Exh. JDW-33CT
Docket UT-181051
Witness: James D. Webber
REDACTED

BEFORE THE WASHINGTON
UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, **Complainant,** **v.** **CENTURYLINK COMMUNICATIONS, LLC,** **Respondent.**	**DOCKET UT-181051**

CROSS-ANSWERING TESTIMONY OF

JAMES D. WEBBER

ON BEHALF OF

STAFF OF THE WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

August 31, 2022

CONFIDENTIAL PER PROTECTIVE ORDER IN DOCKET UT-181051

REDACTED

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I. INTRODUCTION

Q. Please state your name and business address.

A. My name is James D. Webber. My business address is 4240 Colton Circle, Naperville, Illinois 60564.

Q. Have you previously offered testimony in this proceeding?

A. Yes. I offered prefiled direct testimony on behalf of Commission staff (Staff) on December 15, 2021.[1]

Q. What is the purpose of the cross-answering testimony that you are submitting today?

A. My cross-answering testimony generally responds to the March 31, 2022, response testimony filed by witnesses on behalf of CenturyLink Communications, LLC (CenturyLink or Company), who attempt to rebut certain findings, conclusions, and recommendations made in my initial direct testimony.

Q. Is Staff providing additional testimony?

A. Yes. It is my understanding that Staff witness Jacque Hawkins-Jones is providing cross-answering testimony on topics she addressed in her December 15, 2021 direct testimony.[2] Additionally, Dr. Robert Akl, a nationally recognized electrical and

[1] Webber, Exh. JDW-1CT.
[2] Hawkins-Jones, Exh. JHJ-17CT.

computer engineer, expert, and authority on computer sciences with more than 28 years of practical and teaching experience, is also offering cross-answering testimony on behalf of Staff.[3] Dr. Akl's testimony includes his expert evaluation of the causes of the Green and Red network outages in 2018, the relationship between those two events, the foreseeability of the Green network outage after the Red network outage occurred, and CenturyLink's responsibility for the E911 outage.

II. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Q. Are you aware of any changes or corrections that need to be made to your direct testimony filed on December 15, 2021?

A. No, I am not. I continue to fully support the conclusions and recommendations set forth in my direct testimony. I reviewed voluminous materials in this case, including relevant testimony, exhibits, and responses to discovery to date from other parties in this case that bear on the issues I address in my direct testimony and this cross-answering testimony. None of the evidence that my team and I reviewed causes me to alter the conclusions or recommendations in my direct testimony. While I will not restate the entirety of my direct testimony here, I list my key conclusions and recommendations below for the Commission's ease of reference:

- Based on the investigation that I directed and participated in, I conclude that 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 Infinera General Communications Channels (IGCCs), between the nodes on its Green long-haul transport network. Those

[3] Akl, Exh. RA-1CT.

- "unlocked" (i.e., enabled) IGCCs were the primary reason that just four malformed packets propagated and escalated into a debilitating packet storm that ultimately crippled the Green network across dozens of states for over two days, causing the outages experienced on Washington's E911 system.[4] Dr. Akl examined this issue as well and agrees with my conclusions.[5]

- I also concluded that CenturyLink suffered a very highly similar packet storm disruption to another one of its Infinera-equipped long-haul transport networks, the "Red" network, ten months before the December 2018 outage on the Green network. In both situations, the unlocked status of the IGCCs was the primary cause of the transport networks' outages, because if those channels had been locked down (i.e., disabled), neither packet storm could have occurred and there would have been no outage. [redacted]. However, CenturyLink failed to take the same preventative course of action on its Green network prior to its December 2018 catastrophic failure. The December 2018 Green network outage was, therefore, both foreseeable and at the same time readily preventable with minimal effort. As is the case with the Green network outage, I understand Dr. Akl examined the circumstances surrounding the Red network outage as well and agrees with the conclusions articulated in my direct testimony.[6]

- CenturyLink is ultimately responsible for managing its networks in a prudent manner, and by failing to lock down the unused IGCCs on its Green network, I believe it bears direct and causal responsibility for the Green network's packet storm and outage, and therefore the ensuing E911 system failures across Washington.[7] I understand Dr. Akl examined this issue as well and that he concurs with my opinion.[8]

- Based upon the data available to date, I estimate that the December 2018 outage caused approximately [redacted] calls made to the Washington E911 system to fail, constituting nearly [redacted] of the total E911 call volume over that period.[9] Public Counsel Witness Brian Rosen presented a different number of failed calls, but states that his number is a minimum. Given that Witness Rosen's number is a minimum estimate, I would recommend that the Commission rely on my call count, which is based directly upon call detail records (CDRs) for the 911 calls occurring during the outage.

[4] Webber, Exh. JDW-1CT at 6:19 – 7:5.
[5] Akl, Exh. RA-1CT at 5:1 – 6:11.
[6] *Id*. at 9:1 – 9:16.
[7] Webber, Exh. JDW-1CT at 7:21 – 8:4.
[8] Akl, Exh. RA-1CT at 4:12-20; *id*. at 9:18 – 10:21.
[9] Webber, Exh. JDW-1CT at 8:13-15.

Q. Did you review the testimony provided by CenturyLink's witnesses?

A. Yes. I reviewed the March 31, 2022, response testimony sponsored by CenturyLink's witnesses, namely:

- Stacy J. Hartman;
- Valerie Lobdell;
- Carl D. Klein;
- Stephen E. Turner; and
- Martin D. Valence.

I also reviewed the response testimony of Thomas J. McNealy that CenturyLink filed on July 27, 2022.[10]

Based on my review of these documents, it appears CenturyLink is attempting to advance two primary arguments that I respond to. First, the Company's witnesses attempt to advance a theory suggesting that Telecommunication Systems, Inc. (TSYS) is entirely to blame for the failure of nearly 14,000 emergency calls from Washington citizens to Washington 911 PSAPs in December of 2018. They claim that ESInet II's interconnection used for signaling with CenturyLink and its 911 vendor, West/Intrado, failed because TSYS did not have carrier diversity in place for those circuits at the time in December 2018 when CenturyLink's Green Network suffered a disabling packet storm which disrupted those circuits.

[10] *See also* Valence, Exh. MDV-3C.

And second, the Company seeks to deflect blame for its Green network failure in December of 2018, with its witnesses claiming that it was somehow neither foreseeable nor avoidable−despite the fact that CenturyLink experienced a highly similar packet storm even on its Red network just six months before, and despite the fact that there was a simple, known, complete, and cost-free fix: disabling entirely unused IGCCs paths between the nodes on its Green network.

Throughout the remainder of my cross-answering testimony, I respond in detail to the Company's response testimony offered in support of these arguments. The findings, opinions, and conclusions I offer herein are based on the relevant evidence I reviewed as of the filing date of this testimony, including new discovery responses from CenturyLink, TSYS, and other parties. However, I reserve the right to update my findings, conclusions, and recommendations at the hearing, if between then and now I review additional information or learn anything which causes me to update my findings, opinions, or conclusions.

My overall recommendation is that the Commission adopt the findings, opinions, and conclusions made by Staff, Dr. Akl, and myself on the issues in this case, and reject the Company's positions to the extent they conflict with those findings, opinions, and conclusions.

III. THE COMMISSION SHOULD IGNORE THE COMPANIES' ARGUMENTS THAT IT BEARS NO FAULT BECAUSE THE TSYS ESINET II NETWORK WAS IMPROPERLY DESIGNED

Q. Where does Witness Turner place the blame for the December 2018 outage in the Washington E911 network?

A. Witness Turner claims that TSYS is entirely responsible for the December 2018 outage in the Washington E911 network. For example, he states:

> 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.[11]

Q. Do you agree with Witness Turner's analysis and conclusion on this issue?

A. No, I do not. Witness Turner's analysis is faulty in making each of the following claims:

1. TSYS had committed a design flaw for its ESInet II that led to lack of redundancy in its signaling network;[12]
2. TSYS had not implemented an adequate level of diversity in its signaling circuits;[13] and
3. TSYS had violated industry standards for signaling network design by not having carrier diversity for those signaling circuits in place at the time of the December 2018 outage.[14]

In fact, none of these assertions are accurate.

[11] Turner, Exh. SET-1TC at 59:21-24.
[12] Turner, Exh. SET-1TC at 36:9-12 ("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").
[13] Turner, Exh. SET-1TC at 59:21-24.
[14] Turner, Exh. SET-1TC at 27:9 – 29:9.

Q. Please explain how these claims of Witness Turner are contrary to the facts as revealed through discovery in this case.

A. To start with, Witness Turner does not dispute the facts that I presented in my direct testimony concerning the specific signaling circuits for the TSYS ESInet II network that were in place during December 2018 and that were impaired during the Green network outage. My testimony therein cites to the relevant discovery responses supplied by TSYS and CenturyLink as the basis for my understanding of those facts.[15] They include the following statement from TSYS:

[redacted][16]

These [redacted] specific circuits had the intent and effect of creating geographic redundancy and diversity in the signaling paths of the TSYS ESInet II system, by connecting [redacted] The redundancy and diversity of these [redacted] circuits is illustrated schematically in the TSYS diagram supplied in Figure 5 of my direct testimony, which also provides details of the circuits' ID numbers and their originating and terminating locations ("[redacted]" and "[redacted]," respectively).

Q. Did TSYS' use of these [redacted] different circuits establish geographic and physical route diversity for this connectivity?

[15] Webber, Exh. JDW-1CT at 38:1 – 41:11. *See also* Webber, Exh. JDW-1CT at 40:1, Table 5.
[16] Webber, Exh. JDW-22C at 2.

A. Yes, my understanding is that it did, and therefore TSYS had a reasonable expectation that its circuits were redundant and diversely routed for this aspect of its E911 system. It does not appear that the circuits shared a single physical point of failure, which is the key criterion cited by the Federal Communications Commission (FCC) for route diversity for public safety purposes—which both Witness Turner and I rely upon.[17] As part of its lengthy explanation of this concept, the FCC states that:

> Route diversity is generally defined as the communications routing between two points over more than one geographic or physical path with no common points.
> …
> 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. On what basis do you conclude that the [redacted] circuits at issue did not share a single physical point of failure and therefore must have had physical route diversity?

A. I reach that conclusion based on TSYS' explanation that during the Green network outage, [redacted], which would have had to occur if they did share a single physical point of failure. Instead, TSYS states, in part:

> At the onset of the outage, [redacted]

[17] Federal Communications Commission, "Communications Route Diversity for Public Safety," *available at* https://www fcc.gov/general/communications-route-diversity-public-safety. *See also* Turner, Exh. SET-1TC at 25:12 – 26:19 n.18.
[18] Federal Communications Commission, "Communications Route Diversity for Public Safety," *available at* https://www fcc.gov/general/communications-route-diversity-public-safety.

[redacted][19]

Q. Has Witness Turner supplied any evidence to establish that the [redacted] circuits at issue did not have diverse physical routing, as he contends?

A. No. Witness Turner fails to supply any documents or other evidence to show that the [redacted] circuits carrying signals related to the 911 calls at issue in this case were not physically diverse and, therefore, had a single physical point of failure. I also note that TSYS did not want to use SS7 signaling via TNS in the first place. Rather, evidence I reviewed demonstrates [redacted].[20] Had CenturyLink agreed to implement the initial proposal, as requested by TSYS, it is highly unlikely that 911 services in Washington would have been impacted by the December 2018 outage on CenturyLink's Green network.

Q. Does your analysis of CenturyLink's E911 calls data during the December 2018 outage also corroborate this point?

A. Yes, it does. Table 2 in my direct testimony provides the results from my analysis of failed versus completed E911 call counts for calls destined to TSYS-served PSAPs during the December 2018 outage.[21] Calls to those PSAPs could only be completed

[19] Webber, Exh. JDW-19C at 2.
[20] Webber, Exh. JDW-18C at 8; Webber, Exh. JDW-20C; Webber, Exh. JDW-41C at 1-3; Webber, Exh. JDW-43 at 1-2. *See also* Rosen, Exh. BR-17 at 1.
[21] Webber, Exh. JDW-1CT at 53:1.

if at least one of the [redacted] signaling circuits remained operational when the call was initiated and in progress. Table 2 shows that the percentage of calls that failed to get through to the TSYS-served PSAPs [redacted] respectively (i.e., 100% minus their failed call percentages). If all [redacted] of those circuits shared common physical facilities or non-redundant route segments that were vulnerable to a single point of failure (e.g., a cable cut on a shared cable or two parallel fiber cables along the same route segment without healing properties), then it is likely none of the [redacted] circuits could have delivered the signaling information necessary to complete calls in those hour bands (i.e., all [redacted] circuits would have continued to fail simultaneously until the overall outage was resolved).

Q. Has Witness Turner rebutted that portion of your call count analysis?

A. No. Neither Witness Turner nor any of CenturyLink's other witnesses address the analysis presented in my Table 2 in any way.

Q. Does Witness Turner distort the ordinary use of the industry term "single point of failure"?

A. Yes. Witness Turner misconstrues the prevailing FCC and industry standards by broadening them far beyond the commonly used industry meaning. He does this in his assertion that:

> 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**.[22]

Neither of the FCC definitions ("route diversity"[23] and "physically diverse"[24]) that he cites in support of that conclusion (defining "route diversity" and "physically diverse," respectively) make any reference to software as a potential "single point of failure." Similarly, the Communications Security, Reliability, and Interoperability Council (CSRIC) recommendation that Witness Turner cites concerning SS7 link diversity only references "physical validation of equipment" and says nothing about software.[25] My understanding of the term "single point of failure" is that it refers to physical facilities only, not software. Witness Turner appears to distort the prevailing industry standard here by adding "software" as another consideration for "single point of failure," but offers no support for that.[26]

Moreover, while Witness Turner purports to add a definition and requirement that different software be utilized to achieve route diversity, he provides no documentation of any Order or Rule of the FCC or this Commission containing any such requirement, nor how it would be implemented in practice or which of the myriad systems within a telecommunications network or networks would require

[22] Turner, Exh. SET-1TC at 25:7-11 (emphasis added).
[23] Federal Communications Commission, "Communications Route Diversity for Public Safety," *available at* https://www fcc.gov/general/communications-route-diversity-public-safety.
[24] 47 CFR § 9.19 (a)(8).
[25] Turner, Exh. SET-1TC at 27:1-8.
[26] This statement is not meant to suggest that software, programming, application, and database tables should not be backed-up, stored in physically separate equipment or separated geographically (in terms of redundancy and back-ups). In fact, it has been my practice to ensure redundancy and geographic separation in terms of access to both customer software applications and their back-up processes.

different software. Furthermore, he does not identify any industry recommendations describing how software diversity should have been achieved prior to the December 2018 outage, nor does he offer any explanatory language from the relevant authorities, such as the FCC, demonstrating software diversity applied in the circumstance addressed in this proceeding. Finally, as Dr. Akl discusses in his cross-answering testimony, and as I note in my testimony below, software wasn't the issue that caused the outage, it was human error on CenturyLink's part.

Q. Why do you think Witness Turner resorts to distorting the term "single point of failure" in this way?

A. It is clear to me that Witness Turner resorts to this distortion because the Green network failure was not caused by a "single point of failure" in the accepted industry sense, meaning a failure in a single physical facility−for example, a cable cut, which is one of the more frequent causes of network outages. Instead, as I have explained in my direct testimony and as Dr. Akl has concurred,[27] the primary and avoidable cause of the Green network's December 2018 outage was CenturyLink's failure to disable that network's unused IGCCs. That simple and readily actionable preventative measure needed to be conducted for all IGCCs (connecting line modules) in the network, not just for one.

While Witness Turner seeks to characterize the Green network outage as the result of a software problem, at the end of the day it was a human problem, driven by human error and negligence: CenturyLink's network managers failed to act to lock

[27] Akl, Exh. RA-1CT at 5:1 – 6:11; *id*. at 9:1-16.

down each of the IGCCs on that network, even ten months after the February 2018 Red network outage revealed to them the vulnerability of Infinera-equipped [redacted] networks like the Red and Green networks to packet storms propagated through those unlocked IGCCs. It was an entirely foreseeable problem with a simple, known, and straightforward solution that CenturyLink failed to take, thereby causing the E911 outage in December 2018.

Because of CenturyLink's failure to take that action, the resulting packet storm impacted the Green network on a network-wide basis, not just at one physical facility (or even a few facilities).

TSYS described the network-wide character of the Green network outage in these terms:

> [redacted]
>
> CenturyLink/Infinera created a "packet storm," equivalent to a Denial of Service ("DOS") attack against itself, that [a]ffected most or all of the nodes in the "Green" network, and for a several hours within the 37-hour window of the CenturyLink impairment, affected all "Green" network nodes utilized by the TSYS and TNS TDM circuits.[28]

Q. Did TSYS violate the prevailing industry standards for redundancy and route diversity by not having carrier diversity for those SS7 links at the time of the December 2018 outage?

[28] Webber, Exh. JDW-35C at 3.

A. No. First, as I discussed above, [redacted].[30]

Moreover, both Witness Turner and Witness Valence[31] are mistaken in implying that carrier (also known as "supplier") diversity is an industry requirement for SS7 link diversity in the design of E911 networks, and neither of them point to a Commission Order, Rule, or industry standards document that binds TSYS to such a standard.[32] My understanding is that neither the FCC nor CSRIC, for example, had an established standard in December 2018 that required a E911 service provider like TSYS to design, build, and fully maintain carrier diversity into the SS7 links for their network. Moreover, my review of the NENA standards and related documents turned up nothing that approaches such a standard. Finally, as Witness Turner admits,

[29] Webber, Exh. JDW-18C at 8; Webber, Exh. JDW-20C; Webber, Exh. JDW-41C at 1-3; Webber, Exh. JDW-43 at 1-2. *See also* Rosen, Exh. BR-17 at 1.
[30] Webber, Exh. JDW-34C at 3; Webber, Exh. JDW-35C at 2-3.
[31] Turner, Exh. SET-1TC at 27:11 – 29:9; Valence, Exh. MDV-1TC at 20:10-14.
[32] Webber, Exh. JDW-39.

carrier diversity does not guarantee that facilities are deployed in such a manner as to avoid no single point of failure given that carriers often purchase and resell capacity from one another.[33]

Both Witness Turner and I recognize that TSYS previously designed carrier diversity into that portion of its signaling network and maintained it [redacted].[34] Moreover, neither of us dispute that TSYS [redacted]

IV. THE PRIMARY AND AVOIDABLE CAUSE OF THE WASHINGTON E911 NETWORK OUTAGE IN DECEMBER 2018 WAS CENTURYLINK'S FAILURE TO DISABLE THE IGCCs ON ITS GREEN NETWORK

Q. Let's turn to CenturyLink's response to your analysis of the causes of the December 2018 failure of CenturyLink's Green transport network and their relationship to the Red network failure ten months before. Who of CenturyLink's five witnesses responded to your testimony on that issue?

A. Three of CenturyLink's witnesses, Martin Valence, Stephen Turner, and Thomas McNealy responded to my testimony concerning the causes of the Green network's

[33] Turner, Exh. SET-1TC at 25, n.17.
[34] Webber, Exh. JDW-41C.
[35] [redacted]. *See* Webber, Exh. JDW-34C at 2-3.

December 2018 outage and its relationship to the "Red" network outage in February 2018.[36] In addition, CenturyLink's lead witness, Stacy Hartmann, referenced my testimony on this issue, but she does not provide any independent analysis of it and instead simply parrots the assertions on this topic made by Witnesses Valence and Turner.[37]

Finally, Witness Valence initially relied on statements made by Witness McNealy, an employee of CenturyLink's equipment vendor Infinera. Witness McNealy states that he is currently a Senior Director at Infinera Corporation, and my understanding is that, at the time of the outages at issue in this case, Witness McNealy worked for Infinera.[38] Infinera was the primary equipment vendor for the CenturyLink Red and Green optical transport networks. Witness McNealy does not describe his involvement in Infinera's response to the Red and Green network outages in 2018. In addition, Witness McNealy does not [redacted]. Later in my testimony I address Witness McNealy's statements and demonstrate how his testimony supplies a distorted and unsupported view of the relationship between the two outages, all the while seeking to minimize CenturyLink's clear responsibility for the Green network outage.

[36] Valence, Exh. MDV-1TC at 10:10 – 20:4; Turner, Exh. SET-1TC at 49:1 – 57:4; McNealy, Exh. TJM-1TC at 2:14 – 10:12.
[37] Hartman, SJH-1TC at 39:11 – 40:5.
[38] McNealy, Exh. TJM-1TC at 1:3-10.

Q. Has any of CenturyLink's response testimony changed your findings and recommendations on this issue from what you presented in your direct testimony?

A. No. I reviewed all of these witnesses' testimony and conclude that none of their rebuttal assertions on this issue warrant a change in my opinions, conclusions, or recommendations. As I explain in detail below, not only do CenturyLink's witnesses make baseless assertions on this issue that are contrary to the facts, they frequently do so in ways that contradict each other. Moreover, I found that where they agree, they skirt the central facts of the case by focusing on tangential matters of distinctly secondary importance. In my opinion, the overall effect of their testimony is to create a disjointed and skewed presentation of the causes of the December 2018 outage and the degree to which it was foreseeable and avoidable.

Q. Can you provide an example of how Witness Valence's testimony conflicts with that of Witness Turner and Witness McNealy?

A. Yes. Witness McNealy admits that the [redacted][39] Yet in his very first mention of Witness McNealy, Witness Valence makes a contradictory assertion. Witness Valence states:

> Staff witness Mr. Webber states that a packet storm experienced on the Red Infinera network in February 2018 should have led

[39] McNealy, Exh. TJM-1TC at 9:14-20. While Witness McNealy does not cite to any documents, I note that he uses the same language as the 12/31/18 Preliminary Incident Summary for the Green network outage. *Compare*, McNealy, Exh. TJM-1TC at 9:16-17 [redacted] *with*, Webber, Exh. JDW-5C at 24 [redacted].

> CenturyLink to close a management channel on its entirely separate Green Infinera network. On this point, Infinera's technical lead, Thomas McNealy, and I agree. There are no meaningful similarities between the outage on the Red Network and the outage on the Green network.[40]

Q. Which assertion is correct?

A. Witness McNealy is correct [redacted], and a "packet storm" occurred on both networks. My direct testimony explains this in detail[41] based upon multiple credible sources in the record of this case, including the FCC's report from its investigation of the Green network outage and incident analyses released by CenturyLink and Infinera ([redacted]) immediately after the Green network outages.[42]

Conversely, Witness Valence's statement that "there are no meaningful similarities" between the two network outages is both false and contradicts Witness McNealy's testimony.

Q. Has Witness Hartman echoed Witness Valence's false assertion that the two network's outages had "no meaningful similarities"?

A. Yes. In fact, Witness Hartman exaggerates Witness Valence's spurious claim even further, by declaring:

[40] Valence, Exh. MDV-1TC at 3:14-18.
[41] Webber, Exh. JDW-1CT at 22:1 – 26:14.
[42] Infinera was the supplier of the optical switching and networking equipment for both the Green and Red transport networks operated by CenturyLink.

As Mr. Turner and Mr. Valence discuss, the "Red" and "Green" events were completely unrelated and factually distinct.[43]

To summarize, CenturyLink's witnesses make the following chain of assertions, as witnesses restate what other witnesses stated previously:

1. Witness McNealy: [redacted]"[44]
2. Witness Valence: "There are no meaningful similarities between the outage on the Red Network and the outage on the Green network."[45]
3. Witness Hartman: "As Mr. Turner and Mr. Valence discuss, the 'Red' and 'Green' events were completely unrelated and factually distinct."[46]

Q. What do you make of these assertions?

A. To my mind, the progressive distortions as CenturyLink's alleged "facts" are handed off from Witness McNealy to Witness Valence to Witness Hartman are reminiscent of a game of "telephone," where a phrase is passed down from one person to another in series, and what comes out is starkly different than the starting point. CenturyLink is solely responsible for its decision to organize and present its testimony in this serial manner, and to me it certainly has the potential to confuse the record and obfuscate the essential facts of these two network outages. The Commission should disregard the testimony supplied by Witness Valence and Witness Hartman on this point, due to how incompatible they are with the plain, known facts of the Red and Green network outages.

[43] Hartman, Exh. SJH-1TC at 40:3-5.
[44] McNealy, Exh. TJM-1TC at 9:14-20.
[45] Valence, Exh. MDV-1TC at 3:17-18.
[46] Hartman, Exh. SJH-1TC at 40:3-5.

Q. Witness Hartman also cites to Witness Turner's testimony as support for her assertion above. Is her statement that "the 'Red' and 'Green' events were completely unrelated and factually distinct" consistent with Witness Turner's testimony?

A. No. In fact, this bare assertion by Witness Hartman is belied not only by Witness McNealy's statement referenced above, but also by Witness Turner, who states:

> 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.[47]

The Commission should find this contradiction damaging to Witness Hartman's credibility on this issue.

Q. How does this characterization of the Red and Green network outages from Witness Turner compare with your own testimony?

A. This is one instance where Witness Turner gets it right, by conceding these basic facts which were indeed common to both the Red and Green network outages– exactly as I described them in my direct testimony.[48] Moreover, as explained in that testimony, the fact that a packet storm occurred in both instances is the crucial similarity, because it was those packet storms, and not simply the creation of a few malformed packets in each case, that drove both the Red and Green networks to fail. And in both networks' failures, their vulnerability to a packet storm was directly

[47] Turner, Exh. SET-1TC at 51:1-2.
[48] Webber, Exh. JDW-1CT at 6:19 – 7:21; *id. at* 22:1 – 29:3. *See also* Webber, Exh. JDW-5C at 13 [redacted]); Webber, Exh. JDW-14C at 2.

caused by the fact that CenturyLink inexplicably left the IGCCs on those networks enabled (open to transmit packets) even though it was not using them. In fact, in its February 2019 Root Cause Analysis of the December 2018 packet storm, CenturyLink conceded [redacted]:

[redacted]

The FCC Report on the Green network failure also addressed this, explaining:

> System features that are not in use should be turned off or disabled. In this case, the proprietary management channel [IGCC] was enabled by default so that it could be used if needed. While CenturyLink did not intend to use the feature, CenturyLink left it unconfigured and enabled. Leaving the channel enabled created a vulnerability in the network that, in this case, contributed to the outage by allowing malformed packets to be continually rebroadcast across the network.[50]

Additionally, The FCC report clearly stated that the severity of the Green network outage was due to the packet storm phenomenon, and not to the creation of the malformed packets that triggered the storm:

> This outage was caused by an equipment failure catastrophically exacerbated by a network configuration error.[51]

As Dr. Akl explains in his cross-answering testimony, in both the Red and Green network outages, had the IGCC channels been disabled instead of being left open (while being neither used nor configured for use), those malformed packets could not have propagated across those networks and replicated in exponential fashion, and instead would have had no discernible impact on the networks' performance.

[49] Webber, Exh. JDW-14C at 2.
[50] Webber, Exh. JDW-4 at 15 (footnote omitted).
[51] Webber, Exh. JDW-4 at 3 (emphasis added).

By attempting to focus the Commission's attention solely on the "root cause" of how the first few malformed packets were created, CenturyLink seeks yet again to divert from the essential truth that their negligent handling of the unused IGCCs was the direct cause of the December 2018 packet storm and subsequent E911 outage in Washington state.

Q. Please explain how CenturyLink seeks to divert attention from the IGCC's central role in the packet storms driving both networks' outages by attempting to focus on the "root cause" of malformed packet creation.

A. Witness McNealy's conclusory response testimony is the primary evidence and professional opinion offered by CenturyLink regarding the Green and Red network outages,[52] Witness McNealy focuses the majority of his discussion on [redacted][53]

But it is striking to me that Witness McNealy [redacted]

[52] McNealy, Exh. TJM-1TC at 5:4 – 10:12.
[53] McNealy, Exh. TJM-1TC at 7:21; *id.* at 8:14 – 9:20.
[54] McNealy, Exh. TJM-1TC at 8:14 – 9:13.

[redacted][55] [redacted], Witness McNealy only states that "[redacted]."[56] Later in my testimony I identify several key facts about those IGCCs that Witness McNealy neglected to supply in his testimony.

This skewed and misleading presentation of the outages and their causes feeds into Witness McNealy's flawed analysis of the foreseeability of the Green network outage: [redacted]

Q. Is there evidence that Witness McNealy thought that the enabled IGCCs played a key role in the February 2018 Red network outage?

A. Yes. In response to Staff discovery, CenturyLink produced an email [redacted]

[55] McNealy, Exh. TJM-1TC at 6:1.
[56] McNealy, Exh. TJM-1TC at 6:1.
[57] McNealy, Exh. TJM-1TC at 8:14 – 10:6.
[58] Webber, Exh. JDW-36C.

[redacted] This raises significant doubts in my mind about the veracity of his response testimony on this issue.

In stark contrast to Witness McNealy's treatment of the foreseeability issue, Dr. Akl includes the role of the enabled IGCCs in his foreseeability analysis. As a result, he reaches the same conclusions as I have, namely:

1. Both the Red and Green network outages could not have occurred but for the fact that in both networks the IGCCs were left enabled, even though they were not being used; and
2. Once the Red network outage had occurred and been analyzed, it was or should have been entirely foreseeable to CenturyLink that the Green network would continue to have an avoidable vulnerability to a potentially catastrophic packet storm unless it disabled its IGCCs so that no packets could be communicated across them.[62]

[59] Webber, Exh. JDW-36C.
[60] Webber, Exh. JDW-36C.
[61] *Compare*, Webber, Exh. JDW-5C at 3 ([redacted]) *with* Webber, Exh. JDW-36C (stating [redacted]).
[62] Akl, Exh. RA-1CT at 9:1-16.

Indeed, CenturyLink did finally disable its IGCCs, though it did so only after the Green network failed, causing the E911 outage at issue in this matter.[63]

Q. Does Witness Valence offer any independent analysis of the foreseeability of the Green network outage?

A. No, he does not. Witness Valence relies almost entirely on excerpts from the McNealy testimony for his assertion that the two outages "were extremely different and had different root causes," and that "the December 2018 outage was not foreseeable."[64]

Witness Valence frequently repeats the same pattern when addressing other aspects of the two outages, even though documents have been made available through Staff's discovery efforts, such as the numerous CenturyLink and Infinera documents that I cited as the basis for my direct testimony addressing the two outages.[65] When comparing my direct testimony on the Red and Green network outages to the testimony supplied by Witness Valence, I find his criticism that "Mr. Webber's testimony is highly superficial"[66] to be unsupported and misplaced.

Q. What does Witness Turner say about the root cause of the Red network outage?

A. First, Witness Turner mischaracterizes my direct testimony on that issue by asserting that I claimed that "…the enabled Infinera General Communications Channels

[63] Webber, Exh. JDW-4 at 14.
[64] Valence, Exh. MDV-1TC at 10:20 – 11:3.
[65] *See, e.g.*, Webber, Exh. JDW-5C; Webber, Exh.JDW-6C; Webber, Exh. JDW-14C.
[66] Valence, Exh. MDV-1TC at 10:18.

(IGCC) were the root cause" of the Red network outage.[67] He is incorrect: I had not then, and do not today, identify the enabled IGCCs as the "root cause" of that outage. What's more important in the chain of causation are foreseeable events that could have been avoided. From that perspective I reached the following conclusion in my direct testimony, which I fully stand by today:

[redacted][68]

Remarkably, Witness Turner goes on to [redacted]. After citing a definition of "root cause," Witness Turner states that the root cause of the Red network outage was the ongoing software upgrade:

> 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)." Therefore, in looking at what set in motion the Red Network outage, the prime mover was the software upgrade.[69]

In so doing, Witness Turner directly contradicts and undermines Witness McNealy's conclusion that [redacted]

[redacted]

[67] Turner, Exh. SET-1TC at 52:22 – 53:1.
[68] Webber, Exh. JDW-1CT at 7:9-12.
[69] Turner, Exh. SET-1TC at 53:8-11 (citation omitted).
[70] McNealy, Exh. TJM-1TC at 7:5-14.

This is yet another instance where CenturyLink's witnesses provide contradictory testimony regarding important aspects of this case.

Q. Why does focusing exclusively upon the root causes of the two network events, as Witness McNealy and Witness Turner attempt to do, lead to the wrong conclusion concerning the foreseeability of the Green network outage?

A. The fundamental problem with CenturyLink's approach is that it ignores the simple and reasonable actions that CenturyLink could and should have taken to prevent the escalation of a few malformed packets into a "catastrophically exacerbated"[71] (to use the FCC's characterization) and crippling network outage. Once CenturyLink suffered the February 2018 outage on its Red network, and once both Infinera and CenturyLink knew [redacted] and propagated exponentially into a debilitating packet storm, the prudent and absolutely necessary course of action was clear: disable those IGCCs wherever they were not in use, including in the Green network. Dr. Akl explains that CenturyLink erred by [redacted], rather than taking the simplest and most direct preventative measure of disabling the unused IGCCs such that no type of packet could cause a packet storm and result in such a devastating outage.[72]

In fact, the FCC reached the very same conclusion regarding the use of packet filters in its report on the Green network outage, finding (as I had quoted

[71] Webber, Exh. JDW-4 at 3.
[72] Akl, Exh. RA-1CT at 7:15 – 8:27.

previously above) that "leaving the channel [IGCCs] enabled created a vulnerability in the network" and that:

> In this case, filters were designed to only mitigate specific risks. Thus, catch-all filters should be designed to only allow for expected traffic. In this event, the filter prevented transmission of packets 64 bytes or fewer over the proprietary management channel [IGCCs], regardless of packet content. Because other characteristics of the packet were not considered, the malformed packets were able to propagate.[73]

Q. All of this sounds rather technical. Can you supply an analogy that illustrates the basic problem with leaving the unused IGCCs open and relying upon the filtering of specific types of packets to guard against their entry into the IGCCs?

A. Yes. Let's imagine that you've decided to install a chicken coop in your backyard housing a dozen egg-laying hens. Any experienced farmer will tell you that those hens will tempt over lots of predators to try to get into the chicken coop to eat them: foxes, raccoons, skunks, weasels, snakes, and more. The most obvious vulnerability is the door to the chicken coop−so the most basic and prudent action is to close and lock the door when it is not in use.

But let's suppose you've never seen a fox in your neighborhood and think that the only source of trouble could be other types of predators such as snakes, weasels, and skunks, who are not able to get over a three-foot barrier in the doorway. So you build that three-foot barrier and install it right in front of the coop's doorway, but still leave the door itself unlocked and open. A week later, you find your hens are missing, and there are signs that a fox was the culprit.

[73] Webber, Exh. JDW-4 at 15.

In that scenario, could you really claim that it was unforeseeable that a fox could enter the coop and kill your chickens? No, of course not. You failed to close and lock the door when it was unused, which would have prevented any and all types of predators from entering through the door of the coop and wreaking havoc.

The similarity of this scenario to the Green network outage is clear:

1. To maintain your network, be vigilant in its maintenance. If you see a hole, fix it ASAP. You are leaving an opening for network failures.

2. CenturyLink's decision to leave its unused IGCCs on its Infinera networks in their default unlocked (enabled) condition created a serious vulnerability to packet storms; just like leaving the chicken coop door open and unlocked leaves the chickens inside vulnerable to predation.

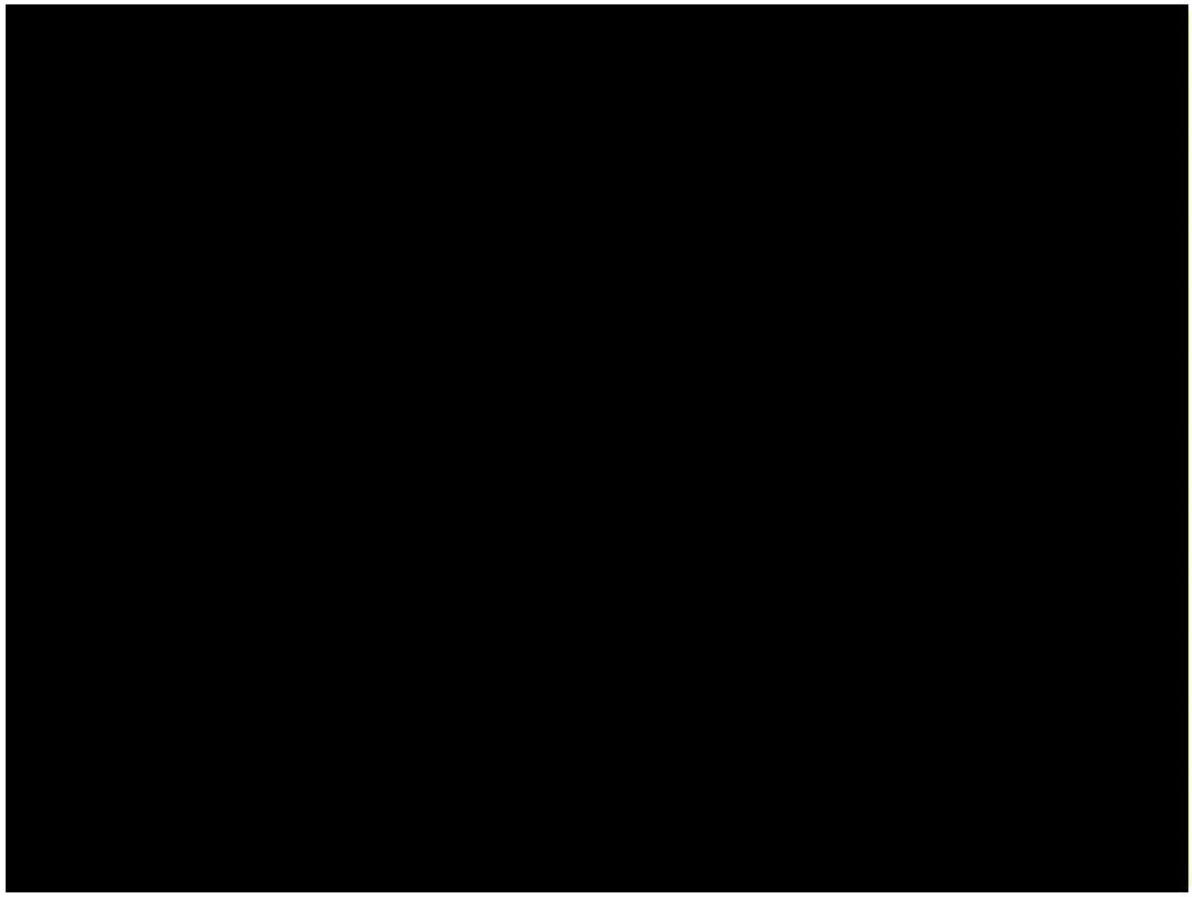
3. Relying upon software filters that only screen out certain types of packets is an inferior form of protection that clearly failed to prevent packet-storm driven outage on the Green network; after the outage on the Red network, it was entirely foreseeable that a packet storm could occur on the Green network unless the IGCCs were locked down (disabled). So too it was entirely foreseeable that leaving the coop's door open and unlocked could lead to intrusions by other predators than those blocked by the three-foot barrier, and that the protection afforded by the barrier was incomplete and no substitute for simply closing and locking that door when unused.

4. Finally, like the owner and operator of the chicken coop, CenturyLink bears full responsibility for the consequences of its decision not to lock down the Green network's IGCCs and instead leave that network wide open to a crippling packet storm, for nearly ten months after it had experienced the earlier packet storm on the Red network that also could have been avoided by simply locking down its IGCCs in the same manner.

Q. When did CenturyLink learn that leaving the IGCCs on its Infinera-equipped Red and Green networks in their default enabled condition created a vulnerability to packet storm-driven outages?

A. Whether or not CenturyLink understood this prior to the February 2018 outage on the Red network, it certainly knew that this vulnerability existed once that outage occurred and was diagnosed, approximately ten months before the Green network outage in late December 2018. I previously provided a detailed analysis of the Red network outage and its causes in my prefiled direct testimony[74] and will not repeat that discussion here. However, drawing upon CenturyLink and Infinera documents contemporaneous to that time, and revealed through persistent discovery, we now know for certain that [redacted]

[74] Webber, Exh. JDW-1CT at 24:21 – 29:3.
[75] Webber, Exh. JDW-37C at 1-2.



[redacted]

[redacted]

Q. After the Red network outage and this email exchanged occurred, did CenturyLink take action to disable the IGCCs on the Green network by [redacted]?

A. No. Both Witness Valence and Witness McNealy confirm that CenturyLink [redacted][77] To be clear, I am using the term "disable the IGCCs" to mean they would be deactivated and no longer able to transmit any packets—as opposed to the filtering out of packets with particular pre-defined characteristics. Dr. Akl explains in his testimony why the latter approach was inappropriate and insufficient once

[76] Webber, Exh. JDW-37C at 1.
[77] *See* Valence, Exh. MDV-1TC at 13:18 – 15:2; McNealy, Exh. TJM-1TC at 7:15 – 8:6.

CenturyLink and Infinera had actual, documented knowledge of the causes of the Red network outage and packet storm (i.e., the enabled IGCCs that CenturyLink inexplicably failed to disable), particularly given that the IGCCs were unused and there existed no plan to use them.[78]

Q. Witness Valence disputes your testimony concerning Infinera's [redacted] and claims you "misinterpreted" the Infinera document you cite as support for your testimony. Do you agree with Witness Valence's criticism?

A. No. Witness Valence's criticism misquotes the document that I referred to in my initial testimony.

Q. Please explain.

A. Immediately after the Red network packet storm, Infinera [redacted]

[78] Akl, Exh. RA-1CT at 7:15 – 8:27.
[79] Webber, Exh. JDW-5C at 9.
[80] Webber, Exh. JDW-5C at 2-12.
[81] Webber, Exh. JDW-5C at 9.

However, Witness Valence's testimony contains the following exchange:

Q. THERE IS A DOCUMENT THAT SAYS INFINERA

A. Yes. Mr. Webber refers to a document where Infinera

Importantly, both the question to and response by Witness Valence appears to suggest that the In fact, Staff attempted to determine the scope of Infinera's , but CenturyLink flatly refused to supply any documents, emails, or other written communication from the time between the two 2018 outages as evidence as to what Infinera actually did.[83]

Witness Valence goes on to claim that and that [84]

Q. Do those documents in fact contain any advice from Infinera that CenturyLink did not need to modify the IGCC settings in the Green network?

[82] Valence, Exh. MDV-1TC at 13:18-23.
[83] Webber, Exh. JDW-1CT at 29:5-20; Webber, Exh. JDW-6C at 15-16.
[84] Valence, Exh. MDV-1TC at 14:5-12 (citing Valence, Exh. MDV-4C).

A. No, they do not. I reviewed Exh. MDV-4C and found that the documents cited are [redacted][85]

Q. Has CenturyLink identified any downsides to disabling the IGCCs where they were enabled by default but unused, such as on the Green network prior to December 2018?

A. No. Witness Valence raises a vague, speculative suggestion that disabling the IGCCs on the Green network could have created some new risks:

> [T]he prudent course was to do exactly as Infinera advised because modifying the software version controlling the IGCC on Green Network nodes could have had unforeseen consequences (e.g., software defects or hardware failure).[86]

But this is a red herring: disabling the IGCCs does not require modifying the "software version" for the IGCC; Infinera already explained that it is simply an on/off setting on each line card ("The only possible settings for the management channel are enabled or disabled, and configured or not configured.").[87]

[85] Valence, Exh. MDV-4C at 1-6.
[86] Valence, Exh. MDV-1TC at 16:5-7.
[87] Webber, Exh. JDW-6C at 1-2.

Moreover, CenturyLink failed to provide a single piece of evidence showing that it is a difficult or costly procedure to disable IGCCs. To the contrary, emails obtained from CenturyLink indicate that [redacted].[88]

Q. Witness Hartman alleges that Staff has not directly tied your findings concerning CenturyLink's Green network outage to specific elements of CenturyLink's appliances, instrumentalities, or services. Do you agree?

A. No. I believe that the connection is already clear due to the nature of CenturyLink's lack of preventative action prior to the December 2018 packet storm and consequent outage on the Green network and the Washington E-911 system. But to forestall any doubt by the Commission, let me state the following directly:

[88] *See* Webber, Exh. JDW-37C at 1.
[89] *See* Webber, Exh. JDW-42C.

The facts of this case as set forth above and in my direct testimony demonstrate that CenturyLink knew after the February 2018 Red network failure that the Green network was at risk from malformed packets potentially entering the network's unused but enabled (unlocked) IGCCs, and propagating exponentially to produce a crippling packet storm. Based on this knowledge, CenturyLink knew or should have known that the prudent course of action was to disable the Green network's IGCCs as soon as possible, to eliminate that vulnerability. Therefore, I maintain that CenturyLink failed to keep its Green network, used to transmit 911 calls from Washington callers to Washington PSAPs, in good condition by failing to lock (disable) the IGCCs on that network, even though the IGCCs were unused. Moreover, this failure was directly related to the 2018 December and the resulting inability to transmit calls during the outage.

V. STAFF'S CALCULATIONS OF THE PENALTIES APPLICABLE TO CENTURYLINK REMAIN SUPPORTED BY MY COUNTS OF WASHINGTON 911 CALLS THAT FAILED DURING THE DECEMBER 27-29, 2018 OUTAGE, WHICH HAVE NOT BEEN REBUTTED IN CENTURYLINK'S RESPONSE TESTIMONY

Q. Witness Hartman observed that Public Counsel concluded that the December 2018 outage resulted in approximately 10,752 failed 911 calls in Washington state,[90] which is [redacted] the count of failed 911 calls that Staff relied upon for its penalty calculations.[91] How do you respond to this apparent discrepancy?

[90] Hartman, Exh. SJH-1TC at 37:5-12.
[91] *See* Hawkins-Jones, Exh. JHJ-1CT at 12:17 – 13:13.

A. Although Staff and Public Counsel proposed different numbers of impacted calls as part of their respective initial testimony, further review indicates that the numbers are not necessarily inconsistent. Witness Rosen states that:

> Comtech data shows it received many fewer calls than would have been expected compared to average counts of calls received. Based on the Comtech call tallies, call volume during the outage, compared to historical averages, suggest at least 10,752 fewer 9-1-1 calls were received that expected, a drop of 34 percent.[92]

Given that Witness Rosen describes his number of calls impacted as a minimum number, Staff and Public Counsel's number of impacted calls are not contradictory. However, I recommend that the Commission determine that [redacted] calls were impacted as a result of the December outage, because that figure was based on review of actual CDR data provided by CenturyLink, rather than an estimate.

Q. Has CenturyLink presented any credible rebuttal to the analysis of the 911 calls during that outage that you have presented in support of the figure?

A. No, it has not. The only CenturyLink witness who offers testimony concerning my 911 calls analysis is Witness Klein. Witness Klein does not contest any of my analysis or results for the 911 calls that failed to complete to the 57 PSAPs served by TSYS at the time of the December 2018 outage. However, he argues that notation associated with several call counts supports his contention that "none of the calls destined for CenturyLink's remaining 15 PSAPs failed to complete as a result of the outage on the [CenturyLink] Green Infinera network."[93] The only source that he cites for those figures is my Exh. JDW-31C. However, that exhibit contains [redacted]

[92] Rosen, Exh. BR-1CTr at 15:4-8 (emphasis added).
[93] Klein, Exh. CDK-1TC at 11:5 – 12:8.

[redacted]. While I relied upon that as the source file for my 911 call counts analysis discussed above, it took considerable analysis of that raw data file to produce my results, including the following steps:

1. Creating an appropriate pivot table to summarize the contents of that Excel spreadsheet;
2. Separately identifying which calls failed and which had succeeded;
3. Determining which calls were intended for PSAPs still served by CenturyLink, versus the 47 PSAPs served by TSYS in December 2018;
4. Determining the specific timeframe of the outage as experienced on the Washington E911 system, and limiting the determination of call counts to that timeframe (as the spreadsheet contains 911 calls spanning more than [redacted] the time that CenturyLink indicated the Green network outage had been resolved); and
5. Summarizing the resulting call counts.

Witness Klein neither cited to nor supplied any such analysis as support for his claimed call counts. Moreover, the single largest figure he provides for failed calls to CenturyLink-served PSAPs, for the Disconnect Reason "Only Party Left in Call" – [redacted] – is actually higher than my figure for all Failed calls to CenturyLink-served PSAPs during the outage period ([redacted]).[94] Consequently, I find Witness Klein's figures to be unsupported, likely incorrect, and recommend that the Commission disregard his testimony on this issue. Instead, the Commission should rely upon my analysis of the 911 calls and find that it supports Staff's recommended penalty amounts.[95]

[94] Webber, Exh. JDW-1CT at 55:1 – 56:2.
[95] Webber, Exh. JDW-1CT at 44:1 – 60:9; Hawkins-Jones, Exh. JHJ-1CT at 13:1-13.

Q. Are you aware of any responsibilities of either Qwest Corporation or CenturyLink to provide services related to PSAPs served by TSYS?

A. Yes, as is discussed in the testimony of Public Counsel's Witness Rosen, [redacted][96] I understand that CenturyLink was [redacted]. Hence, I find it particularly difficult to believe that CenturyLink [redacted].

In fact, [redacted].[97] Hence, while CenturyLink argues it was oblivious to TSYS' actions and use of its facilities for signaling related to 911 in Washington, CenturyLink should have understood TSYS's network during the transition, and [redacted]

[96] Rosen, Exh. BR-1CTr at 7:4-16. *See generally*, Webber, Exh. JDW-38C.
[97] Webber, Exh. JDW-40C; Valence, Exh. MDV-8C.

[redacted]. Given these facts, and CenturyLink's alleged ability to provide diverse routing, I don't understand how CenturyLink did not advise, question, or otherwise note that [redacted].[98]

Q. Does this conclude your cross-answering testimony?

A. Yes.

[98] Webber, Exh. JDW-40C.