

SECRETARY'S RECORD, PUBLIC SERVICE COMMISSION

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Nebraska)	Application No. 911-077/
Public Service Commission, on)	C-5581/PI-252
its own motion, conducting an)	
investigation into the 911)	
service outage on the Lumen)	ORDER OPENING INVESTIGATION
network that began on April 17,)	
2024 in varying areas of)	
Nebraska.)	Entered: April 30, 2024

BY THE COMMISSION:

O P I N I O N S A N D F I N D I N G S

The Nebraska Public Service Commission ("Commission") opens the above-captioned investigation into the 911 emergency telecommunications service outage that occurred over varying areas of the Lumen network in Nebraska beginning on or about 8:30 p.m. on Wednesday, April 17, 2024 (the "Outage"). Based upon initial reports, the Commission understands that during the Outage, callers who dialed 911 in the affected areas experienced sporadic and intermittent difficulty connecting to their 911 service center (also known as public safety answering points or "PSAPs"). Further, some PSAPs experienced intermittent inability to place calls on their administrative lines. 911 service was not fully restored for approximately 3 hours which also may have varied across the state.

In addition to the outage in Nebraska, media reports indicate that at least two other states were impacted, including Nevada and South Dakota. Media reports further indicate that the Outage was due to a fiber cut in Missouri from an unrelated company installing a light pole.

Accordingly, the Commission opens this investigation to determine the scope of the Outage, including which Nebraska PSAPs were impacted, how they were impacted, and the cause or causes of the Outage. This investigation will include, without limitation, an evaluation of all aspects of the 911 system that were impacted within Nebraska in order to ascertain what actions may be warranted by the Commission to respond to this Outage and prevent such occurrences in the future.

Additional points of inquiry will be determining why the Outage appeared to impact PSAPs differently in varying regions, and why the Outage may have impacted both wireless and wireline calls. 911 service providers are required to maintain geographically diverse redundant connections between PSAPs and the telecommunications infrastructure that delivers 911 calls to their

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intended destinations.¹ The Commission seeks both an explanation of why the redundancy required of Lumen failed in this instance and a solution to prevent this from happening again.

O R D E R

IT IS THEREFORE ORDERED by the Nebraska Public Service Commission that the above-captioned investigation be, and hereby is, opened.

ENTERED AND MADE EFFECTIVE at Lincoln, Nebraska this 30th day of April, 2024.

NEBRASKA PUBLIC SERVICE COMMISSION

COMMISSIONERS CONCURRING:

Eric M. Hamler

[Signature]

Tim Schram

Karen Stocker

[Signature]
Chair

ATTEST:

[Signature]
Deputy Director

¹ See, e.g., 47 C.F.R. § 9.19.

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Nebraska	)	Application No. 911-077/
Public Service Commission, on	)	C-5581/PI-252
its own motion, conducting an)	
investigation into 911 service	)	ORDER EXPANDING INVESTIGATION
outages occurring in areas of)	
Nebraska served by Lumen and)	
its affiliates.	)	Entered: August 20, 2024

BY THE COMMISSION:

O P I N I O N S A N D F I N D I N G S

On April 30, 2024, the Nebraska Public Service Commission ("Commission") entered an order opening an investigation into a multi-hour disruption of 911 service to Lumen customers in Nebraska as a result of a fiber cut on Wednesday, April 17, 2024 ("April 2024 Lumen Outage").

Subsequently, on Tuesday, July 9, 2024, 911 service was again disrupted for no less than two hours in Lumen service areas, impacting multiple Public Safety Answering Points ("PSAPs") across Nebraska ("July 2024 Lumen Outage"). Further, the Commission has a second open investigation into a 911 service outage from August of 2023 impacting Lumen's network.¹

The Commission is concerned with what appears to be a pattern of repeated 911 outages on Lumen's network affecting Nebraska PSAPs. These outages lead the Commission to find that this investigation should be expanded to include the July 2024 Lumen Outage, as well as any subsequent Lumen 911 outages which occur during the pendency of this docket. The causes of these outages should be determined, and steps should be identified to prevent future occurrences.

Accordingly, the Commission finds that the investigation already underway in this docket should be expanded to include, without limitation, any cause or causes of the July 2024 Lumen Outage and any subsequent Lumen 911 outages occurring during the pendency of this docket.

¹ See, *In the Matter of the Nebraska Public Service Commission, on its own motion, conducting an investigation into the 911 service outage that began on August 31, 2023, in areas of Nebraska served by Lumen and its affiliates*, App. No. 911-075/ PI-248, Order Opening Investigation (September 12, 2023).

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Application No. 911-077/C-5581/PI-252

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O R D E R

IT IS THEREFORE ORDERED by the Nebraska Public Service Commission that the investigation in this Application No. 911-077/PI-252 be expanded as stated herein.

ENTERED AND MADE EFFECTIVE at Lincoln, Nebraska, this 20th day of August 2024.

NEBRASKA PUBLIC SERVICE COMMISSION

COMMISSIONERS CONCURRING:

Eric M. Hamler

[Signature]

Tim Schram

Kevin Stocker

[Signature]

Chair

ATTEST:

Thomas W. Golden

Executive Director

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Nebraska) Application No. 911-075/
Public Service Commission, on) PI-248
its own motion, conducting an)
investigation into the 911)
service outage that began on)
August 31, 2023 in areas of)
Nebraska served by Lumen and)
its affiliates.)

In the Matter of the Nebraska) Application No. 911-077/
Public Service Commission, on) C-5581/PI-252
its own motion, conducting an)
investigation into 911 service) ORDER ADOPTING PROCEDURAL
outages occurring in areas of) SCHEDULE AND SETTING HEARING
Nebraska served by Lumen and)
its affiliates.) Entered: October 22, 2024

BY THE HEARING OFFICER:

On September 12, 2023, the Nebraska Public Service Commission opened Docket No. 911-075/PI-248 to investigate the 911 emergency telecommunications service outage that occurred over a wide area of the Lumen network in Nebraska beginning at approximately 7:00 p.m. on Thursday, August 31, 2023, and lasting until approximately 7:20 a.m. on Friday, September 1, 2023.

Subsequently, on April 17, 2024, 911 service was again disrupted in Lumen service areas, impacting multiple Public Safety Answering Points ("PSAPs") across Nebraska ("April 2024 Lumen Outage") resulting in the Commission opening a second investigation.¹ On July 9, 2024, ("July 2024 Lumen Outage") a third outage occurred impacting Lumen customers in Nebraska. On August 20, 2024, the Commission entered an Order Expanding Investigation under Docket No. 911-077/C-5581/PI-252 to include both the April and July 2024 outages.²

¹ See, *In the Matter of the Nebraska Public Service Commission, on its own motion, conducting an investigation into the 911 service outage that began on August 31, 2023, in areas of Nebraska served by Lumen and its affiliates*, App. No. 911-075/ PI-248, Order Opening Investigation (September 12, 2023).

² See, Application No. 911-077/C-5581/PI-252, *In the Matter of the Nebraska Public Service Commission, on its own motion, conducting an investigation into the 911 service outages occurring in areas of Nebraska served by Lumen and its affiliates*, Order Expanding Investigation (August 20, 2024).

SECRETARY'S RECORD, PUBLIC SERVICE COMMISSION

Application No. 911-075/PI-248
Application No. 911-077/C-5581/PI-252

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On October 16, 2024, a planning conference was held with the parties in this matter. As a result of the planning conference, several issues were decided. Therefore, this Order serves to memorialize those decisions and provide a timeline for proceedings in this docket. I find that the following schedule should be adopted:

Date	Event
Wednesday, October 30, 2024	All pre-filed testimony, exhibits, and final witness lists due.
Monday, November 4, 2024, at 9:00 a.m. CST; and Tuesday, November 5, 2024, at 9:00 a.m. CST (if necessary)	Hearing(s)

Furthermore, hearing on this matter shall be set for **Monday, November 4, 2024, at 9:00 a.m. Central Time**, and if necessary, **Tuesday, November 5, 2024, at 9:00 a.m. Central Time**, in the Commission Hearing Room, 1200 N Street, Suite 300, Lincoln, Nebraska. This Hearing shall be held in person; however, remote access to the hearing will be available via WebEx at the following link: <https://psc.nebraska.gov/stream> (case sensitive).

If auxiliary aids or reasonable accommodations are needed for attendance at the meeting, please call the Commission at (402) 471-3101. For people with hearing/speech impairments, please call the Nebraska Relay System at (800) 833-7352 (TDD) or (800) 833-0920 (Voice). Advance notice of at least seven days is needed when requesting an interpreter.

O R D E R

IT IS THEREFORE ORDERED by the Hearing Officer that the proposed procedural schedule set forth herein be, and is hereby, adopted.

IT IS FURTHER ORDERED that hearings in the above-captioned matters should be, and are hereby, scheduled for **Monday, November 4, 2024, at 9:00 a.m. Central Time**, and if necessary, **Tuesday, November 5, 2024, at 9:00 a.m. Central Time**, as provided herein.

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Application No. 911-077/C-5581/PI-252

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ENTERED AND MADE EFFECTIVE at Lincoln, Nebraska, this 22nd day of October, 2024.

NEBRASKA PUBLIC SERVICE COMMISSION

By: 

Tim Schram
Hearing Officer

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Nebraska	)	Application No. 911-077/
Public Service Commission, on	)	C-5581/PI-252
its own motion, conducting an)	
investigation into the 911	)	PROTECTIVE ORDER
service outage that began on)	
April 17, 2024 in varying areas)	
of Nebraska.	)	Entered: August 5, 2024

BY THE HEARING OFFICER:

The Nebraska Public Service Commission ("Commission") initiated this proceeding on April 30, 2024 to investigate the 911 emergency telecommunications service outage that occurred in Nebraska beginning on or about Wednesday, April 17, 2024 (the "Outage").

Commission staff intend to serve its First Set of Data Requests ("Data Requests") on CenturyLink Communications, LLC, d/b/a Lumen Technologies Group ("Lumen") during the month of May, 2024 and anticipates, due to a separate open investigation, that Lumen will be seeking the entry of a Protective Order in this docket as they have in prior dockets, to ensure confidential treatment of certain data, information, and/or documentation sought via the Data Requests.

I find that an Amended Order should be entered to cover confidential information and materials provided to the Commission by Lumen during the course of this proceeding. The following Protective Order is hereby entered with respect to all confidential information contained in the above-captioned docket or filed by Lumen in any proceeding in this docket or produced in discovery.

Protective Order

1. This Protective Order shall govern the use of all confidential information and documents submitted to the Commission by, or on behalf of, Lumen. Notwithstanding any order terminating this proceeding, this Protective Order shall remain in effect until specifically modified or terminated by the Nebraska Public Service Commission.

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Application No. 911-077/C-5581/PI-2522

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2. The term "Confidential Materials" shall mean all information and materials and documents designated as such by Lumen in connection with this proceeding and clearly identified by a label, stamp, or prominent watermark indicating same.
3. Except as set forth below, Confidential Materials shall be made available under the terms of this Amended Protective Order only to the Commission and Commission staff and counsel and, as may be requested, to the Federal Communications Commission ("FCC"). Confidential Materials may only be submitted to a consultant, an expert, or an employee of a consultant or an expert retained by the Commission, for the purpose of advising, preparing for, or testifying in this proceeding, once the consultant, expert, or employee of a consultant or expert has executed the Non-Disclosure Agreement attached to this order as "Attachment A". Confidential Materials may only be submitted to the FCC once a representative of the FCC has executed the Non-Disclosure Agreement (Attachment A). As set forth herein, no Confidential Materials may be submitted by the Commission to any consultant, expert, or employee of a consultant or expert, or to the FCC, without first obtaining an executed Non-Disclosure Agreement and providing a copy of same to Lumen and/or its counsel. Confidential Materials shall be treated as proprietary and confidential once submitted, and shall not be made available to the public or published on the Commission website.
4. All Confidential Materials submitted to the Commission and/or from or by the Commission should be done through secure transmission. Should Confidential Materials be inadvertently disclosed, any person who identifies the disclosure must immediately notify the Commission of the disclosure and destroy any copies of the Confidential Materials in their possession or control. Any further disclosure or use of Confidential Materials is strictly prohibited and shall constitute a violation of an order of the Commission.
5. All Confidential Materials shall be submitted to the Commission through secure transmission. Such materials shall be marked as Confidential prior to submission. Participants shall take all reasonable precautions necessary to ensure that Confidential Materials are not distributed to unauthorized persons. The use of such precautions does not, however, alter or extend any filing deadlines previously set in this matter. It is the Participant's responsibility to

SECRETARY'S RECORD, PUBLIC SERVICE COMMISSION

Application No. 911-077/C-5581/PI-2523

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ensure that all materials, including Confidential Materials, are filed in a timely manner.

6. The Commission or the Hearing Officer may alter or amend this Amended Protective Order as circumstances warrant at any time during the course of this proceeding.
7. This Amended Protective Order governs only Confidential Materials filed in the course of this proceeding. Materials submitted in other Commission proceedings are not included in the scope of this Amended Protective Order.
8. Any violation of this Amended Protective Order shall constitute a violation of an order of the Commission.

O R D E R

IT IS THEREFORE ORDERED by the Nebraska Public Service Commission that this Amended Protective Order shall be entered in the above-captioned proceeding.

MADE AND ENTERED at Lincoln, Nebraska this 5th day of August, 2024.

NEBRASKA PUBLIC SERVICE COMMISSION

BY: Eric M. Kamler
Eric Kamler
Hearing Officer

SECRETARY'S RECORD, PUBLIC SERVICE COMMISSION

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Nebraska	)	Application No. 911-077/
Public Service Commission, on	)	C-5581/PI-252
its own motion, conducting an)	
investigation into the 911	)	NON-DISCLOSURE AGREEMENT
service outage that began on)	
April 17, 2024 in varying areas)	
of Nebraska.)	
)	

The undersigned hereby certifies that he/she has been presented with a copy of the Protective Order entered on ____ August 2024, in the above-captioned matter and that the undersigned has read the Protective Order, understands it, and agrees to be bound by it and abide by its terms and conditions.

The undersigned understands that the contents of all Confidential Materials received by the undersigned, and any notes, memoranda, or other form of information that copies or discloses Confidential Materials shall not be disclosed to anyone other than in accordance with the Protective Order.

The undersigned understands and acknowledges that a violation of this Non-Disclosure Agreement constitutes a violation of an order of the Commission and could subject the undersigned to penalties.

BY:

Print Name

Signature

TITLE:

BUSINESS NAME:

BUSINESS ADDRESS:

DATED:

Public Notice Placement Confirmation

Please notify us of any changes ASAP at legals@omahadailyrecord.com

Scheduled Publication

10/24

NEBRASKA PUBLIC SERVICE COMMISSION
300 The Atrium, 1200 N Street
P.O. Box 94927
Lincoln, NE 68509-4927

NOTICE OF PUBLIC HEARING

**APPLICATION NO. 911-075 PI-248 and
APPLICATION NO. 911-077/C-5581/PI-252:**

911-075/PI-248 The Commission, on its own motion, conducting an investigation into the 911 service Outage that began on August 31, 2023, in areas of Nebraska served by Lumen and its affiliates, and;

911-077/C-5581 PI-252 In the Matter of the Nebraska Public Service Commission, on its own Motion, conducting an investigation into the 911 service PI-252 outage on the Lumen network that began on April 3, 2024, in varying areas of Nebraska.

All persons interested in the above-referenced application are hereby notified that this matter has been scheduled for public hearing on **November 4, 2024, at 9:00 a.m. central time, and if necessary, November 5, 2024, at 9:00 a.m. central time** in the Nebraska Public Service Commission Hearing Room, 300 The Atrium, 1200 "N" Street, Lincoln, Nebraska.

Remote access to the hearing will be available via WebEx or by telephone. The Commission WebEx may be accessed by the following link: <https://psc.nebraska.gov/stream>. Those wishing to attend anonymously may use "anonymous" for their name and "a@b.com" for their email address. To attend by telephone, dial 408-418-9388, then enter **1462735624** when prompted for an access code. Visit the [PSC Meeting/Hearing information page](#) for additional details

If auxiliary aids or reasonable accommodations are needed for attendance at a Commission meeting, please call the Commission at 402-471-3101. For people with hearing/speech impairments, please call the Commission at 402-471-0213 (TDD) or the Nebraska Relay System at 800-833-7352 (TDD), or 800-833-0920 (Voice). Advance notice of at least seven days is needed when requesting an interpreter.

10/24

ZNEZ

All notice submissions, changes and cancellations must be made by 12 p.m. two weekdays prior to publication, or by earlier deadlines noted in your confirmation email in advance of court holidays. Please note the The Daily Record reserves the right to delay publication if we are unable to reach you to resolve questions or concerns.

**EXHIBIT
6 (911-077)**

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Nebraska Public Service) Application No. 911-077/C-5581/PI-252
Commission, on its own motion, conducting)
an investigation into the 911 service Outage)
on the Lumen network that began on April 17,)
2024, in varying areas of Nebraska.)
)

**CENTURYLINK COMMUNICATIONS, LLC d/b/a LUMEN
TECHNOLOGIES GROUP’S RESPONSES TO COMMISSION
STAFF’S FIRST SET OF DATA REQUESTS**

COMES NOW CenturyLink Communications, LLC d/b/a Lumen Technologies Group,
(hereafter, “Lumen”), and for its responses to the Nebraska Public Service Commission Staff’s
First Set of Data Requests in the above-captioned matter served upon Lumen on August 13, 2024,
states as follows:

PRELIMINARY STATEMENT

The responses provided herein are based upon information presently available and
specifically known by Lumen. Further discovery and investigation may disclose additional facts
and add meaning to known facts, all of which may lead to additions to, changes in, and/or
variations from, the answers set forth herein. The following answers are given without prejudice
to Lumen’s right to produce evidence of any subsequently discovered fact or facts. Accordingly,
Lumen reserves the right to supplement any and all responses herein if additional information
becomes known.

All responses provided herein are made without waiving any and all objections to
relevancy, privilege, confidentiality, and admissibility of evidence at any evidentiary hearing or
further proceeding.

RESPONSES TO DATA REQUESTS

REQUEST NO. 1: Please describe the part of the Lumen network that failed on 4/17/2024:

- a. What systems were connected by the cut fiber?
- b. Where and how were they connected to the Nebraska 911 service?

RESPONSE TO REQUEST NO. 1:

Lumen's ES Trunks and SS7 links were affected in the Outage.

- a. **What systems were connected by the cut fiber?**

The types of traffic that transit the Cable are classified into three product families: IP, Transport, and Voice. The ES Trunks and SS7 links that were affected in the Outage are classified as Voice products. Voice products include voice communication services, such as local and long-distance calling, voicemail, and caller ID, and can also use different types of optical carriers, depending on the quality and reliability of the voice signals.

While IP and Transport products were not affected in the Outage, IP products that transit the fiber provide connectivity and access to internet services, such as web browsing, email, and streaming, and can use different types of optical carriers, depending on the bandwidth and speed requirements of the customers. Transport products provide the infrastructure and network management for transporting data across different locations and networks. They use specific types of optical carriers, such as OC3, OC12, or OC48, to ensure high performance and availability of the data transmission.

The affected PSAPs were not directly connected to the circuits that were impacted. With respect to Nebraska, the impacted circuits are DS0-level TDM circuits that connect the aggregation points in Nebraska to the LNGs located in Chicago, and Colorado. These LNGs then convert the TDM traffic to IP traffic prior to sending to the ESInet and from there to PSAPs.

- b. **Where and how were they connected to the Nebraska 911 service?**

The systems impacted by the cut fiber were carrying Nebraska ingress voice circuits (ES Trunks) carrying 911 call traffic destined for the NG-911 network.

REQUEST NO. 2: What redundant elements were in place that were supposed to provide back up for the elements that failed following the fiber cut on 4/17/2024?

RESPONSE TO REQUEST NO. 2: The network was designed to have redundant fiber transport paths. Those network designs to address redundancy were in place at the time of this Outage.

REQUEST NO. 3: Why didn't those back-up elements identified in the prior question prevent the service failure on April 17, 2024?

RESPONSE TO REQUEST NO. 3: The Kansas City, Missouri network was and is designed and was constructed to be diverse. Despite this design, Lumen hypothesizes that over a decade ago, to restore service compromised by a previous force majeure flooding event, Lumen took measures intended to temporarily repair a critical fiber path by creating a collapsed ring. Unfortunately, due to procedures in place at the time which did not always record such repairs (an issue that has been remedied under current procedures), the original design configuration was not restored after the event, leaving the collapsed ring configuration intact.

REQUEST NO. 4: Was the circuit that was cut on April 17, 2024, part of a SONET ring with one side disabled or were there two single point to point paths that were intended to be geographically diverse?

- a. If geographically diverse, please explain why this outage occurred?
- b. If not geographically diverse, how long was the network in this state and why?

RESPONSE TO REQUEST NO. 4: There are two separate, bi-directional fiber paths running out of the Kansas City 96 Central Office, designed to be fully diverse. See response to Request No. 3 for why there was a collapsed ring such that an outage occurred when the fiber was cut.

REQUEST NO. 5: How many states did this circuit carrying 9-1-1 traffic service serve?

RESPONSE TO REQUEST NO. 5: The fiber cuts impacted ingress 911 voice traffic for parts of Nebraska and South Dakota.

REQUEST NO. 6: Was this component of the network designed for 99.999 availability?

- a. If so, what was the beginning and endpoint of those specific network components that were included in determining that availability metric which also includes the component (fiber) that was cut?
- b. If not, please explain why it was not designed to meet 99.999 availability?

RESPONSE TO REQUEST NO. 6: The NG-911 network was designed to achieve 99.999% system availability. The fiber cuts at issue here, however, impacted ingress 911 voice traffic. As stated in Response No. 1, which is incorporated herein by reference, the systems impacted by the cut fiber were carrying Nebraska ingress voice circuits (ES Trunks) carrying 911 call traffic *destined* for the NG-911 network.

REQUEST NO. 7: Please provide an engineering analysis that shows how the 9-1-1 system this connection was a part of was intended to achieve its designed availability during the

outage on 4/17/2024.

RESPONSE TO REQUEST NO. 7: See Confidential Exhibit A, provided previously to the Commission and also produced contemporaneous with these Responses, is an aerial photo depicting the Kansas City 96 Central Office and the two physically and logically diverse, bi-directional fiber paths that run out of the office. In the aerial photo, one path is colored green and labeled Path A, and another path is colored yellow and labeled Path B.

Due to an undocumented splicing activity in the past, Paths A and B were tied together using an existing fiber optic cable (collapsed ring), represented in the aerial photo as a blue circle with a blue line.

REQUEST NO. 8: Did the cut have any impact on any SS7 connection between two switches?

- a. If so, please provide a diagram identifying the connection and the switches involved within the network impacted by this fiber cut.
- b. If it did impact an SS7 connection, was this network intended to carry 9-1-1 traffic?
- c. If intended to carry 9-1-1 traffic, please confirm whether this connection had two A-Links from the switch to the STPs? If not, please describe the configuration of the connection.
- d. If this SS7 connection was not intended to carry 9-1-1 traffic, why was it carrying 9-1-1 traffic?

RESPONSE TO REQUEST NO.8: No, not in Nebraska.

REQUEST NO. 9: Is it within the capability of Lumen to determine if a fiber connection carries 9-1-1 traffic? Why or why not? If there are areas of the network that Lumen is able to identify 9-1-1 traffic and other areas that Lumen cannot, please explain the differences.

RESPONSE TO REQUEST NO. 9: Yes, 911 circuits are flagged in inventory as such and can be correlated to higher level circuits and/or fibers.

REQUEST NO. 10. Please supply a listing of all Lumen fiber cuts in the past 10 years that resulted in 9-1-1 service failures in Nebraska. For each cut, specify;

- a. The location of the fiber cut,
- b. Whether the severed fiber was part of a ring,
- c. The alternate paths identified that were supposed to carry the 9-1-1 traffic, in case of a cut and,
- d. What services were impacted by the cut despite redundancy and why.

RESPONSE TO REQUEST NO. 10: Lumen retains data for seven (7) years per its records and retention policy. Lumen does not track whether the service on the severed fiber was on a ring, what alternative paths were supposed to carry the 911 traffic or why service

was affected by the cut despite redundancy arrangements in any ticketing systems. Since designs and records change, there is no way to obtain this information. *See Confidential Exhibit B, produced contemporaneous with these Responses, which is a report of all fiber cut impacting 911 in Nebraska for the past seven years, the majority of which only impacted local Lumen voice.*

REQUEST NO. 11: Please confirm the time of day the fiber cut occurred on April 17, 2024, and the time of day that Lumen was aware the cut impacted 9-1-1 service on April 17, 2024.

RESPONSE TO REQUEST NO. 11: Two fiber cuts occurred in Kansas City, MO on April 17, 2024.

At 2:12 PM CDT, while trying to install a light post for a company unaffiliated with Lumen, an excavator company accidentally damaged a Lumen fiber cable (“First Cut”) while digging at a site where locates that had been requested by Lumen were not visible. There was no immediate interruption of 911-related services provided by Lumen because the fiber optic cable strands carrying SS7 and 911 traffic were not severed. The damage was severe, however, and Lumen technicians believed that the fiber could fail at any time. Lumen thus determined that the damaged section of the cable should be replaced as soon as possible.

The repair – which would involve splicing nearly 1200 feet of new fiber to replace the damaged section – was scheduled to begin at approximately 8 PM CDT (“Second Cut”). Because this fiber circuit was designed to have physical diversity, Lumen reasonably believed that the repair should not have triggered any service disruptions. At 7:58 PM CDT on April 17, 2024, coincident with commencement of the repair, Lumen began receiving alarms indicating disruptions to 911 services.

REQUEST NO. 12: Were alarms in place designed to notify Lumen of a network outage operational on April 17, 2024 and did such alarms operate as expected on April 17, 2024? Why or why not?

RESPONSE TO REQUEST NO. 12: Yes, alarms were in place and operated as expected on April 17, 2024. As stated in the response to Request No. 11, which is fully incorporated here by reference, the alarms immediately alerted Lumen personnel to 911 service impacts. In addition, at approximately 08:06 PM CDT, alarms were triggered in the SS7 Network Operations Center (NOC) indicating two diverse links carrying SS7 traffic through Kansas City had dropped. The SS7 outage, however, did not affect 911 services in Nebraska.

REQUEST NO. 13: Were there any alarms in place which were intended to notify Lumen of a 9-1-1 specific outage in place on April 17, 2024 and did they operate as designed and intended on that date? Why or why not?

RESPONSE TO REQUEST NO. 13: Yes, alarms were in place and operated as

expected on April 17, 2024. Lumen has alarming systems in place that identify inoperable equipment and/or alarms in the 911 network, including the ingress voice and NG911 networks. Such alarms are automatically sent in instances of 911 outages or equipment failures, and, at a minimum, they are received by personnel at Lumen's Public Safety Services (PSS) NOC. As stated in responses to Request Nos. 11 and 12, which are fully incorporated herein by reference, such alarms immediately alerted Lumen personnel to 911 service impacts.

REQUEST NO. 14: How was Lumen made aware that 9-1-1 service was impacted by the fiber cut on April 17, 2024?

RESPONSE TO REQUEST NO. 14: See response to Request No. 13, which is fully incorporated herein by reference. In addition, Lumen received "customer trouble" reports related to the Outage. In conjunction with system alarms, such reports typically assist the PSS NOC in assessing impacts and thereby contribute to diagnostic efforts.

REQUEST NO. 15: When Lumen determined that 9-1-1 was impacted by the fiber cut, what efforts did Lumen implement that were not already in progress?

RESPONSE TO REQUEST NO. 15: The fiber repair was completed within a few minutes of correlating the fiber cut to the 911 impact.

REQUEST NO. 16: How does Lumen prioritize repairs for fiber carrying 9-1-1 traffic?

RESPONSE TO REQUEST NO. 16: It is Lumen's process to identify and prioritize fibers carrying 911 services. In this case, the fiber repair was completed within a few minutes of correlating the fiber cut to the 911 impact.

REQUEST NO. 17: When was the most recent audit for diversity conducted on this circuit prior to April 17, 2024?

RESPONSE TO REQUEST NO. 17: Because the damaged fiber cable was used to provide originating services and was not part of Lumen's covered 911 service network, it was not part of the Company's circuit auditing procedures implemented pursuant to Section 9.19 of the FCC's rules, 47 CFR § 9.19.

REQUEST NO. 18: How frequently does Lumen audit 9-1-1 circuits for diversity?

RESPONSE TO REQUEST NO. 18: See response to Request No. 17, which is fully incorporated herein by reference. Nevertheless, besides having already taken steps to enhance its network change recordkeeping in recent years, Lumen has updated its planning, documentation, verification, and review processes related to fiber repairs to minimize the

potential for recurrence. It also has initiated a physical audit of all national network sites and fiber optic systems carrying 911 originating service traffic destined for a covered NG911 network, with the intent of identifying and rectifying other potential unknown collapsed rings, as well as incorrect or missing records. Further, Lumen is auditing all 911 originating service provider voice trunk path routes to the covered NG911 network to identify any common physical building locations, with the goal, where possible, to add additional physical location diversity where traffic is added to or removed from a fiber system to reduce risk for a single location catastrophic event.

REQUEST NO. 19: When was Lumen 9-1-1 NOC first made aware of the 9-1-1 service failure?

- a. What actions were taken by the NOC upon initial notification?
- b. When were PSAP notifications initiated?
- c. Please identify when each PSAP was notified.
- d. Please identify any difficulties identified in notifying impacted PSAPs.

RESPONSE TO REQUEST NO. 19: The PSS NOC almost immediately began investigating alarms that had registered at 07:58 PM CDT suggesting impacts on ES Trunks supporting 911 traffic over diverse paths through Kansas City. Outbound notifications to Nebraska PSAPs were initiated on April 17, 2024 at 8:52 PM CDT. See Confidential Exhibit C for a list of when each Nebraska PSAP was notified. Lumen did not identify any difficulties in notifying impacted PSAPs.

REQUEST NO. 20: Please provide a diagram or map that illustrates the fiber routing/network pathways that provide 9-1-1 service to Nebraska and within Nebraska.

RESPONSE TO REQUEST NO. 20: Lumen intends to supplement this request with additional information. Lumen also refers the Commission to Confidential Attachment No. 4, NG-911 network diagrams for Nebraska, provided by Lumen in Commission docket No. 911-075/PI-248.

REQUEST NO. 21: Please provide a diagram or map that illustrates all network elements providing 9-1-1 service for Nebraska.

RESPONSE TO REQUEST NO. 21: See Confidential Exhibit D, produced contemporaneous herewith.

Dated this 12th day of September 2024.

Respectfully Submitted,

BY: /s/ Katherine A. McNamara

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**ATTORNEYS FOR CENTURYLINK
COMMUNICATIONS, LLC d/b/a LUMEN
TECHNOLOGIES GROUP**

CERTIFICATE OF SERVICE

The undersigned hereby certifies that on this 12th day of September 2024, the foregoing was submitted electronically to the Nebraska Public Service Commission via e-mail to the following:

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Sara Hulac, #23648
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BY: /s/ Katherine A. McNamara
Katherine A. McNamara, #25142

“Exhibit A” withheld pursuant to protective order.

“Exhibit B” withheld pursuant to protective order.

“Exhibit C” withheld pursuant to protective order.

“Exhibit D” withheld pursuant to protective order.

BEFORE THE NEBRASKA PUBLIC SERVICE COMMISSION

In the Matter of the Nebraska Public Service) Application No. 911-077/C-5581/PI-252
Commission, on its own motion, conducting)
an investigation into the 911 service Outage)
on the Lumen network that began on April 17,)
2024, in varying areas of Nebraska.)
)

**CENTURYLINK COMMUNICATIONS, LLC d/b/a LUMEN
TECHNOLOGIES GROUP’S RESPONSES TO COMMISSION
STAFF’S SECOND SET OF DATA REQUESTS**

COMES NOW CenturyLink Communications, LLC d/b/a Lumen Technologies Group,
(hereafter, “Lumen”), and for its responses to the Nebraska Public Service Commission Staff’s
Second Set of Data Requests in the above-captioned docket served upon Lumen on September 16,
2024, states as follows:

PRELIMINARY STATEMENT

The responses provided herein are based upon information presently available and specifically known by Lumen. Further discovery and investigation may disclose additional facts and add meaning to known facts, all of which may lead to additions to, changes in, and/or variations from, the answers set forth herein. The following answers are given without prejudice to Lumen’s right to produce evidence of any subsequently discovered fact or facts. Accordingly, Lumen reserves the right to supplement any and all responses herein if additional information becomes known.

All responses provided herein are made without waiving any and all objections to relevancy, privilege, confidentiality, and admissibility of evidence at any evidentiary hearing or further proceeding.

RESPONSES TO SECOND SET OF DATA REQUESTS (JULY 2024 OUTAGE)

REQUEST NO. 1: For the July outage, was the SS7 network carrying aggregated 911 traffic from an aggregation arrangement to an LNG on the NG911 network?

(1) If so, please provide a diagram showing how the 911 traffic was routed to the LNG and include in the diagram any aggregation points, switches, and/or multiplexers.

(2) If not, please explain how 911 traffic was routed and provide a diagram showing the same.

RESPONSE TO REQUEST NO. 1: No, it wasn't the SS7 network that carried the 911 traffic. Lumen networks experienced an SS7 outage in July of 2024 which impacted D-Links between Lumen Local and Lumen National networks.

At a high level, the Lumen SS7 networks provide connectivity between devices, internal networks and the PSTN (Public Switch Telephone Networks). The SS7 network connects switching elements to an STP (Signal Traffic Point) pair which then provide routing and connectivity to internal and external networks. What Lumen found during the July outage was it had two T2's (2 layers) that went from the local Spokane, Washington and Rancho Cordova, California, STP Pair to Lumen's Minnesota STP pair. Both the connection from Spokane and Rancho traversed through facilities in the Houston (HSTSTXJV) site. When the Houston site was impacted by Hurricane Beryl and lost all power, those connections were severed.

To remedy the issue the evening of the outage, a facility in Sunnyvale, California was utilized to bring up one D-Link from the Rancho Cordova STP to Tampa, Florida, to Chicago, Illinois, then to Minneapolis. This restored the connections from the Lumen Local to Lumen National network. Attached hereto as Confidential Exhibit 1 are diagrams of the routing before and after the July 2024 outage. The original circuit went from Rancho Cordova (through Houston) to Tampa then to Chicago to reach Minneapolis. The new design removes the leg from Rancho Cordova to Tampa, and now take it straight from Rancho Cordova to Chicago then the Minneapolis.

Again, a diversity issue was discovered when Houston facilities which carried traffic from Spokane/Rancho Cordova and Minneapolis/St Paul STP pair. The root cause of the issue was power outage at the Houston site which uncovered lack of diversity with resolution being gained after rerouting one of the circuits the night of the outage, as described above.

REQUEST NO. 2: For the July outage, please explain what is meant by "on-net solutions" in regard to D Link quads in "Key Findings/ Corrective Actions" on the third page, fourth bullet point, in the "Reason For Outage" document provided by Lumen regarding Ticket ID 29706775.

RESPONSE TO REQUEST NO. 2: "On-net solutions" means utilizing all Lumen-owned (or controlled) fiber and other network assets wherever possible with the intent to

maximize physical location diversity.

REQUEST NO. 3: For the July outage and according to the “Reason For Outage” document referenced in Request No. 2, Each of the four D links were all on one path. Please explain;

- (1) Why they were not on separate (diverse) paths?
- (2) How long were they on one path?

RESPONSE TO REQUEST NO. 3:

- (1) **Lumen discovered a diversity issue in Kansas City during another unrelated issue, and Lumen moved the two Rancho Cordova T1s but did not fully optimize the paths, as Lumen moved two T1s away from Kansas City down to Houston, where the two T1s for the Spokane links were already located. Thus, two T1s from the Spokane STP going to the Minnesota STPs were down as the Spokane STP was originally located in Houston, and after the move referenced above, the connections were not optimized. As a result, the STP in Spokane continued to route down to Houston to utilize the existing connections up to Minnesota.**
- (2) **They were on one path on the date of the outage when issues started at 17:51 GMT (11:50 AM CDT) and ended at 6:58 GMT (12:58 AM CDT)**
 - **Rancho Cordova to St. Paul**
 - **17:50 7/9/2024 to 14:53 7/10/2024 GMT down**
 - **Spokane to St. Paul**
 - **17:50 7/9/2024 to 13:12 7/10/2024 GMT down**
 - **Spokane to Minneapolis**
 - **Bounce at 17:50 7/9/2024 GMT**
 - **Starting at 19:13 7/9/2024 GMT links start bouncing –call failures due to instability in the SS7 network**
 - **At 02:59 7/9/2024 GMT linkset goes down causing complete isolation**
 - **Rancho to Minneapolis**
 - **17:50 7/9/2024 to 06:48 7/10/2024 GMT down, then T1 was moved – clearing the isolation**

REQUEST NO. 4: For the July outage, the last bulleted item from the “Reason For Outage” document referenced in Request No. 2, on Corrective Actions discusses “ticketing” but then discusses the state of the link-sets. Please explain;

- (1) What issues remain with the link-set?
- (2) Are there unresolved ticketing issues with this link set or any other link set that affects 911 in Nebraska?
- (3) If a similar failure were encountered today, would the NOC teams have accurate and timely information on the failure? Why or Why not?

RESPONSE TO REQUEST NO. 4:

- (1) Lumen is currently working with SS7 planning on establishing true diversity between the local and national links.**
- (2) There are no unresolved ticketing issues for Nebraska and no active issues for the circuits feeding the Minneapolis/St. Paul STPs, which are the STPs Nebraska utilizes.**
- (3) If a similar encounter occurred today, the NOC teams would have accurate and timely information because alarm labeling has been updated on the local network side.**

REQUEST NO. 5: For the July outage, please explain in detail why the power failed at the gateway facility in Houston, Texas (HSTSTXJV) and more specifically explain:

- (1) What back up power was available, i.e. batteries, generators, other back-up power options.
- (2) Of each back-up power option available, how long was that power intended to provide power in an emergency?
- (3) Of each back-up power option available, how long was that back-up power operational prior to failing?
- (4) Of each back-up power option available that failed, what caused the failure?

RESPONSE TO REQUEST NO. 5:

- (1) The Houston site had battery strings and a backup generator. In addition, two additional temporary generators were redeployed to the site.**
- (2) Backup batteries on the DC plants are designed to operate for 4 hours without commercial or generator power. For generators, they are designed to operate indefinitely as long as a fuel supply is maintained. The two generators on-site each have a 3500-gallon belly tank and Lumen's plans ensure the generators have fuel for an extended period of time.**
- (3) There was no hard failure of the generators as the site was not immediately without power but instead was not getting enough power. Failure would have been on a circuit by circuit, system by system differentiation.**
- (4) The root cause of the generator failures was: Generator #1 failed due to sediment and algae in the diesel fuel. This is a normal occurrence and was not identified during testing - additional testing and fuel additive measures have been put into place to prevent this occurring in the future. Generator #2 failed due to a failed fuel pump.**

Dated this 16th day of October 2024.

Respectfully Submitted,

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TECHNOLOGIES GROUP**

CERTIFICATE OF SERVICE

The undersigned hereby certifies that on this 16th day of October 2024, the foregoing was submitted electronically to the Nebraska Public Service Commission via e-mail to the following:

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State 911 Administrative Assistant
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BY: /s/ Katherine A. McNamara
Katherine A. McNamara, #25142

“Exhibit 1” withheld pursuant to protective order.

**EXHIBIT
8 (911-077)**



Lumen 2024 911 Outage Report and Analysis

10/23/2024

Prepared by:



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Executive Summary

911 Authority, consultants to the State of Nebraska Public Service Commission (PSC), were commissioned to begin an independent review and assessment of an outage on the Lumen Technologies Group (Lumen) NG911 service and the actions of Lumen leading up to; and after the outage(s) under review.

This report investigates the causes and contributing factors related to the outage(s), the actions of Lumen before, during and after the failure of their NG911 service; and provides recommendations for next steps and actions that may minimize or eliminate the factors identified as contributing to the outage.

911 Authority reviewed the Lumen testimony documents and worked with the State team to identify immediate, near, and long-term remediation plans specific to the factors that contributed to the outages.

Outage Reviewed:

- A. 4/17/2024 – Fiber cut between Kansas City MO and Topeka KS disrupted the NG911 service
- B. 7/9/2024 – AC Power outage disrupted the ingress and aggregation sites, and redundancy did not perform as expected

Section 1 of the report documents what happened in the outage from the State of Nebraska perspective.

Section 2 identifies contributing factors and analysis from an independent NG911 service perspective.

Section 3 provides recommended actions and remedies.

This report reveals that Lumen Communications:

- **Does not fully implement NG911 industry standards:** The Lumen network carrying 911 traffic was operating over a collapsed fiber network. Lumen was not aware of this situation until the fiber path between Kansas City and Topeka was damaged. This indicates that Lumen had not documented the route, nor had they conducted a failover test to validate that the network would survive and that the NG911 system under contract with the State of Nebraska was diverse and redundant by the requirements in the contract and per the NENA STA-010 standard.
- **Neglects risk mitigation:** The company has not adequately planned for contingencies or addressed the risks associated with implementing a public safety-grade system.¹ Lumen is responsible (under the NG911 contract) for Ingress, Core and Egress (end-to-end) services.
- **Operates a vulnerable 911 system:** The manner that Lumen has designed and deployed the NG911 service demonstrates a lack of diversity and redundancy required to reliably deliver expected 911 call delivery results.
- **Fails to conduct adequate audits and assessments:** Regular audits and assessments of the entire service, including the internal processes, business operations boundaries, and aggregation points used for NG911 service only reflect that Lumen has created some variables with respect to delivering a complete diverse and redundant NG911 service. Had a full audit

¹ The term "Public Safety Grade" is a conceptual term that refers to the expectation of emergency response providers and practitioners that their equipment and systems will remain operational during and immediately following a major natural or manmade disaster on a local, regional, and nationwide basis.

and assessment been completed, per the FCC requirements all risks (including the internal boundaries) would have identified the gaps before they occurred, and contingencies may have been in place before risks were exposed.²

Conclusions:

In both incidents described in this outage report, both failures interrupted connections between the local aggregation switch and the LNG. While each incident was a unique failure, the result in the 911 call flow and the NG911 system was the same.

All 911 systems are vulnerable to outages. The crucial distinction lies in preparedness. The failure of Lumen's NG911 service on April 17 disrupted 911 service to a significant portion of the PSAPs in the state. The lack of redundancy and adequate diversity within the system was exposed and caused 911 traffic to not reach the PSAP. Per the Lumen network design, there was a single switch going to a single LNG that had two routes. To meet 99.999% availability Lumen would need two switches, two LNGs and four diverse routes. The secondary route intended to provide diversity and redundancy for the NG911 system (not audited by Lumen) was already re-routed over a decade before the event. Lumen had no knowledge that the primary backup fiber path was never going to supply the contingency they are under contract to provide. This is a failure on Lumen's part to mislead the State of Nebraska by being unprepared for such a risk.

On July 9, 2024, another disruption of service occurred resulting in another 911 service outage. The disruption began when the SS7 STP aggregation sited in Houston, TX experienced an AC Power issue triggered by hurricane Beryl. During this event, the Houston STP which feeds the St Paul MN and Minneapolis MN STPs that connect to Nebraska failed. Trunks between the STPs in Rancho Cordova CA, Spokane WA that were designed through the Houston STP were affected which resulted in isolating traffic at the Houston TX STP.

In each outage, Lumen was unable to provide the level of service expected for 911. Each event, while caused by different circumstances, can be traced to similar mistakes. Lumen did not audit the systems regularly and did not rigorously test the system by failing over components and network segments. If they had, they would have identified the vulnerabilities and created contingencies to avoid the high risk of service outages.

Lumen must thoroughly analyze these incidents, extract valuable lessons, and implement comprehensive changes to prevent future disruptions.

² 47 CFR § 9.19 - covered 911 service providers must annually file a certification with the Commission attesting whether they have taken measures to ensure the reliability of their network with respect to circuit diversity, backup power, and network monitoring

Section 1 Lumen Outage – What Happened?

Lumen Technologies Group provides E911 service and NG911 service to 68 PSAPs in Nebraska. The events documented below highlight the incidents that occurred.

1.1 Incident 1 – 4/17/2024

An outage of 911 service in the State of Nebraska was experienced on April 17, 2024, which lasted for 2 hours and 27 minutes (2:27). This outage was due to a fiber cut in the transport network that Lumen uses for E911 and NG911 services.

Lumen provided documentation that describes their services within the State of Nebraska. Lumen provides E911 service to PSAPs and has been contracted to provide an NG911 service for the entire State. The documentation indicates that the outage occurred on a key backbone fiber path between the State of Nebraska and the Lumen NG911 core. This fiber route is one of two (2) primary paths that route 911 traffic across the NG911 system. Lumen indicates that a fiber cut was due to a locate contractor failure. Once the failure occurred, another issue was exposed. The alternate path which should have prevented a large disruption did not operate according to Lumen assumptions. This second path was manually re-routed over a decade ago and created a collapsed ring.

1.2 Incident 1 Summary:

911 service is commonly delivered in terms of Availability. The expectations on the industry are that all 911 communications are built with “High Availability”. In the table below, the communications industry quantifies high availability as five-nines (99.999%).

Availability %	Downtime per year
90% - "one nine"	36.5 days
99% - "two nines"	3.65 days
99.9% - "three nines"	8.76 hours
99.99% - "four nines"	52.56 minutes
99.999% - "five nines"	5.26 minutes

Availability Reference table

- 1 Lumen’s lack of auditing of the paths used for 911 traffic resulted in the disruption of 911 service to the State of Nebraska. It is possible that if Lumen had realized through a diversity and redundancy audit that the fiber paths were collapsed, they would have re-designed the paths or prepared contingencies in the event of a disruption. However, the inattention to audit the network components and disregard for comprehensive network design exposed the vulnerability for them.
- 2 The Lumen system design exhibits a lack of redundancy. Industry best practices for achieving high availability (and to meet the five-nines SLA in the NG911 contract) typically involve multiple geographically dispersed sites, each housing multiple instances of each component, interconnected by redundant communication links. Lumen has made modifications to their diversity and is working to enhance the redundancy.

- a) **Redundancy:** The lack of redundancy was exposed during the outage. Lumen did not design the system to meet 99.999% availability and did not perform an effective audit of the transport.
- b) **Failover Testing:** Lumen did not conduct a complete failover test that stresses failing over networks and equipment. Had a failover test been conducted properly, Lumen would have known about the collapsed ring and been able to correct it.
- c) **Network Management System Issues:** Lumen did not have adequate network documentation to understand that part of the system was collapsed onto the same path. Once again, a design and network audit would have identified that one of the fiber routes had been changed. Furthermore, it highlights that Lumen does not do well with documentation even without performing an audit. The situation with the re-routed collapsed ring should have been known and avoided.
- d) **Lack of Path Audits:** The failed network paths could have been minimized if Lumen audited the diversity. All paths within a 911 service should undergo regular diversity audits to ensure redundancy and resilience. Shared services do not excuse audit, particularly if they are used to deliver 911.

This incident underscores a failure in risk management, contingency planning, diversity and redundancy modeling, and operational decision-making, which jeopardized public safety.

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1.3 Incident 2 – 7/9/2024 Event

Another 911 outage occurred July 9, 2024. The disruption began when the SS7 STP aggregation sited in Houston, TX experienced an AC Power issue triggered by hurricane Beryl. During this event, the Houston STP which feeds the St Paul MN and Minneapolis MN STPs that connect to Nebraska failed. Trunks between the STPs in Rancho Cordova CA, Spokane WA that were designed through the Houston STP were affected which resulted in isolating traffic at the Houston TX STP.

1.4 Incident 2 Summary:

- 1 Lumen had diverse paths, and redundancy built into the SS7 network; but this outage demonstrates that they did not have enough network diversity and redundancy for 911 services. In this instance, the disruption at the primary aggregation point caused intermittent failures at the rest of the STP's in the series.
- 2 The Lumen system design exhibits a lack of redundancy. Industry best practices for achieving high availability (and to meet the five-nines SLA in the NG911 contract) typically involve multiple geographically dispersed sites, each housing multiple instances of each component, interconnected by redundant communication links. Lumen has made modifications to their diversity and is working to enhance the redundancy.
 - a) **Redundancy:** The aggregation point of interconnect for the SS7 network is in Houston, TX. This is a location known for the potential of weather events including hurricanes. Lumen did have alternative paths, but due to the Houston STP being a primary aggregation point for the traffic from the State of Nebraska poses a vulnerability. As with any situation in 911 the rule that should be followed is a “sunny day” problem. That is simply to say traffic should not fail when it is a sunny day in Nebraska no matter where the issue in the network is. Lumen failed this test and demonstrated that they have not created enough diversity or redundancy in their solution.
 - b) **Lack of Path Audits:** The failed network paths could have been minimized if Lumen audited the diversity. All paths within a 911 service should undergo regular diversity audits to ensure redundancy and resilience. Shared services do not excuse audit, particularly if they are used to deliver 911.

1.5 Conclusions for Incident 1 and Incident 2:

While this report covers only the last two incidents, Lumen has experienced numerous disruptions leading to 911 outages. In each case, the aggregation switch and the LNG have experienced a problem. This indicates that Lumen has not implemented a system designed for reliability and for 99.999% availability. Failures of the magnitude that the State of Nebraska has experienced during the past 12 months demonstrate a pattern that Lumen has not designed a network to support the NG911 standards and has underestimated the necessary diversity, redundancy, and reliability expectations for 911 call delivery.

The root cause of the failure is a lack of diversity and redundancy in the Lumen network. This deficiency encompasses insufficient diversity in physical locations and equipment, the absence of rigorous reliability engineering analysis including risk assessment, analysis and mitigation, and inadequate auditing of the

entire 911 service from end-to-end. The State of Nebraska expects that as the NG911 provider for the state that Lumen will operate a reliable, resilient 911 system which will not be impacted by failures that could have been identified.

Achieving five-nines availability typically necessitates at least two geographically dispersed sites, each with multiple redundant sets of equipment, interconnected by at least four links capable of handling full system load. Furthermore, five-nines availability is not assessed in isolation but by evaluating the entire 911 system. Each component's meantime between failures (MTBF) and meantime to repair (MTTR) must be considered, along with the complete path from the central office (CO) to the PSAP. There is no evidence Lumen conducted such comprehensive analysis particularly at the Aggregation points of interconnection.

Regular redundancy audits are essential to ensure the system's ongoing ability to meet availability goals. Any network or system changes should trigger a redundancy audit, and availability calculations must be reassessed whenever changes occur.

Had Lumen adhered to industry's best practices for reliability and redundancy, the outcomes of these incidents could have been vastly different. The company's failure to do so and their description of how their internal business unit boundaries create gaps raise serious questions about its commitment to maintaining a robust and resilient 911 service in Nebraska.

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Section 2 Contributing Factors Review and Analysis

2.1 Lumen NG911 System

Lumen is contracted to provide a system that adheres to NENA STA-010, which is the NG911 standard. The standard requires diversity, redundancy, and the fundamental prescription that 911 networks cannot fail. From the analysis of these two incidents Lumen has not taken the steps necessary to follow the standard and implement their system according to the requirements that would have minimized, or avoided the circumstances discussed in this report.

2.2 Lumen SLA from NG911 contract

Lumen provided their response to SLA use cases in the NG911 proposal based upon standard service level objectives within their NG911 product. The contract for NG911 utilizes the SLA as the threshold for the operation of the entire system. From the contracted SLA's below with Lumens response and using Lumen' – they have exceeded the threshold.

SLA 1	<p><i>.....Ingress carrier network is designed to have multiple termination locations that can take 100% of the load in the event of a location failure. Connections to the PSAP are sized up to accommodate necessary bandwidth based on a concurrent G.711 SIP session (Call path). Each circuit is engineered to handle 100% of the call demand in the case of a failure of the primary or secondary circuit.....</i></p> <p><i>....CenturyLink integrates a comprehensive set of tools for constant monitoring and management of the network. Multiple network management components will monitor network elements, IP paths, packet rates, packet loss, retransmission, and other IP network metrics. These components will generate alarms to appropriate systems. These components generate alarms to system operators if the reliable delivery of calls or data is threatened. Delivery of monitoring reports, including bandwidth utilization and connectivity, are provided as mutually agreed upon during contract negotiations. Traditional network management tools are complemented by active application monitoring and alerting. Application elements, BRIX probes and well as SDWAN deployment will also report network failures as detected by their monitoring activity, some of which is specific to managing the availability and integrity of the network....</i></p>
SLA 10	<p><i>We will follow standard MTTR operational guidelines for responding to customer troubles and providing updates on all products. Specific MTTR criteria will establish severity levels as part of the mutually agreed SLA. TTR times begin when a trouble ticket is opened after detection or report of an outage. Calculation of TTR service level will be based on the time taken to restore service following an event that results in the outage. MTTR characteristics are commensurate with the appropriate level of service at which the ESInet system is functioning (i.e., system components in the call path are Life and Mission Critical Services (LCMS) while, peripheral systems are considered Business Critical Services (BCS). The MTTR characteristics are listed in the table below.</i></p> <ul style="list-style-type: none"> <i>* Life and Mission Critical Services (LCMS)</i> <i>* Business Critical Services (BCS)</i> <i>* Business Essential Services (BES)</i> <i>* Business Support Services (BSS)</i> <i>* Unsupported Business Services (UBS)</i>

<p>SLA 11</p>	<p><i>Based on our public safety experience, CenturyLink has found that measuring Service Availability from a call processing perspective is more applicable and relevant to 9-1-1 service vs. traditional methods of calculating availability thru MTBF and MTTR measures. CenturyLink believes that the most relevant measure of service availability is evidenced by uninterrupted, reliable 9-1-1 call routing and delivery to the PSAPs. Our NG9-1-1 availability is calculated from the time an outage begins that impacts call processing ability, until such time that the NG9-1-1 call processing ability is restored. This includes all NG9-1-1 downtime for the end-to-end service.</i></p>
<p>SLA 12</p>	<p><i>CenturyLink’s overall reliability is 99.999%. Our CenturyLink network is known for its reliability, security, and redundancy. It uses a private, high-speed, MPLS IP backbone, not the public Internet, for transmission; and it has an availability target of 99.999%. Our CenturyLink network is known for its reliability, security, and redundancy. It uses a private, high-speed, MPLS IP backbone, not the public Internet, for transmission; and it has an availability target of 99.999%. We accomplish this through problem detection, prevention, redundancy, and restoration offers to ensure that the network is always up and running. To ensure circuit 99.999% reliability will require at least two diverse circuits going to different POPs and utilizing different carriers where possible and at a minimum media diversity. Two connections are included in our ESInet design to each Host PSAP site supported by two separate edge routers and two separate IP VRF instances increasing the network reliability. All network routing infrastructure and equipment is designed and deployed in an N+1 model. N+1 redundancy provides a minimum of one additional unit, module, path, or system in addition to the minimum required to satisfy the base connectivity, ensuring that a failure of any single component at a given diverse site, such as an LNG, will not render the location inoperative making our network more reliable. Our two (2) physically diverse MPLS Network to each PSAP are predetermined, so packets travel only along the paths to which they are directed, adding reliability to our network. Our NG9-1-1 ESInet is designed to meet more stringent requirements for security, resiliency, and reliability service levels than most other IP networks. CenturyLink ESInet utilizes an MPLS private IP network that includes the use of third-party network providers that provide the local access and path diversity. These networks are comprised of different components, multiple technical solutions, and various types of interfaces. Due to the nature of MPLS-based transport, WAN failures (within the carrier network or last-mile) may not be immediately detected by NGCS network equipment at the physical layer. Knowing this, the CenturyLink ESInet solution employs a more robust means of end-to-end failure detection to ensure the reliable delivery of 9-1-1 traffic All systems and components have redundant (parallel) capabilities into each of our CenturyLink facilities to provide additional reliability including:</i></p> <ul style="list-style-type: none"> <i>* Datacenters are widely separated, and are powered off of different power grids</i> <i>* Redundant Power systems</i> <i>* Telecommunications services</i> <i>* Network electronics</i> <i>* Cooling</i> <i>* Fuel</i> <p><i>SLA Reliability - Assuming a 7x24x365 deployment (8,760 available hours), these ranges produce the following expected outage totals.</i></p>

SLA 13

1. End-to-end, the CenturyLink solution is architected to be secure, reliable, resilient, and robust. All applications and networks in the 9-1-1 call path are designed to achieve 99.999% system availability using a number of techniques to improve resiliency such as geo-diverse redundancy, fail-over techniques, virtualization, high availability, etc. The solution utilizes redundant hardware components (network interfaces, hard disks, hot swap power supplies, etc.) wherever possible, and the solution has no single point of failure. NGCS services operate in an active-active configuration in two geo-diverse datacenters. This feature employs redundant, high-quality, fault-tolerant critical components operating continuously in tandem. If one should fail, the redundant component continues to carry the entire load with no interruption of service. No failover time is required. All applications are deployed on virtual servers and data is shared among and within each datacenter. These applications leverage high availability functionality within the hypervisor. DRS and HA features are utilized to ensure an “always on” architecture. Because of this, no single point of failure will disrupt the ability to provide on-going call processing. Transactions or call traffic divert to available components on failure or degradation of service of a given functional component or a loss of a physical site. IP transport paths for critical service components are redundant and designed for multipath IP packet delivery so the failure of a given IP transport mechanism does not affect overall service availability. Core sites include redundant network transport and redundant network interfacing elements to ensure optimal operation and availability. Network interfacing elements include switches, routers, SBCs, firewalls, and other security devices. All network routing infrastructure is designed and deployed in an N+1 model. N+1 redundancy provides a minimum of one additional unit, module, path, or system in addition to the minimum required to satisfy the base connectivity, ensuring that a failure of any single component at a given diverse site, such as an LNG, will not render the location inoperative. All network connectivity is established via dynamic routing protocols. The use of dynamic routing protocols allows the routers to automatically discover each connected network and adapt to changes in the network topology. Network probes will also report network failures as detected by their monitoring activity, some of which is specific to managing the availability and integrity of the network. Network Probes – will test end to end call quality metrics (MOS Scoring) this system will also do automatic call testing to insure network availability and functionality. CenturyLink’s Statistic and Risk analysis reporting tools will be used to provide Distribution of calls by destination; Call success rate; Average call length; Average number of calls per day; Ratio of incoming versus outgoing calls; and Average mean opinion score (MOS) value scores. The NG9-1-1 Service availability SLA measures the availability requirement of 99.999% for Call Processing (“Service Availability”). Call Processing is the ability of the Service to deliver calls from the inbound Service demarcation point into the Core Call Processing Nodes and from the Service demarcation point to a Valid Destination (for example a PSAP). The Service Availability is calculated from the time an issue is reported that impacts Call Processing ability, until such time that the Service Call Processing ability is restored. The Service Availability downtime will not exceed 26.3 seconds per month. Customers are eligible for remedies and service credits when the Service Availability SLA is not achieved. 2. We use a combination of platforms for accomplishing monitoring, data management, and oversight tasks, including SolarWinds, Brix network probes. Splunk, and Oracle Operations control Monitor and others. Outputs from the various platforms are gathered, calculated, and combined into single-pane views specific to the NG9-1-1 services arena using developed

tools. This combined approach allows CenturyLink to tailor the solutions to the specific NG9-1-1 environment while leveraging best-in-class off-the-shelf tools where appropriate monthly results are viewable. Service Level Agreements (SLAs) will be provided as a part of our Program Development Plan (PDP). The CenturyLink Program Manager will work with the Commission or PSAP’s to track services against SLAs and provide monthly reporting to the customer. During the planning phase of the project the CPrgM will work with the state to define reporting criteria, format, and frequency. Refer to Attachment labeled “2.d CenturyLink Sample Program Management Plan for Nebraska.”

Nines	Availability	%	Downtime/Year	Downtime/Month*	Downtime/Week
One	0.9	90%	36.5 days	73 hours	17.18 hours
Two	0.99	99%	3.65 days	7.30 hours	1.72 hours
Three	0.999	99.9%	8.76 hours	43.2 minutes	10.1 minutes
Four	0.9999	99.99%	52.56 minutes	4.32 minutes	1.01 minutes
Five	.99999	99.99%	5.3 minutes	25.9 seconds	6 seconds

The SLA provided above is from the State of Nebraska PSC NG911 contract. The statements identified in purple in the table above, are Lumen’s written response to the use cases in the RFP based upon their understanding of the requirement, compliance with the use case, and define the service level objectives that they would provide to meet the NG911 service level requirements.

There are 23 specific service level objective use cases in the RFP, which are also part of the NG911 Contract. Of those 23 SLA provisions Lumen failed to meet their compliance threshold that they defined for 8 of the 23 objectives.

Lumen SLA violations:

- SLA 1 – Lumen did not have multiple termination locations that could 100% of the load in the event of a location failure. Once Houston TX STP failed, OSP traffic (except for a few) was unable to be delivered to the PSAP.
- SLA 10 – MTTR calculations that were completed, should have included a consideration for the length of time to gather approvals, and access to the railroad to complete the restoration of the fiber transport.
- SLA 10 – MTTR defined characteristics, and the calculation was not used to prioritize 911 recovery, and allowed a lack of coordination of priority during recovery and increased the lack of clarity among the PSC and the PSAPs.
- SLA 11 – The SLA response discusses CenturyLink MTTR is based on uninterrupted, reliable 911 calls. And that the calculation is based on the time the outage begins until normal operations have been restored. This indicates that Lumen / CenturyLink understand that this contract is for an end-to-end system. While the ESInet and NGCS did not fail, the system as contracted most certainly did fail.
- SLA 12 – The overall reliability stated by Lumen and agreed to by contract was 99.999%. This is just over 5 minutes a year.
- SLA 13 – States that the 99.999% is end-to-end NG911 service level and does not remove the Ingress and OSP aggregation from the equation.

Overall, Lumen lacked contingency plans that encompassed all of the service elements (Ingress, Core and Egress) which were tied to the SLA; that could have minimized the situation. To evaluate testimony that suggests the outage was an ingress failure and outside of the Lumen authority, which is covered by the NG911 contract for statewide services, is unacceptable. NG911 standards and the State of Nebraska contract call for Lumen to be the 911 System Service Provider (SSP) for 911. The State of Nebraska trusted Lumen with this endeavor and specified that a single authority (Lumen) would be able to work with the PSAPs to connect their 911 to the core. It was Lumen who arranged for the aggregation points of interconnection and worked with the OSPs to connect. Failure of the path from the aggregation points to the core is a Lumen outage, not an E911 outage. In addition, as mentioned earlier, the MTTR calculations should include railroad access to Lumen facilities as they became a barrier to recovery efforts.

2.3 Issues to be resolved

The review of testimony reveals systemic issues within Lumen’s organization regarding personnel, business processes, and system management, all of which contributed to the 911 service failures. The following areas require significant improvement to ensure the technology delivers the reliability expected by the 911 community.

1. **Risk Management:** Lumen has not adequately assessed risks to their system as implemented. A risk assessment if completed would have identified the vulnerabilities in both outages. Risks should have triggered a contingency / alternative plan. Testing the system would have gone a long way to identifying that the fiber path was collapsed, and that the Houston STP was a vulnerable path for their SS7 pairs.
2. **Configuration Management:** Lumen has demonstrated that they are not well informed of their own network components and paths. This is the 4th successive issue with the Lumen system and each time there has been a consistent response that they were not aware, or did not realize that there was a vulnerability. Documentation that supports the configuration of the NG911 system would go a long way in avoiding future disruptions and outages. Configuration management with risk assessments, regular audits and testing intervals is necessary to protect Nebraska from future incidents.
3. **Requirements Management:** Lumen needs a thorough analysis of customer needs and objectives to ensure system requirements are well understood, well defined, and compliant with regulations. All stakeholders must agree on changes impacting project cost, schedule, or performance. Performance requirements must satisfy user needs, and operations and maintenance requirements must be fully specified.
4. **Continuity of Operations:** Lumen must define how 911 services will be maintained regardless of incident magnitude, adhering to the “five nines” requirement as a rule, not an aspiration. This includes ingress, core, and egress without hesitation.

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Section 3 Recommended Actions and Remedies (Conclusions)

This section summarizes the recommended actions and remedies based upon the 911 Authority teams' analysis. They include:

1. Implement NG911 network standards
2. Conduct Lumen Audit of 911 Services
 - a. Risk Assessment
 - b. Configuration Management
 - c. Continuity of Operations
 - d. Disaster Recovery

3.1 Implement NG911 standards

The investigation into Lumen's 911 service outages reveals a critical need for the company to reassess its entire approach to designing, engineering, and implementing 911 services. Lumen cannot continue to ignore the ingress side of the NG911 system as outside of their authority.

The "five nines" standard (high availability) for 911 service is required by the Statewide NG911 contract. High Availability is not an arbitrary goal; it is a non-negotiable requirement to ensure public safety. High Availability is measured from end-to-end (egress of subscriber switch to ingress of PSAP), not on each product boundary. Furthermore, the NG911 contract contains an SLA that makes five-nines a mandatory threshold without regard to ingress core and egress.

Lumen must evaluate all its networks in service in Nebraska to evaluate their ability to provide an NG911 system that meets the NENA standards and exceeds the current legacy 911 framework. Lumen has continued to put the 911 callers and the State of Nebraska in jeopardy due to multiple failures. Implementing NG911 according to the standard is imperative, and it must not be marginalized by the telco groups in favor of their siloed polices with respect to alert and notification, outage management, response, and recovery. This entails applying the most current NG911 standards to every component of their network and service, encompassing multiple paths, multiple vendors, additional network support tools, additional electrical power sources, and modified connections to both OSPs and PSAPs to ensure uninterrupted operation.

Lumen's inability to provide reliable 911 service even if they suggest ingress failures are not a part of the NG911 system; it puts lives at risk and erodes public trust. Each of these incidents could have been prevented or minimized had Lumen implemented to the NG911 standards and conducted a detailed audit of the facilities and design.

3.2 Conduct Audit of Lumen 911 Services

Lumen certifies its annual compliance with the FCC's 911 audit requirements. This audit provides some assurance that the service they are delivering meets a minimum requirement. Commonly the audit process does not uncover individual component issues or directly assess the service and system within the boundaries of industry standards. Based on a review of the outage it is also unlikely that the service meets many of the requirements established in 47 CFR part 9 as follows.

47 CFR 9.19(a)(10) *Provision of reliable 911 service. All covered 911 service providers shall take reasonable measures to provide reliable 911 service with respect to circuit diversity, central-office backup power, and diverse network monitoring. Performance of the elements of the certification set forth in paragraphs (c)(1)(i), (c)(2)(i), and*

(c)(3)(i) of this section shall be deemed to satisfy the requirements of this paragraph. If a covered 911 service provider cannot certify that it has performed a given element, the Commission may determine that such provider nevertheless satisfies the requirements of this paragraph based upon a showing in accordance with paragraph (c) of this section that it is taking alternative measures with respect to that element that are reasonably sufficient to mitigate the risk of failure, or that one or more certification elements are not applicable to its network.

Annual reliability certification. One year after the initial reliability certification described in paragraph (d)(1) of this section and every year thereafter, a certifying official of every covered 911 service provider shall submit a certification to the Commission as follows.

(1) Circuit auditing.

(i) A covered 911 service provider shall certify whether it has, within the past year:

- (A) Conducted diversity audits of critical 911 circuits or equivalent data paths to any PSAP served.*
- (B) Tagged such critical 911 circuits to reduce the probability of inadvertent loss of diversity in the period between audits; and*

I Eliminated all single points of failure in critical 911 circuits or equivalent data paths serving each PSAP.

(ii) If a Covered 911 Service Provider does not conform with all of the elements in paragraph I(1)(i) of this section with respect to the 911 service provided to one or more PSAPs, it must certify with respect to each such PSAP:

- (A) Whether it has taken alternative measures to mitigate the risk of critical 911 circuits that are not physically diverse or is taking steps to remediate any issues that it has identified with respect to 911 service to the PSAP, in which case it shall provide a brief explanation of such alternative measures or such remediation steps, the date by which it anticipates such remediation will be completed, and why it believes those measures are reasonably sufficient to mitigate such risk; or*
- (B) Whether it believes that one or more of the requirements of this paragraph are not applicable to its network, in which case it shall provide a brief explanation of why it believes any such requirement does not apply.*

(3) Network monitoring.

(i) A covered 911 service provider shall certify whether it has, within the past year:

(A) Conducted diversity audits of the aggregation points that it uses to gather network monitoring data in each 911 service area.

(B) Conducted diversity audits of monitoring links between aggregation points and NOCs for each 911 service area in which it operates; and

I Implemented physically diverse aggregation points for network monitoring data in each 911 service area and physically diverse monitoring links from such aggregation points to at least one NOC.

(ii) If a Covered 911 Service Provider does not conform with all of the elements in paragraph I(3)(i) of this section, it must certify with respect to each such 911 Service Area:

- (A) Whether it has taken alternative measures to mitigate the risk of network monitoring facilities that are not physically diverse or is taking steps to remediate any issues that it has identified with respect to diverse network monitoring in that 911 service area, in which case it shall provide a brief explanation of such alternative measures or such remediation steps, the date by which it anticipates such remediation will be completed, and why it believes those measures are reasonably sufficient to mitigate such risk; or*
- (B) Whether it believes that one or more of the requirements of this paragraph are not applicable to its network, in which case it shall provide a brief explanation of why it believes any such requirement does not apply.*

While Lumen self-assures the FCC through this process, Lumen should consider performing an audit of its entire NG911 solution by an independent resource. An Independent Validation and Verification (IVV) would find the gaps in the system operationally and technically. An IVV may identify gaps with the individual product lines integrated into the NG911 contract for services. This type of verification would help Lumen be better prepared to support the State of Nebraska. Lumen should also conduct a full

assessment of the Administration, Operation and Technical aspects of the NG911 service and any system that is being used to deliver 911 from ingress, to core, to egress. An audit of this nature will ensure compliance with the diversity and redundancy requirements from the standards.

Along with the audit for services, Lumen must consider improving their internal operational processes to include:

1. Audit and assessment of all facilities used for 911
 - a. Complete a full-scale audit of all facilities used for 911 call delivery. Lumen clearly makes assumptions based on a false notion that their facilities can meet the 911 requirements. Based on the 4 outages experienced Lumen lacks understanding of where and what their facilities are doing with respect to the State of Nebraska NG911 contract.
2. Risk Assessment
 - a. Complete risk assessment of all networks, components, sub-contractors, and any services provided by other parties necessary for delivering 911 calls. If any of these services or systems experience a disruption or outage, Lumen is responsible. The assessment of risk should include a risk mitigation and response plan even for those services not under direct control of Lumen. Furthermore, the risk assessment should highlight a quantifiable threshold of risk to determine when a system is in jeopardy prior to a full-scale failure.
3. Configuration Management
 - a. Utilize a configuration management database that contains an up to the present documentation of all functional components and networks used in the system. This includes any third-party networks, or equipment. The CMDB should be the primary resource for all documentation and must be kept current with any change management activities that occur.
4. Continuity of Operations
 - a. Lumen must develop a comprehensive Continuity of Operations plan for the NG911 system. The NG911 system itself should not fail on the scale it has in the State of Nebraska. Especially since this is the 3rd, and 4th successive failure in less than 12 months. Lumen must put more emphasis on ensuring that the system and the 911 callers and PSAPs are not put at additional risk by using their NG911 platform.

3.4 Violation Analysis

The figure below defines the boundary expected for NG911 System Service Providers. An NG911 SSP who implements a large statewide system such as the one that Lumen has in Nebraska must include the Ingress Core and Egress in the service platform. While some of the component pieces are not directly under Lumen control, it is their responsibility as contracted to the State. Lumen testified that Ingress is not in their control, but its facilities and systems are an important component in how the network operates upstream.

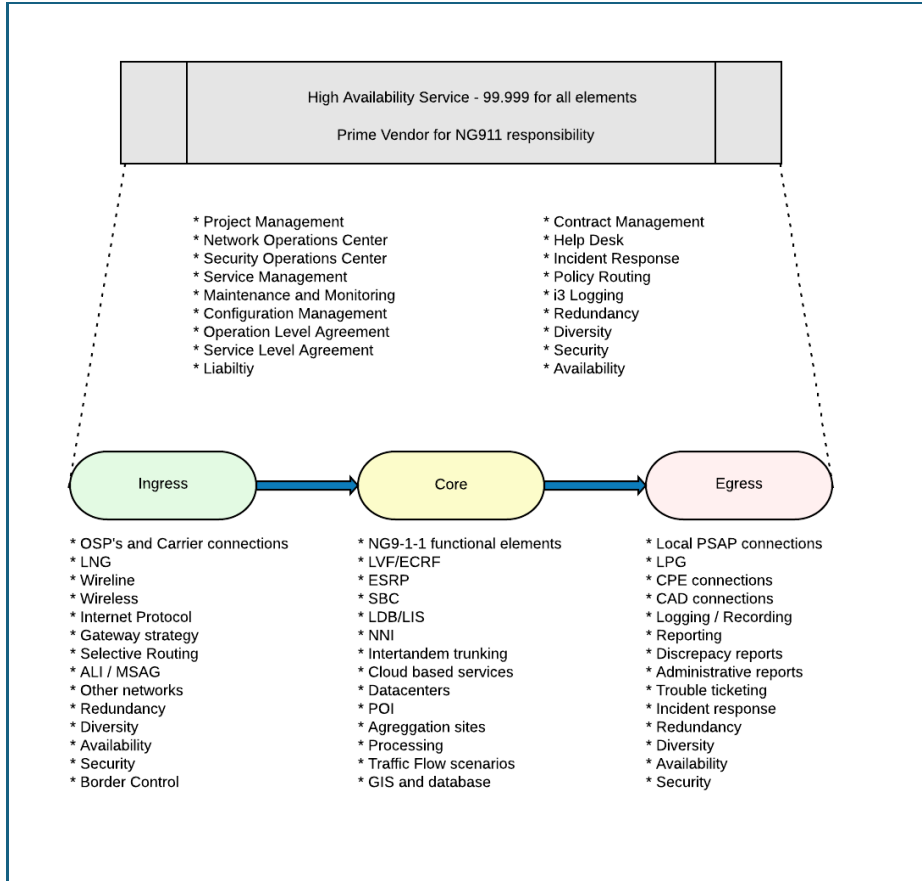


Figure 1: NG911 System Service Provider responsibilities

Appendix A Documentation Citations

- PSAP responses to 7-9-2024 outage.xls
 - a. Spreadsheet of correspondence with PSAPs concerning the effects of the disruption
- PSAP Responses to 4-17-2024 Service Disruption.xlsx
 - a. Spreadsheet of correspondence with PSAPs concerning the effects of the disruption
- RFO_29161686_NE_RFO_Approved.pdf
 - a. Reason For Outage provided by Lumen for 4/12/2024 Outage
- RFO_29706775_State of NE NG911_RFO_Final.
 - a. Reason For Outage provided by Lumen for 7/9/2024 Outage
- Ex 6 Lumen's Responses to First Set of Data Requests.pdf
 - a. Exhibits provided by Lumen
- Ex 7 Lumen's Responses to Second Set of Data Requests.pdf
 - a. Exhibits provided by Lumen
- 2024-08-05 911-077 C-5581 PI-252 Protective Order.pdf
 - a. Lumen Protective Order
- Lumen Contract
 - a. Lumen NG911 Contract
- Lumen NDA
 - a. Lumen NDA
- Lumen – Business Continuity Overview
 - a. Lumen Business Continuity plan
- Lumen – SLA
 - a. Lumen Service Level Agreement for NG911

- NOTHING FOLLOWS -

BEFORE THE NEBRASKA PUBLIC SERVICE
COMMISSION

EXHIBIT 9 (911-077)

In the Matter of the Nebraska Public
Service Commission, on its own
motion, conducting an investigation
into the 911 service outage that began
on August 31, 2023 in areas of
Nebraska served by Lumen and its
affiliates.

) Application No. 911-075/ PI-248
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In the Matter of the Nebraska Public
Service Commission, on its own
motion, conducting an investigation into
911 service outages occurring in areas
of Nebraska served by Lumen and
its affiliates.

) Application No. 911-077/ C-
) 5581/PI-252
) WRITTEN TESTIMONY OF BRIAN
) ROSEN
)
)
)
)

November 5th, 2024:

PSC Docket 911-075 / PI-248 Pre-filed testimony of Brian Rosen

1. What is your name and occupation?

A: Brian Rosen. I am a systems architect and consultant.

2. Did you provide a curriculum vitae and does that document summarize your experience working in the telecommunications industry and is that marked as exhibit 12 on docket 911-077/C-5581/PI-252, and exhibit 61 on docket 911-075/ PI 258 and is the information it contains true and complete to the best of your knowledge?

A: Yes.

3. What is your role with the 911, Authority, LLC?

A: I am a consultant and subcontractor to 911 Authority, LLC.

4. What does 911 Authority, LLC do?

A: We provide consulting services to states and local governments on 911 systems.

5. As part of a contract between the Nebraska Public Service Commission and 911 Authority, LLC were you asked to provide an expert opinion regarding service interruptions that occurred in Nebraska on August 31, 2023, April 17, 2024, and July 9, 2024?

A: Yes

6. Are your findings contained in two reports one being Exhibit 57 under docket 911-075/PI-248 and Exhibit 8 on Docket 911-077/C-5581/PI-252?

A: Yes

7. Please explain your understanding of the part of the Lumen system that failed in all of the events at issue here:

A: Lumen has a "Legacy Network Gateway" which converts legacy 911 signaling to NG911 signaling (also known as i3 signaling). A number of legacy telephone switches connect to a selective router in Nebraska which operates as an aggregation switch, aggregating the 911 calls from all the local switches. There is a network that connects the aggregation switch to the LNG. This network, which uses SS7 signaling, has failed, in different ways for each outage, which interrupts the 911 calls from the aggregation switch to the LNG.

8. Please explain what a 99.999% (or five nines) system means?

A: It represents the percent of the time a system is available to do the job it is intended to do. Five nines systems are only allowed to be down .001% of the time, which is about 5 minutes a year. While we can measure actual availability, typically, we calculate projected availability, which is a product of Mean Time Between Failures and Mean Time to Repair a failure.

9. Please explain how we determine if a system meets a 99.999% availability standard

A: While we can measure actual availability, typically, we calculate projected availability, which is a product of Mean Time Between Failures (MTBF) and Mean Time to Repair a failure (MTTR). We accumulate the MTBF of all the components of the system, and the expected best case and worst case repair time for each component. If a system calculation doesn't meet five nines, we add additional redundancy and/or improve the MTBF or MTTR to achieve our needed availability

10. Is the Lumen 911 network, designed to meet that standard? Why or why not?

A: Not in my opinion. Based on my understanding of typical MTBF and MTTR values of the systems used, and based on the actual results, the system is unable to meet a five 9s standard. While most of the components have a reasonably high Mean Time Between failures, it appears to me there is an exceptionally low level of redundancy. In a typical design, involving an aggregation switch, LNG and the network that connects them in a 911 system, there would be two geographically diverse sites, each containing at least 2 instances of every component, and they would be connected by a total of at least four separate network connections or links, two per site. And given the observed MTBF and MTTR of these events, when considered in total, I think that any real calculation would show that even that would not be sufficient, especially considering the issues raised by these events.

11. What caused the service interruption that occurred on August 31, 2023?

A: Two fiber cuts in a ring service caused a failure in a SS7 network, which was the only connection between the aggregation switch and the Legacy Network Gateway, which resulting in 911 calls traversing that connection to fail.

12. What caused the service interruption on April 17, 2024?

A: A single fiber cut in what was supposed to be a ring connection caused a failure of the same part of the 911 system which was the connection between the aggregation switch and the Legacy Network Gateway, albeit in a different part of that connection. It turned out, according to Lumen's own response, that a failure over a decade ago somewhere else on the ring was never rectified, and thus the single failure in this event caused the connection to fail, which again interrupted calls between the aggregation switch and the Legacy Network Gateway. Normally it would take two fiber cuts to sever the connection, but because the 11 year old cut

was never fixed, at least for this network, a single fiber cut caused the network to fail. In this failure, it wasn't the SS7 signaling that failed, but the trunk connections that actually carry the voice traffic that were severed. The result was the same, 911 calls going between the aggregation switch and the Legacy Network Gateway failed.

13. What caused the service interruption on July 9, 2024?

A: A power failure in a Houston facility caused yet another failure in the same SS7 network, again in a different part of the network than the other incidents. While normally, that part of the SS7 network has components in at least two geographically diverse sites, all four connections were routed through the single Houston site.

14. For all of these service interruptions at least one of the triggering events, occurred outside the state of Nebraska, how and why do out of state events, impact different areas within Nebraska and not the entire state?

A: Lumen chose to use a national network to connect the aggregation switch to the Legacy Network Gateway. That network is a large ring which traverses many states. Failures along the path of the ring can affect calls connecting from the aggregation switch in Nebraska to the LNG in Chicago. In the case of the July 9th incident, the ring itself was not affected, but the switches that connect the Signaling Transfer Points in the network were all routed through Houston, which meant a failure in Texas interfered with calls in Nebraska and other states.

15. The report also outlines root causes for the three service interruptions, please describe what causal commonality each service interruptions share?

A: A surprising lack of redundancy throughout. The aggregation switch (which is not itself redundant) is connected to a single LNG, through a single network. Any failure causes a complete break in the 911 system serving the subscriber switches connected to the aggregation switch. While each incident shows a different lack of redundancy, the pattern is quite clear, and alarming. There is no way rigorous analysis of this network could ever have a five 9s availability, and that availability requirement is on the whole 911 system and not just this piece.

Furthermore, there is a total lack of auditing for diversity. 911 circuits are supposed to be audited periodically and Lumen appears to believe that since the fiber path was not solely dedicated to 911 that it doesn't have to audit it. I think that is wrong. Compounding this, they apparently never test failover, which is a fundamental tool to assure that when you need the redundant elements, they will be available to take over.

16. How does the service interruption that occurred on August 31, 2023, demonstrate that commonality?

A: Failure of a single network, the fiber ring, caused failures for all calls sent between the aggregation switch and the LNG. There was only the one ring that connected the single aggregation switch to the single LNG. None of those should have been single points of failure.

17. How does the service interruption that occurred on April 17, 2024, demonstrate that commonality?

A: The single fiber cut brought down a different part of the network that connected the single aggregation switch to the single LNG. Not only was the ring collapsed for over a decade, but it was the only connection for all the trunks. The lack of auditing and failover allowed the collapsed ring to be undetected prior to the failure.

18. How does the service interruption that occurred on July 9, 2024, demonstrate that commonality?

A failure of a single site brought down a different part of the SS7 network that connected the single aggregation switch to the single LNG. The routes for all four SS7 signaling links ran through a single site. Lack of auditing and lack of failover testing allowed this situation to persist for a long time.

19. In your opinion what changes to Lumen's network would need to be in place to prevent that causal commonality from reoccurring?

A: Lumen must implement true five 9s availability across the entire 911 system it provides to Nebraska, from the egress of a subscriber switch to the ingress of a PSAP. It must complete a thorough reassessment of network design, prioritizing redundancy, and resilience, investing in advanced monitoring and alarm systems, and adopting a proactive maintenance strategy.

20. Would those same changes achieve 5 nines? Why or why not?

A: If implemented conscientiously, I believe they would. If the system was architected for five 9s from subscriber switch egress to PSAP ingress and implemented with care, I believe Nebraska could indeed have a system that was available 99.999% of the time.

21. In your opinion, what changes in Lumen's operating procedures are needed, beyond the changes in the network, to be achieved to prevent these kinds of events from happening?

A: If Lumen did architect the 911 system to meet a 5 nines availability standard, and it implemented the system to that design. it then has to audit the

implementation, to assure Nebraska that the resulting 911 system will meet its SLAs to the State, and FCC regulations. The audit has to be rigorous, and cover the entirety of the 911 system.

And, it has to greatly improve its monitoring and recovery processes. We were struck by the realization that during all of these events, the Lumen 911 staff made no effort to work around the problem; they just waited until the network came back up. They had no contingency planning, no ability to make any kind of alternate arrangements. They just waited until the SS7 network was restored. Lumen must treat 911 as mission critical, and not just another revenue source.

22. Please explain some more about audits. What audits is Lumen not doing which you think they should be doing?

A: Every redundant path has to be audited to assure that it is, indeed redundant, and conforms to the design that was predicted to meet 5 nines. The audit must be at every level: signaling, circuit and physical. The audits have to be completed regularly, as per the FCC regulations.

State contract (Exhibit 10) may be found [here](#).

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Background Summary

Consultant in deployment of Next Generation 9-1-1. Consultant in Video Relay Service (VRS). Primary standards author, system architecture and leadership of Next Generation 9-1-1 project. Forty-year history of bringing groundbreaking technology advances to market. Seasoned entrepreneur and systems architect in computer systems, networking, medical imaging and other disciplines. Aggressive new technology thought leader. Able to rapidly master complex new problems and lead teams to achieve aggressive goals. Subject Matter expert in public safety systems, concentrating on the 9-1-1 system and Video Relay Service. Experienced standards participant with strong leadership credentials.

Work History

2018 – Present Brian Rosen Technologies LLC, Principal. Consultant to states and local governments on deployment of Next Generation 9-1-1. Assist in creating Request For Proposals, evaluation of responses, selection of vendors and monitoring progress. Technical evaluations of failures. Consultant to company's and government on Video Relay Service which serves the deaf community. Currently co-chair of the sipcore and vcon working groups in IETF, and the i3 architecture working group in NENA. Recent projects include:

- Bond Communications: Chief Architect of a new Video Relay Service. Assist founder to specify and implement a new VRS system with deaf children and their families as initial target customers.
- State of Nebraska: Assist in evaluating multiple failures of the 911 system and recommending mitigation measures
- Washington State: expert witness to the State Attorney General Public Counsel regarding failures of the 911 system
- Mitre Corporation: Advise Mitre and FCC on issues in the Video Relay Service.

2005 – 2018. Neustar Inc, Sterling VA. Various Positions, most recently Fellow. Subject Matter Expert for 9-1-1 and other public safety efforts as well as Neustar's participation in Deaf/Hard of Hearing services. Systems Architect for a number of ENUM based services including the iTRS Directory, a highly reliable/redundant call routing database provided under contract to the FCC for the deaf community. Direct contact with FCC staff for deaf communications services. Ran a team building external tests to assure Neustar services remain available to customers. Assisted other teams in architecture, technology direction and standards compliance. Active participant in standards activities in IETF and the National Emergency Number Association.

2004 – 2005 Founder and President, Emergicom, Mars, PA

This was a new startup working on upgrading public safety communications systems including the 9-1-1 system and responder communications networks which was never funded.

1999 – 2004. Marconi (formerly FORE Systems), Warrendale, PA. Various positions, most recently Vice President, Technology Introduction. Reported to Tim Dwight, Chief Technology Officer, Broadband Routing and Switching Division. Marconi was an international leader in telecommunications networking products, with particular strengths in optical, access and broadband routing/switching. Duties include Voice/Video Over IP product direction, architecture, new product innovation and standards activities. I also worked on emergency call (9-1-1) for VoIP. Was a significant contributor to the VoIP efforts at the Internet Engineering Task Force (IETF, the Internet standards body) and NENA, the National Emergency Number Association.

I was the leader of a small team that developed an entirely new telepresence product line for Marconi. Called “ViPr” (for “Virtual Presence”), this product is generally acknowledged as a breakthrough communications tool for geographically dispersed teams. I conceived the product, defined its architecture, recruited the team, and lead the engineering effort through general release to customers.

As an individual contributor, I worked on the area of multimedia communications on data networks as well as security for data networks. I did architecture work on several of Marconi’s telecom products, and was frequently called upon to make presentations to customers on our work in these areas, as well as speak in many industry events.

1994-1998, NOMOS Corporation, Sewickly, PA. Various positions, including Director of Technology Assessment and Vice President of Product Implementation. Reported to Mark Carol, President and Founder, or Gil Peterson, COO. NOMOS manufactures complex computer based systems for treatment planning and delivery of radiation therapy. The products I was involved in are presently the standard of care for certain forms of cancers of the brain and other organs, using Intensity Modulation Radiation Therapy, pioneered by NOMOS. I recruited and lead the initial development team that developed a planning tool as well as the electronics and software for the delivery device and served as the architect of it’s main product from its inception through initial customer release. I later started a project that became the company’s second product line that uses ultrasound to do very accurate soft tissue localization. At NOMOS I created the initial software development process and documentation systems that easily achieved FDA clearance. I managed and staffed most of the company’s administrative, manufacturing and technical support teams from 1994-5. During that time I was also responsible for creating the company’s quality and safety programs.

1992- 1994, Cognos-centi Corporation, Pittsburgh, PA. President. Founded this consulting company which did the initial research and conceptualization for radiation oncology systems under contract to Medical Equipment Development Corporation. In early 1994, MEDCO acquired Cognos-centi and became NOMOS Corporation.

1989-1992, Mars Microsystems, Wexford, PA. President and Founder. Mars designed Sun compatible workstations for far-east manufacturers. Its major product was the Mariner 4i, an innovative workstation that had both SPARC and x86 processors and was 100% compatible with all Solaris and Windows applications. All functions except marketing and sales reported to me. I directed cross-functional teams with Mars engineers, on-site Taiwanese nationals and engineers in Taiwan, with support functions provided by the corporate headquarters staff. I served as the systems architect for the product.

1985-1989, MegaScan Corporation, President and Founder. MegaScan was a venture capital funded startup that developed ultra-high resolution monitors and display controllers. MegaScan's initial product was a 4096 x 3300 resolution, CRT based, 300 dpi, black-and-white display system, used for pre-press automation/page layout. Its major success was a 2560x2048, 12 bit grayscale system which was the first display acceptable by radiologists for diagnosis of chest X-Rays. These products, with nearly identical specifications, are still in production for radiology PACS (Picture Archiving and Communications Systems) in use hospitals worldwide.

1978-1995, Perq Systems (originally, Three Rivers Computer Corp), Founder, Vice President, Engineering and Vice President, Advanced Development. Perq delivered the first engineering workstation, predating Sun Microsystems and all competitors. I was the systems architect and engineering manager for the entire product line that was based on my work at Xerox PARC.

1976-1978, Xerox Palo Alto Development Center, Palo Alto, CA, Member of Technical Staff. Design engineer on the "Dolphin" the middle range processor that was part of Xerox's STAR workstation effort. I also designed the memory system for the "Dorado", the high-end workstation.

1970-1976, Carnegie-Mellon University, Computer Science Department Engineering Laboratory, Staff Engineer. Designed research equipment for artificial intelligence. My major project was a calligraphic computer graphics system.

Industry Organizations

- 2003-present co-chair of National Emergency Number Association (NENA) i3 Architecture working group and active contributor to 5 other work groups. Technical Editor of NENA STA-010.2, the base NG9-1-1 technical standard. Major contributor to APCO/NENA Emergency Incident Data Document work. Also significant contributor to NG GIS, NG PSAP and other NG9-1-1 standards work.
- 2017-present co-chair of Internet Engineering Task Force (IETF) sipcore working group
- 2005-2016 co-chair of Internet Engineering Task Force (IETF) p2psip, siprec and paws working groups. Author/Co-Author of ~17 RFCs

2011-2012 editor of Database-to-Database Synchronization Interoperability Specification, Whitespace Database Administrator's Group
2010-2013 Committee member of various CSRIC groups. Co-chair of WG2, SG2
2004-2009, co-editor of NRIC VII Focus Groups 1b and 1d reports
2001-2003, co-chair of Internet Engineering Task Force SIP Working Group.
2000-2002, organizer of Megaco Interop Events, held at the University of New Hampshire
2000-2002, co-chair of Technical Advisory Committee (TAC) of the International Softswitch Consortium
2000-2001, interim chair, Interoperability Working Group, Multiservice Switching Forum
1999-2002, co-author and IETF editor of RFC3015, Megaco Protocol
1998-2000, contributor to VoATM and Security working groups of the ATM Forum

Volunteer Activities

1997-Present, National Armorer, USA Fencing
1993-2005, Board Member, Pine Township Zoning Hearing Board
1992-1995, Assistant Scoutmaster, Troop 344, Wexford

Personal

Married, 4 children 5 grandchildren.
Leisure activities include gardening, woodworking, most water sports and travel.

“Exhibit 12” withheld pursuant to protective order.

“Exhibit 13” withheld pursuant to protective order.

“Exhibit 14” withheld pursuant to
protective order.