

Redundancy and Resiliency in Vermont's 9-1-1 System

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August 2018

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MEMORANDUM

TO: Joint Fiscal Committee

FROM: Barbara M. Neal, Executive Director *bmn*

DATE: August 31, 2018

RE: Report on Redundancy and Resiliency in Vermont's 9-1-1 System

As required by Act 11 of the 2018 Special Session, this report, *Redundancy and Resiliency in Vermont's 9-1-1 System*, is presented to the Joint Fiscal Committee by the Vermont Enhanced 9-1-1 Board. The purpose of the report is to:

- detail the level of resiliency and redundancy within the 9-1-1 system;
- explain plans for ensuring operational integrity in the event of critical software or hardware failures;
- include, with explanation, identification of the locations and services deemed most vulnerable to system outages or call failures, as determined by the Board;
- include a cost estimate for making any recommended system upgrades.

The information in this report is supported by detailed technical documentation. Every effort has been made to provide a sufficient level of detail to address the report requirements without compromising the security and integrity of the statewide 9-1-1 system.

The Enhanced 9-1-1 Board has established strong relationships with multiple partners who have the shared goal of ensuring the reliable delivery of Vermont 9-1-1 calls. We are committed to working with these partners, the legislature, and all stakeholders, to ensure the integrity of Vermont's statewide 9-1-1 system.

The Enhanced 9-1-1 Board welcomes your questions and comments on this report or any aspect of the statewide 9-1-1 system.

Thank you.

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Executive Summary

Introduction

As required by Act 11 of the 2018 Special Session, this report, *Redundancy and Resiliency in Vermont's 9-1-1 System*, is presented to the Joint Fiscal Committee by the Vermont Enhanced 9-1-1 Board. The purpose of the report is to:

- detail the level of resiliency and redundancy within the 9-1-1 system;
- explain plans for ensuring operational integrity in the event of critical software or hardware failures;
- include, with explanation, identification of the locations and services deemed most vulnerable to system outages or call failures, as determined by the Board;
- include a cost estimate for making any recommended system upgrades.

The information in this report is supported by detailed technical documentation. Every effort has been made to provide a sufficient level of detail to address the report requirements without compromising the security and integrity of the statewide 9-1-1 system.

Multiple Networks Involved in the 9-1-1 Call Delivery

A discussion of redundancy and resiliency within the 9-1-1 system must begin with an understanding of the networks involved in 9-1-1 call delivery. When a call is placed to 9-1-1 in Vermont, it will traverse many networks before being answered by a Vermont 9-1-1 call-taker. These networks can be grouped into three categories:

Originating Service Provider (OSP) Networks – The OSP networks are owned and operated by the service providers that offer calling services to customers such as cellular plans, VoIP or traditional wireline service.

9-1-1 Tandem/Legacy Network Gateway (LNG) Environment – The 9-1-1 tandems serve as the aggregation point for all 9-1-1 traffic from the OSP networks. The aggregated traffic is converted from Time Division Multiplex (TDM) to Internet Protocol (IP) in the LNG for delivery into the Next Generation 9-1-1 system.

Next Generation 9-1-1 (NG911) System – The NG911 system processes and selectively routes 9-1-1 calls to Vermont's six Public Safety Answering Points (PSAPs) and provides associated data to allow the call-taker to effectively assist an emergency caller.

Resiliency and Redundancy in Each Network

OSP Networks

VoIP and Cellular OSPs – Primary and secondary routes are available for the delivery of 9-1-1 calls from VoIP and cellular OSPs to the two geo-diverse 9-1-1 tandems in Vermont. Failure of

both routes results in the calls being delivered directly into the NG911 system via a third dedicated route.

Wireline OSPs – Two routes are available for the delivery of wireline 9-1-1 traffic to the geo-diverse 9-1-1 tandems. In some cases, a third and fourth route also exist.

9-1-1 Tandem/LNG Environment – There are two geo-diverse 9-1-1 tandems in Vermont. Each tandem has five Time Division Multiplexing (TDM) routes for 9-1-1 call processing. Two geographically diverse switches in the LNG environment convert the calls from TDM to IP for delivery into the NG911 system. Each switch has two possible IP routes and one TDM route into the NG911 system. If all routes fail, 9-1-1 calls are delivered to a dispatch line in one of the six PSAPs via a dedicated direct inbound dial (DID) number.

NG911 System – Once a 9-1-1 call is received by the NG911 system from the 9-1-1 tandem/LNG environment, it is routed to the primary PSAP based on the caller's location. If the primary PSAP is unavailable, the call is automatically rerouted to an available call-taker at one of the five remaining PSAPs. The NG911 system is supported by two redundant geo-diverse data centers. A failure of both data centers or a loss of connectivity to all PSAPs results in the delivery of the 9-1-1 call over a dedicated DID number that delivers the calls to a PSAP dispatch line(s).

Identified Vulnerabilities in Each Network, Existing Mitigation, Recommendations for Change and Associated Costs

The table below summarizes the Board's findings related to vulnerabilities in each network involved in 9-1-1 call delivery and provides the existing mitigation for each vulnerability, Board recommendations for any changes, and an estimate of associated costs.

Identified Vulnerabilities in Originating Networks	Mitigation	Recommendation	Costs
Central Office Isolation	Emergency Stand Alone where available	Continued discussion and research of potential mitigation steps	None at this time
Backhaul connectivity for cellular base stations	Overlapping cellular and/or wi-fi signals where available	Encourage continued growth of cellular coverage in Vermont by commercial carriers	N/A
Identified Vulnerabilities in 911 Tandem/LNG Environment	Mitigation	Recommendation	Costs
LNG Environment – Factors contributing to January 5, 2016 event	Final Route to DID	Await PUC investigation results	None at this time
Identified Vulnerabilities in NG911	Mitigation	Recommendation	Costs
Physical diversity to each PSAP	Holistic system design delivers calls to alternate PSAPs when a primary PSAP is offline	None – this vulnerability is mitigated by system design	None

The Vermont 9-1-1 system, and the various networks involved in 9-1-1 call delivery, are resilient and have redundancy throughout. Mitigation steps are in place to lessen the risks of known vulnerabilities.

The Enhanced 9-1-1 Board has established strong relationships with multiple partners who have the shared goal of ensuring the reliable delivery of Vermont 9-1-1 calls. These partnerships also allow the Board to identify the appropriate course of action in the event of any concerns about, or failures of, 9-1-1 call delivery. The Vermont Enhanced 9-1-1 Board is committed to working with these partners, the legislature, and all stakeholders, to ensure continued redundancy and resiliency in the statewide 9-1-1 system.

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Introduction

Overview

This report was developed in response to the requirements of Act 11¹ of the 2018 Special Session of the Vermont General Assembly. Act 11 requires that on or before September 1, 2018, the Executive Director of the Enhanced 9-1-1 Board provide a report to the Joint Fiscal Committee that:

- details the level of resiliency and redundancy within the 9-1-1 system;
- explains plans for ensuring operational integrity in the event of critical software or hardware failures;
- includes, with explanation, identification of the locations and services deemed most vulnerable to system outages or call failures, as determined by the Board;
- includes a cost estimate for making any recommended system upgrades.

This report will focus on the resiliency and redundancy of the networks involved in the delivery of 9-1-1 calls from a service provider's originating network, through the 9-1-1 tandems/Legacy Network Gateway (LNG) environment, and into Vermont's Next Generation 9-1-1 (NG911) system.

The information presented in this report is supported by detailed technical documentation where available. In many cases, the supporting documentation contains proprietary information and/or technical details related to system security. In this report to the Joint Fiscal Committee, every effort has been made to provide a sufficient level of detail to address the report requirements without compromising the security and integrity of the statewide 9-1-1 system.

Background and Current Environment

30 V.S.A Chapter 87² established the Vermont Enhanced 9-1-1 Board as the single governmental agency responsible for the statewide 9-1-1 system. The Board consists of nine members, appointed by the Governor, representing state, local and county law enforcement, emergency medical and fire service, municipalities, and the public. Ten Board staff members are responsible for day-to-day oversight and management of the system and system provider, GIS and database management, training, quality control, public education, and administrative functions.

The Board has developed, and relies upon, effective partnerships with multiple stakeholders to fulfill its responsibility for management and oversight of the statewide 9-1-1 system. The Board works closely with many agencies and organizations – both public and private – to ensure the reliable and effective operation of the 9-1-1 system. Stakeholders include, but are not limited to, Vermont's Agency of Digital Services, Public Service Department, Department of Public Safety,

¹ Act 11 - An act relating to making appropriations for the support of government, financing education and vital records, Sec. E.235, (2018 Spec. Sess.),

<https://legislature.vermont.gov/assets/Documents/2018.1/Docs/Acts/ACT011/ACT011%20As%20Enacted.pdf>

² 30 V.S.A §7051-7061, (1993 Adj. Sess.), <https://legislature.vermont.gov/statutes/chapter/30/087>

Department of Health, regional dispatch centers serving as Public Safety Answering Points (PSAPs), emergency response agencies and their dispatch centers, wireline, cellular and VoIP telephone service providers, and municipal 9-1-1 coordinators in every Vermont town.

Currently, the Board contracts with Consolidated Communications for a fully-hosted NG911 system. Approximately 200,000 9-1-1 calls per year³ are processed by the system and routed to fully trained and certified 9-1-1 call-takers in six geo-diverse PSAPs⁴ in the state. The answering PSAP may provide dispatch services for any given emergency or may transfer the call to one of nearly fifty dispatch centers serving Vermont.

³ Enhanced 9-1-1 Board, *2017 System Statistics*, January 2018, <http://e911.vermont.gov/2017 Stats>

⁴ Enhanced 9-1-1 Board, *PSAP Configuration Map*, updated November 7, 2017, http://e911.vermont.gov/vermont_911

Redundancy and Resiliency in 9-1-1 Call Delivery

Networks Involved in Delivery of 9-1-1 Calls

When a call is placed to 9-1-1 in Vermont, it will traverse many networks before being answered by a Vermont 9-1-1 call-taker. These networks can be grouped into three categories:

Originating Service Provider (OSP) Networks – OSP networks are owned and operated by the service providers that offer calling services to customers such as cellular plans, VoIP or traditional wireline service.

9-1-1 Tandem/Legacy Network Gateway (LNG) Environment – The 9-1-1 tandems, once the selective routers of the original 9-1-1 network in the State of Vermont, now serve only as the aggregation point for all 9-1-1 traffic from the OSP networks. In the LNG, the aggregated traffic is converted from Time Division Multiplex (TDM) to Internet Protocol (IP) and delivered into the state's NG911 system. The tandems and LNG environment also provide service to other Public Switch Telephone Network (PSTN) traffic, such as long distance and subscriber to subscriber calls.

Next Generation 9-1-1 (NG911) System – The NG911 system processes and selectively routes 9-1-1 calls to the PSAPs, queries and delivers Automatic Location Identification (ALI) with the call, provides geo-spatial mapping to the call-taker, identifies the correct emergency response agencies based on caller location, provides text to 9-1-1 capability, stores historical 9-1-1 call data and recordings, allows for ALI and Geographic Information System (GIS) discrepancy processing, and provides access to municipal coordinators for addressing database additions and maintenance.

Figure 1, on the following page, provides a high-level illustration of these networks in Vermont.

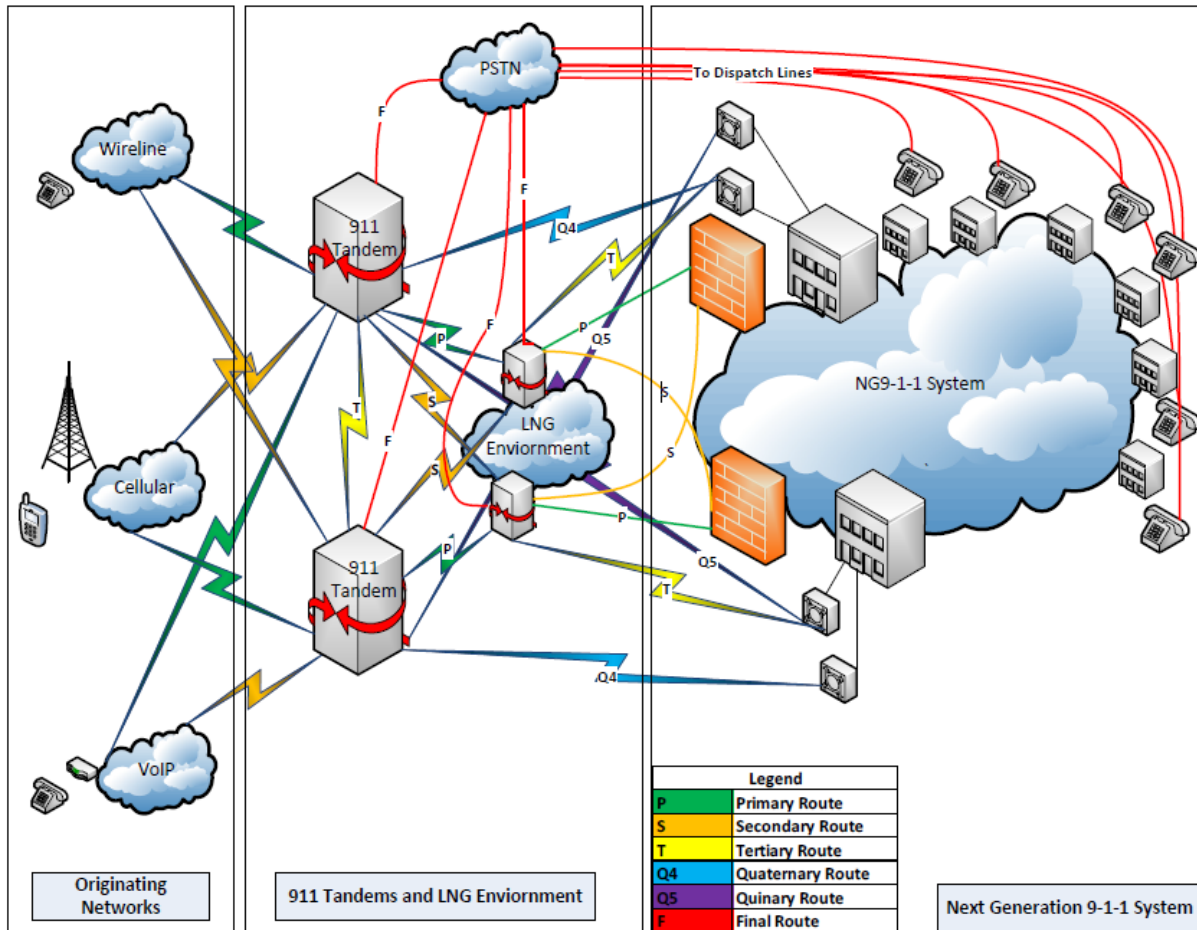


Figure 1 – High Level 9-1-1 System Diagram from Caller to Call-taker

Differences exist in the OSP network architectures, however all 9-1-1 calls in Vermont traverse the 9-1-1 tandem/LNG environment and are delivered into the NG911 system where the calls are answered by certified Vermont 9-1-1 call-takers.

The following sections of this report will discuss resiliency and redundancy within each of the three network categories and identify locations and services within each category that the 9-1-1 Board has determined are most vulnerable to system outages or call failures.

Originating Service Provider (OSP) Networks

Call Flow

Each 9-1-1 call starts within the originating service provider's network. When the digits 9-1-1 are dialed from the user equipment, the call traverses the OSP network and is delivered to one of the two geo-diverse 9-1-1 tandems in Vermont. From there, the call enters the LNG environment and is converted from TDM to IP. Finally, the call is delivered to a certified call-taker at a PSAP within Vermont's NG911 system.

A high-level illustrative overview of call flow from each type of OSP is discussed on the following pages and shown in Figures 2 - 4.

VoIP OSP Call Flow

Call flow begins when a 9-1-1 call is placed on user equipment connected to VoIP service. The 9-1-1 call travels to the VoIP Service Provider (VSP) call server. The VSP call server interacts with the VoIP Positioning Center (VPC) which checks the caller's telephone number for the registered address. The 9-1-1 call is then routed to an Emergency Service Gateway (ESGW) which sends the call over dedicated and redundant 9-1-1 trunk groups to one of the two geo-diverse 9-1-1 tandems in Vermont. The call is then delivered into the Vermont NG911 system. In 2017, VoIP calls accounted for approximately 10% of 9-1-1 call volume.

Primary and secondary trunk groups provide redundancy from the ESGW to the 9-1-1 tandems. If there is a failure of both trunk groups, the call is routed to the VSP's 24 x 7 call center which then manually transfers the call into the Vermont NG911 system. Failures of the VPC route information or the existence of an invalid registered address will also result in the call being routed to the VSP-provided call center for manual delivery into the NG911 system.

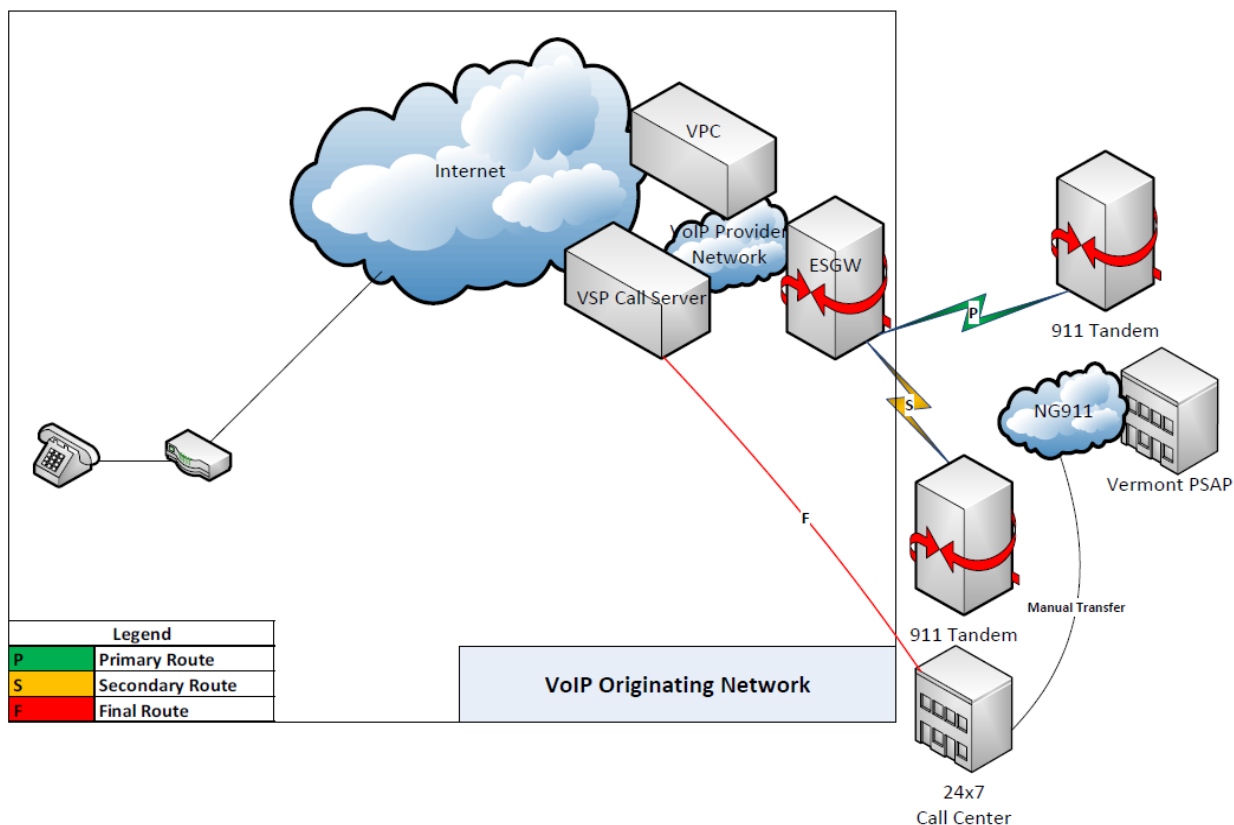


Figure 2 – VoIP Call Flow Illustration

Cellular OSP Call Flow

When a 9-1-1 call is placed by a device connected to a cellular network, the call travels over the cellular OSP's network to the Mobile Switching Center (MSC). The call is then delivered over dedicated and redundant 9-1-1 trunk groups to one of the two geo-diverse 9-1-1 tandems in Vermont before being delivered to the state's NG911 system. Cellular calls make up approximately 66% of Vermont's annual 9-1-1 call volume.

As with VoIP calls, primary and secondary trunk groups provide redundancy from the cellular OSP networks to the Vermont 9-1-1 tandems. Failure of both trunk groups will result in the MSC attempting to deliver the call to Vermont's NG911 system using a pre-programmed direct inbound dial (DID) number that is part of the NG911 system.

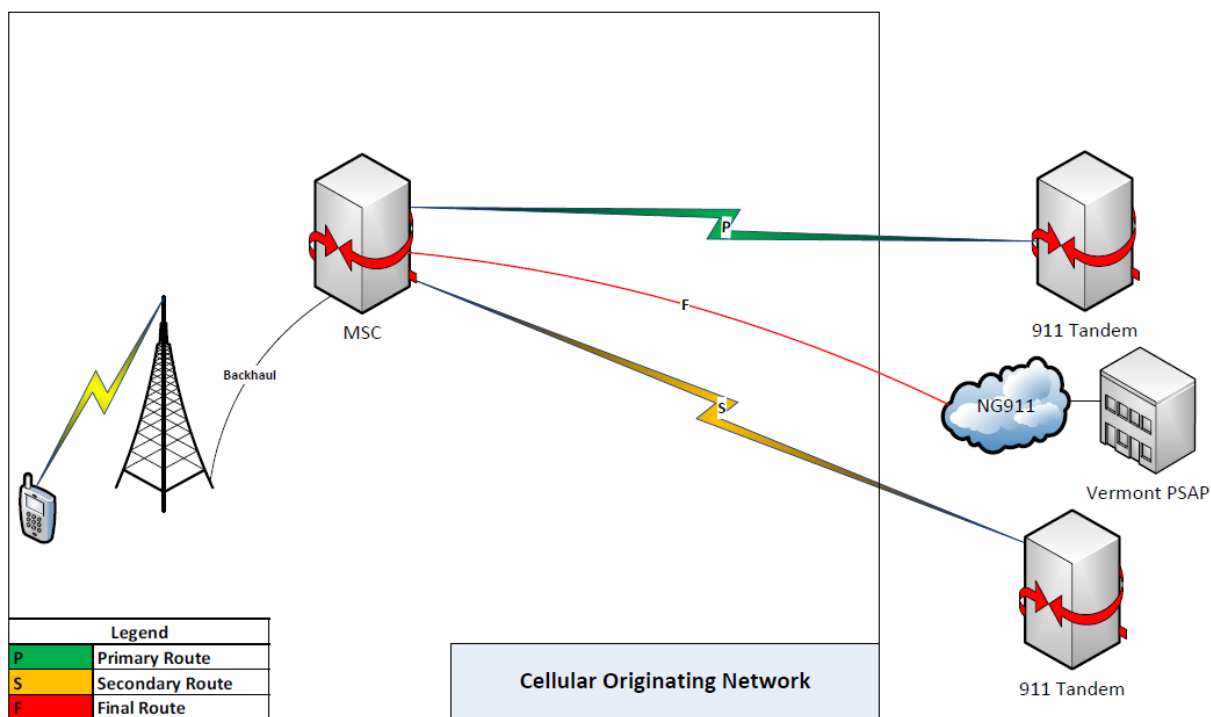


Figure 3 – Cellular OSP Call Flow Illustration

Wireline OSP Call Flow

A 9-1-1 call is placed on user equipment connected to wireline service. The call travels through the central office serving that customer and is delivered over dedicated and redundant 9-1-1 trunk groups to one of the two geo-diverse 9-1-1 tandems in Vermont before being delivered into the NG911 system. Approximately 20% of Vermont's 2017 call volume was from wireline callers.

If the delivery of the call from the dedicated 9-1-1 trunk groups to the 9-1-1 tandems fails, the serving central office has a tertiary route to the Traffic Operator Position System (TOPS)⁵. TOPS uses analog switching to send the call to a TOPS site. In some cases, this may involve a human operator manually routing the call to the appropriate 9-1-1 tandem.

If the TOPS route is unavailable, a quaternary route may exist to send the call to a local 24 x 7 public safety agency, if one served by the same central office switch exists. Due to consolidation of dispatch centers and dispatch centers migrating to other dial tone providers, there are very few instances where the quaternary route is a viable option.

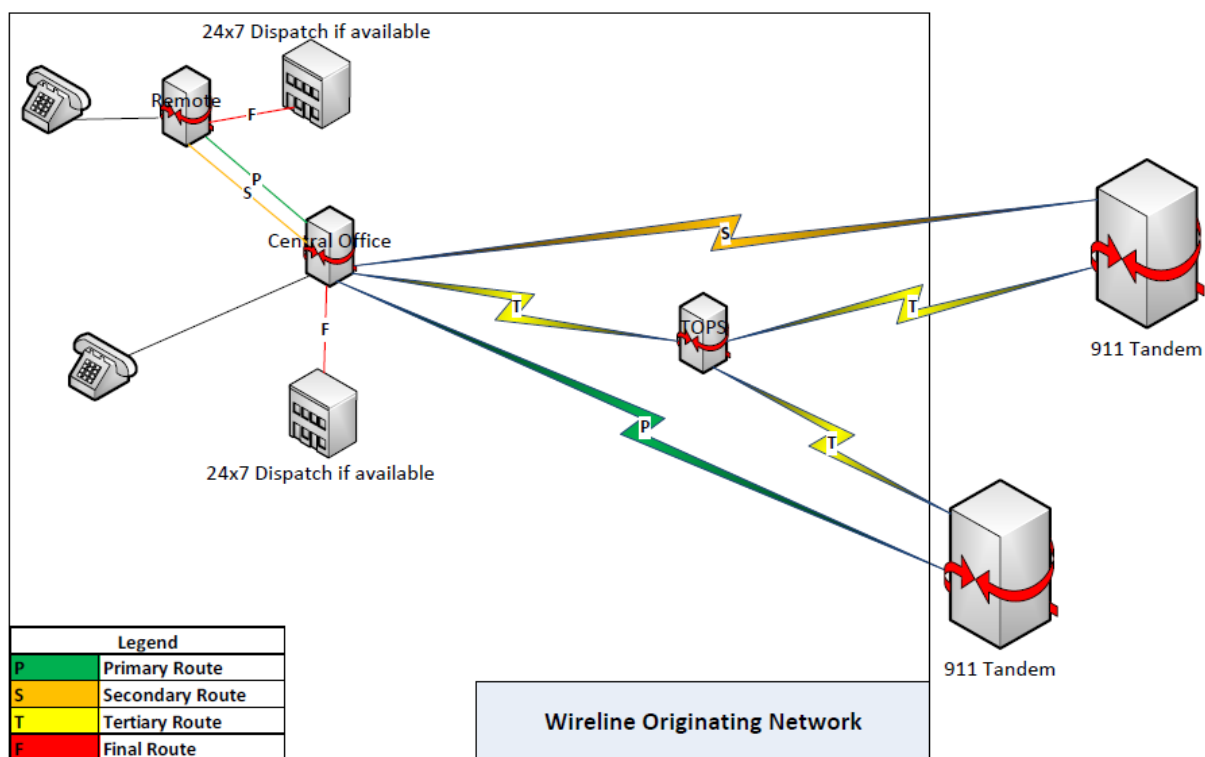


Figure 4: Wireline Call Flow Illustration

⁵ The Tertiary TOPs route only exists in the incumbent local exchange carrier's network. All other LECs serving Vermont have just a primary and secondary route to the two geo-diverse 9-1-1 tandems.

Vulnerabilities in OSPs

VoIP and Cellular OSP Networks

The Federal Communications Commission (FCC) requires interconnected VoIP and cellular service providers to transmit their customers' 9-1-1 calls to Public Safety Answering Points⁶. Many of these providers voluntarily adhere to the Communications Security, Reliability and Interoperability Council's (CSRIC) network reliability best practices. CSRIC's mission is to "provide recommendations to the FCC to ensure, among other things, optimal security and reliability of communications systems, including telecommunications, media, and public safety"⁷. The FCC also requires all originating service providers to report system outages meeting certain conditions.

Interconnected VoIP and cellular OSPs are not currently subject to the same state regulatory authority as traditional wireline service providers. This regulatory environment, along with the proprietary nature of OSP network information, prevents the Enhanced 9-1-1 Board from determining with certainty whether specific single points of failure exist within the VoIP and cellular originating networks. In general terms, however, single points of failure may exist due to failures at a cellular base station when there is not overlapping signal, failures of backhaul connections and/or loss of internet/transport for VoIP customers.

Additional information regarding the FCC requirements for interconnected VoIP service providers can be found on the FCC website.⁸

Wireline OSP Networks

The Vermont Public Utility Commission supervises the quality of service of Vermont's public utilities, including wireline service providers, as defined in 30 V.S.A.⁹. These providers are also subject to requirements related to 9-1-1 call delivery outlined in the 9-1-1 Board's Technical and Operational Standards¹⁰.

Known single points of failure have existed in the wireline network since the inception of 9-1-1 in Vermont. These vulnerabilities are due to the host-remote architecture which, in some cases, allows for the possibility of the isolation of a central office. A central office isolation limits calling only to numbers within the affected exchange. Calls to numbers outside the local exchange, including calls to 9-1-1, are not possible during isolation events.

⁶ 47 C.F.R. §9.5(b)(2), (2005), <https://www.law.cornell.edu/cfr/text/47/9.5> and 47 C.F.R. §20.18(b), (1998), <https://www.law.cornell.edu/cfr/text/47/20.18>

⁷ "CSRIC III", Federal Communications Commission, accessed August 17, 2018, <https://www.fcc.gov/about-fcc/advisory-committees/communications-security-reliability-and-interoperability-1>

⁸ "VoIP and 9-1-1 Service", Federal Communications Commission, last updated/reviewed September 8, 2017, <https://www.fcc.gov/consumers/guides/voip-and-911-service>

⁹ 30 V.S.A., <https://legislature.vermont.gov/statutes/title/30>

¹⁰ Technical & Operational Standards for Enhanced 9-1-1, [31-010-002 Vt. Code R. § 1 \(Lexis Advance through July 18, 2018\)](#)

In July 2018, the 9-1-1 Board requested current information about host-remote vulnerabilities from all wireline providers in Vermont. A precise count of the at-risk locations could not be determined based on the responses; however, the information received indicates host-remote vulnerabilities remain in eleven Vermont counties. A report produced in 2009, indicated approximately sixty host-remote isolation vulnerabilities in the wireline network in Vermont¹¹.

Recommendations and Cost Estimates for OSPs

VoIP and Cellular OSP Networks

There are no specific recommendations related to VoIP and cellular network changes at this time. Senior staff at the Enhanced 9-1-1 Board meet regularly to review FCC actions and inquiries related to VoIP and cellular network requirements and will continue to monitor the reliability of the delivery of 9-1-1 calls from these OSPs. The Board will engage with the FCC to address any reliability concerns that are identified.

Wireline Networks

Additional information is needed to fully understand the feasibility and costs associated with design changes in the wireline networks to remove or reduce host-remote isolation vulnerabilities. Potential next steps could include conducting cost studies¹² to determine the amount required to build in redundancy in these vulnerable host-remote locations and/or continued discussions with each service provider to determine an alternate solution to mitigate an isolation event.

¹¹ Enhanced 9-1-1 Board, *C.O. Isolation Solution*, September 2009

¹² Estimates for cost studies from one service provider range from \$55,000 - \$75,000.

9-1-1 Tandems and LNG Environment

The 9-1-1 tandems, once the selective routers of the original 9-1-1 network in Vermont¹³, now serve only as the aggregation point for all 9-1-1 traffic from the OSP networks.

All 9-1-1 calls from OSPs that serve Vermont customers are delivered to one of the two geo-diverse 9-1-1 tandems. The tandems have multiple routes to deliver the call to the NG911 system, as shown in Figure 5.

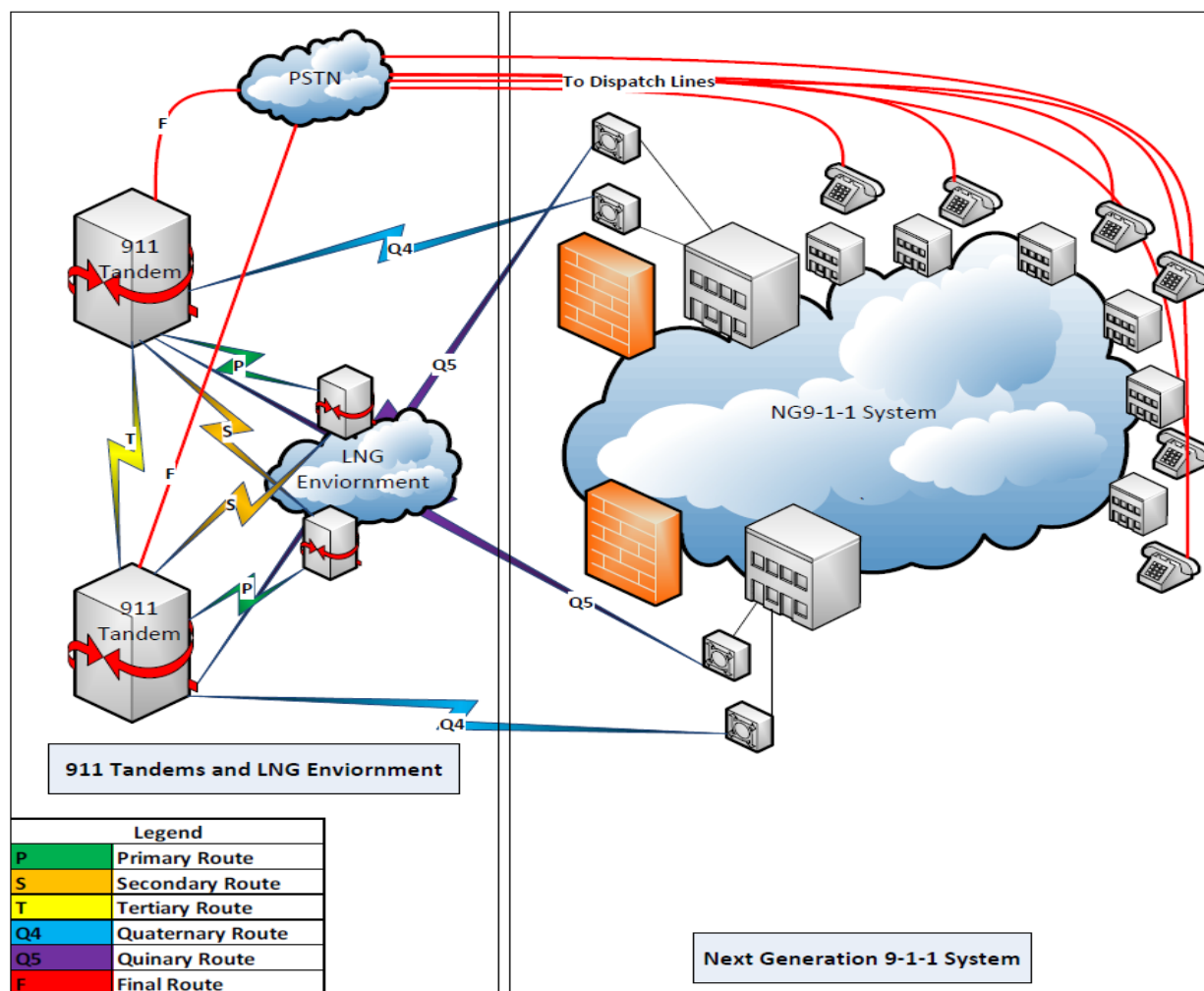


Figure 5: 9-1-1 Tandems and LNG Environment

Each tandem has a primary Time Division Multiplexing (TDM) route, a secondary TDM route, a tertiary (inter-tandem) route, a quaternary TDM route, and a quinary TDM route. If all these routes fail, the call will be delivered to a DID number that will distribute the 9-1-1 calls to PSAP dispatch lines.

¹³ The selective routing of Vermont 9-1-1 calls is now handled by the NG911 system.

The LNG environment consists of two geographically diverse switches that convert 9-1-1 calls from TDM to IP and deliver the calls to the NG911 system.

As shown in Figure 6, each LNG switch has one primary and one secondary IP connection, as well as a tertiary TDM backup route. If all these routes into the NG911 system fail, the call will be delivered to a DID number that will distribute the calls to PSAP dispatch lines.

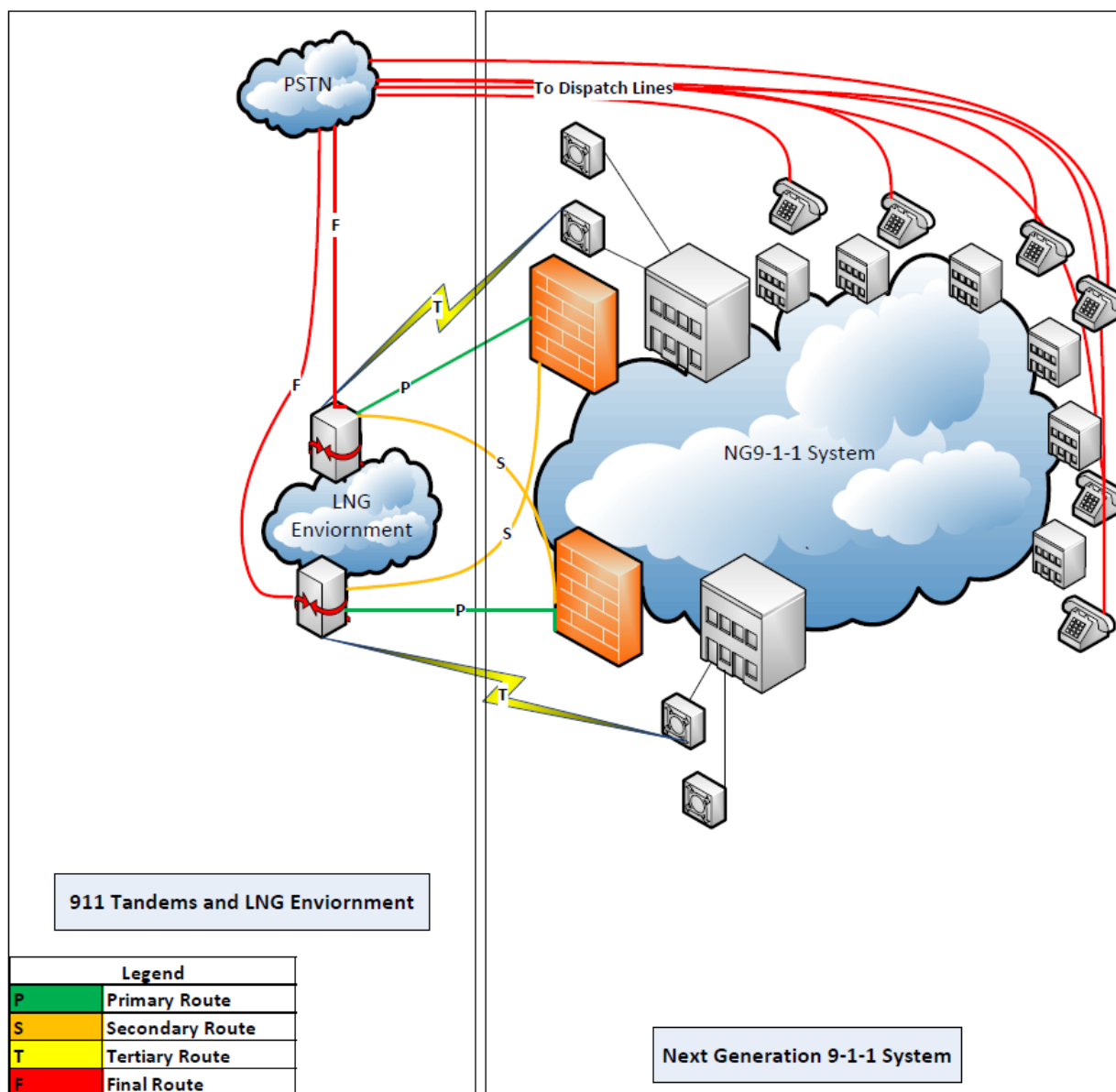


Figure 6: LNG Environment

Vulnerabilities in the 9-1-1 Tandem/LNG Environment

An assessment of the call delivery process and its ability to failover properly - and in an automated manner - was conducted in September 2016.¹⁴ The assessment identified an area of concern within the LNG environment which had, in January 2016, contributed to an event in which the LNG utilized its final route to deliver 9-1-1 calls to PSAP dispatch lines, rather than into the NG911 system as expected. A petition for a Vermont Public Utility Commission (PUC) investigation¹⁵ into the January 5, 2016 event was initiated by the Public Service Department in consultation with the Enhanced 9-1-1 Board. The on-going investigation may include recommendations for change(s) within the LNG environment to improve its reliability and redundancy¹⁶.

There are no other known single points of failure in the 9-1-1 tandems or the LNG environment. Operational integrity is upheld in the tandem/LNG environment through redundancy and diversity.

Recommendations and Cost Estimates for the 9-1-1 Tandem/LNG Environment

The Enhanced 9-1-1 Board must wait for the completion of the PUC investigation before determining next steps and/or recommendations.

¹⁴ FairPoint Communications, *NG911 Automatic System Failover Report (proprietary)*, September 2016

¹⁵ Public Utility Commission, Docket 8850, *Petition of the Vermont Department of Public Service for an investigation into the 1/5/16 FairPoint Network incident that disrupted delivery of calls into the Vermont 911 system*

¹⁶ As of the final review of this report, 8/29/18, the PUC investigation was still ongoing.

Next Generation 9-1-1 System

The NG911 system consists of a managed and secure IP network with six geo-diverse PSAPs and two geo-diverse data centers. Redundant call processing equipment within the system meets the requirement for 99.999% hardware system availability¹⁷. The data centers are equipped with fully redundant networking equipment and have two technology-diverse physical connections between them and at least one connection to each PSAP.

Once a 9-1-1 call is received by the NG911 system from the 9-1-1 tandem/LNG environment, it is routed to the primary PSAP based on the caller's location. If the primary PSAP is unavailable due to a failure or because no call-taker is available, the call is automatically rerouted to an available call-taker at one of the five remaining PSAPs within the NG911 system.

Automatic failover to the redundant PSAP connections is handled by the networking equipment. If neither data center is able to route the call to any PSAP due to failure or because no call-takers are available anywhere in the statewide system, the call will be delivered over a DID number that is pointed to a PSAP dispatch line.

Figure 7, on the following page, illustrates the NG911 system design.

¹⁷ Solacom Technologies Inc., *Systems Engineering Technical Brief – Reliability Analysis Vermont System (proprietary)*, February 2015

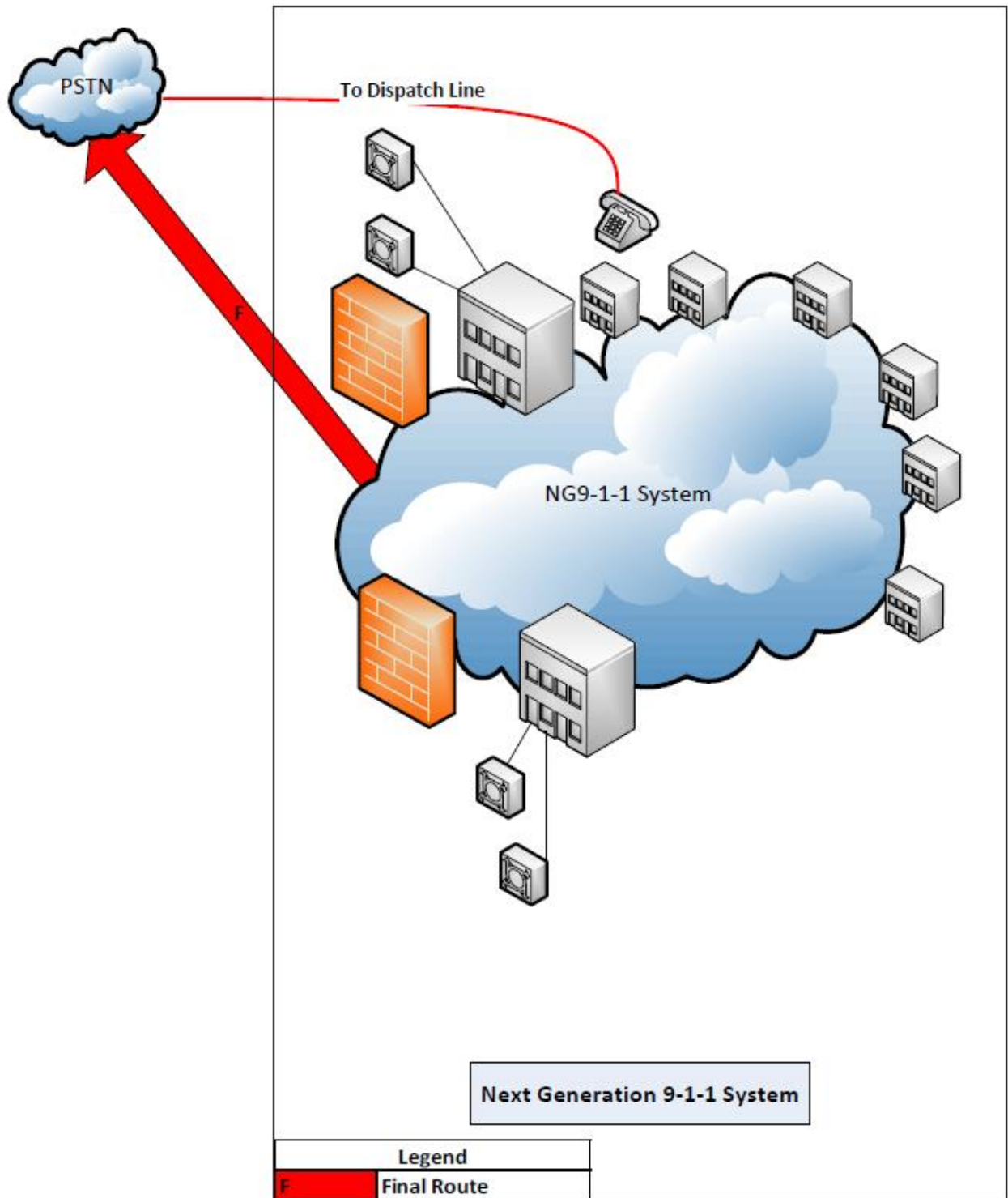


Figure 7: NG911 System Design

Vulnerabilities in the NG911 System

The September 2016 automatic failover report¹⁸ included an assessment of call delivery in terms of the NG911 system's ability to failover properly and in an automated manner. There were no areas of concern identified for Vermont's NG911 system.

Four of Vermont's six PSAPs do not have physical diversity into their buildings or are served from a single switching center. This creates single points of failure if one of the switching center facilities were to fail or if there was a disruption to the physical connections. This vulnerability is mitigated by the geo-diversity of the PSAPs. No two PSAPs are served by the same single switching center, so a loss of a switching center would only impact one PSAP. If a PSAP is taken off-line due to a disruption of the physical connection and/or switching center, the calls will flow automatically to the remaining PSAPs.

Ensuring Operational Integrity in the Event of Critical Software/Hardware Failures in the NG911 System

The NG911 system is designed to automatically failover to the alternate component in the data center or to the alternate data center if there is a critical software or hardware failure.

The NG911 system has comprehensive host, network and application monitoring¹⁹. This monitoring provides operational integrity in that it alerts the system provider that a redundant component has failed. In addition, an internal testing process has been implemented to regularly confirm that critical call processing is stable and capable of processing calls. If the check does not come back correctly after two attempts, a critical alarm is raised to the system provider for an immediate response.

Recommendations and Cost Estimates for the NG911 System

There is robust redundancy and resiliency within the NG911 system. There are no recommendations for changes to the NG911 system at this time.

The Enhanced 9-1-1 Board will ensure that any future procurements of NG911 systems continue to comply with industry standards and best practices related to redundancy and resiliency.

¹⁸ FairPoint Communications, *NG911 Automatic System Failover Report (proprietary)*, September 2016

¹⁹ Solacom Technologies Inc., *Vermont [REDACTED] Monitoring List*, October 2016, NOTE: The document name contains sensitive technical telecommunication information, the disclosure of which could make the 911 system vulnerable to cybercrimes and potential interference threatening the safety of persons and the security of public property. This information is exempt pursuant to 1 V.S.A. §317(c)(25).

Conclusion

Summary Table of Vulnerabilities and Recommendations

The table below summarizes the identified vulnerabilities in each of the three networks involved in the delivery of a 9-1-1 call to a Vermont 9-1-1 call-taker. Also provided is the existing mitigation for each vulnerability, the Enhanced 9-1-1 Board's recommendations for changes and associated costs of those changes.

Identified Vulnerabilities in Originating Networks	Mitigation	Recommendation	Costs
Central Office Isolation	Emergency Stand Alone where available	Continued discussion and research of potential mitigation steps	None at this time
Backhaul connectivity for cellular base stations	Overlapping cellular and/or wi-fi signals where available	Encourage continued growth of cellular coverage in Vermont by commercial carriers	N/A
Identified Vulnerabilities in 9-1-1 Tandem/LNG Environment	Mitigation	Recommendation	Costs
LNG Environment – Factors contributing to January 5, 2016 event	Final Route to DID	Await PUC investigation results	None at this time
Identified Vulnerabilities in NG911	Mitigation	Recommendation	Costs
Physical diversity to each PSAP	Holistic system design delivers calls to alternate PSAPs when a primary PSAP is offline	None – this vulnerability is mitigated by system design	None

The Vermont 9-1-1 system, and the various networks involved in 9-1-1 call delivery, are resilient and have redundancy throughout. Mitigation steps are in place to lessen the risks of known vulnerabilities.

The Enhanced 9-1-1 Board has established strong relationships with multiple partners who have the shared goal of ensuring the reliable delivery of Vermont 9-1-1 calls. These partnerships also allow the Board to identify the appropriate course of action in the event of any concerns about, or failures of, 9-1-1 call delivery. The Vermont Enhanced 9-1-1 Board is committed to working with these partners, the legislature, and all stakeholders, to ensure continued redundancy and resiliency in the statewide 9-1-1 system.

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Glossary

9-1-1 Tandem – The Central Office that provides the tandem switching of 9-1-1 calls. It controls delivery of the voice call with ANI to the PSAP.

Automatic Location Identification (ALI) – The automatic display at the PSAP of the caller's telephone number, the address/location of the telephone and supplementary emergency services information of the location from which a call originates.

Automatic Number Identification (ANI) – Telephone number associated with the access line from which a call originates.

Central Office – The Local Exchange Carrier facility where access lines are connected to switching equipment for connection to the Public Switched Telephone Network.

Communications Security, Reliability and Interoperability Council (CSRIC) – An advisory body of the FCC which provides recommendations to the FCC to ensure, among other things, optimal security and reliability of communications systems, including telecommunications, media, and public safety.

Direct Inbound Dialing (DID) – Telephone company facility that allows an outside caller to connect directly to an inside extension of an office without the help of an attendant or operator.

Emergency Service Gateway (ESGW) – The Emergency Services Gateway (ESGW) is the signaling and media interworking point between the IP domain and conventional trunks to the E911 SR that use either Multi Frequency (MF) or Signaling System #7 (SS7) signaling. The ESGW uses the routing information provided in the received call setup signaling to select the appropriate trunk (group) and proceeds to signal call setup toward the SR using the ESQK to represent the Calling Party Number/Automatic Number Identification information.

Federal Communications Commission (FCC) – An independent U.S. government agency overseen by Congress, the Federal Communications Commission regulates interstate and international communications by radio, television, wire, satellite and cable in all 50 states, the District of Columbia and U.S. territories.

Geographic Information System (GIS) – A system for capturing, storing, displaying, analyzing and managing data and associated attributes which are spatially referenced.

Host Switch – An end office with an internal controller or intelligent process used to complete calls. A host switch controls the function of one or more remote switch units (RSU) via a central “control” or “processor” resident within the host switch.

Internet Protocol (IP) – The method by which data is sent from one computer to another on the Internet or other networks.

Legacy Network Gateway (LNG) – An NG911 Functional Element that provides an interface between a non-IP originating network and a Next Generation Core Services (NGCS) enabled network.

Mobile Switching Center (MSC) – The wireless equivalent of a Central Office, which provides switching functions from wireless calls.

Municipal Coordinators – A contact determined by each municipality participating in the enhanced 9-1-1 system to serve as the liaison to the Board and the system provider on all issues regarding 9-1-1 service.

Next Generation 9-1-1 (NG911) – A system comprised of Emergency Services IP networks (ESInets), IP-based Software Services and Applications, Databases and Data Management processes that are interconnected to Public Safety Answering Point premise equipment. The system provides location-based routing to the appropriate emergency entity. NG911 provides standardized interfaces for call and message services, processes all types of emergency calls including non-voice (multi-media) messages, and acquires and integrates additional data useful to call routing and handling for appropriate emergency entities. NG911 supports all E911 features and functions and meets current and emerging needs for emergency communication from caller to Public Safety entities.

Originating Service Provider (OSP) – An entity that provides telecommunications services to an end user placing a call.

Public Safety Answering Point (PSAP) – An entity responsible for receiving 9-1-1 calls and processing those calls according to a specific operational policy.

Public Switch Telephone Network (PSTN) – The network of equipment, lines, and controls assembled to establish communication paths between calling and called parties in North America.

Remote Switch – A small switching system that is located at a remote point from a host switch. All or most of its call processing capability is obtained from an electronic type host office. The remote is connected to the host by umbilical circuits providing message and signal handling capabilities.

Selective Router – The Central Office that provides the tandem switching of 9-1-1 calls. It controls delivery of the voice call with ANI to the PSAP and provides Selective Routing, Speed Calling, Selective Transfer, Fixed Transfer, and certain maintenance functions for each PSAP.

Time Division Multiplexing (TDM) – A digital multiplexing technique for combining a number of signals into a single transmission facility by interweaving pieces from each source into separate time slots.

Traffic Operator Position System (TOPS) – A computerized operator telephone switchboard.

VoIP – Technology that permits delivery of voice calls and other real-time multimedia sessions over IP networks.

VoIP Positioning Center (VPC) – The VoIP Positioning Center (VPC) is the element that provides routing information to support the routing of VoIP emergency calls and cooperates in delivering location information to the PSAP over the existing ALI DB infrastructure. The VPC supports access to the routing data in the ERDB.

[END OF REPORT]