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BEFORE THE WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant, v. CENTURYLINK COMMUNICATIONS, LLC, Respondent.	DOCKET NO.: UT-181051

RESPONSE TESTIMONY

OF

STEVEN E. TURNER

ON BEHALF OF

CENTURYLINK COMMUNICATIONS, LLC

March 31, 2022

TABLE OF CONTENTS

TABLE OF EXHIBITS

I. INTRODUCTION/QUALIFICATIONS

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Steven E. Turner. My business address is 8251 Greensboro Drive, McLean, Virginia 22102.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am a Senior Managing Director at FTI Consulting, Inc. ("FTI") and co-lead the Telecom, Media, and Technology Dispute Advisory practice.

Q. WHAT IS YOUR EDUCATIONAL BACKGROUND?

A. I hold a Bachelor of Science degree in Electrical Engineering from Auburn University in Auburn, Alabama and a Master of Business Administration in Finance from Georgia State University in Atlanta, Georgia. A copy of my curriculum vitae is attached to this report as Exhibit SET-2, which includes my past testimony.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING?

A. I am testifying on behalf of CenturyLink Communications, LLC ("CLC").[1]

[1] Throughout this document, "CenturyLink" is used to denote the larger family of CenturyLink companies and "CLC" is used to denote the wholly owned subsidiary that is the Respondent in this case.

Q. WHAT ARE YOUR PROFESSIONAL QUALIFICATIONS?

A. I have worked in the telecommunications industry since 1987 and have extensive experience in many different aspects of the business, including switch engineering, transport engineering, signaling, network operations (including system development), fiber and access network design and deployment, access management, tariffs, sales, billing, regulatory, Internet services, and content distribution over multiple platforms (*e.g.*, copper, coax, and fiber). From 1986 through 1987, I was a Research Engineer for General Electric in its Advanced Technologies Department developing high-speed graphics simulators. In 1987, I joined AT&T and, during my career there, held a variety of engineering, operations, and management positions in both its long distance and local services businesses. These positions spanned the switching, transport, and signaling disciplines within AT&T. Of particular relevance to the issues in this complaint, from 1992 through 1994, I was a Project Management / Systems Engineer responsible for the Signaling System 7 ("SS7") network for AT&T from a provisioning, monitoring, and maintenance standpoint.

Moreover, during this timeframe, I was responsible for developing and then implementing a plan to integrate AT&T's SS7 network with every telecommunications carrier in the United States within every geographic area within that carrier's network. As a result, I have a deep knowledge base regarding interconnection between networks for signaling related to voice and data traffic. Moreover, I am very familiar with the underlying transport requirements for signaling networks and the diversity required to ensure the reliability of this platform.

From 1995 until 1997, I worked in the Local Infrastructure and Access Management

organization within AT&T. In this organization, I gained familiarity with many of the regulatory issues surrounding AT&T's local market entry, including issues concerning the unbundling of incumbent local exchange carrier networks. I was responsible for designing and engineering AT&T's local networks within the five-state region of Texas, Missouri, Oklahoma, Kansas, and Arkansas. I also participated on the AT&T team that negotiated interconnection contract terms and conditions with then-Southwestern Bell Telephone Company, including unbundled network element definitions and methods of interconnection.

From 1997 to 2006, I was President of my own consulting firm, Kaleo Consulting, specializing in providing strategic consulting services to companies regarding where and how to enter various telecommunications markets. I also provided expert testimony in technical and financial areas related to telecommunications. My projects involved resolving contractual terms and conditions disputes and issues that arose between telecommunications service providers, assessing networks and performing due diligence work, estimating universal service funding, and identifying underlying costs for network elements including interoffice transport, collocation, loops (media used to connect to end-user premises), switching, and signaling.

Within the same period, from 1998-1999, I also co-founded and served as President for ALT Communications, a Competitive Local Exchange Company (CLEC), in Texas. In this role, we operated the first platform-based CLEC[2] within the state of Texas. My

[2] "Platform-based" refers to the practice of using a combination of all the Unbundled Network Elements ("UNEs") available under the Communications Act of 1996 and subsequent Federal Communications Commission ("FCC") orders and rulings to provide an end-to-end circuit used for telecommunications service.

responsibilities included all aspects of the business: sales, service delivery, maintenance, operations, and finance. In 1999, my partner and I sold ALT Communications to Birch Telecom, and I continued to lead the operations in Texas for the next year.

In December 2006, I joined FTI and have continued to provide consulting services in the telecommunications, media, and technology industries, with a primary focus on integrated communications.[3] As part of this practice, I lead a team of individuals with exceptional technical expertise in designing, implementing, and operating various types of networks. We have worked with wired (copper, coaxial, fiber, hybrid), wireless (fixed and mobile), and satellite carriers to design specific solutions that provide network access. I also routinely perform technical and financial due diligence projects to evaluate companies' communications service architecture as well as their provisioning and operations practices. I routinely operate as our chief network engineer on technical network engagements and have performed detailed network assessments on over 25 network-related transactions involving telecommunications providers in the fiber, cable, wireless (fixed and mobile), satellite, and tower industries. I am knowledgeable in all of the access technologies that these various carriers utilize including fiber-to-the-home, digital loop carrier, DOCSIS (1.0, 2.0, 3.0, 3.1, and 4.0),[4] and fixed and mobile wireless

[3] "Integrated communications" refers to networks that consist of different technology types that must be integrated to function as a whole. 911 service utilizes integrated communications. 911 calls can originate from callers using various technologies: wireless, traditional wireline, VOIP, etc. Those calls can be transmitted to PSAPs using different signaling technologies such as SS7 or IP. All of those technologies must be integrated to complete a 911 call from a customer to a PSAP.

[4] DOCSIS stands for Data Over Cable Service Interface Specification. It is a standard for transmitting data over cable television technology. Introduced in 1997, it has evolved over the years, with several releases. The latest version, DOCSIS 4.0 was released in 2020. For more

technologies. I am also knowledgeable in the operation of the transport and data layers within these businesses and have testified as an expert in the operation of networks on many occasions.

My consulting assignments regularly involve negotiating interconnection agreement terms and conditions between telecommunications companies and resolving disputes arising from those agreements. These negotiations require a sound understanding of the Communications Act of 1934, as amended by the Telecommunications Act of 1996, and associated FCC regulations, along with a knowledge of state, county, and city regulations. I also stay well abreast of network engineering technology and standards as part of my ongoing work that often involves network design and evaluation, financial forecasts, cost-of-service analysis, and rate development.

Q. WHAT IS YOUR EXPERIENCE AS AN EXPERT WITNESS, SPECIFICALLY REGARDING 911 AND SIGNALING ISSUES?

A. I have testified in multiple proceedings in Tennessee and North Carolina related to the provision of 911 services. While these proceedings have involved issues related to the payment of fees for 911 services, I have also developed extensive understanding regarding 911 call flows, the interconnection between the various components of a 911 network, and ultimately the connectivity into the PSAPs.

information, see https://www.cablelabs.com/blog/a-101-on-docsis-technology-the-heart-of-cable-broadband, last accessed March 10, 2022.

Recently, I testified in a proceeding[5] involving the signaling between networks using both SS7 and IP-based technologies on behalf of Plintron, a telecommunications carrier that facilitates the deployment of wireless services for mobile virtual network operators using the underlying physical network of another carrier.

This experience in combination with my ongoing work with carriers in the US both through performance improvement projects as well as diligence on transactions keeps me up-to-date on the operation of carriers in delivering reliable service to 911 PSAPs. Further, I continue to advise clients regarding 911 service issues. I have provided expert testimony on integrated communications network engineering and operations before the public utility commissions of 35 states within the United States and its territories, before the FCC on many occasions, and before the Canadian Radio and Television Commission. I have also provided expert testimony in federal court proceedings and arbitrations involving integrated communications provider disputes. Details related to my expert testimony within the past four years are included in my CV, Exhibit SET-2.

Q. WHAT IS YOUR RATE OF COMPENSATION?

A. FTI is being compensated at a rate of $965 per hour for my services, and the rates for FTI personnel working on this assignment under my direction range from $325 to $795 per hour. FTI's fees are not contingent upon the outcome of this matter.

[5] *Demand for Arbitration*, International Centre for Dispute Resolution, American Arbitration Association, *Surf Telecom S.A. v. Plintron Holdings PTE. Limited*, Case No. 01-20-0014-0883.

II. DESCRIPTION OF ASSIGNMENT AND SUMMARY OF OPINIONS

Q. WHAT IS THE BACKGROUND OF THIS CASE?

A. I understand that the Staff of Washington Utilities and Transport Commission ("Staff") has filed a complaint ("Complaint") against CenturyLink Communications, LLC ("CLC") in Docket UT-181051 in response to the 911 service failure in Washington in December 2018.

This testimony sets forth my expert opinions based on information available to me as of the filing of this testimony. The opinions set forth in this testimony, which are my present opinions, are based on my review of this information as well as my knowledge, education, experience, and training. The information I rely upon in forming my opinions is consistent with materials I review in my normal course of business. To the extent that additional documents, data, or other information is made available to me, I will review such documents, data, and/or other information and may incorporate that additional information learned about the facts or circumstances of this matter into my analyses, conclusions, and/or opinions. I reserve the right to update, supplement, and amend my opinions as additional information becomes available and to provide additional information and opinions regarding the merits of the Staff's claims and CLC's defenses.

Q. WHAT ARE YOUR INSTRUCTIONS FROM COUNSEL?

A. Counsel for CLC has asked me to perform the following assignments:

- Provide a brief description of SS7 switching and industry standard network design for 911 SS7 networks, including demarcation points for both the signaling and voice networks;
- Identify whether the use of SS7 technology caused or prolonged the outage;

- Identify whether Comtech's transport ordering practices met industry standards with respect to the requirements for SS7 network interconnection;

- Identify whether the root cause of the outage on one of the legacy Level 3 optical networks (also referred to as the Red network) was the same as the root cause of the outage on another of the legacy CenturyLink networks (also referred to as the Green network) and whether CLC should have made modifications to the Green network in response to the Red network outage;

- Identify whether best practices require turning down unused services on network elements that are utilized in telecommunications networks in every case; and

- Identify the root cause of the Green network 911 outage and the responsible party.

Q. WHAT CONCLUSIONS AND OPINIONS HAVE YOU REACHED?

A. After reviewing the information in this proceeding, and based on my many years of experience working in the telecommunications space, I have reached the following conclusions and opinions with respect to the final assignment above:

- SS7 technology is commonly used by the industry in 911 network architecture, and the use of SS7 to support the 911 network connecting CenturyLink and Comtech PSAPs was not the cause of the outage.

- According to industry standards, the 911 service provider is responsible for the efficacy and stability of the network (both voice and signaling networks), including route diversity. As the 911 service provider, Comtech should have specified its requirements for network diversity when ordering transport facilities from CenturyLink for use for its SS7 signaling links. Importantly, the use of diversity for SS7 links is fundamental to SS7 network design. All four links[6] ordered by Comtech and connecting the 911 networks between Comtech and CenturyLink used the same Green Infinera switching network

[6] In industry parlance, the term "transport facilities" refers to physical network elements such as fiber optic cable, copper cable, etc., that is used to transport network communications. "SS7 links" specifically refers to transport facilities that interconnect STPs for signaling purposes. "Trunks" refers to transport facilities that interconnect switches and are used to transport voice calls.

that experienced an outage. This is a serious mistake created by Comtech, which directly caused 911 calls destined to PSAPs that had transitioned to Comtech to fail.

- Comtech knew before the service outage that it did not have sufficient diversity in its signaling link transport facilities between its switch and its STP vendor – TNS. Comtech had the opportunity to add network diversity months prior to the outage, but declined to do so on the basis of cost. A failure to ensure that this diversity existed was a clear violation of good network engineering practice on Comtech's part. Comtech described its lack of diversity as "not an ideal situation" and appears to have elected to wait to obtain diversity to avoid termination liability assessments on the non-diverse circuits it had ordered. Comtech admits it did not notify WMD or CenturyLink about the lack of diversity prior to the outage.

- The outage on the Red network had a single root cause: a software upgrade that allowed malformed packets to enter the IGCC. The Green network was using an earlier version of the software; the Red network outage was not related to the Green network outage.

- The Green network outage had different, multiple root causes. Malformed packets, with valid headers and of a size that evaded the filters in place to keep the packets from entering the IGCC, caused the outage. According to Infinera and in my own assessment, this event was unforeseeable; in fact, the cause of the outage was never determined.

- CenturyLink left the IGCC open in its Green network based on Infinera's guidance. In my opinion, it is customary and appropriate to rely upon the statements of an equipment vendor about how to deploy its infrastructure into the network. Regardless, Comtech's failure to ensure diversity in the transport layer of the signaling network between its switch and its own STP provider (TNS) (not the Infinera outage itself) served as the root cause of the Washington 911 outage in December 2018.

III. FOUNDATIONAL NETWORK DESIGN CONCEPTS

Q. COULD YOU EXPLAIN WHAT YOU MEAN BY "FOUNDATIONAL NETWORK DESIGN CONCEPTS?"

A. From my review of the Staff and Public Counsel testimony, there appears to be a misunderstanding of network design principles and how these principles intersect with underlying components that make up the networks. There is essentially a hierarchy inherent in good network design that is a key principle in my evaluation provided in the following pages. In my view, outlining these foundational network design concepts will provide a better understanding of the issues underlying the December 2018 Washington 911 outage if they are discussed up front.

Networks (and this concept would apply to systems generally) are designed with overarching design principles. Those design principles may apply to capacity (how much information can I pass through a network), latency (delay in passing the information through the network), reliability (information that is transmitted is received as intended), efficiency (cost to transmit the information), redundancy (ability to continue the information transmission in spite of an incident), and other factors. All of these factors lead to one important point from a network design standpoint: the architect of the network must plan the overarching network in such a way that the capabilities of the components within the network can be fully utilized and meet the standards that will allow the overall objectives of the network to be accomplished. If a higher-level requirement of the network is violated from a design standpoint and an outage occurs, the root cause of the outage rests with the higher-level design flaw, rather than on any individual component of the network.

Ultimately, I intend to apply the network principle of redundancy mentioned above to the specific issues in this case related to 911 call flows, signaling networks, and the like. But I will begin by illustrating that concept using something more tangible that is directly analogous to the issues in this present complaint.

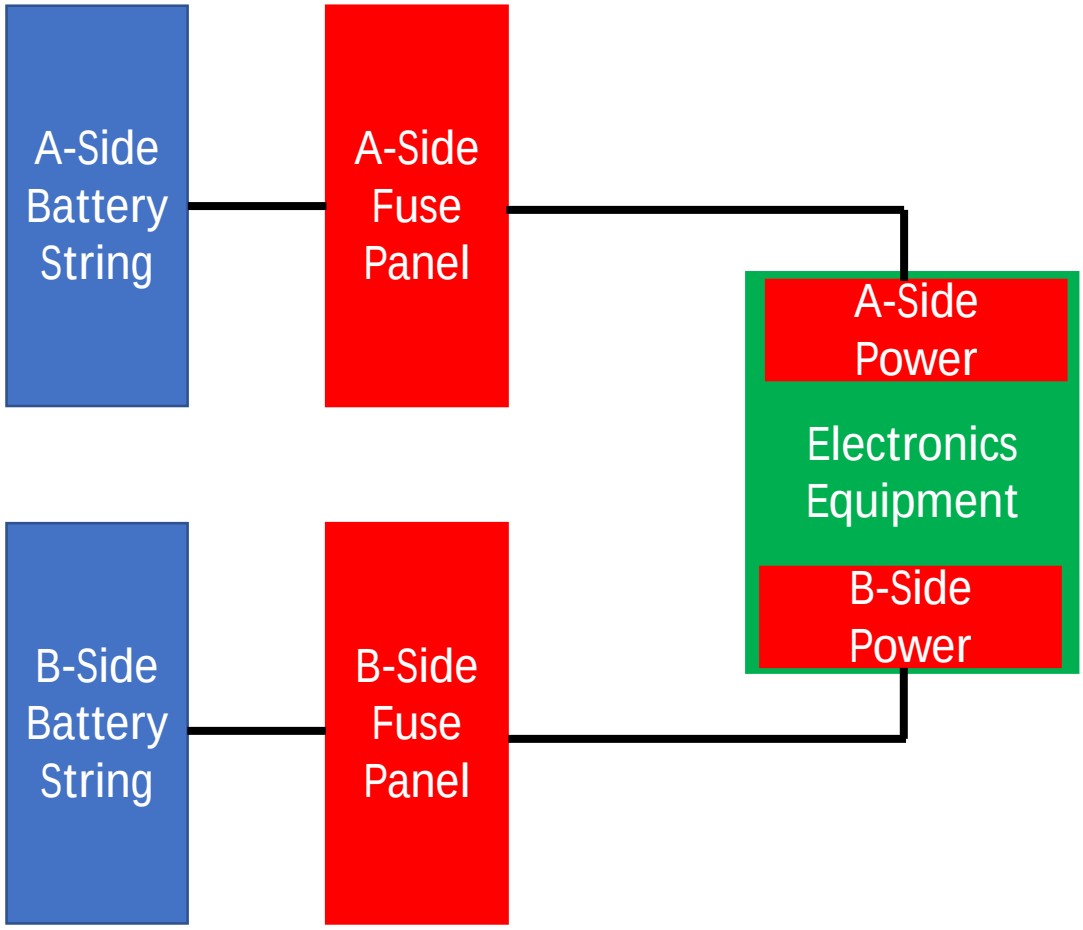
Q. CAN YOU PROVIDE THAT ILLUSTRATION?

A. Yes. I would like to illustrate the design principle of redundancy mentioned above using the example of electrical power. We are all familiar with the need to have electrical power for our equipment to work. Because of the importance of telecommunications in all aspects of business and personal life, the electrical power for virtually every piece of telecommunications electronics equipment is designed to have redundancy. It is referred to in the industry as having "A-Side" and "B-Side" power feeds. In other words, whereas your television may only have one power cord coming into it, with telecommunications equipment there would be two power cords providing what is referred to as "A-Side" and "B-Side" power.

Now, the reason that the equipment is built this way is that the network architect knows a single power failure should never allow that piece of network equipment to fail. In fact, because the telecommunications electronics equipment is built with "A-Side" and "B-Side" power feeds, the network architect should likewise ensure that the electrical power infrastructure within the building that houses the telecommunications equipment is similarly designed to provide separate feeds for the "A-Side" and "B-Side" of the power. There are separate batteries for the "A-Side" and "B-Side" power. There are separate fuses (think of the fuse panel that you have located somewhere in your home) for the "A-Side" and the "B-Side" of the electrical power supply. Figure 1 below provides a

simplified illustration of this architecture.

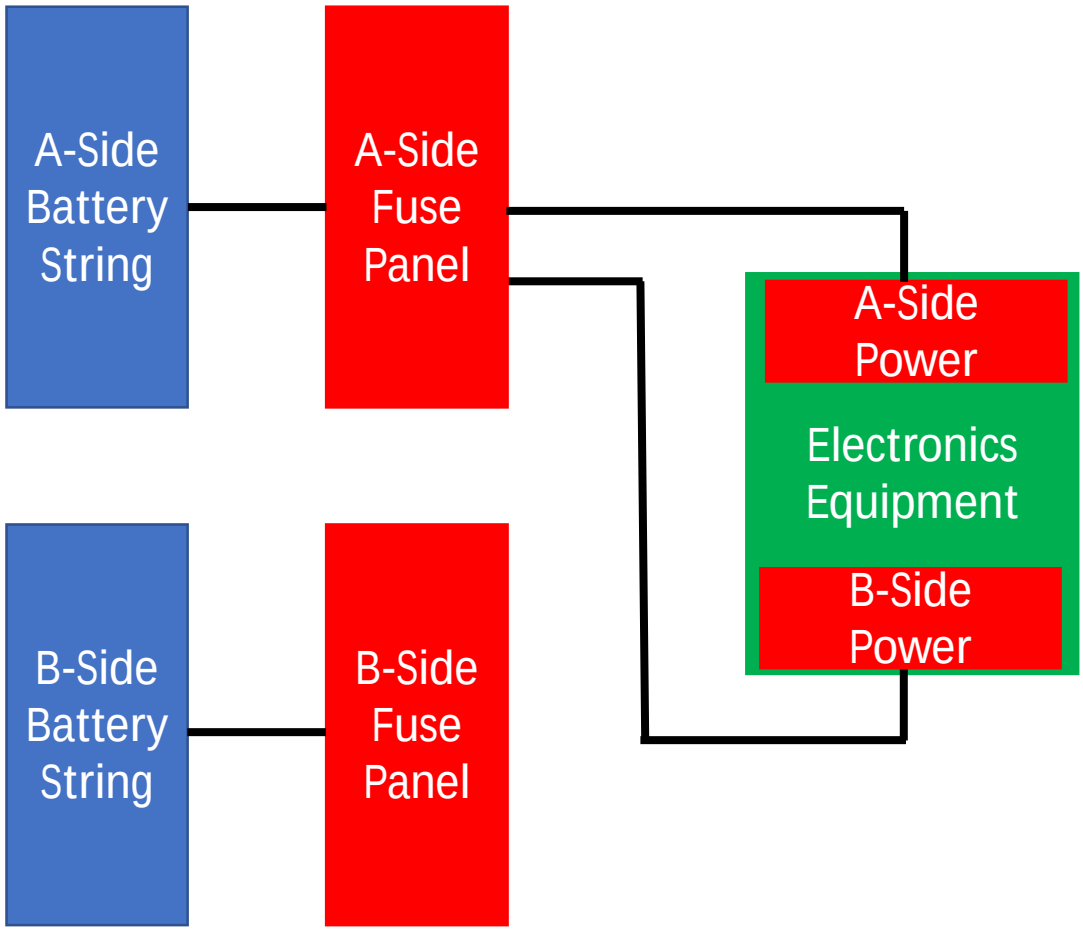
Figure 1
Simplified Power Architecture with "A-Side" and "B-Side" Feeds



With this configuration (which is routinely used with telecommunications equipment) if something happens on the "A-Side" power feed with the batteries or with the fuse such that the power feed is interrupted on the "A-Side," the entire supply of power can come to the electronics equipment through the "B-Side" of the power feed. The reverse situation works as well.

However, as part of field studies that I have routinely performed as part of my work, I have actually observed instances of poor network design as shown in the revision to Figure 2 below.

Figure 2
Simplified Power Architecture with Erroneous Use of "A-Side" Feed Only



In the figure above, instead of utilizing the capability engineered into the equipment, allowing it to use both the "A-Side" and "B-Side" of the power infrastructure inside of the central office, here, the electronics equipment is erroneously only drawing power

from the "A-Side" power. If the "A-Side" power continues to operate (the feed is not interrupted), the electronics equipment will work as intended. However, if an event occurred in the "A-Side" power causing the simple fuse to trip (open up), the power to the electronics equipment would be interrupted, causing a failure for that component in the network.

Q. IF YOU WERE TO EVALUATE THE CAUSE OF THE OUTAGE FOR THE ELECTRONICS EQUIPMENT, WOULD YOU ASSIGN THE CAUSE FOR THE FAULT TO THE FUSE OPENING?

A. Absolutely not. The equipment is designed to have redundant power feeds on the "A-Side" and "B-Side" because network engineers know that failure on one side of the power infrastructure can happen. As such, the failure caused by an open fuse would not cause the equipment failure. If the network was designed properly, the equipment would use the power feed on the other side, preventing the failure. While the failure caused by what might be a $2.00 fuse would explain what led to the power to the electronics equipment to be interrupted for that individual feed, the real issue is that, although the equipment was designed to receive power using redundant power feeds from two independent power plants delivered to the electronics equipment, the party responsible for network design did not use this capability. As such, the root cause of the power outage is poor network design that did not use the full capabilities of the power infrastructure – not the failure of a $2.00 fuse.

Q. WOULD IT THEN BE REASONABLE TO HAVE AN INVESTIGATION AND LITIGATION RELATED TO THE FAILURE OF THE FUSE?

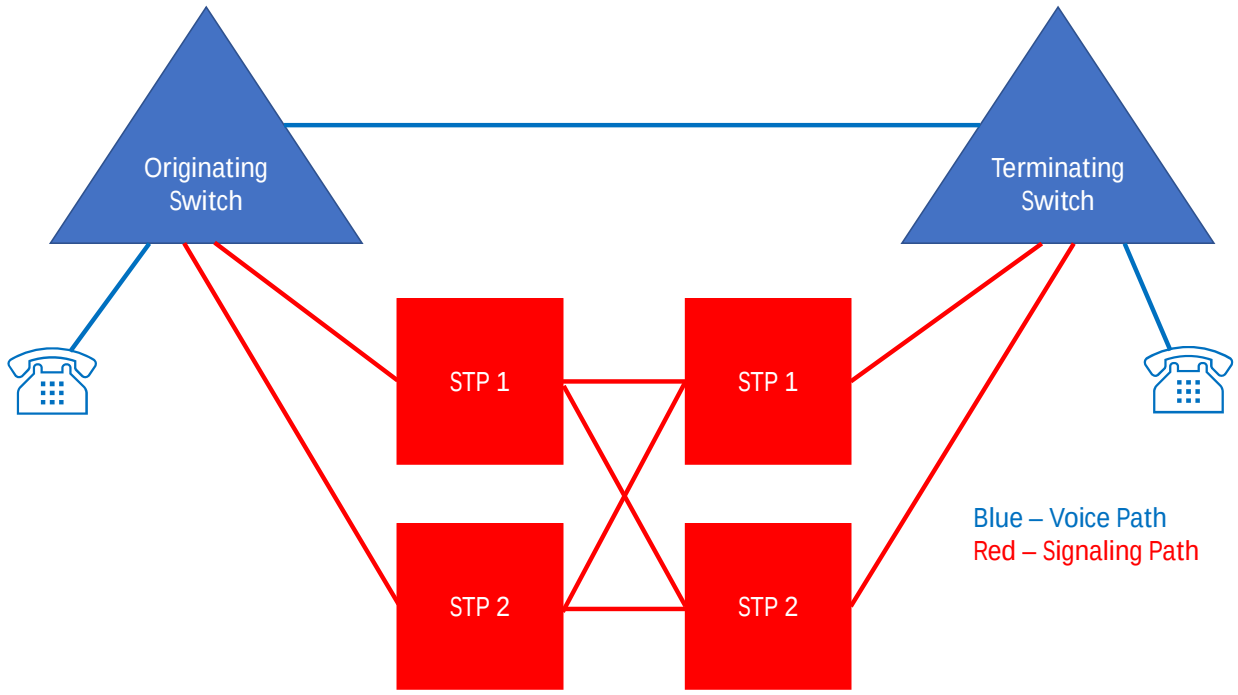
A. While I am not an attorney and do not offer an answer to this question from a legal perspective, from an engineering perspective the answer would be absolutely not. What would be much more pertinent in determining the root cause of the failure would be to understand why the network design utilized equipment designed for redundancy in the power feed, but failed to leverage this redundant capability. In short, an evaluation of the real cause of a network outage requires not only an understanding of the individual components used in the network but also an understanding of how the entire network is put together to allow for potential failures in components. As will be seen later in this testimony, the critical redundancy issue described above for power applies to the signaling network and Comtech's failure to design its network with diverse SS7 links in that network system.

IV. OPERATION AND USE OF SIGNALING NETWORKS

Q. WHAT IS THE PURPOSE OF A SIGNALING NETWORK IN A TELECOMMUNICATIONS NETWORK?

A. Virtually all voice calls are set up with what is known as the signaling network. A signaling network is a separate network parallel to the voice network that is used to transmit packet data information necessary to establish and track critical information about the voice calls. The simplified Figure 3 below shows how a communication between two voice switches uses the separate signaling network to set up the voice call.

Figure 3
Signaling and Voice Paths



In Figure 3 above, the caller on the Originating Switch dials a number served by the Terminating Switch. The Originating Switch then has two connections that go to two Signal Transfer Points (STP1 and STP2). The STPs are the devices that transmit and receive signaling messages to set up the call. The Originating Switch sends the telephone number of the originating caller and the telephone number of the terminating caller to two paired STPs that serve the originating switch. These two STP pairs are linked to one another to ensure call set up and break down messages are exchanged between the Originating Switch and Terminating Switch (as well as any intermediate switches not shown to simplify the diagram) to establish the call. All of the connections between the switches and STPs and between the STPs themselves are set up such that there are redundant connections because unless the STPs serving the Originating and Terminating

Switches can communicate with one another, voice calls cannot be established.

Q. DOES THE ORIGINATING SWITCH ONLY NEED TO SEND A MESSAGE TO ESTABLISH THE CALL OR MUST IT ALSO RECEIVE A MESSAGE BACK?

A. The short answer is that the switches and STPs must be able to transmit information back and forth to establish a call between two switches. This will be an important point later in this testimony with respect to the Comtech network and its failure to provide response messages to set up 911 calls. To provide further detail, I have provided a cite to a document from Rutgers University that provides a summary of the messaging between switches and STPs to set up a basic call.[7] This document identifies 18 steps that transmit and receive information between switches and STPs that may be exchanged in the set up/break down of a call.

For simplicity, however, there are two signaling messages that I will focus on. First, there is a message known as the Initial Address Message (IAM) that is transmitted to initiate a call. This IAM is passed from the Originating Switch through the STPs to the Terminating Switch. The Terminating Switch must then send what is known as an Address Complete Message (ACM) that acknowledges receipt of the request to establish a call and supplies information that defines how that call will be established over the voice network. Sending and receiving messages essentially establishes a "handshake" that defines how to set up a voice call path between two switches. If the IAM is sent but no ACM is returned, a call path cannot be established. It is for this reason that

[7] Rutgers University, "illumenet Signaling System 7 (SS7)," https://people.cs.rutgers.edu/~rmartin/teaching/fall04/cs552/readings/ss7.pdf, last accessed March 20, 2022. Please see Section 7 entitled "Basic Call Setup Example." Exhibit SET-3.

redundancy in the signaling network is so essential. Data must be able to pass from network component to network component to transmit and receive these IAM and ACM messages that are utterly essential to setting up a voice call. Just as with the electrical power example above, if connections to one STP are down, it is essential for the connections to the other STP to be operational so a call path can be established. Otherwise, calls between the switches cannot complete.

Q. HAVE YOU PERSONALLY BEEN RESPONSIBLE FOR ESTABLISHING THE CONNECTIVITY THROUGH SIGNALING NETWORKS?

A. Yes. While I was employed with AT&T, I was responsible for a project where I had to interconnect every AT&T STP with every incumbent LEC STP across the United States. I was responsible for procuring the transport facilities (i.e., signaling links) between the AT&T STPs and the incumbent LEC STPs in every market. The team under my direction provisioned hundreds of STP links during this project.

Q. WAS REDUNDANCY AN IMPORTANT CONSIDERATION IN THIS PROJECT?

A. Absolutely. As is illustrated in the diagram above, STPs are established in what are known as mated pairs. STP1 and STP2 work together so that if one of them fails, the other STP can handle all of the signaling traffic. But to do this, the STPs must also be connected to each of the mated pairs owned by the incumbent LEC.[8] To accomplish this, I had to provision two links between each AT&T STP and the pair of incumbent LEC

[8] An "incumbent LEC," or Local Exchange Carrier, is a term coined by the Telecommunications Act of 1996 that identifies the Local Exchange Carriers (such as Southwestern Bell or GTE) that existed prior to the Act's passage.

STPs. And when I did this, I had to also ensure through the ordering and provisioning processes with the incumbent LECs that the facilities established between us were physically diverse from one another. In other words, I ensured diversity, requiring that circuits were ordered in a manner where no one physical or software outage event would be able to cause both signaling links to fail. This requirement is fundamental to the network design of signaling networks.[9] Networks engineers know that an individual signaling link can fail. However, you design the network so that the failure of one link will do no harm. To do this, you must have redundancy in place so that both paired signaling links cannot fail at the same time.

[9] Please note than when I was deploying the signaling links to implement the project described above was in the early 1990s. The Telecommunications Act of 1996 significantly expanded the range of options for providing options for establishing connectivity between points. To ensure route diversity with a single carrier (which I often had to use), I had to order the circuits in this way. I ensured that the circuits were on different networks, had different entrance facilities into the building (how circuits physical enter a building so that no one cable cut would harm both of the circuits I was provisioning), routed into the building through different facilities, etc. There are circumstances where route diversity does not require that two different carriers (or suppliers) are used. The critical point is that obtaining diversity requires care ensuring that the provisioning process is implemented in a manner that no one failure can affect both links at the same time.

V. WASHINGTON NETWORK TRANSITION

Q. WHAT IS THE BACKGROUND OF THE 911 NETWORK TRANSITION IN WASHINGTON?

A. In 2016, the Washington Military Department (WMD) awarded the state's 911 service network, referred to as ESInet II,[10] to Comtech.[11] WMD ordered a transition plan wherein 911 service originally provided by CLC/Intrado was gradually transitioned to Comtech.

Q. WHAT WERE SOME OF THE PRACTICAL IMPLICATIONS OF THIS PLAN BY WMD?

A. During the transitional period, some of the 911 PSAPs were to be served by CLC and some would be served by Comtech. However (and this will be addressed in more detail below), to determine which PSAPs were on which networks, one of the providers needed to make this first level determination. Under the phased approach that was adopted, CenturyLink was responsible for determining whether a PSAP was continuing to be served on its network. If the PSAP was not, CenturyLink would then route the 911 call to Comtech for Comtech to establish the connection between the caller and the PSAP. CLC witness Carl Klein provides more detail about the transition structure in his Response Testimony.[12]

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[10] ESINet stands for Emergency Services IP Network.

[11] See Exhibit JDW – 3C, p. 8.

[12] See Response Testimony of Carl D. Klein, at 5-11.

Q. DID A NETWORK INCIDENT OCCUR DURING THIS TRANSITIONAL PERIOD?

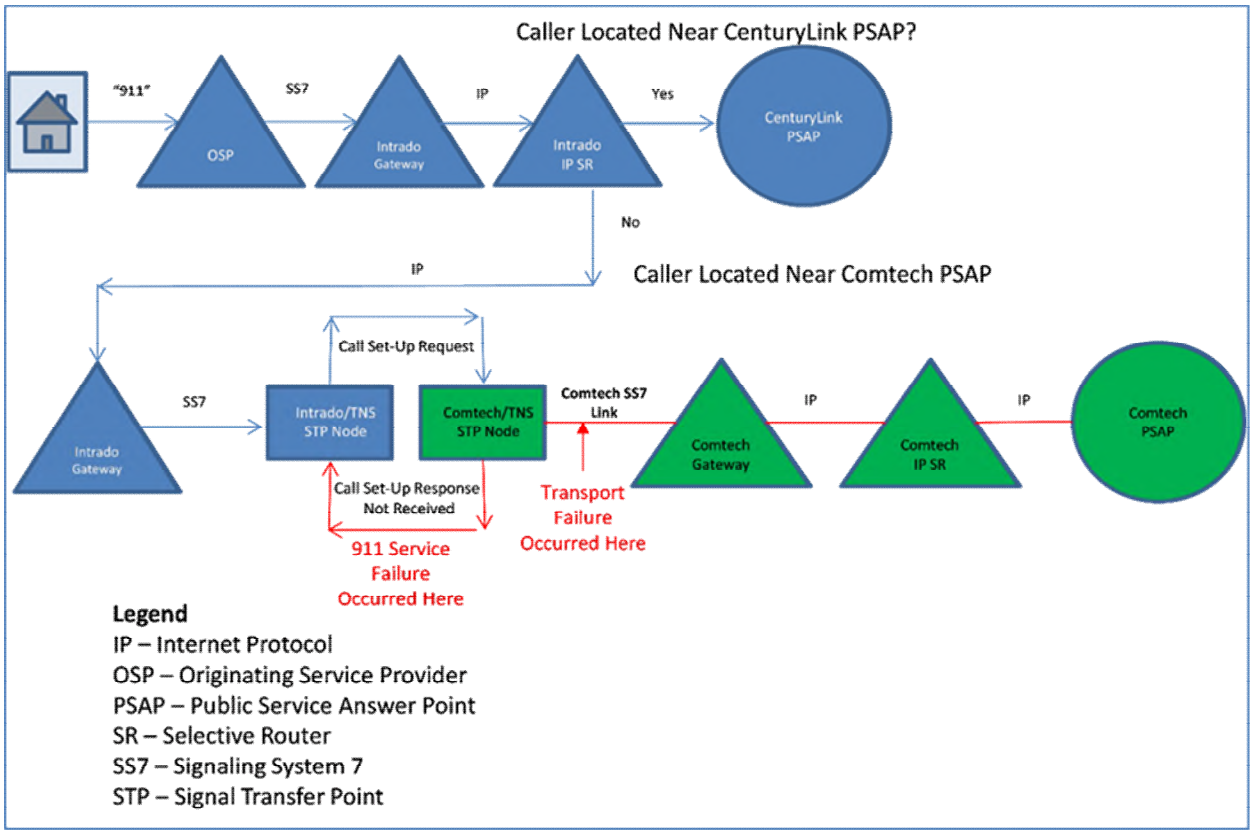
A. Yes. In December 2018, during the transition from CLC/Intrado to Comtech, CLC experienced a packet storm that led to a widespread outage on one of its six transport networks (specifically, CLC's Infinera Green network). As part of this, 911 service to the PSAPs that had transitioned to Comtech experienced service degradation because Comtech had ordered all four signaling links supporting 911 calling in Washington from CLC without specifying the need for diversity.

VI. 911 SERVICE OVERVIEW: WHAT HAPPENS WHEN YOU DIAL 911?

Q. HOW DO 911 CALLS ROUTE?

A. By dialing 911, a caller can access emergency services located near to their location. The call originates with the caller's Originating Service Provider (OSP), which is a telecommunications service provider such as a wireless service provider, a landline service provider, a VOIP service provider, etc. When the caller dials 911, the OSP's switch is programmed to route the call to a 911 service provider. The 911 service provider's network identifies the Public Safety Answering Point (PSAP) with 911 operators nearest to the caller. In the instant case, the role of 911 service provider for the state of Washington was in the process of being transferred from CLC to Comtech. Figure 4 below illustrates the call flow that occurred during this transitional period:

Figure 4
911 Call Flow – Transitional Model



Q. HOW DID A 911 CALL ROUTE IF THE PSAP NEAREST TO THE CALLER WAS STILL OPERATING ON THE CENTURYLINK/INTRADO NETWORK?

A. During the transition period, PSAPs were gradually transitioned from CenturyLink's 911 service provider (Intrado) to Comtech. If a PSAP was still operating on the CenturyLink/Intrado 911 service network, the calls would complete as shown at the top of Figure 4 using the following steps:

- The caller dials 911.

- The Originating Service Provider (OSP) routes the call to the gateway location of CLC's contracted 911 service provider, Intrado.

- Intrado delivers the call to its Selective Router (SR). The SR queries information regarding the party making the 911 call to determine the physical location of the caller so that they can receive 911 services.

- Decision point: If the physical location of the 911 caller is closest to a PSAP served by CenturyLink/Intrado, Intrado would route the call to the appropriate PSAP.

Q. HOW DID A 911 CALL ROUTE IF THE PSAP NEAREST TO THE CALLER HAD TRANSITIONED TO COMTECH?

A. If the 911 caller was located nearest to one of the PSAPs that had already transitioned to Comtech, the first three steps of the call flow described above would be the same, but at the decision point, the call would route differently. The following steps describe the process.

- The caller dials 911.

- The OSP routes the call to the gateway location of CenturyLink's contracted 911 service provider, Intrado.

- Intrado delivers the call to its Selective Router (SR). The SR queries information regarding the party making the 911 call to determine the physical location of the caller.

- Decision point: If the physical location of the 911 caller is closest to a PSAP served by Comtech, Intrado would route the call to Comtech as per the following steps.

- The Intrado SR would indicate to the Intrado Gateway that the call needs to be routed to Comtech. Signaling is required to establish this call path.[13]

[13] As discussed above, signaling would have been necessary for the connections between the OSP, CenturyLink and Intrado to establish a voice call path. I have not addressed every step in the 911 call flow in order to focus on the issues in this dispute.

- Both Intrado and Comtech utilize a company named TNS for signaling (specifically STP) services. Intrado uses its signaling links to transmit the call setup information from its gateway to TNS. TNS would then utilize its signaling links to Comtech to pass this information to the Comtech gateway.

- When the network functions property, the 911 call would then travel to the Comtech 911 network gateway through to the Comtech SR. The Comtech SR queries information regarding the party making the 911 call to determine the physical location of the caller so that they can receive 911 service.[14]

- Comtech would then route the call to the Comtech-served PSAP to connect the 911 caller to the 911 operator.

VII. DECEMBER 2018 WASHINGTON 911 OUTAGE

Q. PLEASE DESCRIBE THE DECEMBER 2018 WASHINGTON 911 OUTAGE.

A. CLC's Infinera Green transport network experienced a widespread outage that affected portions of 911 service in the state of Washington beginning in the early morning of December 27, 2018.[15] The outage was caused by "malformed packets" generated by one of the Infinera switching nodes that proliferated through the network, causing a phenomenon known as a "packet storm."[16] All of Comtech's SS7 links were provisioned over CLC facilities using the affected Infinera Green network. Comtech's design of its signaling network violated industry best practices, that require route diversity for the signaling links between STPs and switches so that a failure on one of the signaling links

[14] Note the call would not route to a PSAP served by CenturyLink/Intrado because CenturyLink/Intrado would have already determined that the nearest PSAP is served by Comtech.

[15] Pub. Safety and Homeland Sec. Bureau, DECEMBER 27, 2018 CENTURYLINK NETWORK OUTAGE REPORT, 6-8 (Fed. Commc'n Comm'n, Aug. 19 2019) [henceforth "FCC Report"]. See Response Testimony of Stacy J. Hartman, Exhibit SJH-13.

[16] Exh. SJH-13, ¶¶ 10-13.

does not prevent calls from completing.

Q. YOU REFERENCED NETWORK REDUNDANCY IN YOUR EARLIER DISCUSSION. DOES ROUTE DIVERSITY RELATE TO PROVIDING NETWORK REDUNDANCY?

A. Absolutely. Best network engineering practices require network redundancy for critical network infrastructure such as signaling. Network redundancy is implemented by means of ensuring route diversity.[17] Route diversity does not simply mean geographic diversity of the transport facilities for the network. Its meaning is much broader. It requires that redundant network components must travel on different routes not only using diverse transport facilities, but also with no single points of failure either from a physical equipment or software standpoint.

Multiple standards-setting bodies cite the need for route diversity in critical network infrastructure. The FCC defines route diversity as follows:

> Route diversity is generally defined as the communications routing between two points over more than one geographic or physical path with no common points. For a PSAP, this means that the connectivity between the PSAP and the local central office (specifically to the 911 selective routers) should have alternative ways and/or means. It also means that there are no common points of connection along the way with the exception potentially at the end points (the PSTN selective router and the PSAP Private Branch Exchange or connection main frame). Strictly speaking, the alternative means may be achieved by completely distinct methods such as copper wireline, fiber optic cable, free space optical or other radio links, or even satellite link. The point is that in order to provide

[17] Supplier diversity (ordering links from different suppliers) can provide a means of achieving route diversity. However, simply buying links from two providers does not ensure overall route diversity. If one supplier is simply buying facilities of the other provider at a wholesale rate and reselling them to a third party, the route may not be diverse.

> diversity, connections between the PSAP and the central offices should be by separate and distinct methods with no common points of connection along the way.
>
> By providing separate and distinct routing methods, it is also implied that there are separate and distinct entry points for each transmission means as they terminate at the end points. In many instances, this means that the separate routes should enter/leave from distinct and separated entry points to the end point facilities. For example, typical route diverse wireline systems enter at separate wiring closets or entrance facilities that support either the central office or the PSAP. It should be noted that route diversity is NOT satisfied by two separate systems that follow a similar geographic path, for example parallel cable systems. Under such circumstances, both means are still vulnerable to outage as if they were a similar single path.
>
> In addition, redundant paths that employ the same transmission means (e.g. two trunks that are on the same cable or two channels on the same radio system) also do not satisfy proper diversity requirements. … ***In summary, route diversity applied to public safety PSAPs ensures that there are no single points of failure in the connection between a PSAP and local networks***.[18]

Q. ARE THERE OTHER DOCUMENTS INDICATING THE CHARACTERISTICS OF A PHYSICALLY DIVERSE NETWORK IN THE CONTEXT OF 911?

A. Yes. The Federal Code of Regulation defines "physically diverse" in the context of 911 networks as follows:

> ***Physically diverse.*** Circuits or equivalent data paths are Physically Diverse if they provide more than one physical route between end points with no common points where a single failure at that point would cause both circuits to fail. Circuits that share a common segment such as a fiber-optic cable or circuit board are not Physically diverse even if they are logically diverse for purposes of transmitting data.[19]

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[18] Federal Communications Commission, "Communications Route Diversity for Public Safety," https://www.fcc.gov/general/communications-route-diversity-public-safety, last accessed March 20, 2022 (emphasis added).

[19] 47 CFR §9.19 (a)(8).

The Communications Security, Reliability, and Interoperability Council (CSRIC), an FCC advisory committee, supports SS7 link diversity as an industry practice, recommending the following:

> Network Operators and Service Providers should follow industry guidelines for validating SS7 link diversity, which should be performed at a minimum of twice a year, and at least one of those validations should include a physical validation of equipment compared to the recorded documentation of diversity.[20]

Q. DOES COMTECH ACKNOWLEDGE THIS REQUIREMENT IN ITS RESPONSES TO DISCOVERY REQUESTS?

A. Comtech appears to vacillate on this issue and offers confusing answers at best. First, in a discovery response,[21] Comtech notes that CSRIC states that:

> Best Practices are voluntary in nature and may not apply in every situation due to the need for flexibility, innovation, and control in the management of different carriers' unique business models, cost, feasibility, resource limitations, or other factors.[22]

While this is an accurate quote, it does not specifically pertain to the diversity requirements associated with signaling links. Moreover, Comtech does not state that the need for diversity "did not apply" when designing the 911 network for Washington. In

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[20] Federal Communications Commission, CSRIC Best Practice 12-10-0594, https://opendata.fcc.gov/Public-Safety/CSRIC-Best-Practices/qb45-rw2t/data, last accessed March 11, 2022.

[21] See Response Testimony of Stacy Hartman, Exhibit SJH-12C, Comtech response to DR CTL-3.

[22] Federal Communications Commission, "Working Group 7: Legacy Network Best Practices Update," https://transition.fcc.gov/pshs/advisory/csric4/CSRIC%20IV%20WG7%20Legacy%20Best%20 Practices%20Final.pdf, last accessed March 11, 2022.

fact, Comtech explained that it wanted, and was actively pursuing diversity, as stated in its response to discovery.

> **CTL-2 At page 29 of his Direct Testimony, Mr. Rosen states Comtech "had identified the issue [of supplier diversity] and was in the process of bringing on another supplier that eventually would provide two of the links, leaving CenturyLink to supply the remaining two."**
>
> **a. Please state whether Mr. Rosen is accurate when he makes this statement.**
>
> **RESPONSE:** Mr. Rosen's statement is accurate. TSYS emphasizes, however, that supplier diversity is not a legal requirement; indeed, many facilities-based legacy 911 providers do not have supplier diversity. That said, if possible, TSYS seeks supplier diversity as a matter of practice.[23]

This response from Comtech is instructive in that it acknowledges that Comtech knew that it had an "issue" with respect to supplier diversity and that it was in the process of bringing on another supplier to address this "issue" with diversity for its signaling links. However, Comtech's response confuses the issue by noting that "many facilities-based legacy 911 providers do not have supplier diversity." My understanding of Comtech's point here is the fact that *PSAPs* may not always have supplier diversity on facilities that connect PSAPs to the 911 service providers. While I would not support that lack of diversity, a failure in the links connecting the 911 service provider to the PSAP would affect only that PSAP (and the customers served by that PSAP). It would not cause a system-wide outage as was the case in the December 2018 911 failure

To repeat, based on my experience in designing and implementing signaling networks, signaling link route diversity is essential between switches and STPs. These are not

[23] See Exhibit SJH-12C, Comtech response to DR CTL-2.

connections to the PSAP. These are connections between network providers. And as noted above from the FCC: "Network Operators and Service Providers should follow industry guidelines for validating SS7 link diversity, which should be performed at a minimum of twice a year, and at least one of those validations should include a physical validation of equipment compared to the recorded documentation of diversity." Quite simply, comparing the industry standard for redundancy and route diversity for network operators with a lesser standard utilized by some PSAPs is not relevant. Comtech simply failed to meet its obligations to provide for physical route diversity in its signaling network.

Q. DID COMTECH FOLLOW INDUSTRY GUIDELINES AND COMPLETE AUDITS TWICE PER YEAR, INCLUDING ONE PHYSICAL VALIDATION?

A. No, Comtech admits that it did not follow these industry guidelines. CLC sent a data request to Comtech asking:

> CTL-8: … With regard to CSRIC 12-10-0594:
> a. Describe all steps that you, TNS or any agent and/or consultant took on your behalf to comply with and/or adhere to this standard in connection with your design, construction, and maintenance of your Phase 1 SS7 network in Washington.
> b. Produce all documents showing the steps that you, TNS or any agent and/or consultant took on your behalf to comply and/or adhere to this standard in connection with your design, construction, and maintenance of your Phase 1 SS7 network in Washington.

Comtech provided no documents in response. After a meet and confer between counsel, Comtech admitted it had no responsive documents.[24] The reason for its lack of documentation is obvious: Comtech knew it did not have route diversity and it did not

[24] See Exh. SET-8, EMAIL ENTITLED "RE: Docket No. UT-181051 - CenturyLink's Second Set of Data Requests to Comtech."

need to complete an audit to verify what it already knew.

Q. DO YOU HAVE ANY OTHER DOCUMENTS INDICATING THE CHARACTERISTICS OF A PHYSICALLY DIVERSE NETWORK IN THE CONTEXT OF 911?

A. Yes. The Department of Homeland Security recommends route diversity as a key means of achieving communications resiliency.

> Communications resiliency means a network is able to withstand damages, thereby minimizing the likelihood of a service outage. Resiliency is the result of three key elements: route diversity, redundancy, and protective/restorative measures.[25]

Further highlighting the importance of route diversity, Homeland Security sponsors a Route Diversity Project that promotes route diversity with its stated purpose as:

> The Department of Homeland Security Office of Emergency Communications (OEC) Route Diversity Project (RDP) helps organizations mitigate threats to communications continuity and supports resilient, "always available" communications.[26]

To summarize, route diversity is an industry standard particularly for signaling links and for 911 calling. This is not only my belief, based on years of industry experience; it is also supported by FCC and Department of Homeland Security advisories.

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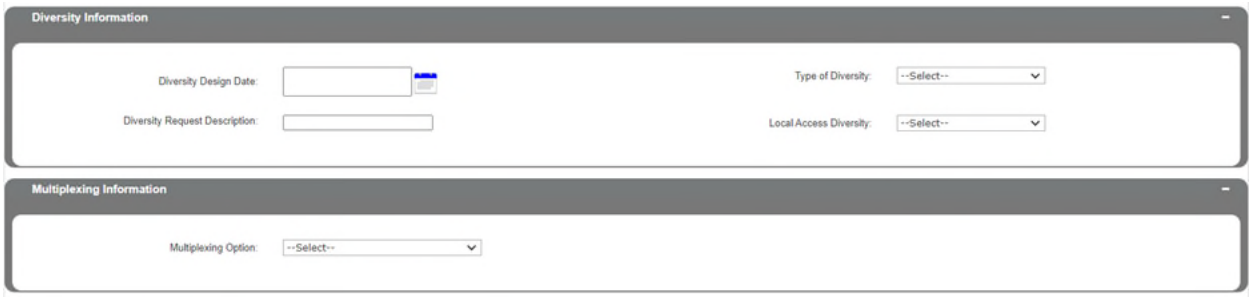
[25] "Ten Keys to Obtaining a Resilient Local Access Network," p. i, https://www.cisa.gov/sites/default/files/publications/07202017_10_Keys_to_Public_Safety_Network_Resiliency_010418_FINAL508C.pdf, last accessed March 11, 2022.

[26] https://www.cisa.gov/sites/default/files/publications/Route%20Diversity%20Project%20Fact%20 Sheet%206-9-16%20Final%20508.pdf, last accessed March 11, 2022.

Q. IS THE INDUSTRY STANDARD OF ROUTE DIVERSITY REFLECTED IN CENTURYLINK'S ORDERING PRACTICES?

A. Yes. Mr. Valence's testimony includes excerpts from CenturyLink's online ordering system (not used by Comtech) that provide opportunities for a carrier to request and obtain route diversity:

Figure 5
CenturyLink Online Ordering Form for Diversity[27]



Mr. Valence then attaches the forms associated with Comtech's order. It appears that Comtech chose to order the circuits through a retail channel rather than the wholesale portal.

[27] Valence Response Testimony, p. 21

Nowhere on the order does Comtech request diversity or specify that the circuits are to be used for SS7 signaling or 911 service.

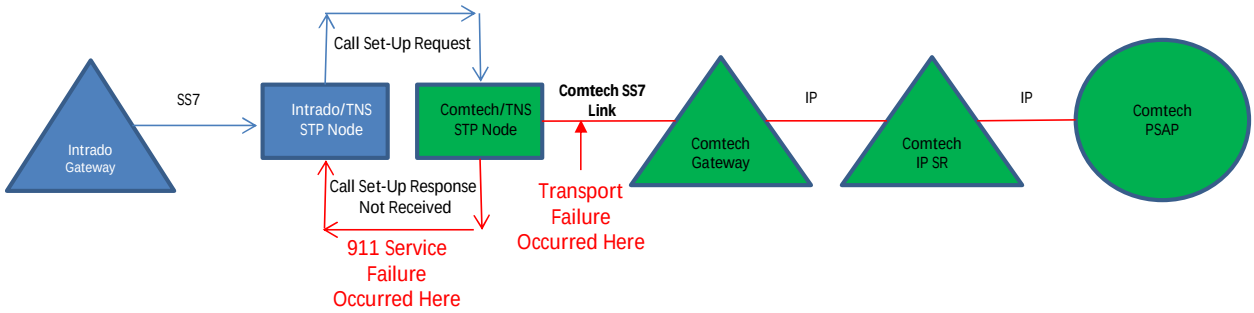
Q. WAS THERE MORE THAN ONE ORDERING PARTY FOR THE STP LINKS?

A. Yes. The figure above clarifies that TNS ordered two circuits for the SS7 links and Comtech was ordering the other two. It is difficult to ensure route diversity when multiple carriers are ordering the underlying SS7 links and are not communicating about the specifics of the circuits obtained. Therefore, it is best to have one party ordering all four STP links to minimize confusion and ensure diversity.

Q. WHY IS AN UNDERSTANDING OF HOW THE SIGNALING NETWORK FUNCTIONS CRITICAL IN UNDERSTANDING THE 911 FAILURE THAT OCCURRED IN DECEMBER 2018?

A. Understanding how signaling networks operate, the requirement for the exchange of messages to set up calls, and the importance of redundancy in the signaling links provides the background to appreciate the actual cause of the 911 network outage in December 2018. The figure below is an excerpt of Figure 4 above and identifies the root cause of the 911 service outage as the lack of diversity in the STP links.

Figure 7
Excerpt of 911 Call Flow



Q. COULD YOU EXPLAIN THE DIAGRAM IN MORE DETAIL?

A. Recall that the call flow in Figure 7 above depicts a 911 call that is destined to a transitioned Comtech PSAP. As discussed above, when the call comes to the Intrado/TNS STP node, its signaling network would send a "Call Set-Up Request" (IAM message) to the Comtech/TNS STP node, basically asking "How do I route this call?" Because the Comtech facilities connecting the Comtech/TNS STP Node(s) to the Comtech gateway were not provisioned using route diversity, the "Call Set-Up Response" (ACM message) – a message that had to be sent from the Comtech Gateway through the Comtech/TNS STP Node(s) for the call to complete – was never received. Because of Comtech network's failure, the 911 calls failed. The physical failure in the transport network was caused by Comtech's decision to route all of the STP links over one switching network, but the ***911 service*** failure occurred because the Comtech/TNS STP node did not respond to the Intrado/TNS node's request to set up the call. Comtech personnel clearly refer to the area labeled "Transport Failure Occurred Here" as

"Comtech's side of the network."[28] Had Comtech provisioned its signaling links using diverse routing, the ***911 service*** failure would never have happened.[29] In contrast to the transport network ordered by Comtech, the signaling links between CenturyLink/Intrado and Comtech worked perfectly.

Q. DID THE OUTAGE ON THE GREEN NETWORK CAUSE THE 911 CALLS TO FAIL?

A. No, it did not. I certainly am not ignoring that a failure occurred. But signaling networks are so vital that good engineering design requires that the signaling links be obtained from route-diverse networks. Again, signaling links fail. That is why the signaling network is supposed to be designed such that the connectivity between the STPs and switches is implemented using route diversity – if one link fails, the calls still complete. If standard network design had been followed, the CenturyLink Green Infinera network would have experienced its outage, but the Comtech 911 network in Washington would

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[28] See Exhibit SJH-12C, Comtech response to DR CTL-4 Attachment.

[29] In response to discovery, Public Counsel admits that it is aware of no failures in the call flow (as displayed in the diagram attached to Mr. Rosen's Direct Testimony as Exhibit BR-5 and also in Figure 7 above). See Exhibit SJH-2, Public Counsel responses to:

- CLC Data Request ("DR") 5 (CenturyLink did not fail to identify whether call destined for CLC or Comtech PSAP);
- CLC DR 6 (no errors or failures within the CenturyLink/Intrado selective router);
- CLC DR 7 (no errors or failures within the CenturyLink/Intrado STP);
- CLC DR 8 (no evidence of failure apart from the Comtech SS7 links); and
- CLC DR 9 (no errors or failures of CenturyLink CAMA trunks).

not have experienced an outage because the redundant signaling links on another physically diverse network would have provided the signaling messages needed to reply with the ACM. The communication between the Comtech RCL and the STPs would have taken place, the voice path for the 911 calls would have been established, and the 911 calls attempted during this network event would have completed.

Q. IS COMTECH'S STP LINK ENGINEERING ERROR EQUIVALENT TO THE FAILURE TO USE THE "B-SIDE" POWER CONNECTION AS YOU DESCRIBED AT THE BEGINNING OF THIS TESTIMONY?

A. It is. Comtech knew that it was supposed to provide redundancy in its signaling network. It knew that this capability existed to allow for redundancy even when one network for its signaling links was affected. However, Comtech simply did not utilize this capability, just as the network design in the power arrangement example did not use the "B-Side" power arrangement in parallel with the "A-Side" power arrangement. As such, when the network event occurred, Comtech lost the connectivity between its RCLs and its STPs. This was a completely unnecessary outage caused by poor engineering judgment on the part of Comtech.

Q. ARE THERE OTHER INDICATIONS THAT COMTECH WAS WELL AWARE OF THE PRECARIOUS SITUATION IT WAS PLACING 911 SERVICE IN BUT CHOSE NOT TO ALTER ITS NETWORK CONFIGURATION?

A. Yes. Email exchanges from August/September 2018,[30] several months before the outage,

[30] See Exhibit SJH-12C, Comtech response to DR CTL-4 Attachment.

are extremely insightful. On August 28, 2018 (4 months before the outage), TNS sent Comtech an email asking whether Comtech was still looking to modify its SS7 network. Comtech responded that it would like to transition two of the links for "redundancy advantages" but on August 31, Comtech personnel said they had to keep the existing circuits for a period of time or pay early termination charges.[31] Early termination charges come into play when a carrier (or customer) purchases a circuit for a fixed term. Normally, agreeing to a long term provides for discounts in the cost of the circuit. However, if the carrier (or customer) cancels the circuit early, it must pay early termination charges. Comtech was liable for such fees until March 22, 2021. In other words, it appears that Comtech had an opportunity to obtain true route diversity on its signaling links (replacing two TDM circuits with two IP connections) in September 2018, but elected to use its flawed network design in order to save money.

Then in September 2018 – over three months before the outage – Loree Parker, Senior Telecom Engineer for Comtech acknowledges that there was a problem with the signaling links between the TNS STPs (which Comtech was relying upon) and its RCL switches:

> The details of your last email aren't entirely accurate, as a few weeks ago Sprint disconnected the remaining TDM circuits terminating to Comtech facilities. Currently, all four existing circuits are from CenturyLink, at least on Comtech's side of the network. ***This is obviously not an ideal situation, and was intended to be extremely temporary***, [redacted].[32]

[31] See Exh. SJH-12C, Comtech Response to CTL-DR4 Attachment.

[32] See Exh. SJH-12C, Comtech response to DR CTL-4 Attachment. This document also validates the problem I highlighted above regarding having two separate vendors responsible for

This is tantamount to an admission that Comtech knew its signaling network lacked route diversity and decided to ignore the known problem so it could avoid the early termination expense. As noted above, Ms. Parker ultimately concluded that Comtech would "need to keep the new circuits in place until 3/22/21 to avoid early termination charges."[33]

Q. DO THE WITNESSES IN THIS PROCEEDING AGREE WITH YOUR EXPLANATION FOR THE 911 OUTAGE?

A. While there is not complete agreement, Staff witness James D. Webber agrees with the point made above that without the signaling call set-up, you cannot establish the voice call path between CenturyLink/Intrado and Comtech. Mr. Webber testifies as follows:

> **Q. If the SS7 component of an ESInet is disrupted by an outage, can voice calls still be completed?**
>
> A. No. Without a successful call setup, which the SS7 component must undertake, the originating voice calls cannot be routed anywhere and will fail to connect. The situation is roughly analogous to what can happen on a railroad when the system that notifies train engineers that the rails ahead are free for their use: when that system goes down, the trains cannot move anywhere (or else risk collisions), even though the tracks and the trains themselves may be in perfect working order.[34]

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ordering the signaling links. This document makes clear that until September 18, 2018, TNS was unaware that CenturyLink was the provider of all four signaling links. Because TNS was providing two of the existing STP links, Comtech should have been particularly careful in communicating with TNS and with its transport provider for the remaining two links to ensure that route diversity could be achieved. Clearly, Comtech did not take these necessary measures.

[33] See Exhibit SJH-12C, Comtech response to DR CTL-4 Attachment.

[34] Direct Testimony of James D. Webber (Dec. 15, 2021), Exhibit JDW-1CT ("Webber Direct Testimony"), p. 36 ll. 20-27.

The failure of the signaling network is what caused the voice calls (911 in this case) to stop being processed. But the network engineering error here was that Comtech did not implement the redundancy that is required for these types of systems.

Similarly, Public Counsel's witness, Mr. Brian Rosen admits that the network "failure occurred because all four links used the same optical network. In building 9-1-1 systems, I generally advise that supplier diversity be used to guard against the kind of failure that occurred here. In this case, there was no supplier diversity."[35]

VIII. APPLICATION OF AMENDMENT M TO THE WMD 911 CONTRACT

Q. HOW DOES AMENDMENT M AFFECT 911 SERVICE RESPONSIBILITY?

A. Amendment M to the contract between the Washington State Military Department and CenturyLink and its predecessors for provision of 911 services specifies the role of "Covered 911 Service Provider" during the transition of 911 service to Comtech. A "Covered 911 Service Provider" is defined, in pertinent part, in the Code of Federal Regulation (CFR) as follows:

> ***Covered 911 service provider:***
>
> (i) Any entity that:
>
> (A) Provides 911, E911, or NG911 capabilities such as call routing, automatic location information (ALI), automatic number identification (ANI), or the functional equivalent of those capabilities, directly to a

[35] Direct Testimony of Brian Rosen (Dec. 15, 2021), Exh. BR-1CT ("Rosen Direct Testimony"), at 20-21.

public safety answering point (PSAP), statewide default answering point, or appropriate local emergency authority as defined in § 9.3.[36]

In short, Amendment M makes clear that CLC is the "Covered 911 Service Provider" for the PSAPS that have not been migrated to Comtech. It also states that Comtech is the "Covered 911 Service Provider" for the PSAPs that have been migrated to Comtech:

> 11. AMENDMENT TERMS AND CONDITIONS:
>
> 1. The existing contract is modified to add the following language to the Transition Services:
>
> a) Covered 911 Service Provider during PSAP Migration. The Department is transitioning the ESINet services to a successor provider via a phased cutover of PSAPs from Contractor's ESlnet I to New Contractor's ESlnet II ("PSAP Migration"). Prior to this cutover, Contractor shall route calls over ESlnet I to the appropriate PSAPs and, as such, during this time, Contractor is a Covered 911 Service Provider as defined in 47 C.F.R. § 12.4(a)(i)(A) ("Covered 911 Service Provider") for all PSAPs in the State. Upon the Department's cut over of one or more PSAPs to ESlnet II ("Migrated PSAPs"), the Department's successor provider shall be a Covered 911 Service Provider for such Migrated PSAPs and shall be solely responsible for routing calls from the Demarcation Point between ESlnet I and ESlnet II to such Migrated PSAPs. During the PSAP Migration, Contractor remains responsible for routing calls to PSAPs that have not migrated to ESlnet II ("Unmigrated PSAPs"), and for routing calls intended for Migrated PSAPs to the Demarcation Point at ESlnet II, at which point the successor provider assumes responsibility for delivering such calls to Migrated PSAPs and is therefore the Covered 911 Service Provider.[37]

Q. WHAT IS A DEMARCATION POINT?

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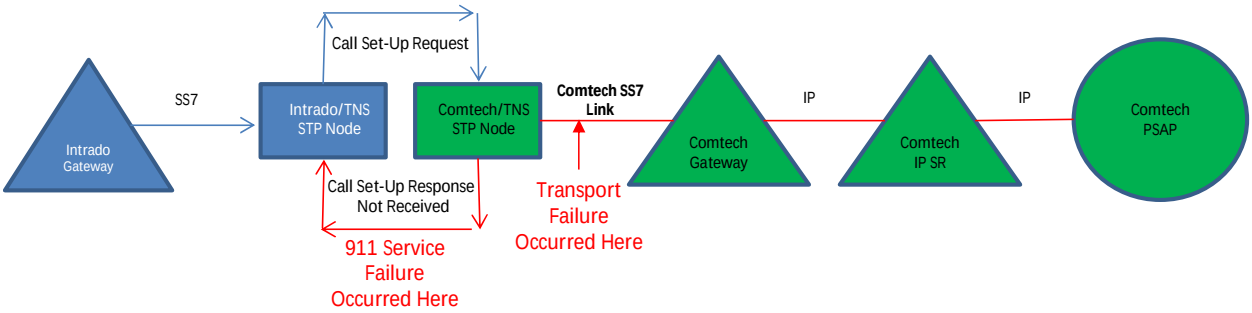
[36] 47 CFR §9.19 (a)(4)(i)(A).

[37] See Exhibit SJH-9C, E09-196 and E09-196M, Amendment M.

A. Amendment M above uses the term "demarcation." A demarcation point, or "demarc" in industry parlance, is a point where one party's responsibility ends and another's begins. We will again use the figure below to discuss demarcation.

Figure 8
Network Demarcation



As discussed above, during the outage, CenturyLink successfully sent a call set-up IAM request message. At that point, the ball is in Comtech's court to respond and set up the call. By Comtech's own admission, the demarcation for both the transport and the 911 service failure occurred on Comtech's "side of the network."[38]

Q. DO YOU AGREE WITH PUBLIC COUNSEL'S INTERPRETATION OF CLC'S RESPONSIBILITIES IN LIGHT OF AMENDMENT M?

A. No. In response to discovery, Public Counsel has said:

> **DATA REQUEST NO. 18.**
>
> In response to CTL-15(b)-(c), you interpreted the contract as holding CenturyLink responsible for providing certain 911 functionality in the

[38] See Exhibit SJH-12C, Comtech response to DR CTL-4 Attachment.

state of Washington. Identify each and every provision of the contract and/or contract amendments that you believe support your response to CTL-15(b)-(c).

RESPONSE:

As cited in Public Counsel's response to CenturyLink's Data Request 15(b) and (c), Public Counsel relied on the Washington State Military Department Contract E09-196 at page 14, requiring CenturyLink to provide "network, transport, PSAP interfaces, 911 trunk support, selective routing and ALI interfaces. The system must be scalable, affordable, reliable, redundant, and capable of resolving the limitations of the current legacy system." *Amendment M to the contract relieved CenturyLink from selective routing and ALI interfaces.*[39]

I disagree with the view of Public Counsel articulated above. I am not a lawyer, but my industry experience informs my response to this issue. Public Counsel appears to view the definition of "Covered 911 Service Provider" in an extremely narrow fashion.

The definition found in the CFR clearly does not provide an exhaustive list of capabilities provided by the Covered 911 Services Provider. Instead, it provides some examples "*such as* call routing, automatic location information (ALI), automatic number identification (ANI), or the functional equivalent of those capabilities."[40]

The FCC provides perspective on the broad role of the Covered 911 Service Provider as follows:

> Ensuring 911 Reliability. Covered 911 service providers, or providers that *aggregate 911 traffic from an originating service provider and deliver it to a 911 call center,* must annually certify to the FCC whether they have

[39] See Exh. SJH-2, Public Counsel response to CLC DR 18. Emphasis added.

[40] 47 CFR §9.19 (a)(4)(i)(A). Emphasis added.

> implemented specific measures within the last year with respect to 911 circuit diversity, central office backup power, and network monitoring.[41]

The italicized FCC language above indicates that a Covered 911 Service Provider includes carriers that "aggregate 911 traffic from an originating service provider and deliver it to a 911 call center." Based on my experience in the industry and guidance from the FCC above, a Covered 911 Service Provider is a comprehensive service provider responsible for carrying a call from an originating customer (a carrier in the case of Comtech) to the correct PSAP (911 call center). This requires far more than "selective routing and ALI interfaces," as Public Counsel stated in its response. Taken literally, Public Counsel's perspective would lead to the irrational conclusion that CLC would still be responsible for 911 service to the PSAPs migrated to Comtech until the transition was complete, even if the outage was in Comtech's network, which is what happened here.

The facilities Comtech (and its agent, TNS) leased from CLC were part of *Comtech's* network and by failing to order route diversity with no single point of failure, Comtech put its network and 911 service in Washington at risk. Comtech admits as much, saying the four links were on its "side of the network" in the September 2018 email exchange with TNS.[42]

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[41] Federal Communications Commission, 911 Reliability, https://www.fcc.gov/911-reliability, last access March 20, 2022. Emphasis (italics) added.

[42] See Exhibit SJH-12C, Comtech response to DR CTL-4 Attachment..

Q. DID YOU REVIEW ANY OTHER DOCUMENTS THAT PROVIDED INSIGHT INTO WHERE THE DEMARCATION POINT WAS BETWEEN CLC AND COMTECH?

A. Yes. Comtech developed a document entitled "State of Washington E-911 Transition Call Flows between CenturyLink/West-Intrado and Comtech TCS ESInets."[43] In this document there is a very clear identification of where the demarcation is between CenturyLink and Comtech: [redacted] Comtech was unable to respond to the IAM message (the equivalent of the INVITE message) because of the lack of diversity in its signaling network as discussed at length above. But this was on Comtech's side of the demarcation and not the responsibility of CTL.

IX. REBUTTAL TO THE DIRECT TESTIMONY OF BRIAN F. ROSEN

Q. WHICH POINTS MADE BY MR. ROSEN DO YOU WISH TO REBUT?

A. Mr. Rosen makes the following points in his Direct Testimony:[46]

- CenturyLink required the use of outdated technology to interconnect the two companies during the transition, which subjected the connection to the known failures of the older technology.

- CenturyLink also failed to ensure redundancy in its system design, which may have prevented the outage or mitigated its impacts.

I rebut each of these points in the subsections that follow.

A. SS7/STP TECHNOLOGY IS NOT OUTDATED AND DID NOT CAUSE THE OUTAGE

Q. DOES MR. ROSEN STATE WHY HE THINKS SS7 TECHNOLOGY IS OUTDATED?

A. Mr. Rosen does not specify why he says SS7 is outdated. He does say that the ALI functionality used newer IP technology and had no outage.[47] However, the ALI interconnection traversed a different service provider, NoaNet: not CLC or Intrado.[48] So, the fact that the ALI network did not fail is an indication of Comtech's use of network diversity at least for this area of its network, not due to the inherent superiority of IP over SS7 technology for this purpose.

Q. DOES MR. WEBBER AGREE WITH MR. ROSEN?

A. As a matter of fact, Mr. Webber disagrees with Mr. Rosen, saying:

> And as I discuss later in my testimony, SS7 is a very flexible technology that can perform many other functions, including transmitting the geographic address of a person dialing 911 to the PSAP receiving an emergency call, in order to speed the response time of the appropriate public safety agency.[49]

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[47] Rosen Direct Testimony, p. 31 ll. 13-14.

[48] Rosen Direct Testimony, Exhibit BR-29C, TeleCommunication System, Inc.'s Response to PC Data Request No. 9.

[49] Webber Direct Testimony, p. 35 ll. 3-6.

Q. DO YOU AGREE WITH MR. WEBBER?

A. As to this point, I agree with Mr. Webber. The use of SS7 technology in 911 switching networks is an industry standard. In fact, Comtech still uses SS7 in its 911 network today as indicated in Comtech's discovery response below.

> **CTL-5 Does Comtech utilize SS7 links anywhere within its 911 network in Washington? If your answer is anything other than yes, fully explain why [*sic*.] do not use SS7 in your network today.**
>
> **RESPONSE:** TSYS currently utilizes SS7 links in Washington to receive traffic delivered by certain TDM-based originating service providers ("OSPs").[50]

Q. IS THERE A NETWORK-BASED EXPLANATION FOR WHY COMTECH CONTINUES TO UTILIZE SS7?

A. In my review of the switches that continue to be in use in Washington, I found that many of these switches are older vintage switches that can only establish calls through SS7. These older switches do not have the ability to set upcalls using IP-based signaling. These same switches can also provide the connections to the PSAPs that are located in the communities where these same legacy switches exist. For Comtech (or CenturyLink for that matter) to interconnect with these switches, Comtech must continue to utilize SS7 because they would otherwise be unable to exchange voice traffic with these switches.

[50] See Exh. SJH-12C, Comtech Response to CTL DR CTL-5.

B. CENTURYLINK'S SIGNALING NETWORK WAS DIVERSE – COMTECH'S SIGNALING NETWORK WAS NOT

Q. DID CLC FAIL TO ENSURE REDUNDANCY IN ITS SIGNALING NETWORK DESIGN?

A. No, CLC utilized supplier diversity to achieve route diversity.

> However, it is CLC's understanding that [redacted] Because CenturyLink utilized both circuit diversity and carrier diversity, calls traversing ESInet1 were not affected by the Infinera network event.[51]

This is why CLC's calls to its 15 remaining PSAPs completed during the December 2018 network event. Even though one set of signaling links used the CLC Green network, the mated pair did not. In contrast, Comtech failed to ensure redundancy in its signaling network design, and as a result 911 calls to its designated PSAPs failed.

Q. DID COMTECH REALIZE ITS NETWORK WAS NOT DIVERSE AND WHAT DID THEY DO ABOUT IT?

A. Yes. Comtech has described its efforts to order diverse circuits: first, from CenturyLink and Sprint. Because Sprint decommissioned its TDM network, Comtech then turned to AT&T as an alternative. AT&T was not able to meet the provisioning deadline.[52] As explained in more detail above, Comtech was aware that the lack of redundancy was a problem, but turned down an offer from TNS for diverse circuits because it did not want

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[51] See Exhibit SET-4, CLC Response to Staff DR 27(c), November 11, 2021.

[52] See Exhibit SJH-12C, Comtech Response to CTL-1(a), February 10, 2022.

to pay early termination charges.[53] When Comtech ordered all four 911 circuits from CenturyLink, Comtech failed to identify the circuits as 911 SS7 circuits or to specify the need for route diversity in the ordering process.[54] As the ordering party, Comtech (or TNS acting on its behalf) is responsible for specifying the need for diversity in situations that are critical, as were the facilities providing the signaling network between TNS and Comtech. Comtech did not do so. Had they specified diverse routing, my understanding is that CenturyLink could have routed facilities on multiple CenturyLink transport networks.[55]

Q. MR ROSEN DISCUSSES THE DEMARCATION POINT DISCUSSED ABOVE. IS HE ACCURATE?

A. As described above, Figure 7 shows the signaling demarcation identifying where the 911 failure originated. Because of the transport failure that occurred on "Comtech's side of the network"[56] (caused by lack of route diversity in its signaling links), the signaling failed and voice calls could not complete. CLC properly sent its IAM message to set up the call. The Comtech RCL failed to respond to CLC's IAM with an ACM message to set up the call. Therefore, the signaling failure and consequent 911 service failure occurred on Comtech's side of the network. In contrast, Mr. Rosen cites: "Finally, WMD understood the demarcation point to be the Comtech RCL, beyond the location at

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[53] See Exhibit SJH-12C, Comtech response to DR CTL-4 Attachment.

[54] See Exhibit SET-5, CLC Response to Staff DR 9, June 25, 2021.

[55] Valence Response Testimony, p. 7.

[56] See Exhibit SJH-12C, Comtech response to DR CTL-4 Attachment.

which the outage affected the connection between CenturyLink and Comtech."[57]

Q. DOES THIS QUOTE DEFINITIVELY STATE THAT THE WMD THOUGHT THE DEMARCATION POINT WAS THE COMTECH RCL?

A. No, the Discovery Response that Rosen quotes does not definitively say the WMD had evidence proving that the demarcation point was at the Comtech RCL. The quote goes on to state:

> However, because it is our understanding that CenturyLink, either directly or through a reseller, was the actual underlying provider of all, or at least portions, of the interconnections, the demarcation point of the actual circuits is ***likely***, the Comtech RCL (LNG), as shown on the CenturyLink provided diagram, numbered CLC-001454.[58]

Further, WMD has agreed that there actually is no demarcation point identified in the contract stating that "no specific demarcation points were identified for the interconnecting trunks."[59] Finally, as I have shown, the demarcation of the signaling network was on Comtech's side of the interconnection and the 911 outage was caused by Comtech's failure to send a call set-up response. As noted above, Comtech seems to admit this. Comtech's email describes all four signaling links as being on its "side of the network."[60] This is common parlance for saying on Comtech's side of the demarcation point. The root cause of the outage was Comtech's failure to order route diversity for its STP signaling links.

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[57] Rosen Direct Testimony, p. 34 ll. 3-5.

[58] Exh. SET-6, WMD Response to DR PC-4, December 8, 2021 (emphasis added).

[59] See Exh. SJH-4, WMD Response to DR CTL-7(a), January 27, 2022.

[60] See Exhibit SJH-12C, Comtech response to DR CTL-4 Attachment.

X. REBUTTAL TO THE TESTIMONY OF JAMES D. WEBBER

Q. WHICH POINTS MADE BY MR. WEBBER DO YOU WISH TO REBUT?

A. Mr. Webber reaches the following conclusions:

- "… the primary and avoidable cause of the Washington E911 network outage in December 2018 was CenturyLink's failure to disable certain unused communications paths, known as [redacted] between the nodes on its [redacted]."[61]

- "I also conclude that the primary driver of the disruptions to Washington's E911 service during the outage was that four SS7 circuits, provided over CenturyLink's Green network, failed due to the packet storm."[62]

I disagree, as outlined below.

A. THE OUTAGE ON CENTURYLINK'S GREEN NETWORK WAS DRIVEN BY VERY DIFFERENT CIRCUMSTANCES THAN THE OUTAGE ON THE RED NETWORK

Q. WHAT WAS THE ROOT CAUSE OF THE OUTAGE ON THE RED NETWORK?

A. Both the Red and the Green networks used by CenturyLink utilize sophisticated techniques to move telecommunications data rapidly from origination switching nodes to termination switching nodes. The following figure shows, at a high level, the configuration of the line modules and the switching modules within an Infinera node.[63]

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[61] Webber Direct Testimony, p. 6, l. 20 – p. 7, l. 1.

[62] Webber Direct Testimony p. 8, ll. 5-7.

[63] Exhibit JDW-4, p. 6.

[redacted]

[redacted]

[redacted]

The system as shown in [redacted] above is designed so that, typically, data arrives at the node via the line module. The switching module decides the best path to send the data towards its destination and sends the data to an outgoing line module. In other words, the switching module decides the best route for the data flow. However, these networks have a management channel called the IGCC (Infinera General Communication Channel). [redacted]

[redacted]

[redacted]

64 Exh. SJH-13, ¶ 6.

In both the Red and the Green network outages, malformed packets propagated through the network using the IGCC, overloading the switches and causing an outage. As stated in the FCC Report:

> This proprietary management channel is designed to allow for very fast, automatic rerouting of traffic to avoid a loss of traffic during a failure in the network. It does this by enabling line modules to send packets directly to other connected nodes without receiving network management instructions about how to route traffic. To prevent management instructions from being sent to other nodes, the proprietary management channel has a filter that prevents packets that are 64 bytes or fewer from using the channel. As the supplier of these nodes, Infinera provides its customers – including CenturyLink in this case – with the proprietary management channel enabled by default. CenturyLink was aware of the channel but neither configured nor used it."[65]

I have reviewed the direct testimony of Martin Valence, who attaches an affidavit from Infinera employee Thomas McNealy. Both Mr. Valence's testimony and Mr. McNealy's affidavit describe what caused the outage on the Red network. According to Mr. McNealy:

[65] Exhibit JDW-4, p. 6.

[66] DTN is Infinera's brand name for one of its switching networks https://www.infinera.com/wp-content/uploads/Infinera-DTN-X-Family-0026-BR-RevA-0419.pdf, last accessed March 24, 2022. This is equivalent to "Infinera Node" in the figure above.

[redacted][67]

Q. DO YOU AGREE WITH MR. WEBBER'S CONCLUSION THAT THE OUTAGE ON THE RED NETWORK SHOULD HAVE INFORMED MEASURES TAKEN BY CLC ON THE GREEN NETWORK?[68]

A. No, I do not. As stated by Mr. McNealy in his affidavit above, Infinera believed that the outage on the Red network was caused by a software upgrade. For the first time, this software upgrade allowed 64-byte messages to pass through the IGCC. [redacted][69]

Mr. Webber disputes that the software upgrade was responsible for the Red network outage, citing a February 2018 Infinera Root Cause Analysis (RCA) document entitled "CenturyLink Red Network 16.1.2 – 16.3.3 Software Upgrade RCA" dated February 14, 2018. He cites the following page from the report as showing that the enabled Infinera

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67 See Exh. MDV-3, Affidavit of Thomas McNealy ("McNealy Affidavit"), ¶¶ 13-15.

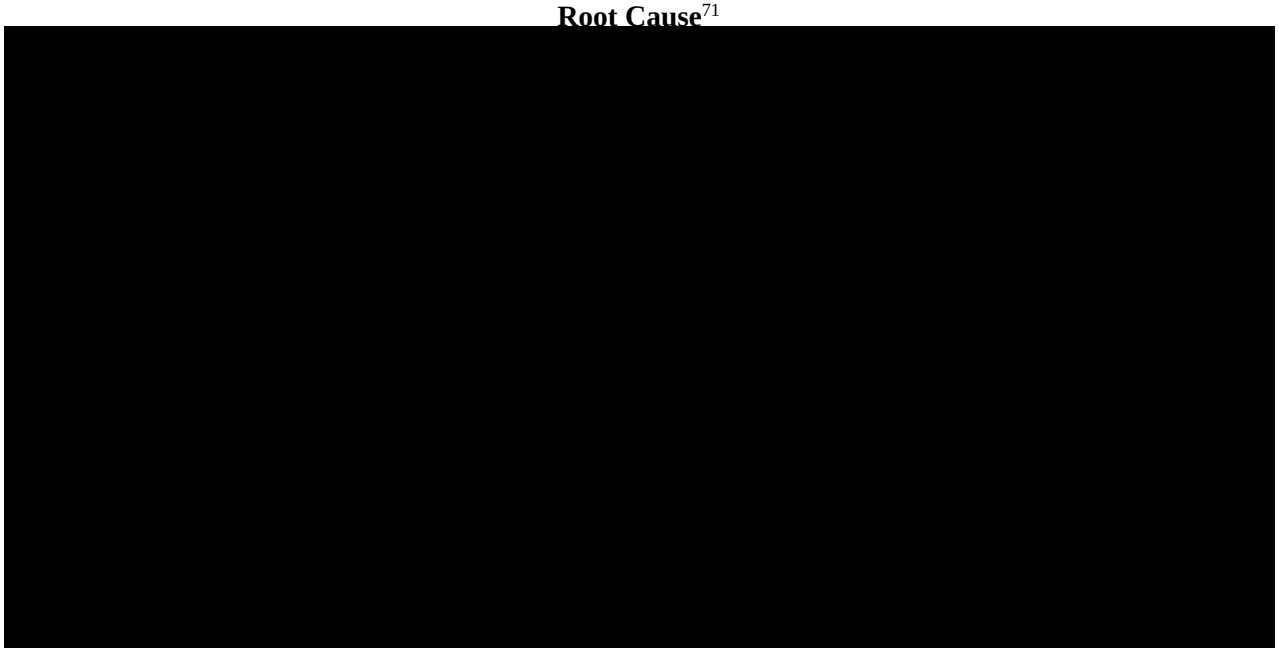
68 Webber Direct Testimony p. 30, l. 11 – p. 31, l. 2.

69 Exh. SET-4C, CenturyLink Responses to UTC Staff Data Request No. 27, November 11, 2021.

General Communications Channels (IGCC) were the root cause. I disagree.

Instead, the [redacted] clearly states that the software update was the root cause of the problem: "The upgrade to 16.3.3 automatically changed IGCC links between line modules across the network."[70]

Figure 10
Root Cause[71]



The American Society for Quality (ASQ) defines root cause as follows: "The root cause is the core issue – the highest-level cause – that sets in motion the entire cause-and-effect reaction that ultimately leads to the problem(s)."[72] Therefore, in looking at what set in motion the Red Network outage, the prime mover was the software upgrade.

In the same Exhibit JDW-6C, Mr. Webber includes the writeup of the Green network

[70] See Exh. MDV-3C, McNealy Affidavit, which discusses the specifics of the software outage.

[71] Exh. JDW-5C (C), p. 5 of 41.

[72] https://asq.org/quality-resources/root-cause-analysis, last accessed March 13, 2022.

failure, entitled "CenturyLink Event TAC Case 282753 PRELIMINARY Incident Summary 12/31/28." A portion of the Executive Summary provided therein follows.

Figure 11
Executive Summary[73]

This report clearly states that the "GREEN network on R15.3.3 was not planned for upgrade due to: …Trigger for RED event (i.e., malformed 64-byte muticast keepalive packets) are blocked from propagating over the IGCC links in this release -> we deemed this release safe."[74] Clearly, Infinera believed that the software release applied to the Red Network allowed the malformed packets to propagate.

[73] Exh. JDW-5C (C), p. 19 of 41.

[74] Exh. JDW-6C (C), p. 19.

B. IT IS REASONABLE FOR COMPANIES TO OPERATE EQUIPMENT ACCORDING TO FACTORY SETTINGS AND SUPPLIER GUIDANCE

Q. DID INFINERA SUGGEST DISABLING THE IGCCS ON THE GREEN NETWORK?

A. No. Infinera did not suggest disabling the IGCCs on the Green network. It was believed they were disabled by default. Mr. McNealy states:

[redacted]

Q. IS IT A NETWORK BEST PRACTICE TO DISABLE ALL UNUSED SERVICES?

A. Mr. Webber cites the general rule that it is often prudent to disable unused services on network elements. This, however, misses the point. The CLC Green network was set up with specific parameters. [redacted]

In my experience, when vendors of sophisticated equipment tell the carrier how to use the equipment, carriers typically follow the guidance of the equipment vendor.

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75 Exh. MDV-3C, McNealy Affidavit, ¶ 13.

76 Exh. MDV-3C, McNealy Affidavit, ¶ 19.

Q. WAS THIS PACKET STORM PREDICTIBLE OR FORSEEABLE?

A. Unlike the Red network outage, the Green network outage had no single cause. In fact, Mr. McNealy identifies three factors that created a "perfect storm" leading to the Green network outage.

[redacted]

In many respects, the software was designed as a fence to protect against packets of a certain size and under. It was not anticipated that it would be possible for a larger size packet to be spontaneously created and that it would also keep the same header structure. The header structure aspect of this issue is important in that the header structure made it appear to the Infinera software that the packets were normal when, in fact, they were not. This combination of events was unforeseeable and led to the outage.

[redacted] These unusual factors worked together in the same time frame to allow the malformed packets to enter the IGCC. If the malformed packets had been 64

[77] Exh. MDV-3C, McNealy Affidavit, ¶¶ 18-21.

bytes or less, they would have been blocked from entering the IGCC. If the malformed packets had not had header information that looked valid, they would have been blocked from entering the IGCC. Instead, these factors worked together to create the unforeseeable "perfect packet storm."

C. THE ROOT CAUSE OF THE 911 SERVICE OUTAGE WAS THE LACK OF DIVERSITY IN FOUR SS7 CIRCUITS – COMTECH WAS AT FAULT

Q. WHAT WAS THE ROOT CAUSE OF THE DECEMBER 2018 911 SERVICE OUTAGE IN WASHINGTON?

A. Mr. Webber's focus on the IGCC issue is misplaced. Regardless of the cause of the CenturyLink Infinera Green network switch outage, the cause of the *911 Service Outage* was Comtech's failure to seek and obtain a diverse route (including switching and transport diversity) for its SS7 signaling network. Route diversity is a key component of most network designs, particularly with regard to signaling networks and 911 networks. Comtech failed to live up to industry standards by ordering four STP links that had a single point of failure: the Infinera equipment in the Green network. Outages unfortunately do happen, and best practice is to design a network such that a failure in one area of the network does not cause a complete outage.

I understand that Comtech did attempt to order diverse routing by ordering from different suppliers (also known as "supplier diversity").[78] It could no longer use Sprint facilities and AT&T could not meet Comtech's deadline.[79] However, Comtech could have easily

[78] As I described above, "supplier diversity" does not guarantee "route diversity." If one of the suppliers wholesales facilities from another supplier, the route using those resold facilities may not be diverse.

[79] See Exh. SJH-12C, Comtech Response to CTL-1(a), February 10, 2022.

ordered diverse routing on one of the other CenturyLink networks.[80] As I understand it, this is precisely how CenturyLink created route diversity on its signaling network dividing the signaling links between the Qwest and Green networks which are only two of many separate fiber optic networks available to CenturyLink.

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. After reviewing the information in this proceeding, and based on my many years of experience working in the telecommunications space, I have reached the following conclusions and opinions with respect to the final assignment above:

- SS7 technology is commonly used by the industry in 911 network architecture, and the use of SS7 to support the 911 network connecting CenturyLink and Comtech PSAPs was not the cause of the outage.

- According to industry standards, the 911 service provider is responsible for the efficacy and stability of the network (both voice and signaling networks), including route diversity. As the 911 service provider, Comtech should have specified its requirements for network diversity when ordering transport facilities from CenturyLink for use for its SS7 signaling links. Importantly, the use of diversity for SS7 links is fundamental to SS7 network design. All four links ordered by Comtech and connecting the 911 networks between Comtech and CenturyLink used the same Green Infinera switching network that experienced an outage. This is a serious mistake created by Comtech, which directly caused 911 calls destined to PSAPs that had transitioned to Comtech to fail.

- Comtech knew before the service outage that it did not have sufficient diversity in its signaling link transport facilities between its switch and its STP

[80] Mr. Webber refers to a trouble ticket dated September 6, 2018 that he says shows that CenturyLink knew TNS was the customer of DS1 23394948, which is one of the four transport network elements that CenturyLink provided for Comtech. While that may be accurate, that is after the fact; the circuits were already installed. Further, to expect a technician in a maintenance center to scrutinize each trouble ticket and ask a question such as: "I wonder if that circuit used by TNS is diverse from other circuits in the interconnection?" is not credible or reasonable, from an operations perspective. See JDW-22C (C), Attachment B.

vendor – TNS. Comtech had the opportunity to add network diversity months prior to the outage, but declined to do so on the basis of cost. A failure to ensure that this diversity existed was a clear violation of good network engineering practice on Comtech's part. Comtech described its lack of diversity as "not an ideal situation" and appears to have elected to wait to obtain diversity to avoid termination liability assessments on the non-diverse circuits it had ordered. Comtech admits it did not notify WMD or CenturyLink about the lack of diversity prior to the outage.

- The outage on the Red network had a single root cause: a software upgrade that allowed malformed packets to enter the IGCC. The Green network was using an earlier version of the software; the Red network outage was not related to the Green network outage.

- The Green network outage had different, multiple root causes. Malformed packets, with valid headers and of a size that evaded the filters in place to keep the packets from entering the IGCC, caused the outage. According to Infinera and in my own assessment, this event was unforeseeable; in fact, the cause of the outage was never determined.

- CenturyLink left the IGCC open in its Green network based on Infinera's guidance. In my opinion, it is customary and appropriate to rely upon the statements of an equipment vendor about how to deploy its infrastructure into the network. Regardless, Comtech's failure to ensure diversity in the transport layer of the signaling network between its switch and its own STP provider (TNS) (not the Infinera outage itself) served as the root cause of the Washington 911 outage in December 2018.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. It does.