal 2019 and 2018 was nominal. All of our available cash and cash equivalents are currently invested in bank deposits and money market deposit accounts which, at this time, are currently yielding an immaterial interest rate.

Provision for (Benefit from) Income Taxes. The provision for income taxes was $3.9 million for fiscal 2019 as compared to a benefit of $5.1 million for fiscal 2018. Our effective tax rate (excluding discrete tax items) for fiscal 2019 was 23.25% and for 2018 was 27.0%.

During fiscal 2019, we recorded a net discrete tax benefit of $2.9 million, primarily related to: (i) the favorable resolution of the IRS' audit of our fiscal 2016 federal income tax return; (ii) discrete tax benefits for stock-based awards that were settled during fiscal 2019; and (iii) the reversal of tax contingencies no longer required due to the expiration of applicable statutes of limitation. During fiscal 2018, we recorded a net discrete tax benefit of $11.8 million which, as a result of Tax Reform, primarily related to the remeasurement of deferred tax liabilities associated with non-deductible amortization related to intangible assets and discrete tax benefits associated with stock-based awards that were settled in fiscal 2018. These benefits were offset, in part, by the finalization of certain tax deductions in connection with the filing of our federal and state tax returns for fiscal 2017. The decrease from 27.0% to 23.25% is principally attributable to the passage of Tax Reform which reduced the statutory income tax rate from 35.0% to 21.0%. Such decrease was partially offset by non-deductible transaction costs related to the acquisition of Solacom and lower tax deductions for certain executive compensation expenses as a result of Tax Reform.

Our federal income tax returns for fiscal 2017 and 2018 are subject to potential future IRS audit. None of our state income tax returns prior to fiscal 2015 are subject to audit. TCS's federal income tax returns for tax year 2015 and the tax period from January 1, 2016 to February 23, 2016, the date we acquired TCS, are subject to potential future IRS audit. None of TCS's state income tax returns prior to calendar year 2014 are subject to audit. Future tax assessments or settlements could have a material adverse effect on our consolidated results of operations and financial condition.

Looking forward, our fiscal 2020 effective tax rate, before discrete tax items is expected to approximate 23.0%.

Net Income. During fiscal 2019, consolidated net income was $25.0 million as compared to $29.8 million during fiscal 2018.

Adjusted EBITDA. Adjusted EBITDA (both in dollars and as a percentage of related net sales) for both fiscal 2019 and 2018 are shown in the table below (numbers in the table may not foot due to rounding):

	Fiscal Years Ended July 31,							
	2019	2018	2019	2018	2019	2018	2019	2018
($ in millions)	Commercial Solutions		Government Solutions		Unallocated		Consolidated	
Net income (loss)	$ 35.9	40.3	29.0	10.8	(39.9)	(21.4)	$ 25.0	29.8
Provision for (benefit from) income taxes	—	0.3	—	—	3.9	(5.4)	3.9	(5.1)
Interest (income) and other	0.1	0.2	—	0.1	—	—	—	0.3
Write-off of deferred financing costs	—	—	—	—	3.2	—	3.2	—
Interest expense	0.1	0.1	—	—	9.2	10.1	9.2	10.2
Amortization of stock-based compensation	—	—	—	—	11.4	8.6	11.4	8.6
Amortization of intangibles	14.9	17.7	3.4	3.4	—	—	18.3	21.1
Depreciation	9.3	9.5	1.9	3.1	0.8	1.1	11.9	13.7
Estimated contract settlement costs	6.4	—	—	—	—	—	6.4	—
Settlement of intellectual property litigation	—	—	—	—	(3.2)	—	(3.2)	—
Acquisition plan expenses	—	—	—	—	5.9	—	5.9	—
Facility exit costs	—	—	1.4	—	—	—	1.4	—
Adjusted EBITDA	$ 66.6	68.0	35.6	17.4	(8.8)	(7.1)	$ 93.5	78.4
Percentage of related net sales	18.6%	19.7%	11.3%	7.7%	NA	NA	13.9%	13.7%

The increase in consolidated Adjusted EBITDA, both in dollars and as a percentage of consolidated net sales, during fiscal 2019 as compared to fiscal 2018 is primarily attributable to higher consolidated net sales and operating income, as discussed above.

The decrease in our Commercial Solutions segment's Adjusted EBITDA, both in dollars and as a percentage of related segment net sales, primarily reflects the lower gross profit percentage we achieved in fiscal 2019 and higher research and development expenses, as discussed above.

The significant increase in our Government Solutions segment's Adjusted EBITDA, both in dollars and as a percentage of related segment net sales, was primarily driven by significantly higher net sales, as discussed above.

Because our consolidated Adjusted EBITDA, as a percentage of consolidated net sales, depends on the volume of sales, sales mix and related gross profit for each individual segment as well as unallocated spending, it is inherently difficult to forecast. In addition, our Business Outlook for Fiscal 2020 includes several items, the timing of which can still shift and impact our expected quarterly financial performance. Looking forward, based on the mix and anticipated timing of shipments and performance related to orders currently in our backlog and the mix and timing of expected new orders and related sales, we are targeting consolidated Adjusted EBITDA (in dollars) to be higher in fiscal 2020 as compared to the $93.5 million we achieved in fiscal 2019. As a percentage of consolidated net sales, Adjusted EBITDA is expected to be similar to the 13.9% achieved in fiscal 2019. If order flow remains strong and we are able to achieve all of our fiscal 2020 business goals, it is possible that our fiscal 2020 Adjusted EBITDA could be higher than our targeted amount.

Reconciliations of our GAAP consolidated operating income, net income and net income per diluted share for fiscal 2019 and 2018 to the corresponding non-GAAP measures are shown in the tables below (numbers and per share amounts in the table may not foot due to rounding):

	Fiscal 2019		
($ in millions, except for per share amount)	Operating Income	Net Income	Net Income per Diluted Share
Reconciliation of GAAP to Non-GAAP Earnings:			
GAAP measures, as reported	$ 41.4	$ 25.0	$ 1.03
Estimated contract settlement costs	6.4	4.9	0.20
Settlement of intellectual property litigation	(3.2)	(2.5)	(0.10)
Facility exit costs	1.4	1.1	0.04
Acquisition plan expenses	5.9	4.5	0.19
Write-off of deferred financing costs	—	2.5	0.10
Net discrete tax benefit	—	(2.9)	(0.12)
Non-GAAP measures	$ 51.8	$ 32.6	$ 1.34

	Fiscal 2018		
($ in millions, except for per share amount)	Operating Income	Net Income	Net Income per Diluted Share
Reconciliation of GAAP to Non-GAAP Earnings:			
GAAP measures, as reported	$ 35.1	$ 29.8	$ 1.24
Net discrete tax benefit	—	(11.8)	(0.49)
Non-GAAP measures	$ 35.1	$ 18.0	$ 0.75

Our Adjusted EBITDA is a Non-GAAP measure that represents earnings (loss) before income taxes, interest (income) and other, write-off of deferred financing costs, interest expense, amortization of stock-based compensation, amortization of intangibles, depreciation expense, estimated contract settlement costs, settlement of intellectual property litigation, acquisition plan expenses, facility exit costs, and strategic alternatives analysis expenses and other. Our definition of Adjusted EBITDA may differ from the definition of EBITDA used by other companies and therefore may not be comparable to similarly titled measures used by other companies. Adjusted EBITDA is also a measure frequently requested by our investors and analysts. We believe that investors and analysts may use Adjusted EBITDA, along with other information contained in our SEC filings, in assessing our performance and comparability of our results with other companies. Our Non-GAAP measures for consolidated operating income, net income and net income per diluted share reflect the GAAP measures as reported, adjusted for certain items as described. These Non-GAAP financial measures have limitations as an analytical tool as they exclude the financial impact of transactions necessary to conduct our business, such as the granting of equity compensation awards, and are not intended to be an alternative to financial measures prepared in accordance with GAAP. These measures are adjusted as described in the reconciliation of GAAP to Non-GAAP in the above tables, but these adjustments should not be construed as an inference that all of these adjustments or costs are unusual, infrequent or non-recurring. Non-GAAP financial measures should be considered in addition to, and not as a substitute for or superior to, financial measures determined in accordance with GAAP. Investors are advised to carefully review the GAAP financial results that are disclosed in our SEC filings. We have not quantitatively reconciled our fiscal 2020 Adjusted EBITDA target to the most directly comparable GAAP measure because items such as stock-based compensation, adjustments to the provision for income taxes, amortization of intangible assets and interest expense, which are specific items that impact these measures, have not yet occurred, are out of our control, or cannot be predicted. For example, quantification of stock-based compensation expense requires inputs such as the number of shares granted and market price that are not currently ascertainable. Accordingly, reconciliations to the Non-GAAP forward looking metrics are not available without unreasonable effort and such unavailable reconciling items could significantly impact our financial results.

Comparison of Fiscal 2018 and 2017

Net Sales. Consolidated net sales were $570.6 million and $550.4 million for fiscal 2018 and 2017, respectively, representing an increase of $20.2 million, or 3.7%. The period-over-period increase in net sales was due to higher net sales in both our Commercial Solutions and Government Solutions segments. Net sales by operating segment are discussed below.

Commercial Solutions
Net sales in our Commercial Solutions segment were $345.1 million for fiscal 2018, as compared to $330.9 million for fiscal 2017, an increase of $14.2 million, or 4.3%. Our Commercial Solutions segment represented 60.5% of consolidated net sales for fiscal 2018 as compared to 60.1% for fiscal 2017.

Our book-to-bill ratio (a measure defined as bookings divided by net sales) in this segment for fiscal 2018 was 1.33.

Net sales of our satellite ground station technologies in fiscal 2018 were higher than fiscal 2017, as we experienced significant growth in our sales to U.S. government customers. We experienced lower sales to international customers in fiscal 2018 as compared to fiscal 2017. Our Heights™ solutions experienced year-over-year revenue growth in fiscal 2018.

Net sales in fiscal 2018 of public safety and location technology solutions were higher as compared to the net sales we achieved in fiscal 2017.

Bookings, sales and profitability in our Commercial Solutions segment can fluctuate from period-to-period due to many factors, including changes in the general business environment. As such, period-to-period comparisons of our results may not be indicative of a trend or future performance.

Government Solutions
Net sales in our Government Solutions segment were $225.5 million for fiscal 2018 as compared to $219.5 million for fiscal 2017, an increase of $6.0 million or 2.7%. Our Government Solutions segment represented 39.5% of consolidated net sales for fiscal 2018, as compared to 39.9% for fiscal 2017.

The increase in net sales primarily reflects significantly higher net sales of our mission-critical technologies offset, in part, by significantly lower net sales of high-performance transmission technologies and the absence of $6.7 million of BFT-1 intellectual property license fees in fiscal 2018.

Our book-to-bill ratio (a measure defined as bookings divided by net sales) in this segment for fiscal 2018 was 1.31.

As of July 31, 2018, backlog for this segment was at the highest level since our acquisition of TCS in February 2016.

Bookings, sales and profitability in our Government Solutions segment can fluctuate dramatically from period-to-period due to many factors, including unpredictable funding, deployment and technology decisions by our U.S. and international government customers. As such, period-to-period comparisons of our results may not be indicative of a trend or future performance.

Geography and Customer Type
Sales by geography and customer type, as a percentage of related sales, for the fiscal years ended July 31, 2018 and 2017 are as follows:

	Fiscal Years Ended July 31,					
	2018	2017	2018	2017	2018	2017
	Commercial Solutions		Government Solutions		Consolidated	
U.S. government	18.1%	15.1%	62.2%	59.2%	35.5%	32.7%
Domestic	54.6%	54.4%	14.9%	15.5%	38.9%	38.9%
Total U.S.	72.7%	69.5%	77.1%	74.7%	74.4%	71.6%
International	27.3%	30.5%	22.9%	25.3%	25.6%	28.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Sales to U.S. government customers include sales to the U.S. Department of Defense ("DoD"), intelligence and civilian agencies, as well as sales directly to or through prime contractors.

Domestic sales include sales to commercial customers, as well as to U.S. state and local governments. Included in domestic sales, are sales to Verizon Communications Inc. ("Verizon"), which represented 10.0% of consolidated net sales for fiscal 2018. There were no customers that represented more than 10% of consolidated net sales for fiscal 2017.

International sales for fiscal 2018 and 2017 (which include sales to U.S. domestic companies for inclusion in products that are sold to international customers) were $145.8 million and $156.5 million, respectively. Except for the U.S., no individual country (including sales to U.S. domestic companies for inclusion in products that are sold to a foreign country) represented more than 10% of consolidated net sales for fiscal 2018 and 2017.

Gross Profit. Gross profit was $223.9 million and $218.2 million for fiscal 2018 and 2017, respectively. The increase of $5.7 million in gross profit dollars was largely driven by higher net sales and increased gross margins in our Commercial Solutions segment, partially offset by lower gross profit contributions from the Government Solutions segment. Gross profit in fiscal 2018 also benefited from a $0.7 million favorable warranty settlement and a $1.0 million favorable sales and use tax settlement, both of which are reflected in our unallocated segment. Gross profit, as a percentage of consolidated net sales, for fiscal 2018 was 39.2% (or 38.9% when excluding the aforementioned favorable settlements), which was slightly lower than the 39.6% achieved in fiscal 2017. This decrease was primarily driven by lower gross margins in our Government Solutions segment that was partially offset by an improvement in gross margins in our Commercial Solutions segment and the aforementioned favorable settlements. Gross profit, as a percentage of related segment net sales, is further discussed below.

Our Commercial Solutions segment's gross profit, as a percentage of related segment net sales, for fiscal 2018 was higher than fiscal 2017. The increase was primarily due to higher net sales and overall favorable product mix changes.

Our Government Solutions segment's gross profit, as a percentage of related segment net sales, for fiscal 2018 was lower than fiscal 2017. The decrease was primarily driven by significantly lower net sales of high-performance transmission technologies and the absence of $6.7 million of BFT-1 intellectual property license fees.

Included in consolidated cost of sales for fiscal 2018 and 2017 are provisions for excess and obsolete inventory of $5.6 million and $2.9 million, respectively. As discussed in "*Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations - Critical Accounting Policies - Provisions for Excess and Obsolete Inventory,*" we regularly review our inventory and record a provision for excess and obsolete inventory based on historical and projected usage trends.

Selling, General and Administrative Expenses. Selling, general and administrative expenses were $113.9 million and $116.1 million for fiscal 2018 and 2017, respectively, representing a decrease of $2.2 million. As a percentage of consolidated net sales, selling, general and administrative expenses were 20.0% and 21.1% (or 22.1% in fiscal 2017 when excluding $5.5 million of favorable adjustments related to a recovery of legal expenses from a third party and adjustments related to reserves associated with the TCS acquisition that were no longer required). There were no comparable adjustments in fiscal 2018.

The decrease in fiscal 2018 spending, both in dollars and as a percentage of consolidated net sales, is primarily attributable to the benefit of cost reduction actions previously initiated and, to a lesser extent, higher consolidated net sales during fiscal 2018, as discussed above.

Amortization of stock-based compensation expense recorded as selling, general and administrative expenses was $6.9 million in fiscal 2018 as compared to $7.1 million in fiscal 2017. Amortization in fiscal 2018 includes the benefit of a $0.4 million reversal of stock-based compensation expense related to certain performance shares previously expected to be earned.

Research and Development Expenses. Research and development expenses were $53.9 million and $54.3 million for fiscal 2018 and 2017, respectively, representing a decrease of $0.4 million, or 0.7%. As a percentage of consolidated net sales, research and development expenses were 9.4% and 9.9% for fiscal 2018 and 2017, respectively.

For fiscal 2018 and 2017, research and development expenses of $46.0 million and $44.7 million, respectively, related to our Commercial Solutions segment, and $7.0 million and $8.9 million, respectively, related to our Government Solutions segment. The remaining research and development expenses of $0.9 million and $0.7 million in fiscal 2018 and 2017, respectively, related to the amortization of stock-based compensation expense.

Whenever possible, we seek customer funding for research and development to adapt our products to specialized customer requirements. During fiscal 2018 and 2017, customers reimbursed us $16.9 million and $27.1 million, respectively, which is not reflected in the reported research and development expenses but is included in net sales with the related costs included in cost of sales.

Amortization of Intangibles. Amortization relating to intangible assets with finite lives was $21.1 million (of which $17.7 million was for the Commercial Solutions segment and $3.4 million was for the Government Solutions segment) for fiscal 2018 and $22.8 million (of which $17.7 million was for the Commercial Solutions segment and $5.1 million was for the Government Solutions segment) for fiscal 2017. The decrease in fiscal 2018 amortization was the result of certain intangibles in our Government Solutions segment that became fully amortized in fiscal 2017.

Settlement of Intellectual Property Litigation. In fiscal 2017, we recorded favorable adjustments to operating income of $12.0 million, net of estimated legal fees, to reflect lower losses than originally estimated for TCS intellectual property matters which were settled during that period. There were no comparable adjustments in fiscal 2018.

Operating Income. Operating income for fiscal 2018 was $35.1 million as compared $37.0 million for fiscal 2017. Operating income by reportable segment is shown in the table below:

	Fiscal Years Ended July 31,							
	2018	2017	2018	2017	2018	2017	2018	2017
($ in millions)	Commercial Solutions		Government Solutions		Unallocated		Consolidated	
Operating income (loss)	$ 40.8	$ 33.2	$ 11.0	$ 9.4	$ (16.7)	$ (5.6)	$ 35.1	$ 37.0
Percentage of related net sales	11.8%	10.0%	4.9%	4.3%	NA	NA	6.2%	6.7%

The increase in our Commercial Solutions segment's operating income, in dollars and as a percentage of related segment net sales, was primarily due to higher net sales, overall favorable product mix changes and the benefit of cost reduction actions previously initiated, as discussed above.

The increase in our Government Solutions segment's operating income, in dollars and as a percentage of related segment net sales, was primarily due to lower operating expenses (including lower amortization of intangibles) that was partially offset by lower gross profit contributions, as discussed above.

Unallocated operating expenses for fiscal 2018 were $16.7 million and were offset by a $0.7 million favorable warranty settlement and a $1.0 million favorable sales and use tax settlement, as discussed above. Excluding these adjustments, unallocated operating expenses for fiscal 2018 would have been $18.4 million. Unallocated operating expenses for fiscal 2017 were $5.6 million and were offset by a number of items that aggregated $18.8 million and included: (i) a $12.0 million favorable adjustment related to the settlement of certain TCS intellectual property matters; (ii) $5.5 million of favorable adjustments which related to a recovery of legal expenses from a third party and reserves associated with the TCS acquisition that were no longer required; and (iii) a $1.3 million benefit (as compared to fiscal 2016) associated with our decision to pay certain fiscal 2017 incentive compensation awards in the form of share units. Excluding these adjustments, unallocated operating expenses for fiscal 2017 would have been $24.4 million. The decrease to $18.4 million in fiscal 2018 from the $24.4 million in fiscal 2017 primarily relates to lower spending. Unallocated expenses for fiscal 2018 and 2017 include amortization of stock-based compensation of $8.6 million and $8.5 million, respectively.

Excluding the aforementioned $1.7 million and $18.8 million of favorable adjustments in fiscal 2018 and 2017, respectively, consolidated operating income for fiscal 2018 and 2017 would have been $33.4 million, or 5.9% of consolidated net sales, and $18.2 million, or 3.3% of consolidated net sales, respectively. This improvement from 3.3% to 5.9% is largely due to the benefit of cost reductions made and changes in gross profit mix and operating expenses, as discussed above.

Interest Expense and Other. Interest expense was $10.2 million and $11.6 million for fiscal 2018 and 2017, respectively. The decline in interest expense primarily reflects lower total indebtedness (excluding unamortized deferred financing costs), which declined from $200.6 million as of July 31, 2017 to $171.3 million as of July 31, 2018. Interest expense for both periods primarily reflects interest on our prior Credit Agreement dated as of February 23, 2016 (as amended by that certain First Amendment, dated as of June 6, 2017).

Interest (Income) and Other. Interest (income) and other for both fiscal 2018 and 2017 was nominal. All of our available cash and cash equivalents are currently invested in bank deposits and money market deposit accounts which, as of July 31, 2018, were yielding a blended annual interest rate of approximately 0.6%.

(Benefit from) Provision for Income Taxes. The benefit from income taxes was $5.1 million for fiscal 2018 as compared to a tax provision of $9.7 million for fiscal 2017.

During fiscal 2018, we recorded a net discrete tax benefit of $11.8 million which, as a result of Tax Reform, primarily related to the remeasurement of deferred tax liabilities associated with non-deductible amortization related to intangible assets and discrete tax benefits associated with stock-based awards that were settled in fiscal 2018. These benefits were offset, in part, by the finalization of certain tax deductions in connection with the filing of our federal and state income tax returns for fiscal 2017. Excluding discrete tax items for fiscal 2018, our effective tax rate was 27.0%.

During fiscal 2017, we recorded a net discrete tax expense of $0.5 million, primarily related to the finalization of certain tax deductions in connection with the filing of our federal and state income tax returns for fiscal 2016, offset, in part, by the reversal of tax contingencies no longer required due to the settlement of the fiscal 2014 federal income tax audit and the expiration of applicable statutes of limitation. Our effective tax rate excluding discrete tax items for fiscal 2017 was 35.75%.

The decrease from 35.75% to 27.0% is principally attributable to the passage of Tax Reform which reduced the statutory income tax rate from 35.0% to 21.0%, or a blended income tax rate of approximately 27.0%.

Our federal income tax returns for fiscal 2017 and 2018 are subject to potential future IRS audit. None of our state income tax returns prior to fiscal 2015 are subject to audit. TCS's federal income tax returns for tax year 2015 and the tax period from January 1, 2016 to February 23, 2016, the date we acquired TCS, are subject to potential future IRS audit. None of TCS's state income tax returns prior to calendar year 2014 are subject to audit. Future tax assessments or settlements could have a material adverse effect on our consolidated results of operations and financial condition.

Net Income. During fiscal 2018, consolidated net income was $29.8 million as compared to $15.8 million during fiscal 2017.

Adjusted EBITDA. Adjusted EBITDA (both in dollars and as a percentage of related net sales) for both fiscal 2018 and 2017 are shown in the table below (numbers in the table may not foot due to rounding):

	Fiscal Years Ended July 31,							
	2018	2017	2018	2017	2018	2017	2018	2017
($ in millions)	Commercial Solutions		Government Solutions		Unallocated		Consolidated	
Net income (loss)	$ 40.3	32.9	10.8	9.4	(21.4)	(26.5)	$ 29.8	15.8
Provision for (benefit from) income taxes	0.3	0.3	—	—	(5.4)	9.4	(5.1)	9.7
Interest (income) and other	0.2	(0.1)	0.1	—	—	0.1	0.3	(0.1)
Interest expense	0.1	0.2	—	—	10.1	11.4	10.2	11.6
Amortization of stock-based compensation	—	—	—	—	8.6	8.5	8.6	8.5
Amortization of intangibles	17.7	17.7	3.4	5.1	—	—	21.1	22.8
Depreciation	9.5	9.9	3.1	2.9	1.1	1.5	13.7	14.4
Settlement of intellectual property litigation	—	—	—	—	—	(12.0)	—	(12.0)
Adjusted EBITDA	$ 68.0	60.9	17.4	17.5	(7.1)	(7.6)	$ 78.4	70.7
Percentage of related net sales	19.7%	18.4%	7.7%	8.0%	NA	NA	13.7%	12.8%

The increase in consolidated Adjusted EBITDA during fiscal 2018 as compared to fiscal 2017 is primarily attributable to higher net sales and overall favorable product mix changes in our Commercial Solutions segment (which historically achieves higher gross margins than our Government Solutions segment), the benefit of cost reduction actions previously taken and the $1.7 million of benefits in fiscal 2018 that resulted from the favorable warranty and sales and use tax settlements, as discussed above.

The increase in our Commercial Solutions segment's Adjusted EBITDA, in dollars and as a percentage of related segment net sales, was primarily attributable to higher net sales, overall favorable product mix changes and the benefit of cost reduction actions previously initiated, as discussed above.

The decrease in our Government Solutions segment's Adjusted EBITDA, in dollars and as a percentage of related segment net sales, was primarily driven by significantly lower net sales of high-performance transmission technologies and the absence of $6.7 million of BFT-1 intellectual property license fees, as discussed above.

Reconciliations of our GAAP consolidated operating income, net income and net income per diluted share for fiscal 2018 and 2017 to the corresponding non-GAAP measures are shown in the tables below (numbers and per share amounts in the table may not foot due to rounding):

	Fiscal 2018		
($ in millions, except for per share amount)	Operating Income	Net Income	Net Income per Diluted Share
Reconciliation of GAAP to Non-GAAP Earnings:			
GAAP measures, as reported	$ 35.1	$ 29.8	$ 1.24
Net discrete tax benefit	—	(11.8)	(0.49)
Non-GAAP measures	$ 35.1	$ 18.0	$ 0.75

	Fiscal 2017		
($ in millions, except for per share amount)	Operating Income	Net Income	Net Income per Diluted Share
Reconciliation of GAAP to Non-GAAP Earnings:			
GAAP measures, as reported	$ 37.0	$ 15.8	$ 0.67
Settlement of intellectual property litigation	(12.0)	(7.7)	(0.33)
Non-GAAP measures	$ 25.0	$ 8.1	$ 0.34

Our Adjusted EBITDA is a Non-GAAP measure that represents earnings (loss) before income taxes, interest (income) and other, write-off of deferred financing costs, interest expense, amortization of stock-based compensation, amortization of intangibles, depreciation expense, estimated contract settlement costs, settlement of intellectual property litigation, acquisition plan expenses, facility exit costs, and strategic alternatives analysis expenses and other. Our definition of Adjusted EBITDA may differ from the definition of EBITDA used by other companies and therefore may not be comparable to similarly titled measures used by other companies. Adjusted EBITDA is also a measure frequently requested by our investors and analysts. We believe that investors and analysts may use Adjusted EBITDA, along with other information contained in our SEC filings, in assessing our performance and comparability of our results with other companies. Our Non-GAAP measures for consolidated operating income, net income and net income per diluted share reflect the GAAP measures as reported, adjusted for certain items as described. These Non-GAAP financial measures have limitations as an analytical tool as they exclude the financial impact of transactions necessary to conduct our business, such as the granting of equity compensation awards, and are not intended to be an alternative to financial measures prepared in accordance with GAAP. These measures are adjusted as described in the reconciliation of GAAP to Non-GAAP in the above tables, but these adjustments should not be construed as an inference that all of these adjustments or costs are unusual, infrequent or non-recurring. Non-GAAP financial measures should be considered in addition to, and not as a substitute for or superior to, financial measures determined in accordance with GAAP. Investors are advised to carefully review the GAAP financial results that are disclosed in our SEC filings.

Liquidity and Capital Resources

Our cash and cash equivalents increased to $45.6 million at July 31, 2019 from $43.5 million at July 31, 2018, an increase of $2.1 million. The increase in cash and cash equivalents during fiscal 2019 was driven by the following:

- Net cash provided by operating activities was $68.0 million for fiscal 2019 as compared to $50.3 million for fiscal 2018. The period-over-period increase in cash flow from operating activities reflects overall changes in net working capital requirements, principally the timing of shipments, billings and payments.

- Net cash used in investing activities for fiscal 2019 was $44.7 million as compared to $8.6 million for fiscal 2018. During fiscal 2019, we paid $35.9 million of cash in connection with our fiscal 2019 acquisitions, net of cash acquired. The remaining portion of net cash used in both periods primarily represented expenditures relating to ongoing equipment upgrades and enhancements.

- Net cash used in financing activities was $21.3 million for fiscal 2019 as compared to $40.1 million for fiscal 2018. During fiscal 2019, we entered into a new Credit Facility and repaid in full the outstanding borrowings under our Prior Credit Facility. During fiscal 2019 and 2018, we paid $9.8 million and $9.5 million, respectively, in cash dividends to our stockholders. We also made $5.0 million and $1.1 million, respectively, of payments to remit employees' statutory tax withholding requirements related to the net settlement of stock-based awards during fiscal 2019 and 2018.

The Credit Facility is discussed below and in *"Notes to Consolidated Financial Statements - Note (8) - Credit Facility"* included in *"Part II - Item 8. - Financial Statements and Supplementary Data"* included in this Annual Report on Form 10-K.

Our investment policy relating to our cash and cash equivalents is intended to minimize principal loss while at the same time maximize the income we receive without significantly increasing risk. To minimize risk, we generally invest our cash and cash equivalents in money market mutual funds (both government and commercial), certificates of deposit, bank deposits, and U.S. Treasury securities. Many of our money market mutual funds invest in direct obligations of the U.S. government, bank securities guaranteed by the Federal Deposit Insurance Corporation, certificates of deposit and commercial paper and other securities issued by other companies. While we cannot predict future market conditions or market liquidity, we believe our investment policies are appropriate in the current environment. Ultimately, the availability of our cash and cash equivalents is dependent on a well-functioning liquid market.

As of July 31, 2019, our material short-term cash requirements primarily consist of: (i) estimated interest payments under our Credit Facility; (ii) payments related to lease commitments; (iii) our ongoing working capital needs, including income tax payments; and (iv) payment of accrued quarterly dividends. We continue to focus on acquisitions to supplement our expected organic growth. If our acquisition plan is successful, we may be required to pay for such acquisition primarily with existing cash and cash equivalents and increased borrowings under our Credit Facility.

In December 2018, we filed a $400.0 million shelf registration statement with the SEC for the sale of various types of securities, including debt. The shelf registration statement was declared effective by the SEC as of December 14, 2018.

As of July 31, 2019 and September 24, 2019, we were authorized to repurchase up to an additional $8.7 million of our common stock, pursuant to our current $100.0 million stock repurchase program. Our stock repurchase program has no time restrictions and repurchases may be made in open-market or privately negotiated transactions and may be made pursuant to SEC Rule 10b5-1 trading plans. There were no repurchases of our common stock during fiscal 2019 and 2018.

On September 26, 2018, December 6, 2018, March 6, 2019 and June 5, 2019, our Board of Directors declared a dividend of $0.10 per common share, which was paid on November 16, 2018, February 15, 2019, May 17, 2019 and August 16, 2019, respectively. On September 24, 2019, our Board of Directors declared a dividend of $0.10 per common share, payable on November 15, 2019 to stockholders of record at the close of business on October 16, 2019. Future dividends remain subject to compliance with financial covenants under our Credit Facility, as amended, as well as Board approval.

Our material long-term cash requirements primarily consist of mandatory interest payments pursuant to our Credit Facility and lease commitments.

We have historically met both our short-term and long-term cash requirements with funds provided by a combination of cash and cash equivalent balances, cash generated from operating activities and cash generated from financing transactions. Based on our anticipated level of future sales and operating income, we believe that our existing cash and cash equivalent balances, our cash generated from operating activities and amounts potentially available under our Credit Facility will be sufficient to meet both our currently anticipated short-term and long-term operating cash requirements.

Although it is difficult in the current economic and credit environment to predict the terms and conditions of financing that may be available in the future, should our short-term or long-term cash requirements increase beyond our current expectations, we believe that we would have sufficient access to credit from financial institutions and/or financing from public and private debt and equity markets.

Credit Facility

On October 31, 2018, we entered into a First Amended and Restated Credit Agreement (the "Credit Facility") with a syndicate of lenders, replacing our prior Credit Agreement dated as of February 23, 2016 (as amended by that certain First Amendment, dated as of June 6, 2017 (the "Prior Credit Facility")).

The new Credit Facility provides a senior secured loan facility of up to $550.0 million consisting of: (i) a revolving loan facility ("Revolving Loan Facility") with a borrowing limit of $300.0 million; (ii) an accordion feature allowing us to borrow up to an additional $250.0 million; (iii) a $35.0 million letter of credit sublimit; and (iv) a swingline loan credit sublimit of $25.0 million.

The Credit Facility matures on October 31, 2023 (the "Revolving Maturity Date"). If we issue new unsecured debt in excess of $5.0 million with a maturity date that is less than 91 days from October 31, 2023, the Revolving Maturity Date would automatically accelerate so that it would be 91 days earlier than the maturity date of the new unsecured debt.

The proceeds of the new Credit Facility were used, in part, to repay in full the outstanding borrowings under the Prior Credit Facility, and additional proceeds of the Credit Facility are expected to be used by us for working capital and other general corporate purposes. As of July 31, 2019, the amount outstanding under our Credit Facility was $165.0 million, which is reflected in the non-current portion of long-term debt on our Consolidated Balance Sheet. At July 31, 2019, we had $2.7 million of standby letters of credit outstanding under our Credit Facility related to our guarantees of future performance on certain customer contracts and no outstanding commercial letters of credit. Since October 31, 2018, we had outstanding balances under the new Credit Facility, ranging from $150.0 million to $184.0 million. In addition, we had outstanding balances under the Revolving Loan Facility of the Prior Credit Facility, ranging from $34.9 million to $63.8 million during the three months ended October 31, 2018.

Borrowings under the Credit Facility shall be either: (i) Alternate Base Rate borrowings, which bear interest from the applicable borrowing date at a rate per annum equal to (x) the greatest of (a) the Prime Rate (as defined) in effect on such day, (b) the Federal Funds Effective Rate (as defined) in effect on such day plus 1/2 of 1.00% per annum and (c) the Adjusted LIBO Rate (as defined) on such day (or, if such day is not a business day, the immediately preceding business day) plus 1.00% per annum, plus (y) the Applicable Rate (as defined), or (ii) Eurodollar borrowings, which bear interest from the applicable borrowing date at a rate per annum equal to (x) the Adjusted LIBO Rate for such interest period plus (y) the Applicable Rate. Determination of the Applicable Rate is based on a pricing grid that is dependent upon our Secured Leverage Ratio (as defined) as of the end of each fiscal quarter for which consolidated financial statements have been most recently delivered.

The Credit Facility contains customary representations, warranties and affirmative covenants. The Credit Facility also contains customary negative covenants, subject to negotiated exceptions, including but not limited to: (i) liens, (ii) investments, (iii) indebtedness, (iv) significant corporate changes, including mergers and acquisitions, (v) dispositions, (vi) restricted payments, including stockholder dividends, and (vii) certain other restrictive agreements. The Credit Facility also contains certain financial covenants and customary events of default (subject to grace periods, as appropriate), such as payment defaults, cross-defaults to other material indebtedness, bankruptcy and insolvency, the occurrence of a defined change in control and the failure to observe the negative covenants and other covenants related to the operation of our business. In addition, under certain circumstances, we may be required to enter into amendments to the Credit Facility in connection with any further syndication of the Credit Facility.

The Credit Facility provides for, among other things: (i) no scheduled payments of principal until maturity; (ii) a maximum Secured Leverage Ratio of 3.75x trailing twelve months ("TTM") Adjusted Earnings Before Interest, Taxes, Depreciation and Amortization ("Adjusted EBITDA") and a Maximum Total Leverage Ratio of 4.50x TTM Adjusted EBITDA, each with no step downs; and (iii) a Minimum Interest Expense Coverage Ratio of 3.25x TTM Adjusted EBITDA.

As of July 31, 2019, our Secured Leverage Ratio was 1.74x TTM Adjusted EBITDA compared to the maximum allowable Secured Leverage Ratio of 3.75x TTM Adjusted EBITDA. Our Interest Expense Coverage Ratio as of July 31, 2019 was 12.05x TTM Adjusted EBITDA compared to the Minimum Interest Expense Coverage Ratio of 3.25x TTM Adjusted EBITDA. Given our expected future business performance, we anticipate maintaining compliance with the terms and financial covenants in our Credit Facility for the foreseeable future.

The obligations under the Credit Facility are guaranteed by certain of our domestic subsidiaries (the "Guarantors"). As collateral security under the Credit Facility and the guarantees thereof, we and the Guarantors have granted to the administrative agent, for the benefit of the lenders, a lien on, and first priority security interest in, substantially all of our tangible and intangible assets.

On December 6, 2018, we entered into the first amendment to the Credit Facility. The purpose of the amendment is to provide for a mechanism to replace the LIBO Rate for Eurodollar borrowings with an alternative benchmark interest rate, should the LIBO Rate generally become unavailable in the future on an other-than-temporary basis.

Capitalized terms used but not defined herein have the meanings set forth for such terms in the Credit Facility and the Prior Credit Facility, which have been documented and filed with the SEC.

Off-Balance Sheet Arrangements

As of July 31, 2019, we did not have any off-balance sheet arrangements as defined in Item 303(a)(4) of Regulation S-K.

Commitments

In the normal course of business, other than as discussed below, we routinely enter into binding and non-binding purchase obligations primarily covering anticipated purchases of inventory and equipment. We do not expect that these commitments, as of July 31, 2019, will materially adversely affect our liquidity.

At July 31, 2019, cash payments due under long-term obligations (including estimated interest expense on our Credit Facility), excluding purchase orders that we entered into in our normal course of business, are as follows:

	Obligations Due by Fiscal Years or Maturity Date (in thousands)				
	Total	2020	2021 and 2022	2023 and 2024	After 2024
Credit Facility - principal payments	$ 165,000	—	—	165,000	—
Credit Facility - interest payments	31,423	7,397	14,793	9,233	—
Operating lease commitments	44,214	11,812	16,066	9,206	7,130
Capital lease and other obligations	789	789	—	—	—
Net contractual cash obligations	$ 241,426	19,998	30,859	183,439	7,130

As discussed further in "*Notes to Consolidated Financial Statements - Note (8) - Credit Facility*" included in "*Part II - Item 8. - Financial Statements and Supplementary Data,*" included in this Annual Report on Form 10-K, on October 31, 2018, we entered into a new Credit Facility, replacing our Prior Credit Facility dated as of February 23, 2016. The new Credit Facility provides a senior secured loan facility of up to $550.0 million consisting of: (i) a revolving loan facility ("Revolving Loan Facility") with a borrowing limit of $300.0 million; (ii) an accordion feature allowing us to borrow up to an additional $250.0 million; (iii) a $35.0 million letter of credit sublimit; and (iv) a swingline loan credit sublimit of $25.0 million. The Credit Facility matures on October 31, 2023 (the "Revolving Maturity Date"). In addition, if we issue new unsecured debt in excess of $5.0 million with a maturity date that is less than 91 days from October 31, 2023, the Revolving Maturity Date would automatically accelerate so that it would be 91 days earlier than the maturity date of the new unsecured debt.

As discussed further in "*Notes to Consolidated Financial Statements - Note (16) - Stockholders' Equity*" included in "*Part II - Item 8. - Financial Statements and Supplementary Data,*" included in this Annual Report on Form 10-K, on September 24, 2019, our Board of Directors declared a dividend of $0.10 per common share, payable on November 15, 2019 to stockholders of record at the close of business on October 16, 2019. Future dividends remain subject to compliance with financial covenants under our Credit Facility, as amended, as well as Board approval.

At July 31, 2019, we have approximately $2.7 million of standby letters of credit outstanding under our Credit Facility related to our guarantees of future performance on certain customer contracts. Such amounts are not included in the above table.

In fiscal 2018, we entered into a full and final warranty settlement with AT&T, the largest customer/distributor of a small product line that we refer to as the TCS 911 call handling software solution. As discussed in *"Notes to Consolidated Financial Statements - Note (6) - Accrued Expenses and Other Current Liabilities,"* included in "*Part II - Item 8.- Financial Statements and Supplementary Data*," included in this Annual Report on Form 10-K, pursuant to the settlement agreement, we issued thirty-six credits to AT&T of $0.2 million which AT&T can apply on a monthly basis to purchases of solutions from us, beginning October 2017 through September 2020. As of July 31, 2019, the total present value of these monthly credits is $2.0 million, of which $1.7 million is included in accrued expenses and other current liabilities and $0.3 million is reflected in other liabilities (non-current) on our Consolidated Balance Sheet. These amounts are not shown in the above commitment table.

As discussed in *Notes to Consolidated Financial Statements - Note (7) - Cost Reduction Actions,"* included in "*Part II - Item 8.- Financial Statements and Supplementary Data*," included in this Annual Report on Form 10-K, during the three months ended October 31, 2018, we exited our Government Solutions segment's manufacturing facility located in Tampa, Florida and recorded a related charge of $1.4 million in selling, general and administrative expenses on our Consolidated Statement of Operations. As of July 31, 2019, the remaining estimated facility exit costs was $0.6 million which is included in "accrued expenses and other current liabilities" on our Consolidated Balance Sheet. Such amounts are not shown in the above commitment table.

In the ordinary course of business, we include indemnification provisions in certain of our customer contracts. Pursuant to these agreements, we have agreed to indemnify, hold harmless and reimburse the indemnified party for certain losses suffered or incurred by the indemnified party, including but not limited to losses related to third-party intellectual property claims. It is not possible to determine the maximum potential amount under these agreements due to a history of nominal claims in the Comtech legacy business and the unique facts and circumstances involved in each particular agreement. As discussed further in "*Notes to Consolidated Financial Statements - Note (13) - Commitments and Contingencies,*" included in "*Part II - Item 8.- Financial Statements and Supplementary Data*," included in this Annual Report on Form 10-K, TCS is subject to a number of indemnification demands and we are incurring ongoing legal expenses in connection with these matters. Our insurance policies may not cover the cost of defending indemnification claims or providing indemnification. As a result, pending or future claims asserted against us by a party that we have agreed to indemnify could result in legal costs and damages that could have a material adverse effect on our consolidated results of operations and financial condition.

We have change in control agreements, severance agreements and indemnification agreements with certain of our executive officers and certain key employees. All of these agreements may require payments by us, in certain circumstances, including, but not limited to, a change in control of our Company or an involuntary termination of employment without cause.

Our Consolidated Balance Sheet at July 31, 2019 includes total liabilities of $7.2 million for uncertain tax positions, including interest, any or all of which may result in a cash payment. The future payments related to uncertain tax positions have not been presented in the table above due to the uncertainty of the amounts and timing of any potential cash settlement with the taxing authorities.

Recent Accounting Pronouncements

We are required to prepare our consolidated financial statements in accordance with the Financial Accounting Standards Board ("FASB") Accounting Standards Codification ("ASC") which is the source for all authoritative U.S. generally accepted accounting principles, which is commonly referred to as "GAAP." The FASB ASC is subject to updates by the FASB, which are known as Accounting Standards Updates ("ASUs").

As further discussed in "*Notes to Consolidated Financial Statements – Note (1)(o) - Adoption of Accounting Standards and Updates*" included in "*Part II - Item 8. - Financial Statements and Supplementary Data,*" included in this Annual Report on Form 10-K, during fiscal 2019, we adopted:

- FASB ASU No. 2014-09 "Revenue from Contracts with Customers (Topic 606)." See *"Notes to Consolidated Financial Statements - Note (1)(d) - Summary of Significant Accounting and Reporting Policies - Revenue Recognition,"* included in "*Part II - Item 8. - Financial Statements and Supplementary Data,*" included in this Annual Report on Form 10-K, for further information.

- FASB ASU No. 2016-16, issued in October 2016, which eliminates a prior exception and now requires an entity to recognize the income tax consequences of an intra-entity transfer of an asset other than inventory (for example, intellectual property and property, plant and equipment) when the transfer occurs. We adopted this ASU on August 1, 2018. There was no material impact to our consolidated financial statements (including any cumulative effect adjustment) and disclosures upon such adoption.

- FASB ASU No. 2019-07, issued in June 2019, which amends various SEC guidance pursuant to the issuance of SEC Final Rule Release No. 33-10532, 33-10231, and 33-10442. This ASU clarifies or improves the disclosure and presentation requirements of a variety of Codification Topics by aligning them with the SEC's regulations, eliminating redundancies, and making the Codification easier to apply. There was no material impact to our consolidated financial statements and related disclosures upon such adoption.

In addition, the following FASB ASUs have been issued and incorporated into the FASB ASC and have not yet been adopted by us as of July 31, 2019:

- FASB ASU No. 2016-02, issued in February 2016 "Leases (Topic 842)," which requires lessees to recognize the following for all leases (with the exception of short-term leases): (i) a lease liability, which is a lessee's obligation to make lease payments arising from a lease, initially measured at the present value of the lease payments; and (ii) a right-of-use asset, which is an asset that represents the lessee's right to use a specified asset for the lease term. In January 2018, FASB ASU No. 2018-01 was issued to permit an entity to elect an optional transition practical expedient to not evaluate under Topic 842 land easements that exist or expired before the entity's adoption of Topic 842. In July 2018, the FASB issued ASU Nos. 2018-10 and 2018-11, which provide further codification improvements and relieves the requirement to present prior comparative year results when adopting the new lease standard. Instead, companies can choose to recognize the cumulative effect of applying the new standard to leased assets and liabilities as an adjustment to opening retained earnings. In December 2018, FASB ASU No. 2018-20 was issued to simplify the implementation of Topic 842 for lessors as it relates to sales taxes, lessor costs paid directly by the lessee and recognition of variable payments for contracts with lease and non-lease components. In March 2019, FASB ASU No. 2019-01 was issued, which addresses: (i) determining the fair value of the underlying asset by lessors that are not manufacturers or dealers; (ii) presentation of sales types and direct financing leases on the statement of cash flows; and (iii) transition disclosures related to Topic 250, "Accounting Changes and Error Corrections." This latest ASU specifically provides an exception to the paragraph 250-10-50-3 that would otherwise have required interim disclosures in the period of an accounting change including the effect of that change on income from continuing operations, net income, any other financial statement line item and any affected per-share amounts. As further discussed in "*Notes to Consolidated Financial Statements - Note (1)(c)- Summary of Significant Accounting and Reporting Policies - Adoption of New Leasing Standard*" included in Part II - Item 8. - *Financial Statements and Supplementary Data*, on August 1, 2019, we adopted the new leasing standard using the modified retrospective approach. In addition, we elected certain practical expedients permitted under the transition guidance within the new standard. Except for recording a total right-of-use asset and corresponding lease liability on our Consolidated Balance Sheet, which amount approximates 4.0% of our total consolidated assets at July 31, 2019, our adoption of Topic 842 is not expected to have a material impact to our future statements of operations or cash flows.

- FASB ASU No. 2016-13 issued in June 2016 and ASU No. 2018-19 issued in November 2018, which require the measurement of expected credit losses for financial assets held at the reporting date to be based on historical experience, current conditions and reasonable and supportable forecasts. In April 2019, FASB ASU No. 2019-04 was issued to provide clarification guidance in the following areas: (i) accrued interest; (ii) recoveries; (iii) projections of the interest rate environment; (iv) consideration of prepayments; and (v) other topics. In May 2019, FASB ASU No. 2019-05 was issued to provide entities with an option to irrevocably elect the fair value option applied on an instrument by instrument basis for eligible instruments. These ASUs are effective for fiscal years beginning after December 15, 2019 (our fiscal year beginning on August 1, 2020), including interim periods within those fiscal years. All entities may adopt the amendments in this ASU earlier as of the fiscal years beginning after December 15, 2018, including interim periods within those fiscal years. Except for a prospective transition approach required for debt securities for which an other-than-temporary impairment had been recognized before the effective date, an entity will apply the amendments in this ASU through a cumulative effect adjustment to retained earnings as of the beginning of the first reporting period in which the guidance is effective (that is, on a modified-retrospective approach). We are evaluating the impact of this ASU on our consolidated financial statements and disclosures.

- FASB ASU No. 2017-11, issued in July 2017, which provides guidance on the accounting for certain financial instruments with embedded features that result in the strike price of the instrument or embedded conversion option being reduced on the basis of the pricing of future equity offerings (commonly referred to as "down round" features). On August 1, 2019, we adopted this ASU. Our adoption of this ASU did not have any impact on our consolidated financial statements and disclosures, as we did not have any financial instruments with such "down round" features.

- FASB ASU No. 2017-12, issued in August 2017, which expands and refines hedge accounting for both non-financial and financial risk components and simplifies and aligns the recognition and presentation of the effects of the hedging instrument and the hedged item in the financial statements. On August 1, 2019, we adopted this ASU. Our adoption of this ASU did not have any impact on our consolidated financial statements and disclosures, as we are currently not a party to any such hedging transactions.

- FASB ASU No. 2018-07, issued in June 2018, which expands the scope of Topic 718 to include certain share-based payment transactions for acquiring goods and services from nonemployees. On August 1, 2019, we adopted this ASU. Our adoption of this ASU did not have any impact on our consolidated financial statements and disclosures, as we currently do not have any outstanding share-based awards with nonemployees that require remeasurement.

- FASB ASU No. 2018-13, issued in August 2018, which modifies the disclosure requirements for fair value measurements in Topic 820. This ASU is effective for fiscal years, and interim periods within those fiscal years, beginning after December 15, 2019 (our fiscal year beginning on August 1, 2020). Upon the effective date, certain provisions are to be applied prospectively, while others are to be applied retrospectively to all periods presented. An entity is permitted to early adopt any removed or modified disclosures upon issuance of this ASU and delay adoption of the additional disclosures until their effective date. We are evaluating the impact of this ASU on our consolidated financial statement disclosures.

- FASB ASU No. 2018-15, issued in August 2018, which aligns the requirements for capitalizing implementation costs incurred in a hosting arrangement that is a service contract with the requirements for capitalizing implementation costs incurred to develop or obtain internal use software (and hosting arrangements that include an internal use software license). The accounting for the service element of a hosting arrangement that is a service contract is not affected by the amendments in this ASU. This ASU is effective for fiscal years beginning after December 15, 2019 (our fiscal year beginning on August 1, 2020), and interim periods within those fiscal years. Early adoption is permitted, including adoption in any interim period. This ASU should be applied either retrospectively or prospectively to all implementation costs incurred after the date of adoption. We are evaluating the impact of this ASU on our consolidated financial statements and disclosures.

- FASB ASU No. 2018-16, issued in October 2018, which expands the list of eligible U.S. benchmark interest rates permitted in the application of hedge accounting due to broad concerns about the long-term sustainability of the LIBO Rate. This ASU adds the Overnight Index Swap ("OIS") rate, based on the Secured Overnight Financing Rate ("SOFR"), as an eligible U.S. benchmark interest rate. On August 1, 2019, we adopted this ASU. Our adoption of this ASU did not have any impact on our consolidated financial statements and disclosures, as we are currently not a party to any such hedging transactions.

- FASB ASU No. 2018-17, issued in October 2018, which requires entities to consider indirect interests held through related parties under common control on a proportional basis, rather than as the equivalent of a direct interest in its entirety when determining whether a decision-making fee is a variable interest. This ASU is effective for fiscal years beginning after December 15, 2019 (our fiscal year beginning on August 1, 2020) and for interim periods therein, with early adoption permitted. We are evaluating the impact of this ASU on our consolidated financial statements and disclosures; however, we do not expect the adoption to have any effect given that we currently do not have any indirect interests held through related parties in common control.

- FASB ASU No. 2018-18, issued in November 2018, which clarifies when certain transactions between collaborative arrangement participants should be accounted for under ASC 606 and incorporates unit-of-account guidance consistent with ASC 606 to aid in this determination. The ASU also precludes entities from presenting consideration from transactions with a collaborator that is not a customer together with revenue recognized from contracts with customers. This ASU is effective for fiscal years beginning after December 15, 2019 (our fiscal year beginning on August 1, 2020) and for interim periods therein, with early adoption permitted. We are evaluating the impact of this ASU on our consolidated financial statements and disclosures; however, we do not expect the adoption to have any effect given that we are currently not engaged in such collaborative arrangement transactions.

ITEM 7A. QUANTITATIVE AND QUALITATIVE DISCLOSURES ABOUT MARKET RISK

Our earnings and cash flows are subject to fluctuations due to changes in interest rates primarily from borrowings under our Credit Facility. Based on the amount of outstanding debt under our Credit Facility, a hypothetical change in interest rates by 10% would change interest expense by $0.7 million over a one-year period. Although we do not currently use interest rate derivative instruments to manage exposure to interest rate changes, we may choose to do so in the future in connection with our Credit Facility.

Our earnings and cash flows are also subject to fluctuations due to changes in interest rates on our investment of available cash balances. As of July 31, 2019, we had cash and cash equivalents of $45.6 million, which consisted of cash and highly-liquid money market deposit accounts. Many of these investments are subject to fluctuations in interest rates, which could impact our results. Based on our investment portfolio balance as of July 31, 2019, a hypothetical change in interest rates of 10% would have a nominal impact on interest income over a one-year period. Ultimately, the availability of our cash and cash equivalents is dependent on a well-functioning liquid market.

ITEM 8. FINANCIAL STATEMENTS AND SUPPLEMENTARY DATA

Reports of Independent Registered Public Accounting Firm, Consolidated Financial Statements, Notes to Consolidated Financial Statements and Related Financial Schedule are listed in the Index to Consolidated Financial Statements and Schedule annexed hereto.

ITEM 9. CHANGES IN AND DISAGREEMENTS WITH ACCOUNTANTS ON ACCOUNTING AND FINANCIAL DISCLOSURE

None.

ITEM 9A. CONTROLS AND PROCEDURES

Evaluation of Disclosure Controls and Procedures

As of the end of the period covered by this Annual Report on Form 10-K, an evaluation of the effectiveness of the design and operation of our disclosure controls and procedures was carried out by us under the supervision and with the participation of our management, including our President, Chief Executive Officer and Chairman and Chief Financial Officer. Based on that evaluation, our President, Chief Executive Officer and Chairman and Chief Financial Officer concluded that our disclosure controls and procedures were effective as of the end of the period covered by the report to provide reasonable assurance that the information required to be disclosed by us in reports filed under the Securities Exchange Act of 1934, as amended, is recorded, processed, summarized and reported, within the time periods specified in the SEC's rules and forms and is accumulated and communicated to management, as appropriate, to allow timely decisions regarding required disclosure. A system of controls, no matter how well designed and operated, cannot provide absolute assurance that the objectives of the system of controls are met, and no evaluation of controls can provide absolute assurance that all control issues and instances of fraud, if any, within a company have been detected.

Management's Report on Internal Control Over Financial Reporting

Management is responsible for establishing and maintaining adequate internal control over financial reporting as defined in Rules 13a-15(f) and 15d-15(f) under the Securities Exchange Act of 1934. Our internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. All internal control systems, no matter how well designed, have inherent limitations. Therefore, even those systems determined to be effective can provide only reasonable assurance with respect to financial statement preparation and presentation. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

Management assessed the effectiveness of our internal control over financial reporting as of July 31, 2019. In making this assessment, we used the criteria set forth by the Committee of Sponsoring Organizations of the Treadway Commission ("COSO") in *Internal Control – Integrated Framework (2013)*. Based on our assessment, we determined that, as of July 31, 2019, our internal control over financial reporting was effective based on those criteria.

Deloitte and Touche LLP, our independent registered public accounting firm, has performed an audit of our internal control over financial reporting as of July 31, 2019 based on criteria established in *Internal Control – Integrated Framework (2013)* issued by the COSO. This audit is required to be performed in accordance with the standards of the Public Company Accounting Oversight Board (United States). Our independent auditors were given unrestricted access to all financial records and related data. Deloitte's audit reports appear on pages F-2 and F-3 of this annual report.

Changes In Internal Control Over Financial Reporting

There have been no changes in our internal control over financial reporting as defined in Rules 13a-15(f) and 15d-15(f) under the Exchange Act that occurred during our fiscal quarter ended July 31, 2019, that have materially affected, or are reasonably likely to materially affect, our internal control over financial reporting.

ITEM 9B. OTHER INFORMATION

Not applicable.

PART III

ITEM 10. DIRECTORS, EXECUTIVE OFFICERS AND CORPORATE GOVERNANCE

Certain information concerning directors and officers is incorporated by reference to our Proxy Statement for the Annual Meeting of Stockholders (the "Proxy Statement") which will be filed with the Securities and Exchange Commission no more than 120 days after the close of our fiscal year.

ITEM 11. EXECUTIVE COMPENSATION

Information regarding executive compensation is incorporated by reference to the Proxy Statement, which will be filed with the Securities and Exchange Commission no more than 120 days after the close of our fiscal year.

ITEM 12. SECURITY OWNERSHIP OF CERTAIN BENEFICIAL OWNERS AND MANAGEMENT AND RELATED STOCKHOLDER MATTERS

Information regarding securities authorized for issuance under equity compensation plans and certain information regarding security ownership of certain beneficial owners and management is incorporated by reference to the Proxy Statement, which will be filed with the Securities and Exchange Commission no more than 120 days after the close of our fiscal year.

ITEM 13. CERTAIN RELATIONSHIPS AND RELATED TRANSACTIONS, AND DIRECTOR INDEPENDENCE

Information regarding certain relationships and related transactions is incorporated by reference to the Proxy Statement, which will be filed with the Securities and Exchange Commission no more than 120 days after the close of our fiscal year.

ITEM 14. PRINCIPAL ACCOUNTING FEES AND SERVICES

Information regarding principal accountant fees and services is incorporated by reference to the Proxy Statement, which will be filed with the Securities and Exchange Commission no more than 120 days after the close of our fiscal year.

PART IV

ITEM 15. EXHIBITS, FINANCIAL STATEMENT SCHEDULES

(a) (1) The Registrant's financial statements together with a separate index are annexed hereto.

(2) The Financial Statement Schedule listed in a separate index is annexed hereto.

(3) Exhibits required by Item 601 of Regulation S-K are listed below.

Exhibit Number	Description of Exhibit	Incorporated By Reference to Exhibit
3(a)(i)	Restated Certificate of Incorporation of the Registrant	Exhibit 3(a)(i) to the Registrant's 2006 Form 10-K
3(a)(ii)	Third Amended and Restated By-Laws of the Registrant, as of September 26, 2017	Exhibit 3(a)(ii) to the Registrant's 2017 Form 10-K
10(a)(1)*	Sixth Amended and Restated Employment Agreement, dated November 18, 2016, between the Registrant and Fred Kornberg	Exhibit 10.1 to the Registrant's Form 10-Q, filed December 7, 2016
10(a)(2)*	Amendment to Sixth Amended and Restated Employment Agreement, dated June 6, 2017, between the Registrant and Fred Kornberg	Exhibit 10.7 to the Registrant's Form 8-K, filed June 7, 2017
10(a)(3)*	Lease agreement, dated September 23, 2011, on the Melville, New York Facility	Exhibit 10(s) to the Registrant's 2011 Form 10-K
10(b)*	Second Amended and Restated 2001 Employee Stock Purchase Plan	Exhibit A to the Registrant's Proxy Statement, filed November 16, 2018
10(c)*	2000 Stock Incentive Plan, Amended and Restated, Effective March 6, 2018	Exhibit 10.1 to the Registrant's Form 10-Q, filed June 6, 2018
10(d)(1)*	Form of Stock Option Agreement pursuant to the 2000 Stock Incentive Plan	Exhibit 10(f)(7) to the Registrant's 2005 Form 10-K
10(d)(2)*	Form of Stock Option Agreement for Non-employee Directors pursuant to the 2000 Stock Incentive Plan	Exhibit 10(f)(8) to the Registrant's 2006 Form 10-K
10(e)(1)*	Form of Performance Share Agreement pursuant to the 2000 Stock Incentive Plan	Exhibit 10(s) to the Registrant's 2012 Form 10-K
10(e)(2)*	Form of Performance Share Agreement (eligible for dividend equivalents) (Auto Deferral) pursuant to the 2000 Stock Incentive Plan	Exhibit 10(z) to the Registrant's 2013 Form 10-K
10(f)(1)*	Form of Long-Term Performance Share Award Agreement pursuant to the 2000 Stock Incentive Plan - 2017	Exhibit 10.8 to the Registrant's Form 8-K, filed June 7, 2017
10(f)(2)*	Form of Long-Term Performance Share Award Agreement pursuant to the 2000 Stock Incentive Plan - 2018	
10(g)(1)*	Form of Restricted Stock Agreement for Employees pursuant to the 2000 Stock Incentive Plan	Exhibit 10(y) to the Registrant's 2016 Form 10-K
10(g)(2)*	Form of Restricted Stock Agreement for Non-employee Directors pursuant to the 2000 Stock Incentive Plan	Exhibit 10(ab) to the Registrant's 2016 Form 10-K

Exhibit Number	Description of Exhibit	Incorporated By Reference to Exhibit
10(g)(3)*	Form of Restricted Stock Agreement (eligible for dividend equivalents) for Non-employee Directors pursuant to the 2000 Stock Incentive Plan - 2019	
10(h)(1)*	Form of Restricted Stock Unit Agreement for Employees pursuant to the 2000 Stock Incentive Plan - 2017	Exhibit 10(h)(1) to the Registrant's 2017 Form 10-K
10(h)(2)*	Form of Restricted Stock Unit Agreement for Employees pursuant to the 2000 Stock Incentive Plan - 2016	Exhibit 10(z) to the Registrant's 2016 Form 10-K
10(h)(3)*	Form of Restricted Stock Unit Agreement for Employees pursuant to the 2000 Stock Incentive Plan - 2013	Exhibit 10(w) to the Registrant's 2013 Form 10-K
10(h)(4)*	Form of Restricted Stock Unit Agreement for Non-employee Directors pursuant to the 2000 Stock Incentive Plan	Exhibit 10.2 to the Registrant's Form 10-Q, filed June 7, 2012
10(h)(5)*	Form of Restricted Stock Unit Agreement (eligible for dividend equivalents) for Non-employee Directors pursuant to the 2000 Stock Incentive Plan	Exhibit 10(aa) to the Registrant's 2016 Form 10-K
10(h)(6)*	Form of Restricted Stock Unit Agreement (eligible for dividend equivalents) for Non-employee Directors pursuant to the 2000 Stock Incentive Plan - 2013	Exhibit 10(x) to the Registrant's 2013 Form 10-K
10(i)(1)*	Form of Stock Unit Agreement for Non-employee Directors pursuant to the 2000 Stock Incentive Plan	Exhibit 10.1 to the Registrant's Form 10-Q, filed June 7, 2012
10(i)(2)*	Form of Stock Unit Agreement (eligible for dividend equivalents) for Non-employee Directors pursuant to the 2000 Stock Incentive Plan	Exhibit 10(v) to the Registrant's 2013 Form 10-K
10(j)(1)*	Form of Share Unit Agreement (eligible for dividend equivalents) for Employees pursuant to the 2000 Stock Incentive Plan	Exhibit 10.2 to the Registrant's Form 10-Q, filed December 9, 2013
10(j)(2)*	Form of Share Unit Agreement (eligible for dividend equivalents) for Employees pursuant to the 2000 Stock Incentive Plan - 2018	Exhibit 10(j)(2) to the Registrant's 2018 Form 10-K
10(k)*	Form of Indemnification Agreement between the Registrant and the Named Executive Officers and Certain Other Executive Officers	Exhibit 10.1 to Registrant's Form 8-K, filed on March 8, 2007
10(l)(1)*	Form of Change-in-Control Agreement (Tier 2) between the Registrant and Named Executive Officers (other than the CEO) and Certain Other Executive Officers	Exhibit 10.2 to the Registrant's Form 8-K, filed June 7, 2017
10(l)(2)*	Form of Change-in-Control Agreement (Tier 2) between the Registrant and Named Executive Officers (other than the CEO) and Certain Other Executive Officers (California Employees)	Exhibit 10.3 to the Registrant's Form 8-K, filed June 7, 2017
10(l)(3)*	Form of Change-in-Control Agreement (Tier 2) between the Registrant and Named Executive Officers (other than the CEO) and Certain Other Executive Officers (Divisional/Subsidiary Presidents)	Exhibit 10.4 to the Registrant's Form 8-K, filed June 7, 2017
10(l)(4)*	Form of Change-in-Control Agreement (Tier 2) between the Registrant and Named Executive Officers (other than the CEO) and Certain Other Executive Officers (California Divisional/ Subsidiary Presidents)	Exhibit 10.5 to the Registrant's Form 8-K, filed June 7, 2017

Exhibit Number	Description of Exhibit	Incorporated By Reference to Exhibit
10(l)(5)*	Form of Change-in-Control Agreement (Tier 3) between the Registrant and Certain Non-Executive Officers	Exhibit 10.6 to the Registrant's Form 8-K, filed June 7, 2017
10(m)*	Agreement and Plan of Merger, dated as of November 22, 2015, among Comtech Telecommunications Corp., Typhoon Acquisition Corp. and TeleCommunication Systems, Inc.	Exhibit 2.1 to the Registrant's Form 8-K, filed November 23, 2015
10(n)(1)*	First Amended and Restated Credit Agreement, dated as of October 31, 2018, among Comtech Telecommunications Corp., the lenders party thereto and Citibank N.A., as administrative agent, issuing bank and swingline lender.	Exhibit 10.1 to the Registrant's Form 8-K, filed November 5, 2018
21	Subsidiaries of the Registrant	
23.1	Consent of Independent Registered Public Accounting Firm	
31.1	Certification of President, CEO and Chairman pursuant to Section 302 of the Sarbanes-Oxley Act of 2002	
31.2	Certification of Chief Financial Officer pursuant to Section 302 of the Sarbanes-Oxley Act of 2002	
32.1	Certification of President, CEO and Chairman pursuant to Section 906 of the Sarbanes-Oxley Act of 2002	
32.2	Certification of Chief Financial Officer pursuant to Section 906 of the Sarbanes-Oxley Act of 2002	
101.INS	XBRL Instance Document	
101.SCH	XBRL Taxonomy Extension Schema Document	
101.CAL	XBRL Taxonomy Extension Calculation Linkbase Document	
101.LAB	XBRL Taxonomy Extension Labels Linkbase Document	
101.PRE	XBRL Taxonomy Extension Presentation Linkbase Document	
101.DEF	XBRL Taxonomy Extension Definition Linkbase Document	

* Management contract or compensatory plan or arrangement.

SIGNATURES

Pursuant to the requirements of Section 13 or 15(d) of the Securities and Exchange Act of 1934, the registrant has duly caused this report to be signed on its behalf by the undersigned, thereunto duly authorized.

COMTECH TELECOMMUNICATIONS CORP.

September 24, 2019
(Date)

By: /s/Fred Kornberg
Fred Kornberg, Chairman of the Board
Chief Executive Officer and President

Pursuant to the requirements of the Securities Exchange Act of 1934, this report has been signed below by the following persons on behalf of the registrant and in the capacities and on the dates indicated.

	Signature	Title
September 24, 2019 (Date)	/s/Fred Kornberg Fred Kornberg	Chairman of the Board Chief Executive Officer and President (Principal Executive Officer)
September 24, 2019 (Date)	/s/Michael A. Bondi Michael A. Bondi	Chief Financial Officer (Principal Financial and Accounting Officer)
September 24, 2019 (Date)	/s/Edwin Kantor Edwin Kantor	Director
September 24, 2019 (Date)	/s/Ira S. Kaplan Ira S. Kaplan	Director
September 24, 2019 (Date)	/s/Robert G. Paul Robert G. Paul	Director
September 24, 2019 (Date)	/s/Dr. Yacov A. Shamash Dr. Yacov A. Shamash	Director
September 24, 2019 (Date)	/s/Lawrence J. Waldman Lawrence J. Waldman	Director

COMTECH TELECOMMUNICATIONS CORP. AND SUBSIDIARIES

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Schedules not listed above have been omitted because they are either not applicable or the required information has been provided elsewhere in the consolidated financial statements or notes thereto.

REPORT OF INDEPENDENT REGISTERED PUBLIC ACCOUNTING FIRM

To the stockholders and the Board of Directors of
Comtech Telecommunications Corp.
Melville, New York

Opinion on the Financial Statements

We have audited the accompanying consolidated balance sheets of Comtech Telecommunications Corp. and subsidiaries (the "Company") as of July 31, 2019 and 2018, the related consolidated statements of operations, stockholders' equity, and cash flows, for each of the three years in the period ended July 31, 2019, and the related notes and the schedule listed in the Index at Item 15 (collectively referred to as the "financial statements"). In our opinion, the financial statements present fairly, in all material respects, the financial position of the Company as of July 31, 2019 and 2018, and the results of its operations and its cash flows for each of the three years in the period ended July 31, 2019, in conformity with accounting principles generally accepted in the United States of America.

We have also audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) (PCAOB), the Company's internal control over financial reporting as of July 31, 2019, based on criteria established in *Internal Control-Integrated Framework (2013)* issued by the Committee of Sponsoring Organizations of the Treadway Commission and our report dated September 24, 2019, expressed an unqualified opinion on the Company's internal control over financial reporting.

Basis for Opinion

These financial statements are the responsibility of the Company's management. Our responsibility is to express an opinion on the Company's financial statements based on our audits. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audits in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement, whether due to error or fraud. Our audits included performing procedures to assess the risks of material misstatement of the financial statements, whether due to error or fraud, and performing procedures that respond to those risks. Such procedures included examining, on a test basis, evidence regarding the amounts and disclosures in the financial statements. Our audits also included evaluating the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the financial statements. We believe that our audits provide a reasonable basis for our opinion.

/s/ DELOITTE & TOUCHE LLP

Jericho, New York
September 24, 2019

We have served as the Company's auditor since 2015.

Deloitte.

REPORT OF INDEPENDENT REGISTERED PUBLIC ACCOUNTING FIRM

To the stockholders and the Board of Directors of
Comtech Telecommunications Corp.
Melville, New York

Opinion on Internal Control over Financial Reporting

We have audited the internal control over financial reporting of Comtech Telecommunications Corp. and subsidiaries (the "Company") as of July 31, 2019, based on criteria established in *Internal Control - Integrated Framework (2013)* issued by the Committee of Sponsoring Organizations of the Treadway Commission (COSO). In our opinion, the Company maintained, in all material respects, effective internal control over financial reporting as of July 31, 2019, based on criteria established in *Internal Control - Integrated Framework (2013)* issued by COSO.

We have also audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) (PCAOB), the consolidated financial statements and financial statement schedule as of and for the year ended July 31, 2019, of the Company and our report dated September 24, 2019, expressed an unqualified opinion on those financial statements and financial statement schedule.

Basis for Opinion

The Company's management is responsible for maintaining effective internal control over financial reporting and for its assessment of the effectiveness of internal control over financial reporting, included in the accompanying Management's Report on Internal Control Over Financial Reporting. Our responsibility is to express an opinion on the Company's internal control over financial reporting based on our audit. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audit in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether effective internal control over financial reporting was maintained in all material respects. Our audit included obtaining an understanding of internal control over financial reporting, assessing the risk that a material weakness exists, testing and evaluating the design and operating effectiveness of internal control based on the assessed risk, and performing such other procedures as we considered necessary in the circumstances. We believe that our audit provides a reasonable basis for our opinion.

Definition and Limitations of Internal Control over Financial Reporting

A company’s internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company’s internal control over financial reporting includes those policies and procedures that (1) pertain to the maintenance of records that, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the company; (2) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the company are being made only in accordance with authorizations of management and directors of the company; and (3) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company’s assets that could have a material effect on the financial statements.

Because of its inherent limitations, internal control over financial reporting may not prevent or detect misstatements. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

/s/ DELOITTE & TOUCHE LLP

Jericho, New York
September 24, 2019

COMTECH TELECOMMUNICATIONS CORP.
AND SUBSIDIARIES
Consolidated Balance Sheets
As of July 31, 2019 and 2018

Assets	2019	2018
Current assets:		
Cash and cash equivalents	$ 45,576,000	43,484,000
Accounts receivable, net	145,032,000	147,439,000
Inventories, net	74,839,000	75,076,000
Prepaid expenses and other current assets	14,867,000	13,794,000
Total current assets	280,314,000	279,793,000
Property, plant and equipment, net	28,026,000	28,987,000
Goodwill	310,489,000	290,633,000
Intangibles with finite lives, net	261,890,000	240,796,000
Deferred financing costs, net	3,128,000	2,205,000
Other assets, net	3,864,000	2,743,000
Total assets	$ 887,711,000	845,157,000
Liabilities and Stockholders' Equity		
Current liabilities:		
Accounts payable	$ 24,330,000	43,928,000
Accrued expenses and other current liabilities	78,584,000	65,034,000
Dividends payable	2,406,000	2,356,000
Contract liabilities	38,682,000	34,452,000
Current portion of long-term debt	—	17,211,000
Current portion of capital lease and other obligations	757,000	1,836,000
Interest payable	588,000	499,000
Total current liabilities	145,347,000	165,316,000
Non-current portion of long-term debt, net	165,000,000	148,087,000
Non-current portion of capital lease and other obligations	—	765,000
Income taxes payable	325,000	2,572,000
Deferred tax liability, net	12,481,000	10,927,000
Long-term contract liabilities	10,654,000	7,689,000
Other liabilities	18,822,000	4,117,000
Total liabilities	352,629,000	339,473,000
Commitments and contingencies (See Note 13)		
Stockholders' equity:		
Preferred stock, par value $.10 per share; shares authorized and unissued 2,000,000	—	—
Common stock, par value $.10 per share; authorized 100,000,000 shares; issued 39,276,161 shares and 38,860,571 shares at July 31, 2019 and 2018, respectively	3,928,000	3,886,000
Additional paid-in capital	552,670,000	538,453,000
Retained earnings	420,333,000	405,194,000
	976,931,000	947,533,000
Less:		
Treasury stock, at cost (15,033,317 shares at July 31, 2019 and 2018)	(441,849,000)	(441,849,000)
Total stockholders' equity	535,082,000	505,684,000
Total liabilities and stockholders' equity	$ 887,711,000	845,157,000

See accompanying notes to consolidated financial statements.

COMTECH TELECOMMUNICATIONS CORP.
AND SUBSIDIARIES
Consolidated Statements of Operations
Fiscal Years Ended July 31, 2019, 2018 and 2017

	2019	2018	2017
Net sales	$ 671,797,000	570,589,000	550,368,000
Cost of sales	424,357,000	346,648,000	332,183,000
Gross profit	247,440,000	223,941,000	218,185,000
Expenses:			
Selling, general and administrative	128,639,000	113,922,000	116,080,000
Research and development	56,407,000	53,869,000	54,260,000
Amortization of intangibles	18,320,000	21,075,000	22,823,000
Settlement of intellectual property litigation	(3,204,000)	—	(12,020,000)
Acquisition plan expenses	5,871,000	—	—
	206,033,000	188,866,000	181,143,000
Operating income	41,407,000	35,075,000	37,042,000
Other expenses (income):			
Interest expense	9,245,000	10,195,000	11,629,000
Write-off of deferred financing costs	3,217,000	—	—
Interest (income) and other	35,000	254,000	(68,000)
Income before provision for (benefit from) income taxes	28,910,000	24,626,000	25,481,000
Provision for (benefit from) income taxes	3,869,000	(5,143,000)	9,654,000
Net income	$ 25,041,000	29,769,000	15,827,000
Net income per share:			
Basic	$ 1.04	1.25	0.68
Diluted	$ 1.03	1.24	0.67
Weighted average number of common shares outstanding – basic	24,124,000	23,825,000	23,433,000
Weighted average number of common and common equivalent shares outstanding – diluted	24,302,000	24,040,000	23,489,000

See accompanying notes to consolidated financial statements.

COMTECH TELECOMMUNICATIONS CORP.
AND SUBSIDIARIES
Consolidated Statements of Stockholders' Equity
Fiscal Years Ended July 31, 2019, 2018 and 2017

	Common Stock		Additional Paid-in Capital	Retained Earnings	Treasury Stock		Stockholders' Equity
	Shares	Amount			Shares	Amount	
Balance as of July 31, 2016	38,367,997	$ 3,837,000	$ 524,797,000	$ 383,616,000	15,033,317	$ (441,849,000)	$ 470,401,000
Equity-classified stock award compensation	—	—	8,467,000	—	—	—	8,467,000
Proceeds from issuance of employee stock purchase plan shares	64,367	7,000	687,000	—	—	—	694,000
Issuance of restricted stock, net	144,988	14,000	(14,000)	—	—	—	—
Net settlement of stock-based awards	42,115	4,000	(266,000)	—	—	—	(262,000)
Cash dividends declared ($0.60 per share)	—	—	—	(14,034,000)	—	—	(14,034,000)
Accrual of dividend equivalents, net of reversal ($0.60 per share)	—	—	—	(273,000)	—	—	(273,000)
Net income tax shortfall from settlement of stock-based awards	—	—	(248,000)	—	—	—	(248,000)
Reversal of deferred tax assets associated with expired and unexercised stock-based awards	—	—	(422,000)	—	—	—	(422,000)
Net income	—	—	—	15,827,000	—	—	15,827,000
Balance as of July 31, 2017	38,619,467	3,862,000	533,001,000	385,136,000	15,033,317	(441,849,000)	480,150,000
Equity-classified stock award compensation	—	—	8,605,000	—	—	—	8,605,000
Proceeds from exercises of stock options	13,100	1,000	325,000	—	—	—	326,000
Proceeds from issuance of employee stock purchase plan shares	44,996	5,000	850,000	—	—	—	855,000
Forfeiture of restricted stock	(10,254)	(1,000)	1,000	—	—	—	—
Net settlement of stock-based awards	193,262	19,000	(4,329,000)	—	—	—	(4,310,000)
Cash dividends declared ($0.40 per share)	—	—	—	(9,411,000)	—	—	(9,411,000)
Accrual of dividend equivalents, net of reversal ($0.40 per share)	—	—	—	(300,000)	—	—	(300,000)
Net income	—	—	—	29,769,000	—	—	29,769,000
Balance as of July 31, 2018	38,860,571	3,886,000	538,453,000	405,194,000	15,033,317	(441,849,000)	505,684,000
Equity-classified stock award compensation	—	—	11,427,000	—	—	—	11,427,000
Proceeds from exercises of stock options	8,100	1,000	215,000	—	—	—	216,000
Proceeds from issuance of employee stock purchase plan shares	43,316	4,000	922,000	—	—	—	926,000
Issuance of restricted stock	10,386	1,000	(1,000)	—	—	—	—
Net settlement of stock-based awards	145,119	15,000	(3,931,000)	—	—	—	(3,916,000)
Common stock issued for acquisition of Solacom Technologies, Inc.	208,669	21,000	5,585,000	—	—	—	5,606,000
Cash dividends declared, net ($0.40 per share)	—	—	—	(9,575,000)	—	—	(9,575,000)
Accrual of dividend equivalents, net of reversal ($0.40 per share)	—	—	—	(327,000)	—	—	(327,000)
Net income	—	—	—	25,041,000	—	—	25,041,000
Balance as of July 31, 2019	39,276,161	$ 3,928,000	$ 552,670,000	$ 420,333,000	15,033,317	$ (441,849,000)	$ 535,082,000

See accompanying notes to consolidated financial statements.

COMTECH TELECOMMUNICATIONS CORP.
AND SUBSIDIARIES
Consolidated Statements of Cash Flows
Fiscal Years Ended July 31, 2019, 2018 and 2017

	2019	2018	2017
Cash flows from operating activities:			
Net income	$ 25,041,000	29,769,000	15,827,000
Adjustments to reconcile net income to net cash provided by operating activities:			
Depreciation and amortization of property, plant and equipment	11,927,000	13,655,000	14,354,000
Amortization of intangible assets with finite lives	18,320,000	21,075,000	22,823,000
Amortization of stock-based compensation	11,427,000	8,569,000	8,506,000
Amortization of deferred financing costs	1,099,000	2,196,000	1,977,000
Estimated contract settlement costs	6,351,000	—	—
Settlement of intellectual property litigation	(3,204,000)	—	(12,020,000)
Write-off of deferred financing costs	3,217,000	—	—
Changes in other liabilities	(1,056,000)	—	—
Loss (gain) on disposal of property, plant and equipment	144,000	79,000	(126,000)
Provision for allowance for doubtful accounts	1,136,000	573,000	497,000
Provision for excess and obsolete inventory	6,015,000	5,628,000	2,900,000
Deferred income tax expense (benefit)	4,283,000	(6,379,000)	9,056,000
Excess income tax benefit from stock-based award exercises	—	—	(82,000)
Changes in assets and liabilities, net of effects of business acquisition:			
Accounts receivable	6,315,000	(24,578,000)	25,508,000
Inventories	(3,787,000)	(20,065,000)	7,812,000
Prepaid expenses and other current assets	915,000	787,000	(956,000)
Other assets	102,000	(140,000)	666,000
Accounts payable	(21,290,000)	13,728,000	(4,472,000)
Accrued expenses and other current liabilities	3,554,000	(3,374,000)	(21,796,000)
Contract liabilities	(127,000)	9,143,000	(2,431,000)
Other liabilities, non-current	(84,000)	(682,000)	(1,442,000)
Interest payable	151,000	234,000	(1,039,000)
Income taxes payable	(2,418,000)	126,000	1,355,000
Net cash provided by operating activities	68,031,000	50,344,000	66,917,000
Cash flows from investing activities:			
Payment for acquisition of Solacom Technologies Inc., net of cash acquired	(25,883,000)	—	—
Payment for acquisition of the GD NG-911 business	(10,000,000)	—	—
Purchases of property, plant and equipment	(8,785,000)	(8,642,000)	(8,150,000)
Net cash used in investing activities	(44,668,000)	(8,642,000)	(8,150,000)
Cash flows from financing activities:			
Net borrowings of long-term debt under Credit Facility	165,000,000	—	—
Repayment of debt under Term Loan portion of Prior Credit Facility	(120,121,000)	(18,960,000)	(33,567,000)
Net payments under Revolving Loan portion of Prior Credit Facility	(48,603,000)	(8,800,000)	(26,500,000)
Cash dividends paid	(9,789,000)	(9,538,000)	(18,872,000)
Remittance of employees' statutory tax withholdings for stock awards	(5,042,000)	(1,143,000)	(262,000)
Repayment of principal amounts under capital lease and other obligations	(1,906,000)	(2,802,000)	(3,592,000)
Payment of deferred financing costs	(1,813,000)	—	(1,085,000)
Proceeds from issuance of employee stock purchase plan shares	935,000	855,000	694,000
Proceeds from exercises of stock options	216,000	326,000	—
Payment of shelf registration costs and equity issuance costs	(148,000)	—	(626,000)
Excess income tax benefit from stock-based award exercises	—	—	82,000
Net cash used in financing activities	(21,271,000)	(40,062,000)	(83,728,000)

(Continued)

COMTECH TELECOMMUNICATIONS CORP.
AND SUBSIDIARIES
Consolidated Statements of Cash Flows (continued)
Fiscal Years Ended July 31, 2019, 2018 and 2017

	2019	2018	2017
Net increase (decrease) in cash and cash equivalents	$ 2,092,000	1,640,000	(24,961,000)
Cash and cash equivalents at beginning of year	43,484,000	41,844,000	66,805,000
Cash and cash equivalents at end of year	$ 45,576,000	43,484,000	41,844,000
Supplemental cash flow disclosure			
Cash paid (received) during the year for:			
Interest	$ 7,669,000	7,291,000	10,424,000
Income taxes, net	$ 2,005,000	1,112,000	(758,000)
Non-cash investing and financing activities:			
Accrued remittance of employees' statutory tax withholdings for fully-vested share units	$ 1,787,000	2,963,000	—
Cash dividends declared but unpaid (including accrual of dividend equivalents)	$ 2,733,000	2,656,000	2,616,000
Capital lease and other obligations incurred	$ —	1,306,000	68,000
Accrued additions to property, plant and equipment	$ 902,000	719,000	1,221,000
Issuance (forfeiture) of restricted stock	$ 1,000	(1,000)	14,000
Common stock issued for acquisition of Solacom Technologies Inc.	$ 5,606,000	—	—

See accompanying notes to consolidated financial statements.

(1) Summary of Significant Accounting and Reporting Policies

(a) Principles of Consolidation

The accompanying consolidated financial statements include the accounts of Comtech Telecommunications Corp. and its subsidiaries ("Comtech," "we," "us," or "our"), all of which are wholly-owned. All significant intercompany balances and transactions have been eliminated in consolidation.

(b) Nature of Business

We design, develop, produce and market innovative products, systems and services for advanced communications solutions. We conduct our business through two reportable operating segments: Commercial Solutions and Government Solutions.

Our business is highly competitive and characterized by rapid technological change. Our growth and financial position depends on our ability to keep pace with such changes and developments and to respond to the sophisticated requirements of an increasing variety of secure wireless communications technology users, among other things. Many of our competitors are substantially larger, and have significantly greater financial, marketing and operating resources and broader product lines than our own. A significant technological or sales breakthrough by others, including smaller competitors or new companies, could have a material adverse effect on our business. In addition, certain of our customers have technological capabilities in our product areas and could choose to replace our products with their own.

International sales expose us to certain risks, including barriers to trade, fluctuations in foreign currency exchange rates (which may make our products less price competitive), political and economic instability, availability of suitable export financing, export license requirements, tariff regulations, and other United States ("U.S.") and foreign regulations that may apply to the export of our products, as well as the generally greater difficulties of doing business abroad. We attempt to reduce the risk of doing business in foreign countries by seeking contracts denominated in U.S. dollars, advance or milestone payments, credit insurance and irrevocable letters of credit in our favor.

(c) Adoption of New Leasing Standard

On August 1, 2019 (the start of our first quarter of fiscal 2020), we adopted ASU No. 2016-02 "Leases (Topic 842)," which requires lessees to recognize the following for all leases (with the exception of short-term leases): (i) a lease liability, which is a lessee's obligation to make lease payments arising from a lease, initially measured at the present value of the lease payments; and (ii) a right-of-use asset, which is an asset that represents the lessee's right to use a specified asset for the lease term. In January 2018, FASB ASU No. 2018-01 was issued to permit an entity to elect an optional transition practical expedient to not evaluate under Topic 842 land easements that exist or expired before the entity’s adoption of Topic 842. In July 2018, the FASB issued ASU Nos. 2018-10 and 2018-11, which provide further codification improvements and relieves the requirement to present prior comparative year results when adopting the new lease standard. Instead, companies can choose to recognize the cumulative effect of applying the new standard to leased assets and liabilities as an adjustment to opening retained earnings. In December 2018, FASB ASU No. 2018-20 was issued to simplify the implementation of Topic 842 for lessors as it relates to sales taxes, lessor costs paid directly by the lessee and recognition of variable payments for contracts with lease and non-lease components. In March 2019, FASB ASU No. 2019-01 was issued, which addresses: (i) determining the fair value of the underlying asset by lessors that are not manufacturers or dealers; (ii) presentation of sales types and direct financing leases on the statement of cash flows; and (iii) transition disclosures related to Topic 250, "Accounting Changes and Error Corrections." This latest ASU specifically provides an exception to the paragraph 250-10-50-3 that would otherwise have required interim disclosures in the period of an accounting change including the effect of that change on income from continuing operations, net income, any other financial statement line item and any affected per-share amounts. On August 1, 2019, we adopted the new leasing standard using the modified retrospective approach. In addition, we elected certain practical expedients permitted under the transition guidance within the new standard. Except for recording a total right-of-use asset and corresponding lease liability on our Consolidated Balance Sheet, which amount approximates 4.0% of our total consolidated assets at July 31, 2019, our adoption of Topic 842 is not expected to have a material impact to our future statements of operations or cash flows.

(d) Revenue Recognition

On August 1, 2018, we adopted ASU No. 2014-09 "Revenue from Contracts with Customers (Topic 606)" or "ASC 606" applying the modified retrospective transition method. Except for new presentation or disclosure requirements, the impact of adoption, both as of August 1, 2018 and for fiscal 2019, was not material to our business, results of operations or financial condition. As a practical expedient, we adopted the new standard only for existing contracts as of August 1, 2018. All periods prior to August 1, 2018 will continue to be reported under the accounting standards in effect in those periods. As a result of ASC 606, we made the following adjustments to our Consolidated Balance Sheet as of August 1, 2018:

	As reported at July 31, 2018	Adoption of ASC 606	Balance at August 1, 2018
Accrued expenses and other current liabilities[1]	$ 65,034,000	$ (2,079,000)	$ 62,955,000
Contract liabilities, current and non-current[2]	42,141,000	2,079,000	44,220,000

[1] See *Note (6)* - "*Accrued Expenses and Other Current Liabilities*" for further discussion of reclassification.
[2] Formerly presented on the face of our Consolidated Balance Sheet as "Customer advances and deposits, current and non-current" prior to our adoption of ASC 606.

The core principle of ASC 606 is that revenue should be recorded in an amount that reflects the consideration to which we expect to be entitled in exchange for goods or services promised to customers. Under ASC 606, we follow a five-step model to: (1) identify the contract with our customer; (2) identify our performance obligations in our contract; (3) determine the transaction price for our contract; (4) allocate the transaction price to our performance obligations; and (5) recognize revenue using one of the following two methods:

- *Over time* - We recognize revenue using the over time method when there is a continuous transfer of control to the customer over the contractual period of performance. This generally occurs when we enter into a long-term contract relating to the design, development or manufacture of complex equipment or technology platforms to a buyer's specification (or to provide services related to the performance of such contracts). Continuous transfer of control is typically supported by contract clauses which allow our customers to unilaterally terminate a contract for convenience, pay for costs incurred plus a reasonable profit and take control of work-in-process. Revenue recognized over time is generally based on the extent of progress toward completion of the related performance obligations. The selection of the method to measure progress requires judgment and is based on the nature of the products or services provided. In certain instances, typically for firm fixed-price contracts, we use the cost-to-cost measure because it best depicts the transfer of control to the customer which occurs as we incur costs on our contracts. Under the cost-to-cost measure, the extent of progress toward completion is measured based on the ratio of costs incurred to date to the total estimated costs at completion, including warranty costs. Revenues, including estimated fees or profits, are recorded proportionally as costs are incurred. Costs to fulfill generally include direct labor, materials, subcontractor costs, other direct costs and an allocation of indirect costs. When these contracts are modified, the additional goods or services are generally not distinct from those already provided. As a result, these modifications form part of an existing contract and we must update the transaction price and our measure of progress for the single performance obligation and recognize a cumulative catch-up to revenue and gross profits.

  For over time contracts using a cost-to-cost measure of progress, we have an estimate at completion ("EAC") process in which management reviews the progress and execution of our performance obligations. This EAC process requires management judgment relative to assessing risks, estimating contract revenue and costs, and making assumptions for schedule and technical issues. Since certain contracts extend over a long period of time, the impact of revisions in revenue and or cost estimates during the progress of work may impact current period earnings through a cumulative adjustment. Additionally, if the EAC process indicates a loss, a provision is made for the total anticipated loss in the period that it becomes evident. Contract revenue and cost estimates for significant contracts are generally reviewed and reassessed at least quarterly.

The cost-to-cost method is principally used to account for contracts in our mission-critical technologies and high-performance transmission technologies product lines and, to a lesser extent, certain location-based and messaging infrastructure contracts in our public safety and location technologies product line. For service-based contracts in our public safety and location technologies product line, we recognize revenue over time. These services are typically recognized as a series of services performed over the contract term using the straight-line method, or based on our customers' actual usage of the networks and platforms which we provide.

- *Point in time* - When a performance obligation is not satisfied over time, we must record revenue using the point in time accounting method which generally results in revenue being recognized upon shipment or delivery of a promised good or service to a customer. This generally occurs when we enter into short term contracts or purchase orders where items are provided to customers with relatively quick turn-around times. Modifications to such contracts and or purchase orders, which typically provide for additional quantities or services, are accounted for as a new contract because the pricing for these additional quantities or services are based on standalone selling prices.

  Point in time accounting is principally applied to contracts in our satellite ground station technologies product line (which includes satellite modems, solid-state and traveling wave tube amplifiers) and certain contracts for our solid-state, high-power amplifiers in our high-performance transmission technologies product line. Point in time accounting is also applied to certain contracts in our mission-critical technologies product line. The contracts related to these product lines do not meet the requirements for over time revenue recognition because our customers cannot utilize the equipment for its intended purpose during any phase of our manufacturing process; customers do not simultaneously receive and or consume the benefits provided by our performance; customers do not control the asset (i.e., prior to delivery, customers cannot direct the use of the asset, sell or exchange the equipment, etc.); and, although many of our contracts have termination for convenience clauses and or an enforceable right to payment for performance completed to date, our performance creates an asset with an alternative use through the point of delivery.

  In determining that our equipment has alternative use, we considered the underlying manufacturing process for our products. In the early phases of manufacturing, raw materials and work in process (including subassemblies) consist of common parts that are highly fungible among many different types of products and customer applications. Finished products are either configured to our standard configuration or based on our customers' specifications. Finished products, whether built to our standard specification or to a customers' specification, can be sold to a variety of customers and across many different end use applications with minimal rework, if needed, and without incurring a significant economic loss.

When identifying a contract with our customer, we consider when it has approval and commitment from both parties, if the rights of the parties are identified, if the payment terms are identified, if it has commercial substance and if collectability is probable.

When identifying performance obligations, we consider whether there are multiple promises and how to account for them. In our contracts, multiple promises are separated if they are distinct, both individually and in the context of the contract. If multiple promises in a contract are highly interrelated or comprise a series of distinct services performed over time, they are combined into a single performance obligation. In some cases, we may also provide the customer with an additional service-type warranty, which we recognize as a separate performance obligation. Service-type warranties do not represent a significant portion of our consolidated net sales. When service-type warranties represent a separate performance obligation, the revenue is deferred and recognized ratably over the extended warranty period. Our contracts, from time-to-time, may also include options for additional goods and services. To-date, these options have not represented material rights to the customer as the pricing for them reflects standalone selling prices. As a result, we do not consider options we offer to be performance obligations for which we must allocate a portion of the transaction price. In many cases, we provide assurance-type warranty coverage for some of our products for a period of at least one year from the date of delivery.

When identifying the transaction price, we typically utilize the contract's stated price as a starting point. The transaction price in certain arrangements may include estimated amounts of variable consideration, including award fees, incentive fees or other provisions that can either increase or decrease the transaction price. We estimate variable consideration as the amount to which we expect to be entitled, and we include estimated amounts in the transaction price to the extent it is probable that a significant reversal of cumulative revenue recognized will not occur when the estimation uncertainty is resolved. The estimation of this variable consideration and determination of whether to include estimated amounts in the transaction price are based largely on an assessment of our anticipated performance and all information (e.g., historical, current and forecasted) that is reasonably available to us.

When allocating the contract's transaction price, we consider each distinct performance obligation. For contracts with multiple performance obligations, we allocate the contract's transaction price to each performance obligation using our best estimate of the standalone selling price of each distinct good or service in the contract. We determine standalone selling price based on the price at which the performance obligation is sold separately. If the standalone selling price is not observable through past transactions, we estimate the standalone selling price taking into account available information such as market conditions, including geographic or regional specific factors, competitive positioning, internal costs, profit objectives and internally approved pricing guidelines related to the performance obligations.

Almost all of our contracts with customers are denominated in U.S. dollars and typically are either firm fixed-price or cost reimbursable type contracts (including fixed-fee, incentive-fee and time-and-material type contracts). In almost all of our contracts with customers, we are the principal in the arrangement and report revenue on a gross basis. Transaction prices for contracts with U.S. domestic and international customers are usually based on specific negotiations with each customer and in the case of the U.S. government, sometimes based on estimated or actual costs of providing the goods or services in accordance with applicable regulations. Sales by geography and customer type, as a percentage of consolidated net sales, are as follows:

	Fiscal Years Ended July 31,		
	2019	2018	2017
United States			
U.S. government	40.1%	35.5%	32.7%
Domestic	34.5%	38.9%	38.9%
Total United States	74.6%	74.4%	71.6%
International	25.4%	25.6%	28.4%
Total	100.0%	100.0%	100.0%

Sales to U.S. government customers include sales to the U.S. Department of Defense ("DoD"), intelligence and civilian agencies, as well as sales directly to or through prime contractors. Domestic sales include sales to commercial customers, as well as to U.S. state and local governments. Included in domestic sales are sales to Verizon Communications Inc. ("Verizon"). Sales to Verizon were 10.0% of consolidated net sales for fiscal 2018. Except for the U.S. government, there were no customers that represented more than 10.0% of consolidated net sales during fiscal 2019 and 2017. International sales for fiscal 2019, 2018 and 2017 (which include sales to U.S. domestic companies for inclusion in products that are sold to international customers) were $170,607,000, $145,784,000 and $156,483,000, respectively. Except for the U.S., no individual country (including sales to U.S. domestic companies for inclusion in products that are sold to a foreign country) represented more than 10% of consolidated net sales for fiscal 2019, 2018 and 2017.

The following tables summarize our disaggregation of revenue consistent with information reviewed by our chief operating decision-maker ("CODM") for the fiscal year ended July 31, 2019. We believe these categories best depict how the nature, amount, timing and uncertainty of revenue and cash flows are affected by economic factors which impact our business:

	Fiscal Year Ended July 31, 2019		
	Commercial Solutions	Government Solutions	Total
Geographical region and customer type			
U.S. government	$ 68,534,000	200,708,000	$ 269,242,000
Domestic	192,516,000	39,432,000	231,948,000
Total United States	261,050,000	240,140,000	501,190,000
International	96,243,000	74,364,000	170,607,000
Total	$ 357,293,000	314,504,000	$ 671,797,000
Contract type			
Firm fixed-price	$ 350,850,000	231,400,000	$ 582,250,000
Cost reimbursable	6,443,000	83,104,000	89,547,000
Total	$ 357,293,000	314,504,000	$ 671,797,000
Transfer of control			
Point in time	$ 177,090,000	176,067,000	$ 353,157,000
Over time	180,203,000	138,437,000	318,640,000
Total	$ 357,293,000	314,504,000	$ 671,797,000

The timing of revenue recognition, billings and collections results in receivables, unbilled receivables and contract liabilities on our Consolidated Balance Sheet. Under typical payment terms for our contracts accounted for over time, amounts are billed as work progresses in accordance with agreed-upon contractual terms, either at periodic intervals (e.g., monthly) or upon achievement of contractual milestones. For certain contracts with provisions that are intended to protect customers in the event we do not satisfy our performance obligations, billings occur subsequent to revenue recognition, resulting in what we have historically presented as unbilled receivables. Contract assets increased $3,331,000 due to business combinations discussed in *Note (2) - "Acquisitions."* Under ASC 606, unbilled receivables constitute contract assets. There were no material impairment losses recognized on contract assets during the fiscal year ended 2019. On large long-term contracts, and for contracts with international customers that do not do business with us regularly, payment terms typically require advanced payments and deposits. Under ASC 606, payments received from customers in excess of revenue recognized to-date results in a contract liability. These contract liabilities are not considered to represent a significant financing component of the contract because we believe these cash advances and deposits are generally used to meet working capital demands which can be higher in the earlier stages of a contract. Also, advanced payments and deposits provide us with some measure of assurance that the customer will perform on its obligations under the contract. Under the typical payment terms for our contracts accounted for at a point in time, costs are accumulated in inventory until the time of billing, which generally coincides with revenue recognition. Contract liabilities increased $5,411,000 due to business combinations discussed in *Note (2) - "Acquisitions."* Of the total contract liabilities at August 1, 2018, $33,139,000 was recognized as revenue during fiscal 2019.

We recognize the incremental costs to obtain or fulfill a contract as an expense when incurred if the amortization period of the asset is one year or less. Incremental costs to obtain or fulfill contracts with an amortization period greater than one year were not material.

As commissions payable to our internal sales and marketing employees or contractors are contingent upon multiple factors, such commissions are not considered direct costs to obtain or fulfill a contract with a customer and are expensed as incurred in selling, general and administrative expenses on our Consolidated Statements of Operations. As for commissions payable to third-party sales representatives related to large long-term contracts, we do consider these types of commissions both direct and incremental costs to obtain and fulfill such contracts. Therefore, such types of commissions are included in total estimated costs at completion for such contracts and expensed over time through cost of sales on our Consolidated Statements of Operations.

Remaining performance obligations represent the transaction price of firm orders for which work has not been performed as of the end of a fiscal period. Remaining performance obligations, which we refer to as backlog, exclude unexercised contract options and potential orders under indefinite delivery / indefinite quantity ("IDIQ") contracts. As of July 31, 2019, the aggregate amount of the transaction price allocated to remaining performance obligations was $682,954,000 (which represents the amount of our consolidated backlog). We expect that a significant portion of our remaining performance obligations at July 31, 2019 will be completed and recognized as revenue during the next twelve-month period. During fiscal 2019, revenue recognized from performance obligations satisfied, or partially satisfied, in previous periods (for example due to changes in the transaction price) was not material.

(e) Cash and Cash Equivalents

Our cash equivalents are short-term, highly liquid investments that are both readily convertible to known amounts of cash and have insignificant risk of change in value as a result of changes in interest rates. Our cash and cash equivalents, as of July 31, 2019 and 2018, amounted to $45,576,000 and $43,484,000, respectively, and primarily consist of bank deposits and money market deposit accounts insured by the Federal Deposit Insurance Corporation. Cash equivalents are carried at cost, which approximates fair value.

(f) Inventories

Our inventories are stated at the lower of cost and net realizable value, the latter of which is defined as the estimated selling price in the ordinary course of business, less reasonably predictable costs of completion, disposal and transportation. Our inventories are reduced to their estimated net realizable value by a charge to cost of sales in the period such excess costs are determined. Our inventories are principally recorded using either average or standard costing methods.

Work-in-process (including our contracts-in-progress) and finished goods inventory reflect all accumulated production costs, which are comprised of direct production costs and overhead, and is reduced by amounts recorded in cost of sales as the related revenue is recognized. Indirect costs relating to long-term contracts, which include expenses such as general and administrative, are charged to expense as incurred and are not included in our cost of sales or work-in-process (including our contracts-in-progress) and finished goods inventory.

(g) Long-Lived Assets

Our machinery and equipment, which are recorded at cost, are depreciated or amortized over their estimated useful lives (three to eight years) under the straight-line method. Capitalized values of properties and leasehold improvements under leases are amortized over the life of the lease or the estimated life of the asset, whichever is less.

Goodwill represents the excess cost of a business acquisition over the fair value of the net assets acquired. In accordance with FASB ASC 350 "*Intangibles - Goodwill and Other*" goodwill is not amortized. We periodically, at least on an annual basis in the first quarter of each fiscal year, review goodwill, considering factors such as projected cash flows and revenue and earnings multiples, to determine whether the carrying value of the goodwill is impaired. If we fail the quantitative assessment of goodwill impairment ("quantitative assessment"), we would be required to recognize an impairment loss equal to the amount that a reporting unit's carrying value exceeded its fair value; however, any loss recognized should not exceed the total amount of goodwill allocated to that reporting unit. We define our reporting units to be the same as our operating segments.

We performed our annual goodwill impairment assessment for fiscal 2020 on August 1, 2019 (the first day of our fiscal 2020). See *Note (14)* - "*Goodwill*" for more information. Unless there are future indicators that the fair value of a reporting unit is more likely than not less than its carrying value, such as a significant adverse change in our future financial performance, our next impairment assessment for goodwill will be performed and completed in the first quarter of fiscal 2021. Any impairment charges that we may record in the future could be material to our results of operations and financial condition.

We assess the recoverability of the carrying value of our other long-lived assets, including identifiable intangible assets with finite useful lives, whenever events or changes in circumstances indicate that the carrying amount of the assets may not be recoverable. We evaluate the recoverability of such assets based upon the expectations of undiscounted cash flows from such assets. If the sum of the expected future undiscounted cash flows were less than the carrying amount of the asset, a loss would be recognized for the difference between the fair value and the carrying amount.

(h) Research and Development Costs

We charge research and development costs to operations as incurred, except in those cases in which such costs are reimbursable under customer funded contracts. In fiscal 2019, 2018 and 2017, we were reimbursed by customers for such activities in the amount of $14,679,000, $16,924,000 and $27,050,000, respectively. These amounts are not reflected in the reported research and development expenses in each of the respective periods but are included in net sales with the related costs included in cost of sales in each of the respective periods.

(i) Income Taxes

Income taxes are accounted for under the asset and liability method. Deferred tax assets and liabilities are recognized for the future tax consequences attributable to differences between the financial statement carrying amounts of existing assets and liabilities and their respective tax bases and operating loss and tax credit carryforwards. Deferred tax assets and liabilities are measured using the enacted tax rates expected to apply to taxable income in the years in which those temporary differences are expected to be recovered or settled. The effect on deferred tax assets and liabilities of a change in tax rates is recognized in income in the period that includes the enactment date.

We determine the uncertain tax positions taken or expected to be taken in income tax returns in accordance with the provisions of FASB ASC 740-10-25 "*Income Taxes,*" which prescribes a two-step evaluation process for tax positions. The first step is recognition based on a determination of whether it is more-likely-than-not that a tax position will be sustained upon examination, including resolution of any related appeals or litigation processes, based on the technical merits of the position. The second step is to measure a tax position that meets the more-likely-than-not threshold. The tax position is measured as the largest amount of benefit that is greater than 50% likely of being realized upon ultimate settlement. If a tax position does not meet the more-likely-than-not recognition threshold, the benefit of that position is not recognized in the financial statements. Our policy is to recognize potential interest and penalties related to uncertain tax positions in income tax expense.

(j) Earnings Per Share

Our basic earnings per share ("EPS") is computed based on the weighted average number of common shares (including vested but unissued stock units, share units, performance shares and restricted stock units ("RSUs")), outstanding during each respective period. Our diluted EPS reflects the dilution from potential common stock issuable pursuant to the exercise of equity-classified stock-based awards, if dilutive, outstanding during each respective period. Pursuant to FASB ASC 260 "*Earnings Per Share,*" equity-classified stock-based awards that are subject to performance conditions are not considered in our diluted EPS calculations until the respective performance conditions have been satisfied. When calculating our diluted earnings per share, we consider the amount an employee must pay upon assumed exercise of stock-based awards and the amount of stock-based compensation cost attributed to future services and not yet recognized. As a result of our adoption of ASU No. 2016-09 on August 1, 2017 (the start of our first quarter of fiscal 2018), the amount of excess tax benefits assuming exercise of in-the-money stock-based awards is no longer included in the calculation of diluted earnings per share on a prospective basis and the denominator for our diluted calculation could increase in the future as compared to prior calculations. See *Note (11)* - "*Stock-Based Compensation*" for more information on the impact of adopting ASU No. 2016-09.

There were no repurchases of our common stock during the fiscal years ended July 31, 2019, 2018 and 2017. See *Note (16)* - "*Stockholders' Equity*" for more information.

Weighted average stock options, RSUs and restricted stock outstanding of 1,347,000, 1,739,000 and 1,986,000 shares for fiscal 2019, 2018 and 2017, respectively, were not included in our diluted EPS calculation because their effect would have been anti-dilutive.

Our EPS calculations exclude 243,000, 258,000 and 228,000 weighted average performance shares outstanding for fiscal 2019, 2018 and 2017, respectively, as the performance conditions have not yet been satisfied. However, net income (the numerator) for EPS calculations for each respective period, is reduced by the compensation expense related to these awards.

The following table reconciles the numerators and denominators used in the basic and diluted EPS calculations:

	Fiscal Years Ended July 31,		
	2019	2018	2017
Numerator:			
Net income for basic calculation	$ 25,041,000	29,769,000	15,827,000
Numerator for diluted calculation	$ 25,041,000	29,769,000	15,827,000
Denominator:			
Denominator for basic calculation	24,124,000	23,825,000	23,433,000
Effect of dilutive securities:			
Stock-based awards	178,000	215,000	56,000
Denominator for diluted calculation	24,302,000	24,040,000	23,489,000

(k) Fair Value Measurements and Financial Instruments

Using the fair value hierarchy described in FASB ASC 820 "*Fair Value Measurements and Disclosures,"* we valued our cash and cash equivalents using Level 1 inputs that were based on quoted market prices.

We believe that the carrying amounts of our other current financial assets (such as accounts receivable) and other current liabilities (including accounts payable, accrued expenses and the current portion of our favorable AT&T warranty settlement) approximate their fair values due to their short-term maturities. We believe the fair value of our current portion of capital lease and other obligations, which currently has a blended interest rate of approximately 7.0%, would not be materially different than its carrying value as of July 31, 2019.

The fair value of our Credit Facility that we entered into on October 31, 2018 approximates its carrying amount due to its variable interest rate and pricing grid that is dependent upon our leverage ratio as of the end of each fiscal quarter.

The fair value of the non-current portion of our favorable AT&T warranty settlement would not be materially different than its carrying value as of July 31, 2019, given our belief that the present value of such liability reflects market participants' assumptions for a similar junior, unsecured debt instrument. See *Note (6) - "Accrued Expenses and Other Current Liabilities"* for further discussion of the favorable AT&T warranty settlement.

As of July 31, 2019 and 2018, other than the financial instruments discussed above, we had no other significant assets or liabilities included in our Consolidated Balance Sheets recorded at fair value, as such term is defined by FASB ASC 820.

(l) Use of Estimates

The preparation of consolidated financial statements in conformity with accounting principles generally accepted in the United States of America requires management to make estimates and assumptions that affect the reported amount of assets and liabilities, and disclosure of contingent assets and liabilities, at the date of the consolidated financial statements and the reported amounts of net sales and expenses during the reported period. We make significant estimates in many areas of our accounting, including but not limited to the following: long-term contracts, stock-based compensation, intangible assets and liabilities including goodwill, provision for excess and obsolete inventory, allowance for doubtful accounts, warranty obligations and income taxes. Actual results may differ from those estimates.

(m) Comprehensive Income

In accordance with FASB ASC 220 "*Comprehensive Income*," we report all changes in equity during a period, except those resulting from investment by owners and distribution to owners, for the period in which they are recognized. Comprehensive income is the total of net income and all other non-owner changes in equity (or other comprehensive income) such as unrealized gains/losses on securities classified as available-for-sale, foreign currency translation adjustments and minimum pension liability adjustments. Comprehensive income was the same as our net income in fiscal 2019, 2018 and 2017.

(n) Reclassifications

Certain reclassifications have been made to previously reported consolidated financial statements to conform to the fiscal 2019 presentation.

(o) Adoption of Accounting Standards and Updates

We are required to prepare our consolidated financial statements in accordance with the Financial Accounting Standards Board ("FASB") Accounting Standards Codification ("ASC") which is the source for all authoritative U.S. generally accepted accounting principles, which are commonly referred to as "GAAP." The FASB ASC is subject to updates by the FASB, which are known as Accounting Standards Updates ("ASUs"). During fiscal 2019, we adopted:

- FASB ASU No. 2014-09 "Revenue from Contracts with Customers (Topic 606)." See *Note (1)(d) - "Revenue Recognition"* for further information.

- FASB ASU No. 2016-16 "Intra-Entity Transfers of Assets Other Than Inventory," which eliminates a prior exception and now requires an entity to recognize the income tax consequences of an intra-entity transfer of an asset other than inventory (for example, intellectual property and property, plant and equipment) when the transfer occurs. We adopted this ASU on August 1, 2018. There was no material impact to our consolidated financial statements (including any cumulative effect adjustment) and related disclosures upon such adoption.

- FASB ASU No. 2019-07, issued in June 2019, which amends various SEC guidance pursuant to the issuance of recent SEC Final Rule Release No. 33-10532, 33-10231, and 33-10442. This ASU clarifies or improves the disclosure and presentation requirements of a variety of Codification Topics by aligning them with the SEC's regulations, eliminating redundancies, and making the Codification easier to apply. There was no material impact to our consolidated financial statements and related disclosures upon such adoption.

(2) Acquisitions

Solacom Technologies Inc.

On February 28, 2019, we completed our acquisition of Solacom Technologies Inc. ("Solacom"), pursuant to the Arrangement Agreement, dated as of January 7, 2019, by and among Solacom, Comtech and Solar Acquisition Corp., a Canadian corporation and a direct, wholly-owned subsidiary of Comtech. Solacom is a leading provider of Next Generation 911 ("NG-911") solutions for public safety agencies. The acquisition of Solacom was a significant step in our strategy of enhancing our public safety and location technologies.

The acquisition has an aggregate purchase price for accounting purposes of $32,934,000, of which $27,328,000 was settled in cash and $5,606,000 was settled with the issuance of 208,669 shares of Comtech's common stock at a volume weighted average stock price of $26.86. The fair value of consideration transferred in connection with this acquisition was $31,489,000, which was net of $1,445,000 of cash acquired. The cash portion of the purchase price was funded principally through borrowings under our Credit Facility.

We are accounting for the acquisition of Solacom under the acquisition method of accounting in accordance with FASB ASC 805, "Business Combinations" ("ASC 805"). The purchase price was allocated to the assets acquired and liabilities assumed, based on their preliminary fair value as of February 28, 2019, pursuant to the business combination accounting rules. Acquisition plan expenses were not included as a component of consideration transferred and were expensed in the period incurred. Our Consolidated Statement of Operations for fiscal 2019 includes a nominal amount of revenue and contribution from Solacom. Pro forma financial information is not disclosed, as the acquisition is not material.

The following table summarizes the preliminary fair value of the assets acquired and liabilities assumed in connection with the Solacom acquisition:

	Preliminary Purchase Price Allocation [1]	Measurement Period Adjustments	Purchase Price Allocation (as adjusted)	
Settled in cash	$ 27,328,000	—	$ 27,328,000	
Settled in common stock issued by Comtech	5,606,000	—	5,606,000	
Aggregate purchase price at fair value	$ 32,934,000	—	$ 32,934,000	
Allocation of aggregate purchase price:				
Cash and cash equivalents	$ 1,445,000	—	$ 1,445,000	
Current assets	9,425,000	471,000	9,896,000	
Property, plant and equipment	777,000	—	777,000	
Deferred tax assets, non-current	5,374,000	(315,000)	5,059,000	
Accrued warranty obligations	(1,431,000)	—	(1,431,000)	
Current liabilities	(4,477,000)	—	(4,477,000)	
Contract liabilities, non-current	(1,604,000)	—	(1,604,000)	
Net tangible assets at preliminary fair value	$ 9,509,000	156,000	$ 9,665,000	
Identifiable intangibles, deferred taxes and goodwill:				Estimated Useful Lives
Technology	$ 6,779,000	—	$ 6,779,000	10 years
Customer relationships	7,007,000	—	7,007,000	20 years
Trade name	1,828,000	—	1,828,000	20 years
Deferred tax liabilities	(4,153,000)	—	(4,153,000)	
Goodwill	11,964,000	(156,000)	11,808,000	Indefinite
Allocation of aggregate purchase price	$ 32,934,000	—	$ 32,934,000	

[1] As initially reported in the Company's Quarterly Report on Form 10-Q for the three and nine months ended April 30, 2019.

The acquired identifiable intangible assets are being amortized on a straight-line basis, which we believe approximates the pattern in which the assets are utilized over their estimated useful lives. The fair value of customer relationships and backlog was estimated primarily based on the value of the discounted cash flows that the related intangible asset could be expected to generate in the future. The fair value of technology and trade name was estimated based on the discounted capitalization of royalty expense saved because we now own the assets. Among the factors contributing to the recognition of goodwill, as a component of the purchase price allocation, were synergies in products and technologies and the addition of a skilled, assembled workforce. This goodwill has been assigned to our Commercial Solutions segment based on specific identification and is generally not deductible for income tax purposes.

The allocation of the aggregate purchase price shown in the above table was based upon a valuation and estimates and assumptions that are subject to change within the purchase price allocation period (generally one year from the acquisition date). The primary areas of the purchase price allocation not yet finalized include a final assessment of income taxes and residual goodwill.

GD NG-911 Business

On April 29, 2019, we completed the acquisition of a state and local government NG-911 business pursuant to the Asset Purchase Agreement, dated as of April 29, 2019, by and among General Dynamics Information Technology, Inc., Comtech and Comtech NextGen LLC, a Delaware limited liability company and indirect, wholly-owned subsidiary of Comtech. The acquisition of this NG-911 business from GD (the "GD NG-911 business") has a preliminary cash purchase price of $10,000,000 (which is subject to a working capital adjustment). In connection with this acquisition, we also announced an award of a five-year contract to develop, implement and operate a NG-911 emergency communications system for a Northeastern state. Immediately after our announcement of this acquisition, we hired approximately sixty GD NG-911 employees and completed the integration of this business into our Commercial Solutions segment's public safety and location technologies product line. The acquisition, contract award and hiring of talented employees are expected to strengthen Comtech's position in the growing NG-911 solutions market.

We are accounting for the acquisition of this business under the acquisition method of accounting in accordance with FASB ASC 805. The purchase price, which is subject to a pending closing date balance sheet adjustment process under the purchase agreement, was allocated to the assets acquired and liabilities assumed, based on their preliminary fair value as of April 29, 2019, pursuant to the business combination accounting rules. Acquisition plan expenses were not included as a component of consideration transferred and were expensed in the period incurred. Our Consolidated Statements of Operatons for fiscal 2019 include a nominal amount of revenue and contribution from the GD NG-911 business. Pro forma financial information is not disclosed, as the acquisition is not material.

The following table summarizes the preliminary fair value of the assets acquired and liabilities assumed in connection with the acquisition of the GD NG-911 business:

	Preliminary Purchase Price Allocation [1]	Measurement Period Adjustments	Purchase Price Allocation (as adjusted)	
Aggregate purchase price at fair value	$ 10,000,000	—	$ 10,000,000	
Allocation of aggregate purchase price:				
Current assets	$ 5,790,000	(1,330,000)	$ 4,460,000	
Property, plant and equipment	646,000	—	646,000	
Deferred tax assets, non-current	3,292,000	134,000	3,426,000	
Accrued warranty obligations	(5,000,000)	—	(5,000,000)	
Current liabilities	(3,960,000)	798,000	(3,162,000)	
Net tangible assets at preliminary fair value	$ 768,000	(398,000)	$ 370,000	
Identifiable intangibles, deferred taxes and goodwill:				Estimated Useful Lives
Customer relationships	$ 20,300,000	$ —	$ 20,300,000	10 years
Technology	3,500,000	—	3,500,000	15 years
Other liabilities	(21,700,000)	—	(21,700,000)	
Deferred tax liabilities	(518,000)	—	(518,000)	
Goodwill	7,650,000	398,000	8,048,000	Indefinite
Allocation of aggregate purchase price	$ 10,000,000	—	$ 10,000,000	

[1] As initially reported in the Company's Quarterly Report on Form 10-Q for the three and nine months ended April 30, 2019.

The acquired identifiable intangible assets are being amortized on a straight-line basis, which we believe approximates the pattern in which the assets are utilized over their estimated useful lives. The fair value of customer relationships was estimated based on the value of the discounted cash flows that the related intangible asset could be expected to generate in the future. The fair value of technology was estimated based on the discounted capitalization of royalty expense saved because we now own the assets. The preliminary fair value of other liabilities was based on the difference in discounted cash flows related to remaining performance obligations under a certain acquired contract as compared to current market terms for similar arrangements that a market participant would expect. Other liabilities will be credited against cost of sales over the remaining performance of the contract, which was 5.25 years as of the acquisition date.

Among the factors contributing to the recognition of goodwill, as a component of the purchase price allocation, were synergies in solution offerings and the addition of a skilled, assembled workforce. We currently estimate that approximately $7,300,000 of goodwill resulting from the acquisition will be tax deductible. This goodwill has been assigned to our Commercial Solutions segment based on specific identification.

We are currently finalizing a working capital adjustment, pursuant to the terms of the purchase agreement. In August 2019, the seller proposed and requested an approximate $2,900,000 upward adjustment to the preliminary purchase price. We do not agree with their proposed adjustment and believe that we are entitled to a reduction of approximately $890,000 to the preliminary purchase price. We expect to reach an amicable resolution.

The allocation of the preliminary purchase price shown in the above table was based on a valuation and estimates and assumptions that are subject to change within the purchase price allocation period (generally one year from the acquisition date). The primary areas of the purchase price allocation not yet finalized include the purchase price (due to a pending closing date balance sheet adjustment process under the purchase agreement), a final assessment of accrued warranty obligations, income taxes and residual goodwill.

(3) Accounts Receivable

Accounts receivable consist of the following at July 31, 2019 and 2018:

	2019	2018
Receivables from commercial and international customers	$ 85,556,000	83,411,000
Unbilled receivables from commercial and international customers	20,469,000	19,731,000
Receivables from the U.S. government and its agencies	38,856,000	26,251,000
Unbilled receivables from the U.S government and its agencies	2,018,000	19,807,000
Total accounts receivable	146,899,000	149,200,000
Less allowance for doubtful accounts	1,867,000	1,761,000
Accounts receivable, net	$ 145,032,000	147,439,000

Unbilled receivables as of July 31, 2019 relate to contracts-in-progress for which revenue has been recognized, but for which we have not yet earned the right to bill the customer for work performed to-date. Under ASC 606, which we adopted on August 1, 2018 (see *Note (1)(d) - "Revenue Recognition"*), unbilled receivables constitute contract assets. Management estimates that substantially all amounts not yet billed at July 31, 2019 will be billed and collected within one year.

As of July 31, 2019, except for the U.S. government (and its agencies), which represented 27.8% of total accounts receivable, there were no other customers which accounted for greater than 10.0% of total accounts receivable. As of July 31, 2018, the U.S. government (and its agencies) and Verizon represented 30.9% and 10.1%, respectively, of total accounts receivable.

(4) Inventories

Inventories consist of the following at July 31, 2019 and 2018:

	2019	2018
Raw materials and components	$ 53,959,000	53,649,000
Work-in-process and finished goods	40,576,000	38,854,000
Total inventories	94,535,000	92,503,000
Less reserve for excess and obsolete inventories	19,696,000	17,427,000
Inventories, net	$ 74,839,000	75,076,000

As of July 31, 2019 and 2018, the amount of inventory directly related to long-term contracts (including contracts-in-progress) was $4,053,000 and $1,249,000, respectively, and the amount of inventory related to contracts from third-party commercial customers who outsource their manufacturing to us was $1,513,000 and $1,310,000, respectively.

(5) Property, Plant and Equipment

Property, plant and equipment consist of the following at July 31, 2019 and 2018:

	2019	2018
Machinery and equipment	$ 159,882,000	154,556,000
Leasehold improvements	14,265,000	13,807,000
	174,147,000	168,363,000
Less accumulated depreciation and amortization	146,121,000	139,376,000
Property, plant and equipment, net	$ 28,026,000	28,987,000

Depreciation and amortization expense on property, plant and equipment amounted to $11,927,000, $13,655,000 and $14,354,000 for the fiscal years ended July 31, 2019, 2018 and 2017, respectively.

(6) Accrued Expenses and Other Current Liabilities

Accrued expenses and other current liabilities consist of the following at July 31, 2019 and 2018:

	2019	2018
Accrued wages and benefits	$ 23,295,000	23,936,000
Accrued contract costs	15,007,000	10,016,000
Accrued warranty obligations	15,968,000	11,738,000
Accrued legal costs	2,835,000	6,179,000
Accrued commissions and royalties	5,114,000	4,654,000
Other	16,365,000	8,511,000
Accrued expenses and other current liabilities	$ 78,584,000	65,034,000

On August 1, 2018, in connection with our adoption of ASC 606, $2,079,000 of accrued expenses and other current liabilities were reclassified to contract liabilities on our Consolidated Balance Sheet. Of this total amount, $1,679,000 and $400,000, respectively, was reclassified from the "accrued warranty obligations" and "other" categories presented in the above table to contract liabilities, as they represented deferred revenue related to service-type warranty performance obligations. See *Note (1)(d) - "Revenue Recognition"* for further discussion of our adoption of ASC 606. Accrued expenses and other current liabilities as of July 31, 2019 includes the amounts from our acquisitions of Solacom and the GD NG-911 business, as discussed in *Note (2) "Acquisitions."*

Accrued wages and benefits as of July 31, 2019 and 2018 include $1,787,000 and $2,963,000, respectively, of accrued remittance of employees' statutory tax withholdings related to the net settlement of fully-vested share units, as discussed in more detail in *Note (11)* - "*Stock-Based Compensation.*"

Accrued contract costs represent direct and indirect costs on contracts as well as estimates of amounts owed for invoices not yet received from vendors or reflected in accounts payable.

Accrued legal costs as of July 31, 2018 included $3,372,000 related to estimated costs associated with a certain TeleCommunication Systems, Inc. ("TCS") intellectual property matter. During the fiscal year ended July 31, 2019, this matter was resolved in our favor. As a result, we reduced such accrued legal costs and recorded a $3,204,000 benefit in the Consolidated Statement of Operations. See *Note (13)(b)* - "*Commitments and Contingencies - Legal Proceedings and Other Matters*" for additional information.

Other accrued expenses as of July 31, 2019 include $568,000 for the current portion of facility exit costs related to the closure of a manufacturing facility, as discussed in more detail in *Note (7) - "Cost Reduction Actions."*

Accrued warranty obligations as of July 31, 2019 relate to estimated liabilities for assurance type warranty coverage that we provide to our customers. We generally provide warranty coverage for some of our products for a period of at least one year from the date of delivery. We record a liability for estimated warranty expense based on historical claims, product failure rates, a consideration of contractual obligations, future costs to resolve software issues and other factors. Some of our product warranties are provided under long-term contracts, the costs of which are incorporated into our estimates of total contract costs.

Changes in our accrued warranty obligations during the fiscal years ended July 31, 2019 and 2018 were as follows:

	2019	2018
Balance at beginning of year	$ 11,738,000	17,617,000
Reclass to contract liabilities as of August 1, 2018	(1,679,000)	—
Provision for warranty obligations	3,902,000	5,055,000
Additions (in connection with acquisitions)	6,431,000	—
Charges incurred	(6,151,000)	(8,244,000)
Warranty settlement and reclass (see below)	1,727,000	(2,690,000)
Balance at end of year	$ 15,968,000	11,738,000

Our current accrued warranty obligations at July 31, 2019 and 2018 include $3,999,000 and $4,650,000, respectively, of warranty obligations for a small product line that we refer to as the TCS 911 call handling software solution. This solution was licensed to customers prior to our acquisition of TCS. During the fiscal year ended July 31, 2018, we entered into a full and final warranty settlement with AT&T, the largest customer/distributor of this product line, pursuant to which we issued thirty-six credits to AT&T of $153,000 which AT&T can apply on a monthly basis to purchases of solutions from us, beginning October 2017 through September 2020. As of July 31, 2019, the total present value of these monthly credits is $2,029,000, of which $1,727,000 is included in our current accrued warranty obligations and $302,000 is reflected in other liabilities (non-current) on our Consolidated Balance Sheet. In connection with this favorable settlement, during the fiscal year ended July 31, 2018, we recorded a benefit to cost of sales of $660,000.

In connection with our acquisition of Solacom and the GD NG-911 business, during the fiscal year ended July 31, 2019, we assumed warranty obligations related to certain contracts acquired. See *Note (2) - "Acquisitions"* for further information pertaining to these acquisitions.

(7) Cost Reduction Actions

During the three months ended October 31, 2018, we took steps to improve our future operating results and successfully consolidated our Government Solutions segment's manufacturing facility located in Tampa, Florida with another facility that we maintain in Orlando, Florida. In doing so, we accrued $1,373,000 of facility exit costs, which were recorded in selling, general and administrative expenses in our Consolidated Statements of Operations.

During the fiscal year ended 2019, we made cash payments of $805,000 related to such facility exit cost accrual. As of July 31, 2019, the remaining estimated facility exit costs amounted to $568,000, which is included in accrued expenses on our Consolidated Balance Sheet. To-date, we have incurred an immaterial amount of severance and retention costs related to our Florida facilities consolidation.

During the second quarter of fiscal 2019, we began an evaluation and repositioning of our public safety and location technologies solutions in order to focus on providing higher margin solution offerings. This evaluation and repositioning continued throughout the remainder of fiscal 2019 and is ongoing. To date, we have ceased offering certain solutions, have worked with customers to wind-down certain legacy contracts and have not renewed certain contracts. In connection with this ongoing repositioning, we recorded $6,351,000 of estimated contract settlement costs in our Commercial Solutions segment during the fiscal year ended July 31, 2019.

(8) Credit Facility

On October 31, 2018, we entered into a First Amended and Restated Credit Agreement (the "Credit Facility") with a syndicate of lenders, replacing our prior Credit Agreement dated as of February 23, 2016 (as amended by that certain First Amendment, dated as of June 6, 2017 (the "Prior Credit Facility")). In connection with the establishment of our new Credit Facility, during the three months ended October 31, 2018, we wrote-off $3,217,000 of deferred financing costs primarily related to the Term Loan Facility portion of our Prior Credit Facility and capitalized deferred financing costs of $1,813,000 related to the new Credit Facility.

The Credit Facility provides a senior secured loan facility of up to $550,000,000 consisting of: (i) a revolving loan facility ("Revolving Loan Facility") with a borrowing limit of $300,000,000; (ii) an accordion feature allowing us to borrow up to an additional $250,000,000; (iii) a $35,000,000 letter of credit sublimit; and (iv) a swingline loan credit sublimit of $25,000,000.

The Credit Facility matures on October 31, 2023 (the "Revolving Maturity Date"). If we issue new unsecured debt in excess of $5,000,000 with a maturity date that is less than 91 days from October 31, 2023, the Revolving Maturity Date would automatically accelerate so that it would be 91 days earlier than the maturity date of the new unsecured debt.

The proceeds of the new Credit Facility were used, in part, to repay in full the outstanding borrowings under the Prior Credit Facility, and additional proceeds of the Credit Facility are expected to be used by us for working capital and other general corporate purposes. As of July 31, 2019, the amount outstanding under our Credit Facility was $165,000,000 which is reflected in the non-current portion of long-term debt on our Consolidated Balance Sheet. At July 31, 2019, we had $2,686,000 of standby letters of credit outstanding under our Credit Facility related to guarantees of future performance on certain customer contracts and no outstanding commercial letters of credit. Since October 31, 2018, we had outstanding balances under the new Credit Facility ranging from $150,000,000 to $184,000,000.

As of July 31, 2019, total net deferred financing costs related to the Credit Facility were $3,128,000 and are being amortized over the term of our Credit Facility through October 31, 2023.

Interest expense, including amortization of deferred financing costs, recorded during the fiscal years ended July 31, 2019, 2018 and 2017 was $8,859,000, $9,614,000 and $11,106,000, respectively. The amount for the most recent fiscal year relates to both our Prior Credit Facility and new Credit Facility; whereas, the amount in the prior fiscal years relates to our Prior Credit Facility. Our blended interest rate approximated 5.25%, 5.40% and 4.90% for fiscal 2019, 2018 and 2017, respectively.

Borrowings under the Credit Facility shall be either: (i) Alternate Base Rate borrowings, which bear interest from the applicable borrowing date at a rate per annum equal to (x) the greatest of (a) the Prime Rate (as defined) in effect on such day, (b) the Federal Funds Effective Rate (as defined) in effect on such day plus 1/2 of 1.00% per annum and (c) the Adjusted LIBO Rate (as defined) on such day (or, if such day is not a business day, the immediately preceding business day) plus 1.00% per annum, plus (y) the Applicable Rate (as defined), or (ii) Eurodollar borrowings, which bear interest from the applicable borrowing date at a rate per annum equal to (x) the Adjusted LIBO Rate for such interest period plus (y) the Applicable Rate. Determination of the Applicable Rate is based on a pricing grid that is dependent upon our Secured Leverage Ratio (as defined) as of the end of each fiscal quarter for which consolidated financial statements have been most recently delivered.

The Credit Facility contains customary representations, warranties and affirmative covenants. The Credit Facility also contains customary negative covenants, subject to negotiated exceptions, including but not limited to: (i) liens, (ii) investments, (iii) indebtedness, (iv) significant corporate changes, including mergers and acquisitions, (v) dispositions, (vi) restricted payments, including stockholder dividends, and (vii) certain other restrictive agreements. The Credit Facility also contains certain financial covenants and customary events of default (subject to grace periods, as appropriate), such as payment defaults, cross-defaults to other material indebtedness, bankruptcy and insolvency, the occurrence of a defined change in control and the failure to observe the negative covenants and other covenants related to the operation of our business. In addition, under certain circumstances, we may be required to enter into amendments to the Credit Facility in connection with any further syndication of the Credit Facility.

The Credit Facility provides for, among other things: (i) no scheduled payments of principal until maturity; (ii) a maximum Secured Leverage Ratio of 3.75x trailing twelve months ("TTM") Adjusted Earnings Before Interest, Taxes, Depreciation and Amortization ("Adjusted EBITDA") and a Maximum Total Leverage Ratio of 4.50x TTM Adjusted EBITDA, each with no step downs; and (iii) a Minimum Interest Expense Coverage Ratio of 3.25x TTM Adjusted EBITDA.

As of July 31, 2019, our Secured Leverage Ratio was 1.74x TTM Adjusted EBITDA compared to the maximum allowable Secured Leverage Ratio of 3.75x TTM Adjusted EBITDA. Our Interest Expense Coverage Ratio as of July 31, 2019 was 12.05x TTM Adjusted EBITDA compared to the Minimum Interest Expense Coverage Ratio of 3.25x TTM Adjusted EBITDA. Given our expected future business performance, we anticipate maintaining compliance with the terms and financial covenants in our Credit Facility for the foreseeable future.

The obligations under the Credit Facility are guaranteed by certain of our domestic subsidiaries (the "Guarantors"). As collateral security under the Credit Facility and the guarantees thereof, we and the Guarantors have granted to the administrative agent, for the benefit of the lenders, a lien on, and first priority security interest in, substantially all of our tangible and intangible assets.

On December 6, 2018, we entered into the first amendment to the Credit Facility. The purpose of the amendment is to provide for a mechanism to replace the LIBO Rate for Eurodollar borrowings with an alternative benchmark interest rate, should the LIBO Rate generally become unavailable in the future on an other-than-temporary basis.

The Prior Credit Facility was a $400,000,000 secured credit facility and comprised of a senior secured term loan A facility of $250,000,000 (the "Term Loan Facility") and a secured revolving loan facility of up to $150,000,000, including a $25,000,000 letter of credit sublimit (the "Revolving Loan Facility"). The proceeds of the Prior Credit Facility were primarily used to finance our acquisition of TCS, including the repayment of certain existing indebtedness of TCS. During the three months ended October 31, 2018, we had outstanding balances under the Revolving Loan Facility, ranging from $34,904,000 to $63,804,000.

As of July 31, 2018, the net amount outstanding under the Prior Credit Facility was as follows:

	2018
Term Loan Facility	$ 120,121,000
Less unamortized deferred financing costs related to Term Loan Facility	3,427,000
Term Loan Facility, net	116,694,000
Revolving Loan Facility	48,604,000
Amount outstanding under Secured Credit Facility, net	165,298,000
Less current portion of long-term debt	17,211,000
Non-current portion of long-term debt	$ 148,087,000

Capitalized terms used but not defined herein have the meanings set forth for such terms in the Credit Facility and the Prior Credit Facility, which have been documented and filed with the SEC.

(9) Capital Lease and Other Obligations

We lease certain equipment under capital leases. As of July 31, 2019 and 2018, the net book value of the leased assets which collateralize the capital lease and other obligations was $864,000 and $2,547,000, respectively, and consisted primarily of machinery and equipment. Depreciation of leased assets is included in depreciation expense.

As of July 31, 2019, our capital lease and other obligations reflect a blended interest rate of approximately 7.00%. Our capital leases generally contain provisions whereby we can purchase the equipment at the end of the lease for a one dollar buyout.

Future minimum payments under capital lease and other obligations consisted of the following at July 31, 2019:

Fiscal 2020	$ 789,000
Total minimum lease payments	789,000
Less: amounts representing interest	32,000
Present value of net minimum lease payments	757,000
Current portion of capital lease and other obligations	757,000
Non-current portion of capital lease and other obligations	$ —

(10) Income Taxes

On December 22, 2017, H.R.1, also known as the Tax Cuts and Jobs Act ("Tax Reform"), was enacted in the U.S. Tax Reform significantly lowered the amount of our current and future income tax expense primarily due to the reduction in the U.S. statutory income tax rate from 35.0% to 21.0%. This provision went into effect on January 1, 2018 and required us to remeasure our deferred tax assets and liabilities. In connection with Tax Reform, during fiscal 2018, we recorded a net discrete tax benefit of $11,792,000, primarily related to the remeasurement of deferred tax liabilities associated with non-deductible amortization related to intangible assets. This remeasurement was recorded pursuant to ASC 740 *"Income Taxes"* and SEC Staff Accounting Bulletin ("SAB") 118, using estimates based on reasonable and supportable assumptions and available information as of such reporting date. In the event the Internal Revenue Service ("IRS") issues clarifying or interpretive guidance related to Tax Reform, it may result in a change to our estimated income tax. In fiscal 2019 and beyond, Tax Reform will result in the loss of our ability to take the domestic production activities deduction, which has been repealed, and is also likely to result in lower tax deductions for certain executive compensation expenses.

For fiscal 2019, we were subject to a U.S. statutory income tax rate of 21.0%. For fiscal 2018, we were subject to a 35.0% statutory income tax rate with respect to the period August 1, 2017 through December 31, 2017 and a 21.0% statutory income tax rate with respect to the period January 1, 2018 through July 31, 2018, or a blended U.S. statutory income tax rate for fiscal 2018 of approximately 27.0%. As such, our effective tax rate for accounting purposes in fiscal 2018, excluding discrete items, was 27.0%.

Income before provision for (benefit from) income taxes consists of the following:

	Fiscal Years Ended July 31,		
	2019	2018	2017
U.S.	$ 28,813,000	22,243,000	23,732,000
Foreign	97,000	2,383,000	1,749,000
	$ 28,910,000	24,626,000	25,481,000

The provision for (benefit from) income taxes included in the accompanying Consolidated Statements of Operations consists of the following:

	Fiscal Years Ended July 31,		
	2019	2018	2017
Federal – current	$ (2,190,000)	367,000	(441,000)
Federal – deferred	4,782,000	(7,499,000)	8,399,000
State and local – current	1,715,000	440,000	608,000
State and local – deferred	(321,000)	1,115,000	659,000
Foreign – current	62,000	429,000	413,000
Foreign – deferred	(179,000)	5,000	16,000
Provision for (benefit from) income taxes	$ 3,869,000	(5,143,000)	9,654,000

The provision for (benefit from) income taxes differed from the amounts computed by applying the U.S. Federal income tax rate as a result of the following:

	Fiscal Years Ended July 31,					
	2019		2018		2017	
	Amount	Rate	Amount	Rate	Amount	Rate
Computed "expected" tax expense	$ 6,071,000	21.0%	6,615,000	27.0 %	8,919,000	35.0%
Increase (reduction) in income taxes resulting from:						
State and local income taxes, net of federal benefit	967,000	3.3	1,193,000	4.8	1,257,000	4.9
Stock-based compensation	(44,000)	(0.1)	(1,112,000)	(4.5)	78,000	0.3
Research and experimentation credits	(1,129,000)	(3.9)	(678,000)	(2.8)	(919,000)	(3.6)
Foreign-derived intangible income deduction	(632,000)	(2.2)	—	—	—	—
Nondeductible transaction costs	394,000	1.4	—	—	—	—
Nondeductible executive compensation	330,000	1.1	(22,000)	(0.1)	88,000	0.3
Audit settlements	(2,081,000)	(7.2)	—	—	—	—
Tax Reform remeasurement of deferred taxes	—	—	(11,317,000)	(46.0)	—	—
Foreign income taxes	5,000	—	(221,000)	(0.9)	(151,000)	(0.6)
Other, net	(12,000)	—	399,000	1.5	382,000	1.6
Provision for (benefit from) income taxes	$ 3,869,000	13.4%	(5,143,000)	(21.0)%	9,654,000	37.9%

The tax effects of temporary differences that give rise to significant portions of the deferred tax assets and liabilities at July 31, 2019 and 2018 are presented below:

	2019	2018
Deferred tax assets:		
Inventory and warranty reserves	$ 7,318,000	5,089,000
Compensation and commissions	3,548,000	3,511,000
Contract liabilities	5,331,000	—
Federal, state and foreign research and experimentation credits	18,183,000	18,816,000
Federal alternative minimum tax credit	1,800,000	3,243,000
Stock-based compensation	5,817,000	5,092,000
Acquisition-related contingent liabilities	1,250,000	2,477,000
Federal, state and foreign net operating losses	6,248,000	7,349,000
Other	7,651,000	4,672,000
Less: valuation allowance	(12,568,000)	(11,854,000)
Total deferred tax assets	44,578,000	38,395,000
Deferred tax liabilities:		
Plant and equipment	(1,362,000)	(1,155,000)
Intangibles	(54,612,000)	(48,167,000)
Total deferred tax liabilities	(55,974,000)	(49,322,000)
Net deferred tax liabilities	$ (11,396,000)	(10,927,000)

At July 31, 2019, our net deferred tax liability of $11,396,000 includes $1,085,000 of foreign net deferred tax assets that were recorded as other assets, net in our Consolidated Balance Sheets. At July 31, 2018, the entire $10,927,000 of net deferred tax liabilities were recorded as deferred tax liability, net in our Consolidated Balance Sheets.

We provide for income taxes under the provisions of FASB ASC 740 *"Income Taxes."* FASB ASC 740 requires an asset and liability based approach in accounting for income taxes. In assessing the realizability of deferred tax assets, management considers whether it is more likely than not that some portion or all of them will not be realized. If management determines that it is more likely than not that some or all of its deferred tax assets will not be realized, a valuation allowance will be recorded against such deferred tax assets.

At July 31, 2019, we had federal alternative minimum tax credit carryforwards of $1,800,000, which are available to offset future federal income taxes. We have federal research and experimentation credits of $8,725,000 that will begin to expire in 2027. The timing and manner in which we may utilize tax credits in future tax years will be limited by the amounts and timing of future taxable income and by the application of the ownership change rules under Section 383 of the Internal Revenue Code.

We have state net operating loss carryforwards available of $3,808,000 which expire through 2038, utilization of which will be limited by the amounts and timing of future taxable income and by the application of the ownership change rules under Section 382 of the Internal Revenue Code. We believe that it is more likely than not that the benefit from certain state net operating loss carryforwards will not be realized. In recognition of this risk, we have provided a valuation allowance of $3,746,000 on the deferred tax assets relating to these state net operating loss carryforwards. We have state research and experimentation credit carryforwards of $7,032,000 expiring through 2038. We believe that it is more likely than not that the benefit from certain state research and experimentation credits will not be realized. In recognition of this risk, we have provided a valuation allowance of $6,820,000 on the deferred tax assets relating to these state credits.

At July 31, 2019, we had foreign deferred tax assets relating to net operating loss carryforwards of $2,440,000. These losses were generated by Solacom prior to being acquired by Comtech and will begin to expire in 2023. We believe that it is more likely than not that a portion of these net operating loss carryforwards may not be realized. In recognition of this risk, we have provided a valuation allowance of $656,000 on the deferred tax assets relating to these net operating loss carryforwards. We have foreign deferred tax assets relating to research and experimentation credits of $2,426,000 that will begin to expire in 2019. We believe that it is more likely than not that the benefit from certain foreign research and experimentation credits may not be realized. In recognition of this risk, we have provided a valuation allowance of $539,000 on the deferred tax assets relating to foreign research and experimentation credits. At July 31, 2018, our foreign deferred tax assets relating to research and experimentation credits have been offset by a valuation allowance as they may not be utilized in a future period. Our foreign earnings and profits are insignificant and, as such, we have not recorded any deferred tax liability on unremitted foreign earnings.

We must generate $197,600,000 of taxable income in the future to fully utilize our net deferred tax assets as of July 31, 2019. Management believes it is more likely than not that the results of future operations will generate sufficient taxable income to realize the net deferred tax assets.

At July 31, 2019 and 2018, total unrecognized tax benefits were $7,215,000 and $9,339,000, respectively, including interest of $12,000 and $202,000, respectively. At July 31, 2019 and 2018, $325,000 and 2,572,000, respectively, of our unrecognized tax benefits were recorded as non-current income taxes payable on our Consolidated Balance Sheets. The remaining unrecognized tax benefits of $6,890,000 and $6,767,000 at July 31, 2019 and 2018, respectively, were presented as an offset to the associated non-current deferred tax assets on our Consolidated Balance Sheets. Of the total unrecognized tax benefits, $6,670,000 and $8,563,000 at July 31, 2019 and 2018, respectively, net of the reversal of the federal benefit recognized as a deferred tax asset relating to state reserves, would favorably impact our effective tax rate, if recognized. Unrecognized tax benefits result from income tax positions taken or expected to be taken on our income tax returns for which a tax benefit has not been recorded in our consolidated financial statements. We do not expect that there will be any significant changes to our total unrecognized tax benefits within the next twelve months.

Our policy is to recognize potential interest and penalties relating to uncertain tax positions in income tax expense. The following table summarizes the activity related to our unrecognized tax benefits for fiscal years 2019, 2018 and 2017 (excluding interest):

	2019	2018	2017
Balance at beginning of period	$ 9,137,000	8,586,000	9,108,000
Increase related to current period	893,000	645,000	587,000
Increase related to prior periods	17,000	49,000	86,000
Expiration of statute of limitations	(394,000)	(81,000)	(404,000)
Decrease related to prior periods	(2,450,000)	(62,000)	(791,000)
Balance at end of period	$ 7,203,000	9,137,000	8,586,000

Our federal income tax returns for fiscal 2017 and 2018 are subject to potential future IRS audit. None of our state income tax returns prior to fiscal 2015 are subject to audit. TCS's federal income tax returns for tax year 2015 and the tax period from January 1, 2016 to February 23, 2016, the date we acquired TCS, are subject to potential future IRS audit. None of TCS's state income tax returns prior to calendar year 2014 are subject to audit. Future tax assessments or settlements could have a material adverse effect on our consolidated results of operations and financial condition.

(11) Stock-Based Compensation

Overview

We issue stock-based awards to certain of our employees and our Board of Directors pursuant to our 2000 Stock Incentive Plan, as amended, (the "Plan") and our 2001 Employee Stock Purchase Plan (the "ESPP") and recognize related stock-based compensation in our consolidated financial statements. The Plan provides for the granting to employees and consultants of Comtech (including prospective employees and consultants): (i) incentive and non-qualified stock options, (ii) restricted stock units ("RSUs"), (iii) RSUs with performance measures (which we refer to as "performance shares"), (iv) restricted stock, (v) stock units (reserved for issuance to non-employee directors) and share units (reserved for issuance to employees) (collectively, "share units") and (vi) stock appreciation rights ("SARs"), among other types of awards. Our non-employee directors are eligible to receive non-discretionary grants of stock-based awards, subject to certain limitations.

On August 1, 2017 (the start of our first quarter of fiscal 2018), we adopted ASU No. 2016-09, which amended several aspects of the accounting for and reporting of our share-based payment transactions, including:

Excess tax benefits and shortfalls - ASU No. 2016-09 requires that all tax effects related to our share-based awards be recognized in the Consolidated Statement of Operations. ASU No. 2016-09 also removed the prior requirement to delay recognition of excess tax benefits until it reduces current taxes payable; instead, we are now required to recognize excess tax benefits as discrete items in the interim period in which they occur, subject to normal valuation allowance considerations. As ASU No. 2016-09 eliminated the concept of accumulated hypothetical tax benefits, excess tax benefits and shortfalls are no longer recognized in stockholders' equity. As a result, ASU No. 2016-09 is expected to result in future volatility of our income tax expense (as the future tax effects of share-based awards will be dependent on the price of our common stock at the time of settlement). Additionally, on a prospective basis, excess income tax benefits from the settlement of share-based awards are presented as a cash inflow from operating activities in our Consolidated Statement of Cash Flows.

Diluted earnings per share - Prior to the adoption of ASU No. 2016-09, in addition to considering the amount an employee must pay upon assumed exercise of stock-based awards and the amount of stock-based compensation cost attributed to future services and not yet recognized, when calculating our diluted earnings per share, the assumed proceeds also included the amount of excess tax benefits, if any, that would have been credited to additional paid-in capital assuming exercise of in-the-money stock-based awards. Effective with our adoption of ASU No. 2016-09, excess tax benefits are to be excluded from the calculation on a prospective basis. As a result, the denominator for our diluted calculations could increase in the future as compared to prior calculations.

Forfeitures - As permitted by ASU No. 2016-09, we elected to continue to estimate forfeitures of share-based awards.

Statutory Tax Withholding Requirements - ASU No. 2016-09 now allows us, when net settling share-based awards, to withhold an amount up to the employees' maximum individual tax rate in the relevant jurisdiction, without resulting in liability classification of the award. To qualify, we must have at least some withholding obligation. This aspect of adopting ASU No. 2016-09 did not have any material impact on us. However, with respect to cash payments that we make to taxing authorities on behalf of employees for such shares withheld, on a retrospective basis, we are required to present such payments as a cash outflow from financing activities in our Consolidated Statements of Cash Flows (as opposed to operating activities).

As of July 31, 2019, the aggregate number of shares of common stock which may be issued, pursuant to the Plan, may not exceed 10,362,500. Stock options granted may not have a term exceeding ten years or, in the case of an incentive stock award granted to a stockholder who owns stock representing more than 10.0% of the voting power, no more than five years. We expect to settle all outstanding awards under the Plan and employee purchases under the ESPP with the issuance of new shares of our common stock.

As of July 31, 2019, we had granted stock-based awards pursuant to the Plan representing the right to purchase and/or acquire an aggregate of 8,546,187 shares (net of 3,989,425 expired and canceled awards), of which an aggregate of 6,035,956 have been exercised or settled.

As of July 31, 2019, the following stock-based awards, by award type, were outstanding:

	July 31, 2019
Stock options	1,555,555
Performance shares	261,336
RSUs and restricted stock	432,550
Share units	260,790
Total	2,510,231

Our ESPP provides for the issuance of up to 1,050,000 shares of our common stock. Our ESPP is intended to provide our eligible employees the opportunity to acquire our common stock at 85% of fair market value at the date of issuance. Through July 31, 2019, we have cumulatively issued 787,051 shares of our common stock to participating employees in connection with our ESPP.

Stock-based compensation for awards issued is reflected in the following line items in our Consolidated Statements of Operations:

	Fiscal Years Ended July 31,		
	2019	2018	2017
Cost of sales	$ 1,047,000	758,000	760,000
Selling, general and administrative expenses	9,336,000	6,866,000	7,071,000
Research and development expenses	1,044,000	945,000	675,000
Stock-based compensation expense before income tax benefit	11,427,000	8,569,000	8,506,000
Estimated income tax benefit	(2,553,000)	(2,005,000)	(3,065,000)
Net stock-based compensation expense	$ 8,874,000	6,564,000	5,441,000

Stock-based compensation for equity-classified awards is measured at the date of grant, based on an estimate of the fair value of the award and is generally expensed over the vesting period of the award. At July 31, 2019, unrecognized stock-based compensation of $7,714,000, net of estimated forfeitures of $869,000, is expected to be recognized over a weighted average period of 2.8 years. Total stock-based compensation capitalized and included in ending inventory at both July 31, 2019 and 2018 was $48,000. There are no liability-classified stock-based awards outstanding as of July 31, 2019 or 2018.

Stock-based compensation expense, by award type, is summarized as follows:

	Fiscal Years Ended July 31,		
	2019	2018	2017
Stock options	$ 739,000	1,089,000	1,400,000
Performance shares	1,554,000	1,013,000	1,607,000
RSUs and restricted stock	2,149,000	1,458,000	829,000
ESPP	215,000	205,000	162,000
Share units	6,770,000	4,804,000	4,508,000
Stock-based compensation expense before income tax benefit	11,427,000	8,569,000	8,506,000
Estimated income tax benefit	(2,553,000)	(2,005,000)	(3,065,000)
Net stock-based compensation expense	$ 8,874,000	6,564,000	5,441,000

ESPP stock-based compensation expense primarily relates to the 15% discount offered to participants in the ESPP. During the fiscal years ended July 31, 2019 and 2018, we recorded benefits of $130,000 and $62,000, respectively, which primarily represents the recoupment of certain share units.

The estimated income tax benefit as shown in the above table was computed using income tax rates expected to apply when the awards are settled. Such deferred tax asset was recorded net as part of our non-current deferred tax liability on our Consolidated Balance Sheet as of July 31, 2019 and 2018. The actual income tax benefit recognized for tax reporting is based on the fair market value of our common stock at the time of settlement and can significantly differ from the estimated income tax benefit recorded for financial reporting.

Stock Options

The following table summarizes the Plan's activity:

	Awards (in Shares)	Weighted Average Exercise Price	Weighted Average Remaining Contractual Term (Years)	Aggregate Intrinsic Value
Outstanding at July 31, 2016	2,256,679	$ 28.87		
Expired/canceled	(400,804)	30.15		
Outstanding at July 31, 2017	1,855,875	28.60		
Expired/canceled	(72,190)	27.58		
Exercised	(114,710)	27.44		
Outstanding at July 31, 2018	1,668,975	28.72		
Expired/canceled	(32,490)	30.11		
Exercised	(80,930)	28.18		
Outstanding at July 31, 2019	1,555,555	$ 28.72	3.54	$ 2,512,000
Exercisable at July 31, 2019	1,389,895	$ 28.73	3.26	$ 2,186,000
Vested and expected to vest at July 31, 2019	1,538,930	$ 28.75	3.51	$ 2,460,000

Stock options outstanding as of July 31, 2019 have exercise prices ranging from $20.90 - $33.94, representing the fair market value of our common stock on the date of grant, a contractual term of five or ten years and a vesting period of three or five years. The total intrinsic value relating to stock options exercised during the fiscal years ended July 31, 2019 and 2018 was $576,000 and $469,000, respectively. There were no stock options exercised during the fiscal year ended 2017.

During fiscal 2019 and 2018, at the election of certain holders of vested stock options, 72,830 and 101,610 stock options, respectively, were net settled upon exercise. As a result, 9,345 and 8,706 net shares of our common stock were issued during the fiscal years ended July 31, 2019 and 2018, respectively, after reduction of shares retained to satisfy the exercise price and minimum statutory tax withholding requirements.

Performance Shares, RSUs, Restricted Stock and Share Unit Awards

The following table summarizes the Plan's activity relating to performance shares, RSUs, restricted stock and share units:

	Awards (in Shares)	Weighted Average Grant Date Fair Value	Aggregate Intrinsic Value
Outstanding at July 31, 2016	217,213	$ 28.32	
Granted	705,241	14.31	
Settled	(61,462)	26.63	
Forfeited	(30,795)	17.13	
Outstanding at July 31, 2017	830,197	16.95	
Granted	473,005	22.45	
Settled	(354,822)	17.66	
Canceled/Forfeited	(129,942)	17.26	
Outstanding at July 31, 2018	818,438	19.78	
Granted	442,363	29.76	
Settled	(275,619)	26.05	
Canceled/Forfeited	(30,506)	25.52	
Outstanding at July 31, 2019	954,676	$ 22.40	$ 28,411,000
Vested at July 31, 2019	321,702	$ 25.82	$ 9,574,000
Vested and expected to vest at July 31, 2019	914,082	$ 22.55	$ 27,203,000

The total intrinsic value relating to fully-vested awards settled during the fiscal years ended July 31, 2019, 2018 and 2017 was $8,772,000, $10,473,000 and $1,039,000 respectively.

The performance shares granted to employees since fiscal 2014 principally vest over a three-year performance period, if pre-established performance goals are attained, or as specified pursuant to the Plan and related agreements. As of July 31, 2019, the number of outstanding performance shares included in the above table, and the related compensation expense prior to consideration of estimated pre-vesting forfeitures, assume achievement of the pre-established goals at a target level.

RSUs and restricted stock granted to non-employee directors have a vesting period of three years and are convertible into shares of our common stock generally at the time of termination, on a one-for-one basis for no cash consideration, or earlier under certain circumstances. RSUs granted to employees have a vesting period of five years and are convertible into shares of our common stock generally at the time of vesting, on a one-for-one basis for no cash consideration.

Share units granted prior to July 31, 2017 were vested when issued and are convertible into shares of our common stock, generally at the time of termination, on a one-for-one basis for no cash consideration, or earlier under certain circumstances. Share units granted on or after July 31, 2017 were granted to certain employees in lieu of non-equity incentive compensation and are convertible into shares of our common stock on the one-year anniversary of the respective grant date.

On July 31, 2019, 257,608 fully vested share units were granted to certain employees in lieu of fiscal 2019 non-equity incentive compensation. Also, on July 31, 2019, 146,410 fully vested share units (previously granted in lieu of fiscal 2018 non-equity incentive compensation) were settled by delivery of 90,928 shares of our common stock after reduction of share units retained to satisfy employees' statutory tax withholding requirements. Cumulatively, through July 31, 2019, 421,966 share units granted have been settled.

The fair value of performance shares, RSUs, restricted stock and share units is determined using the closing market price of our common stock on the date of grant, less the present value of any estimated future dividend equivalents such awards are not entitled to receive and an applicable estimated discount for any post-vesting transfer restrictions. RSUs, performance shares and restricted stock granted since fiscal 2013 are entitled to dividend equivalents unless forfeited before vesting occurs. Share units granted since fiscal 2014 are entitled to dividend equivalents while the underlying shares are unissued.

Dividend equivalents are subject to forfeiture, similar to the terms of the underlying stock-based awards, and are payable in cash generally at the time of settlement of the underlying award. During fiscal 2019, 2018 and 2017, we accrued $327,000, $300,000 and $273,000, respectively, of dividend equivalents (net of forfeitures) and paid out $263,000, $141,000 and $176,000, respectively. Accrued dividend equivalents were recorded as a reduction to retained earnings. As of July 31, 2019 and 2018, accrued dividend equivalents were $777,000 and $713,000, respectively.

With respect to the actual settlement of stock-based awards for income tax reporting, during the fiscal years ended July 31, 2019 and 2018 we recorded income tax benefits of $479,000 and $1,193,000, respectively, which primarily represent the net excess income tax benefits upon settlement of stock-based awards during each of the respective periods. During fiscal 2017, net income tax shortfalls from similar items totaled $670,000 and, pursuant to prior GAAP, were recorded as a reduction to additional paid-in capital.

Subsequent Events

In the first quarter of fiscal 2020, our Board of Directors authorized the issuance of stock-based awards with a total unrecognized compensation expense, net of estimated forfeitures, of approximately $5,632,000.

(12) Segment Information

Reportable operating segments are determined based on Comtech's management approach. The management approach, as defined by FASB ASC 280 *"Segment Reporting"* is based on the way that the CODM organizes the segments within an enterprise for making decisions about resources to be allocated and assessing their performance. Our CODM, for purposes of FASB ASC 280, is our Chief Executive Officer and President.

Our Commercial Solutions segment offers satellite ground station technologies (such as modems and amplifiers) and public safety and location technologies (such as 911 call routing and mapping solutions) to commercial customers and smaller government customers, such as state and local governments. This segment also serves certain large government customers (including the U.S. government) that have requirements for off-the-shelf commercial equipment.

Our Government Solutions segment provides mission-critical technologies (such as tactical satellite-based networks and ongoing support for complicated communications networks) and high-performance transmission technologies (such as troposcatter systems and solid-state, high-power amplifiers) to large government end-users (including those of foreign countries), large international customers and domestic prime contractors.

Our CODM primarily uses a metric that we refer to as Adjusted EBITDA to measure an operating segment's performance and to make decisions about resources to be allocated. Our Adjusted EBITDA metric for the Commercial Solutions and Government Solutions segments do not consider any allocation of indirect expenses, or any of the following: income taxes, interest (income) and other, write-off of deferred financing costs, interest expense, amortization of stock-based compensation, amortization of intangible assets, depreciation expense, estimated contract settlement costs, settlement of intellectual property litigation, acquisition plan expenses, facility exit costs or strategic alternatives analysis expenses and other expenses that relate to our Unallocated segment. These items, while periodically affecting our results, may vary significantly from period to period and may have a disproportionate effect in a given period, thereby affecting the comparability of results. Any amounts shown in the Adjusted EBITDA calculation for our Commercial Solutions and Government Solutions segments are directly attributable to those segments. Our Adjusted EBITDA is also used by our management in assessing the Company's operating results. Although closely aligned, the Company's definition of Adjusted EBITDA is different than the Consolidated EBITDA (as such term is defined in our Credit Facility) utilized for financial covenant calculations and also may differ from the definition of EBITDA or Adjusted EBITDA used by other companies and, therefore, may not be comparable to similarly titled measures used by other companies.

Operating segment information, along with a reconciliation of segment net income (loss) and consolidated net income to Adjusted EBITDA is presented in the tables below:

	Fiscal Year Ended July 31, 2019			
	Commercial Solutions	Government Solutions	Unallocated	Total
Net sales	$ 357,293,000	314,504,000	—	$ 671,797,000
Operating income (loss)	$ 36,053,000	28,997,000	(23,643,000)	$ 41,407,000
Net income (loss)	$ 35,888,000	29,029,000	(39,876,000)	$ 25,041,000
Provision for income taxes	19,000	—	3,850,000	3,869,000
Interest (income) and other	75,000	(41,000)	1,000	35,000
Write-off of deferred financing costs	—	—	3,217,000	3,217,000
Interest expense	71,000	9,000	9,165,000	9,245,000
Amortization of stock-based compensation	—	—	11,427,000	11,427,000
Amortization of intangibles	14,944,000	3,376,000	—	18,320,000
Depreciation	9,265,000	1,891,000	771,000	11,927,000
Estimated contract settlement costs	6,351,000	—	—	6,351,000
Settlement of intellectual property litigation	—	—	(3,204,000)	(3,204,000)
Acquisition plan expenses	—	—	5,871,000	5,871,000
Facility exit costs	—	1,373,000	—	1,373,000
Adjusted EBITDA	$ 66,613,000	35,637,000	(8,778,000)	$ 93,472,000
Purchases of property, plant and equipment	$ 6,293,000	1,902,000	590,000	$ 8,785,000
Long-lived assets acquired in connection with acquisitions	$ 60,693,000	—	—	$ 60,693,000
Total assets at July 31, 2019	$ 662,580,000	186,438,000	38,693,000	$ 887,711,000

	Fiscal Year Ended July 31, 2018			
	Commercial Solutions	Government Solutions	Unallocated	Total
Net sales	$ 345,076,000	225,513,000	—	$ 570,589,000
Operating income (loss)	$ 40,837,000	10,950,000	(16,712,000)	$ 35,075,000
Net income (loss)	$ 40,297,000	10,835,000	(21,363,000)	$ 29,769,000
Provision for (benefit from) income taxes	270,000	—	(5,413,000)	(5,143,000)
Interest (income) and other	151,000	112,000	(9,000)	254,000
Interest expense	119,000	3,000	10,073,000	10,195,000
Amortization of stock-based compensation	—	—	8,569,000	8,569,000
Amortization of intangibles	17,699,000	3,376,000	—	21,075,000
Depreciation	9,479,000	3,088,000	1,088,000	13,655,000
Adjusted EBITDA	$ 68,015,000	17,414,000	(7,055,000)	$ 78,374,000
Purchases of property, plant and equipment	$ 7,151,000	901,000	590,000	$ 8,642,000
Total assets at July 31, 2018	$ 610,166,000	195,924,000	39,067,000	$ 845,157,000

	Fiscal Year Ended July 31, 2017			
	Commercial Solutions	Government Solutions	Unallocated	Total
Net sales	$ 330,867,000	219,501,000	—	$ 550,368,000
Operating income (loss)	$ 33,234,000	9,393,000	(5,585,000)	$ 37,042,000
Net income (loss)	$ 32,871,000	9,421,000	(26,465,000)	$ 15,827,000
Provision for income taxes	258,000	—	9,396,000	9,654,000
Interest (income) and other	(108,000)	(34,000)	74,000	(68,000)
Interest expense	213,000	6,000	11,410,000	11,629,000
Amortization of stock-based compensation	—	—	8,506,000	8,506,000
Amortization of intangibles	17,698,000	5,125,000	—	22,823,000
Depreciation	9,938,000	2,938,000	1,478,000	14,354,000
Settlement of intellectual property litigation	—	—	(12,020,000)	(12,020,000)
Adjusted EBITDA	$ 60,870,000	17,456,000	(7,621,000)	$ 70,705,000
Purchases of property, plant and equipment	$ 7,007,000	1,046,000	97,000	$ 8,150,000
Total assets at July 31, 2017	$ 606,436,000	185,234,000	40,393,000	$ 832,063,000

Unallocated expenses result from corporate expenses such as executive compensation, accounting, legal and other regulatory compliance related costs and also includes all of our amortization of stock-based compensation. During fiscal 2019, unallocated expenses also include $5,871,000 of acquisition plan expenses. In addition, offsetting unallocated expenses in fiscal 2019 is a $3,204,000 benefit resulting from a favorable ruling of the U.S. Court of Appeals for the Federal Circuit related to a legacy TCS intellectual property matter. See *Note (13)*(b)- *"Commitments and Contingencies - Legal Proceedings and Other Matters"* for further information. Unallocated expenses reflect favorable adjustments to operating income related to: (i) warranty and sales and use tax settlements in fiscal 2018; and (ii) settlement of certain legacy TCS intellectual property matters in fiscal 2017.

Interest expense in the tables above relate to our Prior Credit Facility and new Credit Facility, and includes the amortization of deferred financing costs. In addition, during fiscal 2019, we recorded a $3,217,000 loss from the write-off of deferred financing costs primarily related to the Term Loan Facility portion of our Prior Credit Facility. See *Note (8)* - "*Credit Facility*" for further discussion. There were no comparable losses recorded in fiscal 2018 and 2017.

Intersegment sales in fiscal 2019, 2018 and 2017 by the Commercial Solutions segment to the Government Solutions segment were $17,371,000, $9,630,000 and $12,492,000, respectively. There were nominal sales by the Government Solutions segment to the Commercial Solutions segment for these fiscal periods. All intersegment sales are eliminated in consolidation and are excluded from the tables above.

Unallocated assets at July 31, 2019 consist principally of cash and cash equivalents, income taxes receivable, corporate property, plant and equipment and deferred financing costs. Substantially all of our long-lived assets are located in the U.S.

(13) Commitments and Contingencies

(a) Operating Leases

At July 31, 2019, future minimum lease payments, net of subleases, under non-cancelable operating lease agreements are as follows:

Fiscal Year:		
2020	$	11,812,000
2021		8,723,000
2022		7,343,000
2023		5,776,000
2024		3,430,000
Thereafter		7,130,000
Total	$	44,214,000

Lease expense charged to operations was $11,953,000, $12,733,000 and $13,270,000 in fiscal 2019, 2018 and 2017, respectively.

We lease our Melville, New York production facility from a partnership controlled by our President, CEO and Chairman. Lease payments made in fiscal 2019 were $636,000. The current lease provides for our use of the premises as they exist through December 2021 with an option for an additional 10 years. The annual rent of the facility for calendar year 2020 is $657,000 and is subject to customary adjustments. We have a right of first refusal in the event of a sale of the facility.

(b) Legal Proceedings and Other Matters

Legacy TCS Intellectual Property Matter - Vehicle IP

In December 2009, Vehicle IP, LLC ("Vehicle IP") filed a patent infringement lawsuit in the U.S. District Court for the District of Delaware (the "District Court"), seeking monetary damages, fees and expenses and other relief from, among others, our customer Verizon Wireless ("Verizon") based on the VZ Navigator product. TCS defended Verizon against Vehicle IP. In January 2019, we received a ruling from the U.S. Court of Appeals for the Federal Circuit upholding the District Court's claim construction in our favor. Consequently, we and Vehicle IP filed a joint stipulation requesting a judgment of non-infringement, which judgment was entered on March 5, 2019. As a result of the Federal Circuit Court's decision, this matter is now closed and during the second quarter of fiscal 2019, we reduced our accrued legal costs related to this matter and recorded a $3,204,000 benefit in the Consolidated Statement of Operations. See *Note (6)* - "*Accrued Expenses and Other Current Liabilities*" for additional information.

Legacy TCS 911 Call Handling Software Matter

A customer that purchased a TCS 911 call handling software solution in December 2014 (which was more than one year prior to our acquisition of TCS) (the "TCS Legacy Customer") informed us in fiscal 2019 that it experienced several network outages and that it would seek indemnification for any claims made against it as a result of such outages.

In connection with these outages, the TCS Legacy Customer informed us that it believed certain communication failover redundancies promised to it by former senior management of TCS were never completed and had originally demanded that we refund to it all amounts previously paid to us under the contract, which through July 31, 2019 exceeded $14,000,000. In response to such claim, we engaged legal counsel to review the claims made by our customer.

Settlement conversations were had with this customer for several months and a mutual agreement was not reached. In September 2019, this customer filed a lawsuit in the Sixth Judicial Circuit Court of the State of South Dakota and has accused us of committing fraud because, among other things, we failed to provide them with certain redundancy. We believe that TCS has complied with its contractual requirements and that the customer is not entitled to any such reimbursement. Our contract to provide services to this customer expires in December 2019 and the amount of annual revenue we generate from this customer is immaterial.

We vigorously contest that we violated any contractual obligations, much less committed fraud, and have submitted notification to our insurance carriers of the lawsuit for review and consideration of coverage for potential liability that may arise from this lawsuit. We are also reviewing with counsel our multiple counter claims against this TCS Legacy Customer.

We also filed a lawsuit in March 2019 against a former employee and her new employer arising from such former employee's violation of her obligation to TCS of confidentiality, non-competition and non-solicitation of customers, including the TCS Legacy Customer. The former employee has responded with her own lawsuit against us.

The ultimate resolution of these matters could vary and have a material adverse effect on our consolidated results of operations, financial position or cash flows in future periods.

Other Matters

In October 2014, we disclosed to the U.S. Department of the Treasury, Office of Foreign Assets Control ("OFAC") that we learned during a self-assessment of our export transactions that a shipment of modems sent to a Canadian customer by Comtech EF Data Corp. was incorporated into a communication system, the ultimate end user of which was the Sudan Civil Aviation Authority. The sales value of this equipment was approximately $288,000. At the time of shipment, OFAC regulations prohibited U.S. persons from doing business directly or indirectly with Sudan. In late 2015, OFAC issued an administrative subpoena seeking information about the disclosed transaction. We responded to the subpoena, including alerting OFAC to Comtech's repair of three modems for a customer in Lebanon who may have rerouted the modems from Lebanon to Sudan without the required U.S. licensing authorization. In September 2018, Comtech agreed to enter into a Tolling Agreement with OFAC, which extends the statute of limitations in this matter through December 31, 2019. The Tolling Agreement was shortly followed by a second administrative subpoena seeking additional information about the disclosed transaction. In December 2018, Comtech responded to a second administrative subpoena from OFAC, answering the questions it posed and providing all the documents it sought. U.S. sanctions with respect to Sudan were revoked in 2017. Consistent with the revocation of the Sudan Sanction Regulations ("SSR"), shipments to the Sudan Civil Aviation Authority by U.S. persons are now permissible. We are not able to predict whether OFAC will take any enforcement action against us in light of the revocation of the SSR. If OFAC determines that we have violated U.S. trade sanctions, civil and criminal penalties could apply, and we may suffer reputational harm. Even though we take precautions to avoid engaging in transactions that may violate U.S. trade sanctions, those measures may not be effective in every instance.

In May 2018, we were informed by the Office of Export Enforcement ("OEE") of the Department of Commerce ("DoC") that it was forwarding to the DoC's Office of Chief Counsel, the results of its audit of international shipments by Comtech Xicom Technology, Inc. for further review and possible determination of an administrative penalty. We fully cooperated with the OEE in their audit and, based on our self-assessment of the approximately 7,800 individual transactions audited, have determined that six (6) transactions may not have been fully in compliance with the Export Administration Regulations ("EAR"). These six (6) items, for which export licenses were not obtained, were either spares or repaired power amplifier subassembly components valued at less than $100,000 (in aggregate) and were shipped to Brazil, Italy, Russia, Thailand and the United Arab Emirates. The EAR provides an exception to the requirement to obtain an export license for the replacement of a defective or damaged component. During our self-assessment, we determined that we inadvertently did not obtain export licenses for the spares or evidence of the return or destruction of the defective or damaged components necessary to authorize our use of the export license exception for the replacements. Since discovering this issue, we have implemented additional controls and procedures and have increased awareness of these specific export requirements throughout the Company to help avoid similar occurrences in the future. Administrative penalties under the EAR can range from a warning letter to a denial of export privileges. A civil monetary penalty not to exceed the amount set forth in the Export Administration Act ("EAA") may be imposed for each violation, and in the event that any provision of the EAR is continued by any other authority, the maximum monetary civil penalty for each violation shall be that provided by such other authority. Administrative penalties under the EAR are currently determined pursuant to the International Emergency Economic Powers Act ("IEEPA"), which can reach the greater of twice the amount of the transaction that is the basis of the violation or approximately $300,000 per violation. We have not recorded an accrual related to a possible administrative penalty and continue to work cooperatively with the OEE.

In the ordinary course of business, we include indemnification provisions in certain of our customer contracts to indemnify, hold harmless and reimburse such customers for certain losses, including but not limited to losses related to third-party claims of intellectual property infringement arising from the customer's use of our products or services. We may also, from time to time, receive indemnification requests from customers related to third-party claims that 911 calls were improperly routed during an emergency. We evaluate such claims as and when they arise. We do not always agree with customers that they are entitled to indemnification and in such cases reject their claims. Despite maintaining that we have properly carried out our duties, we may seek coverage under our various insurance policies; however, we cannot be sure that we will be able to maintain or obtain insurance coverage at acceptable costs or in sufficient amounts or that our insurer will not disclaim coverage as to such claims. Accordingly, pending or future claims asserted against us by a party that we agree to indemnify could result in legal costs and damages that could have a material adverse effect on our consolidated results of operations and financial condition.

There are certain other pending and threatened legal actions which arise in the normal course of business. Although the ultimate outcome of litigation is difficult to accurately predict, we believe that the outcome of these other pending and threatened actions will not have a material adverse effect on our consolidated financial condition or results of operations.

(c) Employment Change of Control and Indemnification Agreements

We have an employment agreement with our CEO and President. The employment agreement generally provides for an annual salary and bonus award. We have also entered into change of control agreements with certain of our executive officers and certain key employees. All of these agreements may require payments by us, in certain circumstances, including, but not limited to, a change in control of our Company.

(14) Goodwill

The following table represents goodwill by reportable operating segment, including the changes in the net carrying value of goodwill during the fiscal year ended July 31, 2019:

	Commercial Solutions	Government Solutions	Total
Balance as of July 31, 2018	$ 231,440,000	59,193,000	$ 290,633,000
Addition resulting from Solacom acquisition	11,808,000	—	11,808,000
Addition resulting from the GD NG-911 acquisition	8,048,000	—	8,048,000
Balance as of July 31, 2019	$ 251,296,000	59,193,000	$ 310,489,000

As discussed further in *Note (2)* -"*Acquisitions*," the goodwill resulting from the acquisitions of Solacom and the GD NG-911 business was based upon valuation and estimates and assumptions that are subject to change within the purchase price allocation period (generally one year from the acquisition date).

In accordance with FASB ASC 350 "*Intangibles - Goodwill and Other,*" we perform a goodwill impairment analysis at least annually (in the first quarter of each fiscal year), unless indicators of impairment exist in interim periods. If we fail the quantitative assessment of goodwill impairment ("quantitative assessment"), we would be required to recognize an impairment loss equal to the amount that a reporting unit's carrying value exceeded its fair value; however, any loss recognized should not exceed the total amount of goodwill allocated to that reporting unit.

On August 1, 2019 (the first day of our fiscal 2020), we performed our annual quantitative assessment using market participant assumptions to determine if the fair value of each of our reporting units with goodwill exceeded its carrying value. In making this assessment, we considered, among other things, expectations of projected net sales and cash flows, assumptions impacting the weighted average cost of capital, trends in trading multiples of comparable companies, changes in our stock price and changes in the carrying values of our reporting units with goodwill. We also considered overall business conditions.

In performing the quantitative assessment, we estimated the fair value of each of our reporting units using a combination of the income and market approaches. The income approach, also known as the discounted cash flow ("DCF") method, utilizes the present value of cash flows to estimate fair value. The future cash flows for our reporting units were projected based on our estimates, at that time, of future revenues, operating income and other factors (such as working capital and capital expenditures). For purposes of conducting our impairment analysis, we assumed revenue growth rates and cash flow projections that are below our actual long-term expectations. The discount rates used in our DCF method were based on a weighted-average cost of capital ("WACC") determined from relevant market comparisons, adjusted upward for specific reporting unit risks (primarily the uncertainty of achieving projected operating cash flows). A terminal value growth rate was applied to the final year of the projected period, which reflects our estimate of stable, perpetual growth. We then calculated a present value of the respective cash flows for each reporting unit to arrive at an estimate of fair value under the income approach. Under the market approach, we estimated a fair value based on comparable companies' market multiples of revenues and earnings before interest, taxes, depreciation and amortization and factored in a control premium. Finally, we compared our estimates of fair values to our August 1, 2019 total public market capitalization and assessed implied control premiums based on our common stock price of $29.54 as of August 1, 2019.

Based on our quantitative evaluation, we determined that our Commercial Solutions and Government Solutions reporting units had estimated fair values in excess of their carrying values of at least 29.0% and 122.2%, respectively, and concluded that our goodwill was not impaired and that neither of our two reporting units was at risk of failing the quantitative assessment. It is possible that, during fiscal 2020 or beyond, business conditions (both in the U.S. and internationally) could deteriorate from the current state, our current or prospective customers could materially postpone, reduce or even forgo purchases of our products and services to a greater extent than we currently anticipate, or our common stock price could decline. A significant decline in our customers' spending that is greater than we anticipate or a shift in funding priorities may also have a negative effect on future orders, sales, income and cash flows and we might be required to perform a quantitative assessment during fiscal 2020 or beyond. If assumed net sales and cash flow projections are not achieved in future periods or our common stock price significantly declines from current levels, our Commercial Solutions and Government Solutions reporting units could be at risk of failing the quantitative assessment and goodwill assigned to the respective reporting units could be impaired.

In any event, we are required to perform the next annual goodwill impairment analysis on August 1, 2020 (the start of our fiscal 2021). If our assumptions and related estimates change in the future, or if we change our reporting unit structure or other events and circumstances change (e.g., a sustained decrease in the price of our common stock (considered on both absolute terms and relative to peers)), we may be required to record impairment charges when we perform these tests, or in other future periods. Any impairment charges that we may record in the future could be material to our results of operations and financial condition.

(15) Intangible Assets

Intangible assets with finite lives as of July 31, 2019 and 2018 are as follows:

	July 31, 2019			
	Weighted Average Amortization Period	Gross Carrying Amount	Accumulated Amortization	Net Carrying Amount
Customer relationships	20.5	$ 276,834,000	66,484,000	$ 210,350,000
Technologies	12.7	92,649,000	59,522,000	33,127,000
Trademarks and other	16.7	31,026,000	12,613,000	18,413,000
Total		$ 400,509,000	138,619,000	$ 261,890,000

	July 31, 2018			
	Weighted Average Amortization Period	Gross Carrying Amount	Accumulated Amortization	Net Carrying Amount
Customer relationships	21.0	$ 249,831,000	55,350,000	$ 194,481,000
Technologies	12.8	82,370,000	54,386,000	27,984,000
Trademarks and other	16.4	28,894,000	10,563,000	18,331,000
Total		$ 361,095,000	120,299,000	$ 240,796,000

The weighted average amortization period in the above table excludes fully amortized intangible assets.

Amortization expense for the fiscal years ended July 31, 2019, 2018 and 2017 was $18,320,000, $21,075,000 and $22,823,000, respectively.

As further discussed in *Note (2)* -"*Acquisitions*," intangible assets as of July 31, 2019 include recently acquired intangibles resulting from the acquisitions of Solacom and the GD NG-911 business.

The estimated amortization expense consists of the following for the fiscal years ending July 31:

2020	$ 20,700,000
2021	19,563,000
2022	18,322,000
2023	18,322,000
2024	17,631,000

We review net intangible assets with finite lives for impairment when an event occurs indicating the potential for impairment. No such event has occurred during the fiscal year ended July 31, 2019. We believe that the carrying values of our net intangible assets were recoverable as of July 31, 2019. Any impairment charges that we may record in the future could be material to our results of operations and financial condition.

(16) Stockholders' Equity

Sale of Common Stock

In December 2018, we filed a $400,000,000 shelf registration with the SEC for the sale of various types of securities, including debt. The shelf registration was declared effective by the SEC as of December 14, 2018. To-date, we have not issued any securities related to our $400,000,000 shelf registration.

Stock Repurchase Program

As of July 31, 2019 and September 24, 2019, we were authorized to repurchase up to an additional $8,664,000 of our common stock, pursuant to our current $100,000,000 stock repurchase program. Our stock repurchase program has no time restrictions and repurchases may be made in open-market or privately negotiated transactions and may be made pursuant to SEC Rule 10b5-1 trading plans. There were no repurchases made during the fiscal years ended July 31, 2019 or 2018.

Dividends

Since September 2010, we have paid quarterly dividends pursuant to an annual targeted dividend amount that was established by our Board of Directors. On September 26, 2018, December 6, 2018, March 6, 2019 and June 5, 2019, our Board of Directors declared a dividend of $0.10 per common share, which were paid on November 16, 2018, February 15, 2019, May 17, 2019 and August 16, 2019, respectively. On September 24, 2019, our Board of Directors declared a dividend of $0.10 per common share, payable on November 15, 2019 to stockholders of record at the close of business on October 16, 2019.

Future dividends remain subject to compliance with financial covenants under our Credit Facility as well as Board approval.

(17) Unaudited Quarterly Financial Data

The following is a summary of unaudited quarterly operating results:

Fiscal 2019	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Total
Net sales	$ 160,844,000	164,133,000	170,448,000	176,372,000	$ 671,797,000
Gross profit	57,769,000	61,245,000	64,416,000	64,010,000	247,440,000
Net income	3,468,000	7,826,000	7,612,000	6,135,000	25,041,000
Diluted income per share	0.14	0.32	0.31	0.25	1.03 *

Fiscal 2018	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Total
Net sales	$ 121,569,000	133,731,000	147,854,000	167,435,000	$ 570,589,000
Gross profit	47,716,000	50,801,000	62,436,000	62,988,000	223,941,000
Net (loss) income	(1,660,000)	15,761,000	8,210,000	7,458,000	29,769,000
Diluted (loss) income per share	(0.07)	0.66	0.34	0.31	1.24 *

Fiscal 2017	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Total
Net sales	$ 135,786,000	139,028,000	127,792,000	147,762,000	$ 550,368,000
Gross profit	52,108,000	53,204,000	52,461,000	60,412,000	218,185,000
Net (loss) income	(2,489,000)	6,585,000	4,417,000	7,314,000	15,827,000
Diluted (loss) income per share	(0.11)	0.28	0.19	0.31	0.67 *

* The per share information is computed independently for each quarter and the full year based on the respective weighted average number of common shares outstanding. Therefore, income per share information for the full fiscal year may not equal the total of the quarters within the year.

Schedule II

COMTECH TELECOMMUNICATIONS CORP.
AND SUBSIDIARIES

Valuation and Qualifying Accounts and Reserves

Fiscal Years Ended July 31, 2019, 2018 and 2017

Column A	Column B	Column C Additions				Column D		Column E
Description	Balance at beginning of period	Charged to cost and expenses		Charged to other accounts - describe		Transfers (deductions) - describe		Balance at end of period
Allowance for doubtful accounts receivable:								
Year ended July 31,								
2019	$ 1,761,000	1,136,000	(A)	—		(1,030,000)	(B)	$ 1,867,000
2018	1,300,000	573,000	(A)	—		(112,000)	(B)	1,761,000
2017	1,029,000	497,000	(A)	—		(226,000)	(B)	1,300,000
Inventory reserves:								
Year ended July 31,								
2019	$ 17,427,000	6,015,000	(C)	—		(3,746,000)	(D)	$ 19,696,000
2018	16,019,000	5,628,000	(C)	—		(4,220,000)	(D)	17,427,000
2017	16,198,000	2,900,000	(C)	—		(3,079,000)	(D)	16,019,000
Valuation allowance for deferred tax assets:								
Year ended July 31,								
2019	$ 11,854,000	58,000	(E)	656,000	(F)	—		$ 12,568,000
2018	8,633,000	3,221,000	(E)	—		—		11,854,000
2017	9,624,000	324,000	(E)	121,000	(F)	(1,436,000)	(F)	8,633,000

(A) Provision for doubtful accounts.
(B) Write-off of uncollectible receivables.
(C) Provision for excess and obsolete inventory.
(D) Write-off of inventory.
(E) Change in valuation allowance.
(F) Acquisition related valuation allowance charged to (deducted from) goodwill.

Exhibit 10(f)(2)

LONG TERM PERFORMANCE SHARE AWARD AGREEMENT PURSUANT TO THE COMTECH TELECOMMUNICATIONS CORP. 2000 STOCK INCENTIVE PLAN

THIS LONG TERM PERFORMANCE SHARE AWARD AGREEMENT (this "Agreement"), made effective as of [GRANT DATE], by and between Comtech Telecommunications Corp. (the "Company") and [PARTICIPANT NAME] (the "Participant").

WHEREAS, the Board of Directors of the Company (the "Board") adopted, and the stockholders of the Company approved, the Comtech Telecommunications Corp. 2000 Stock Incentive Plan (Amended and Restated Effective [DATE]) (as amended and/or restated from time to time, the "Plan");

WHEREAS, pursuant to Section 3.3 of the Plan, the Committee appointed by the Company's Board of Directors to administer the Plan (the "Committee") has adopted the Guidelines for Deferrable Long Term Performance Shares Granted under the Plan, as amended and in effect at the date hereof (the "Guidelines");

WHEREAS, the Company, through the Committee under the Plan, wishes to grant to the Participant a Performance Share Award under Article IX of the Plan that, following the achievement of the specified levels of performance, as set forth on the document titled "Performance Goals and Corresponding Earned Shares" attached hereto as Appendix A (the "Performance Goals"), and, subject to the Participant's continuing service with the Company or an Affiliate through the Final Certification Date (as defined below), may provide for the issuance of a number of shares of the Company's Common Stock corresponding to the level of achievement of the Performance Goals (subject to accelerated earning, vesting and payment of such shares as specifically provided herein);

WHEREAS, the Performance Goals are intended to constitute "Performance Goals," as set forth under the Plan; and

WHEREAS, such shares of Common Stock, when issued to the Participant, shall be subject to the terms of this Agreement.

NOW, THEREFORE, the Company and the Participant agree as follows

1. **Grant of Performance Share Award.** Subject to the restrictions, terms and conditions of the Plan, the Guidelines and this Agreement, on [GRANT DATE] (the "Grant Date") the Company awarded and granted to the Participant an award under Article IX of the Plan with the designated target number of [TARGET PERFORMANCE SHARES] Performance Shares (the "Target Performance Shares"), and providing to the Participant a conditional right to earn the Target Performance Shares, or a number of Performance Shares for each Applicable Performance Period (as defined below) ranging from 70% (at each applicable Threshold Performance level) to 200% (at each applicable Maximum Performance level) of the Target Performance Shares, by achievement of the designated levels of performance of each performance criteria as specified in the Performance Goals attached hereto as Appendix A, the earning of which would entitle the Participant to receive for each Performance Share earned, in accordance with Section 2 below, one share of Common Stock, subject to the provisions of Sections 3 and 4 below (the "Performance Share Award"). The Performance Shares granted under the Performance Share Award are Deferrable Performance Shares under the Guidelines, and the payment of shares of Common Stock

following vesting of Earned Shares (as defined below) in accordance with the terms and conditions of this Agreement may be deferred by the Participant in accordance with Section 4.2 of the Guidelines. If the Participant desires to defer the payment of Earned Shares, the Participant must complete an election form prescribed by the Committee and deliver it to the Company no later than six months before the end of the Applicable Performance Period (as defined in Section 2) or, if earlier, the date the number of Performance Shares to be earned has become readily ascertainable within the meaning of Treasury Regulation Section 1.409A-2(a)(8).

2. **Certification Date.** Subject to the Participant's not incurring a Termination of Employment prior to the Final Certification Date (except as otherwise specifically set forth in this Agreement), upon the Committee determining and certifying the achievement of the Applicable Performance Goals on each of the applicable Annual Certification Dates with respect to the performance period beginning on [FULL PERFORMANCE PERIOD] (the "Full Three-Year Performance Period"), the performance period commencing on [FIRST APPLICABLE PERFORMANCE PERIOD], or the performance period beginning on [SECOND APPLICABLE PERFORMANCE PERIOD] (each an "Applicable Performance Period"), the Participant shall have the right to receive one share of Common Stock for each Performance Share earned based on the level of attainment of the applicable Performance Goals for the Applicable Performance Period in accordance with Appendix A ("Earned Shares") during the Applicable Performance Period, subject to the Participant remaining employed through the applicable Annual Certification Date, except as otherwise provided in Section 3. The Committee shall certify the level of achievement of each of the Performance Goals no later than seventy-five (75) days following the end of the Applicable Performance Period (the date of each such certification the "Annual Certification Date", and the date of the Annual Certification Date following the Full Three-Year Performance Period, the "Final Certification Date"), at which time a number of Earned Shares calculated in accordance with this Section 2 and Appendix A hereto shall become earned. All Performance Shares that do not become Earned Shares following the Committee's certification on the Final Certification Date under the terms hereof shall be forfeited on such Final Certification Date.

3. **Death or Disability/Change in Control before the Final Certification Date; Effect of Terminations of Employment.**

3.1. Death**, Disability and Termination of Employment.**

(i) In the event of the Participant's death or Disability prior to the Final Certification Date and prior to forfeiture of the Performance Shares, the Performance Goals for the Full Three-Year Performance Period shall be deemed to be satisfied at a level equal to the greater of the designated Target Performance level or the Projected Performance Level (as defined in Appendix A) as of the date of such death or Disability, and the resulting number of Earned Shares less Earned Shares earned for a prior completed Applicable Performance Period (if any), together with the number of Earned Shares earned for any previously completed Applicable Performance Period shall become fully vested and shall (subject to Plan Section 17.13) be distributed to the Participant or his or her beneficiary within sixty (60) days following the end of the fiscal quarter in which the Participant's death or Disability occurs. The term "Disability" shall have the meaning as set forth in Plan Section 2.14 treating the Performance Shares as being subject to Code Section 409A, provided that a "Disability" shall be deemed to have occurred only if it qualifies as a disability within the meaning of Treasury Regulation Section 1.409A-1(e)(1).

(ii) In the event of the Participant's Termination of Employment without Cause (and other than due to death or Disability) on a date that is both prior to the Final Certification Date and

prior to a 409A Change in Control occurring, the Participant shall earn for each Applicable Performance Period not completed on the date of the Termination of Employment a number of Earned Shares (which shall not be less than zero) in an amount equal to: (I) the product of (x) the number of Performance Shares the Participant would have earned based on the projected achievement of each of the Performance Goals for the Applicable Performance Period which shall be calculated utilizing the actual achievement of the applicable portion of the Performance Goals and assuming the same level of performance through the end of the Applicable Performance Period, measured on the last day of the fiscal quarter in which the Termination of Employment occurs, times (y) a fraction, the numerator of which is the number of days during the Applicable Performance Period in which the Participant was employed, and the denominator of which is the number of days in the Applicable Performance Period; less (II) any Earned Shares earned for any prior Applicable Performance Periods. The resulting number of Earned Shares (if any) plus the Earned Shares previously earned for previously completed Applicable Performance Periods (if any), shall become fully vested and shall (subject to Plan Section 17.13) be distributed to the Participant in accordance with Section 4 hereof, subject to Participant's timely execution and non-revocation of a release agreement prior to the Final Certification Date in a form required by the Company.

(iii) In the event of a Termination of Employment due to the Participant's resignation for any or no reason on a date that is both prior to the Final Certification Date and prior to a 409A Change in Control occurring, the following provisions shall apply:

(a) If on the Grant Date, the Participant has ten or more years of qualifying service with the Company (as determined by the Committee in its sole discretion) (a "Qualifying Long-Term Employee"), any Earned Shares earned with respect to any previously-completed Applicable Performance Period shall be forfeited and disregarded, and the Participant shall earn for the Full Three-Year Performance Period a number of Earned Shares (which shall not be less than zero) in an amount equal to the product of (x) the number of Performance Shares the Participant would have earned based on the actual achievement of each of the Performance Goals for the Full Three-Year Performance Period if the Participant remained employed by the Company through the Final Certification Date, times (y) a fraction, the numerator of which is the number of days during the Full Three-Year Performance Period that the Participant was employed by the Company, and the denominator of which is 1,095. The resulting number of Earned Shares (if any) shall become fully vested and shall (subject to Plan Section 17.13) be distributed to the Participant in accordance with Section 4 hereof, subject to Participant's timely execution and non-revocation of a release agreement prior to the Final Certification Date in a form required by the Company.

(b) If on the Grant Date, the Participant is not a Qualifying Long-Term Employee, all Performance Shares, including any Earned Shares, shall be forfeited on the date of such Termination of Employment for no consideration.

(iv) In the event of a Termination of Employment for Cause, all Performance Shares, including any Earned Shares, shall be forfeited on the date of such Termination of Employment for Cause for no consideration.

3.2. **409A Change in Control.** In the event of a 409A Change in Control prior to the Final

Certification Date, the Performance Goal for the Full Three-Year Performance Period shall be deemed to be satisfied at a level equal to the greater of the designated Target Performance level or the Projected Performance Level (as defined in Appendix A) as of the date of such 409A Change in Control, and the resulting number of earned Performance Shares, less any previously earned Earned Shares, shall be deemed to be Earned Shares and shall become fully vested as of the 409A Change in Control (including in the case of a Participant whose employment terminated between the time of the 409A Change in Control and the Assumption Deadline (as defined below)) and all vested Earned Shares shall (subject to Plan Section 17.13 and any limitations under Section 409A of the Code) be distributed to the Participant within sixty (60) days following the end of the fiscal quarter in which the 409A Change in Control occurs, provided, that, notwithstanding the foregoing, if the Committee reasonably determines in good faith but subject to and only in accordance with Section 409A of the Code, prior to the Assumption Deadline, that any Performance Shares that are not Earned Shares shall be honored or assumed, or new awards substituted therefor (each such honored, assumed or substituted Performance Share hereinafter called an "Alternative Performance Share"), by Participant's employer (or the parent or a subsidiary of such employer) by the Assumption Deadline, then no acceleration of earning or vesting shall occur with respect to the Performance Shares solely due to such event, provided that, such Alternative Performance Shares must meet the following criteria:

(i) Each Alternative Performance Share must be based on stock that is traded on an established securities market, or that will be so traded within 30 days after the 409A Change in Control, or provide for a cash payment not less than the cash value of the Performance Share based on the highest consideration per share received by a holder of Common Stock in the transaction or series of transactions that gave rise to the 409A Change in Control;

(ii) The Alternative Performance Shares must provide such Participant with rights, terms, conditions and entitlements substantially equivalent to or better than the rights, terms, conditions and entitlements applicable under the Performance Shares, including, but not limited to, an identical or better vesting schedule than applied prior to the 409A Change in Control;

(iii) The Alternative Performance Share must have economic value substantially equivalent to the value of each Performance Share (such equivalent values to be determined as of the time of the 409A Change in Control);

(iv) In furtherance of clause (ii) above, the performance goal applicable to the Alternative Performance Shares (the "Alternative Performance Goal") and the corresponding level at which Alternative Performance Shares shall be earned must be determined by the Committee to be not less probable of being achieved than the Performance Goal immediately prior to the 409A Change in Control (assuming the 409A Change in Control had not occurred and assuming that the Company had incurred no expense in connection with the 409A Change in Control);

(v) The Alternate Performance Shares must be structured in a manner intended to comply with Section 409A of the Code to avoid any adverse tax consequences thereunder, to the extent applicable;

(vi) The Alternative Performance Shares shall provide that, in the event that, within two years following the 409A Change in Control and prior to the Final Certification Date, either the Participant has a Termination of Employment by his or her employer other than for Cause (with the result that immediately thereafter the Participant is not employed by such

employer or its parent or other affiliates or that the Alternative Performance Shares otherwise would be forfeited under their terms but for this provision), or if the Participant would be paid a CIC Payment under Section 3(b)(i) of the Company's Change-in-Control Agreement upon a Termination of Employment by the Participant for "Good Reason" (however designated), or under any other agreement with the employer or its parent or other affiliates and Participant effects a Termination of Employment for such Good Reason, then the Alternative Performance Goal for the Full Three-Year Performance Period shall be deemed to be satisfied at the Maximum Performance level as of the date of such Termination of Employment, and the resulting number of earned Alternative Performance Shares less any Performance Shares previously earned for a completed Applicable Performance Period, which together with Earned Shares previously earned for previously completed Applicable Performance Periods (if any) shall be the resulting Earned Shares (or awarded cash), shall become fully vested (to the extent not vested prior thereto) and shall be distributed to the Participant within five business days thereafter.

(vii) Any changes after the 409A Change in Control to the businesses the performance of which is measured under the Alternative Performance Goal, including but not limited to asset sales or dispositions, reorganizations, restructurings, acquisitions, or discontinuations of operations, that will or could have an adverse effect on the performance criteria under the Alternative Performance Goal during the Full Three-Year Performance Period shall be accompanied by adjustments to the Alternative Performance Goal so that such changes do not reduce the probability of the Performance Goal being achieved at the level that would have been obtained in the absence of such changes.

For purposes of this Section 3.2, the "Assumption Deadline" shall be the date of the 409A Change in Control if the Company had at least 20 days' advance notice that the 409A Change in Control was anticipated to occur, and otherwise the Assumption Deadline shall be the date ten business days after the 409A Change in Control.

The provisions of this Agreement supersede Plan Section 14.1(a).

4. **Vesting and Distribution of Earned Shares.** Subject to Section 3, Earned Shares shall vest and be distributed to the Participant on the Final Certification Date; provided, that, in the event the Participant has made a valid deferral election in accordance with Section 4.2 of the Guidelines the vested Earned Shares shall be distributed to the Participant in accordance with such deferral election and the Guidelines (a "Deferral Election").

Except as otherwise provided herein, there shall be no proportionate or partial vesting in the periods prior to the Final Certification Date and all vesting shall occur only on the Final Certification Date.

5. **Dividend Equivalents.** In the event that the Company declares and pays ordinary cash dividends on its outstanding Common Stock the record date for which is on or after the Grant Date and on or before the date of distribution of Earned Shares (including during any period of deferral at the election of the Participant), the Participant shall be credited, as of the dividend payment date, for each Performance Share that is potentially earnable under this Agreement, a cash amount equivalent to the cash amount paid at that date on one share of Common Stock, under Section 9.2(d) of the Plan. Such credited cash amount of dividend equivalents shall be earned and vested if and only if the related Performance Share becomes earned and vested (i.e., it is forfeitable to the same extent as the related Performance Share). No interest will be credited on accrued dividend equivalents. Dividend equivalents will be distributable at such time as the Earned Shares resulting from the earning and vesting of the Performance Shares to which the dividend equivalents relate

are distributed; provided, however, that the Company may withhold cash dividend equivalents to satisfy then applicable tax withholding obligations relating to Earned Shares (to minimize the number of Earned Shares being withheld to satisfy tax obligations) under Section 12.

6. **Detrimental Activity.** In the event the Participant engages in Detrimental Activity prior to, or during the one year period following the earlier of the Participant's Termination of Employment or the Final Certification Date, the Committee may direct (at any time within one year thereafter) that all Performance Shares shall be immediately forfeited to the Company and that the Participant shall pay over to the Company an amount equal to the gain realized at the time of vesting and distribution of any Earned Shares.

7. **Restrictions on Transfer.** The Participant shall not sell, negotiate, transfer, pledge, hypothecate, assign, encumber, anticipate or otherwise dispose of the Performance Share Award or Performance Shares, and such Performance Share Award and Performance Shares shall not be subject to attachment or garnishment by creditors of Participant or Participant's beneficiaries (if any), except as specifically permitted by the Plan and this Agreement, and only to the extent permitted under Code Section 409A. Any attempted Transfer in violation of this Agreement and the Plan shall be void and of no effect.

8. **Issuance Restrictions.** The Company is not obligated to issue any securities if, in the opinion of counsel for the Company, the issuance of such Common Stock shall constitute a violation by the Participant or the Company of any provisions of any law or of any regulations of any governmental authority or any national securities exchange.

9. **Securities Representations.** The shares of Common Stock will be issued to the Participant and this Agreement is being made by the Company in reliance upon the following express representations and warranties of the Participant. The Participant acknowledges, represents and warrants that:

9.1. The Participant has been advised that the Participant may be an "affiliate" within the meaning of Rule 144 under the Securities Act and in this connection the Company is relying in part on the Participant's representations set forth in this section;

9.2. The Common Stock must be held indefinitely by the Participant unless (i) an exemption from the registration requirements of the Securities Act is available for the resale of such Common Stock or (ii) the Company files an additional registration statement (or a "re-offer prospectus") with regard to the resale of such Common Stock and the Company is under no obligation to continue in effect a Form S-8 Registration Statement or to otherwise register the resale of the Common Stock (or to file a "re-offer prospectus");

9.3. The exemption from registration under Rule 144 will not be available under current law unless (i) a public trading market then exists for the Common Stock, (ii) adequate information concerning the Company is then available to the public, and (iii) other terms and conditions of Rule 144 or any exemption therefrom are complied with and that any sale of the Common Stock may be made only in limited amounts in accordance with such terms and conditions.

10. **Not an Employment Agreement.** Neither the execution of this Agreement nor the issuance of the Performance Share Award or the Common Stock hereunder constitute an agreement by the Company to employ or to continue to employ the Participant during the entire, or any portion of, the term of this Agreement, including but not limited to any period during which any shares of Common Stock are outstanding.

11. **Power of Attorney.** The Company, its successors and assigns, is hereby appointed the attorney-in-fact, with full power of substitution, of the Participant for the purpose of carrying out the provisions of this Agreement and taking any action and executing any instruments which such attorney-in-fact may deem necessary or advisable to accomplish the purposes hereof, which appointment as attorney-in-fact is irrevocable and coupled with an interest. The Company, as attorney-in-fact for the Participant, may in the name and stead of the Participant, make and execute all conveyances, assignments and transfers of Common Stock and property provided for herein, and the Participant hereby ratifies and confirms that which the Company, as said attorney-in-fact, shall do by virtue hereof. Nevertheless, the Participant shall, if so requested by the Company, execute and deliver to the Company all such instruments as may, in the judgment of the Company, be advisable for this purpose.

12. **Withholding.** The Participant acknowledges that the Participant is solely responsible for all applicable foreign, federal, state, and local taxes with respect to the Performance Share Award and the payments thereunder; provided, however, that at any time the Company is required or permitted to withhold any such taxes (including, without limitation, any employment taxes), the Participant shall pay, or make arrangements to pay, in a manner satisfactory to the Company, an amount equal to the amount of all applicable federal, state and local or foreign taxes that the Company is required or permitted to withhold at any time, including, if then permitted by the Company, by electing to reduce the number of shares of Common Stock otherwise then deliverable to the Participant under this Agreement. Unless the Participant has informed the Company of the Participant's intent to make alternate arrangements to satisfy the Participant's withholding obligations satisfactory to the Company within either sixty (60) days in advance of the applicable tax date or at a time when the participant is not otherwise precluded from trading Common Stock under the Company's insider trading policies (unless otherwise determined by the Company) and relevant amounts are actually paid, the Company or one of its Affiliates shall have the automatic right to withhold such taxes from any amounts payable to the Participant (including salary, wages and other compensation), including, but not limited to, the right to withhold shares of Common Stock otherwise deliverable to the Participant under this Agreement. The Company will withhold taxes (e.g., federal, state and local taxes, including payroll taxes) in an amount at least equal to the statutory minimum taxes required to be withheld; provided, however, at the Participant's advance election the participant may request the Company withhold additional amounts up to the Participant's maximum individual tax rate in each relevant jurisdiction applicable to the Participant at such time of withholding, so long as the withholdings do not result in this Performance Share Award being classified as a liability-based award in accordance with applicable accounting standards.

13. **Miscellaneous.**

13.1. This Agreement shall inure to the benefit of and be binding upon the parties hereto and their respective heirs, personal legal representatives, successors, trustees, administrators, distributees, devisees and legatees. The Company may assign to, and require, any successor (whether direct or indirect, by purchase, merger, consolidation or otherwise) to all or substantially all of the business and/or assets of the Company or any affiliate by which the Participant is employed to expressly assume and agree in writing to perform this Agreement. Notwithstanding the foregoing, the Participant may not assign this Agreement other than with respect to shares of Common Stock Transferred in compliance with the terms hereof.

13.2. This award of the Performance Share Award and the issuance of Common Stock thereunder shall not affect in any way the right or power of the Board or stockholders of the Company to make or authorize an adjustment, recapitalization or other change in the capital structure or the business

of the Company, any merger or consolidation of the Company or subsidiaries, any issue of bonds, debentures, preferred or prior preference stock ahead of or affecting the Common Stock, the dissolution or liquidation of the Company, any sale or transfer of all or part of its assets or business or any other corporate act or proceeding. Performance Shares and Earned Shares shall be subject to adjustment in accordance with Section 4.2(b) of the Plan, including during any period in which payment of the Award is deferred at the election of Participant. For clarity, ordinary dividends on Common Stock will not trigger adjustments to Performance Shares and Earned Shares, and any adjustments to Performance Shares and Earned Shares shall take into account dividend equivalents credited thereon under Section 5.

13.3. The Participant agrees that the award of the Performance Share Award under this Agreement and the issuance of Common Stock thereunder is special incentive compensation and that the Performance Share Award (even if treated as compensation for tax purposes) will not be taken into account as "salary" or "compensation" or "bonus" in determining the amount of any payment under any pension, retirement or profit-sharing plan of the Company or any life insurance, disability or other benefit plan of the Company.

13.4. No modification or waiver of any of the provisions of this Agreement shall be effective unless in writing and signed by the party against whom it is sought to be enforced.

13.5. The failure of any party hereto at any time to require performance by another party of any provision of this Agreement shall not affect the right of such party to require performance of that provision, and any waiver by any party of any breach of any provision of this Agreement shall not be construed as a waiver of any continuing or succeeding breach of such provision, a waiver of the provision itself, or a waiver of any right under this Agreement.

13.6. The headings of the sections of this Agreement have been inserted for convenience of reference only and shall in no way restrict or modify any of the terms or provisions hereof.

13.7. All notices, consents, requests, approvals, instructions and other communications provided for herein shall be in writing and validly given or made when delivered, or on the second succeeding business day after being mailed by registered or certified mail, whichever is earlier, to the persons entitled or required to receive the same, at the addresses set forth at the heading of this Agreement or to such other address as either party may designate by like notice. Notices to the Company shall be addressed to the Compensation Committee of the Board.

13.8. This Agreement shall be construed, interpreted and governed and the legal relationships of the parties determined in accordance with the internal laws of the State of Delaware without reference to rules relating to conflicts of law.

13.9. The right to receive each payment of Earned Shares shall be treated as a separate award for purposes of Section 409A of the Code.

14. **Rights as a Stockholder.** The Participant shall have no rights as a stockholder with respect to any shares of Common Stock covered by the Performance Share Award unless and until the Participant has become the holder of record of the shares of Common Stock.

15. **Provisions of Plan Control.** This Agreement is subject to all the terms, conditions and provisions of the Plan, including, without limitation, Section 17.13 of the Plan (Section 409A of the Code), the amendment provisions thereof, and to such rules, regulations and interpretations relating to the Plan as may be adopted by the Committee and as may be in effect from time to

time. The Plan is incorporated herein by reference. A copy of the Plan has been delivered to the Participant. If and to the extent that this Agreement conflicts or is inconsistent with the terms, conditions and provisions of the Plan, unless this Agreement expressly provides otherwise, the Plan shall control, and this Agreement shall be deemed to be modified accordingly. Unless otherwise indicated, any capitalized term used but not defined herein shall have the meaning ascribed to such term in the Plan. This Agreement contains the entire understanding of the parties with respect to the subject matter hereof (other than any other documents expressly contemplated herein or in the Plan) and supersedes any prior agreements between the Company and the Participant.

16. **Agreement and Grant Not Effective Unless Accepted.** By signing below the Participant agrees (i) to enter into this Agreement, and (ii) to the terms and conditions of the Agreement. Until the Participant signs below and the Agreement is countersigned by the Company, this Performance Share Award shall not be effective and, if the Participant does not sign below and return to the Company within 14 days from the date the Agreement is made available to the Participant, this Performance Share Award shall be null and void.

IN WITNESS WHEREOF, the parties have executed this Agreement on the date and year first above written.

_____	COMTECH TELECOMMUNICATIONS CORP.
Employee's Signature	
Social Security No. _____	
	By: _____
Home Address: _____	Authorized Officer
Street	
_____	
City State Zip Code	

APPENDIX A

LONG TERM PERFORMANCE SHARE AWARD AGREEMENT
Performance Goal and Corresponding Earned Shares
Under the Comtech Telecommunications Corp.
2000 Stock Incentive Plan, as Amended and Restated [DATE]

Fiscal [YEAR - YEAR] Performance Period

The Participant shall earn Performance Shares in accordance with the provisions set forth below, with any earned Performance Shares constituting Earned Shares under the Participant's Long Term Performance Share Award Agreement of which this Appendix is a part (the "Performance Share Agreement"). Capitalized terms in this Appendix shall have the meanings as defined in the Performance Share Agreement.

[PERFORMANCE GOALS]

Exhibit 10(g)(3)

[GRANT NUMBER]

RESTRICTED STOCK AWARD AGREEMENT PURSUANT TO THE COMTECH TELECOMMUNICATIONS CORP. 2000 STOCK INCENTIVE PLAN

Dear [Director Name]:

Preliminary Statement

As a non-employee director of Comtech Telecommunications Corp. (the "Company"), and pursuant to your election made in accordance with Section 13.6(a) of The Comtech Telecommunications Corp. 2000 Stock Incentive Plan, as amended (the "Plan"), you were automatically granted on [Date] (the "Grant Date"), pursuant to the terms of the Plan and this Restricted Stock Award Agreement (this "Agreement"), the number of shares of Restricted Stock set forth below.

The terms of the grant are as follows:

1. **Grant of Restricted Stock**. Subject in all respects to the Plan and the terms and conditions set forth herein and therein, on the Grant Date you were automatically granted [#] shares of Restricted Stock (the "Award"). To the extent required by law, you shall pay to the Company the par value ($0.10) for each share of Restricted Stock awarded to you simultaneously with the execution of this Agreement.

2. **Vesting**. This Award shall vest in installments over a five (5) year period, commencing on the Grant Date, at the rate of 20% effective on each of the first, second, third, fourth and fifth anniversaries of the Grant Date; provided that you have not incurred a Termination of Directorship (as defined below) prior to the applicable vesting date. Notwithstanding the foregoing, the Award shall become fully vested prior to your Termination of Directorship upon (i) your death or (ii) a Change in Control. Each anniversary date that a share of Restricted Stock becomes vested shall be referred to herein as the "Vesting Date".

There shall be no proportionate or partial vesting in the periods prior to each Vesting Date and all vesting shall occur only on the appropriate Vesting Date.

3. **Dividends**. Any dividends which would have been paid on shares of Restricted Stock but for the restrictions thereon prior to the Vesting Date shall be credited to a dividend book entry account on your behalf (any such credited amount, a "Dividend Equivalent"). Any cash Dividend Equivalents shall not be deemed to be reinvested in shares of Common Stock and will be held uninvested and without interest. Your right to receive any Dividend Equivalents with respect to cash dividends shall vest only if and when the related Restricted Stock vests, and an amount equal to such cash dividends shall be paid to you in cash on the applicable Vesting Date on which the Restricted Stock vests. Your right to receive any Dividend Equivalents with respect to dividends other than cash dividends shall vest only if and when the related Restricted Stock vests, and on the applicable Vesting Date you will be paid an

amount in cash equal to the Fair Market Value of the property underlying such dividend as of the applicable Vesting Date. Prior to the payment thereof, any Dividend Equivalents will be encompassed within the term "Award" with respect to the relevant shares of Restricted Stock.

4. **Termination**. Except as otherwise provided in Section 2 hereof, any shares of Restricted Stock (including any Dividend Equivalents credited thereupon) that are not vested upon your Termination of Directorship shall, upon such Termination of Directorship, terminate and be forfeited in their entirety as of the date of such Termination of Directorship. For the purposes of this Agreement, "Termination of Directorship" means that you have ceased to be a director of the Company; provided, that in the event that you become an Eligible Employee or a Consultant upon your ceasing to be a director, a Termination of Directorship shall not be deemed to occur until such time as such you are no longer an Eligible Employee or Consultant.

5. **Restriction on Transfer**. Unless otherwise approved by the Committee, the Award is not transferable other than by will or by the laws of descent and distribution. In addition, unless otherwise approved in writing by the Committee, the Award shall not be assigned, negotiated, pledged or hypothecated in any way (whether by operation of law or otherwise), and the Award shall not be subject to execution, attachment or similar process. Upon any attempt to transfer, assign, negotiate, pledge or hypothecate all or part of the Award or in the event of any levy upon the Award by reason of any execution, attachment or similar process contrary to the provisions hereof not otherwise approved in writing by the Committee, the Award shall immediately become null and void. In addition, you shall not be permitted to Transfer the shares of Restricted Stock (including any Dividend Equivalents credited thereupon) awarded to you prior to vesting.

6. **Legend**. You shall be issued your shares of Restricted Stock as book entries by the transfer agent, as evidencing ownership of shares of Restricted Stock. Any such book entry shares shall be registered in your name, and shall bear an appropriate legend referring to the terms, conditions, and restrictions applicable to such Award, substantially in the following form:

> "The anticipation, alienation, attachment, sale, transfer, assignment, pledge, encumbrance or charge of the shares of stock represented hereby are subject to the terms and conditions (including forfeiture) of The Comtech Telecommunications Corp. 2000 Stock Incentive Plan (the "Plan") and a Restricted Stock Award Agreement (the "Agreement") entered into between the registered owner and the Company dated [Date]. Copies of such Plan and Agreement are on file at the principal office of the Company."

7. **Rights as a Stockholder**. You shall have, with respect to your shares of Restricted Stock, all of the rights of a holder of shares of Common Stock of the Company including, without limitation, the right to vote such shares and, subject to and conditioned upon the full vesting of shares of Restricted Stock, the right to tender such shares; provided, however, that except as expressly provided herein, you shall not have the right to receive any dividends with respect to your shares of Restricted Stock unless and until your shares of Restricted Stock vest and all Dividend Equivalents shall be paid in cash. If and when your shares of Restricted Stock vest, the certificates for such shares shall be delivered to you. All legends shall be removed from said certificates at the time of delivery to you except as otherwise required by applicable law.

8. **Provisions of Plan Control**. This grant is subject to all the terms, conditions and provisions of the Plan, including, without limitation, the amendment provisions of the Plan, and to such rules, regulations and interpretations relating to the Plan as may be adopted by the Board of Directors of the Company and as may be in effect from time to time. Any capitalized term used but not defined herein shall have the meaning ascribed to such term in the Plan. The Plan is incorporated herein by reference. If and to the extent that this grant conflicts or is inconsistent with the terms, conditions and provisions of the Plan, the Plan shall control, and this grant shall be deemed to be modified accordingly.

9. **Notices**. Any notice or communication given hereunder shall be in writing and shall be deemed to have been duly given when delivered in person, or by United States mail, to the appropriate party at the address set forth below (or such other address as the party shall from time to time specify):

If to the Company, to:

Comtech Telecommunications Corp.
68 South Service Road, Suite 230
Melville, NY 11747
Attention: Secretary

If to you, to the address indicated after your signature at the end of this Agreement.

10. **Securities Representations**. The grant of the Award and the issuance of shares of Restricted Stock pursuant hereto shall be subject to, and in compliance with, all applicable requirements of federal, state or foreign securities law. No shares of Restricted Stock may be issued hereunder if the issuance of such shares would constitute a violation of any applicable federal, state or foreign securities laws or other law or regulations or the requirements of any stock exchange or market system upon which such shares may then be listed. As a condition to the grant of the Award, the Company may require you to satisfy any qualifications that may be necessary or appropriate, to evidence compliance with any applicable law or regulation.

The shares of Restricted Stock are being issued to you and this Agreement is being made by the Company in reliance upon the following express representations and warranties. By accepting this Award, you acknowledge, represent and warrant that:

(a) you have been advised that you may be an "affiliate" within the meaning of Rule 144 under the Securities Act of 1933, as amended (the "Act") and in this connection the Company is relying in part on your representations set forth in this section.

(b) if you are deemed to be an affiliate within the meaning of Rule 144 of the Act, the shares issued to you must be held indefinitely unless an exemption from any applicable resale restrictions is available or the Company files an additional registration statement (or a "re-offer prospectus") with regard to such shares and the Company is under no obligation to register the shares (or to file a "re-offer prospectus").

(c) if you are deemed to be an affiliate within the meaning of Rule 144 of the Act, you understand that the exemption from registration under Rule 144 will not be available unless (i) a public trading market then exists for the shares, (ii) adequate information concerning the Company is then available to the public, and (iii) other terms and conditions of Rule 144 or any exemption therefrom are complied with; and that any sales of the shares may be made only in limited amounts in accordance with such terms and conditions.

11. **Power of Attorney**. The Company, its successors and assigns, is hereby appointed the attorney-in-fact, with full power of substitution, of you for the purpose of carrying out the provisions of this Agreement and taking any action and executing any instruments which such attorney-in-fact may deem necessary or advisable to accomplish the purposes hereof, which appointment as attorney-in-fact is irrevocable and coupled with an interest. The Company, as attorney-in-fact for you, may in your name and stead, make and execute all conveyances, assignments and transfers of Common Stock and property provided for herein, and you hereby ratify and confirm that which the Company, as said attorney-in-fact, shall do by virtue hereof. Nevertheless, you shall, if so requested by the Company, execute and deliver to the Company all such instruments as may, in the judgment of the Company, be advisable for this purpose.

12. **Detrimental Activity**. In the event you engage in Detrimental Activity prior to, or during the one year period following your Termination of Directorship, the Board may direct (at any time within one year thereafter) that all shares of Common Stock delivered to you pursuant to this Agreement shall be immediately forfeited to the Company and you shall pay over to the Company an amount equal to the gain realized at the time of vesting of any the shares of Restricted Stock.

13. **Right to Terminate Directorship**. Neither the Plan nor the grant of the Award hereunder shall impose any obligations on the Company and/or the stockholders of the Company to retain you as a director, nor shall it impose any obligation on your part to remain as a director of the Company.

14. **Miscellaneous**.

(a) This Agreement shall inure to the benefit of and be binding upon the parties hereto and their respective heirs, personal legal representatives, successors, trustees, administrators, distributees, devisees and legatees. The Company may assign to, and require, any successor (whether direct or indirect, by purchase, merger, consolidation or otherwise) to all or substantially all of the business and/ or assets of the Company or any affiliate to which you are rendering services to expressly assume and agree in writing to perform this Agreement. Notwithstanding the foregoing, you may not assign this Agreement other than with respect to shares of Common Stock Transferred in compliance with the terms hereof.

(b) This Award shall not affect in any way the right or power of the Board or stockholders of the Company to make or authorize an adjustment, recapitalization or other change in the capital structure or the business of the Company, any merger or consolidation of the Company or subsidiaries, any issue of bonds, debentures, preferred or prior preference stock ahead of or affecting the Common Stock, the dissolution or liquidation of the Company, any sale or transfer of all or part of its assets or business or any other corporate act or proceeding. The shares of Restricted Stock granted hereunder shall be subject to adjustment in accordance with Section 4.2(b) of the Plan.

(c) No modification or waiver of any of the provisions of this Agreement shall be effective unless in writing and signed by the party against whom it is sought to be enforced.

(d) The failure of any party hereto at any time to require performance by another party of any provision of this Agreement shall not affect the right of such party to require performance of that provision, and any waiver by any party of any breach of any provision of this Agreement shall not be construed as a waiver of any continuing or succeeding breach of such provision, a waiver of the provision itself, or a waiver of any right under this Agreement.

(e) The headings of the sections of this Agreement have been inserted for convenience of reference only and shall in no way restrict or modify any of the terms or provisions hereof.

(f) This Agreement shall be construed, interpreted and governed and the legal relationships of the parties determined in accordance with the internal laws of the State of Delaware without reference to rules relating to conflicts of law.

15. **Agreement and Grant Not Effective Unless Accepted**. By selecting the "Accept" button below you agree (i) to enter into this Agreement electronically, and (ii) to the terms and conditions of the Agreement. Until you select the "Accept" button below and accept the corresponding Irrevocable Stock Power (the "Power"), this Award shall not be effective and if you do not select the "Accept" button and accept the corresponding Power within 14 days from the date the Agreement is made available to you electronically this Award shall be null and void.

IRREVOCABLE STOCK POWER

KNOW ALL MEN BY THESE PRESENTS, that [Director Name] (the "Transferor"), for value received, has assigned and transferred, and by these presents does assign and transfer unto Comtech Telecommunications Corp., a Delaware corporation, (the "Company") [#] shares of the common stock, par value $0.10 per share, of the Company standing in the Transferor's name on the books of the Company, and does hereby constitute and appoint the Secretary of the Company, his true and lawful attorney, irrevocable for him and in his name and stead, to assign, transfer and set over said stock, and for that purpose, to make and execute all necessary acts of assignment and transfer, and one or more persons to substitute with like full power, hereby ratifying and confirming all that his said attorney, or the substitute or substitutes, shall lawfully do by virtue hereof.

By selecting the "Accept" button below you, [Director Name], agree (i) to execute this Irrevocable Stock Power (the "Power") electronically, and (ii) to the terms and conditions of the Power. Until you select the "Accept" button below, this Power shall not be effective and if you do not select the "Accept" button and accept the corresponding Restricted Stock Award within 14 days from the date the Power is made available to you electronically this Power shall be null and void.

Exhibit 21

Subsidiaries of Comtech Telecommunications Corp.*

Subsidiaries	Jurisdiction of Incorporation
Comtech AeroAstro, Inc.	Delaware
Comtech EF Data Corp.	Delaware
Comtech EF Data Pte. Ltd.	Singapore
Comtech Mobile Datacom Corporation	Delaware
Comtech PST Corp.	New York
Comtech Systems, Inc.	Delaware
Comtech Xicom Technology, Inc.	California
Beijing Comtech EF Data Equipment Repair Service, Co., Ltd. (a subsidiary of Comtech EF Data Corp.)	China
Memotec Inc. (a subsidiary of Comtech EF Data Corp.)	Canada
Xicom Technology Europe, Ltd. (a subsidiary of Comtech Xicom Technology, Inc.)	United Kingdom
TeleCommunication Systems, Inc.	Maryland
NextGen Communications, Inc. (a subsidiary of TeleCommunication Systems, Inc.)	Maryland
microDATA LLC (a subsidiary of TeleCommunication Systems, Inc.)	Maryland
microDATA GIS, Inc. (a subsidiary of microDATA LLC)	Vermont
Comtech Solacom Technologies, Inc.	Canada
Solacom Technologies (US), Inc. (a subsidiary of Comtech Solacom Technologies, Inc.)	Delaware
Comtech NextGen LLC (a subsidiary of TeleCommunications Systems, Inc.)	Delaware

* Pursuant to Item 601(b)(21)(ii) of Regulation SK, the names of other subsidiaries of Comtech are omitted because, considered in the aggregate, they would not constitute a significant subsidiary as of the end of the year covered by this report.

Exhibit 23.1

CONSENT OF INDEPENDENT REGISTERED PUBLIC ACCOUNTING FIRM

We consent to the incorporation by reference in Registration Statements on Form S-8 (Nos. 333-125625, 333-143548, 333-166754, 333-51708 and 333-228690) and Registration Statement No. 333-228691 on Form S-3 of our reports dated September 24, 2019, relating to the consolidated financial statements and financial statement schedule of Comtech Telecommunications Corp., and the effectiveness of Comtech Telecommunications Corp.'s internal control over financial reporting, appearing in this Annual Report on Form 10-K of Comtech Telecommunications Corp. for the year ended July 31, 2019.

/s/ DELOITTE & TOUCHE LLP

Jericho, New York
September 24, 2019

Exhibit 31.1

CERTIFICATION PURSUANT TO
18 U.S.C. ss.1350,
AS ADOPTED PURSUANT TO
SECTION 302 OF THE SARBANES-OXLEY ACT OF 2002

I, Fred Kornberg, certify that:

1. I have reviewed this annual report on Form 10-K of Comtech Telecommunications Corp.;

2. Based on my knowledge, this report does not contain any untrue statement of a material fact or omit to state a material fact necessary to make the statements made, in light of the circumstances under which such statements were made, not misleading with respect to the period covered by this report;

3. Based on my knowledge, the financial statements, and other financial information included in this report, fairly present in all material respects the financial condition, results of operations and cash flows of the registrant as of, and for, the periods presented in this report;

4. The registrant's other certifying officer(s) and I are responsible for establishing and maintaining disclosure controls and procedures (as defined in Exchange Act Rules 13a-15(e) and 15d-15(e)) and internal control over financial reporting (as defined in Exchange Act Rules 13a-15(f) and 15d-15(f)) for the registrant and have:

    a. Designed such disclosure controls and procedures, or caused such disclosure controls and procedures to be designed under our supervision, to ensure that material information relating to the registrant, including its consolidated subsidiaries, is made known to us by others within those entities, particularly during the period in which this report is being prepared;

    b. Designed such internal control over financial reporting, or caused such internal control over financial reporting to be designed under our supervision, to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles;

    c. Evaluated the effectiveness of the registrant's disclosure controls and procedures and presented in this report our conclusions about the effectiveness of the disclosure controls and procedures, as of the end of the period covered by this report based on such evaluation; and

    d. Disclosed in this report any change in the registrant's internal control over financial reporting that occurred during the registrant's most recent fiscal quarter (the registrant's fourth fiscal quarter in the case of an annual report) that has materially affected, or is reasonably likely to materially affect, the registrant's internal control over financial reporting; and

5. The registrant's other certifying officer(s) and I have disclosed, based on our most recent evaluation of internal control over financial reporting, to the registrant's auditors and the audit committee of the registrant's board of directors (or persons performing the equivalent functions):

    a. All significant deficiencies and material weaknesses in the design or operation of internal control over financial reporting which are reasonably likely to adversely affect the registrant's ability to record, process, summarize and report financial information; and

    b. Any fraud, whether or not material, that involves management or other employees who have a significant role in the registrant's internal control over financial reporting.

Date: September 24, 2019

/s/ Fred Kornberg

Fred Kornberg
Chairman of the Board
Chief Executive Officer and President

Exhibit 31.2

CERTIFICATION PURSUANT TO
18 U.S.C. ss.1350,
AS ADOPTED PURSUANT TO
SECTION 302 OF THE SARBANES-OXLEY ACT OF 2002

I, Michael A. Bondi, certify that:

1. I have reviewed this annual report on Form 10-K of Comtech Telecommunications Corp.;

2. Based on my knowledge, this report does not contain any untrue statement of a material fact or omit to state a material fact necessary to make the statements made, in light of the circumstances under which such statements were made, not misleading with respect to the period covered by this report;

3. Based on my knowledge, the financial statements, and other financial information included in this report, fairly present in all material respects the financial condition, results of operations and cash flows of the registrant as of, and for, the periods presented in this report;

4. The registrant's other certifying officer(s) and I are responsible for establishing and maintaining disclosure controls and procedures (as defined in Exchange Act Rules 13a-15(e) and 15d-15(e)) and internal control over financial reporting (as defined in Exchange Act Rules 13a-15(f) and 15d-15(f)) for the registrant and have:

    a. Designed such disclosure controls and procedures, or caused such disclosure controls and procedures to be designed under our supervision, to ensure that material information relating to the registrant, including its consolidated subsidiaries, is made known to us by others within those entities, particularly during the period in which this report is being prepared;

    b. Designed such internal control over financial reporting, or caused such internal control over financial reporting to be designed under our supervision, to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles;

    c. Evaluated the effectiveness of the registrant's disclosure controls and procedures and presented in this report our conclusions about the effectiveness of the disclosure controls and procedures, as of the end of the period covered by this report based on such evaluation; and

    d. Disclosed in this report any change in the registrant's internal control over financial reporting that occurred during the registrant's most recent fiscal quarter (the registrant's fourth fiscal quarter in the case of an annual report) that has materially affected, or is reasonably likely to materially affect, the registrant's internal control over financial reporting; and

5. The registrant's other certifying officer(s) and I have disclosed, based on our most recent evaluation of internal control over financial reporting, to the registrant's auditors and the audit committee of the registrant's board of directors (or persons performing the equivalent functions):

    a. All significant deficiencies and material weaknesses in the design or operation of internal control over financial reporting which are reasonably likely to adversely affect the registrant's ability to record, process, summarize and report financial information; and

    b. Any fraud, whether or not material, that involves management or other employees who have a significant role in the registrant's internal control over financial reporting.

Date: September 24, 2019

/s/ Michael A. Bondi

Michael A. Bondi
Chief Financial Officer

Exhibit 32.1

CERTIFICATION PURSUANT TO

SECTION 906 OF THE SARBANES-OXLEY ACT OF 2002

In connection with the annual report of Comtech Telecommunications Corp. (the "Company") on Form 10-K for the fiscal year ended July 31, 2019 as filed with the Securities and Exchange Commission on the date hereof (the "Report"), I, Fred Kornberg, President and Chief Executive Officer of the Company, certify that:

1. The Report fully complies with the requirements of Section 13(a) or 15(d) of the Securities Exchange Act of 1934; and

2. The information contained in the Report fairly presents, in all material respects, the financial condition and results of operations of the Company.

Date: September 24, 2019

/s/ Fred Kornberg

Fred Kornberg
Chairman of the Board
Chief Executive Officer and President

Exhibit 32.2

CERTIFICATION PURSUANT TO

SECTION 906 OF THE SARBANES-OXLEY ACT OF 2002

In connection with the annual report of Comtech Telecommunications Corp. (the "Company") on Form 10-K for the fiscal year ended July 31, 2019 as filed with the Securities and Exchange Commission on the date hereof (the "Report"), I, Michael A. Bondi, Chief Financial Officer of the Company, certify that:

1. The Report fully complies with the requirements of Section 13(a) or 15(d) of the Securities Exchange Act of 1934; and

2. The information contained in the Report fairly presents, in all material respects, the financial condition and results of operations of the Company.

Date: September 24, 2019

/s/ Michael A. Bondi

Michael A. Bondi
Chief Financial Officer

Nebraska Public Service Commission

COMMISSIONERS:
ANNE C. BOYLE
ROD JOHNSON
FRANK E. LANDIS
TIM SCHRAM
GERALD L. VAP

EXECUTIVE DIRECTOR:
MICHAEL G. HYBL

300 The Atrium, 1200 N Street, Lincoln, NE 68508
Post Office Box 94927, Lincoln, NE 68509-4927
Website: psc.nebraska.gov
Phone: (402) 471-3101
Fax: (402) 471-0254

NEBRASKA CONSUMER HOTLINE:
1-800-526-0017

January 26, 2010

CERTIFICATION

To Whom It May Concern:

I, Mike Hybl, Executive Director of the Nebraska Public Service Commission, hereby certify that the enclosed is a true and correct copy of the original order made and entered in the proceeding docketed C-4228 on the 26th day of January 2010. The original order is filed and recorded in the official records of the Commission.

Please direct any questions concerning this order to Shana Knutson, Attorney, at 402-471-3101.

IN TESTIMONY WHEREOF, I have hereunto set my hand and affixed the Seal of the Nebraska Public Service Commission, Lincoln, Nebraska, this 26th day of January 2010.

Sincerely,

Mike Hybl
Executive Director

MH:sh

Enclosure

cc: Stinson Morison Hecker, LLP, H. Russell Frisby, Jr., Douglas E. Micheel, 1150 18th St. NW Ste. 800, Washington, DC 20036-3816
NextGen Communications, Inc., c/o Telecommunication Systems, Inc., Maurice B. Tose 275 West Street, Annapolis, MD 21401

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BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Application of NextGen Communications, Inc. d/b/a Maryland TeleCommunication Systems, Inc., Annapolis, Maryland, seeking authority to operate as a local exchange carrier of telecommunications services within the State of Nebraska.	)	Application No. C-4228 GRANTED Entered: January 26, 2010

BY THE COMMISSION:

By its application filed November 18, 2009, NextGen Communications, Inc. d/b/a Maryland Telecommunication Systems, Inc., Annapolis, Maryland, (NextGen or Applicant) seeks authority to provide local exchange telecommunications services in the State of Nebraska. Notice of the application appeared in The Daily Record on November 20, 2009. No protests or petitions of formal intervention were filed; therefore, the Commission processes this application pursuant to its rule on modified procedure.

E V I D E N C E

In its verified application, NextGen provided as follows:

Applicant is wholly owned by TeleCommunication Systems, Inc. (TCS), a publicly owned corporation organized under the laws of the State of Maryland, and has its principal office located in Annapolis, Maryland. Applicant has obtained authority to transact business in the State of Nebraska.

Applicant is a facilities-based and non-facilities based local exchange carrier intending to aggregate and transport emergency local, VoIP, telemetric, PBX, and mobile E911 traffic, manage and transmit location and calling number data, and provide call routing management for the delivery of emergency calls to PSAPs in the State of Nebraska. Applicant does not propose to offer long distance voice toll services, local exchange voice dial tone services, directory assistance, operator assistance services or Telephone Relay services. However, to perform these services, Applicant will require interconnection and collocation made available to certified Competitive Local Exchange Carriers (CLECs). Applicant agrees to adhere to all state laws and all Commission policies, rules and orders.

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Applicant is currently transacting business in California, Florida, Iowa, Indiana, Michigan, Minnesota, Tennessee, Texas, Utah, Virginia and Washington.

No officer, director or shareholder having five percent or more of applicant's voting securities nor any of applicant's business operations have been involved in a formal complaint or other investigatory or enforcement proceeding.

Applicant states that it possesses the requisite managerial and technical capabilities to provide the proposed services in Nebraska. Applicant also states that it possesses the financial ability to provide the proposed services. Attached to the application, Applicant filed an independently-prepared financial statement for the fiscal year ending December 31, 2008.

Applicant states that a grant of this application would serve the public interest by providing necessary E911 services. Applicant generally provides that the public will benefit from high quality, cost effective telecommunications services.

O P I N I O N A N D F I N D I N G S

The Commission considers this application for authority in light of the following criteria and standards established in the Commission's telecommunications rules:

(a) Whether the Applicant has provided the information required by the Commission;

(b) Whether the Applicant has provided a performance bond, if required;

(c) Whether the Applicant possesses adequate financial resources to provide the proposed service;

(d) Whether the Applicant possesses adequate technical competence and resources to provide the proposed service;

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(e) Whether the Applicant possesses adequate managerial competence to provide the proposed service; and

(f) Whether granting the Applicant a certificate preserves and advances universal service, protects the public safety and welfare, ensures the continued quality of telecommunications services and safeguards the rights of consumers, pursuant to Section 253(b) of the Act.

Applicant has demonstrated that it meets the standards of financial, technical and managerial competence and all other criteria necessary to provide the proposed service in the state of Nebraska. No party in this proceeding refuted the applicant's competence.

Applicant states in its application that it is seeking authority so that it may aggregate and transport emergency local, Voice over the Internet Protocol (VoIP), telemetric, PBX, and mobile E911 traffic, manage and transmit location and calling number data, and provide call routing management for the delivery of emergency calls to public safety answering points (PSAPs) in Nebraska, and will not be providing local dial tone or traditional consumer voice communications. As such, we find Applicant will not require access to traditional numbering resources such as full Codes or Blocks but only access to those numbering resources that would allow them to properly route E911 traffic. Accordingly, Applicant shall only have access to those numbering resources necessary to properly route E911 traffic.

These opinions and findings carry no precedential value other than establishing minimum standards and criteria to apply when considering applications to provide local exchange service in Nebraska. All telecommunications carriers seeking such a certificate must demonstrate that they meet, at a minimum, the standards and criteria set forth herein.

Before the Applicant is allowed to provide local exchange service to its users, it must either:

1. Through negotiation or arbitration, reach an interconnection/resale agreement with the pertinent incumbent local exchange carrier and receive Commission approval of the interconnection/resale agreement; or

2. In the event a certified local exchange carrier provides a wholesale tariff, applicant must purchase rates from that tariff, file its own tariff and receive Commission approval of its tariff. To the

extent that Applicant provides services on an individual contract basis (ICB), applicant shall provide to the Commission, upon request, copies of agreements containing pricing information for the services offered.

This order does not terminate, waive or in any manner diminish the exemptions and protections created by the Act for rural carriers, as defined by the Act. This order does not address the issue of the rural local exchange carrier exemption under the Act. Rural exemptions may be terminated, suspended or modified only as provided in Section 251(f) of the Act.

Prior to providing local exchange service in any area in the State of Nebraska, Applicant must file tariffs in accordance with the provisions of Section 002.21 of the Neb. Admin. R. & Regs. Title 291, Ch. 5.

As a certificated local exchange service provider in the State of Nebraska, Applicant would be subject to the same laws, rules and regulations, both federal and state (including any laws, rules or regulations regarding universal service, restrictions on joint marketing and quality of service), applicable to any other local exchange company except those obligations imposed on incumbent local exchange carriers pursuant to Section 251(c) of the Act.

O R D E R

IT IS THEREFORE ORDERED by the Nebraska Public Service Commission that Application No. C-4228 be, and hereby is, granted as provided herein.

IT IS FURTHER ORDERED that the Applicant comply with Section 251(f)(1)(B) of the Telecommunications Act of 1996 and that the applicant submit any bona fide request(s) for interconnection, services or network elements from a rural telephone company to the Commission for its approval.

IT IS FURTHER ORDERED that Applicant is obligated to abide by the same laws, rules and regulations, both federal and state (including any laws, rules or regulations regarding universal service, restrictions on joint marketing and quality of service), applicable to any other interexchange and local exchange carriers, except obligations imposed on incumbent local exchange carriers pursuant to Section 251(c) of the Act.

IT IS FURTHER ORDERED that, to the extent Applicant provides access line service as referenced in the

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Telecommunications Relay System Act, Neb. Rev. Stat. 86-301 through 86-315 (Relay Act) and defined in Neb. Admin. R. & Reg. Title 291, Ch. 5 § 001.01B, the Applicant shall collect from its subscribers a surcharge (Relay Surcharge) pursuant to the Relay Act and the Commission's annual orders establishing the amount of the surcharge, and shall remit to the Commission the proceeds from the relay surcharge as provided by the relay act.

IT IS FURTHER ORDERED that the Applicant shall only have access to those numbering resources necessary to properly route E911 traffic.

IT IS FURTHER ORDERED that the Applicant comply with all necessary statutes and Commission Rules and Regulations as they pertain to the Nebraska Universal Service Fund.

IT IS FURTHER ORDERED that Applicant shall file, in accordance with the applicable statutes, on or before April 30 of each year, an annual report with the Commission consisting of: (a) a copy of any report filed with the Federal Communications Commission; (b) a copy of any annual report to stockholders; and (c) a copy of the latest Form 10-K filed with the Securities and Exchange Commission. If such reports are unavailable, applicant shall file a balance sheet and income statement for the previous year of operation, and for the state of Nebraska on a combined interstate-intrastate basis, the investment in the telephone plant and equipment located within the state, accumulated depreciation thereon, operating revenues, operating expenses and taxes.

IT IS FURTHER ORDERED that within 30 days from the entry of this order that the Applicant file a tariff along with the applicable tariff fee with the Commission as required by State Statutes and the Commission's Regulations.

IT IS FINALLY ORDERED that this order be, and hereby is, made the Commission's official Certificate of Public Convenience and Necessity to the Applicant to provide local exchange telecommunications services in the State of Nebraska.

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MADE AND ENTERED at Lincoln, Nebraska, this 26th day of January, 2010.

NEBRASKA PUBLIC SERVICE COMMISSION

COMMISSIONERS CONCURRING:

Rod Johnson

Anne C. Boyle

Tim Schram

//s// Frank E. Landis
//s// Gerald L. Vap

Chairman Gerald L. Vap

ATTEST:

Executive Director

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STATE OF NEBRASKA

United States of America, } ss.
State of Nebraska }

Secretary of State
State Capitol
Lincoln, Nebraska

I, Robert B. Evnen, Secretary of State of the State of Nebraska, do hereby certify that

MARYLAND TELECOMMUNICATION SYSTEMS, INC.

a Maryland corporation is authorized to transact business in Nebraska;

that no occupation taxes due from and assessable against the Corporation are unpaid and have become delinquent;

that no annual or biennial report required to be forwarded by the Corporation to the Secretary of State has become delinquent;

that a Certificate of Withdrawal has not been filed.

This certificate is not to be construed as an endorsement, recommendation, or notice of approval of the entity's financial condition or business activities and practices.

In Testimony Whereof,

I have hereunto set my hand and affixed the Great Seal of the State of Nebraska on this date of

May 6, 2020

Secretary of State

Verification ID 6bc646f has been assigned to this document. Go to ne.gov/go/validate to validate authenticity for up to 12 months.

SEVERITY LEVEL 1 (SL 1)

An incident shall be categorized as a "Severity 1 Incident" if the incident is characterized by the following attributes:

a. Renders a business-critical system, service, software, equipment or network component unavailable or substantially unavailable, or seriously impacts normal business operations, in each case prohibiting the execution of productive work.

b. Affects either (i) a group or groups of people, or (ii) a single individual performing a critical business function.

*means a problem that renders the solution completely inoperative at one or more end points

SEVERITY LEVEL 2 (SL 2)

An incident shall be categorized as a "Severity 2 Incident" if the incident is characterized by the following attributes; an incident that:

a. Does not render a business-critical system, service, software, equipment or network component unavailable or substantially unavailable, but a function or functions are not available, substantially available, or functioning as they should, in each case prohibiting the execution of productive work.

b. Affects either (i) a group or groups of people, or (ii) a single individual performing a critical business function.

*means a problem that renders the solution completely inoperative at one or more end points

SEVERITY LEVEL 3 (SL 3)

An incident shall be categorized as a "Severity 3 Incident" if the incident is characterized by the following attributes:

a. An incident causes a group or individual to experience an incident with accessing or using a system, service, software, equipment or network component or a key feature thereof and a reasonable workaround is not available but does not prohibit the execution of productive work.

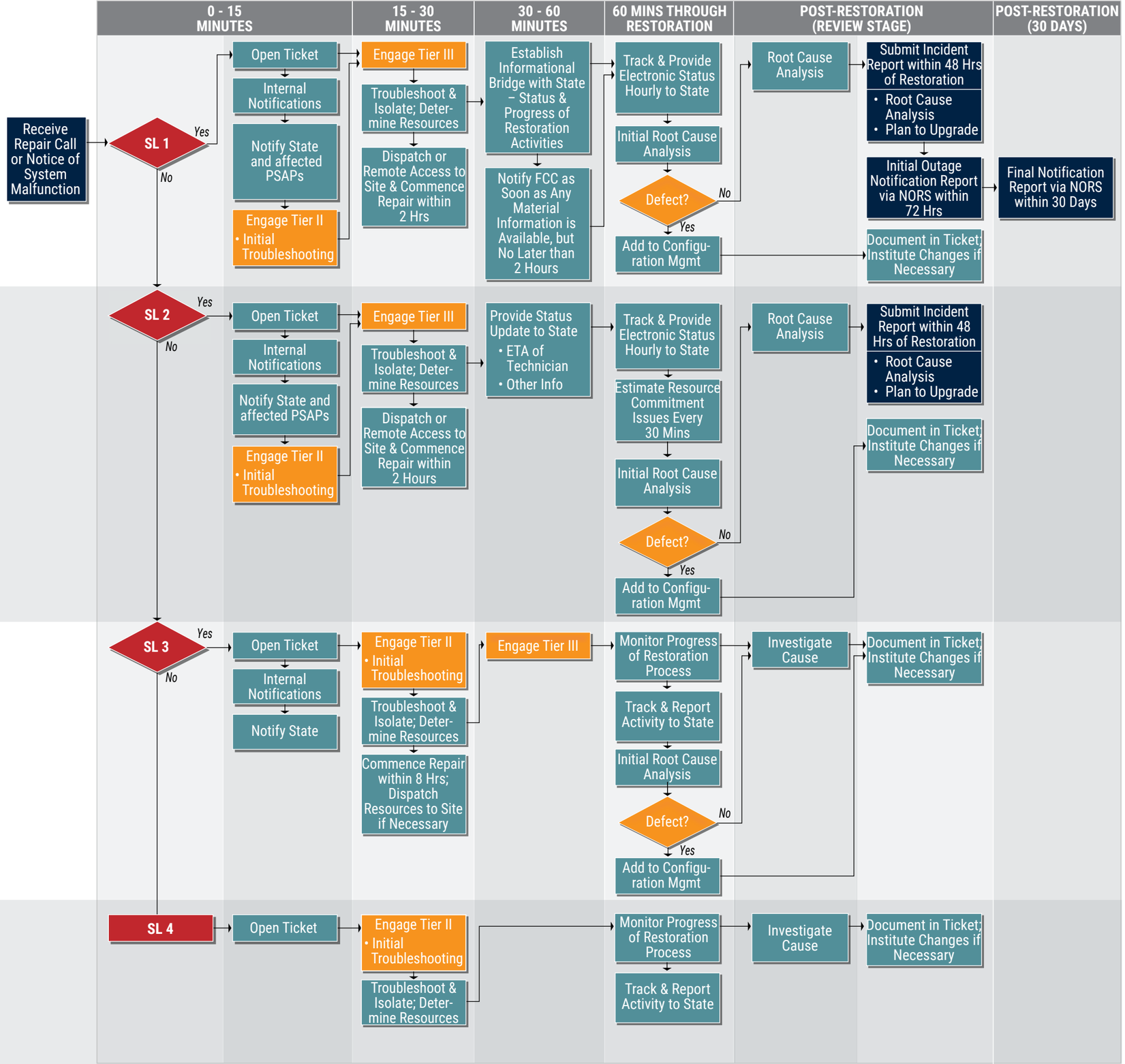
*means any problem with the solution that marginally affects system performance and functionality but allows the PSAPs to function

SEVERITY LEVEL 4 (SL 4)

An incident shall be categorized as a "Severity 4 Incident" if the incident is characterized by the following attributes:

a. An incident may require an extended resolution time but does not prohibit the execution of productive work and a reasonable workaround is available.

*means a combination of minor system faults and items that have minimal impact on system performance and functionality for the PSAPs



Comtech Nebraska
Incident Escalation Contact List

Team Member	Service Escalation Level	Phone
Vice President NG9-1-1 Solutions xxx@comtechtel.com	SL 1, SL 2	xxx-xxx-xxxx xxx-xxx-xxxx
NG9-1-1 Operations/ NSOC Management xxx@comtechtel.com	SL 1, SL 2, SL 3	xxx-xxx-xxxx xxx-xxx-xxxx
Tier II/III Engineering SME xxx@comtechtel.com	SL 1, SL 2, SL 3	xxx-xxx-xxxx xxx-xxx-xxxx
Help Desk Analyst Lead xxx@comtechtel.com	SL 1, SL 2, SL 3, SL 4	xxx-xxx-xxxx xxx-xxx-xxxx
Help Desk Analyst Alternate xxx@comtechtel.com	SL 1, SL 2, SL 3, SL 4	xxx-xxx-xxxx xxx-xxx-xxxx

ESCALATION