Federal Communications Commission

Task Force on Optimal Public Safety Answering Point Architecture (TFOPA)

Working Group 2 Report: Optimal 9-1-1 Service Architecture

December 10, 2015

Preface

The Task Force on Optimal PSAP Architecture (TFOPA) is a federal advisory committee chartered under the Federal Advisory Committee Act (FOCA) to provide recommendations to the Federal Communications Commission (FCC) regarding actions that Public Safety Answering Points (PSAPs) can take to optimize their security, operations, and funding as they migrate to Next Generation 9-1-1 (NG9-1-1).

The Chair of the TFOPA is Steve Souder, Director, Department of Public Safety Communications, Fairfax County. The TFOPA has three Working Groups:

Working Group 1: *Optimal Approach to Cybersecurity for PSAPs*, Chair: Jay English, Association of Public-Safety Communications Officials;

Working Group 2: *Optimal Approach to NG9-1-1 Architecture Implementation by PSAPs*, Chair: David Holl, National Association of State 9-1-1 Administrators and Pennsylvania Emergency Management Agency;

Working Group 3: *Optimal Approach to Next-Generation 9-1-1 Resource Allocation for PSAPs*, Chair: Philip Jones, Washington State Utilities and Transportation Commission.

Under the Charter, Working Group 2 was responsible for creating this report covering and developing recommendations on:

- How PSAPs can improve 9-1-1 functionality and cost effectiveness through NG9-1-1 network architecture design and operation;
- Optimal NG9-1-1 system and network configurations for a range of existing PSAP use cases (e.g., large urban, rural);
- Projected costs and transition periods associated with optimized configurations;
- Ensuring and improving access to NG9-1-1 for people with disabilities;
- Updating previous best practices for legacy PSAPs identified by CSRIC to address the specific requirements that PSAPs will face in the NG9-1-1 environment.

I want to thank all members of the TFOPA Working Group 2 for their hard work, expertise, countless hours of research, discussion, writing, reviews, and their overall dedication to the mission in support of public safety. In addition to their regular employment responsibilities, they devoted countless hours in reviewing various works on these subjects and developing the text presented in this report. Working Group 2 members are listed in Appendix A of this document. Their collective efforts reflect overall consensus of a "volunteer" effort by both the Chair and all 43 members of WG2.

David L. Holl, ENP, Chairman

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Section 1 - Executive Summary

1.1 The Evolution of Next Generation 9-1-1 Systems

Each year more than an estimated 240 million emergency calls are made to 9-1-1 across the United States. 9-1-1 centers, or Public Safety Answering Points (PSAPs), are the gateways for access to emergency services for the public. By simply dialing the three digits "9-1-1", callers in need of police, fire, emergency medical services, or other emergency responders, can speak to a PSAP telecommunicator who is their first link in the often lifesaving emergency response public safety ecosystem chain.

For well over forty years this system has served effectively and honorably. As of March 2015, the United States had 5,906 primary and secondary PSAPs.[1] Dedicated professional telecommunicators in these PSAPs stand ready twenty-four hours a day, three hundred sixty five days a year, to receive calls and summon assistance for any number of critical emergency situations.

While 9-1-1 continues to perform admirably, communication technologies have evolved presenting new challenges and requirements for the 9-1-1 community. Founded on time-division multiplexing (TDM) circuit switched voice services technology, wireline phone systems managed by telephone companies are the platform for making and receiving calls to 9-1-1. Internet Protocol (IP) network based technologies are now replacing the TDM (legacy) system. Known as the "TDM-to-IP" transition by the FCC, the copper infrastructure across the nation will eventually be completely replaced by IP enabled systems.[2]

These transitions are not new in the technology realm. Estimates as of November 2013 indicated that nearly 38% of all U.S. households currently rely on wireless as their primary service (having given up TDM wireline service).[3] This reliance on wireless technology results in about 70% of all 9-1-1 calls being placed from wireless phones annually.[4]

Despite the enhanced multi-media capability of wireless and VoIP devices, a 9-1-1 caller can currently only employ the voice capability or, in limited jurisdictions, text. The challenge for policy makers and 9-1-1 Authorities is that the legacy 9-1-1 systems they

[1] http://www.nena.org/?page=911Statistics, last accessed 11/17/2015

[2] https://www.fcc.gov/guides/ip-transition, last accessed 11/10/15

[3] http://www.ctia.org/policy-initiatives/policy-topics/911, last accessed 11/10/15

[4] https://www.fcc.gov/guides/wireless-911-services, last accessed 11/10/15

have utilized over forty plus years are not capable of receiving the forms of multi-media common among everyday telephone users.

Any transition comes with difficult decisions for policy-makers and implementers. Choosing the best options by a 9-1-1 Authority often requires technology and funding considerations that demand a sound understanding of the systems and processes that will need to be put in place to effect responsible change. The evolution to “Next Generation 9-1-1” (NG9-1-1) technology presents potentially even greater challenges since it is not merely a linear progression, but a paradigm shift.

9-1-1 Authorities have operated legacy 9-1-1 in relatively independent and isolated operational environments. NG9-1-1 implies a significant change in roles and responsibilities. This report introduces the expanded nature of NG9-1-1 as including what we term the Originating Service Environment (OSE). This environment includes IP call set-up, location determination, validation and delivery to ESInets across the country.

The NG9-1-1 architecture will require many 9-1-1 Authorities to begin evolving a vision of collaboration as they develop new models of 9-1-1 service delivery. Although much has been written about the NG9-1-1 transition, and the required steps for migration, Working Group 2 believes there continues to be a lack of clarity among those responsible to develop and implement NG9-1-1 systems at the 9-1-1 Authority level.

This report was developed with the intent to help clarify and educate decision-makers tasked with the critical responsibility to move from the current legacy 9-1-1 operational model to the Next Generation 9-1-1 framework. Accordingly, Working Group 2 divided their work into four distinct areas of the emerging NG9-1-1 environment. Namely, the:

- Emergency Services IP transport network (ESInet)
- Access and NG9-1-1 Core Services (NGCS),
- PSAP Terminating Equipment/Call-taking Support subsystems (Computer Aided Dispatch (CAD), Management Information Systems (MIS), Dispatching Equipment, etc.
- Governance

Each subgroup undertook the study, research, discussion, and development of various sections of this report. Collectively, Working Group 2 reviewed the work of each subgroup and had ongoing discussions to arrive at this final report.

Figure 1-1 below is a depiction of these areas and the various configuration options that they represent:

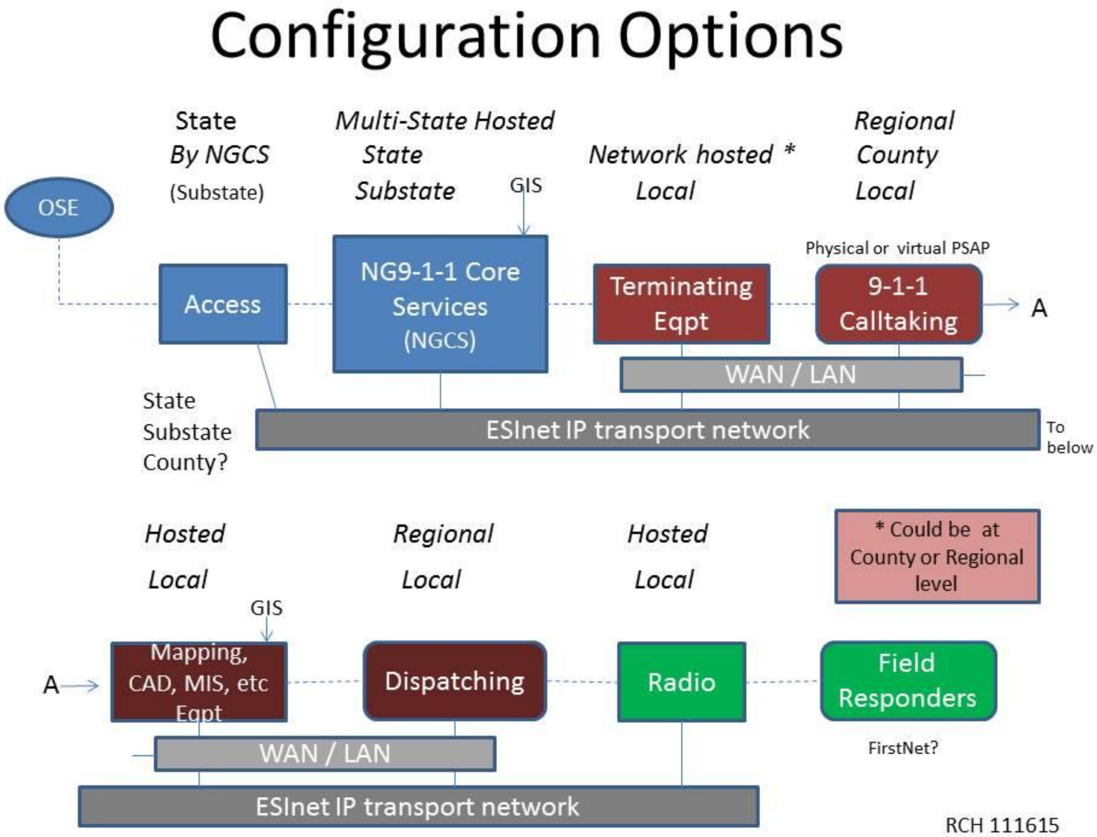

Figure 1-1

With the configuration options shown above, each component in Figure 1-1 is further described and referenced individually and collectively throughout this report.

Based upon the above network model, this report describes options for NG9-1-1 services optimization, including infrastructure sharing by PSAPs. It also describes the Emergency Service IP Network (ESInet) and NG9-1-1 core services functions (NGCS) that provide and control delivery of calls, messages, and data to PSAPs. Sharing infrastructure among multiple PSAPs involves the utilization of equipment and software that take advantage of internet protocol (IP) technology via the ESInet transport networks. Infrastructure sharing offers the potential for optimization in many areas such as cost, operations, interoperability, shared services and survivability.

In discussing the current legacy 9-1-1 environment, the report acknowledges that the aging analog 9-1-1 systems operating across the nation were developed when landlines were the only phone service available. The original systems were not designed to receive calls and data from IP-based services. While sophisticated technical advances have been incorporated into the legacy 9-1-1 systems and have provided 9-1-1 functionality for wireless and Voice over IP (VoIP) service, the report observes that evolution of the 9-1-1 system is essential. The advancement of the 9-1-1 system is essential to meet public expectations to correlate basic telecommunications functionality with the capabilities of the modern mobile devices so ubiquitous in our nation. Without it, transmission and reception of essential emergency information including texts, photos, video, data, and telemetry – in real-time – is not feasible.

The report notes that the ultimate goal of NG9-1-1 deployment is the development of a standardized nationwide, interconnected “system of systems” for 9-1-1 emergency communications without regard to jurisdictional or market-based (LATA) boundaries. NG9-1-1 systems in their transition and end states can allow and support significantly enhanced redundancy, real-time and alternate call routing, improved call transfer capabilities, multi-media capability, additional data, and back-up improvements.

This report discusses several potential architectural models for transitioning 9-1-1 Authority systems through the implementation and deployment of “Next Generation 9-1-1” (NG9-1-1) technology. It explores some of the basic operational and architectural possibilities available as well as the technical components, requirements, challenges and opportunities associated with deployment of NG9-1-1 systems, with significant focus on options for maximizing cost-effectiveness and efficiency.

The legacy 9-1-1 environments of the past 40 plus years are rapidly coming to an end no matter which deployment model is chosen. Independent systems will in most cases be too costly for single NG9-1-1 implementations. The new paradigm of NG9-1-1 will be based upon system roles in an emergency services ecosystem as depicted below.

Next Generation 9-1-1 Emergency Services Ecosystem

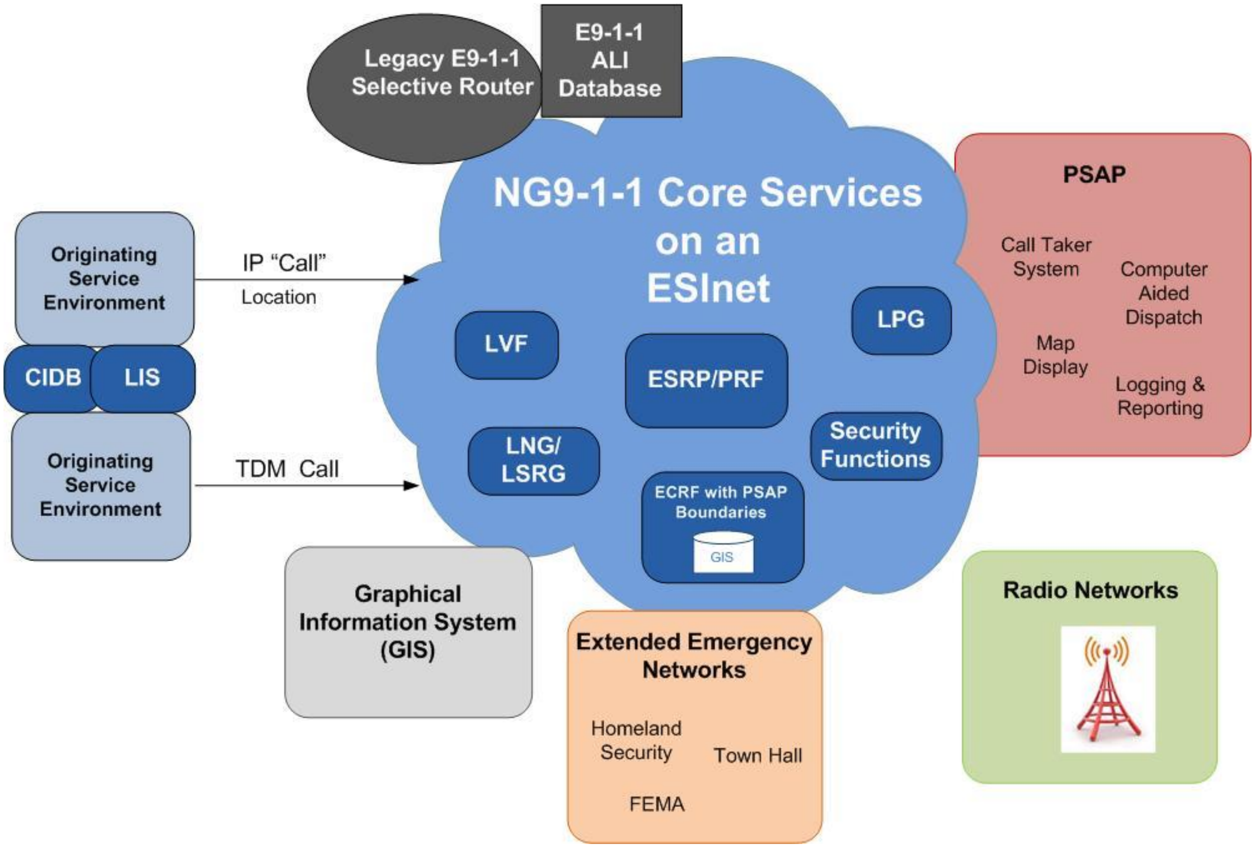

Figure 1-2

In legacy 9-1-1 networks the systems centered on the TDM networks of the OSPs. In NG9-1-1 a new Originating Service Environment (OSE) emerges where any number of points can originate calls or other requests for service. Those requests for service will be processed through the NG9-1-1 Core Services and be transported to the PSAP via ESInet(s) for dispatch of first responders.

9-1-1 calls for service will not be limited to only voice telephony since the NG9-1-1 framework will accept calls for service from a variety of media types. For example, text to 9-1-1 will revolutionize the functionality of 9-1-1 for deaf and hard of hearing individuals, and will, provide alternative communications path between a 9-1-1 caller and the responsible PSAP. In addition to improving 9-1-1 service, deployment of NG9-1-1 systems offers the potential for efficiencies that can assist with optimizing PSAP operations.

This report documents that the envisioned NG9-1-1 technology offers tremendous flexibility to PSAPs in terms of sharing equipment, infrastructure, facilities and personnel. NG9-1-1 technology can be employed to streamline operations, reduce duplication and provide significantly improved redundancy, interoperability and robustness. It describes the opportunities and challenges to seeking efficiencies in the 9-1-1 environment which may lie more in political, governance, operational and management considerations than in the wide-ranging capabilities emerging in the NG9-1-1 technical environment.

New roles and responsibilities will inevitably emerge as Originating Service Providers (OSPs) evolve to an Originating Service Environment (OSEs) and Next Generation 9-1-1 Core Services (NGCS) are developed and implemented. As depicted below, 9-1-1 Authorities as they have existed in the legacy environment will also change as broadening of role and responsibilities occurs as more multi-jurisdictional, regional, statewide, or even multi-state relationships are organized.

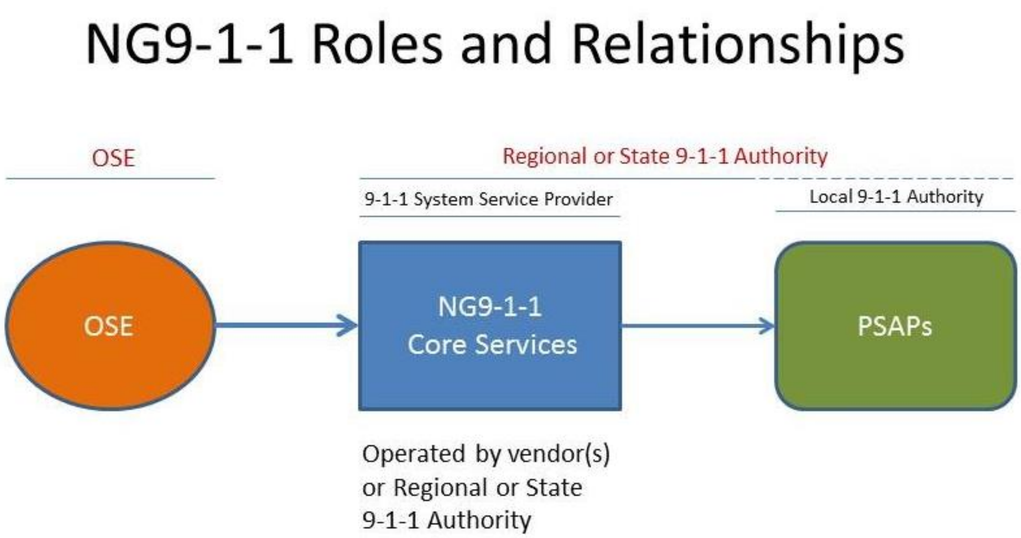

Figure 1-3

There are many variations on roles between 9-1-1 Authorities at local, regional, and state levels (including some areas where none of the three formally exist). When viewed at a national level however, there is a gradual trend toward the roles and relationships depicted above as NG9-1-1 work proceeds. The 9-1-1 Authority term is somewhat generic, as the name of organizations that fill that role vary greatly, such as 9-1-1 Administrator, Emergency Telephone Service Board (ETSB), etc. In many cases, the regional or state 9-1-1 Authority does not have direct governance over the local 9-1-1 Authorities. As this report discusses, referencing the organizational roles in the figure above instead of just the physical components is one way to more clearly state relationships in the 9-1-1 environment.

The report considers 9-1-1 system optimization to maximize efficiency and improve call flow. The system solution architecture described in the report enables a transition to a more collaborative and interoperable 9-1-1 system. Advantages and challenges of various PSAP configurations are discussed to assist in determining which model might best meet the unique needs of a particular jurisdiction.

Transition from legacy 9-1-1 to Next Generation 9-1-1 raises a myriad of questions and concerns. Deploying Next Generation 9-1-1 capabilities is not a question of 'if', but rather 'when' the transition will occur. A primary message in this report is that NG9-1-1 architecture can be customized to support almost any configuration of PSAP operations. Factors that affect these configurations include financial, political, governmental and operational considerations. The overall goal of this report is that the reader will have a better understanding of NG9-1-1, its components, capabilities, deployment options, and potential benefits. Armed with this understanding, 9-1-1 Authorities and decision-makers will be able to apply that knowledge to ongoing objective and collaborative dialogues that will enable them to craft a NG9-1-1 plan that meets the needs of their jurisdictions.

Section 2 - Introduction

2.1 The Emergence of 9-1-1 for a Nation: History of 9-1-1

Since the late 1960's, the 9-1-1 system has been advancing and evolving throughout the United States. Throughout the years, 9-1-1 has stood as the sole number for notifying a Public Safety Answering Point (PSAP) that an emergency is occurring and the caller needs law enforcement, fire, or emergency medical assistance from emergency responders. Based on the telephone network that existed, it was logical to use a feature known as "selective call routing" to support the implementation of 9-1-1 calling through central offices, nationwide. Backed by Congress and various other industry groups, E9-1-1 systems and networks supporting 9-1-1 calling spread across the nation.[5]

Information provided by NENA, The 9-1-1 Association states:

- By the end of 1976, 9-1-1 was serving about 17% of the population of the United States. In 1979, approximately 26% of the population of the United States had 9-1-1 service, and nine states had enacted 9-1-1 legislation. At this time, 9-1-1 service was growing at the rate of 70 new systems per year. By 1987, those figures had grown to indicate that 50% of the US population had access to 9-1-1 emergency service numbers.
- At the end of the 20th century, nearly 93% of the population of the United States was covered by some type of 9-1-1 service. Ninety-five percent of that coverage was Enhanced 9-1-1. Approximately 96% of the geographic US is covered by some type of basic 9-1-1 or E9-1-1. The rest use remote call forwarding of 9-1-1 to a ten-digit number at a selected answering point.

In the 1980s the telephone company "Operator Services" technology was adapted for 9-1-1 providing the PSAPs with the caller's telephone number, commonly known as Automatic Number Identification (ANI). Dedicated 9-1-1 networks utilizing circuit switched Selective Routing (SR) functionality accommodated the need for routing of 9-1-1 calls to differing jurisdictions. Telephone company customer records contained specific address information that correlated to the telephone number enabling 9-1-1 Authorities to partner in 9-1-1 database development of what is known today as Automatic Location Identification (ALI). The technology adaptations became the norm for 9-1-1 services deployed throughout the United States establishing the Enhanced 9-1-1 features commonly referred to as ANI/ALI/SR. Although cell phone technology existed as early as 1973, it was not until the mid-nineteen eighties that the next major step occurred in mobile phone technology with the First Generation (1G) fully automatic cellular networks

[5] Status of Legislation Concerning 911 The Emergency Telephone Number, U.S. Dept. of Transportation; U.S. Dept. of Commerce, NTIA. July, 1979. Archived – National Emergency Number Association.

introduction. In 1983 the FCC approved the first ever mobile phone and the evolution of cellular technology for 9-1-1 moved forward. It was at this point that, the Telephone Number to Dispatchable Address correlation became invalid, as numbers became mobile with the device. Mechanisms were developed to accommodate cellular 9-1-1 in the wired landline E9-1-1 model, and while it provided a stop gap measure, each technology advancement in cellular deployment widened the gap between the technology and the solution. Compounding the complexity of the problem further, the advancement and acceptance of Voice over Internet Protocol (VoIP) technology introduced a new era. Communication challenges for 9-1-1 continued to emerge as fixed devices became nomadic and mobile cell phones entered into the IP digital age where both data as well as voice was seamlessly delivered.

In 2014 CTIA reported that US cellphone penetration surpassed the population by 10%, indicating that there were more cellphones than recorded population.[6] With nearly everyone, teenager to older adult, possessing some form of cellular technology, they hold the key to immediate 9-1-1 access in the palm of their hand. 9-1-1 calling behaviors began to change and the exponential growth in cellular and IP technology continues to strain the 9-1-1 network. The FCC estimates that over 70% of all 9-1-1 calls are placed from wireless phones. Selective routing provided through analog technology is rapidly moving toward extinction. IP based technology is essential for the future.

Throughout the U.S. the legacy forty-year-old 9-1-1 solution cannot support the needs of advanced communication technologies. Public expectations are changing and new technology will afford public safety the opportunity to provide more effective emergency response. We must embrace a new approach to keep pace with evolving consumer communication services and emergency response needs.

2.2 Emerging NG9-1-1 Environment

This report is designed to provide an overview to emerging Next Generation 9-1-1 systems, sets the stage for better insight into the system descriptions, and allows for an analysis of PSAP and NG9-1-1 architecture optimization. The report is structured to provide a thorough understanding of Public Safety Answering Point (PSAP) and NG9-1-1 operational models and includes an objective analysis of operational efficiencies gained through upgrading to more advanced technologies. In contrast, the authors of this report also included administrative challenges that could exist when planning for NG9-1-1.

Throughout the report the reader will find that NG9-1-1 introduces a more efficient, precise technical infrastructure for handling 9-1-1 emergency requests through intelligence inherent in the technology. For example, the system when fully implemented, will completely change the way 9-1-1 calls, or requests for assistance are routed. Greater

[6] "Annual Wireless Industry Survey" http://www.ctia.org/your-wireless-life/how-wireless-works/annual-wireless-industry-survey. CTIA, June 2015. Web. Last Accessed 12/03/2015.

intelligence in the call routing functionality will minimize the need to transfer a call to the correct PSAP, which is a normal operational occurrence today in legacy 9-1-1 systems. Location based call routing allows the location data of the individual initiating the 9-1-1 request to more precisely route to the PSAP responsible for the service request.

NG9-1-1 enables the general public to have options beyond voice and TTY/TDD regarding how they contact 9-1-1 centers for emergency assistance, and can also allow for providing additional data beyond what is transmitted to 9-1-1 today. Texting, sharing photos and establishing video calls are now commonplace in our society and it is logical that we create a 9-1-1 system that accommodates these applications. In addition, it is critical that individuals with speech or hearing disabilities have a method, other than TTY/TDD, to contact 9-1-1. NG9-1-1 will establish the underlying technical platform and functional applications to phase in these technologies.

As stated earlier, the legacy 9-1-1 systems deployed throughout the United States today are limited and cannot fully support the advanced communication technologies used by the general public. Upgrading legacy 9-1-1 systems requires knowledge of the technological advancements in 9-1-1, evaluation of 9-1-1 service optimization options, and development of a well-coordinated plan. The following sections of this report are designed to provide the foundation for planning, integration and implementation of NG9-1-1.

2.3 Purpose of the Report

2.3.1 The Intent of This Work

With the evolution of 9-1-1 technologies, it is clear that the term “Next Generation 9-1-1” needs to be better understood by all stakeholders. Many organizations and industry authorities have contributed to the development of NG9-1-1, and several well respected reports were completed in the early stages of the evolution. What was lacking in these efforts however was an overall comprehensive understanding and roadmap pooling of the disparate “facts” into a single resource that would provide guidance to decision-makers as they moved forward with their vision and ideas.

This introduces several questions concerning the optimal architecture for NG9-1-1:

- Is there one “best and optimal design”?
- If so, what are the elements required for that design?
- If not, what are the various configurations that could be combined together to reach that optimal objective?
- And how do you best accomplish the transition from legacy to NG9-1-1?

These and many other questions have been confronting decision-makers as they consider the transition to NG9-1-1. The attempt to correlate and understand competing information is creating confusion.

To clarify this confusion, this report addresses various optimal architectures for Next Generation 9-1-1. By reading this report, decision-makers tasked with the challenges of making choices for design and configuration of their 9-1-1 systems and will be capable of understanding not only the key decision factors, but also the broader understanding of the relevant impact of those decisions.

The Working Group does not believe there is a single best system design, but rather various options that may be selected representing an “optimal architecture” for each specific NG9-1-1 system. Our intent is to create a road map that identifies the components and optimal configuration choices available to decision-makers. These configuration choices include access for the originating service providers, NG9-1-1 core services, ESInet, and the call-taking and dispatching infrastructure. Emergency response and incident management are outside the scope of this report.

This report provides criteria and comparative information to 9-1-1 Authorities and related stakeholders at all levels of government, so they can determine what choices best meets their respective needs.

Section 3 - Current PSAP Decentralized Environment

3.1 Description of Decentralized Environment

The decentralized PSAP environment is prone to fragmentation and duplication. Optimization opportunities for this environment, while still maintaining its decentralized characteristics, are limited and challenging. However, options such as utilizing virtual PSAP arrangements, network-based terminating equipment, and network-based support systems (CAD, MIS, Recording, etc.) can be applied without changing the local structure of PSAPs. Essentially the sharing of such infrastructure can result in a single virtual PSAP scenario or continued independent operation through use of multi-tenancy.

3.1.1. Decentralized Environment Characteristics

3.1.1.1. PSAP Infrastructure Elements

In the typical legacy environment, PSAP equipment and software are predominantly located within the boundary of each PSAP (though remote positions associated with a particular PSAP may be present). The list of functional elements (FE) is comprised of but not limited to the list below. A simplified diagram illustrates the connections:

Typical Legacy 9-1-1 Functional Elements

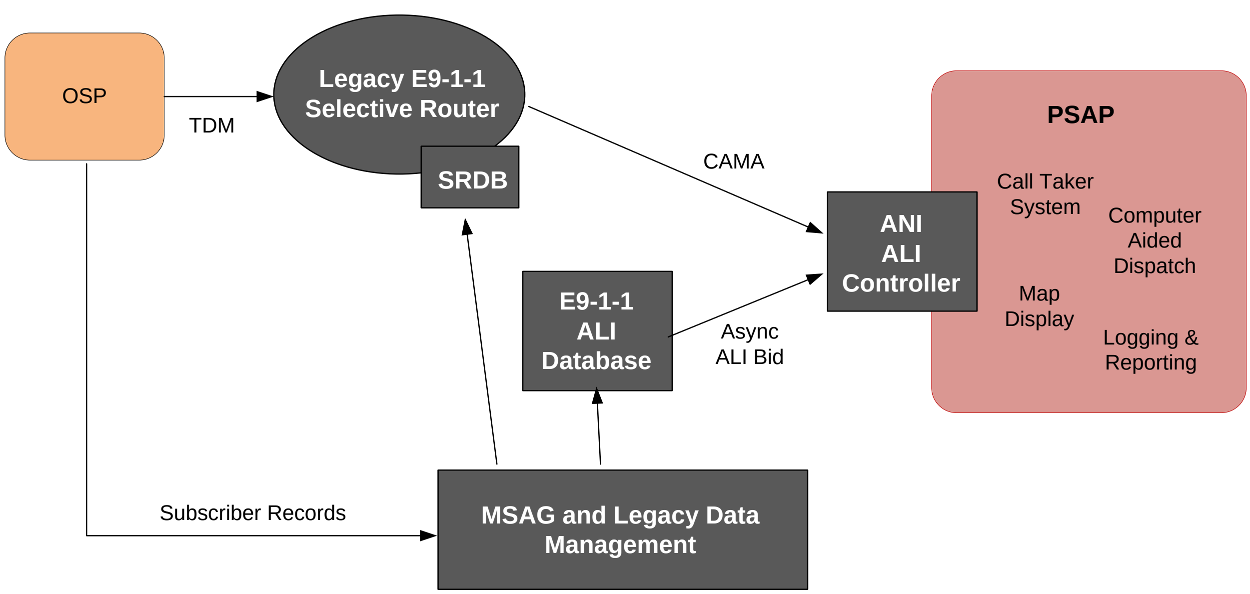

Figure 3-1

Administrative Phone System: The Administrative phone system includes telecommunication equipment that handles processing of administrative telephone communications.

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. The ALI Database is a set of ALI records residing on computer servers[7].

PSAP Phone System/Customer Premise Equipment: Equipment used for handling emergency 9-1-1 and non-emergency calls for service. Manages all communication from the caller, and includes the interfaces, devices and applications utilized by the 9-1-1 Telecommunicator to handle the call. This can also include administrative telephone systems used within an agency but not integrated into the 9-1-1 equipment.

Computer Aided Dispatch (CAD): An integrated technology solution for management of public safety incident creation functions associated with emergency and non-emergency calls for assistance, dispatch of first responders and incident tracking. CAD also operates as a connection to other information sources and databases through various interfaces built into the system such as, but not limited to:

- National, State, Regional or local databases
- Emergency Medical Dispatch software or card system.

Geographic Information System (GIS): A system that allows for mapping, model, query and analysis of spatial or geographical data.

Instant Recall Recorder (IRR): A device that enables the playback of recent audio conversations and radio traffic related to emergency communications.

Local Area Network (LAN): The local area network within the PSAP. There can be multiple networks, with multiple sub-nets and IP schemas.

Logging Recorder: The technology used for **r**epository of emergency incident communications and related voice data.

Management Information System (MIS): The MIS system provides reporting services based on data collected from other FEs.

Map Database: Stores a set of data layers obtained from a GIS and provides a query function that returns a set of features within a defined boundary that may be used to create a map for display.

[7] NENA Master Glossary of 9-1-1 Terminology, 2014

Records Management System (RMS): An agency-wide system that provides for the storage, retrieval and retention, archiving and viewing of, information, records, documents or files pertaining to public safety operations. RMS covers the entire lifespan of public safety records development from the initial generation to its completion.

System Alarms: A mechanism to provide notification to internal or external entities of system errors, failures, or other conditions of interest.

Time Server: A Functional Element that provides Network Time Protocol (NTP) time services to other Functional Elements.

Wide Area Network (WAN): The wide area network the PSAP must access for connectivity to external resources including but not limited to hardware and data services.

3.1.1.2. PSAP Structure & Governance

In March 1973, the White House's Office of Telecommunications issued a national policy statement which recognized the benefits of 9-1-1, encouraged the nationwide adoption of 9-1-1, and provided for the establishment of a Federal Information Center to assist units of government in planning and implementation.[8] Units of government, usually cities and counties, across the United States began implementing 9-1-1 for their citizens, which led to the creation of a large number of Public Safety Answering Points (PSAPs) across the United States. This initial approach enabled a wide variation of governance models.

Over time, and for various reasons, the number of PSAPs has declined in some locations. For example, in 1981 Oregon had over 280 PSAPs and today there are 43.

The decline in the number of PSAPs across the nation can be attributed to the formation of other governmental mechanisms serving several jurisdictions at a:

- county
- regional, or
- state level

Some PSAPs have also joined together to share equipment, services, and resources through:

- Shared infrastructure such as CPE, Controllers, CAD systems, recording systems, notification systems, etc.
- Shared resources for training, GIS and MSAG maintenance, 9-1-1 call taking and processing, etc.

However, there are still many PSAPs serving a single jurisdiction and are managed by the city, county, police, or fire department they serve. In some areas these single

[8] National Emergency Number Association, archives.

jurisdiction PSAPs have joined together under a joint management structure while maintaining their independence serving their jurisdiction.

Governance of any of these structures must be based on what works best for those involved. The governance and management of joining together as described above must be based on an intergovernmental agreement of the parties involved. The form of the agreement should be based on state statutes or local ordinances. The agreement should identify the management of the agreed upon services, and establish performance standards for what is considered successful program performance.

3.1.1.3. PSAP Operations

PSAPs operate independently and autonomously. Operations of a PSAP are typically handled within the confines of the PSAP itself and are dependent on serving those agencies identified within the PSAPs 9-1-1 Service Plan.

PSAPs perform varying functions based on the local agencies it serves. PSAPs must tailor Standard Operating Procedures (SOPs) around the utilization and support of the PSAPs basic functions and the infrastructure elements outlined in 3.1.1.1. PSAPs are responsible to answer, arbitrate and coordinate appropriate responses to emergency requests received by the PSAP. The services provided by a PSAP will vary based on PSAP type (primary or secondary), managerial functions, fiscal appropriations, interoperability, and local control. A PSAP receives emergency requests for service in a variety of mechanisms and channels. There is an initial alert that occurs, followed by information delivery. The media of the information could be delivered via audio, data or text and the PSAP uses several systems to process emergency calls as defined in Figure 3-2 below:

METHODS FOR ACCESSING PSAP	9-1-1 TECHNOLOGY USED BY PSAPs	PSAP DISPATCH RESOURCES	COMMENTS
Wireline (Home, Business, etc.)	Basic 9-1-1, Enhanced 9-1-1, NextGen9-1-1*, 10-digit Emergency Lines, TTY/TDD	Emergency Dispatch Protocols, Computer Aided Dispatch, Enhanced External Data Sources, GIS Systems, Emergency Notification System	Additional Data Sources (i.e., Smart9-1-1) Reverse Notification Systems (i.e., Code Red, Reverse 9-1-1, Everbridge, etc.)
Wireless (Mobile Devices)	Basic 9-1-1, Enhanced 9-1-1, NextGen9-1-1, 10-digit Emergency	Emergency Dispatch Protocols, Computer Aided Dispatch, Enhanced External Data Sources, GIS	

	Lines, TTY/TDD	Systems, Mobile Device Applications, Emergency Notification Systems	
Text	Web Client, TTY/TDD, or Integrated into 9-1-1 Equipment	Emergency Dispatch Protocols, Computer Aided Dispatch, Enhanced External Data Sources, GIS Systems, Mobile Device Applications	
Telematics	Basic 9-1-1, Enhanced 9-1-1, NextGen9-1-1	Emergency Dispatch Protocols, Computer Aided Dispatch, Enhanced External Data Sources, GIS Systems	
Relay Centers	Basic 9-1-1, Enhanced 9-1-1, NextGen9-1-1, 10-digit Emergency Lines, TTY/TDD	Emergency Dispatch Protocols, Computer Aided Dispatch, Enhanced External Data Sources, GIS Systems,	
Social Media	Basic 9-1-1, Enhanced 9-1-1, NextGen9-1-1, 10-digit Emergency Lines, TTY/TDD	Emergency Dispatch Protocols, Computer Aided Dispatch, Enhanced External Data Sources, GIS Systems,	

Figure 3-2

PSAP Operations encompasses a multitude of technologies and information sources as identified above, and these sources are used to process a variety of emergency calls on a daily basis. The various calls can range from someone calling for assistance from their home or office; to an alarm company advising on a critical alarm status; to an automobile involved in a collision needing emergency assistance. The combination of technologies, information sources and skilled 9-1-1 personnel are what make a difference in dispatching emergency response to save a life or protect property.

3.1.1.4. Legacy PSAP to PSAP Communication

The current definition of “Interoperability” by the U.S. Department of Homeland Security is “To enable the emergency response community to communicate and share information across levels of government, jurisdictions, disciplines, and organizations for all threats and hazards, as needed and when authorized.”

Most legacy PSAPs are stand-alone entities and very autonomous. As a result, local telecommunications interoperability among PSAPs operating in this environment is limited to the transfer of calls to another PSAP that has been pre-identified by the PSAPs involved, and arranged through the serving local exchange carrier (LEC). In some legacy PSAP environments the public telephone switch telephone network is used for call transfer of emergency calls and does not include the transfer of critical data such as caller telephone number or address location. Such limitations can impact the dispatch of emergency services. Legacy 9-1-1 technology also struggles with receiving text, expanded data and wireless location information that is commonly available today. A "Band-Aid" solution to the old legacy technology is no longer sufficient and the limitations continue to impact sharing of information impeding incident situational awareness among multiple responding services. For example, multiple physical radios placed in a police unit or fire apparatus to serve mutual aid agreements with adjacent jurisdictions. While some of these obstacles have been overcome in some regions, it continues to be a problem for the majority.

3.1.1.5. PSAP Optimization Considerations and Factors for the Decentralized Environment

Optimization: Making the best, of anything. Many think PSAP optimization means consolidation. However, in a decentralized environment PSAPs can make the best of that environment in several ways.[9] They can judge that decision based on:

- Does it make sense
  - Operationally
  - Financially
  - Politically

Done correctly, they can optimize operations by:

- Sharing systems
- Joint purchasing
- Shared networks
- Shared staff

PSAP Optimization in a Next Generation 9-1-1 environment is expanded and included in Section 4 of this report.

[9] Cooperative Service Through Consolidations, Mergers, and Contracts…Making the Pieces Fit. By: Chief Jack W. Snook and Chief Jeffrey D. Johnson. http://esci.us/resources/making-the-pieces-fit/ Last accessed 12/02/15

Section 4 - PSAP Optimization Options

4.1 PSAP Operations Optimization

4.1.1 Basis For Operational Optimization

PSAPs often function as the emergency communications hub for the communities they serve. The critical goal of any optimization initiative is to further enhance public safety. As agencies open discussions regarding the potential for physical optimization, it is critical that operational expectations, such as expected service levels, are clearly identified.

The basis of PSAP optimization assumes that Next Generation 9-1-1 Core Services and the ESInet have been considered as discussed in Sections 5 and 6 of this report. Whether deployed at the County, Regional or State level, the NG9-1-1 environment provides PSAPs the flexibility to configure call flow and applications in a manner not previously available.

4.1.2 Optimized PSAP - Operational Models

In each model below, call handling is the common functionality. In a true NG9-1-1 deployment, it is not necessary for the CPE to be of the same manufacturer, and in larger deployments, e.g. regional or State, it is assumed that numerous CPE vendors will be in use.

4.1.2.1 Shared Services (Centralized)

A shared services center is where existing PSAPs centers are brought together under one roof or facility and possibly share management and resources. Several examples include Bexar Metro 911 District[10], Licking County Regional Communications Center, Ohio[11], and Bergen County Public Safety Operations, New Jersey.[12] A formal relationship is established through inter-local agreements, setting the entry and exit of agencies and the operational environment involved under the governing PSAP agency or authority. The public safety agencies themselves (law, fire, EMS) could operate as a combined entity, or individual separate entities. This model provides services for all public safety call intake and dispatching within the assigned area. Staff may utilize common technology, operational policies under a single form of governance.

[10] Buchholtz, B. (10/02/05). Email Interview.
[11] Carver, K. (10/27/15) Email Interview.
[12] DelVecchio F. (11/20/15) Email Interview.

Advantages:

- Common facilities provide the ability to share the benefits of common support services such as janitorial, food services, office supplies, and the support infrastructure.
- Takes advantage of common electrical, HVAC, and emergency power subsystems.
- The employees can be cross-trained and the schedules can be combined for added personnel efficiency.
- Creates an environment that is more flexible, and amplifies the commonalties in law, fire and medical dispatch.
- One operating environment for the consolidated 9-1-1 operations can optimize the use of computer aided dispatch (CAD), radio, mobile data, audio recorders, mapping, geographic information system (GIS, CPE and telephony systems) and Database Systems.

Challenges:

- Maintaining numerous service level agreements (SLA's) for specific PSAPs may be challenging.
- Combining multiple agencies, which utilize different and incompatible computer systems into a multi-jurisdictional, multi-disciplinary, multi- agency, high-volume center can be difficult to implement and support.
- Bigger is not necessarily better if neither efficiencies in service delivery nor economies of scale would result from consolidation of services.
- Emergency communications could be interrupted for all of the jurisdictions involved if proper attention is not given to redundancy and fallback planning.

4.1.2.2 Hybrid

This model can include variations wherein PSAPs maintain separate physical locations but share common call handling, and other services such as, radio, CAD or other public safety dispatching equipment over a secure managed network. These environments are positioned to readily move toward Next Generation 9-1-1 architectures.

An example of this model might be four local PSAPs sharing a common PSAP enterprise network, secondary network connectivity for redundancy, hosted CAD and CPE equipment. Additionally, radio technicians, system administrators, dispatchers and supervisors are able to assist each agency due to the common technology, applications, appliances and configuration of the hosted solutions and common technology platforms deployed among and between the PSAPs. Examples of this include Boulder County Regional PSAP and Upper Peninsula 911 Authority, Michigan. [13] [14]

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[13] West, P. (12/05/05). Email Interview
[14] Johnson, G. (11/06/05). Email Interview.

Advantages:

- Local operational control, management and governance are maintained by each PSAP agency.
- The employees are cross-trained at the technical and operational level to assist each of the PSAPs.
- Common operating platforms and costs are shared among the PSAPs allowing the agencies the use of computer aided dispatch (CAD), radio, mobile data, audio recorders, mapping, geographic information system (GIS, CPE and telephony systems).
- Interoperability is increased with the use of common network and equipment so data and emergency calls can be transferred between the PSAPs.
- The design in itself is a disaster recovery design, allowing for primary PSAP personnel to easily move to a sister PSAP and continue operations.

Challenges:

- Where there is no regional 9-1-1 Authority, this model requires additional cooperation and trust among the agencies to manage global and agency configurations. For example, interfaces that rely on the PSAP and their sub agencies add complexity as equipment and appliances may be inconsistent across sub agencies or contract agencies.
- Difficult to implement and support if a common funding model is not established to share implementation and on-going support costs
- Requires PSAPs to collaborate, agree to modify operational policies, and spend additional time to gain consensus to move issues to conclusion that affect operations and technology implementation

4.1.2.3 Centralized Call Taking Center

In this model, 9-1-1 calls, which would normally be directed to individual PSAPs, are routed to a centralized call taking facility. These call takers perform immediate analysis and triage, then transfer the call to the appropriate law enforcement, or fire/ems agency of the jurisdictions involved for dispatch. They may also bridge multiple agencies together to respond to specific events or situations.

The dispatch agencies may share the same facility or be located at numerous geographic locations. Examples of this include Honolulu Police Dept. and Harris County 9-1-1 District, Texas. [15] [16]

All PSAP functions can remain the same.

[15] Burns, T. (10/02/05). Email Interview.
[16] Harris Info (11/01/05). Email Interview.

Advantages:

- A large staffing base insures 9-1-1 calls are answered in a timely manner, potentially increasing service levels.
- Addresses local calling spikes, where a local PSAP may have required calls to queue prior to being sent to their designated ‘overflow’ PSAP.
- Provides a non-partisan call-taking environment.
- Regional call-routing is simplified which could result in fewer call transfers.

Challenges:

- Requires a well-planned governance structure.
- Coordination and sharing of resources.
- Coming to a common ground on standard operating procedures can be difficult.
- Time is added to call processing.
- May be duplication of functions.
- Every Police/Fire/EMS call requires a transfer
- For very large call taking centers, appropriate geographic and tribal knowledge may not be available.

4.1.2.4 Consolidation by Discipline

This model keeps the existing PSAP structure in place, with law enforcement answering all 9-1-1 calls. However, Fire/EMS calls are transferred to a consolidated secondary PSAP. In this model, the secondary PSAP has the ability to dispatch Fire/EMS for all associated agencies. It provides for a higher level of specialization for both the Primary and Secondary staff. As an example, this model is currently being used successfully in one of the largest geographic Counties in the nation.

Advantages:

- Call takers are able to specialize in a specific discipline. As an example, dealing only with EMS types of calls. This may provide better quality of service to the public.
- Staffing provides the ability to handle ‘surge capacity’ or large call volume increases from a specific geographic area surrounding a single PSAP.
- Primary PSAPs will experience a decreased workload

Challenges:

- Every Fire/EMS call requires a transfer.
- Coming to a common ground on standard operating procedures can be difficult.
- Time is added to call processing.
- There is duplication of functions.

4.1.2.5 Virtual

This model requires shared infrastructure. The PSAP call handling equipment can be local or reside at a remote site or data center. An ESInet provides transport for the calls to be routed to numerous PSAPs. Provides for remote Session Initiation Protocol (SIP) positions anywhere.

Virtual environments can enable the use of shared PSAP subsystems such as CAD, Automatic Call Distribution (ACD), MIS, and mapping. Current examples of these include State of Maine 9-1-1 Program and Palm Beach County, Florida.[17] [18]

Advantages:

- Call routing is transparent to the 9-1-1 caller, regardless of location.
- PSAPs can expand coverage areas and balance calls among sites
- Good model for handling surge call volume
- Each PSAP can still maintain their own local governance structure.
- Each PSAP can still choose local policy routing (e.g. ring all or ACD)
- Good model to support disaster recovery
- This could be configured to enable multiple PSAPs to operate as one virtual call center.

Challenges:

- Requires detailed coordination between PSAPs.
- Appropriate operational structure (ex. Administration and support) needed to support the virtual environment.
- Local knowledge.
- Coordination and sharing of resources.
- Coming to a common ground on standard operating procedures can be difficult.
- Requires ongoing cooperation and coordination of all participants.

4.1.3 Optimization Considerations and Factors

The goal of this section is to help the reader determine the PSAP optimization solution which best meets the unique needs of a given jurisdiction or area (local, county, region, state). Inherent in that process is the task of comparing the desired components of 9-1-1 service against the specific circumstances comprising a jurisdiction's needs. Each jurisdiction is unique and multiple technical and non-technical factors should be considered to work towards a final decision that is

[17] Jacques, M. (09/23/05). Email Interview.
[18] Spalding, C. (10/07/05). Email Interview

appropriate for a given community at a given time. The following reference documents provide optimization consideration factors:

> The Minnesota Governor's Work Group's "Public Safety Answering Point Consolidation: A Guidebook for Consolidation Strategies," states, "An overall improvement in the level of 9-1-1 answering and dispatch services provided to the community, participating agencies, and field personnel is the single most important reason to consider PSAP consolidation. "[19]
>
> An Oregon document, entitled, "Consolidation Analysis and Next Generation 9-1-1 Implementation Study" states, "9-1-1 telecommunicators are truly the "first responder on the scene" and can substantially affect the outcome of an incident."[20]
>
> As California's 2010 Strategic Plan states, As stewards of the public trust, 9-1-1 public safety organizations have an obligation to enhance internal capability and autonomy through the retention of adequate resources, skilled personnel, technological capability, and authority to execute all aspects of the 9-1-1 Program."[21]

The following section of this document is not exhaustive, but includes issues that authorities/agencies may wish to consider as part of the overall process of determining the optimal 9-1-1 solution in relation to the specific circumstances in the community they serve.

This process has two assumptions:

1. Primary objective is meeting the needs of 9-1-1 callers by improving the capabilities and quality of 9-1-1 answering and dispatch services.[22]

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[20] "State of Oregon Office of Emergency Management, Consolidation Analysis and Next Generation 9-1-1 Implementation Study": http://www.oregon.gov/OMD/OEM/or911/docs/kimball_consolidation_analysis_next_gen_implementation_study.pdf Last accessed December 4, 2015.

[21] California Office of Emergency Services, California 911 Strategic Plan (2010), http://www.caloes.ca.gov/for-businesses-organizations/plan-prepare/ca-9-1-1-information, last accessed September 3, 2015.

[22] Minnesota Governors Work Group "Public Safety Answering Point Consolidation: A Guidebook for Consolidation Strategies, "An overall improvement in the level of 911 answering and dispatch services provided to the community, participating agencies, and field personnel is the single most important reason to consider PSAP consolidation."

2. Secondary objective is providing necessary resources for the 9-1-1 Telecommunicator, previously defined as a "person employed by a PSAP and/or an EMD Service Provider qualified to answer incoming emergency telephone calls and/or provides for the appropriate emergency response either directly or through communication with the appropriate PSAP".[23]

4.1.3.1 Operational Considerations

Technical, administrative, and financial issues, as identified in Section 7, are important considerations in evaluating the potential of sharing resources, but of equal importance, are operational considerations. Deciding exactly what resources will be shared and how the work of PSAPs will utilize the shared resources has important implications for exactly how the public's need for 9-1-1 service will be met. It will also directly affect the telecommunicators who are held responsible for handling 9-1-1 calls from the community.

PSAP operations have historically been unique to each PSAP, and driven by the needs of the agencies they serve and the individual agencies actively participate in defining the operational procedures specific to that agency. The more agencies served by a single PSAP the more complex the operational procedures become. However, it is important to note that as Next Generation 9-1-1 efficiencies are gained with optimized networks and core services, the melding of standardized operating procedures will need to be accomplished. Through cooperation and partnerships with multiple agencies a detailed comparison of existing policies and procedures will be required, as well as careful consideration should be given to how all changes could affect PSAP service requirements. Part of this comparison must include examination of the roles and responsibilities of the telecommunicator, and modify roles, where appropriate, to ensure the successful fulfillment of their assigned duties.

9-1-1 Jurisdictions currently have procedures and processes in place to deploy, manage and maintain E9-1-1 systems, and their interactions with vendors, especially a 9-1-1 service provider. As PSAPs migrate to NG9-1-1 those procedures and processes may need to evolve to support the next generation environment.

NENA's NG9-1-1 Transition Planning Considerations Committee produced the "NENA NG9-1-1 Transition Plan Considerations Information Document"[24] which

[23] National Emergency Number Association, NENA Master Glossary of 9-1-1 Terminology, http://www.nena.org/?page=Glossary Last accessed December 2, 2015.
[24] NENA NG911 Planning Document: http://www.nena.org/?page=ng911planning Last accessed December 2, 2015.

addresses technical and limited data transition elements (based on originating and terminating entities as they progress from legacy to NG9-1-1 environments). However, the PSAP operational impacts associated with NG9-1-1 warrant similar attention. As noted by NENA NG9-1-1 Planning document,

> *The transition to NG9-1-1 has impacts upon operations within all stakeholder organizations. The level of impact may depend upon the responsibility of the entity processing the emergency call. For example, for entities in originating networks it may be as simple as redirecting calls to the NG9-1-1 network. For entities such as 9-1-1 Authorities it may require developing transition plans to upgrade or replace equipment, and to cope with the databases that support the NG9-1-1 services and capabilities. It is expected that NENA's Committees will continue to develop operational standards that will facilitate the introduction of NG9-1-1.*

At the publication of this report NENA, officially initiated the development of *Operations, Monitoring and Managing NG9-1-1 Systems* document and interested parties should monitor the NENA website for publication of this guide.

4.1.3.2 Organizational Operation

In the legacy 9-1-1 environments, public safety agencies have had the luxury to operate in silos. Local police, fire and EMS agencies have designed their responses to fit local needs. In general, agencies expect their PSAPs to dispatch them to a finite level. Each entity being able to individualize the way they respond to specific call types with a very localized fit. As NG9-1-1 becomes a reality, it will allow PSAPs the capability to dynamically utilize partner PSAPs to assist during heavy call traffic situations and/or outages. During those times, we will need to work out how first responders will receive the call for them to respond to. As PSAPs must cooperate and collaborate call answering, call entry and call delivery, it will be imperative that local public safety agencies begin to cooperate and collaborate to design local responses to be as like as possible to the extent possible. TFOPA WG2 recommends that local and regional PSAPs begin partnerships and collaborations for the planning, implementation and operations of NG9-1-1 systems.

At the organizational level, it will be important to come to agreement on the desired outcomes for operational consideration and specific actions for reaching those outcomes. The priorities of each individual agency must be considered, and collective goals made for providing 9-1-1 services. Discussion and decision may include such varied topics as:

- Establishment of Multi-jurisdictional Operations Planning Committee (Policy, operational procedures and cross-jurisdictional boundary issues)
- Personnel Operational Issues (i.e. Salaries, Benefits, Code of Conduct, etc.)
- Labor Laws / Labor Contracts
- Services Provided (e.g. EMD, Police, Fire Dispatch, Poison Control, Language Line)
- Operational Politics
- Desired method of operation[25]
- Desired level of efficiency
- Required level of business continuity
- Load sharing
- Framework for cooperative decisions
- Quality Assurance (QA) / Quality Control (QC)
- Security – physical and cybersecurity
- Differences in CAD, phone, radio, recording equipment, GIS
- Existing processes for budgeting, accounting, payroll
- Accreditations and certifications
- Disaster Recovery
- Continuity of Operations plans
- Plans for deploying advancing technology
- Managing relationships with carriers and emergency responders

All operational functions should be accounted for and agreed upon as part of any resource sharing agreement.

The largest ongoing investment most PSAPs make is in personnel, and multiple publicly available reports cite personnel as the largest cost for PSAPs. It is the responsibility of the agency that employs telecommunicators to ensure that they have the tools to succeed in answering and processing 9-1-1 calls. Sharing

[25] Recommended Call Processing Standards currently exists with the National Emergency Number Association, APCO International and the National Fire Protection Association. At the publishing of this document NENA was reviewing, updating and consolidating a recommended standard covering the following NENA documents:
56-001 Guidelines for Minimum Response to Wireless 9-1-1 Calls
56-005 Call Answering Standard / Model Recommendation
56-006 Emergency Call Processing Protocol Standard
56-501 Silent or Hang-Up 9-1-1 Calls for Service Information Document

services among PSAPs not only requires technical, administrative and financial arrangements, but must also include issues related to staffing, such as:

- Discrepancies in policies and standard operating procedures
- Variances in job descriptions (including non-9-1-1 duties), hiring practices, pay, scheduling, supervision, seniority, benefits and other HR issues (e.g., reward and discipline procedures)
- Inconsistencies in staffing levels
- Addressing staffing issues related to fatigue. As with other "shift" workers, shift rotations of the Telecommunicator require proper planning to minimize the health effects of the 24 hours operation. Staffing resources are available that incorporate appropriate measures, and jurisdictions are encouraged to include such ideas when considering how to combine staffing. [26]

4.1.3.3 Training and Support

The training provided to telecommunicators varies widely among PSAPs. Comparison of existing training requirements among PSAPs may reveal gaps or inconsistencies that must be addressed to ensure seamless provision of shared services.

Combining training for multiple PSAPs may increase efficiency. When each PSAP is no longer exclusively responsible for its own training, it becomes possible to share training sessions and provide coverage for each other's training sessions. Standardized training offers the option of load sharing and the possibility of covering for each other's PSAP, if staffing needs suddenly increase. In order to enjoy these benefits, plans must be developed and executed that address and include:

- An agreed upon method of operation
  - Desired levels of efficiency
  - Load sharing
- Differences on job descriptions (i.e., call processing, dispatching)
- Discrepancies in CAD systems
- Inconsistencies in standard operating procedures
- Variances in training and how they will be addressed.

In addition to the items above there should be consideration and focus given to emotional and quality of life issues. PSAP consolidation represents change for

26 http://www.cdc.gov/niosh/docs/97-145/pdfs/97-145.pdf, Last accessed December 2, 2015.

existing PSAP employees and stakeholders and may require difficult adjustments. Managing this change is critical to the success of any resource sharing effort. Change management methods, including the active involvement of staff may be key in successful transition. There will be a need to provide a steady stream of updates and accurate information as deliberations occur, and if decisions are made and implemented.

Additional and enhanced data that will also be provided via the 9-1-1 caller will requirement management oversight and additional operational procedures. At the publication of this report, an Operations Monitoring and Managing of NG9-1-1 was in development by NENA.

There is widespread acceptance of the fact that the job of the 9-1-1 telecommunicator is stressful.[27] Telecommunicators are expected to process calls where terrible events have occurred. But repeated exposure can take its toll. And a study by researchers at Northern Illinois University suggests that the telecommunicators are at risk for developing symptoms of post-traumatic stress disorder (PTSD). Researchers analyzed the responses of almost 200 experienced (averaged more than 10 years) emergency dispatchers from 24 states and found almost five percent reported symptoms severe enough to qualify for a diagnosis of PTSD.[28]

Managing any additional stress brought on by organizational change will be important to the success of any efforts to share resources, whether the shared resources are virtual or physical. Taking the opportunity to address stress for telecommunicators may have a positive effect on job satisfaction, performance, and retention. There are resources available that employ effective methods for dealing with stress and PTSD symptoms, that allow the telecommunicator to stay on the job and will allow the PSAP to benefit from the expertise gained from successful handling of difficult situations.[29] Incorporating the availability of stress resources within the context of managing change could be an important way of demonstrating the value of staff to the organization, and a worthy investment.

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[27] Gouveia, A. (2013). The Top 10 Most Stressful Jobs Find Out Which Careers Come with the Most Worry. http://www.salary.com/the-top-10-most-stressful-jobs/slide/5/ Last accessed August 8, 2015

[28] Northern Illinois University, NIU researchers find link between 9-1-1 dispatchers, PTSD symptoms, s/news/2012/03/911-ptsd.shtml" http://www.niu.edu/mediarelations/news/2012/03/911-ptsd.shtml, last accessed August 8, 2015.

[29] 911 Wellness Foundation, Building Your Stress Program, .com/building-your-psap-csmp/" http://911wellness.com/building-your-psap-csmp/ last accessed August 8, 2015.

4.2 PSAP Infrastructure Architecture Deployment Optimization Models

Whereas other sections described NG9-1-1 PSAP optimization from a governance and operational perspective, this section describes the PSAP infrastructure architecture models that enable the efficient sharing of hardware within a single PSAP, or the efficient sharing of both hardware and software services across multiple PSAPs. These architectural models for sharing infrastructure and software services have become prevalent in commercial and enterprise markets and can be applied to future NG9-1-1 deployments.

These infrastructure deployment models configured to support each of the operational models discussed previously, thus allowing PSAPs telecommunicators in diverse physical locations to function in a coordinated manner as a virtual PSAP environment, or in a more traditional multi-PSAP environment with separate jurisdictional/ administrative domains.

Further these deployment models can be implemented independently at the level of individual services, such as call taking or CAD, or in combination if there is a desire on the part of those deploying these solutions that some services be shared while others are not. Finally these models can be deployed at any scale required, including at the local, regional or state level. Therefore rather than describe every permutation of potential deployment models, this section will focus on the high level models themselves.

Additionally, these PSAP infrastructure deployment models offer PSAPs flexible purchase, implementation, operation and maintenance, and service options which allow jurisdictions to implement the appropriate level of optimization based on their needs. To fully understand the shared infrastructure architecture models we have also provided a discussion of the On-Premise Dedicated Infrastructure model for comparison purposes.

NG9-1-1 PSAP architecture optimization will build upon the use of several by now widely deployed enterprise technologies that make up the core of modern computing and communications systems and which PSAPs will start to utilize even more extensively than they do today as they transition to NG9-1-1 systems. These technologies form the foundation for next generation infrastructure deployments across all industries, and not just in NG9-1-1.

- **Internet Protocol (IP):** Internet Protocol-based networking is foundational to NG9-1-1, the ESInet WAN and PSAP LAN. The multimedia capability, interoperability, scalability and robustness of the technology that underlies the Internet are leveraged in NG9-1-1 by the use of IP-based networks and communications systems.
- **Client-Server:** Modern data processing and communication systems utilize this model in which client software deployed at the user end point (in the public safety context, usually at a PSAP telecommunicator position) works in conjunction with server software deployed in an on-premise data equipment room or a shared

infrastructure data center. The server-side implementation of client-server deployment is typically called a software service.

- **Server Virtualization** Software technologies, including virtual machine and emerging container technologies, that allow multiple applications to share a common server hardware and storage platform.
- **Cloud** Virtualization technology taken to a larger scale where virtual machines / containers can be created for software services in an on-demand fashion using a private government intranet infrastructure or an internet-accessible public infrastructure of computing hardware and storage; cloud technology improves infrastructure usage efficiency and service reliability and provides elasticity to support peak demands on resources.

The following subsections will describe the various types of PSAP architecture deployment models and their relative impact on specific optimization factors. The models described are those envisioned as potential "real world" PSAP deployments.

This section is related to technical architecture, and will not address some of the political factors such as governance, joint service agreements, cost and operational allocations to jurisdictions, and legal considerations. Those factors are described in other sections. However, these architecture models do significantly impact specific relevant optimization factors that can in turn be qualitatively compared and contrasted in terms of their relative value for each model.

Key optimization factors that should be included in a jurisdiction's consideration of the optimization models include but may not be limited to:

- Financial
  - Solution costs (e.g., equipment, capital expenditure/operational expense)
- Interoperability
  - Functional interoperability
  - Geographic interoperability: local, county, multi-county, state, national
  - Data sharing
- Survivability/Reliability (operational)
  - Level of service redundancy
  - Level of geo-diversity
- Elasticity/ Scalability
  - Ability to adapt to unanticipated peak loads
  - Ability to bring on additional jurisdictions without re-architecting
- Security
  - Information Security
  - Cyber-attack resiliency
- Operational Staffing
  - Technical Support

4.2.1 NG9-1-1 PSAP Functional Elements

Next Generation 9-1-1 PSAPs will benefit from several new capabilities that will provide greater insight into the nature of each caller's emergency and will help guide telecommunicators on the most effective response that should be dispatched. Further discussion is needed in reference to applications, interfaces, and services expected to be available in NG-9-1-1. While referenced below, this document does not go into detail on each.

NG9-1-1 PSAP infrastructure elements, many of which carry-over as expected from legacy PSAP operations, may include but is not limited to the following:

- 9-1-1 Call-taking (Voice, Text, Data, Images, Video)
- Management Information System (MIS) and Analytics
- Incident recording (Multimedia - Voice, Text, Data, Images, Video)
- Geographic Information Systems (GIS)
- Computer Aided Dispatching (CAD)
- Records Management Systems (RMS)
- Data Retention/Records maintenance
- Addressing- Automatic Number Identification (ANI) Automatic Location Identification (ALI) services
- Advanced Services & Applications
    - Criminal Justice Information Database Access
    - Emergency Medical Dispatch (EMD)
    - Social Media Mining
    - Social Media External Communications
    - Internet of Things (IoT) Ingest
    - Data Analytics (Descriptive, Predictive, Prescriptive)
    - Video Surveillance
    - Media Analytics (Video, Audio)
    - Situational Awareness
    - Analytics Visualizations
    - Others
- Location Validation Function (LVF)[30]

[30] LVF is a NG911 core service that can be collocated with other NG9-1-1 core services or with the PSAP infrastructure elements.

4.2.2 NG9-1-1 Architecture Deployment Models

4.2.2.1 Dedicated Infrastructure Architecture Model

4.2.2.1.1 On-Premise Dedicated Infrastructure Architecture Model

This model has been used universally in the past, and is still used by the vast majority of PSAPs. Premise-based deployments are characterized by having all clients and required servers collocated at a single physical facility. This architecture is applicable to a single jurisdiction that wants to more effectively utilize server and storage hardware across a single PSAPs functional elements (Call-taking, CAD, RMS, etc.). In this configuration there is no sharing of resources outside of the PSAP or command center in question.

4.2.2.1.1.1 Options

4.2.2.1.1.1.1 Implementation Options

- Geo-diversity
- Virtualization

4.2.2.1.1.1.2 Financial Acquisition Options

- Non-Recurring Cost/CAPEX
- Recurring Cost/OPEX
- Combination of the above

4.2.2.1.1.1.3 Network Options

- Government owned and managed
- Vendor owned and managed
- Combination of the above

4.2.2.1.1.1.5 System Maintenance

- Government operated and managed
- Vendor operated and managed
    - Software as a Service
    - Infrastructure as a Service
- Combination of the above

Figure 4-1 is a pictorial representation of this architecture model.

On Premise Dedicated Infrastructure Architecture Model

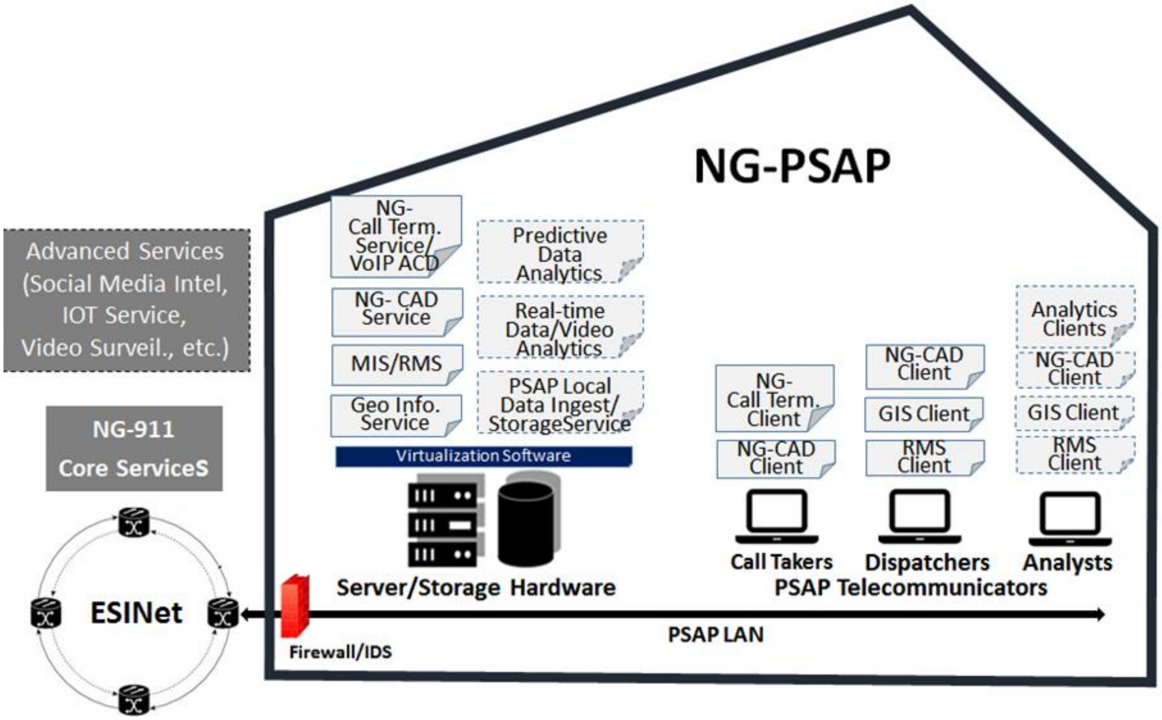

Figure 4-1: On-Premise Dedicated Infrastructure Architecture Model Example

Advantages

- Political – Same as what is done today
- Governance – Relatively straightforward, maps to what is deployed today; each PSAP uses its own governance model
- Security – Relatively secure.
- Operational – Same as what exists today; requires no real additional effort

Challenges

- Financial – May be the most expensive option as backroom hardware and related services are duplicated in every PSAP. To verify or validate this, further study may be warranted.
- Interoperability– Is inherently the least interoperable option; by definition standalone unless specific effort is made to interconnect "islands" of capability at each individual PSAP
- Survivability – Is inherently the least survivable option.

4.2.2.2 Shared Infrastructure Architecture Model

The shared infrastructure model enables multiple PSAPs to share the NG9-1-1 PSAP functional infrastructure elements that meet the needs of individual PSAPs or other jurisdictional entities fielding a system. This shared infrastructure deployment model enables multiple PSAPs (multiple tenants) to share the server-side components of NG9-1-1 PSAP functional infrastructure elements within either one of the PSAP facilities (on-premise shared infrastructure), or in a shared data center facility (data center hosted, shared infrastructure). This model can retain independent client-side deployments at the respective PSAP facilities housing the telecommunicators.

4.2.2.2.1 On-Premise Shared Infrastructure Architecture Model

In an on-premise shared infrastructure deployment model, the server-based hardware and storage components providing required PSAP functionality are located in PSAPs and shared by multiple PSAPs.

4.2.2.2.1.1 Options

4.2.2.2.1.1.1 Implementation Options

- Geo-diversity
- Virtualization

4.2.2.2.1.1.2 Financial Acquisition Options

- Non-Recurring Cost/CAPEX
- Recurring Cost/OPEX
    - Software as a Service (SaaS)
    - Infrastructure as a Service (IaaS)
- Combination of the above

4.2.2.2.1.1.3 Network Options

- Government owned and managed
- Vendor owned and managed
- Combination of the above

4.2.2.2.1.1.5 System Maintenance

- Government operated and managed
- Vendor operated and managed
    - Software as a Service (SaaS)
    - Infrastructure as a Service (IaaS)
- Combination of the above

4.2.2.2.2 Hosted, Shared Infrastructure Architecture Model

In a data center hosted, shared infrastructure deployment model, the server-based hardware and storage components providing required PSAP functionality are "hosted," in a data center and shared by multiple PSAPs. In an on-premise shared infrastructure deployment model, the server-based hardware and storage components providing required PSAP functionality are located in PSAPs and shared by multiple PSAPs.

PSAP facilities require client software on a PC, laptop, or tablet at their operator positions to access these shared services. In this model, PSAP administrators can retain the use of local telecommunicators, and in fact these individuals can be deployed anywhere that has network access connectivity back to the shared data center or to the PSAP facility hosting the shared infrastructure.

4.2.2.2.2.1 Options

4.2.2.2.2.1.1 Implementation Options

- Geo-diversity
- Virtualization

4.2.2.2.2.1.2 Financial Acquisition Options

- Non-Recurring Cost/CAPEX
- Recurring Cost/OPEX
    - Software as a Service (SaaS)
    - Infrastructure as a Service (IaaS)
- Combination of the above

4.2.2.2.2.1.3 Network Options

- Government owned and managed
- Vendor owned and managed
- Combination of the above

4.2.2.2.2.1.4 Data Center Options

- Government owned and managed
- Vendor owned and managed
- Combination of the above

4.2.2.2.2.1.6 System Maintenance

- Government operated and managed
- Vendor operated and managed
    - Software as a Service (SaaS)
    - Infrastructure as a Service (IaaS)
- Combination of the above

Figure 4-2 is a pictorial representation of this deployment model.

Sample Hosted, Shared Infrastructure Architecture Model

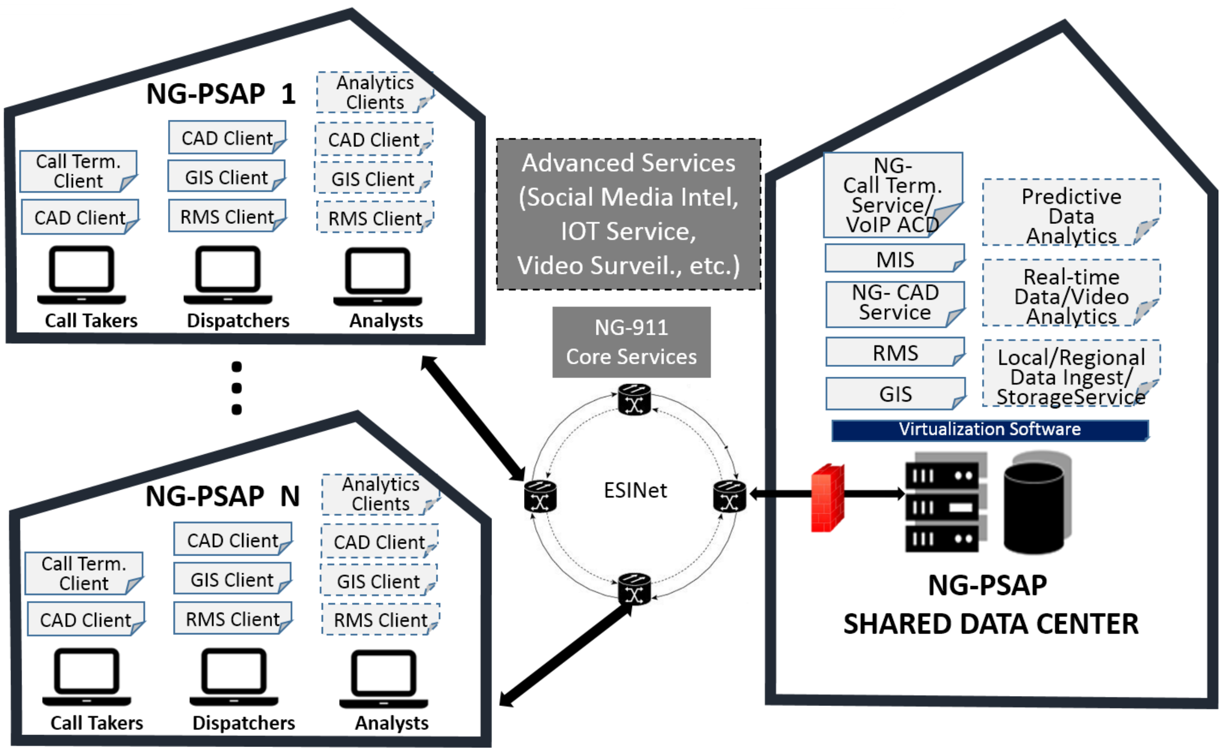

Figure 4-2

Advantages

- Interoperability – Inherent in system architecture and relatively easy to setup between PSAPs
- Financial – Shared infrastructure resources reduces overall cost of system and allows that cost to be shared.
- Survivability – automatic failover and geo-diversity options are typically inherent in system architecture; higher survivability in terms of 9-1-1 service provision

Challenges

- Governance – Independent PSAP governance is no longer an option and therefore work must be done to develop a joint governance model

- Political will – In a fully shared infrastructure model, all but a single PSAP, or potentially none, will retain a "full system". Most will be using only clients to connect to the shared infrastructure services. Potential "loss of prestige"
- Operational – Like governance, will require some effort to create a joint operational model, something that does not already exist in all areas.

4.2.2.3 Hybrid – Dedicated / Shared Infrastructure Architecture Model

In a Hybrid Dedicated & Shared Infrastructure Architecture, server-based hardware and storage components providing required PSAP functionality are deployed in a combination of both on-premise dedicated and shared infrastructure as required and appropriate. This model allows administrators to share certain PSAP infrastructure and functions (such as call processing and mapping) while maintaining dedicated infrastructure for other functions (such as CAD, RMS and incident recording). When assessing this model one must keep in mind that the advantages associated with infrastructure sharing only apply to those infrastructure services and functions which are shared. Figure 4-3 is a pictorial representation of this specific architecture deployment, which is only one of many potential examples of combining dedicated on-premise and shared services.

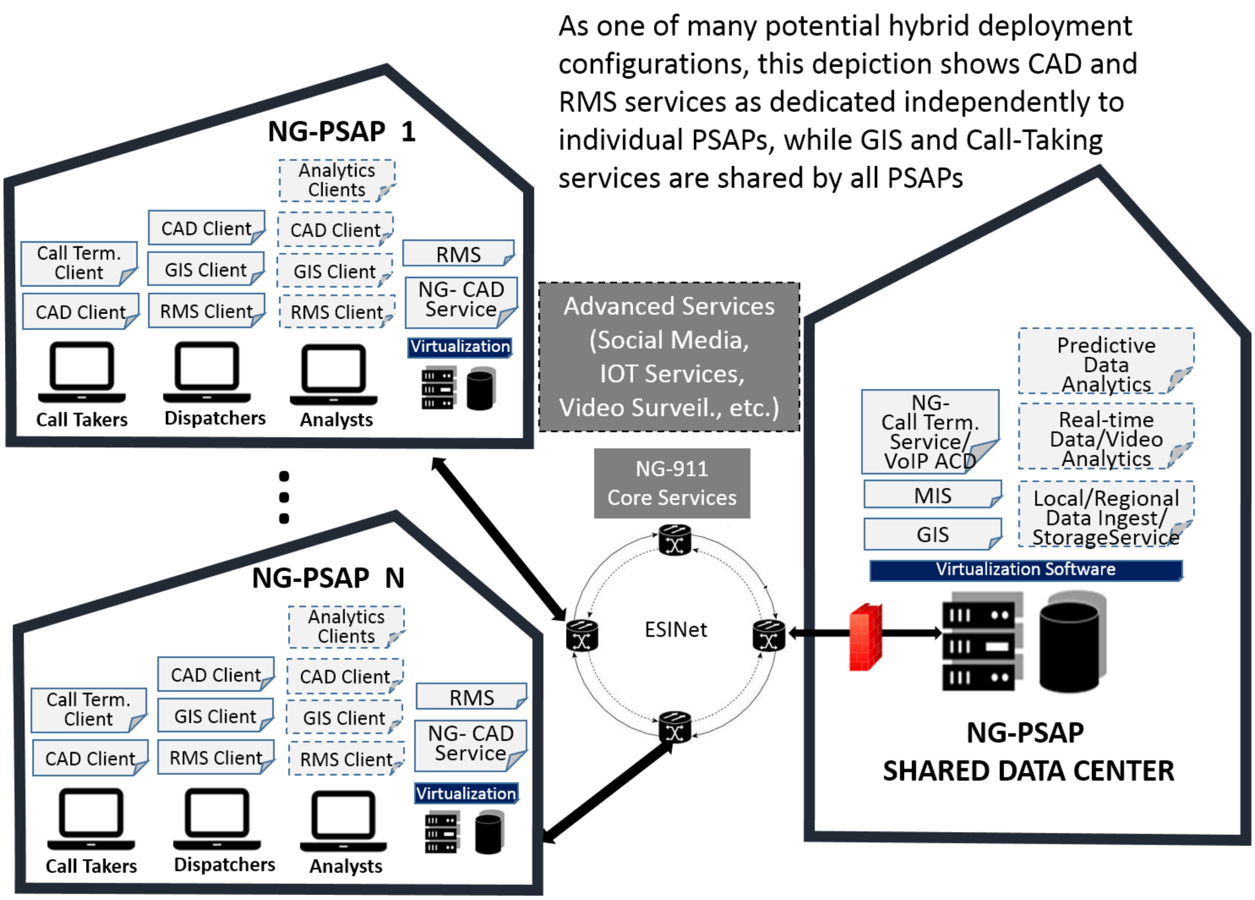

Figure 4-3

4.2.2.3.1 Options

4.2.2.3.1.1 Implementation Options

- Geo-diversity
- Virtualization

4.2.2.3.1.2 Financial Acquisition Options

- Non-Recurring Cost/CAPEX
- Recurring Cost/OPEX
  - Software as a Service (SaaS)
  - Infrastructure as a Service (IaaS)
- Combination of the above

4.2.2.3.1.3 Network Options

- Government owned and managed
- Vendor owned and managed
- Combination of the above

4.2.2.3.1.4 Data Center Options

- Government owned and managed
- Vendor owned and managed
- Combination of the above

4.2.2.3.1.5 System Maintenance

- Government operated and managed
- Vendor operated and managed
  - Software as a Service (SaaS)
  - Infrastructure as a Service (IaaS)
- Combination of the above

Section 5 - ESInet Optimization Considerations and Factors

5.1 ESInet Architecture

ESInet Architectures are following an evolutionary model. IP network capabilities are deployed based on Public Safety needs and readiness to implement NG9-1-1 services. The ESInets deployed today are primarily used for delivery of limited NG9-1-1 Services such as legacy Selective Router and ALI replacement. As such, all external interfaces, or demarcation points, are well defined, limited in scope and well controlled. This limited ESInet Architecture norm will change as the NENA i3 vision is realized with Originating Service Providers (OSPs) providing data feeds, enhanced service providers establish interconnections with ESInets across the United States and ESInets become interconnected. The Economics, including funding, is a challenge in this changing environment as legacy conventions are challenged and Public Safety Authorities work towards providing new emergency services capabilities.

Over time, ESInet Architectures will become more complex to design, manage, secure and evolve. ESInets should be modular in nature, evolution and change is expected. ESInet architectures are explained in the NENA document 08-506 “Emergency Services IP Network Design”. The ESInet definition from NENA 08-506 is as follows:

> “An ESInet is a managed IP network that is used for emergency services communications, and which can be shared by all public safety agencies. It provides the IP transport infrastructure upon which independent application platforms and core functional processes can be deployed, including, but not restricted to, those necessary for providing NG9-1-1 services. ESInets may be constructed from a mix of dedicated and shared facilities. ESInets may be interconnected at local, regional, state, federal, national and international levels to form an IP-based inter-network (network of networks).”

ESInets consist of the following categories of capabilities. For the purposes of ESInet discussions and brevity, these categories are abstracted from generally accepted networking models.

- Transport
- Internet Protocol (IP) Services
- Management Infrastructure
- Security Infrastructure

5.1.1 Transport

Transport provides the physical medium to move IP packets within an ESInet and establish interface points with external entities. Transport includes physical conduits and IP equipment, such as routers and switches. Common circuit types for ESInets are MPLS, Fiber, Sonet, Metro Ethernet, T1/DS3, Microwave and 3G/4G wireless. ESInets may be constructed from a mix of dedicated and shared transport facilities. Transport for an ESInet may be purchased from a bandwidth provider or utilize a network of the Public Safety entity or its associated government establishment. Regardless, the business model to establish the transport, the network and facilities must meet "Public Safety Grade". The provider of the Transport must be aware of the emergency services requirements for redundancy, availability, performance and management. Including specific rules such as FCC *Report and Order* 13-158 "…to improve the reliability and resiliency of 9-1-1 communications networks…" Providers must implement management processes capable of meeting emergency services criteria, including 99.999% availability which equates to 5.26 minutes of unscheduled downtime per year. Bandwidth strategies must consider current needs, economics of bandwidth available products and expandability to future needs.

An ESInet has the following interfaces with corresponding points of demarcation. Demarcation points, or the interface where formal change of oversight responsibility is differentiated between two parties, are usually a port on an interface device, such as a router, SBC, Firewall, or a TDM port card. An ESInet has, or can have, the following interfaces types:

- Originating Service Providers (OSPs)
- PSAP Customer Premise/Processing Equipment (CPE)
- Legacy Selective Routers
- Other ESInets
- FirstNet (future)
- Emergency Communications Cybersecurity Center (future)
- Provisioning interfaces
- Management interfaces
- Supplemental Services (e.g., Additional Data Services)
- The Public Internet (NOT RECOMMENDED)

5.1.2 Internet Protocol (IP) Services

Internet Protocol (IP) Services includes IP Addressing and Dynamic Routing Protocols. Quality of Service (QOS) mechanisms must be implemented to ensure critical 9-1-1 services are not impacted by other services provided on the ESInet. ESInets are complex IP networks that are evolving and will become ever more complex as more capabilities are provided and more entities participate in providing features. The ESInet requires an experienced authority to manage Internet Protocol Services to performance, reliability, redundancy and security requirements. An additional set of routers and switches may be present for IP Services, especially if the Transport network provider is a different entity from the ESInet Service Authority. A private Directory Name Service (DNS) is expected to exist within each ESInet. IP Addressing is managed within well controlled and defined addressing domains that also map to the security strategy. Addressing is specific to each solution domain and all interfaces are well defined and managed. An open interface to the public “Internet” should not be allowed.

5.1.3 Management Infrastructure

Management infrastructure provides the overall framework for provisioning, monitoring, reporting and maintaining the ESInet. Provisioning functions exist for the ESInet itself and for the services that are built upon the ESInet. Network Operations Centers (NOCs) are key elements of an ESInet management infrastructure. There will usually be multiple NOCs involved, considering Transport services, ESInet management and the services that reside upon the ESInet. Management of the ESInet should consider the operational risks that are introduced in a dynamic and changing operating environment. Coordination of management functions to maintain expected services quality is a significant endeavor.

5.1.4 Security Infrastructure

Security Infrastructure includes appliances and practices to secure, monitor, detect intrusions, authenticate users, mitigate events and recover. The ESInet provides a foundation of security capabilities to protect the ESInet itself and the services that reside upon the ESInet. Border Control Functions (BCF) functions, including Sessions Border Controllers (SBCs) and Firewalls are used to secure interface demarcation points. Security concepts and capabilities are discussed in Security “NENA 75-001 Security for Next-Generation 9-1-1 Standard (NG-SEC)”. Again, security is present at many levels and involves all entities that are providing services and capabilities to the ESInet and the services that reside upon the ESInet. The Security requirements and practices are touched on here to identify their need and emphasize their importance as an integral ESInet design consideration. However, they are more thoroughly addressed within the TFOPA WG-1 report focused on Cyber Security.

5.2 Defined Uses & Configurations

As with traditional IP networks, there is no single definition or configuration that can be used to summarize all possible ESInets. Rather, several use cases are presented to define the configurations which are representative of the majority of ESInets uses envisioned. It must be recognized that specific local, regional, or state requirements for ESInets will vary widely, therefore the following use cases are presented from a macro perspective. These use cases define a framework definition for functionality that an ESInet is intended to provide, but it is also instructive to define what an ESInet is not intended to provide as well.

Today many agencies have a variety of IP networks within their facilities and jurisdictions. Within the PSAP environment many IP networks are "walled gardens" and typically serve a specific application. [31] For example, many call handling platforms rely on a walled garden network to provide connectivity between telephony workstations and servers at the premise, but have limited or no connectivity to other networks. Similar configurations are common within radio communications console environments and computer aided dispatch networks.

The use of walled garden environments was a chosen and acceptable architecture in the past, as there were limited use cases for interconnectivity among disparate networks. In addition, application vendors preferred walled gardens due to their high degree of security and control. The convergence of applications and the ever-increasing case for data sharing have drastically diminished the usefulness and applicability of the walled garden architecture. Connectivity between networks is now more the norm than the exception.

Connectivity between emergency services application networks, however, does not necessarily create an ESInet. The interconnection between a telephony network and a radio or computer aided dispatch network, for example, does not in and of itself create an ESInet. Emergency services applications that may transit an agency, jurisdictional, or regional intranet similarly do not create an ESInet.

As defined, an ESInet must provide, "…the IP transport infrastructure upon which independent application platforms *and core functional processes* can be deployed, *including*, but not restricted to, those necessary for providing NG9-1-1 services. [emphasis added]"

The end-state of a fully NG9-1-1 environment is a network of networks. Optimization results from scale. Optimal configurations will result from ESInets that are designed and

[31] A "walled garden" refers to an environment where users and applications are restricted to certain content and connectivity and are allowed to access specific, limited portions of the local network. The main purpose of creating a walled garden is to shield users, applications, and network devices and to create a quarantined environment that is difficult to infiltrate.

deployed to serve populations that maximize the utilization of the networks and meet the needs of the served Public Safety Authorities.

The following use cases do not distinguish who operates and maintains the ESInet IP transport elements. An entity may choose to operate their own IP transport or contract for those services. In most cases IP transport is procured from IP transport providers, but, all or part of the IP transport services may be provided by local, regional or state funded multi-purpose IP networks. 9-1-1 Jurisdictions utilizing multi-purpose IP transport networks for 9-1-1 call traffic must be aware of the special requirements placed on emergency services network functions. These include:

- Availability of infrastructure elements and the overall service
- Identification / tagging of infrastructure elements to ensure appropriate protections and handling.
- Management life cycle – End of Life product cycles must be managed
- Critical timeframes – 9-1-1 calls volume periods should be considered when planning and performing maintenance events.
- Quality of Service (QOS) – 9-1-1 functions must be given priority over other functions/services utilizing the network and 9-1-1 calls and call setup times must not be impacted.

In all cases where products and services are being procured by a 9-1-1 Authority, there will be contract management oversight responsibilities.

5.2.1 Use Case: Local ESInet

This use case defines a configuration in which the local authority elects to host Next Generation Core Services (NGCS) within existing PSAP datacenters or facilities and maintains their own ESInet. For this use case the agency or authority maintains robust, reliable facilities within which the NGCS are hosted.

The authority either provides or sub-contracts management functions to provide public-safety grade reliability and uptime of 99.999% or greater. Given the complexity of managing a network of this type – one that provides NGCS to a local area– and the resources required to maintain the network, this is likely the least common type of deployment.

Advantages:

- Local Control of platform and applications
- Establish as initial or “seed” ESInet that may expand to include other 9-1-1 Authorities to become a shared ESInet

Challenges:

- Cost of dedicated platforms and redundancy
- Difficulty of staffing/retention of SME knowledge within local area
- Does not achieve any economies of scale for investment or staff

5.2.2 Use Case: Shared-Hosted ESInet

This use case defines a configuration in which a regional entity authority (group of PSAPs, county, multiple counties or state) elects to host Next Generation Core Services (NGCS) on a shared ESInet. This use case is optimized through economies of scale, either by maximizing the number of agencies served, by optimizing the number of calls processed by the infrastructure, or by serving a large geographic region.

The authority either provides or sub-contracts management functions to provide public-safety grade reliability and uptime of 99.999% or greater.

Advantages:

- Regional Control of platform and applications
- Dedicated Resources – should reach an economy where resources can be dedicated but may need some subcontract work to maintain expertise and sufficient staff for vacation coverage.

Challenges:

- Cost of dedicated platforms and redundancy if not sufficient scale to realize efficiencies.
- Depending on deployment size, may not achieve any economies of scale for investment or staff
- Difficulty of staffing/retention of SME knowledge within area, depending on scale of deployment or authority.

5.2.3 “Hybrid” ESInet

This use case defines a configuration where some elements of the Shared Hosted ESInet are combined with elements that are contracted. For example, a 9-1-1 Authority may provide their own “dark fiber” network facilities and contract a service provider to build and manage the IP network services ride upon those network facilities.

Advantages:

- Greater control of specific network elements
- Potential for greater redundancy

- Leverage existing facilities, resources and capabilities where they exist and supplement only those specific elements that don't

Challenges:

- Potentially greater capital expenditures
- Increased management & administration requirements to integrate disparate elements
- Additional effort to identify facilities, resources and capabilities that can meet requirements.

5.2.4 Use Case: Contracted, Managed ESInet

This use case defines both the most basic and most prevalent type of ESInet deployment at the time of this document. This is a "shared" network between multiple served PSAP tenants, which could scale from small region to nationwide. The managed service vendor builds and maintains the ESInet. The PSAPs served by this infrastructure could be geographically near or distant from each other. This model assumes that the 9-1-1 Authority does not operate the ESInet themselves but that all operational and management functions are performed by the hosting service.

This type of ESInet does not necessarily connect directly to the PSAP premise, but could provide terminating circuits to the PSAP CPE in a hosted location. A hosted PSAP CPE model may serve multiple PSAPs in a multi-tenant fashion. In the case of call handling equipment that is hosted within the ESInet, the only connectivity from the ESInet to the PSAP is for the purpose of workstation connectivity. This use case does not preclude multiple ESInets from co-existing across the same geographic region; rather it defines a configuration in which a network provider has capacity and resources with which to provide services throughout a region, state, the nation – or even internationally.

Advantages:

- This provides advantages in case of local disaster; the infrastructure serving the PSAP is not necessarily in the affected area.
- Expertise and focus of the provider which becomes increasingly important as these network solutions become increasingly complex.
- Economy of scale of a shared infrastructure. Given the duplicative services and capacity created as the number of ESInets increases, optimal configurations are achieved through economies of scale serving large geographic regions.
- Originating Service Providers (OSPs) can potentially require fewer points of interface to deliver 9-1-1 traffic.

Challenges:

- Localities may perceive loss of local control by not having facilities near served PSAPs
- May not support historical bias towards having local facilities
- Local jobs may be fewer based on the economies gained through centralized services.
- As the number of tenants increase the Network complexity would increase with a larger number of possible IP routes

The following diagram illustrates the hosted shared ESInet deployment models. The primary concepts of serving many PSAPs, OSP connections and geographic data centers are illustrated.

Hosted Shared ESInet Deployment Models

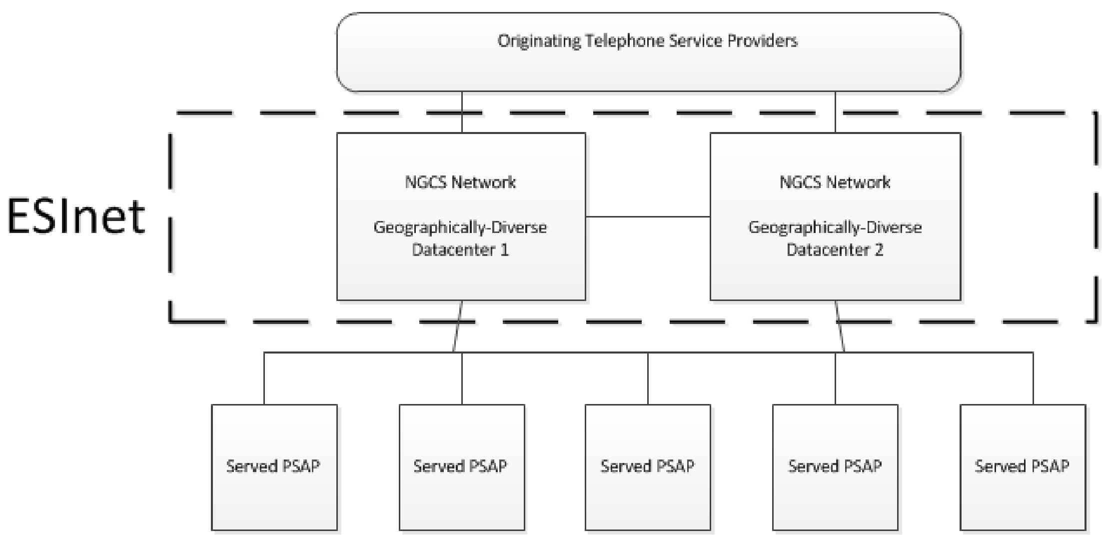

Figure 5-1

5.3 Network Monitoring & Operational Metrics

The ESInet should be monitored 24x7 by a Network Operations Center with visibility across the network. Network elements should be alarmed and current network diagrams should be available to assess any loss of connectivity. This should include a Simple Network Management Protocol (SNMP) system to monitor the devices in the system. Priority should be established for network alarms with service impacts taking top priority. Potential service disruptions such as the loss of redundancy should also be prioritized.

The ESInet is a critical component for end to end service delivery, but not the only one as access networks, Next Gen core service providers, local area networks, and customer premise equipment all have a role in successful voice & data delivery. As such, clear rules and responsibilities need to be established and to the extent possible one party have accountability for coordinating across these entities for maintenance and restoral efforts. Operating procedures that include contact information, notification requirements, and escalation points help to address service issues and in some cases avoid a disruption.

Emergency communication networks strive to be reliable with high availability. Five nine's (99.999%) is the goal for availability of these networks and is achieved through various means focused on diversity, redundancy, and alternate routing. While five nine's is the generally accepted minimum availability service level, it should be noted that this equates to 5.26 minutes of unscheduled downtime or service unavailability per year. Another important factor when comparing network availability to consider is specifically how different network service providers define availability and how it is calculated. For example, scheduled maintenance events are typically not included / classified as downtime. The ESInet by design incorporates multiple paths for voice and data transmission. The failure of a single element within the network or congestion along a path will not necessarily limit the ability to deliver traffic. Availability can be enhanced with multiple ingress and egress circuits, alternate routing to a back-up location, or a parallel network path with transport diversity. The specific approach will need to be developed based on the governing entity's service requirements and funding capability. There can be a variety of approaches that balance circuit diversity, redundancy, and alternative routing to a back-up location and ensure high availability.

When designed appropriately, IP networks provide alternate paths for voice and data traffic that provide increased reliability and avoid any single point of failure. The bandwidth requirements and delay sensitivity will vary by traffic type. Key performance metrics for an IP based application include Latency, Packet Loss, and Jitter.

> **Latency** is the duration when a packet enters the network to the time it exits the network. It can be measured as a one-way transmission across the network or a round trip. Round trip latency is measured from a single point and is used most often in the form of a ping that provides insight to the network performance.
>
> **Packet Loss** occurs when one or more packets traveling across the network fail to reach their destination. This typically occurs when network congestion along the path results in packets being dropped. When the offered packets exceeds the ability of a particular segment to transmit them, packets are dropped.
>
> **Jitter** occurs when the receipt of packets is out of sequence from what was transmitted. Packets can take more than one route through the network and the delay (latency) across the network can vary depending on the path used. Buffering is typically used to mitigate Jitter and properly sequence packets upon arrival.

All three of these metrics can be indicative of the overall network performance and service quality. Individual provider targets may vary, but packet loss of <1%, latency of <15-20 mS, and jitter variance of <20 mS represent sample targets per NENA document 08-506 “Emergency Services IP Network Design.”

Section 6 - Access and NG9-1-1 Core Services Implementation

NG9-1-1 implies routing a call based on a caller's location information as provided by the Originating Service Environments (OSE) (a combination of Originating Service Provider, Network Access Provider, Location Information Provider and SmartPhone Apps provider). A 9-1-1 service system in its simplest form is illustrated below:

NG9-1-1 System in Simplest Form

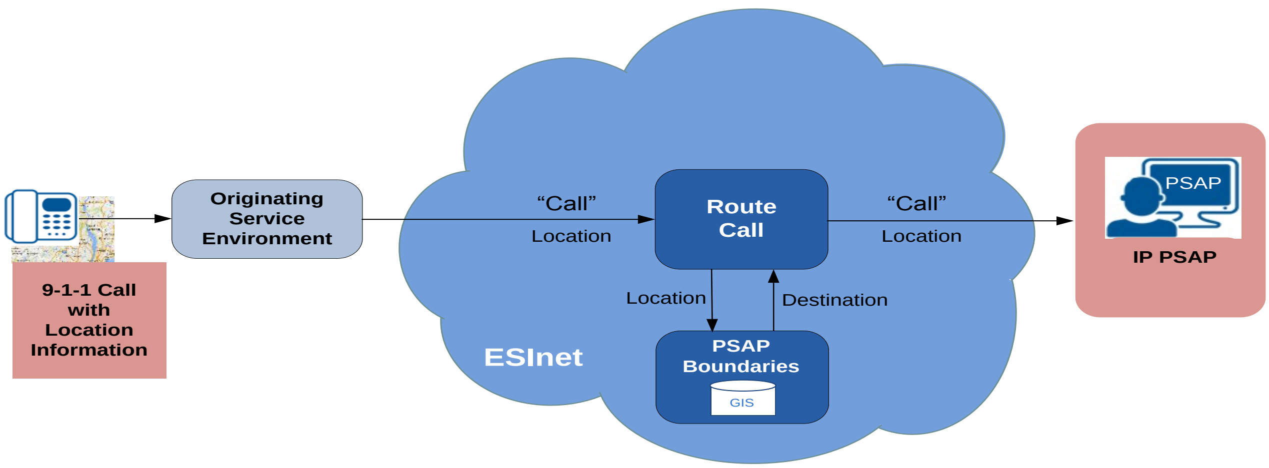

Figure 6-1

Additional complexity is added when it is necessary to determine the responsible Public Safety Authority, as illustrated below (e.g. where the OSP's territory potentially covers multiple PSAPs or Public Safety Authority regions).

Additional Complexity Where OSP's Territory Potentially Covers Multiple PSAPs or Public Safety Authority Regions

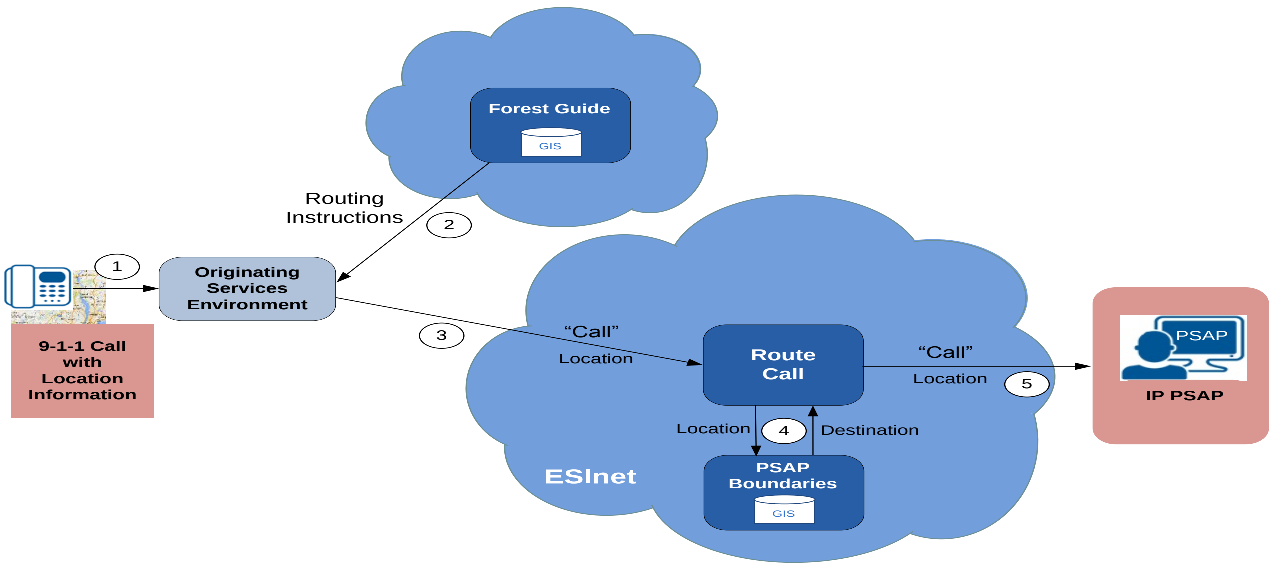

Figure 6-2

6.1 Specific NG9-1-1 Access Implementation Options

NG9-1-1 architecture concepts and functional services do not assume that the Originating Service Environment (OSE) necessarily knows who the PSAP and/or 9-1-1 Authority is for a given geographic area. In the legacy model the service area of TDM switches was coincident with one (or a few) PSAP(s). In an IP based world, the user could be in any PSAP and 9-1-1 Authority's jurisdiction. Therefore, NG9-1-1 requires services that make it possible to determine the appropriate 9-1-1 Authority's NG9-1-1 network, in order to then be routed to the appropriate PSAP within that NG9-1-1 system.

Since users can roam with their communication devices across the country or the world, the OSE may potentially need to support connectivity to many Public Safety Authorities.

The OSE has several operations that require interaction with a Public Safety Authority:

- Validate Location Information
- Determine the appropriate Public Safety Authority to receive a 9-1-1 call or message
- Obtain a copy of the rules to validate location information (LVF function)

The OSE must connect to each Public Safety Authority's LVF to determine if addresses they will be providing to the Public Safety Authority's NG9-1-1 system during 9-1-1 call setup are valid addresses according to the given Public Safety Authorities addressing rules.

In order to determine the appropriate Public Safety Authority an NG9-1-1 service (Forest Guide) is provided that allows OSEs to query and determine the responsible Public Safety Authority or representative of the Public Safety Authority. It is possible, and likely, that an ESInet with NG9-1-1 services represents many Public Safety Authorities. The general Forest Guide concept is a tree structure where an OSE queries at the level for which they know the subscriber/user resides. In some cases, the OSE would query the top level Forest Guide for the United States (National Forest Guide). The Forest Guide returns the "next hop" which may be another Forest Guide function to inspect or the target ESInet with NG9-1-1 services. In general, a Forest Guide is a unique instance of a NENA i3 ECRF functional entity. The geographic polygons in the NG9-1-1 core services ECRF are simply more granular, pointing to specific PSAPs, then what would be expected in a Forest Guide, pointing to a state service or ESInet with NG9-1-1 services.

GIS Data and Security Services Foundation

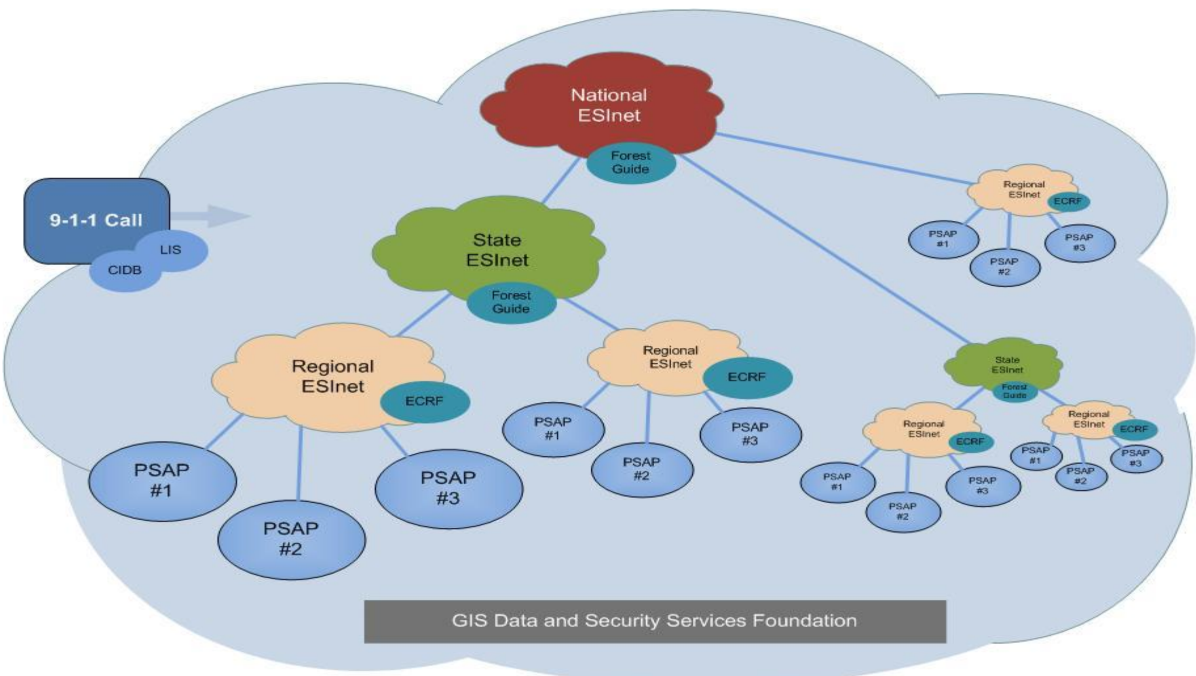

Figure 6-3

The concept of Forest Guides requires cooperative sharing of the respective geographic polygons that define Public Safety Authority's service area. These mechanisms are complex and have many issues to resolve with respect to sharing and change management.

The need to dynamically determine responsible Public Safety Authorities is a NENA i3 end-state architecture requirement. However, during many phases of the NENA i3 transition model the Public Safety Authority is still determined by local infrastructure connectivity and therefore does not require Forest Guides. This is the reason that no NG9-1-1 Forest Guides exist today. VoIP service providers (VSPs) have a similar issue, but they have long standing network routing control solutions that are used in lieu of the existence of NG9-1-1 Forest Guides.

Inversely to the OSE accessing NG9-1-1 services, conditions exist where the NG9-1-1 Services require access to services provided by the OSE. In the full concept of NG9-1-1, OSEs would have Location Information Servers (LIS) and Customer Information Data Bases (CIDBs) that would provide this data upon query from various NG9-1-1 systems. In the transitional period, location data is acquired from ALI servers, (typically provided by third party vendors), etc. that are `standing in' for the LIS and CIDB functions. Existing ALI servers are being retro-fitted to accept NG9-1-1 protocols and provide the functions of the LIS and CIDB during an unknown transition period.[32] Various forms of access needs in these areas will continue for the foreseeable future.

If third party vendors continue to evolve services to support the above, consolidation for these processes may mean that multiple NG9-1-1 systems connect to these vendors, rather than there being access connections for each NG9-1-1 system separately. While and where stand-alone ESInets exist, multiple OSPs would need to access multiple ESInet points. With the proper ESInet interconnectivity in or among regions and states, these access connections could become simplified. Analogous options exist for call and messaging access to multiple NG9-1-1 systems, utilizing the `Forest Guide' structure.

NG9-1-1 involves periodic and continuous evolution for the foreseeable future, both in access methods and in the NG9-1-1 core services interfaces.

6.2 National Forest Guide

Fundamentally required if the NENA i3 end-state operational model is realized.

Advantages

- Ubiquitous solution for determining 9-1-1 call management responsibilities

Challenges

- Fundamentally required if the NENA i3 end-state operational model is to be realized.
- A nationwide access implies significant security challenges

[32] See NENA-INF-008.2-2014,NG9-1-1 Transition Planning Guide Considerations Information Document

- Complex data distribution and change management model
- Who will fund the National Forest Guide
- Who will operate the National Forest Guide (whether outsourced responsibility or not)
- Will all ECRF Guides representing states or entities below the National Forest Guide exist and operate appropriately
- Will the foundation GIS data for Forest Guides be properly managed and distributed as necessary

6.2.1 Service Utilizing Forest Guides

One of the fundamental problems in routing of emergency calls is to determine which Public Safety Answering Point (PSAP) to direct the call to. In the general emergency services architecture originally developed by the Internet Engineering Task Force (IETF), mapping between the caller's location and the destination PSAP is obtained using the Location-to-Service Translation Protocol (LoST) defined in Request For Comment (RFC) 5222.

Since each Emergency Call Routing Function (ECRF) or Forest Guide only contains service information relating to a specific geographic area, in order to route an emergency call, it is necessary to locate the ECRF with the mapping information specific to the caller's location. These are referred to as authoritative servers because the data has been compiled and loaded by the entity responsible for ensuring the correctness of this data.

Forest Guides enable geographically and logically dispersed ECRFs to operate as a coherent whole somewhat resembling the hierarchical model used by the Domain Name Service (DNS), with the hierarchy based on geographical and service boundaries.

In practice Forest Guide architectures may be operated at the National, State or Regional levels. Also, Forest Guides may be reachable over the public Internet, or queries may only be accepted from within the ESInet. Finally, call routing and emergency call termination may be provided for arbitrary applications, or only for applications with termination agreements. The sections that follow examine the implications of these choices.

6.2.2 Mapping: Internet vs. ESInet Access

The original IETF architecture assumed that a calling device making an emergency call would obtain its location and then query a LoST server to determine where to direct the emergency call. This required LoST servers to be reachable over the Internet by any device/application capable of making an emergency call. The ECRF and Forest Guide solution included within NENA i3 is based on the IETF approach model in which LoST servers are accessible on the public Internet.

Allowing LoST servers to be accessible via the Internet provides maximum flexibility for applications making emergency calls. However, it also enables adversaries to attack the 9-1-1 emergency service system from the Internet.

By only allowing ECRF queries to be handled from within the ESInet, attacks on the emergency service system can be limited to attackers with access to the emergency network. Rather than requiring mapping data to be published to publicly facing entities, if the mapping service is only accessible from within the emergency network, only trusted entities are ever queried and only authorized entities are permitted to query the Forest Guide. Accessing entities are expected to be validated and authorized. This is further discussed below.

The level of vulnerability of the NG9-1-1 system to attackers within an emergency network depends on the level of connectivity between emergency networks. In order to allow the network of Forest Guides to function when location mapping queries are only enabled from within the ESInet, ESInet connectivity needs to be provided commensurate with the level of administration. For example, a National Forest Guide accessible from the ESInet requires connectivity between ESInets nation-wide; State Forest Guides require connectivity within state-wide ESInets, etc.

6.2.2.2 Application Restrictions

The rapid adoption of smartphones and the increasing popularity of mobile emergency service applications is one of the major areas of technological innovation within NG9-1-1 today. With applications catering to the needs of a wide range of demographic groups including families, college students/universities, retirees, the disabled, etc. mobile emergency service applications have the potential to have a major impact on the evolution of NG9-1-1.

Rather than allowing emergency calls to be placed from arbitrary applications, calls connecting to the ESInet typically require interconnection agreements to be in place, with the service provider directing calls to the ESInet being accountable to some extent for the authenticity and the validity of information provided with the call. In order to enable deployment of emergency mobile applications, applications providers could be allowed to act as “service providers”. While this imposes a hurdle on the development of new emergency services applications, it also offers a way to limit damage from rogue applications. The balance between the ease of access and mitigation of attack or destructive impacts becomes a matter of policy and cyber security.

6.2.3 Forest Guides Governance and Funding

6.2.3.1 Governance and Funding Issues

The establishment and operation of a National Forest Guide is likely to require development of funding and governance models as well as interoperability requirements and operational procedures. These requirements and procedures would in turn dictate the information to be pushed from lower-levels to higher-levels, and the frequency with which the data replication would occur.

Solutions that minimize the complexity and volume of data exchanges also minimize upstream dependency on this data and so minimize the need for imposition of national requirements and procedures at the state and local level.

6.2.3.2 NENA National Forest Guide Management

In Figure 6-4, geographic mapping information is populated and maintained within local or regional LoST servers (ECRF databases). The data is then published to nodes deemed to be “higher up the tree”. These higher-up nodes are then responsible for combining and compiling all of the data form the leaf-nodes so that they can provide a consistent view to their higher-up nodes and so on. The identity of the authoritative server is always maintained with the data so that it is easy to determine from where it originated. All of this leads to a significant amount of data transfer and processing, and small changes at the county-level may result in republication of state information to a National Forest Guide.

National Forest Guide Hierarchical Data Roll Up

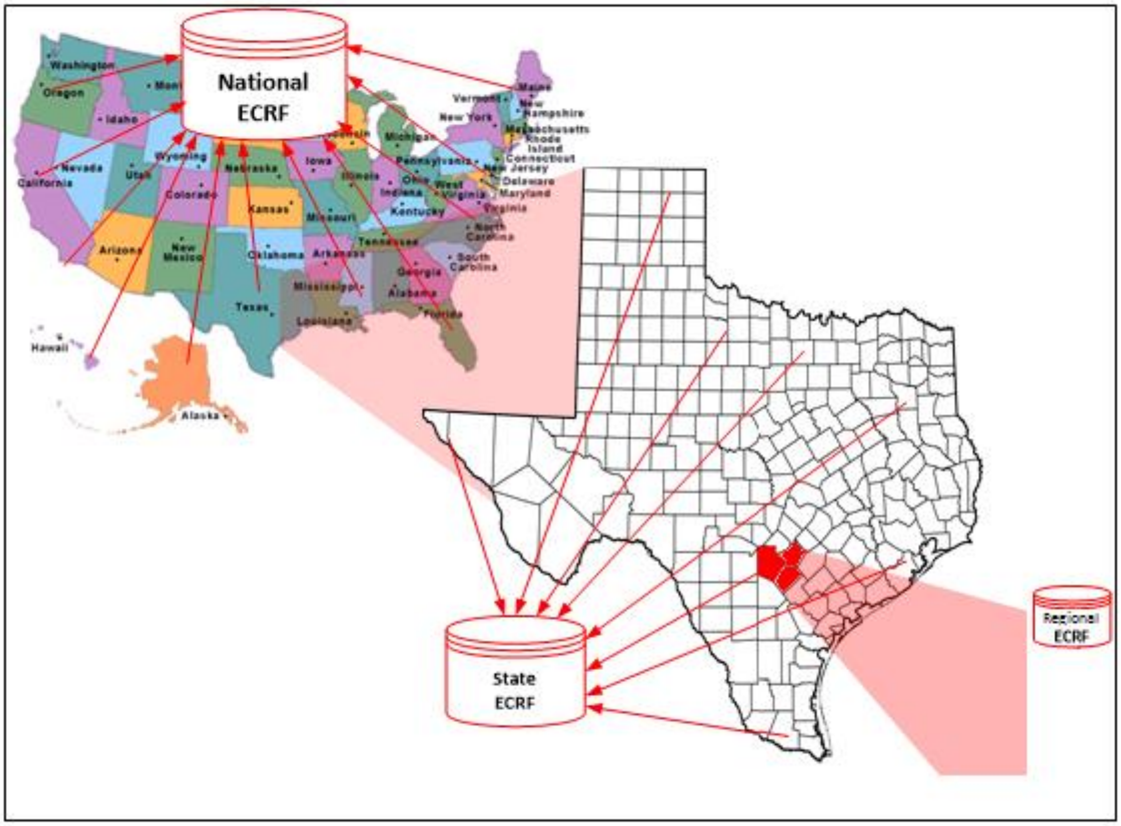

Figure 6-4 (Texas is used for illustrative purposes only)

Advantages:

- Significantly simplifies routing discovery function; all discovery can be accomplished through the National Forest Guide.
- Provides a national approach so that any device/entity can determine the correct route for an emergency call, providing the data is populated into ECRFs. Employs international standards.

Challenges:

- Requires consistent operating procedures across all levels and regions.
- Requires massive volumes of data to be acquired and groomed if all boundary information is at the National Forest Guide level.
- Requires massive volumes of data to be transferred between entities if all boundary information is at the National Forest Guide level.

- Requires funding model for National Forest Guide. All devices/entities must support both redirection (if the LoST service is publicly reachable) and recursion.
- Significantly increases load at the national Forest Guide level if all queries go through the national Forest Guide.

6.3 State-wide

In the figure below, geographic mapping information is populated and maintained within local or regional ECRF servers.

State Forest Guide Hierarchical Roll Up

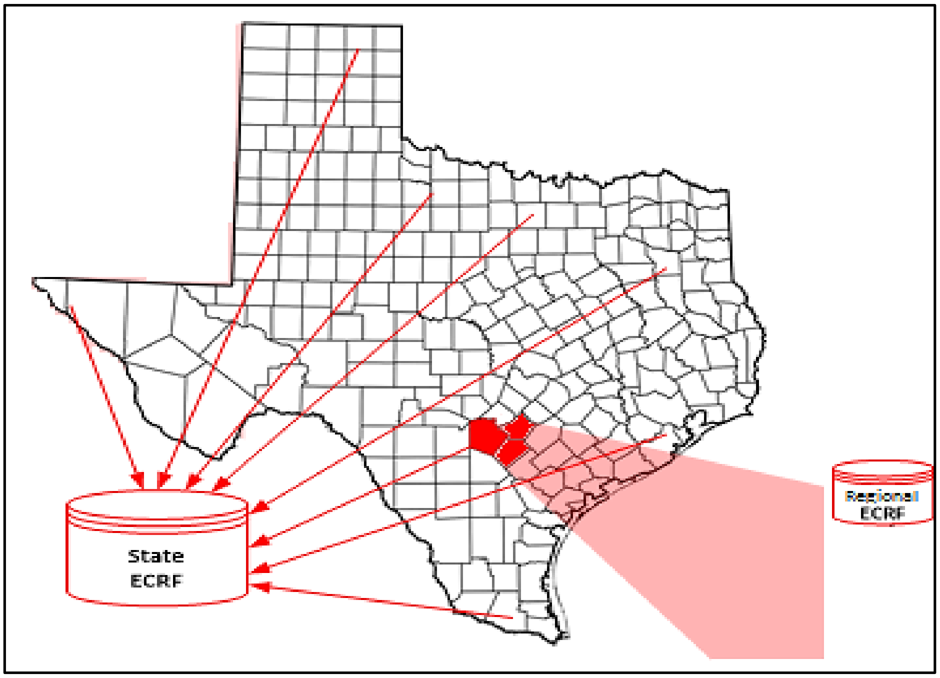

Figure 6-5 (Texas is used for illustrative purposes only)

The data is then published to the state-wide nodes, which provide a consistent view within the state. The identity of the authoritative server is always maintained with the data so that it is easy to determine from where it originated. Data transfer occurs only within the state so that changes at the county-level do not propagate beyond the state.

However, in the absence of a National Forest Guide, it is no longer possible to query any ECRF server and receive in response a Universal Resource Identifier (URI) pointing to the destination state ECRF or regional ECRFs within the state. Instead, individual state-wide ECRF servers need to be queried – and if the location is outside the state, this could imply querying multiple state-wide ECRF servers in order to obtain a response.

If the state-wide ECRF servers are reachable over the Internet, emergency services applications would need to be configured with the names of the state-wide ECRF servers. If state-wide ECRF servers were not reachable over the Internet, then either a National Gateway would need to be provided that could query the state-level ECRF servers in order to route calls, or individual State Gateways would need to be provided, serving as entry points to the emergency network within each state. If the State Gateways do not emerge or were not configured in a consistent manner, the result would be additional complexity exposed to originating service providers.

Advantages:

- Reduces the volume of data that needs to be transferred as compared to maintenance of data for a national Forest Guide
  - Transfers only occur between the local and state levels.
- Funding model for State Forest Guide can be determined within each state.
- Employs international standards.

Challenges:

- Complicates the routing function since queries must now be directed to the correct State Forest Guide in order to receive a successful response. (This is workable since there is a high probability that the OSP would know the state in which their customer is located, and therefore which state to query.)

6.4 Regional

If Access is regional, corresponding to a regional NG9-1-1 service system, then the NG9-1-1 Core Services provides the routing function, through the ECRF and ESRP process, to the related PSAPs. However, if the NG9-1-1 systems are implemented at lower than regional level, there may need to be a regional level routing process to differentiate between the subtending NG9-1-1 systems based on originating caller location.

Advantages:

- Creating a Regional Access model provides a template for local ECRF server authorities to include in their initial architecture build.
- Provides a forum for Local entities to communicate with neighboring authorities to build in the proper URI ‘pointer response’ to a non-local query.

- Ensures 9-1-1 calls destined for termination points within the Region are routed correctly

Challenges:

- Requires leadership, cooperation and funding,
- Ongoing administrative process and procedures may require interoperable arrangements

6.5 Local Access

If NG9-1-1 Core Services were implemented at a local geographic level (such as an individual County), they would be accessed either locally or at higher levels via regional or state gateways an since NG9-1-1 would not initially be interconnected to other local areas as is the case when implemented regionally or at state-wide levels.

Advantages:

- Inter-governmental relationships are minimized
- Initial local implementations can be transitional toward a later more collaborative approach in a host or hybrid configuration.

Challenges:

- If not interconnected with neighboring systems, routing outside of local boundaries requires additional technical solutions and adds complications
- May require substantial work to redesign the local ECRF functionality in the event a Regional model is deployed at a later date
- Complicates potential communication and collaboration between local NG9-1-1 deployments by creating a barrier to interoperability

In all cases above, it is assumed that customer data provision and validation processes would be implemented at the related level of NG9-1-1 system implementation, unless a third party provided an aggregation service between multiple service providers and multiple 9-1-1 system service providers.

6.6 Specific NG9-1-1 Core Services Implementation Options

The working group has studied NG9-1-1 implementations that are being accomplished around the nation. It is clear that certain operational functions provided by PSAPs must remain at the local level. However, there are architectural functions of NG9-1-1 core services that should be done at a regional, statewide or national level. PSAPs must continue to provide operational aspects of 9-1-1, emergency communications and dispatch functionality. However, operation of the Core Service elements of NG9-1-1 most effectively and economically occur above the local level. This approach must include regional and state level collaboration for cost effective implementation and the ability to provide backup capabilities.

6.6.1 9-1-1 Services Architecture

The movement to Next Generation 9-1-1 (NG9-1-1) implies a progression from legacy architecture to the future vision. However, several elements of the future vision are not practical or available in today's business environment, thereby, giving way to transitional architectures that step toward more complete NG9-1-1. NG9-1-1 implies changes not only to the 9-1-1 System Service Provider and PSAP operations, but also at Originating Service Providers (OSPs) who provide communication services to subscribers and deliver 9-1-1 calls through the central NG9-1-1 Core Service system. Access Network Providers who provide Location Information service are also impacted.[33]

9-1-1 solution architectures can be considered as a progression from the legacy state to the future vision state with transitional steps in between.

- Legacy 9-1-1 Architecture
- Transitional 9-1-1 Architectures
- NENA i3 Vision Long Term NG9-1-1 Architecture (NENA Standard STA-010.2)

The legacy architecture is very common and more or less consistent across the United States. The transitional architectures are intermediate steps that replace the legacy architecture with an IP technology foundation. The NENA i3 NG9-1-1 architecture requires fundamental changes in roles and responsibilities, the underlying data and the steps to process calls. Fundamentally, the way the Originating Service Environment (OSE) prepares data and delivery calls to Regional 9-1-1 Systems Service Providers changes from legacy approaches to Next Generation 9-1-1.

Each of the 9-1-1 architectures has two basic areas:

1. Pre–call data preparation
2. Steps performed to process a 9-1-1 Call, including use of core services features during and after call delivery

The pre-call data preparation creates a necessary foundation for each call time processing scenario. The legacy architecture prepared predetermined static data

[33] NENA 08-003 Page 16, Access Network Providers (e.g., DSL providers, fiber network providers, WiMax providers, Long Term Evolution (LTE) wireless carriers, etc.) have installed, provisioned and operated some kind of location function for their networks. Location functions are critical for 9-1-1 calls originating on an IP network because it provides a 9-1-1 valid location to IP clients that bundle their location in the SIP signaling to the ESInet. Last Accessed December 2, 2015 http://c.ymcdn.com/sites/www.nena.org/resource/resmgr/Standards/08

relationships that were required to exist prior to successfully routing a 9-1-1 call. The Next Generation architecture determines call routing dynamically based on the caller's location and jurisdictional service boundaries.

6.6.2 Legacy 9-1-1

The foundation of the Legacy 9-1-1 architecture is the creation of a set of rules used to validate subscriber addresses. The Master Street Address Guide (MSAG) contains a set of rules that determine whether an address is acceptable to the 9-1-1 Service Provider. If an address is recognized and passes MSAG validation it is determined that the address is "dispatch-able", meaning that an emergency services first responder should recognize the address unambiguously. These dispatch-able addresses help determine the exact location to send emergency services.

In addition to validating addresses, the MSAG creates a relationship between addresses and Emergency Services Numbers (ESNs). Addresses or address ranges are assigned an ESN. An address range is a specific locality's street name and an address range such as "all the even addresses on Main Street 1002 through 2000". Therefore, an address of "1226 Main Street" would pass validation for the given locality. The ESN designates the primary and alternate destinations that should receive the 9-1-1 call for the corresponding set of TNs assigned with that ESN. The ESN destination is usually a PSAP, but, could also be a Public Switched Telephone Network (PSTN) phone number. The ESN may also designate the emergency service providers (e.g., Police, Fire, Medical) for the specific area if the given Regional 9-1-1 Service Provider utilizes Selective Transfer features.

The legacy 9-1-1 architecture is based on OSPs providing content from their Subscriber Service Order (SO) records to each Regional 9-1-1 Service Provider. The OSP subscriber records include the Subscriber's address, class of service and telephone number. These SO based records are MSAG validated and assigned an ESN. After this process is completed, the addresses are posted in the Automatic Location Identification (ALI) database and the TN ESN relationship is posted in the Selective Routing Database (SRDB).

A legacy 9-1-1 call progresses from the OSP to the legacy selective router (SR) over TDM trunks, typically Signaling System 7 (SS7) protocols. The legacy SR determines the PSAP to receive the call, typically using the telephone number of the subscriber (Automatic Number Identification or 'calling number') to retrieve an ESN from the SRDB. The SR then directs the call to the PSAP and that has typically been over legacy TDM trunks called CAMA trunks, again passing ANI to the PSAP. The PSAP receives this call and uses the ANI to retrieve location information from the ALI database and display the location and call information to a 9-1-1 call taker. This is a simplistic scenario that does not address all of the variations that can occur, but does represent a basic call flow. (The TDM trunks to the PSAPs have often been replaced with digital or even IP connectivity to reduce costs and provide faster call delivery to the PSAP.)

Wireline calls are the most straight forward legacy call processing scenario, since the legacy 9-1-1 solution was designed for fixed location or the Wireline telephone service model. Wireless, VoIP and Text Messaging all have workarounds due to the limitations of the legacy 9-1-1 operating environment. These workarounds, not described here, have allowed the legacy architecture to adequately address the processing of wireless and VoIP 9-1-1 calls. However, the legacy operating environment has become more complicated with these workarounds and is not extensible to support new features or new forms of "calls for help". As a result, NENA began design of a new 9-1-1 service system in 2001, now known as NG9-1-1.

6.7 NENA i3 Vision

The NENA i3 vision Long Term architecture standard changes the processing model for 9-1-1 calls and defines different responsibilities for both the 9-1-1 Service Provider and OSEs. The biggest changes evolve around the use of Geographical Information System (GIS) technology and OSEs providing the caller's location information during call setup.

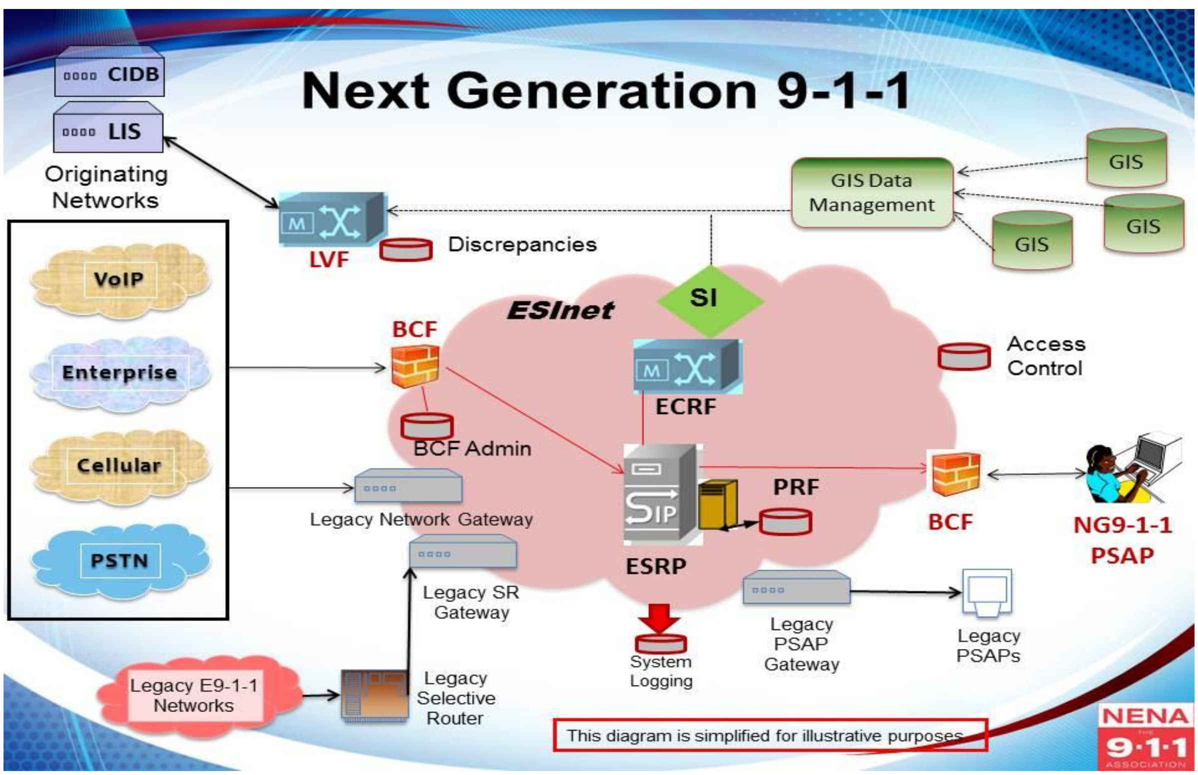

Figure 6-6

The local 9-1-1 Authority shifts from managing the MSAG for address validation purposes to managing basically the same data, minus the ESN, in a GIS tool. The GIS tool incorporates the address validation data of the MSAG and also includes jurisdictional boundaries of PSAPs and optionally boundaries of emergency service providers. The legacy ESN is dropped and replaced with an algorithm at call processing time that locates the caller's location within the set of jurisdictional polygon boundaries. The elimination of the ESN with this dynamic "location within a service boundary" algorithm greatly simplifies 9-1-1 data management and the number of changes necessary to implement routing changes. Also, the 9-1-1 Service Provider is expected to provide an address validation service; the Location Validation Function (LVF), is used by the OSE for 9-1-1 data preparation.

OSE responsibilities are also changed. OSEs are no longer expected to deliver their SO record content to the 9-1-1 Service Providers. Instead, OSEs retain their subscriber and address information in a Location Information Server (LIS). OSEs access LVFs provided by 9-1-1 Service Providers to ensure their location information is acceptable for 9-1-1 purposes. OSEs deliver their calls via IP technology and retire Time Division Multiplexing (TDM) circuits. The OSE delivers caller location, or the ability to retrieve caller location information, co-incident with the 9-1-1 call to the 9-1-1 Service Provider. The OSE has the option of delivering the location with the call signaling messages or providing a reference key so the receiver of the call can retrieve the caller's location later. 9-1-1 callers that are calling from a device that allows mobility are the primary example of when an OSE should provide a location reference for retrieving the caller's location.

The transition to IP technology requires various security and networking appliances to be introduced to the 9-1-1 Service Provider domain. Border Control Functions (BCFs), including Session border controllers, firewalls, intrusion detection, and identity verification solutions all must be incorporated into the NG9-1-1 solution. Various cybersecurity policies and procedures, as described elsewhere in this report and the TFOPA Working Group 1 report, apply at physical network, NG9-1-1 software, and database levels. The NENA i3 architecture standard also includes ICAM (Identity, Credential and Access Management) procedures to control user access based on their roles in operations or maintenance activities. While it is recognized that ICAM in the larger sense has multi-system involvement, the NENA standard does not speak to details of integrating ICAM with other related systems in the Public Safety environment. It does include various functions and features not discussed here that provide routing control and post call delivery functionality not previously available in the E9-1-1 environment.

An i3 architecture call begins with the OSE accessing the caller's location information and signaling the 9-1-1 System Service Provider that a 9-1-1 call is available. These messages will pass through the NG9-1-1 system Border Control Functions. The NG9-1-1 core services system obtains the caller's location information and, combined with jurisdictional boundaries from a GIS database, determines the serving PSAP. Any special conditions the PSAP may have set are checked in the Policy Routing Function (PRF) and the call is delivered to the designated PSAP. If the call was delivered with a "Location by Reference" approach, the PSAP can use the reference information to retrieve updates of the caller's location information.

In addition to the elements described above, additional functions are required when an all IP call processing environment is established. Specifically, a function called the “Forest Guide” will allow an OSE to determine which NG9-1-1 Service system (via ESInet) to send a given 9-1-1 call.

6.8 Evolutionary NG9-1-1 Architectures

Several aspects of the NENA i3 long term vision architecture are barriers to immediate implementation. Primarily, OSEs are not prepared today to deliver 9-1-1 calls via IP technology with location information to 9-1-1 Service Providers. Transitional NG9-1-1 architectures have been defined that allow the movement to NG9-1-1 to begin. Two basic forms of evolutionary architectures exist.

- IP Selective Router (IPSR) – essentially E9-1-1 on an IP network
- NENA i3 Transitional Architecture

An IPSR transition architecture replaces the legacy SR with an IP infrastructure and continues to process 9-1-1 calls based on the callers ANI and a mapped ESN. Essentially this is E9-1-1 utilizing an ESInet as IP transport. This approach allows the retirement of legacy selective routers with an IP infrastructure that is programmable and expandable to support the NENA i3 algorithms. The IPSR approach utilizes several of the “gateway elements”, or protocol conversion elements, also deployed in the NENA i3 transitional architecture.

The NENA i3 transitional architecture introduces elements to map legacy interfaces to NENA i3 architecture defined interfaces and provide the caller’s location information during call setup. Calls from OSPs can be delivered via legacy TDM circuits into gateway devices that convert TDM protocols to IP protocols. These gateways, or Legacy Network Gateway (LNGs), provide protocol conversion functions and are the defined functional element to retrieve the caller’s location information and send it through the other i3 processing elements to complete call processing. Note that the NENA i3 document defines these elements as “logical” and not necessarily “physical” real world devices. A NENA i3 logical functional element may be satisfied by one or more physical processing elements.

An additional gateway element is defined for interacting with legacy SRs, the Legacy Selective Router Gateway (LSRG), and an element is defined for interacting with legacy PSAP call handling equipment, the Legacy PSAP Gateway (LPG). These elements all provide protocol conversion and allow the NENA i3 functions to interact with legacy 9-1-1 equipment and interfaces. Note that this approach allows legacy PSAPs only limited utilization of the NG9-1-1 core services features.

Call processing is accomplished as defined by the NENA i3 architecture with the exception that the gateways provide protocol conversion and the caller’s location information is retrieved from some source that is not necessarily the OSE. In practice today, the caller's location is often being retrieved from or through the legacy ALI database.

6.9 NG9-1-1 Implementation Options

6.9.1 Multi-State Hosted

This model uses a geographically distributed set of redundant NG9-1-1 functions and an associated ESInet to support areas of NG9-1-1 service and related PSAPs within and across multiple states. The architecture supports a multi-tenant model where many PSAPs or 9-1-1 jurisdictions have a perception of a dedicated set of NG9-1-1 services even though the infrastructure is supporting various unassociated PSAPs. Regional facilities are deployed as necessary, such as Legacy Network Gateways to collect TDM call traffic. Those regional facilities are connected back to two or more core processing centers that contain the majority of the NG9-1-1 Service functions (e.g., ESRP, ECRF, BCF, DNS, and Logging Service).

The architecture serving the PSAPs would not have more than one Core site near the served PSAPs and actually may not need any core sites physically near the served PSAPs. Today's IP broadband networks make the physical location of core sites nonmaterial, therefore the benefits of distributing core NG9-1-1 functions can be realized. The trend toward OSPs moving away from TDM circuits and connecting via IP also benefits this model. Efficiencies and benefits of scale are created by OSPs connecting to a few geographically distributed NG9-1-1 services core sites.

The Multi-Stated Hosted model has the following advantages and challenges.

Advantages:

- In case of local disaster, the infrastructure serving the PSAP(s) is not necessarily in the affected area.
- Enables development of specific expertise and focus of a provider, which becomes increasingly important as these solutions become increasingly complex.
- Economy of scale of a shared infrastructure. Given the duplicative services and capacity created as the number of NG9-1-1 systems increases, optimal configurations are achieved through economies of scale serving large geographic regions.
- Troubleshooting and recovery may be enabled by larger service system size and impacts under one management structure.

- Originating Service Providers (OSPs) can connect to fewer points of interface to deliver 9-1-1 traffic.

Challenges:

- Localities, regional and state level 9-1-1 Authorities may perceive loss of control by not having 9-1-1 systems near served PSAPs or within related regulatory and legislative boundaries.
- Disrupts historical tendency towards having central 9-1-1 services in vicinity of jurisdictions.
- Local jobs may be fewer based on the economies gained through centralized services.
- As the number of users increase, the 9-1-1 service system complexity would increase with a larger number of possible IP routes
- Troubleshooting and recovery along with service area impacts may be may be more complicated and larger.

6.9.2 Statewide

In this scenario, Next Generation 9-1-1 Core Services is implemented for state-wide use by all 9-1-1 Authorities, under a state level organized governance structure, which should also include regional or local government representatives for planning and management decision making. NG9-1-1 may be operated on a single state-wide ESInet or multiple interconnected ESInets, which may support other Emergency Services applications at state or more localized levels.

The architecture supports a multi-tenant model where many PSAPs or 9-1-1 jurisdictions utilize a dedicated set of NG9-1-1 services. Two or more locations for access points, either individually and/or via a state level Forest Guide, are deployed as necessary. Access facilities are connected to two or more duplicated, geographically diverse core processing centers that contain the majority of the NG9-1-1 Service functions (e.g., ESRP, ECRF, BCF, DNS, and Logging Service).

Advantages

- NG9-1-1 core services and management/administration costs are spread across many 9-1-1 Authorities for a single NG9-1-1 core service system – lessens impact on local funding compared to other choices
- Common procedures for the above are established
- Makes access structure for OSPs simpler than lower level implementation choices

- More directly supports interoperability due to common architecture and procedures
- Makes shared and hosted facilities and equipment more workable
- Involves planned multi-level governance arrangements
- May make cybersecurity and physical security simpler than other choices

Challenges

- Survivability is potentially affected by limited geo-diversity of service, beyond the normal duplication and diversity of data centers supporting NG9-1-1 core services
- Requires planned multi-level governance arrangements
- Involves potential political issues and changes
- Probably requires new legal arrangements re governance and funding aspects
- Requires specific plans for and implementation of inter-state ESInet connectivity to support interoperability

6.9.3 Regional

In this scenario, Next Generation 9-1-1 Core Services is implemented for multi-county or multi-PSAP use by all associated 9-1-1 Authorities, under a sub-state level organized governance structure, which should also include local government representatives for planning and management decision making. NG9-1-1 may be operated on a single statewide or region-wide ESInet or multiple interconnected ESInets within the region, which may support other Emergency Services applications at state or more localized levels.

The architecture supports a multi-tenant model where many PSAPs or 9-1-1 jurisdictions utilize a dedicated set of NG9-1-1 services. Two or more locations for access points are deployed as necessary, such as Legacy Network Gateways to collect TDM call traffic. A state-level Forest Guide may support access. Access facilities are connected to two duplicated, geographically diverse core processing centers that contain the majority of the NG9-1-1 Service functions (e.g., ESRP, ECRF, BCF, DNS, and Logging Service).

Advantages

- NG9-1-1 core services and management/administration costs are spread across multiple 9-1-1 Authorities for a single NG9-1-1 core service system – less impact on local funding compared to more localized choices
- Common procedures for the above are established
- Makes access structure for OSPs simpler than local implementation choices
- More directly supports interoperability due to common architecture and procedures

- Makes shared and hosted facilities and equipment more workable
- Involves planned multi-level governance arrangements
- May make cybersecurity and physical security simpler than more localized choices

Challenges

- Survivability and reliability is potentially affected by limited geo-diversity of service, beyond the normal duplication and diversity of data centers supporting NG9-1-1 core services
- Requires planned multi-level governance arrangements
- Involves potential political issues and changes
- Probably requires new legal arrangements re governance and funding aspects
- Requires specific plans for and implementation of inter-regional and inter-state ESInet connectivity to support interoperability

6.9.4 Localized Scenario

Next Generation 9-1-1 Core Services is implemented for a single county PSAP or set of PSAPs, under a locally organized governance structure, which should include local government representatives for planning and management decision making. NG9-1-1 may be operated on a local or shared ESInet, which may support other Emergency Services applications at state or more localized levels.

The architecture supports a multi-tenant model where several PSAPs or 9-1-1 jurisdictions utilize a dedicated set of NG9-1-1 services. Two or more locations for access points are deployed as necessary, such as Legacy Network Gateways to collect TDM call traffic. A state-level or regional Forest Guide may support access. Access facilities are connected to two duplicated, geographically diverse core processing centers that contain the majority of the NG9-1-1 Service functions (e.g., ESRP, ECRF, BCF, DNS, Logging Service).

Advantages

- Requires only local procedures

Challenges

- Survivability and reliability is potentially affected by limited geo-diversity of service, beyond the normal duplication and diversity of data centers supporting NG9-1-1 core services
- Usually not economical compared to other choices, unless the intent is to have a local NG9-1-1 implementation expand to a regional approach after initial

deployment in a single County, and utilize cost sharing across all resulting counties (or equivalent). Higher impact on local funding compared to other choices

- Makes access structure for OSPs more complex than other choices
- Interoperability beyond the local system is more difficult
- May make cybersecurity and physical security more costly and more difficult to implement and sustain than other choices

Section 7 - Governance

7.1 General Governance Considerations

The Miriam Webster dictionary defines governance as:

- To officially control and lead (a group of people): to make decisions about laws, taxes, social programs, etc., for (a country, state, etc.)
- To control the way that (something) is done
- To control or guide the actions of (someone or something)[34].

The governance of PSAPs and 9-1-1 systems may include any and all of these concepts.

PSAP governance challenges are complicated. While technological issues related to resource sharing can be challenging, governance may present even more complex, less straightforward issues. Resource sharing and consolidation could be defined to include the sharing of contracts, virtual infrastructure, brick and mortar infrastructure, staff, or all of the above. However it is defined, decisions regarding governance are extremely important. As stated by Mr. Barry Furey in comments made at the 2015 annual conference of the Association of Public Safety Communications Officials, “Consolidation can work in many forms, under a variety of management and funding scenarios. This leads us to the key issue in consolidation - politics. The technical issues can typically be effectively solved. The real work involves getting the buy in required to both take the leap and to maintain the continued support required to continue operation... Yes, a technology roadmap is required, but the most pressing issue is the creation of governing memoranda of understanding and/or interagency agreements.”

7.1.1 Moving from an Independent to Interconnected System

It is important to understand how the original, or legacy, 9-1-1 system was established. The first 9-1-1 systems in this country were like the first law enforcement agencies in this country. Each was responsible for a specific area or region and operated independent of each other. The advent of NG9-1-1 will change the 9-1-1 governance model and basic elements of the 9-1-1 “culture.” In the legacy 9-1-1 environment, it was not technically possible for PSAPs to be fully interconnected, and therefore each PSAP tended to function as an independent agency. With each PSAP operating independently, governance was naturally decentralized, and governance models varied greatly, in terms of authority, responsibility, and the location of 9-1-1 agencies within local and state governments.

[34] Miriam Webster Dictionary, webster.com/dictionary/govern" http://www.merriam-webster.com/dictionary/govern, last accessed October 12, 2015

This decentralized model has been in place for over 40 years, and despite significant variances, it has generally worked well in meeting the primary objective of providing 9-1-1 service to citizens. PSAPs increasingly work together each day, with multiple goals including enhancing their operational effectiveness by utilizing various partnership models. Many states now authorize regional or statewide "9-1-1 Authorities" by statute that provide financial and 9-1-1 service support to their member jurisdictions – a concept even more important for NG9-1-1. But, even where such statutory environment does not exist, there are multiple instances of PSAPs working together on NG9-1-1 implementation. For example:

- **The Counties of Southern Illinois Next Generation 9-1-1 Project**. Stakeholders in this project are 17 Emergency Telephone System Boards in southern Illinois, who have bound together through inter-governmental agreements to create a secure public safety broadband network. Their intent is to, "share voice and data associated with a next generation capable 9-1-1 system," and, "provide future services at a substantial savings to each agency by sharing costs and technology."[35]

- **Pennsylvania Emergency Management Agency**. Pennsylvania is implementing NG9-1-1 via the deployment of multiple regional ESInets. One of the projects is designed to develop a thirteen county ESInet in South Western Pennsylvania, which allows for cost savings through the sharing of equipment and networks, and is planned to be the foundation for NG9-1-1 core services implementation in that area of the state. This deployment is designed to help ensure that implementation of NG9-1-1 capability across the Commonwealth is completed in the most cost efficient, timely, equitable, and reliable manner possible.

NG9-1-1 increases the opportunity for PSAPs to share resources and to cooperate and collaborate at multiple levels with potentially greater economic and technical efficiencies. NG9-1-1 technology has the potential to assist local stakeholders in their pursuit of shared models like "regionalization thru technology," (e.g., hosted, cloud, hybrid) and to lead to a consolidated approach. PSAPs could begin to identify common challenges that have been listed throughout this document like regional mapping, hosted CPE, CAD, shared voice logging, shared telephony, etc., and through discussion and careful planning, explore how they can best coordinate activities and share resources. NG moves us away from the legacy system to a place where "sharing" and "synergy" become the norm among local, regional or state connected PSAPs. Sharing resources brings challenges and opportunities to technical aspects such as cyber security, as well as nontechnical issues like consistency, uniformity, cooperation and collaboration. While these concepts will be discussed in greater detail in the following sections, further research is warranted to document these efficiencies.

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[35] Counties of Southern Illinois Next Generation 911 Project. http://jc911.org/index.php/nextgen-9-1-1-project last accessed December 2, 2015

A common plan for NG9-1-1 implementation facilitates discussion and begins to identify common public safety benefits. A common plan facilitates developing a more regional governance approach which could lead to resource sharing. PSAP stakeholders may realize that NG9-1-1 allows for more centralized operations and provides for more flexible management options. Many of the more intrinsic problems faced by the current legacy consolidation model may be addressed and resolved as part of a larger regional and collaborative NG9-1-1 approach.

The extent to which any jurisdiction can address resource sharing is dependent on its willingness to share not only resources, but also dedicated control of infrastructure and operations. Existing relationships among jurisdictions may or may not support the level of cooperation and collaboration necessary to take full advantage of the technical and operational opportunities that NG9-1-1 offers. NG9-1-1 supports standardized operational models that promote resource sharing and interoperability. The nature of existing governance models and the relationships between and among jurisdictions will directly impact how, and to what extent, the NG9-1-1 model is utilized. In most cases Statutes and/or regulations may require creation or updates to allow or enable the cooperative activities envisioned by the NG9-1-1 system.

In the legacy 9-1-1 system, PSAP managers needed fewer external relationships:

- Collaboration with other PSAPs was limited to special events or call fail-over scenarios.
- A single contractual relationship with the Local Exchange Carrier (LEC) that has typically enabled the receipt and processing of 9-1-1 calls.
- Relationships with first responders (law enforcement, fire service, emergency medical services) were relatively simple.

With migration to NG9-1-1, many more combinations and permutations of roles, relationships, and considerations are required. The following are examples:

- Service Agreements with other PSAPS and other Jurisdictions with PSAPs
- Expanded Liability issues
- Human Resources related to interconnected services
- Levels of Certification (NCMEC, Active Shooter, ADA)
- Mutual Aid agreements and MOUs
- GIS services
- Position Location providers for Emergency Responders
- Incident Management, Emergency Management
- Databases (Amber, Medical, etc.)
- Expanded Roles - enhanced interaction with Medical Community
- Video and photograph providers and technical support
- Text message service providers

- Evolution/Advances in technologies used by Police, Fire, EMS (e.g. LMR, FirstNet and others)
- New certifications

These additional relationships and the opportunities enabled by NG9-1-1 create complexity. This complexity must be managed as part of the governance model NG9-1-1 helps. PSAPs take full advantage of new forms of information and implement operational processes that increase overall emergency response capabilities.

Governance of the 9-1-1 service process and Public Safety Access Points (PSAPs) is currently a responsibility shared by local, regional and state governmental agencies. Demographics, funding, operational capability, and geographical location of the PSAP have contributed to the evolution of PSAP governance and its variation across the United States up to date.

The development and deployment of NG9-1-1 capable system architecture introduces additional infrastructure configurations along with new technologies and the products that will run them. Staffing, logistics, sustainment and day-to-day operations of the 9-1-1 service process and PSAPs will undoubtedly drive evolution of the governance to ensure the 9-1-1 caller continues to receive equal or greater levels of 9-1-1 dependability and reliability.

Previous FCC and other advisory groups have deliberated the governance issue within the context of possible consolidation. For example the report of Working Group 1A of the CSRIC II (convened 2009-2011) noted, "Successful consolidations require that a trusted and secure governance structure be established, a champion must lead the project and the political leadership must be in place to support the effort." The "effective practices" related to governance found in the report, while too lengthy to include in this document, are also a valuable reference.[36]

In the technical transition to NG9-1-1, the role of the governing body must evolve. It will continue to be important for governing bodies to consider how to meet the often unique circumstances and needs of local citizens and local responders. But as the transition to NG9-1-1 takes place, the role of governing bodies will also include balancing local needs with forming collaborative relationships to maximize the benefits that NG9-1-1 offers. By reaching across jurisdictional boundaries, there are technical, operational and financial benefits that can be realized. The members of the Working Group 2 strongly encourage 9-1-1 governance bodies to explore and embrace strategies to collaborate and share resources in transitioning to NG9-1-1 as a way to meet their responsibility for providing an optimally effective and efficient emergency communications system for their citizens and emergency responders.

[36] CSRIC WG1A – Key Findings and Effective Practices for Public Safety Consolidation, ocs/csric/CSRIC-1A-Report.pdf" https://transition.fcc.gov/pshs/docs/csric/CSRIC-1A-Report.pdf , last accessed December 4, 2015

7.1.2 Moving the Sharing Process Forward

PSAP managers, 9-1-1 Authorities and their governing bodies will ultimately have to decide whether to remain independent or share resources, and are responsible for the consequences of those decisions. If they decide that for certain technical, operational or financial aspects, there's value in working together, it will become important to establish the parameters and processes of their business relationship. It is essential to identify the person(s) that will lead the group - someone to moderate, mediate and manage that process.

The working group recommends having an advocate or a champion in favor of the resource sharing process. Understanding stakeholder, agency and individual perspectives is critical when considering sharing 9-1-1 operational procedures and resources.

As jurisdictions have grappled with how to share governance, multiple models have been considered. Citing two existing examples:

- In Michigan, considerations included:
  - A separate department within an existing department's governmental structure. This model has a civilian director who reports within the department's organizational structure with other department heads.
  - A department that is part of a participating/existing agency. Sworn personnel manage the PSAP and fall under the management of that department.
  - Independent Authority. A civilian director typically manages these agencies and reports to a board of representatives from participating members.
  - Contractual. Governmental units can enter into contractual agreements with one another in order to provide PSAP and/or dispatch service[37].

- The Minnesota model was selected to simultaneously maximize the benefits of improved service and cost savings and minimize the concern relative to loss of control. The following were considered:
  - Separate Emergency Dispatch Department within a Participating Agency (County). The PSAP is part of the organizational structure of one of the participating entities and the PSAP is its own independent department or part of an existing department.
  - Joint Powers Structure. The PSAP is not part of any larger government structure, but is in fact an independent entity, and a commission or board is created with representatives of participating PSAPs.

[37] Michigan Public Safety Answering Point (PSAP) Consolidation Considerations, http://www.michigannena.org/forms/Michigan PSAP Consolidation Considerations.pdf, last accessed December 2, 2015.

- Part of a Participating Agency (Contract Arrangement). Under this type of structure, sworn personnel often manage the PSAP and fall under the authority of the hosting agency head such as the sheriff, law enforcement, or fire chief. [38]

Resources providing guidance on shared governance are available from numerous organizations:

- NENA has recently (January 2015) published an "Inter-Agency Agreements Model Recommendations Information Document, describing several collaborative agreements, including templates for Memorandum of Understanding, Mutual Aid Agreement and Memorandum of Agreement. [39]
- The National 9-1-1 Program published "Guidelines for State NG9-1-1 Legislative Language" to facilitate the process of updating local and state statutes.[40]
- The National 9-1-1 Program, through a contract with the "National Conference of State Legislatures", maintains a 9-1-1 Legislation Tracking Database, which tracks state 9-1-1 legislation (introduced and enacted).[41]
- The 2015 "Emergency Communications Governance Guide for State, Local, Tribal, and Territorial Officials" is a tool for public safety professionals at all levels of government and disciplines to use in assessing, establishing, and sustaining effective emergency communications governance.[42]
- The reports for specific jurisdictions considering some form of consolidation are often publicly available as final reports presented to their governing body, and the majority of these reports contain consideration of governance models. The reader is encouraged to seek out these reports, which may be available by contacting:
  - The Association of Public Safety Communications Officials https://www.apcointl.org/
  - The National Association of State 9-1-1 Administrators http://nasna911.org/
  - The National Emergency Number Association http://www.nena.org/

[38] Minnesota Public Safety Answering Point (PSAP) Consolidation Guidebook/Resources. 2004 Report to the Legislature on PSAP Consolidation, https://dps.mn.gov/divisions/ecn/programs/911/Documents/Central_MNPSAP_Consolidation_Study10062010.pdf, last accessed August 7, 2015.

[39] NENA Inter-Agency Agreements NENA-INF-012.2-2015, rg/?page=InterAgencyAgreemnts" http://www.nena.org/?page=InterAgencyAgreemnts, last accessed August 7, 2015

[40] National 911 Program, Guidelines for State NG911 Legislative Language, " http://www.911.gov/pdf/ModelNG911legis-110812.pdf, last accessed August 7, 2015

[41] National 911 Program, National Conference of State Legislatures, 9-1-1 Legislation Tracking Database, x" http://www.ncsl.org/research/telecommunications-and-information-technology/911-database-overview.aspx, last accessed August 7, 2015.

[42] The 2015 Emergency Communications Governance Guide for State, Local, Tribal, and territorial Officials. http://www.dhs.gov/safecom,

7.1.3 The Need for Standard Data

There is a need for detailed, consistently measured, specific and well-documented data to support decisions related to how shared governance agreements will be developed and executed. These are essential in establishing clear lines of authority, roles, and financial responsibility. Attention to detail, as well as the active development of positive and ongoing relationships among all participating organizations, is necessary. The benefits of control and collaboration must be weighed and balanced by participating jurisdictions, to establish a governance model that maximizes the effectiveness and efficiency of its 9-1-1 system.

The collection and analysis of data are essential to the development of a compelling business case that supports the operation of any particular 9-1-1 model – whether the model is an independent operation or in combination with other PSAPs/9-1-1 Authorities. The analysis of standardized administrative, operational, cost and, CAD data, etc. could all be key components in substantiating decisions to operate as a single or combined entity. This is not an exhaustive list; additional data components could be added in any standardized collection and analysis. Collecting and analyzing data over time will also provide evidence of increased efficiency, effectiveness and cost savings as a result of decisions made.

While some jurisdictions collect and analyze their own 9-1-1 data, there is no single standardized data set or collection method that could serve as the basis for objective comparison among PSAPs. Creation of a uniform data system would be useful in the ongoing evaluation of individual PSAPs, and the evaluation of progress among PSAPs nationwide. Additionally metrics provide an opportunity for further analysis and to strengthen justification for targeted program funding to fill funding gaps. The National Emergency Medical Services Information System (NEMSIS) could provide a model for a similar data system for 9-1-1.

NEMSIS is a national effort to standardize the data collected by EMS agencies. Funded by a line item in the budget of the Office of Emergency Medical Services (EMS) at the U.S. Department of Transportation, a uniform prehospital EMS dataset was established, a national data dictionary was created MOUs were signed by all 56 states and territories, and a technical assistance center was established to support state implementation, and certify the compliance levels of software vendors.[43] EMS stakeholders and software vendors were all included in this process.

As of June of 2015, 49 states & territories have implemented NEMSIS, and standard data is collected from every EMS patient care record in those jurisdictions[44]. Local and state

[43] National Emergency Medical Services Information System, History of NEMSIS, http://www.nemsis.org/theProject/historyofNemsis.html, last accessed August 24, 2015
[44] National Emergency Medical Services Information System, State & Territory Version 2 Information, ateProgressReports/index.html" http://www.nemsis.org/support/stateProgressReports/index.html,

systems are free to collect as much data as they deem appropriate to evaluate the performance of their EMS system, and a much smaller subset of data is submitted to the national EMS database. As of June, this national database housed data from over 43 million patient care records – all available for analysis. If such a system were available for PSAPs and 9-1-1 Authorities, valuable cost and performance data could be collected in a uniform manner, and provide essential information to substantiate decisions and any resulting improvements. For other public safety industry standards on data collection please refer to:

https://nfirs.fema.gov/ - NFIRS – National Fire Incident Reporting System

https://www.fbi.gov/about-us/cjis/overview - CJIS - Criminal Justice Information Services

https://www.fbi.gov/about-us/cjis/ucr/nibrs - NIBRS - National Incident-Based Reporting System

7.1.4 Value Proposition

As any 9-1-1 Authority considers the evolution into a NG9-1-1 systems environment, they will need to look critically at the value proposition of any proposed strategy. A value proposition is a review and analysis of the benefits, costs, and value that an organization can deliver for the defined services it wishes to provide. It is essentially a promise of value to be delivered to stakeholders.

Questions could include, but not be limited to:

- Provides the ability to receive originating text messages and transfer misdirected text messages to other intrastate and interstate PSAPs?
- Provides the ability to transfer calls for service received via voice to other PSAPs intrastate and interstate; including call source, location, and other metadata attached to the call?
- Provides the ability to receive video and photos from a caller and transfer those video feeds and/or images to first responder in real time?
- Provides the ability to locate callers on an aggregated shared GIS platform across multiple jurisdictions?
- Provides for integrated relay and other services for the deaf, hard of hearing, and other disability stakeholders?

These and other components that make up basic value propositions are being requested by 9-1-1 consumers and will need to be addressed in any migration design from legacy to NG9-1-1 PSAPs.

NG9-1-1 decision-makers have competing priorities and limited funds. As a result, an analysis of those costs and benefits can assist in making the best implementation choice for their jurisdiction. Some of the factors in this cost benefit analysis process may include infrastructure design, quality of service, resiliency, redundancy, reliability, and operational efficiency. Best practices in these elements are in place and/or evolving.

Value proposition factors that may require critical consideration by 9-1-1 Authorities could include workforce elements, circuits and networks, core services and other infrastructure configurations, physical and cyber security, applications, system administration expertise, cross jurisdiction governance difficulties, and any other collection of ROI elements. Reasonable analysis would be necessary by decision-makers to determine if the cost of continuing independent operations of a 9-1-1 service, given all the required elements of NG9-1-1 configurations, has a low or high return on investment for the services required to be delivered and the risk necessary to provide those services. When both financial costs and efficiency costs exceed the risk, it may be advisable to seriously look at shared, collaborative, NG9-1-1 in any numbers of models described within this report.

Value Proposition

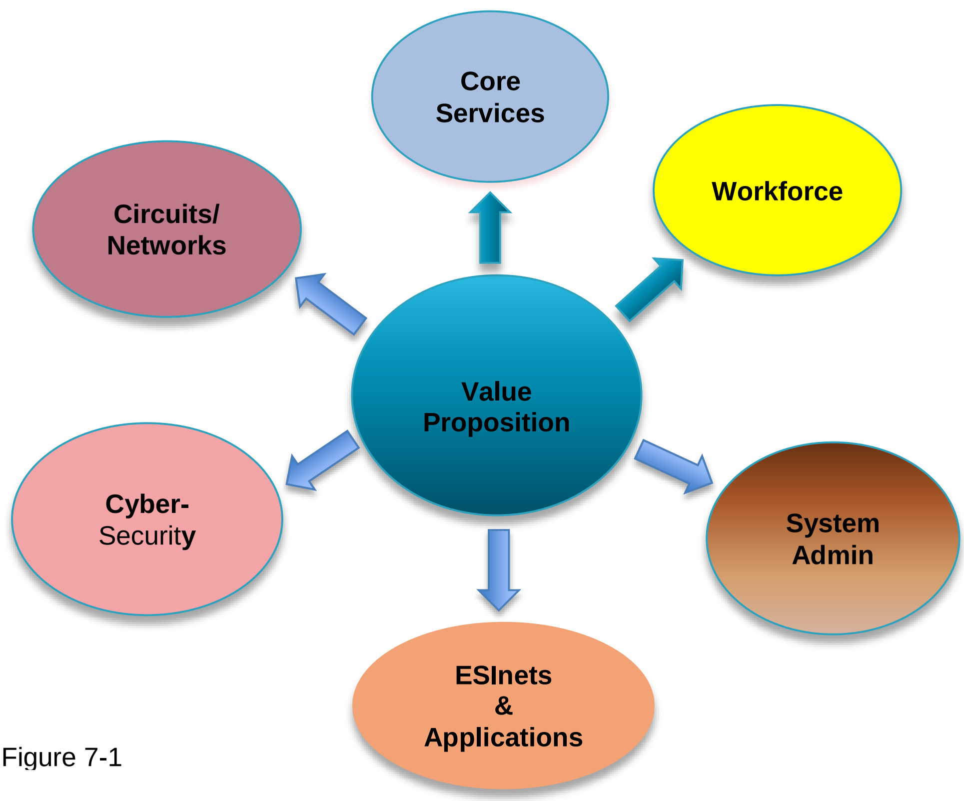

Figure 7-1

There are a number of sources available to decision-makers to frame this value proposition decision-making process. The CIO Council, Best Practices Committee developed a “How-to Guide” that speaks to Value Measuring Methodology (VMM). The purpose of Value Measuring Methodology is to "define, capture, and measure value associated with electronic services unaccounted for in traditional Return-on-Investment (ROI) calculations, to fully account for costs, and to identify and consider risk."[45]

Financial, statutory, and intergovernmental considerations should be paramount regardless of what analytical review process is used in the value proposition. A 9-1-1 Authority (or a collection of collaborating 9-1-1 Authorities) may review a wide array of tools and potential metrics to investigate a proper value proposition. It may be reasonable for NG9-1-1 services to remain within a single 9-1-1 authority. This possibility does not relinquish the responsibility of the single 9-1-1 Authority to forge collaborative relationships on a larger geographic scale to provide for integrated service models across 9-1-1 jurisdictional boundaries.

7.2 Financial Considerations

Financial considerations range from revenue and methods of revenue, to the cost of providing emergency communication services. Matters of revenue are addressed in greater detail by Working Group #3 through their report on "Optimal Resource Allocation." This section will explore matters of cost, as it relates to the overall focus of this report.

In some cases, decisions related to sharing PSAP resources are directly related to cost and cost estimates. Local and state governments are charged with providing effective and efficient 9-1-1 services. The responsible stewardship of public resources includes consideration of potential cost savings, cost efficiency and value / return on investment.

Cost savings, or forecasting of cost savings, come in various forms. For example, there are many permutations of resource sharing that result in different levels of perceived cost savings. The amount of savings may vary among jurisdictions, because costs vary from one jurisdiction to another - even for the same components or processes. This makes cost comparison with other jurisdictions difficult. There is also limited NG9-1-1 savings data available. While direct comparison of cost elements may be difficult, many models have been utilized by local and state jurisdictions in considering the sharing of 9-1-1 resources, and these general models may offer a framework for others who are similar in size, capacity, or situation. Only one thing is definite – a model in which every single PSAP deploys its own independent NG9-1-1 system will be the most expensive to deploy and operate.

With NG9-1-1, every PSAP does not require its own infrastructure or core services. Whether it is GIS, translation services, cybersecurity support, or sharing of personnel and

[45] http://www.cioindex.com/article/articleid/67467/introduction-to-value-measuring-methodology-vmm
Last Accessed December 4, 2015

buildings, NG9-1-1 implementation further enables sharing, and raises the question of cost sharing.

In order to assess current costs, the costs of implementing NG9-1-1, and potential cost savings, it is important to define which elements are included in the definition of cost. There is not one commonly accepted definition of cost among all PSAPs. Jurisdictions may define cost by statute or by the costs they are allowed to pay for with surcharge funds. Others might include some cost elements (e.g. equipment, operational costs) and not others (i.e., personnel). Some jurisdictions could also use the calculated cost per 9-1-1 call. Whatever definition is used, it is essential to ensure that the cost elements that comprise overall cost for any single jurisdiction are standardized before they are combined or compared with those of potential collaborating jurisdictions. Working Group 2 recommends TFOPA be tasked with providing additional research defining common elements of PSAP cost, and potential cost savings.

Once cost is defined and current sources of funding are identified and understood, it is important to establish the terms of cost sharing that collaborating jurisdictions will utilize. Making a decision on cost sharing models will be based on multiple considerations:

- Equity: What amount/proportion of total costs will each participant pay, when multiple 9-1-1 entities are working together in cooperative arrangements? Cost sharing can be based on call volume, CAD incidents, population, geographic area, property value, etc. A few examples of formulas considered, in a publicly available report out of Minnesota[3]:
  - Call Volume and Population Formula - percent of population within a consolidated entity, with a service delivery variable such as calls for service
  - Equal Share and Population Formula - distribute costs based on a fixed equal share, plus a proportionate share based on population.
  - Equal Share, Population, and Equalized Value Formula –
    (20% equal share + proportion of population x 80% of costs divided by 2 + proportion of equalized value x 80% of costs divided by 2 = cost share.) In this case, each participant would be charged a 20% equal share. The balance would be divided equally between each county's proportionate share of population and equalized value.
  - Equal Share, Population, Equalized Value, and Call Volume - include call volume in the formula together with equal share, population, and equalized value.
    (20% equal share + proportion of population x 80% of costs divided by 3 + proportion of equalized value x 80% of costs divided by 3 + proportion share of calls (with fire EMS calls doubled) x 80% of costs divided by 3 = cost share)

According to Minnesota's *2004 Report to the Legislature on PSAP Consolidation*,"…one of the most significant issues faced by public sector collaborations is agreement as to the cost allocation methodology. In fact, in our experience with consolidated operations, one of the most frequent concerns of members and/or causes of dissolution is the perception of unfair cost allocation practices. Therefore, it is important to get agreement up front as to the methodology to be used for allocating costs to participants and more importantly the framework within which this methodology will be reviewed and revised."[46] Costs and savings may not be evenly distributed. It will be important for participants to understand and expect uneven costs and benefits as part of any cost sharing plan.

The same report also lists several "Best Practices for Cost Sharing" that may be useful as jurisdictions establish roles and responsibilities related to cost sharing. For example, in selecting a cost sharing model, it may be useful to select a model that allows additional participants to be added at a later date.

Other considerations for cost sharing models:

- The cost of sharing – cost sharing may require additional spending to facilitate the process. These additional costs may be one-time, or ongoing. Migration costs may include such items as:
- Training,
- Mechanisms to establish operational consistency,
- Extraordinary legal or legislative expenses to achieve cost sharing model,
- Connectivity,
- Support for ongoing coordination/governance,
- Harmonization of CAD, software, GIS, and
- Structural evaluations, renovations, and electrical modifications.

It is important to include additional costs in any plan, particularly to manage expectations for cost savings. Cost sharing in a traditional sense does not always result in immediate cost savings. High start-up and capital costs may delay any cost savings for several years.

- Population – any cost sharing model based on population should consider:
  - Population disbursement and density
  - Seasonal and single incident related population variances (e.g., large events) for example, Burning Man…
- Call volume - The importance of call data cannot be overestimated in providing a clear picture of the quantity of 9-1-1 service required to provide adequate

[46] https://dps.mn.gov/divisions/ecn/programs/911/Documents/mn_psap_2004_final_report.pdf, last accessed 12-4-2015

coverage. The level of detail for these data is also important, and it may be useful to parse out:
- Scalability: seasonal and single, large incident related variances in call data (e.g., sporting events, concerts, festivals)
- Geographic areas yielding larger call volumes than others
- Call duration
- Types of calls – voice, text, 9-1-1 calls vs. administrative calls

- Property (Real) Value – some cost sharing models include data on property value. In this method the cost to each county is based on the assessed value of the county property. It may be important to understand that assessed value rates may not correlate well with public safety communications service requirements. Some geographic areas having low property value may generate a high number of 9-1-1 calls.

A clear advantage to combined spending is accomplished with the bargaining/purchasing clout of a larger collective entity – especially compared with the buying power of the individual PSAP. Economies of scale may result in lower costs per unit of functionality for participating jurisdictions.

Performing a cost-benefit analysis may be useful in quantifying the potential savings that could be appreciated by cost sharing. Traditional methods of cost-benefit analysis can be helpful, but the framework used by other parts of government may not be directly applicable to public safety, in terms of what is valued. The Value Measuring Methodology, utilized by the U.S. Department of Transportation's NG9-1-1 Initiative[47], allows the calculation of non-financial value that might not be accounted for in traditional financial metric calculations, and can provide a more rigorous comparison of alternatives[48], particularly in assessing the value of public safety.

7.2.1 Statutory/Legal Considerations

No discussion of non-technical considerations would be complete without legal considerations. Since existing statutes and regulations vary widely among jurisdictions, it will be important to assess to what extent they allow the implementation of new technologies and such actions as the sharing of resources and merger of PSAP operations. Any significant differences will have to be addressed before any action can be taken toward sharing resources.

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[47] U.S. Department of Transportation, NG911 System Initiative, Final Analysis of Cost, Value and Risk, http://ntl.bts.gov/lib/35000/35600/35650/USDOT_NG911_4-A2_FINAL_FinalCostValueRiskAnalysis_v1-0.pdf, last accessed August 8, 2015.
[48] CIO Council Best Practices Committee, Value Measuring Methodology How-To Guide, https://cio.gov/wp-content/uploads/downloads/2012/11/ValueMeasuring_Methodology_HowToGuide_Oct_2002.pdf, last accessed August 8, 2015

There may be implications for the resource sharing project in its entirety, or differences in how specific elements are addressed, such as:

- Employment Regulations
- Privacy laws
- Chain of evidence laws
- Liability
- FOIA
- Discrepancy in procurement laws

The list of statutes, rules and regulations that govern 9-1-1 service operations are publicly available in many jurisdictions. For example, the Florida Department of Management Services Web site includes information on state statutes and the rules that pertain to their authority to function and their responsibilities[49].

7.3 Intergovernmental Considerations

Historically, incumbent local exchange companies served as regulated monopoly E9-1-1 service providers within specific geographic regions. In more recent years that environment is changing with advancements in modern communications. As the historical monopoly environment is being replaced by competitive providers of interconnected network elements that may each be provided on local, regional, statewide or national scopes, the management and governance of these elements must be adapted. ESInet and next generation core functions and services are part of that evolution.

The provisioning, use and maintenance of the NG9-1-1 system by nature requires an operational and administrative environment to insure its continuity, security and function. The nature of that environment will depend in part upon the scale of the system, along with the functions or services to be supported, and the stakeholders or customers to be served. The scale may vary from a statewide system put into place by a state-level 9-1-1 Authority or entity, to regional systems put into place by regional 9-1-1 Authorities (or groups of 9-1-1 Authorities), to more local systems put into place to serve specific jurisdictional areas.[50] Combinations of the above may exist as well, and the nature of "interconnection" is a factor that must be considered.

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[49] Florida E911 Board, E911 Legislative and Rule Resources, http://www.dms.myflorida.com/business_operations/telecommunications/enhanced_911/e911_legislative_and_rule_resources, last accessed September 3, 2015.

[50] This potentially could include formalized interlocal arrangements of 9-1-1 Authorities serving an entire state.

7.3.1 Provisioning of the NG9-1-1 System

Logically there are three 9-1-1 Authority(s) approaches to provisioning such a system:

- Managed services from a vendor may be procured to fully provide and maintain the infrastructure involved, in which case the 9-1-1 Authority is responsible for procuring and contracting for the services involved, and effectively overseeing the management of that engagement in an ongoing, operational environment;

- Functions and services may be procured incrementally, in which case the 9-1-1 Authority (or groups of 9-1-1 Authorities depending upon the scale of the system) will be responsible for procuring and overseeing multiple contractors, and insuring that their services interoperate effectively together in a cohesive and productive matter;[51]

- 9-1-1 Authority or groups of 9-1-1 Authorities may elect to retain the services of a third party "multi-sourcing service integrator" to manage and oversee the incremental approach, in which case the 9-1-1 Authority is responsible for managing that engagement.

What procurement approach works best for a 9-1-1 Authority will depend in part upon historical governmental and institutional relationships, the nature and scope of the statutory environment involved, and other system goals and needs. In any of these cases, service concerns will be similar, and will revolve around interests like:

- Incident, problem, change, and configuration management, along with request management and fulfillment
- Service delivery services, including, but not limited to matters of availability, capacity, service level, continuity, security and service component management and coordination
- Equipment and Software Services, as appropriate, including, but not limited to things like long range planning, evaluation and testing, services and products being delivered
- Finance and budgeting

Other administrative/operational considerations include:

- General project management and support
- Project planning, as new projects emerge

[51] For example, 9-1-1 Authorities may elect to procure duplicative infrastructure from more than one vendor to augment network robustness and redundancy.

- Resource allocation and management
- Vendor management and coordination
- Quality assurance
- Documentation
- Crisis management
- Training and education

If the ESInet involved supports other emergency services beyond NG9-1-1 core functions, then other stakeholders are likely to be involved, with their own set of functional requirements and interests that must also be accommodated in the context of the above.[52]

7.3.2 9-1-1 Authorities

NENA describes a "9-1-1 Authority" as a

> *. . . State, County, Regional or other governmental entity responsible for 9-1-1 service operations. For example, this could be a county/parish or city government, a special 9-1-1 or Emergency Communications District, a Council of Governments or other similar body.*[53]

In the context of this discussion, a 9-1-1 Authority could also be a PSAP host governmental agency that is directly responsible for the dispatch of emergency response services (e.g., a municipality or a county), or a separate entity that is not directly responsible for emergency response, but oversees the planning and coordination of 9-1-1 for a defined geographic region (e.g., an emergency communications district or council of governments). Often such special purpose entities also provide funding and supportive services to multiple PSAP host governmental agencies.[54] Such institutional environments will impact the governmental and administrative arrangements necessary for NG9-1-1.

7.3.2.1 Single 9-1-1 Authority

If a single 9-1-1 Authority desires to provision a NG9-1-1 system, then governance, oversight and operation of the system is logically the responsibility of that entity. Such an

[52] An ESInet broadly provides a network infrastructure environment for "emergency services," including 9-1-1 services, but also potentially including broader public safety services like first responder communications, emergency preparedness, homeland security, and similar functions. The scale of an ESInet may be a large geographic area depending upon the services involved, and the interconnectivity desired. Different functional software environments may be operated by different stakeholders (e.g., supporting applications for functions other than 9-1-1, etc.)

[53] "NENA Master Glossary of 9-1-1 Terminology," National Emergency Number Association (NENA), NENA-ADM-000.18-2014, 07/29/2014, p 18.

[54] For example, database services, network infrastructure, call-handling equipment, maintenance, etc

authority could be a unit of state government with statewide jurisdiction, or a sub-state authority responsible for a defined geographic area as described above. If the latter, and, if said authority is also a PSAP host governmental agency, then decisions regarding the scope and nature of provisioning will logically be limited to that entity.[55]

On the other hand, it is likely that NG9-1-1 will foster broader geographic arrangements requiring systems serving multiple PSAP host governmental entities – arrangements that would maximize the opportunity for infrastructure sharing and interoperability. That opportunity fits well with state and regional 9-1-1 Authorities that already support 9-1-1 services in larger geographic areas. Such entities are likely to already have in place governmental and administrative arrangements with their PSAP host governmental customers that can serve as a starting point for the migration to NG9-1-1.

On the other hand, the nature of NG9-1-1 potentially involves a different kind of relationship with served PSAPs. The nature of support that a 9-1-1 Authority provides its PSAP customers may change to include, for example, ESInet and NGCS provisioning – infrastructure over which, by definition, 9-1-1 calls will be delivered utilizing new IP based technology. That is likely to generate new matters of policy and operational management involving both the procuring agency (i.e., the 9-1-1 Authority) and user agencies (i.e., the PSAPs).[56]

Governmental and administrative mechanisms structured around policy and operational matters may need to be put into place to insure the appropriate involvement and input from all relevant stakeholders. For a single 9-1-1 Authority, the policy side of that may already be adequately addressed by nature of the authority's structure. However, it is likely that new or enhanced operational mechanisms will need to be developed to deal with the nature of NG9-1-1 and changing roles and services.

7.3.2.2 Multiple 9-1-1 Authority Arrangements

NG9-1-1 is being designed to support an interconnected system of local, regional and state emergency services networks. Effective interconnection requires effective planning and coordination, and will be based upon a variety of factors, including, but not limited to local, regional and state emergency event response considerations, historical institutional, statutory, and geo-political cultural arrangements, existing and desired joint service environments, and resource sharing opportunities, factors and constraints.

Reconciling all of those factors may suggest NG9-1-1 systems beyond the scale of a single 9-1-1 Authority region. When that occurs, multiple 9-1-1 Authorities may be engaged, and new intergovernmental arrangements must be developed to oversee the

[55] Recognizing that the need for interoperability with neighboring governments will necessarily involve varying degrees of joint coordination and planning.

[56] For example, security and access management, data sourcing and maintenance, domain name service (DNS) and IP addressing management, network logging, voice recording, network operations and software support, etc.

service environment desired – arrangements that provide a fair and equal role for all the 9-1-1 Authority stakeholders involved. Many if not most states have statutes in place to support interlocal cooperation among local governments. Texas, for example, has a section of its Government Code that specifically is designed ". . . to increase the efficiency and effectiveness of local governments by authorizing them to contract, to the greatest possible extent, with one another and with agencies of the state."[57] Florida has their "Interlocal Cooperation Act of 1969." Generally, such statutory authority allows local governments to enter into arrangements together to perform any governmental function or service that each entity is authorized to perform individually.[58] The Florida Act ". . . authorizes local government units to enter into interlocal service agreements either with the public or private sector. Florida's Interlocal Cooperation Act reflects also a general law allowing a mix in the approaches adopted to deliver services, which has led to extensive use of interlocal service agreements by counties in Florida."[59]

There are many examples of these kinds of arrangements. One of the better ones is the Greater Austin Area Telecommunications Network (GAATN) in Texas that exists through the above statute and provides fiber optic connections to member agencies to support communications services.[60] Members include the Austin Independent School District, Austin Community College, City of Austin, Lower Colorado River Authority, Travis County, the State of Texas, and the University of Texas. GAATN provides a variety of networking technologies to its members, including support for emergency notification and high speed backbone network infrastructure to transmit GIS data for emergency service delivery.

GAATN has a Board of Directors composed of members from each member entity that provides policy oversight over the operations and services of the network. A "Technical Subcommittee" is appointed by the Board to plan, review and make technical recommendations to the Board. The Board in turn solicits proposals to network maintenance, management, legal services, insurance, and other related matters. Costs are shared by terms of the agreement.

GAATN, by nature, is an intergovernmental governance arrangement created to support specific services beneficial to all its members. Similar arrangements can be utilized, as appropriate, to support ESInets and NG9-1-1 systems serving larger scale geographic areas when the optimal service paradigms call for it. In such cases, the interlocal arrangement oversees the procurement, deployment and operations of the ESInet.[61]

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[57] Texas Government Code, Title 7. Intergovernmental Relations. Chapter 791, Interlocal Cooperation Contracts. Sub chapter A. General Provisions.

[58] There is a long history of local governments working together in different ways to provide joint services. For example, A Wayne State University study on "Interlocal Contractual Arrangements in the Provision of Public Safety" identified ". . . 2,251 different types of contractual arrangements in the provision of public safety." Andrew, Simon A., "Interlocal Contractual Arrangements in the Provision of Public Safety" (2005).Working Group on Interlocal Services Cooperation. Paper 6. http://digitalcommons.wayne.edu/interlocal_coop/6 last accessed December 2, 2015

[60] Andrew, ibid. p10.

[60] For more information about GAATN, see: https://www.gaatn.org/index.php Last accessed December 2, 2015

[61] There is a lot of flexibility in how such arrangements operate. For example, individual members can be assigned or assume specific responsibilities for which they may be uniquely qualified.

There is no set size to such arrangements. It depends on needs and the factors describe above. And, such arrangements may enter into agreements with similar organizations to insure interoperability.[62]

7.4 Collaboration to Promote System Reliability and Continuity

The transition to IP-based technologies and the standardized architecture developed to support NG9-1-1 are explicitly designed to promote a diverse public / private ecosystem that will increase innovation, reliability, and competition, and enhance the functionality and utility of 9-1-1 services, and these principles should be promoted.

Efforts should be made to accelerate the continued development and implementation of NG9-1-1 standards and systems, while assuring reliability (including where systems serve diverse geographic areas). Federal, state, regional, and local authorities, as well as 9-1-1 service providers and other providers, have existing roles and responsibilities to meet increased consumer expectations for reliable 9-1-1 services which span 9-1-1 coordination, operations and governance. The migration to NG9-1-1 compels the entire emergency communications industry to evaluate whether and how these roles are changing, including the appropriate demarcation points between networks used to access NG9-1-1 services and the actual NG9-1-1 services provided by 9-1-1 service providers. Increased clarity on these issues will help to reduce potential delays in NG9-1-1 deployment.

Migration to NG9-1-1 provides the opportunity for PSAPs and jurisdictions to share resources at a level not possible in the legacy environment. It also raises the question of whether or not resource sharing should be considered such as technical or nontechnical resources, virtual sharing or sharing of brick and mortar. All deliberation will include discussion of the exact nature of how all relevant stakeholders will relate to each other – governance. The nature of existing governance models, and the relationships between and among jurisdictions, will directly impact how, and to what extent, the NG9-1-1 model is deployed and the extent to which their citizens will realize its benefits.

[62] Ultimately such mechanisms can be used to support state-wide NG9-1-1 services, including functions like state-level "forest guides" that help route emergency calls to the most appropriate serving NG9-1-1 system. Such guides keep track of the geographic coverage of the system in a state.

Section 8 - NG9-1-1 Planning and Transition Considerations

8.1 NG9-1-1 Transition

The movement toward nationwide Next Generation 9-1-1 continues to be an evolving process. Most PSAPs continue to function in 'Legacy 9-1-1' configurations, a number can be considered to be 'Transitional', but as of the time of this report no 9-1-1 Authority has attained a 'Fully Functional NG9-1-1' implementation. As described in Section 3 of this report, Legacy PSAPs continue to operate in a TDM central office switched environment and have not moved toward the necessary IP environment with core service elements for Next Generation 9-1-1.

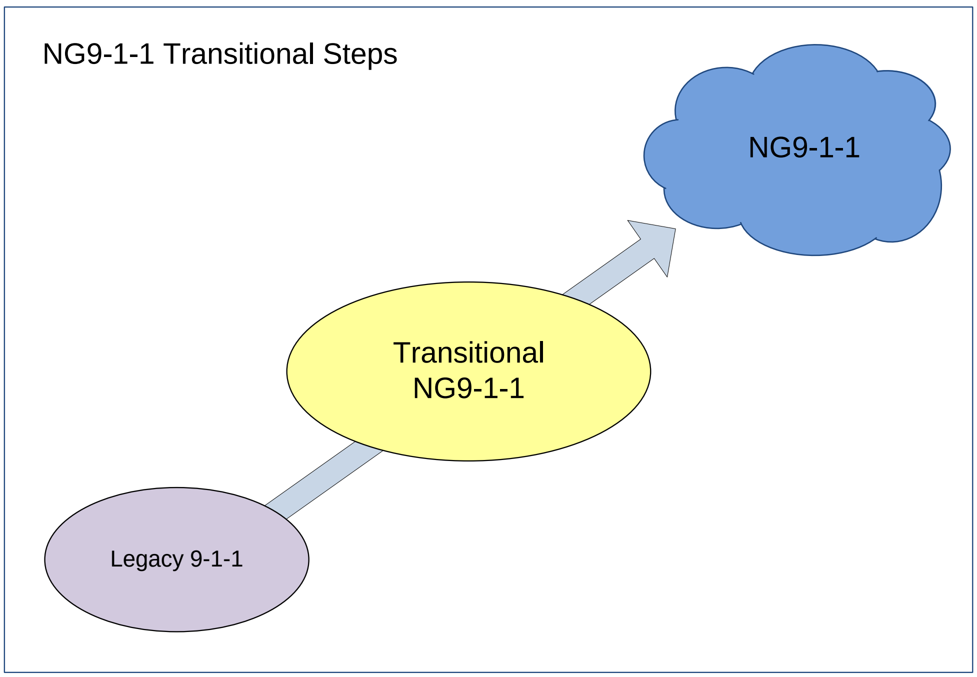

Figure 8-1

The end state is illustrated in Figure 8-2. The operating domains, OSEs, NG9-1-1 Core Services Providers, and PSAPs operate together to provide complete 9-1-1 services. OSEs deliver "calls" to NG9-1-1 Core Services Providers who route those requests for assistance to the proper PSAPs. These operating domains are interconnected via the ESInet, which provides IP transport and other networking services. The capabilities of OSEs are expected to change over time as Access Network Providers and Communication Service Providers evolve their products and capabilities. New emergency service features will also be introduced into the overall NG9-1-1 System Services Environment.

Figure 8-2

Ultimately, 9-1-1 Authorities need to make decisions necessary to begin the transition process. In most cases, these governance decisions will not be made by single PSAP Authorities even though those PSAP Authorities may currently have self-contained legacy 9-1-1 systems. Instead, new coalitions and collaborations of cooperative PSAP Authorities, at various levels, will need to evolve and work together to achieve economies of scale. These new 9-1-1 Authorities will emerge at the state and/or multi-jurisdictional levels, as discussed in previous sections of this report.

The evolution strategy from legacy 9-1-1 to NG9-1-1 is critical to 9-1-1 Authorities due to the complexities involved and costs imposed by duplication. Conversion delays, which create a combined legacy network and Next Generation 9-1-1 architecture, will require funding overlapping systems. It is inevitable that not all PSAPs will have the advantage of migrating to a NG9-1-1 environment at the exact same time. There will be early adopters and those delayed for a variety of reasons. The 9-1-1 Authority will bear larger costs while the two-system hybrid architecture remains in place. Also, PSAPs will not have the full advantages offered by an integrated NG9-1-1 environment, such as multi-media information exchange between PSAPs, while the hybrid environment exists and sets of PSAPs are served by different systems. Therefore, it is recommended that 9-1-1 Authorities explore transition strategies which reasonably minimize duplication.

Figure 8-3 below illustrates a dual environment where the legacy Selective Router is maintained and PSAPs are served by either the legacy Selective Router or NG9-1-1 Core Services. A common industry transition strategy is to deploy the ESInet, with either IP Selective Router functions or NG9-1-1 Core Services, and connect to PSAPs but leave the legacy Selective Router in place. This deployment strategy allows PSAPs to connect to the ESInet without the added complexity of trying to work with a variety of OSP/OSE to “re-home” their ingress traffic. After PSAPs are fully connected and receiving calls from the NG9-1-1 Core Services, the legacy Selective Routers can be removed from the call path for those PSAPs converted. However, legacy Selective Routers may serve more than the PSAPs migrating, therefore, the legacy Selective Router will be required to remain in service until all PSAPs have migrated to NG9-1-1 Core Services. This may require additional costs to all the PSAPs served by that legacy Selective Router and those still served by that legacy Selective Router.

Dual Legacy and NG9-1-1 Environment

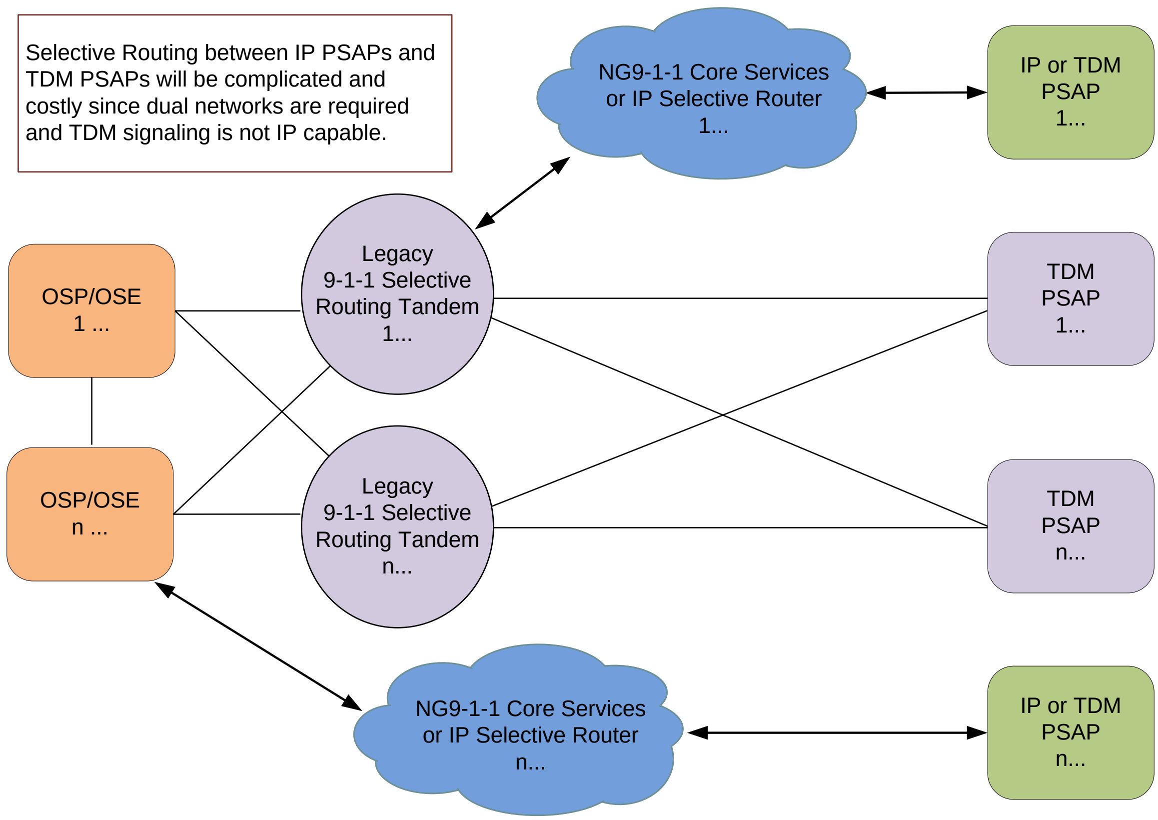

Figure 8-3

In NG9-1-1 configurations, through the establishment of Emergency Services IP networks, NG9-1-1 Core Services can reside anywhere on the network and can be economically shared in collaborative environments as depicted below. An important understanding in this transition planning process will be for the 9-1-1 Authority to have a true appreciation for what is involved in the NG9-1-1 ecosystem from a technology and functionality position.

Transitional NG9-1-1

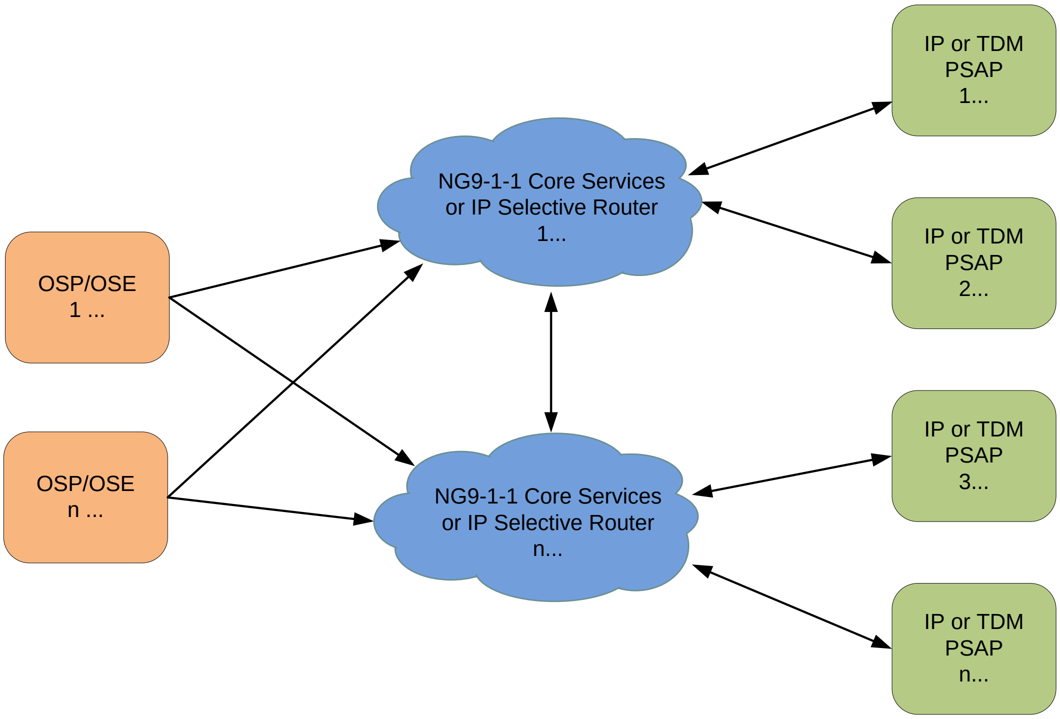

Figure 8-4

9-1-1 Authorities should develop an in-depth NG9-1-1 transition plan. With proper planning, Next Generation 9-1-1 Core Services, as described in this report, can be implemented in a reasonable time frame. Through economies of scale 9-1-1 Authorities can minimize transitional costs and maintain positive outcomes with maximum fiscal responsibility.

9-1-1 Authorities need to develop an understanding of the steps appropriate for them and their specific situation. Figure 8-5 below suggests that there are three primary capabilities or "Foundation Elements" that must be established to achieve NG9-1-1. These elements, ESInet, IP PSAP and GIS Data Preparation, do not necessarily need to be accomplished simultaneously or in any particular order, but completion will be driven by the 9-1-1 Authorities goals and NG9-1-1 transition plan. The timeline at the bottom will be determined by the 9-1-1 Authority's planning and ability to fund the various stages of system development and implementation.

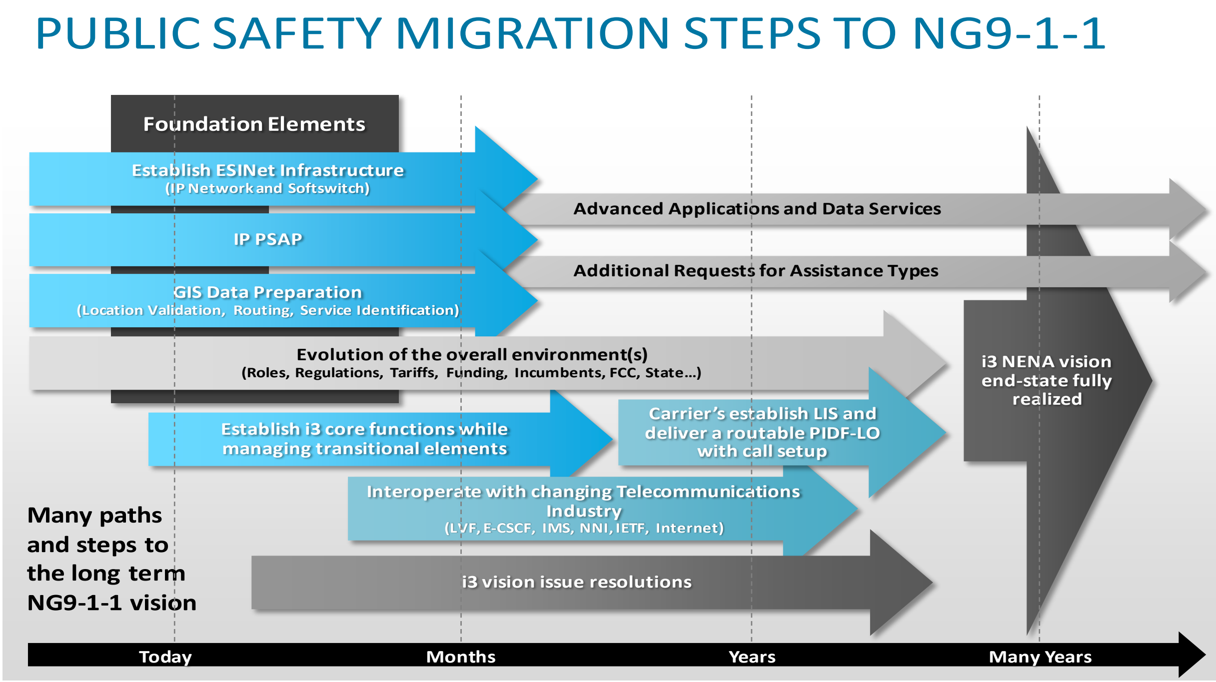

Figure 8-5

With NG9-1-1 configurations, 9-1-1 Authorities need to examine all of the considerations discussed in the previous Sections of this report to determine the optimal arrangements for their particular circumstances. To support this planning, the 9-1-1 Authority needs to consider the baseline features and functions as described in this report and determine their migration to NG9-1-1. The table below describes baseline features and functions according to the most recent NENA standards.

Function	Transitional NG9-1-1	Full NG9-1-1	Notes
Base Transport Network	ESInet	ESInet	Emergency Services IP network
Traditional OSP Access	LNG, LSRG	Multimedia IP interface	IP such as IMS ESInet
Other OSP Access	Multimedia IP interface	Multimedia IP interface	
Location Validation	LVF/GIS or MSAG equiv	LVF/GIS	LVF can be internal or external
Primary Routing	ECRF/ESRP	ECRF/ESRP	GIS controlled in both

Policy Routing	Base PRF equivalent	PRF	
Geospatial DB	GIS	GIS	
Primary Data Access	ALI, MPC, VPC, etc.	LIS, CIDB and variants	
Additional Data Access via NG9-1-1 core system	Maybe	Yes	
National and State ECRFs	No	Yes	Forest Guide process
Call transfer w added data	Maybe	Yes	
Interoperability w other NG9-1-1 systems	Maybe	Yes	Requires ESInet Interconnection
Full NG9-1-1 monitoring/logging	Partial	Yes	
PSAP interface	LPG or IP	IP interface	Legacy or NG capable PSAP

Source: NENA – see also the Baseline NG9-1-1 Description [63]

NENA Baseline NG9-1-1 is a description of a basic set of features & functions that constitute a NENA Standards based Next Generation 9-1-1 solution, on the path to an end-state NENA i3 architecture. The NENA i3 architecture components are only one aspect of NG9-1-1. There are more components that make up a complete NG9-1-1 "system", such as fully NG9-1-1 compliant PSAP equipment and the provision of GIS data. As future needs are identified, overall NG9-1-1 standards will be updated.

In order to be fully compliant with NENA NG9-1-1, the baseline NG9-1-1 system must include the functions of the legacy E9-1-1 system replicated in IP technologies as defined by NENA NG9-1-1 Standards. This includes all network and PSAP components of the system and a number of capabilities beyond E9-1-1 functions, such as the basic ability to support non-voice multimedia, e.g., text and video. While these forms of communication may not be immediately available through traditional originating service providers, baseline NG9-1-1 has the system functionality to support multimedia, perform routing,

[63] http://www.nena.org/?NG911_Baseline last accessed December 2, 2015

provide for call media logging, and enable PSAP/caller interactive communications (voice & non-voice).

Therefore, as originating service provider IP based standards are finalized and aligned with NENA NG9-1-1 standards, disruptive software application or hardware changes are not expected in NG9-1-1 systems.

Minimally required components or capabilities of baseline NG9-1-1 include, but are not limited to:

1. ESInet (Emergency Service IP transport network)

2. GIS data creation to support 3 and 6 below, and associated management tools

3. Location information validation functions (LVF)
   Publication of Authoritative NG9-1-1 Validation Functions for use by OSEs to pre-validate civic addresses (in replacement of MSAG).

4. Publication of Authoritative NG9-1-1 Routing Data for 9-1-1 Authorities. This Boundary data is loaded into ECRF and Forest Guide functions.

5. Support for legacy originating services via gateways (e.g., Legacy Network Gateways, Legacy SR Gateway), including access to MPCs, VPCs, and traditional ALI databases)

6. Geospatial controlled call routing functions (ECRF and ESRP)

7. The ability to control call routing based upon a policy routing function (PRF) with standardized methods to define/build and control Policy Rules

8. Additional data acquisition after call delivery via NG9-1-1 core services to facilitate call processing by calltaker or other public safety entities, including wireless location information rebid

9. Support for transfer of calls with accumulated calltaker notes and added data, or an access key to such data, to any authorized entity interconnected by ESInets

10. Ability to interconnect with other NG9-1-1 systems and to interwork with E9-1-1 systems

11. Support for system monitoring/logging/discrepancy reporting necessary to support troubleshooting and ongoing operation and maintenance

The above minimally required components or capabilities of baseline NG9-1-1 must include architectural, security, confidentiality, interconnection with other 9-1-1 systems, and operations aspects of NG9-1-1 service as defined in NENA Standards and related documentation. The use of legacy PSAP software through legacy PSAP Gateways will limit PSAP access to NG9-1-1 features. Fully capable NG9-1-1 PSAPs can make full use of NG9-1-1 Core Services.

The following is an example progression chart that illustrates the planning path to NG9-1-1 from legacy TDM.

NG9-1-1 Deployment Progression Chart

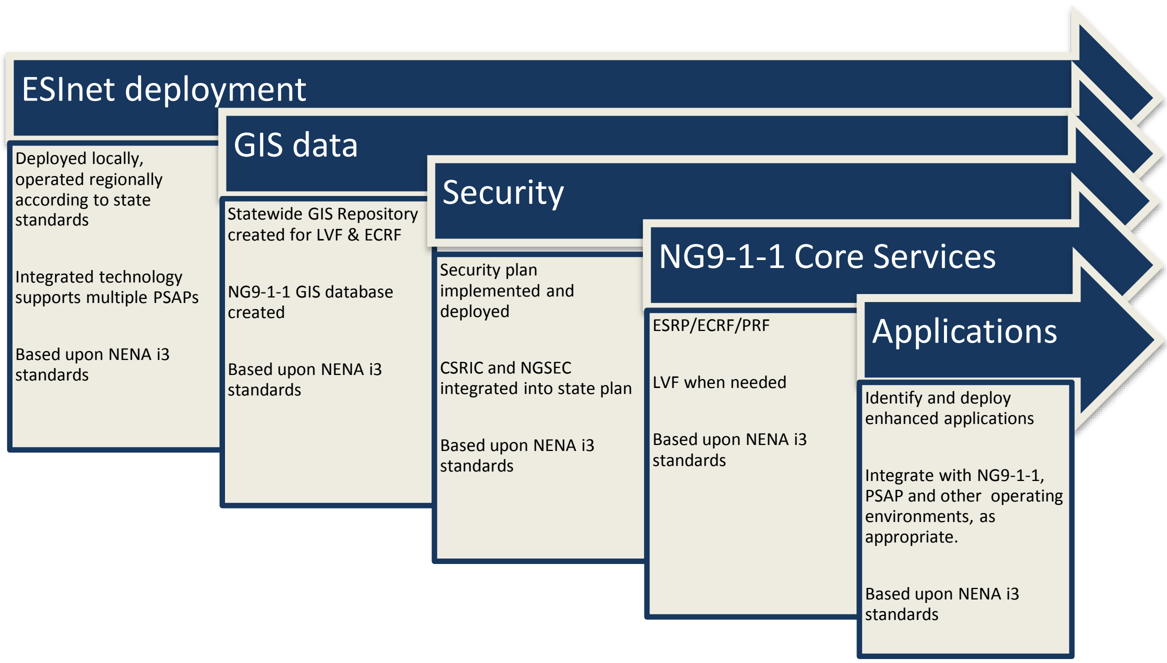

Figure 8-6

PSAPs should work with their 9-1-1 Authority to create an overall plan and progression chart for their particular situation. In cases where there is no established 9-1-1 Authority, PSAPs should first address their organizational approach and financial capabilities to move forward. A plan should include the basic migration steps explained above and move toward the more detailed functional capabilities and functional elements. 9-1-1 Authorities should continue to monitor industry standards organizations to ensure they stay abreast of best practices and industry directions.

Section 9 - Summary, Recommendations, and Conclusion

9.1 Summary

Historically, the public safety community has faced numerous transitions and enhancements to newer, better, faster, technologies that are used to support the delivery of services. These transitions, migrations and adoptions often come with complexities and consternations.

The evolution and eventual transition of 9-1-1 services to NG9-1-1 technology is similar to the continuing digitalization of land mobile radio services and the adoption of Project 25 (P25) standards based technologies that have been ongoing for the past 30+ years. With P25, the technology of public safety radio took a giant leap forward with the move to digital protocols for radio. This has not come easily as it required substantial education and understanding of the fundamental changes of how this new technology could be applied and support operations with a myriad of new features, functionality, and capabilities. The advent of FirstNet and the envisioned move of public safety wireless/mobile data services to Long Term Evolution (LTE) technology represent another similar technology migration and provide an opportunity for a holistic approach to emergency communications as an enterprise.

Generally, the items below are fundamental considerations that should be identified, addressed, and researched to satisfy the concerns of fitness and readiness of the identified technology to support critical public safety services. As this document illustrates, the aspects of transitioning 9-1-1 services from the current legacy environment to the NG9-1-1 environment will present a myriad of technical, operational, and political choices for governments and the public safety community at all levels. Some of the overarching elements are categorized and presented below.

9.1.1 Governance and Policy

As NG9-1-1 accelerates and matures, current roles and responsibilities among all entities involved in providing 9-1-1 services will be impacted by the impending technology choices and changes. As is common with the evolution of technology, existing legal and regulatory environments will be reactive and will not always effectively accommodate their implementation.

The deployments of NG9-1-1 will require increased coordination and partnerships among governments and public safety stakeholders at all levels. This includes 9-1-1 PSAP administrators, service providers, carriers, services and equipment providers, in order to collaborate and coordinate research and planning functions to ensure that the selected approach for a given PSAP or 9-1-1 Authority, is indeed the most appropriate implementation of the NG9-1-1 infrastructure. The selection, development, and ultimate implementation of the new NG9-1-1 infrastructure will often require personnel with differing skill sets and modification of service roles and responsibilities.

Effective communications and coordination with political and public safety agency leadership and the general public will be important in addressing concerns and managing expectations. As a result, both legislative and regulatory arrangements at all levels of government that extend oversight into the 9-1-1 environment may require reexamination and some existing statues, policies, rules and regulation will certainly require modification in order to effectively support NG9-1-1 implementations.

9.1.2 Operational Considerations

In order to realize the true potential of NG9-1-1 technologies, the operations of the nation's 9-1-1 systems at multiple levels will undergo significant changes and benefit from a multitude of additional capabilities to enhance the receipt and processing of citizens' calls for public safety services.

While combinations or consolidations of PSAPs, may appear as an advantageous alternative during the transition to NG9-1-1 technologies, the decision to do so requires significant analysis and reflection to ensure that the best decision is made based on the overall needs of the affected stakeholders. Transitions to NG9-1-1 technologies do not inherently require that PSAPs undergo a combination or consolidation of facilities as the technology is highly flexible and as illustrated herein offers many deployment choices. The NG9-1-1 technology decision should be premised primarily upon what is the best manner and method for the 9-1-1 Ecosystem to deliver public safety call receipt and processing services to the citizenry and the public safety response agencies.

The roles, responsibilities, and expectations of 9-1-1 personnel will change dramatically with the additional communications pathways that will be afforded to the citizenry to contact PSAPs for public safety services. There will be an increased quantity of available multimedia information that will enhance and expand existing call handling and processing functions. The existence and application of this expanded information should allow for better and more informed decision processes and subsequently better and more appropriate responses of public safety field resources. The safety of citizens and public safety personnel should be enhanced through the implementation of NG9-1-1 services.

However, the existence and accessibility of more information surrounding a call for services or an ongoing incident may also create elongated processing of 9-1-1 calls, increase the workload of the call takers and telecommunicators, and as more NG9-1-1 capabilities are introduced, significantly change the calltaker/telecommunicator's experience through available visual media in addition to audio, text, and additional data information. Alternatively, there may well be situations in which the implementation of NG9-1-1 services and systems will save significant time in the receipt, processing and dispatching of calls for service.

The implementation of NG9-1-1 technology will require significant training, re-training and recurring supplemental training and education through the transition into the end state of the technology implementation. This training will not be limited only to PSAP personnel, but should also include personnel from those public safety agencies that receive services from the PSAP. Government officials and agency leadership should also be provided overview training and education to further understanding and gain champions and buy-in through the transition into the end state of the implementation.

The 9-1-1 PSAP community will incur more expansive operational responsibilities with the implementation of NG9-1-1 technologies. PSAP leadership and technical staffs will be responsible for managing a significantly more complex and connected network infrastructure. This will include the challenges of managing a broader set of shared resources, (e.g. CAD, RMS, alarms, alert & warning systems, video monitoring, telephony systems, etc.) that facilitate the delivery of multi-discipline public safety responses.

The transition to NG9-1-1 technologies assumes that PSAPs are likely starting with an environment consisting of traditional E9-1-1 components such as an ALI system, selective router(s), a Database Management System (DBMS), tabular MSAG, and a legacy 9-1-1 network. It also assumes that PSAPs have developed a set of GIS data to a level of granularity that approximates the contents of the tabular MSAG. Furthermore, it assumes that PSAPs and/or 9-1-1 Authorities that are using GIS have previously performed preliminary reconciliation between their GIS data and their MSAGs. This is essential to provision the NG9-1-1 technology GIS based Location Validation Function (LVF) and Emergency Call Routing Function (ECRF).If this is not the case, the preparatory work for PSAPs and/or 9-1-1 Authorities to implement NG9-1-1 services will be substantially elongated as the technology is dependent upon the foundational GIS elements of street centerlines, PSAP boundary, public safety services boundaries, and authoritative boundaries. Also, if PSAPs and/or 9-1-1 Authorities using GIS have not performed reconciliation work between their GIS and US postal service address data, this work should be undertaken as soon as practical. This is considered one of the first steps in NG9-1-1 data transition.
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9.1.3 Technology Standards

Adherence to accredited technical standards and accepted technical specifications is of fundamental importance and essential to the end state implementation of NG9-1-1 technologies. The use of standards and industry accepted specifications promotes and enhances data and systems interoperability on a nationwide scale among the geographically dispersed 9-1-1 systems and public safety response agencies. The foundation of NG9-1-1 is an interconnected system architecture that incorporates a plethora of different technical standards and specifications to support the operational requirements of the network components and services in the IP world. Currently, a collection of telecommunications, networking, and telephony standards and specifications that impact and delineate NG9-1-1 networks, components and services have been developed with many others still in process. As these standards and specifications evolve, so too will the path to NG9-1-1 implementation.

Public safety and industry standards development organizations have arrived at a consensus regarding the technical architecture of NG9-1-1 systems which builds upon the capabilities and benefits of the industry-recognized and accepted deployments of IP enabled network and internetworking environments. Standards and specifications are dynamic and their development takes into account compatibilities with past and present standards to the degree that is technically feasible. As the 9-1-1 community contemplates transition and migration to NG9-1-1, they must remain aware of new and amended standards and specifications that may impact the development, planning, and implementation of NG9-1-1. While baseline technology standards and specifications have been developed, degrees of uncertainty remain among 9-1-1 decision-makers, public safety agencies, and service and equipment providers which may hinder near term transitions to NG9-1-1 technology.

9.2 Findings and Considerations

This work is not exhaustive. Additional guidance needs to be developed to best make use of this information, and we encourage the Federal Communications Commission to charter such efforts as part of the 2016 TFOPA initiative. Potential topics to be explored could be the potential costs of transition, comparative early developer use cases, additional study of access for people with speech and hearing disabilities, and the integration of applications which provide access to the 9-1-1 system.

The Working Group is aware that communications and communications technologies like the Internet of Things (IoT), Over The Top apps (OTT), analytics, and other new networking technologies continue to rapidly evolve and will eventually become part of the public safety ecosystem. How these technologies will affect public safety and effect how emergency response is executed in the future is a topic for potential further consideration. As the public safety technology ecosystem expands, how the new technologies and capabilities will be integrated into the NG9-1-1 environment will be an important consideration for future study and analysis.

A primary message in this report is that NG9-1-1 architecture can be customized to support almost any configuration of PSAP operations. Factors that affect these configurations include financial, political, governmental and operational considerations. An overall goal of the report was to educate 9-1-1 Authorities and policy officials so they have an understanding of NG9-1-1, its components, capabilities, deployment options, and potential benefits.

Armed with this understanding, 9-1-1 Authorities and decision-makers will be able to apply that knowledge to ongoing objective and collaborative dialogues that will enable them to craft a NG9-1-1 plan that meets the needs of their jurisdictions, ensuring all citizens including persons with disabilities have direct access to 9-1-1. As stated throughout this report, it was not the intent of the Working Group to recommend a particular configuration for the deployment of NG9-1-1, therefore the report is absent a "one-size fits all" architectural recommendation. The Working Group did feel it important to identify key "Findings and Considerations" contained in the report that 9-1-1 Authorities might consider to assist in the planning and deployment of a NG9-1-1 system. The following represents the highlights of those considerations:

POLICY/REGULATION

- Legacy terminology is not always as precise as it needs to be; and in this transformative time in the evolution of 9-1-1, terminology that applies to NG9-1-1 should be more detailed and specific.
- Providers of 9-1-1 services must be accountable for the reliability of their services, and vendor contracts, buttressed by state-sanctioned tariffs where needed, can provide an effective means to address the availability and reliability of 9-1-1 service.
- While the transition to NG9-1-1 will bring significant benefits, it must be accomplished in a manner that does not undermine the availability, reliability, and resiliency of the 9-1-1 system.
- Consistent with existing law, regulatory policies should continue to recognize the distinction between access to the 9-1-1 system provided by Originating Service Environments and their vendors, and the 9-1-1 system itself provided by 9-1-1 System Service Providers that contract with states, regions, and local authorities for provisioning of various 9-1-1 services. As the transition to NG9-1-1 occurs, considerations should be given to whether and how the distinctions between these roles will impact overall 9-1-1 reliability. Jurisdiction in certain areas of 9-1-1 access to PSAPs is yet to be defined (e.g., applications, VoIP, etc.).
- The legacy single 9-1-1 service provider environment upon which most of the current 9-1-1 regulation was formed will need to be readdressed in the current NG9-1-1 market. Regulations that addressed needs in the legacy 9-1-1 world need to be reevaluated to determine if they are still relevant and, in some cases, may create unnecessary barriers to transition to NG9-1-1.

- Since existing statutes and regulations vary widely among jurisdictions. Therefore, it will be important to assess to what extent they allow the implementation of new technologies and optimizations such as the sharing of resources and merger of PSAP operations. Any significant differences will have to be addressed before any formal action can be taken toward sharing resources.
- Effective communications and coordination among political leaders, public safety agency leadership, and the general public will be important in addressing concerns and managing expectations of all stakeholders. In this process, both legislative and regulatory arrangements at all levels of government that extend oversight into the 9-1-1 environment may require reexamination and some existing statues, policies, rules and regulation will certainly require modification in order to effectively support NG9-1-1 implementations.

GOVERNANCE

- A national system enabling the collection and analysis of standardized administrative data, operational data, cost data and CAD data should be developed and made available to PSAPs and 9-1-1 Authorities, to provide essential information to substantiate decisions and improvements.
- Further enhancements to the governance/regulation of 9-1-1 systems and services should be developed by an advisory committee comprised of organizations such as NARUC, NASNA, NENA, APCO, and other organizations representing state, local, regional 9-1-1, and industry officials, whose recommendations would be augmented by public comment.
- Public safety agencies often contract with their 9-1-1 service providers for such services as network operations center (NOC) functionality and related features. Contracts should include Service Level Agreements (SLAs) and other provisions to assure service quality and reliability, which provisions will likely need to evolve in scope going forward.
- New governance structures designed to optimize the potential benefits of NG9-1-1 must be based on mutual agreement and formalized by 9-1-1 Authorities. The form of the agreement should be based on state statutes or local ordinances and should set standards for what is considered successful performance.
- NG9-1-1 Core Services are not intended to be locally duplicated, but rather utilized as a cross-network resource in support of interoperability and backup capabilities. Additionally, it appears that regional or state level implementation of NG9-1-1 Core Services tend to be more cost effective and provide more opportunities for consistent operations and services to the public as opposed to localized implementations. As the intent of NG9-1-1 implementation is to ultimately interconnect regional, state, and national networks, it is

recommended that 9-1-1 Authorities explore regional or state level NG9-1-1 Core Service implementations. Local networks of PSAPs are encouraged to integrate into Regional, State, and National Networks using a transitional plan that best fits their requirements and circumstances. However, it is understood that local regions cannot always readily implement NG9-1-1 functionality due to political, monetary, or operational limitations. The Working Group supports region-specific transitional schedules, which may differ from one another because of the limitations mentioned above. 9-1-1 Authorities at all levels are encouraged to coordinate their planning.

- We recommend 9-1-1 Authorities explore the use of a shared infrastructure model and embrace strategies to collaborate and share resources when transitioning to NG9-1-1 as a way to meet their responsibility for providing an optimally effective and efficient emergency communications system for their citizens and emergency responders. Having an advocate in favor of the resource sharing is critical when considering sharing 9-1-1 operational procedures and resources. Understanding stakeholder, agency and individual perspectives will be critical to the success of the program.
- There is a need for detailed, consistently measured, specific and well-documented standardized data to support decisions related to how shared governance agreements will be developed and executed. Additional research by TFOPA is needed defining common elements of PSAP cost, and potential cost savings. Once cost is defined and current sources of funding are identified and understood, it is important to establish the terms of cost sharing that collaborating jurisdictions will utilize.

ARCHITECTUAL/TECHNICAL

- PSAP managers and other 9-1-1 Authority leaders should start to familiarize themselves, if they haven't already, with the technologies and components that make up modern communications and data processing systems. While management personnel do not need to become technical experts, they should begin to investigate and have a basic working knowledge of technical concepts such as Internet Protocol-based networking, client/server computing, server virtualization, and cloud computing. PSAP architecture optimization will build upon the use of several of these enterprise technologies that are utilized within modern computing and communications systems including those employed in Public Safety. Managers will need to have at least a basic understanding of these technology concepts to meaningfully participate in the NG9-1-1 conversation with vendors, regulators and certain technology-savvy sectors of the general public.
- Jurisdictions/9-1-1 Authorities should analyze and consider the following factors as they evaluate the optimization models included in this report for

suitability for their own unique environment. Note that this is not an exhaustive list of optimization factors but rather a list of those considered most imperative for use as model evaluation criteria by individual jurisdictions:

- Financial
- Interoperability
- Survivability/Reliability (Operational)
- Elasticity/ Scalability
- Security
- Operational Staffing
- Service Operations Effectiveness

- PSAP Managers/9-1-1 Authority leaders must keep in mind that the advantages associated with infrastructure sharing only apply to those infrastructure services and functions which are actually shared. While the report covers the potential deployment models available to PSAP and 9-1-1 Authority management, some of the models definitely involve resource and functional systems sharing across PSAPs and / or jurisdictions and their advantages (and challenges) are clearly delineated. These management teams should undertake clear, purposeful, and painstaking analyses of their individual circumstances with all of the identified advantages and challenges of each deployment model clearly in mind, so that decisions on chosen deployment models are made deliberately with full knowledge. Likewise, the continued reliance on legacy architecture should also be a deliberate choice rather than the result of "institutional inertia."
- Those responsible for NG9-1-1 systems deployment should be looking for ways to drive network interconnection across their jurisdiction and, where possible and necessary, with other jurisdictions. The use of "walled garden" environments may have been a chosen and acceptable architecture in the past, as there were limited use cases for interconnectivity among disparate networks, but today, connectivity between networks is now more the norm than the exception. The end-state of a fully NG9-1-1 environment is a network of network. Optimization results from scale. Optimal configurations will result from ESInets and NG9-1-1 Core services that are designed and deployed to serve populations that maximize the utilization of the networks and shared NG9-1-1 infrastructure and meet the needs of the served Public Safety Authorities.
- We recommend that the ESInet, the NG9-1-1 Core Services functions, and controlling databases be monitored 24x7x365 by a Network Operations Center with visibility across the network. (Note that monitoring above the physical network layer may not be part of current NOC responsibilities.) All elements should be alarmed and current network and system diagrams should be available to assess any loss of connectivity or functional performance. This should include a Simple Network Management Protocol (SNMP) system to monitor the devices in the system. Priority should be established for network

alarms with service impacts taking top priority. Potential service disruptions such as the loss of redundancy should also be prioritized.

- The ESInet should be secured using state of the art security technology (outlined in standards and best practice documents) that includes appliances and security practices designed to secure, monitor, detect intrusions, authenticate users, mitigate events and recover. Border Control Functions (BCF) functions, including Sessions Border Controllers (SBCs) and Firewalls as discussed in "NENA 75-001 Security for Next-Generation 9-1-1 Standard (NG-SEC)" should be employed to secure ESInet from security threats. Security requirements and practices are more thoroughly addressed within the TFOPA WG-1 report focused on Security.

STANDARDS / BEST PRACTICES

- The integration and transition of end user applications into the NG9-1-1 System Infrastructure should be developed. End user applications will be used as 9-1-1 call origination sources and may include unique interface and security aspects. An industry group is recommended to study the implications of end user application access to NG9-1-1.
- Collaboration and consensus-based forums should be used to develop and finalize voluntary best practices for providing public safety grade NG9-1-1 services. These include examining overall monitoring, reliability, notifications, and accountability in NG9-1-1 environments, which should be accomplished in an appropriate and timely manner.
    - The focus of this collaborative effort should be to develop and implement processes in the evolving NG9-1-1 environment to (1) *Identify* risks that could result in disruptions to 9-1-1 service; (2) *Protect* against such risks; (3) *Detect* future 9-1-1 outages; (4) *Respond* to such outages with remedial actions, including notification to affected 9-1-1 Authorities, and (5) *Recover* from such outages on a timely basis in cooperation with any affected subcontractors.[64] These five elements, although taken from National Institute of Standards and Technology NIST documents, have always been fundamentally applicable to overall 9-1-1 service management.
    - Recognizing that the implementation of best practices may obviate the need for additional rules beyond those adopted in the FCC's 9-1-1 Reliability Order, a consensus based process should recommend any changes believed to be necessary to reflect the emerging NG9-1-1 ecosystem. These recommendations should be consistent with the overarching goals

[64] http://www.nist.gov/cyberframework/index.cfm last accessed December 2, 2015

of encouraging innovation and investment in NG9-1-1 and avoiding duplicative regulatory requirements.

- Best practices should also be developed for contract provisions between state and local public safety agencies and their 9-1-1 service providers to facilitate NOC functionality and other enhanced services that would promote reliability.
- As with all best practices, the collaborative work of this consensus body should also be flexible to account for differences in the financial and personnel resources available to individual PSAPs, state and local governments, and 9-1-1 Service Providers, as well as differences in the legal and governance environments in which 9-1-1 services are provided.
- Efforts should be made to accelerate the continued development and implementation of NG9-1-1 standards and systems, while assuring reliability.

EDUCATION / TRAINING

- The implementation of NG9-1-1 technology will require significant training, re-training and recurring supplemental training and education through the transition into the end state of the technology implementation. This training will not be limited only to PSAP and 9-1-1 Authority operations personnel, but should also include personnel from those public safety agencies that receive services from the PSAP.
- Comprehensive outreach and education for both 9-1-1 stakeholders and the public is critical to the effectiveness and overall acceptance of all aspects of NG9-1-1. PSAPs, the public safety community, and their governmental entities must fully communicate the challenges, the needs and requirements of the envisioned transition including the identification of adequate capital and sustainment funding of the transitional and end state NG9-1-1 technology implementation.
- PSAPs, the public safety community, services and equipment providers, policymakers, and the public need to know more about and remain informed of the impending transition to NG9-1-1 technologies and how it is impacting public safety communications and the provision of services by PSAPs. Comprehensive outreach and education for both 9-1-1 stakeholders and the public is critical to the effectiveness and overall acceptance of all aspects of NG9-1-1. PSAPs, the public safety community, and their governmental entities must fully communicate the challenges, the needs and requirements of the envisioned transition including the identification of adequate capital and sustainment funding of the transitional and end state NG9-1-1 technology implementation. As early adopters across the nation implement their NG9-1-1

networks and advanced capabilities, ample lessons learned and successful achievements abound and can be used to further design and implement programs, practices, and methods to successfully and effectively deploy NG9-1-1.

9.3 Conclusion

The infrastructure that provides 9-1-1 is undergoing rapid change and the legacy 9-1-1 infrastructure is inadequate to meet consumer communication expectations. NG9-1-1 is a continuous evolution of infrastructure and capabilities that will enhance emergency service capabilities, including ensuring and improving access to 9-1-1 for people with disabilities. It is imperative that PSAPs begin the transition from the legacy infrastructure to NG9-1-1 capabilities and consider the timeframe in which both the legacy and NG9-1-1 infrastructure will coexist. 9-1-1 Authorities and PSAPs across the United States have different challenges and factors that must be addressed and will influence their plans for implementing Next Generation 9-1-1.

Many factors influence PSAP paths to NG9-1-1, including financial, political, government, operational and, in some cases, even the formation of a 9-1-1 Authority. There is not one specific recommended architecture model but there are clearly advantages to groups of PSAPs sharing infrastructure and the systems that provide NG9-1-1 services. NG9-1-1 needs to move forward and it is up to governmental jurisdictions and 9-1-1 Authorities to collaboratively complete plans and develop paths forward.

Section 10 – Appendices

Appendix A – Working Group 2 Members

Task Force on Optimal Public Safety Answering Point Architecture (TFOPA) Working Group 2 Members		
Name	**Organization Representing**	**Title**
Chair - David Holl	National Association of 9-1-1 Administrators and the Pennsylvania Emergency Management Agency	Special Assistant to the Director
Members:		
Aboba, Bernard	Microsoft Skype	Principal Architect in Microsoft's Skype organization
Blanken, Brad	Competitive Carriers Association	Vice President - Industry Development
Bocanegra, Alfredo	911ResQ	CEO
Bourdens. Dean	AT&T	Principal - Network Planning Engineer, AT&T Technology Operations - Technology Planning & Engineering
Boyd, Mary	Intrado	Vice President – External Affairs
Brown, Robert	National Public Safety Telecommunications Council (NPSTC)	IT Manager V, NH Division of Emergency Services and Communications (9-1-1)
Connelly, Michael	FCC	Attorney Advisor
Counterman, Sharon	National Emergency Number Association	CEO/President, Sharon Counterman Consulting
DeRango, Mario	Motorola Solutions Inc.	Vice President, Advanced System Architectures within Chief Technology Office
Dollar, Craig	Motorola Solutions	Motorola Solutions
English, Jay	APCO International	Director, Comm. Center and 9-1-1 Services
Felty, Tracy, Lt	Saline County, IL	E9-1-1 Director for Saline County
Flaherty, Laurie	NHTSA	Coordinator, National 9-1-1 Program
Fletcher, Mark	AVAYA	Chief Architect – Worldwide Public Safety Solutions
Fontes, Brian	NENA	CEO
Goerke, Jim	Texas 9-1-1 Alliance	CEO
Green, Jeanna	Sprint	Telecommunications Design Engineer III
Gusty, Denis	DHS - Science and Technology/Office for Interoperability and Compatibility	Program Manager

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Hixson, Roger	National Emergency Number Association (NENA)	Technical Issues Director
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Negahban, Mehrdad	BeamSmart, Inc.	Chairman and Chief Technology Officer
Nelson, Michael	Intrado	VP, Senior Technical Officer
Petty, Sean	iCERT	Senior Technology Specialist, Mission Critical Partners
Ray, Richard	National Association for the Deaf	
Rhoads, Dusty	DHS - Office of Emergency Communications	
Richmond, Randy	Zetron	Standards and Regulatory Specialist
Rockwell, Cheri Lynn	Butte County Communications, (Butte Co., CA)	Butte County 9-1-1 Coordinator/WE9-1-1 Northern Regional Coordinator
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Souder, Steve	Fairfax County, Virginia	Director Dept. of 9-1-1 / Public Safety Comm.
Spalding, Chuck	Palm Beach County, FL	9-1-1 Program Director
Vick, Chuck	Verizon	Group Manager of E9-1-1 Product Management and Operations
Wahlberg, Dana	Minnesota Dept. of Public Safety	9-1-1 Program Manager
West, Patti	Boulder Regional Emergency Telephone Service Authority	9-1-1 Emergency Communications Manager, Longmont Department of Public Safety, Colorado
Wittek, Jeff	Airbus DS Communications	Chief Strategic Officer
Rockwell, Cheri Lynn	Tracy Police Department	Supervisor

Appendix B – Definitions

9-1-1 Authority: a State, County, Regional or other governmental entity responsible for 9-1-1 service operations. For example, this could be a county/parish or city government, a special 9-1-1 or Emergency Communications District, a Council of Governments or other similar body. Note that various types of responsibilities may apply, such as funding, planning, management, and/or operations of certain service components.

9-1-1 General Roles and Responsibilities: While there are many variations on roles between 9-1-1 Authorities at local, regional, and state levels (including some areas where none of the three formally exist), when viewed at a national level, there is a gradual trend toward the roles and relationships depicted in Figure 1-3 as NG9-1-1 work proceeds. The 9-1-1 Authority term is somewhat generic, as the name of organizations that fill that role vary greatly, such as 9-1-1 Administrator, Emergency telephone Service Board (ETSB), etc. In many cases, the regional or state 9-1-1 Authority does not have direct governance over the local 9-1-1 Authorities. As this report discusses, referencing the roles instead of just the `things' is one way to more clearly state relationships in the 9-1-1 environment.

9-1-1 System Service Provider: the operational and management entity that provides and runs the central 9-1-1 core services components.

Client-Server: Modern data processing and communication systems utilize this model in which client software deployed at the user end point (in the public safety context, usually at a PSAP telecommunicator position) works in conjunction with server software deployed in an on-premise data equipment room or a shared infrastructure data center. The server-side implementation of client-server deployment is typically called a software service.

Cloud Virtualization: technology taken to a larger scale where virtual machines / containers can be created for software services in an on-demand fashion within a private government intranet "cloud" or an internet-accessible public "cloud" of computing hardware and storage; cloud technology improves infrastructure usage efficiency and service reliability, provides elasticity to offered load to support peak demands,

Container technologies: an approach to virtualization in which the virtualization layer runs as an application within the operating system (OS)

Data Center Options: Options for the data center infrastructure for PSAPs including the facilities equipment.

- **Government owned and managed** - the data center is owned and managed by the PSAPs or PSAP government.
- **Vendor owned and managed** - the data center is owned and managed by a vendor.

DDOS: Distributed Denial of Service, an attack using mass amounts of access attempts in an effort to slow or bring a system down.

Financial Acquisition Options: Options for the purchase of customer premise equipment.

- **Non-Recurring Cost (NRC)** - charges or fees which only occurred one time. Also referred to as Capital Expenditure (CAPEX).
- **Recurring Cost (RC)** - a regularly occurring cost or estimated cost. Also referred to as Operating Expense (OPEX).

Interlocal: As in Interlocal Agreement, meaning an agreement among local governmental entities for mutual aid and support for emergency operations

Implementation: Options for the implementation and distribution of customer premise equipment.

- **Geo-diversity** - short for geographic diversity and means physical separation between the primary and backup customer premise equipment. When a system is said to be geo-diverse, operations can continue after a total loss of the primary CPE as the backup is offsite and able to perform all the functions the primary performed.
- **Virtualization** - use of a virtual machine/server/or network vs. a physical machine/server/network router through the use of software emulation or configuration. Multiple virtual machines/servers can be run on a single physical machine/server, allowing a PSAP to use a single machine/server provide several functions. Multiple networks can be configured and administered on a single network router.

Infrastructure as a Service (IaaS): A form of cloud computing that uses virtualized computing resources over the internet or a private network.

Internet Protocol (IP): Internet Protocol-based networking is foundational to NG9-1-1 and the ESInet WAN and PSAP LAN. The multimedia capability, interoperability, scalability and robustness of the technology that underlies the Internet are leveraged in NG9-1-1 by the use of IP-based networks and communications systems.

IPSR: IP-based Selective Router, typically a softswitch and programming to replace the traditional telephone switch based E9-1-1 Selective Router. The IPSR and an IP network between it and PSAPs allows for reduced costs compared to the traditional switch and analog or digital trunking.

LoST: IETF term meaning Location to Service translation, used in NG9-1-1 in the form of the ECRF, which identifies from the presented caller location which PSAP is normally to receive the call.

NGCS: NG9-1-1 Core Services, the functional components of the central NG9-1-1 process between the OSE and PSAP environments

- **Border Control Function (BCF)**: Provides a secure entry into the ESInet for emergency calls presented to the network. The BCF incorporates firewall, admission control, and may include anchoring of session and media as well as other security mechanisms to prevent deliberate or malicious attacks on PSAPs or other entities connected to the ESInet.
- **Location Validation Function (LVF):** Ensures that a civic address can be used to properly route a 9-1-1 call to the correct PSAP. A functional element in an NGCS that is a LoST protocol server where civic location information is validated against the authoritative GIS database information. A civic address is considered valid if it can be located within the database uniquely, is suitable to provide an accurate route for an emergency call and adequate and specific enough to direct responders to the right location.
- **Policy Routing Function (PRF)**: That functional component of an Emergency Services Routing Proxy that determines the next hop in the SIP signaling path using the policy of the nominal next element determined by querying the ECRF with the location of the caller. A database function that analyzes and applies ESInet or PSAP state elements to route calls, based on policy information associated with the next-hop
- **Network Options:** Options for the deployment of the customer premise equipment network (within the PSAP, excludes the ESInet).
- **Government owned and managed** - the network and network equipment is owned and managed by PSAP resources (ex. PSAP IT staff).
- **Vendor owned and managed** - the network and network equipment is owned and managed by a vendor.

PSAP: Public Safety Answering Point, may be called a 9-1-1 Center. Where 9-1-1 requests are answered, evaluated, and processed to determine whether dispatch of field responders is needed, and in what form.

Session Initiation Protocol: is a communications **protocol** for signaling and controlling multimedia communication sessions. The most common applications of **SIP** are in Internet telephony for voice and video calls, as well as instant messaging, over Internet Protocol (IP) networks.

System Maintenance: Options for handling system support such as installation, configuration, monitoring, upgrading, and troubleshooting of customer premise equipment.

- **Government operated and managed** - Customer premise equipment is maintained and managed by PSAP resources.
- **Vendor operated and managed** - Customer premise equipment is maintained and managed by vendor resources.

Server Virtualization Software technologies: including virtual machine and emerging container technologies that allow multiple applications to share a common server hardware and storage platform.

Software as a Service (SaaS): Software licensing and delivery model in which software is licensed on a subscription bases and is centrally hosted. Sometimes referred to as "on-demand software".

OSE: Originating Service Environment, a term coined to represent various forms of call, message, and data originating entities facing the calling customer, such as OSPs, Access providers, PBX provider/operators, Smartphone application originators

XDoS: XML denial-of-service attack (XDoS attack) is a content-borne denial-of-service attack whose purpose is to shut down a web service or system running that service. A common XDoS attack occurs when an XML message is sent with a multitude of digital signatures that uses up computer time to try to validate.

Appendix C – Acronyms

Acronym	Acronym Term	Section	Page
1G	First Generation (1G)	2	11
ACD	Automatic Call Distribution	4	25
ADA	Americans with Disabilities Act	6	73
ALI	Automatic Location Identification	2	11
ANI	Automatic Number Identification	2	11
BCF	Border Control Functions (BCF)	5	44
CAD	Computer Aided Dispatch	1	5
CAMA	Centralized Automatic Message Accounting	6	62
CIDB	Customer Information Data Bases	6	54
CPE	Customer Premise Equipment	3	17
CPE	Call Processing Equipment	5	48
CSRIC	Communications Security, Reliability and Interoperability Council's	Preface	2
DBMS	Database Management System	9	100
DNS	Domain Name Service (DNS)	6	55
DNS	Directory Name Service	5	44
ECRF	Emergency Call Routing Function	6	55
EMD	Emergency Medical Dispatch	4	27
EMS	Emergency Medical Services	4	21
ESInet	Emergency Services IP transport network	1	5
ESN	Emergency Services Numbers	6	62
ESRP	Emergency Services Routing Proxy	6	66
FACA	Federal Advisory Committee Act	Preface	2
FCC	Federal Communications Commission	Preface	2
FE	Functional Elements	3	15
GAATN	Greater Austin Area Telecommunications Network (GAATN)	7	87
GIS	Geographic Information System	3	16
HVAC	Heating, Ventilating, and Air Conditioning	4	22
IaaS	Infrastructure as a Service	4	35
IETF	Internet Engineering Task Force	6	55
IoT	Internet of Things	4	34
IP	Internet Protocol	1	4
IPSR	IP Selective Router	6	65
IRR	Instant Recall Recorder	3	16
LAN	Local Area Network	3	16
LATA	Local access and transport area	1	6
LEC	local exchange carrier	3	19
LIS	Location Information Servers	6	54
LMR	Land Mobile Radio	6	70
LNG	Legacy Network Gateway	6	65

LoST Protocol	Location-to-Service Translation Protocol	6	55
LPG	Legacy PSAP Gateway	6	65
LSRG	Legacy Selective Router Gateway	6	65
LTE	Long Term Evolution	9	98
LVF	Location Validation Function	4	34
MIS	Management Information System	1	5
MOUs	Memorandum of Understanding	6	73
MPC	Mobile Positioning Center	8	95
MSAG	Master Street Address Guide	6	62
NCMEC	National Center for Missing and Exploited Children	6	73
NEMSIS	National Emergency Medical Services Information System	7	77
NENA	National Emergency Numbering Association	2	11
NG9-1-1	Next Generation 9-1-1	Preface	2
NGCS	Next Generation Core Services	1	5
NIST	NIST	9	105
NOC	Network Operating Centers	5	44
OSE	Originating Service Environments	1	5
OSP	Originating Service Providers	5	42
P25	Project 25	9	98
PRF	Policy Routing Function	6	64
PSAP	Public Safety Answering Points	Preface	2
PSTN	Public Switched Telephone Network	6	62
PTSD	Post-Traumatic Stress Disorder	4	31
QA	Quality Assurance	4	29
QC	Quality Control	4	29
QOS	Quality of Service	5	43
RFC	Request For Comment	6	55
RMS	Records Management System	3	16
ROI	Return-on-Investment	7	79
SaaS	Software as a Service	4	35
SBC	Sessions Border Controllers	5	44
SLA	Service Level Agreements	4	22
SNMP	Simple Network Management Protocol	5	49
SO	Subscriber Service Order	6	62
SOP	Standard Operating Procedures	3	18
SR	Selective Routing	2	11
SR	Selective Router	6	62
SRDB	Selective Routing Database	6	62
SS7	Signaling System 7	6	62
TDM	time-division multiplexing	1	4
TFOPA	Task Force on Optimal PSAP Architecture	Preface	2
TN	Telephone Number	6	62
URI	Universal Resource Identifier	6	59

USPS	US Postal Service	9	100
VMM	Value Measuring Methodology (VMM)	7	79
VoIP	Voice over Internet Protocol	2	12
VPC	VoIP Positioning Center	8	95
VSPs	VoIP service providers (VSPs)	6	54
WAN	Wide Area Network	3	17

Appendix D - Figures

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Appendix E - References for Additional Information Figures

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