Regis University

ePublications at Regis University

Regis University Student Publications (comprehensive collection)

Regis University Student Publications

Fall 2011

An Inquiry Regarding the Development of an Effectual Architecture Framework Supporting Next Generation 9-1-1

Patrick Purdy
Regis University

Follow this and additional works at: https://epublications.regis.edu/theses

Part of the Computer Sciences Commons

Recommended Citation

Purdy, Patrick, "An Inquiry Regarding the Development of an Effectual Architecture Framework Supporting Next Generation 9-1-1" (2011). *Regis University Student Publications (comprehensive collection)*. 631.
https://epublications.regis.edu/theses/631

This Thesis - Open Access is brought to you for free and open access by the Regis University Student Publications at ePublications at Regis University. It has been accepted for inclusion in Regis University Student Publications (comprehensive collection) by an authorized administrator of ePublications at Regis University. For more information, please contact epublications@regis.edu.

Regis University
College for Professional Studies Graduate Programs
Final Project/Thesis

Disclaimer

Use of the materials available in the Regis University Thesis Collection ("Collection") is limited and restricted to those users who agree to comply with the following terms of use. Regis University reserves the right to deny access to the Collection to any person who violates these terms of use or who seeks to or does alter, avoid or supersede the functional conditions, restrictions and limitations of the Collection.

The site may be used only for lawful purposes. The user is solely responsible for knowing and adhering to any and all applicable laws, rules, and regulations relating or pertaining to use of the Collection.

All content in this Collection is owned by and subject to the exclusive control of Regis University and the authors of the materials. It is available only for research purposes and may not be used in violation of copyright laws or for unlawful purposes. The materials may not be downloaded in whole or in part without permission of the copyright holder or as otherwise authorized in the "fair use" standards of the U.S. copyright laws and regulations.

AN INQUIRY REGARDING THE DEVELOPMENT OF AN EFFECTUAL ARCHITECTURE FRAMEWORK SUPPORTING NEXT GENERATION 9-1-1

A THESIS

SUBMITTED ON 5

OCTOBER, 2011

TO THE DEPARTMENT OF INFORMATION

TECHNOLOGY OF THE SCHOOL OF

COMPUTER & INFORMATION SCIENCES OF

REGIS UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF MASTER OF SCIENCE IN

INFORMATION TECHNOLOGY MANAGEMENT

BY

Patrick Purdy

APPROVALS

Charles Thies, Thesis Advisor

Shari Plantz-Masters

Robert T. Mason, Ph.D.

AN INQUIRY REGARDING THE DEVELOPMENT OF AN EFFECTUAL ARCHITECTURE FRAMEWORK SUPPORTING NEXT GENERATION 9-1-1

A THESIS

SUBMITTED ON 5

OCTOBER, 2011

TO THE DEPARTMENT OF INFORMATION

TECHNOLOGY OF THE SCHOOL OF

COMPUTER & INFORMATION SCIENCES OF

REGIS UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF MASTER OF SCIENCE IN

INFORMATION TECHNOLOGY MANAGEMENT

BY

Patrick Purdy

APPROVALS

_____

Charles Thies, Thesis Advisor

_____

Ranked Faculty Name

_____

Abstract

The emergency 9-1-1 service is a vital part of our nation's emergency response and disaster preparedness systems. At last count there were 6100 Public Safety Answering Points across the United States, 97 of those reside in the State of Colorado, and the citizens of the United States cannot email, text, or instant message these types of non-traditional communication to those Public Safety Answering Points due to technological limitations. The trends in personal communication technologies are accelerating the obsolescence of the current 9-1-1 systems. The Public Safety Answering Point of today is designed to accept and process voice media only; and proved successful in delivering emergency services in times of personal, regional, and national need. The current circuit-switched infrastructure of the 9-1-1 Public Safety Answering Point network cannot receive digital data (e.g., text messages, email, photographs, and video) from the communication devices commonly used by the public today. A national movement known as Next Generation 9-1-1 is underway that will support non-traditional communication digital data processing in the Public Safety Answering Point. This case study will attempt to determine if practical service oriented architecture methodology can be used in the development of an effectual architecture framework supporting the Next Generation 9-1-1framework and the non-traditional communication technology within the Public Safety Answering Points of Colorado.

Acknowledgements

I wish to thank my family for being supportive and understanding during this arduous series of events. I would like to thank my advisor, Charles Thies, for his encouragement to pursue this project and his guidance. I would also like to thank the National Emergency Number Association for their dedication in the pursuit of Next Generation 9-1-1 solutions that will make this country safer.

Table of Contents

Certification of Authorship of Thesis/Practicum Work i

Authorization to Publish Student Work ii

Releasor Authorization to Publish Student Work on WWW iii

Advisor/Faculty Approval Form iv

Abstract v

Acknowledgements vi

Table of Contents vii

List of Figures x

Chapter 1 - Introduction 1

Chapter 2 – Review of Literature and Research 3

Chapter 3 – Research Methodology 35

Chapter 4 – Data Analysis and Results 47

Chapter 5-Recommendations and Conclusions 58

Chapter 6- Areas for Further Research 60

References 61

Appendix A 65

Appendix B 77

Glossary 78

List of Figures

Figure 1: E9-1-1 Data Process Model.....5

Figure 2: Next Generation 9-1-1 Data Process Model.....12

Figure 3: Legacy 9-1-1 Telephony Network 21

Figure 4: Next Generation 9-1-1 Network Model 22

Figure 5: NENA i3 Interface Diagram.....23

Figure 6: Next Generation 9-1-1 Infrastructure Architecture 25

Figure 7: SOA Enterprise Service Bus Architecture 28

Figure 8: NG9-1-1 Information Sharing Network Architecture.....29

Figure 9: SOA Reference Architecture.....34

Figure 10: NICE Logger 9-1-1 Web Service.....57

Chapter 1 – Introduction

The emergency 9-1-1 service is a vital part of our nation's emergency response and disaster preparedness systems. Today there are over 6100 Emergency 9-1-1 Call Centers, officially titled Public Safety Answering Points (PSAPs) across the United States (NENA, 2010). The citizens of the United States cannot email, text or send any other type of non-traditional communication to their local PSAP. These trends in personal communication technologies are accelerating the obsolescence of the current 9-1-1 systems. The PSAP of today is designed to accept and process voice media only, and for 40 years, this technology was sufficient, and proved successful in delivering emergency services.

The PSAP's legacy architectural framework is outdated and needs upgrading to an effectual architectural framework that will allow for the acceptance and processing of non-traditional communication methods. The implementation of service-oriented architecture is also the key to interoperability, and data sharing amount the public safety community. The PSAP of tomorrow will need to incorporate these newer types of transmission in order to meet the needs of the citizens.

The goal of this case study is to verify the feasibility of implementing an effectual architectural framework, with an emphasis on service oriented architecture (SOA), that can accept and process non-traditional communication technology in the Colorado 9-1-1 public safety answering point (PSAP).

The objective of this case study is to provide a complete logical model of existing 9-1-1 emergency call taking systems from a large sampling of the ninety-seven (97) PSAPs in the state of Colorado. The researcher will conduct a qualitative research study to measure and evaluate the technical emergency call handling process in order to establish an effectual architecture

design for the State of Colorado PSAPs. The researcher has conducted an action research case study with three (3) Colorado PSAPs, which will demonstrate the feasibility of the service oriented architecture methodology.

Chapter 2 – Review of Literature and Research

The current analog based 9-1-1 emergency call network uses technology that dates back to 1968 when the first 9-1-1 emergency call was made in Haleyville, Alabama (911Dispatch, 2011). According to the U.S. Department of Transportation's Research and Innovative Technology Administration (RITA), the nation's current 9-1-1 system is designed around telephone technology and cannot handle the text, data, images and video that are both increasingly common in personal communications and critical to future transportation safety and mobility advances, these advancements in personal communication technologies are accelerating the obsolescence of the current 9-1-1 system. Because these outmoded networks cannot provide the public with access to 9-1-1 services from newer technologies and devices, 9-1-1 networks and call centers must change (RITA, 2010). In a recent request for proposal generated by the Colorado 9-1-1 Resource Center it is stated that the current 9-1-1 system in Colorado is based on a traditional Public Switched Telephone Network (PSTN) implemented and maintained by the Basic Emergency Service Provider (BESP), currently Qwest Communications, Inc. The BESP was established through state statue (all statutes directly related to the delivery of 9-1-1 services can be found in Colorado Revised Statutes (CRS 29-11-100.5 through 29-11-106) and is designed to ensure there is a single, statewide network for 9-1-1 call routing and delivery, including Automatic Number Information/Automatic Location Information (ANI/ALI). The BESP was tasked with creating a statewide network that provides ubiquitous access to 9-1-1 while distributing the costs of the network equally across the state. The current 9-1-1network supports approximately 100 primary and secondary Public Safety Answering Points (PSAPs), (Co9-1-1, 2011).

Congress recognized the importance of 9-1-1 in 1999 by making 9-1-1 the universal number for emergency calling in the U.S. In 2004, Congress recognized the evolving challenges and needs of the 9-1-1 system by enacting the ENHANCE 911 Act (Public Law 108-494). The law created a National 9-1-1 Implementation and Coordination Office (ICO), and authorized up to $250 million per year in matching grants to be made available for states, and local governments and tribal organizations to improve their 9-1-1 communication systems.

Today the Public Safety Answering Points are setup and maintained locally, usually by cities or counties, often in a joint effort between local government and a telephone company active in the area. In order to be effective, an emergency system needs to do three basic things:

1. Recognize when someone dials the emergency number on any phone.
2. Route the call to the nearest answering point based on the calls originating location.
3. Notify the appropriate agency as quickly as possible so it can respond to the emergency.

Figure 1 illustrates an effective E9-1-1 data process model utilizing legacy technology, and "enhanced" 9-1-1 which provides location and number identification (ALI & ANI) to the emergency call center adding more critical data. The use of advanced geographical information system (GIS) information through the form of advanced vehicle locate (AVL), utilizing global positioning system (GPS) through satelitte navigation, providing location and time information to identify the closest first responder apparatus to the incident. The need for accurate location informtation for repsonding emergency services will be a key factor in fulfilling the NG9-1-1 requirements.

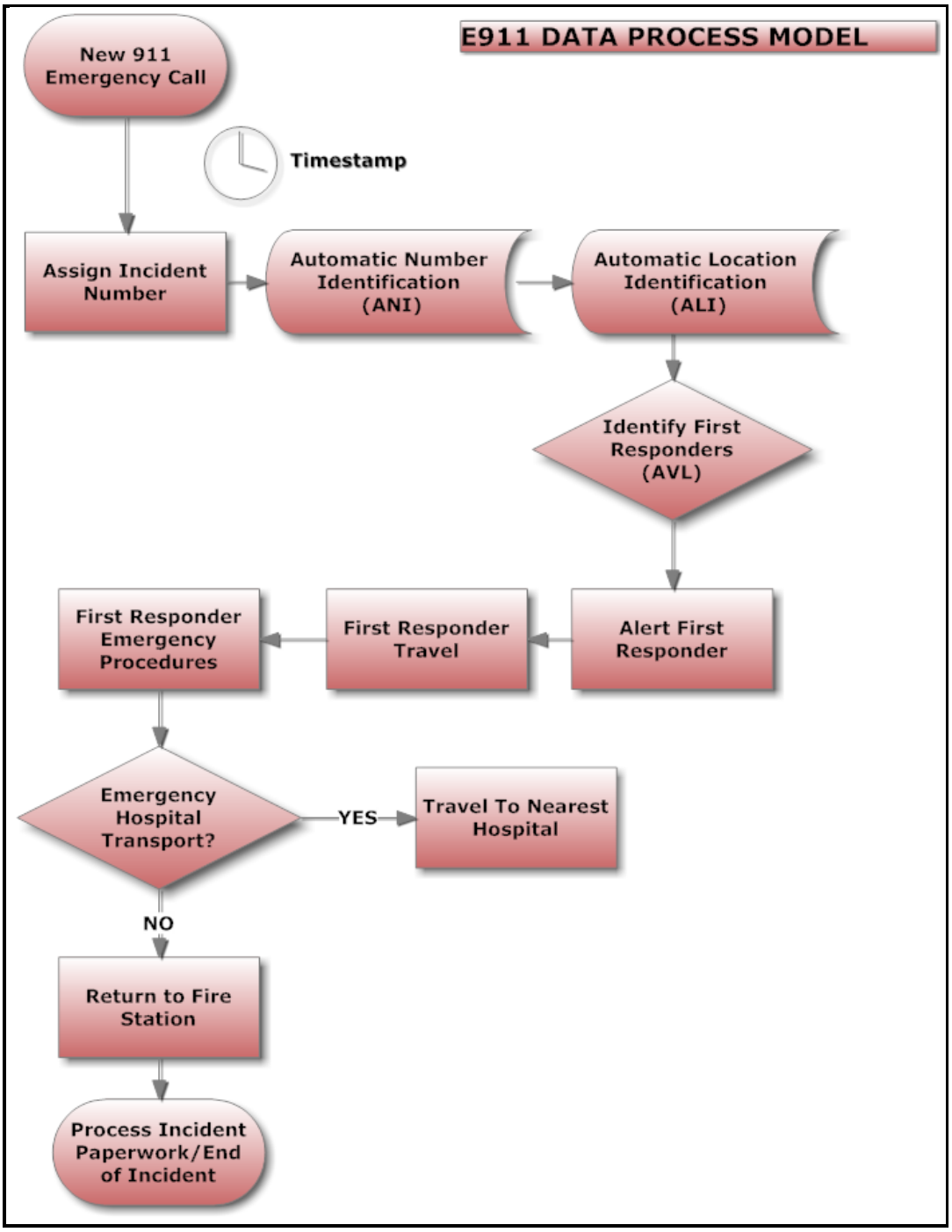


Figure 1: E9-1-1 Data Process Model

The critical first step in migrating to NG9-1-1 is to build the foundation based on common protocols and standards. In 2000, The National Emergency Number Association

(NENA) began the development of the NENA i3 Standard, a set of technical standards and policy documentation for the sole purpose of redesigning the 9-1-1service systems (NENA, 2006). NENA has identified four segments of system development that are critical to the NG9-1-Project Plan:

1. *Fully replace Enhanced 9-1-1, with all capabilities and functions in place today.*

Change over to a new base technology (IP) and entirely different software based and database control mechanisms to perform 9-1-1 system capabilities and features, for both emergency callers and PSAPs. All current originating service types must continue to be supported seamlessly, with no service dropout during the transition from E9-1-1 to NG9-1-1.

2. *Add capabilities to support changes for current and new types of Originating Service Providers.*

E9-1-1 supports voice calling for wire-line, cellular, and VoIP service providers today. There are current and certainly future needs for different and new calling technologies, including non-voice messaging of various types, devices generating data-only messages (such as sensors), photo and video transmission, and unknown future services. A primary objective is to establish a common, IP based interface that developers can design to as they develop new services, so that 9-1-1 can be planned for and then connected to quickly as 9-1-1 call and message-generating services are introduced to the public.

3. *Add flexibility for the PSAPs and 9-1-1 Authorities.*

These range from the ability to transfer calls, messages, and data between any PSAPs on

any interconnected NG9-1-1 system anywhere in the country (and beyond), ability to directly activate alternate routing much more quickly, to controlling data flow. The PSAP will be able to access a wide range of supportive databases and share new and more robust forms of data to facilitate call processing, emergency response and comprehensive incident management. Provide basic tools to support disaster related 9-1-1 call control, and to handle non-voice call types are also involved.

4. *Add capabilities to integrate and interoperate with emergency entities beyond the PSAP.*

Other emergency and public safety related entities will be able to interconnect to the NG9-1-1 network and system, and be able to receive calls and data sent by the NG9-1-1 system or PSAPs, as well as (with access controls) acquire and pass data between all entities. Inherent in this portion is support for disaster management and intercommunications with and between PSAPs, EOCs, DHS, and other emergency management entities.

The identified four areas of system development also require that many policy, educational and operations issues be treated as part of the overall project prior to implementation. The addition of capabilities beyond those of today's E9-1-1 systems, for instance, drive needs in these areas that are not easily derived from past practice or experience. System and procedural tools are required to support 9-1-1 PSAPs, and to deal with additional data sources, different types of calling technologies and changes in call processing times at the PSAP, and new features that require new procedures. A variety of educational products are required to allow understanding, and support preparation, smooth transition and ongoing operation of NG9-1-1.

The National Emergency Number Association (NENA) is a primary source for information and literature concerning next generation 9-1-1(NG9-1-1). NENA is taking the lead in the evolution of NG9-1-1 from a standards based perspective. NENA is working to develop technology and processing standards for the United States. In the NENA Functional and Interface Standards for Next Generation 9-1-1 version 1.0(i3) it is mentioned that "rapid evolution of the type of devices and services that can be to call for help, plus increasing volume and diversity of information that can be made available to assist PSAPs and responders in an emergency require major changes in the architecture" (NENA, 2006). The next generation 9-1-1 emergency call taking will soon have a government mandate, a regulation requiring PSAPs to be prepared to accept and process non-traditional communication emergency calls (Davis, 2009). The Next Generation Transition Planning Committee (NGTPC) is a joint effort between NENA's Operations and Technical Committees. The primary objective of the NGTPC is to identify and describe the NG9-1-1 transition recommendations useful to Public Safety Authorities and other stakeholders in moving from each 9-1-1 systems and service environment starting point to NG9-1-1. These include the related development actions needed to enable transition to a fully capable NG9-1-1 service. The NGTPC will define transition plans for the migration from the legacy 9-1-1 environment to NG9-1-1 systems supporting emergency services. Jones, Hinkle, Goerke & Sherry (2007) are the lead members of the NGTPC and their scope will focus on three categories of networks and associated subsystems: originating networks, the core emergency services network(s) and PSAP Networks, and the necessary operational, service and management features required for the overall NG9-1-1 system to function. Their direction is to develop a gap analysis and transition plans based upon an initial assessment of base-lining legacy and NG9-1-1 starting points. To date the committee is busy collecting data toward their goals.

Guidelines and recommendations for the transition of stakeholders to NG9-1-1 are critical. All of these aspects are represented and, as additional perspectives occur, periodically updated in the development activities in the NG9-1-1 Project plan. The National Emergency Number Association's i3 standard includes the Technical Requirements Document (NENA 08-751); this document is intended to be used by Standard Development Organizations (SDO), and or designers and manufacturers of systems that are used for the purpose of processing emergency calls. It should be considered to be a source for identifying the requirements necessary to meet the needs of the emergency services industry as it applies to the subject covered in document 08-751. The document is not intended to provide complete design specifications or parameters for systems that process emergency calls (NENA, 2006). Additional requirements and mandates will come from the FCC, primarily concerning telephone service providers and interconnection, and cooperation issues. These interconnection issues can be technology and standards-based as well, each telephone service provider maintains proprietary customer premise equipment (CPE); regulations from the FCC would help alleviate this vendor-driven problem for sharing calls and data across PSAPs that operate on different telephony systems. Identified within the Federal Communications Commission Next Generation 9-1-1 Initiative helps define the system architecture and develop a transition plan to establish a digital, Internet Protocol (IP)-based foundation for the delivery of non-traditional 9-1-1 emergency calls. Once these standards are broadly accepted, CPE providers will then be able to interoperate with other providers, networks, devices and government agencies using a standard IP communication link. Specific web service features will then be layered upon this foundation allowing for real-time sharing of GPS, AVL, CAD and RMS in the public safety arena, many other shared opportunities outside public safety include; courts, utilities, public works and 311, across multiple agencies, departments and

jurisdictions.

In a recent interview conducted with 9-1-1 Magazine, Roger Hixson, NENA's Technical Issues Director; Mr. Hixson stated that part of the purpose of the NENA i3 standards proposal is to create an environment in which anyone willing to meet the requirements of the public safety environment can become a certified 9-1-1 call handler," even to the point of having that not be a public safety agency. The goal is to create an environment infused with new innovation, but Hixson said, "We want responsible innovation, as much [innovation] as possible but responsible and coordinated, so the end result is a system that is as good or better than today at fulfilling the needs of the citizens"(NENA, 2011).

In the *New and Emerging Technologies911 Improvement Act of 2008 (NET 911 Improvement Act, Public Law 110-283)* Congress tasked the National E9-1-1 Implementation Coordination Office (ICO) to develop "a national plan for migrating to a national [Internet-Protocol] IP-enabled emergency network capable of receiving and responding to all citizen-activated emergency communications and improving information sharing among all emergency response entities."(p.1)

Figure 2 illustrates an effective emergency system design, a NG9-1-1 data process model will be similar in nature to the E9-1-1 data process model, but will not be a siloed solution, it can be Software as a Service (SaaS), hosted by one or many state or local PSAPs. The process of collecting the emergency call information will change in relation to what technology can be used to provide the emergency call; voice, instant message (IM), email, video; the first responders will be identified through a shared or hosted advanced vehicle locate (AVL), the first responder will also be logged-in to the emergency services web portal that provides them with all the emergency applications and information, and allows those first responders to self-dispatch to the

emergency incident. The use of advanced geographical information system (GIS) information through the form of AVL, utilizing global positioning system (GPS) through satellite navigation, providing location and time information to identify the closest first responder apparatus to the incident. The need for accurate location informtation for dispatching and repsonding emergency services will be a key factor in fulfilling the NG9-1-1 requirements. The NG9-1-1 model will require more GIS and GPS information, Location Information Service (LIS), and Location Validation Function (LVF) will replace Automatic Location Information (ALI). The GIS/GPS and required mapping systems will serve a critical function in the NG9-1-1 design; gaining awareness of current first repsonder resources will aid in more efficent and effective 9-1-1 dispatching. GIS/GPS functionality is a topic that deserves it's own case study and warrants further research, and will only be included in this case study to assist in connecting the functionality to the NG9-1-1 effectual architecutre.

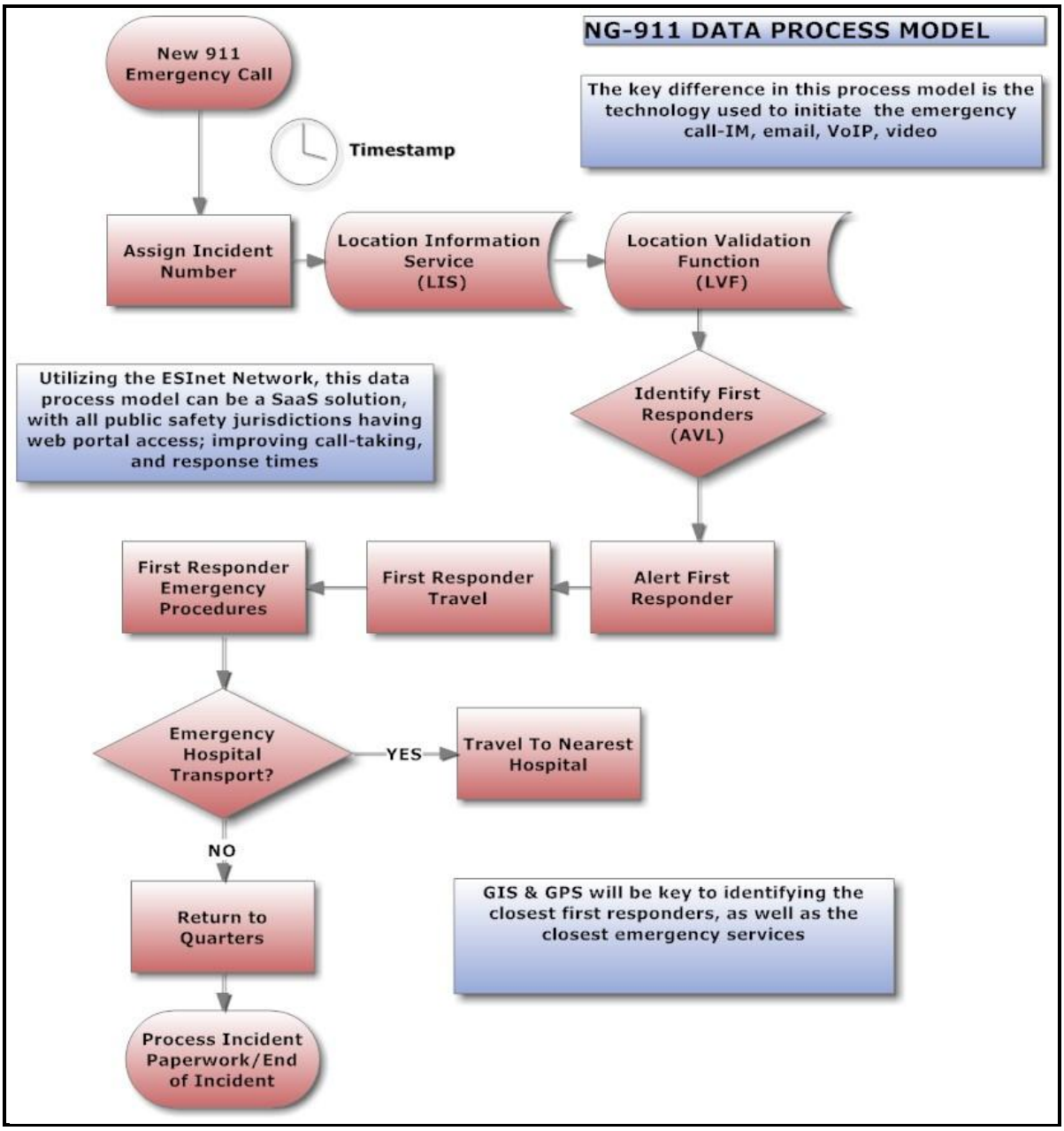


Figure 2: Next Generation 9-1-1 Data Process Model

In their book: *Service Oriented Architecture Field Guide for Executives,* Gabhart & Bhattacharya define SOA as: "SOA is about connecting customer requirements with enterprise capabilities, regardless of technology landscape or arbitrary organizational boundaries."(p.7) Service-oriented architecture delivers on the promise of technology and business integration allowing for the reuse of current infrastructure architecture and applications into new business solutions (Erl, 2005) mentions the apparent "newness" of SOA in its current definition of combining traditional and new concepts in support of a unique architectural model, is not so new. Erl also indicates that the SOA foundation is based on an old school of thought "service-orientation, as a means of separating things into independent and logical units, a very common concept." The "newness" has appeal to both business and technology strategists; business is looking to bring to market new business ideas in a very short timeframe, technologists are interested because reuse of existing architectures has the potential to shorten development time.

The overlying message is that business needs to become more effective and efficient, and can utilize and reshape existing technology in a cost effective manner in an attempt to achieve this, the service oriented architecture provides the vehicle for eliminating redundancy and inefficiency while maximizing reuse, automation and productivity. While this concept sounds incredibly complex it is not new – some may argue that SOA evolved out of the experiences associated with designing and developing distributed systems based on previously available technologies. Many of the concepts associated with SOA such as services, discovery and late binding were associated with CORBA and DCOM. Similarly, many service design principles have much in common with earlier OOA/OOD techniques based upon encapsulation, abstraction and clearly defined interfaces (Evdemon, 2005).

Agility is often promoted as one of the biggest benefits of SOA – an organization with business processes implemented on a loosely-coupled infrastructure is much more open to change than an organization constrained underlying monolithic applications that require weeks to implement the smallest change. Loosely coupled systems result in loosely coupled business processes, since the business processes are no longer constrained by the limitations of the underlying infrastructure. Services and their associated interfaces must remain stable, enabling them to be re-configured or re-aggregated to meet the ever-changing needs of business (Evdemon, 2005).

The SOA Practitioners' Guide Part 2(2006) identifies three foundation components with the SOA reference architecture that are necessary for a successful SOA development: business architecture, infrastructure architecture, and information architecture.

1. "Business architecture describes the business strategy, objectives, priorities, and processes to be supported by the SOA. SOA is only successful if it delivers on the business architecture. Reuse of business processes provides higher ROI than the potential reuse of infrastructure or data components."
2. "Infrastructure architecture is the engine that enables SOA. It should address all the aspects of the scalable infrastructure from networks, enterprise servers, data centers, and firewalls, to application infrastructure, security, monitoring, and middleware."
3. "Data and Information architecture models key concepts and events for a given business process.

In Durvasula et al, *The SOA Practitioners' Guide Part 2(2006)* also identifies the Enterprise SOA Maturity Model as a requirement to understanding the reference architecture as the ideal

"target" architecture for a successful SOA methodology. The Enterprise SOA Maturity Model consists of three stages:

1. Web Application Development Stage

   Provide rich client and browser-based business solutions to both internal and external users.

2. Develop Composite Applications Stage

   Provide information and data from a variety of sources and channels, and make them available to internal and external users as appropriate.

3. Automate Business Process Stage

   The applications, data, and infrastructure help users to perform their roles effectively by providing the right information at the right time.

The researcher in this case study will use the three SOA foundation components and the SOA Maturity Model as the "target" architecture concept describes in The SOA Practitioners' Guide Part 2(2006), making it a model for explaining how SOA can work for the design and deployment of the Next Generation 9-1-1 for the PSAPs of Colorado.

Public Safety Answering Points within the state of Colorado have a series of business processes across many separate systems; an Automatic Number Identification (ANI), which corresponds to the subscriber's ten digit telephone number, an Automatic Location Identification (ALI) which provides for an address display of the subscriber calling 911, both ANI and ALI systems are maintained off site by our largest telecommunications company, a GIS database utilized for mapping 9-1-1 call information, maintained off site by a private vendor, an emergency 9-1-1 call recording system maintained by individual 9-1-1 information technology departments, a computer-aided dispatching (CAD) and records management systems also

maintained by individual 9-1-1 IT departments, and a dedicated circuit-switched telephony system processing the 9-1-1 calls. These business processes are repeated numerous times throughout the state of Colorado, the PSAP survey for this case study will provide more specific details on the actual count. The Colorado NG9-1-1 case study will focus the SOA initiative on providing web services for these key business processes identified previously.

A leading difficulty identified by The National E9-1-1 Implementation Coordination Office (ICO), in their report titled: *A National Plan for Migrating to IP-Enabled 9-1-1 Systems;* will be the financial burden of deploying an NG9-1-1 solution; despite emerging requirements for IP-enabled emergency communications services, 9-1-1 Authorities and PSAPs throughout the nation may struggle to finance new systems while continuing to operate their current systems (ICO, 2009). It was also noted in the report that "the transition period will involve operating the legacy system and the IP-enabled 9-1-1 system side-by-side. In an IP-enabled 9-1-1 environment, allocating costs will be an institutional and administrative challenge." Though a SOA adoption is costly, the timing could be right to move toward a web services based solution. In plain terms, if the money needs to be spent on the NG9-1-1 initiative, why not go the extra step and create a solution using the SOA methodology, and assist in "future-proofing" the NG9-1-1 technologies. Through the utilization of the SOA web services, the potential for reuse of existing infrastructure, applications, and business process within the PSAP can result in stable, long-lasting efficient and effective methods for processing emergency 9-1-1 calls.

The SOA "top-down" design approach will be considered in this case study for the primary purpose of reusing legacy applications, this design will allow for the encapsulation of the legacy applications with a service and offer them as software as a service (SaaS) solution to the PSAPs, and other agencies. This approach will also allow for the assessment and identify

potential service candidates and capabilities within those legacy applications. Given the nature of the NG9-1-1 business services, the service offerings must be designed for both availability and stability. This design approach will also require additional research in the areas of security and disaster recovery- those topics will not be discussed in detail in this case study, but warrant further research.

The researcher has fifteen years of first-hand knowledge and experience of the Colorado PSAP, and 9-1-1 emergency services in general, with that said the researcher struggles with the hardware and application vendors that influence the selection of technology in the PSAP today. Business and IT leaders attempt to work together to institute interoperability, but many times lack of governance and funding require business and IT stakeholders to do whatever it takes to meet a particular department needs. This immediate need driven by lack of governance as well as the nature of the 9-1-1 business; results in many applications that may or may not be integrated into the existing architecture. This design requires numerous application programming interfaces (APIs); creating a unique set of specifications on how the applications communicate. These vendor proprietary applications and in many cases proprietary hardware specifications, create siloed systems that are difficult to track key performance indicators, as well as create different operational data stores.

Based on the survey results the PSAPs of Colorado have deployed multiple systems that perform the same tasks within an enterprise. The redundant infrastructure solutions across public safety jurisdictions for authentication, data mining, and applications (COTS or custom) that compound the complexity and costs for each agency resulting in a nearly impossible efficient and effective method for implementing change to current 9-1-1 emergency call taking business processes. The NENA i3 standard will assist in establishing a best practice for the

implementation of NG9-1-1 in the Colorado PSAP; the implementation of service oriented architecture will streamline the processes and improve the public safety agencies ability to efficiently and effectively deal with traditional as well as non-traditional communication to the PSAP.

In the *National Plan for Migrating to IP-Enabled 9-1-1 Systems (2009)* research paper it is noted that the key value elements of the 9-1-1 system overall and their relative weights of importance were identified through a series of facilitated discussions with selected 9-1-1 system stakeholders. Of the 17 measures considered in this analysis, the five (5) with the highest priority across all stakeholders were-

- Accessibility. 9-1-1 system is equally accessible to all members of the general public. The system is also equally accessible to all PSAP call takers.
- Reliability of Service**.** 9-1-1 system has no single point of failure and has established redundancy to minimize service disruptions and limit susceptibility to failure and/or natural disaster.
- Call Taker Timeliness**.** 9-1-1 calls are received and processed by PSAP call takers and handed off to emergency responders in a timely manner.
- Public Safety**.** The system provides for the general safety of the public (e.g., reduced congestion or increased communications in the case of public emergencies).
- Safety to Responders**.** The team responding to automated emergency calls has all of the information necessary to address the situation appropriately.

These five (5) key value elements of the 9-1-1 system overall are addressed with the service oriented architecture (SOA). Through the ESInet network and the web portal service available to all public safety agencies in a defined area, accessibility will be available to all that require

access. From a reliability perspective, the SOA approach will eliminate a single point of failure, and will provide ample systems and connectivity for redundancy. Call taker timeliness will also show improvements using the SOA methodology, all call takers and systems will be available for any call, the emergency call transfer will be eliminated, and the public safety jurisdictions will be eliminated as well. The integrations of emergency systems will allow for seamless call taking, and fewer application programming interfaces. The ESInet network with the software as service functionality for 9-1-1 emergency systems availability will provide call sharing, and load balancing with automatic failover to allow for less communication traffic congestion. The web services portal will allow mobile first responders access to the system through cellular connectivity, giving the responders access to all of the critical information and more.

The Next Generation 9-1-1 requires an IP-based 9-1-1 emergency services network both outside and inside the PSAP, enabling sharing and distribution of emergency services from all sources on a common network. The National Emergency Number Association (NENA) has established The Functional and Interface Standards for Next Generation 9-1-1 version 1.0(i3), and the NENA i3 Technical Requirements Document 08-751, which is essential in order to achieve national interoperability. NG9-1-1 is based on packet-switched technology or Internet Protocol (IP). In NG9-1-1, a 9-1-1 emergency call does not have to be voice or TTY, or even come from a telephone type of device. In NG9-1-1, a 9-1-1 call is a generic term that is used to include any device that may request emergency assistance. The 9-1-1 call can be a sensor sending data of smoke, a personal medical device sending data when someone is having a heart attack, a telematics (OnStar) signal from a damaged vehicle, text, images and/or video from a smart phone, or a plain old wired telephone. According the NENA's i3 Functional and Interface Standards document (08-003v1), the validation of calling device's location uses the 9-1-1

authority's locally derived data to validate the location. The device, that is capable of placing the call to 9-1-1, goes through a location information server (LIS) to a location validation function (LVF). The LVF uses the local 9-1-1 authority's geographic information system (GIS) data to validate the location. Once validated the GIS will be part of the 9-1-1 call, and assist the responders in finding the emergency incident. There are private business groups currently working on this technology, one such company is 911 Datamaster, which has developed a database that is built by correlating postal, Master Street Address Guide (MSAG) and GIS data. The majority of this data is automated using their proprietary correlation engine; further refinement of the data is accomplished through an intuitive web-based user interface. The user interface can live in the ESInet web portal, thus reinforcing the software as a service concept. Recently 911 Datamaster, and seven other leading vendors providing application and network functionality for public safety announced unprecedented collaboration in support of the immediate ratification of NENA's i3 Functional and Interface Standards document as the sole NG9-1-1 network architecture and interface standard (NENA, 2011).

In order for the reader to gain a full understanding of what the NG9-1-1 emergency call process will look like in the future it is necessary to include historical information about the legacy 9-1-1 call process, and associated network infrastructure; Figure 3 is the Legacy 9-1-1 Telephony Network. Figure 4 is the Next Generation 9-1-1 Telephony Network.

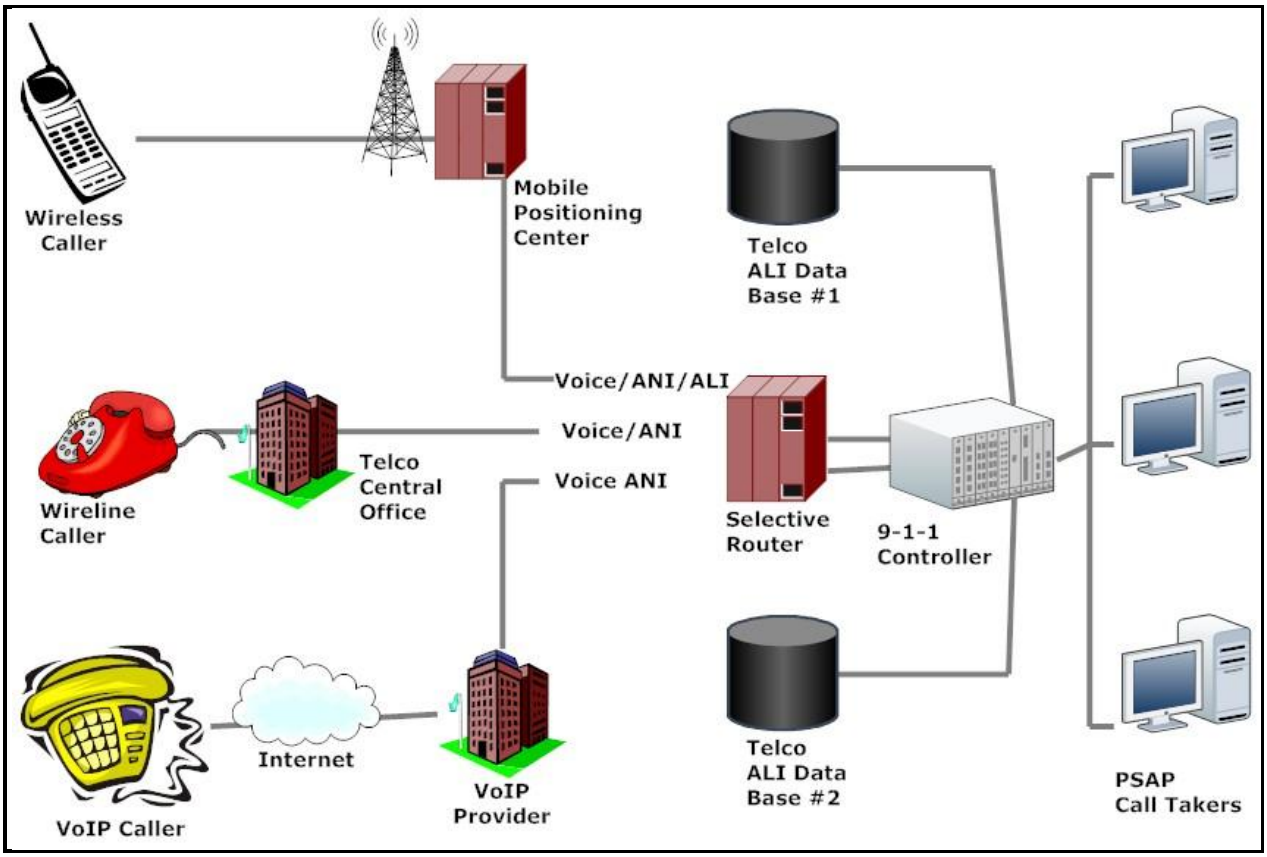


Figure 3: Legacy 9-1-1 Telephony Network

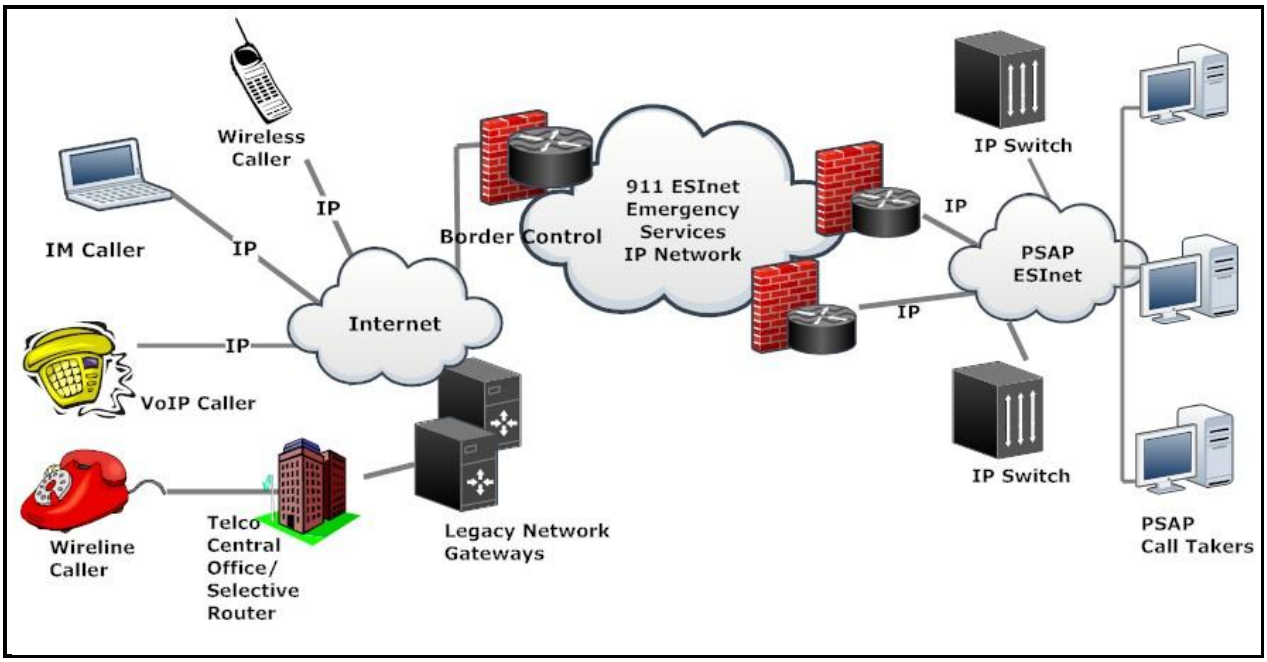


Figure 4: Next Generation 9-1-1 Network

The key differences in the two technologies; legacy 9-1-1 and NG9-1-1 are apparent in respect to the connectivity. The global shift to broadband, IP-based communications and services, such as the Internet, instant messaging, text messaging, video and voice-over-IP (VoIP) requires a commensurate shift in 9-1-1 service standards. NENA has led the way in the standards development process, and their Technical Requirements Document 08-751(NENA, 2006) is intended to be used by Standard Development Organizations (SDO), and designers and manufacturers of systems that are used for the purpose of processing emergency calls. The intent of this document is to specify the requirements the i3 Standard should meet. Figure 5, the NENA i3 Logical Interface Diagram visually highlights the “in” and “out” scope requirements.

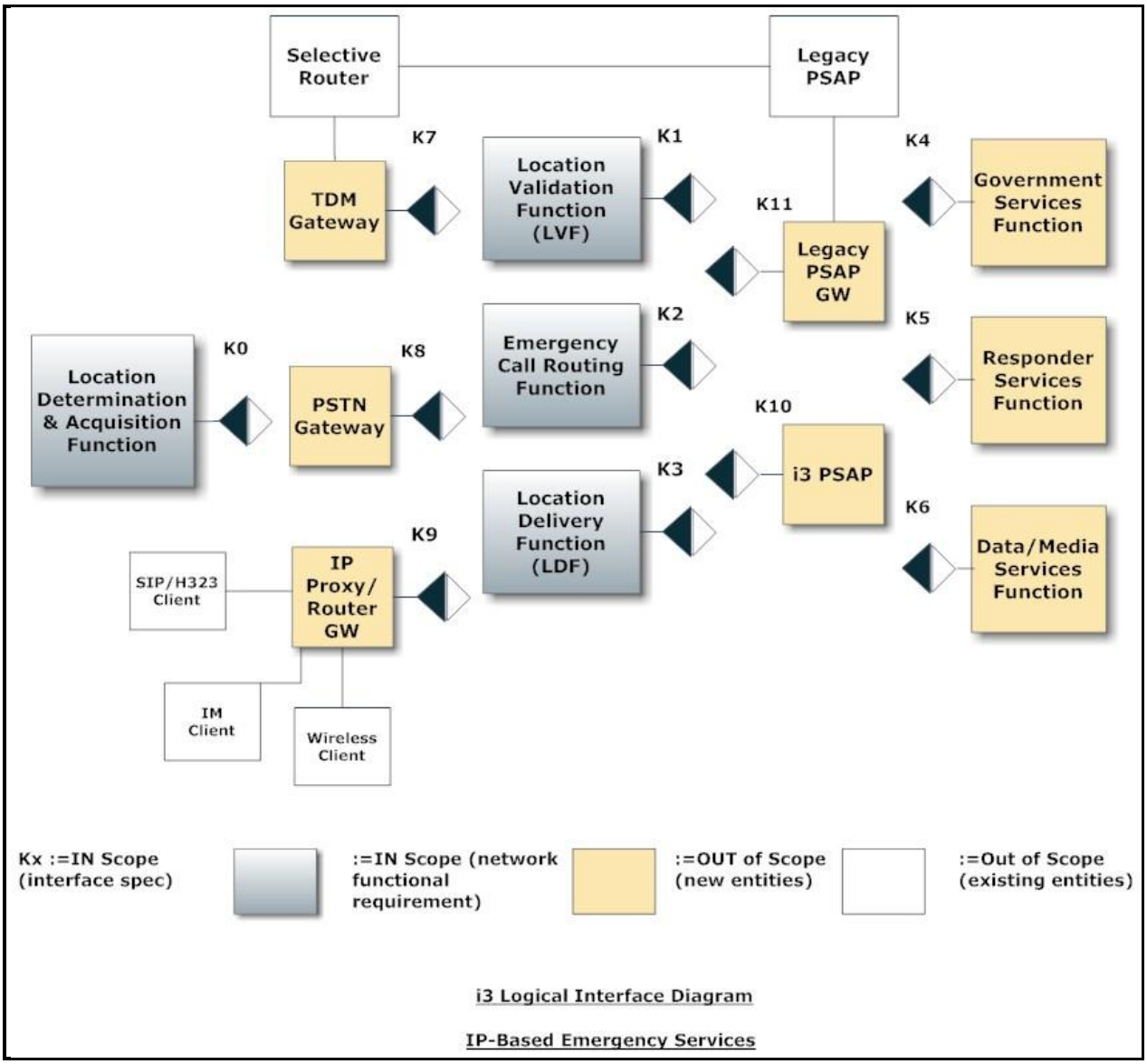


Figure 5: NENA i3 Logical Interface Diagram

The NENA i3 solution encompasses the definition of:

- External Interfaces between PSAPs and public/private networks delivering 9-1-1 calls to the Emergency Service system.
- External Interfaces to systems and databases not in the PSAP that supply data and assistance in processing a call.

- External Interfaces to systems that handle a call past the point where a call taker has exclusive control over it, such as the handoff to the Computer Aided Dispatch system.
- External Interfaces to upper level management systems, such as disaster management systems, as well as peer PSAPs.

Explicitly not in scope are interfaces within an i3 PSAP.

The i3 standard is inclusive in relation to providing the ESInet network infrastructure, but stops short on delivering the potential for service oriented architecture, a perfect example is the last statement about "explicitly not in scope"- this is where the SOA methodology can expand on the i3 PSAP solution. The i3 PSAP is a silo of applications and technology, with the use of a SOA methodology, each of these applications can be web enabled through services that allow multiple public safety agencies and others total access, for extending the jurisdictional boundaries, and the multi-agency sharing of data, computer-aided dispatching, records management systems, 9-1-1 telephony, and GPS/GIS data information.

The NENA ESInet network concept allows for a standards based IP private network, creating the desired interoperability, shared services, and reduced costs of repeat deployments of similar architecture by each PSAP. This case study fills a research gap by taking the effectual architecture to the next level, through the service oriented architecture (SOA) model were PSAPs can now regionalize and consolidate proprietary 9-1-1 emergency systems that have long been isolated and siloed. The web services provided through the service-oriented architecture along with the NENA ESInet will allow for PSAPs and other public safety agencies a unified means of processing both traditional and non-traditional means of communication. In an article titled: *The Role of SOA in Business, William Ulrich* describes the consolidation, streamlining and automation of business processes that the 9-1-1-business model truly needs. For many years each

PSAP has devoted millions of taxpayers' dollars into isolated proprietary emergency 9-1-1 systems from computer aided dispatch (CAD), to dedicated 9-1-1 telephony systems; the SOA methodology will allow the current processes to expand into boundless business opportunities that can synchronize as-is business processes under service oriented architecture. "Day-to-day tactical demands and cost containment directives drive continuous changes across user requirements", notes Ulrich (2006).

Figure 6, the *Next Generation 9-1-1 Infrastructure Architecture* is a high-level depiction of multi-agency data sharing, and emergency call processing utilizing the SOA methodology.

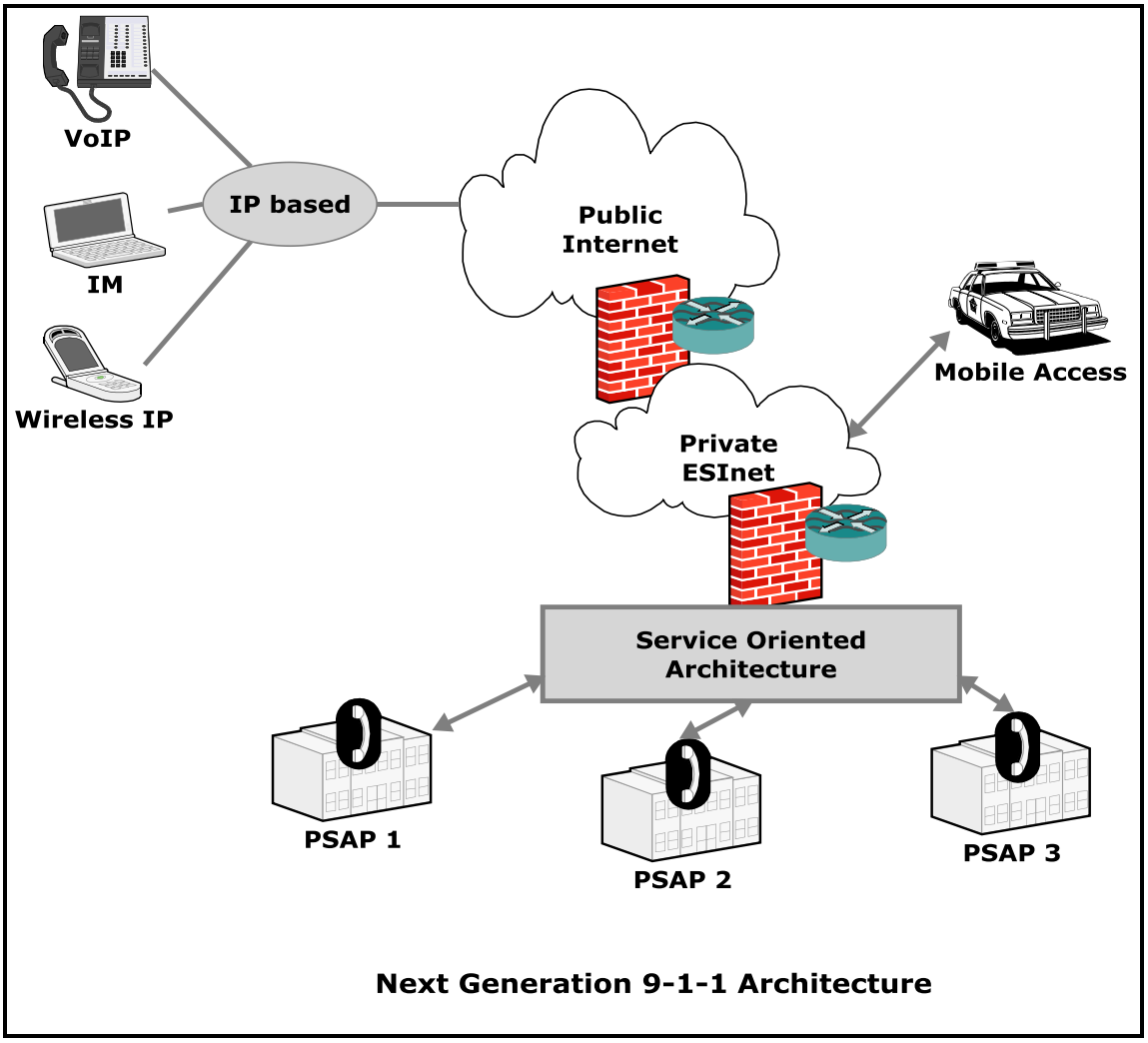


Figure 6: Next Generation 9-1-1 Infrastructure Architecture

The infrastructure architecture design for NG9-1-1 needs to overcome the traditional barriers to interoperability and allow Colorado PSAPs and other public agencies to share authorized data anywhere, anytime. Utilizing the SOA methodology and web enabled services a real-time data sharing technology for multiple cooperating public safety agencies from multiple disparate systems are possible. With the SOA methodology and a web application delivery chain, a case can be made for shared services and interoperable amongst Colorado PSAPs and NG9-1-1 services. The NENA ESInet network is the core global network design, providing the i3 IP-based standards; each agency or group of agencies can also have a localized ESInet style private network, this would allow local public safety agencies the ability to share authorized information immediately.

Public Safety agencies face a key hurdle in relation to true regional or multi-agency data sharing; the PSAPs of Colorado have multiple CAD, RMS, and mobile/GPS solutions by numerous vendors, all providing the same set of services. Each emergency services solution provides a wealth of 9-1-1 information that critical to the PSAP, in Colorado each PSAP stores their data independent of each other. With the new NG9-1-1 emergency service solution the tendency to collect and store data will far exceed the current capacity. Bergen County, NJ deployed the C.O.B.R.A. a real-time, cross jurisdictional data sharing and analysis system designed by CODY Systems. The integrated solution is updated up-to-the-second, on people, places, vehicles, etc., as well as network-wide analysis to fusion centers. C.O.B.R.A. is designed specifically to work with disparate RMS vendor systems, which has been used to great effect in Bergen County to link municipal and county agencies together (Hendonpub, 2010). Next Generation 9-1-1 emergency systems will require fully integrated data systems, the NENA i3

Technical Requirements Document under section 4.1.5 Additional Information; identifies three data classification categories:

- Tier 1 (Essential)
- Tier 2 (Supportive)
- Tier 3 (Supplemental)

Tier 1 information is defined as "data that supports call delivery and adequate response capability." Examples include callback number and caller location. Tier 2 information is defined as information beyond essential data that may support call handling and the dispatch of a call. An example of this type of data may be vehicle information such as "vehicle rolled." Tier 3 information may supplement the call handling and dispatch, but not necessary to complete the handling of the situation. An example of this may be personal medical information. NENA expects Tier 1 data, or reference to it, to be delivered with the call, and Tier 2/Tier 3 data available within the Emergency Services IP Network (ESInet), (NENA, 2010).

In Utah, the Department of Public Safety (DPS) and other agencies implemented an interoperable network that allows over 120 agencies and departments to share real-time information on a secure network.

Similarly, Valley Emergency Communications Center (VECC), a multi-jurisdictional communications agency that serves roughly 38 percent of Utah's population, created an interoperable network that is utilized by eight police departments and twenty-one fire agencies. The VECC network integrates disparate RMS and CAD systems, and enables officers, supervisors, chiefs, administrators and other designated personnel to share authorized, secure, real-time information at any location; look up key information in local, state, and federal databases with one query; streamline administrative, operational, and training processes; and

replace paper-based documentation with electronic records. The VECC's progress provides encouragement and guidance for agencies that are tackling interoperability challenges. The project took approximately 18 months to complete and involved both agencies CAD vendors as well as a third party vendor to deploy an Enterprise Service Bus (ESB). The project was developed to expedite information from one PSAP to the other as well as to reduce the duplication of questioning, that was time consuming and frustrating for the emergency caller (VECC, 2011).

The SOA Enterprise Service Bus (ESB) is the key component for delivering a service-oriented infrastructure for IT agility and alignment with business needs (Durvasula et al., 2006).

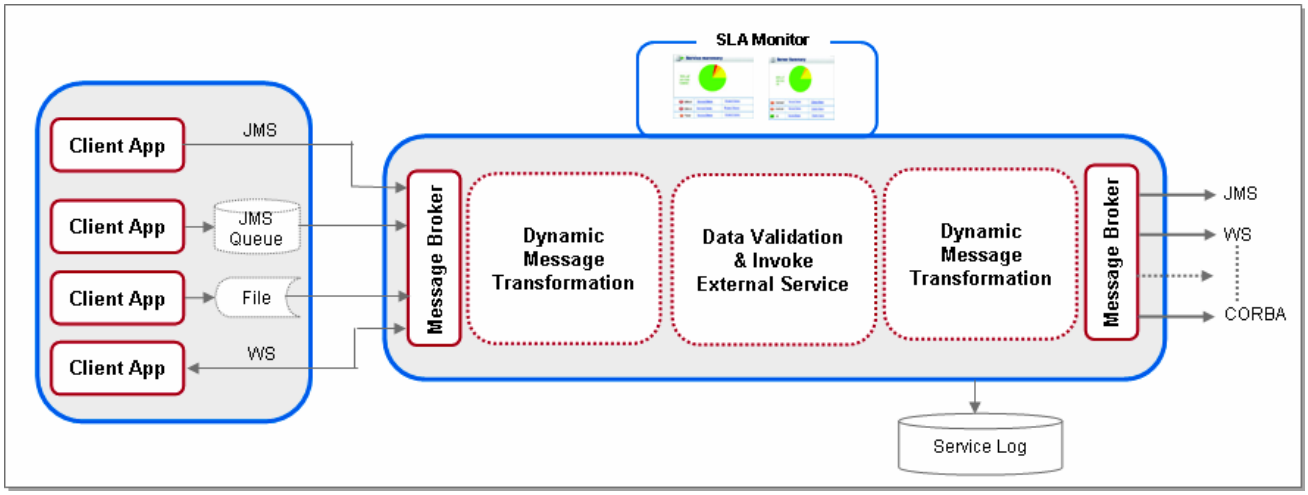


Figure 7: SOA Enterprise Service Bus Architecture

The NG9-1-1 SOA design is similar in basic functionality as described in figure 7 referencing the SOA Enterprise Service Bus. Figure 8 is the design concept for the NG9-1-1 Information Sharing Network Architecture centralized service bus that will allow for the interfacing of multiple public safety systems i.e. computer-aided dispatching, records management systems, 9-1-1 telephony, logging recorder and AVL/GIS/GPS. The web-based services will provide real-time data sharing across multiple agencies, departments and jurisdictions, providing a common

emergency operational picture of current emergency incidents allowing for the extension of fixed and mobile systems/applications to both individual agencies and regional information sharing platforms.

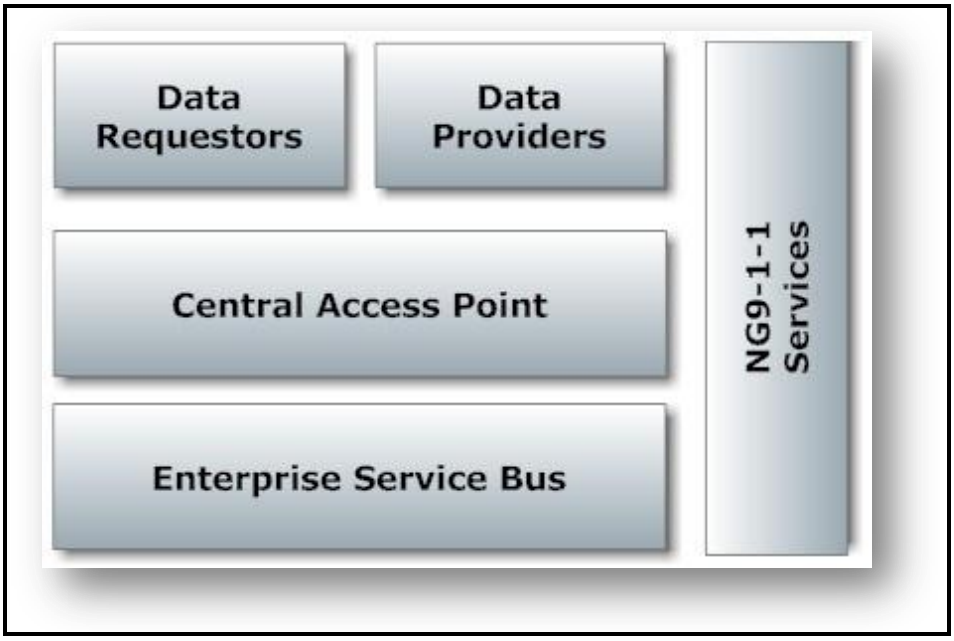


Figure 8: NG9-1-1 Information Sharing Network Architecture

The implementation of a service-oriented architecture to simplify integration between several local, county and state agencies; and associated systems with diverse architectures, with the ultimate goals of interoperability and data sharing.

A web-based NG9-1-1 service will allow the linking of multiple public safety agencies; with the ability to log in to the system from anywhere, at anytime. The web-based services can save significant resources and eliminate the need to implement the applications on individual desktops, limiting the need for additional support staff. The potential for reducing the time required to process an emergency 9-1-1 call, dispatch the appropriate first responders, and limit the duplications of efforts involving records management systems has the potential to save lives. The NG9-1-1 NENA i3 standards emphasizes the utilization of IP-based infrastructure and

applications, this framework will allow for the implementation of a design that incorporates scalability and upgradeability to meet the needs of single or multiple agencies while future-proofing the technology. Utilizing the SOA methodology will allow for streamlining the development process, allowing for reuse of current applications, and enabling dependent systems to share data to ensure accurate, timely handling of emergency incidents and information.

The regionalization of PSAPs has gained widespread interest in recent years, and NG9-1-1 will be a tool that can help get this accomplished by embracing the standards based 9-1-1 solutions that invite the elimination of duplicated efforts and individual stovepipe systems. Regionalization from a technology standpoint means retiring legacy systems and facilities that do not meet the needs of the NG9-1-1 future. With acquisition comes efficiencies and effectiveness through the elimination of duplicated efforts. The potential for elimination of call transfers that are necessary when you have multiple PSAPs serving a regional area can result in delayed responses by the dispatching agency and the first responders.

There is a known Regional 911 Feasibility Study conducted by 19 entities in the state of Massachusetts, the steering committee SREPDD consists of Police and Fire Chiefs and town managers to formulate the scope of the feasibility study that will analyze the 19 current dispatch operations and PSAPs and make recommendations on ways to improve public safety and increase operational efficiencies through forming a regional consolidation of dispatch operations. The 9-1-1Questionnaire results indicated a high level of interest in regionalizing 911 dispatch responsibilities, especially as a future option. This is an expensive municipal service, with the average annual community expenditure over $300,000 and the regional total for dispatch services in excess of $8.0 million. “This is a great opportunity for us to explore our options and investigate inter-discipline and inter-jurisdictional changes that will improve public safety,” said Acushnet Police Chief Michael Alves who is cooperating with the study (SREPDD, 2010).

In 2004 The State of Montana Public Safety Service Bureau (PSSB) implemented a statewide 9-1-1 system in the effort to consolidate 40 rural PSAPs. Rather than funding dozens of individual stovepipe systems, and their proprietary information, a statewide system was deployed to reduce overall PSAP expenditures, and improve knowledge management by eliminating duplication (2009). The key word for knowledge management in the public safety arena is interoperability. Interoperability is defined by SAFECOM as "the ability of emergency response agencies to talk across disciplines and jurisdictions via radio communications systems, exchanging voice and /or data with one another on demand, in real time, when authorized" (SAFECOM, 2009). Knowledge management contributes to the effectiveness of the business; the 9-1-1 business maintains many types of information and knowledge that prove valuable every day to public safety agencies. Through SOA implementation, data sharing will allow PSAPs the luxury of obtaining data and information that was once siloed by proprietary applications and technologies; through the service orientated architecture this data will be available to any public safety agency that needs it. The web portal service will be the primary method for accessing the shared data systems.

Durvasula et al. (2006), describes the Enterprise SOA Maturity Model in three stages:

Stage 1: Develop Web Applications

Develop/enhance web presence (applications) both externally and internally

Stage 2: Develop Composite Applications

Develop a composite application that aggregates information from multiple business systems.

Stage 3: Automate Business Processes

Automate business processes across various business units/systems and provide business performance matrix.

Web Application Development Stage:

The web portal will allow users, both internal and external access to a suite of specialized modules for a host of 9-1-1 emergency applications. This 9-1-1 portal will serve as a single, customizable interface for many functions and settings. Durvasula et al. (2006) mentions that during the web application development business requirement stage, the team should focus on unifying user experience on the external site, making it easy for users to find the information they need; a single standardized look and feel across all sites (internal and external) as well as across processes and procedures for publishing content. The web portal should provide the users with a framework, where the tools, functional components, and applications needed to perform their jobs are integrated with a single sign-on authentication.

Composite Application Development Stage:

This stage in the Enterprise SOA Maturity Model describes the business requirements which should be considered; accessibility of information from multiple applications, a reduction in operations and support costs, and a reduction in maintenance costs from a standardizing on one platform (2006).

San Joaquin County, CA. has implemented a SOA to simplify integration between several county law and justice systems with diverse architectures, requiring a transfer of data to a centralized mainframe system. The agency deployed an application development framework integrating the various data sources, creating a web-based system that links 15 offices. The system was standards based with access from anywhere in the country. The web-based system eliminated the need for individual desktop installations reducing technical support resources. The police officers reduced their records management system processing time by one-fourth; improved data security features enabled advanced authentication and authorization based on

defined user descriptions (2009). NG9-1-1 is still being developed, even though there are applications today that can be reused for SOA, and NG9-1-1 it will be imperative that the additional application development remain flexibility and easily modified over time. SOA provides the "loose-coupling" design that will allow for the individual parts of the application to be independently developed and tested without effecting the overall application. Gabhart & Bhattacharya (2008) describe service orientation as methodology for taking apart the monolithic solutions and creating flexible, reusable loosely-coupled components available to service requests from anywhere in the network without the traditional barriers of operating system, programming language, or platform technology.

Business Process Automation Stage:

Providing effective and efficient information at the right time is critical to emergency 9-1-1 call processing. NG9-1-1 requires an IP-based 9-1-1 Emergency Services Network(ESInet) outside the PSAP, and within the PSAP the ability to route and locate all call types, traditional land non-traditional, as well as the sharing and distribution of emergency services from all sources from a standardized user interface. NG9-1-1 will create an entirely new way of processing non-traditional call types (instant message, email, and video), this will require the end-users to know both the current process, and way to improve that process, as well as learn the new processes. The PSAP will benefit from business process automation by identifying key target processes, documenting and refining those processes by reshaping to improve the effectiveness. The 9-1-1 emergency applications vendors will be tasked to provide the majority of this process automation, if you review questions 11, 12 and 15 from the NG9-1-1 PSAP survey it will identify the CAD systems in use at various Colorado PSAPs, all of those identified are off the shelf applications. The researcher has first-hand experience and without question the

majority of the systems used today are COTS, so the majority of the business process automation will reside with the vendor. Figure 9, SOA Reference Architecture highlights the workflow that the NG9-1-1 business process will need to take: from infrastructure to web application tier, to web portal, to packaged applications.

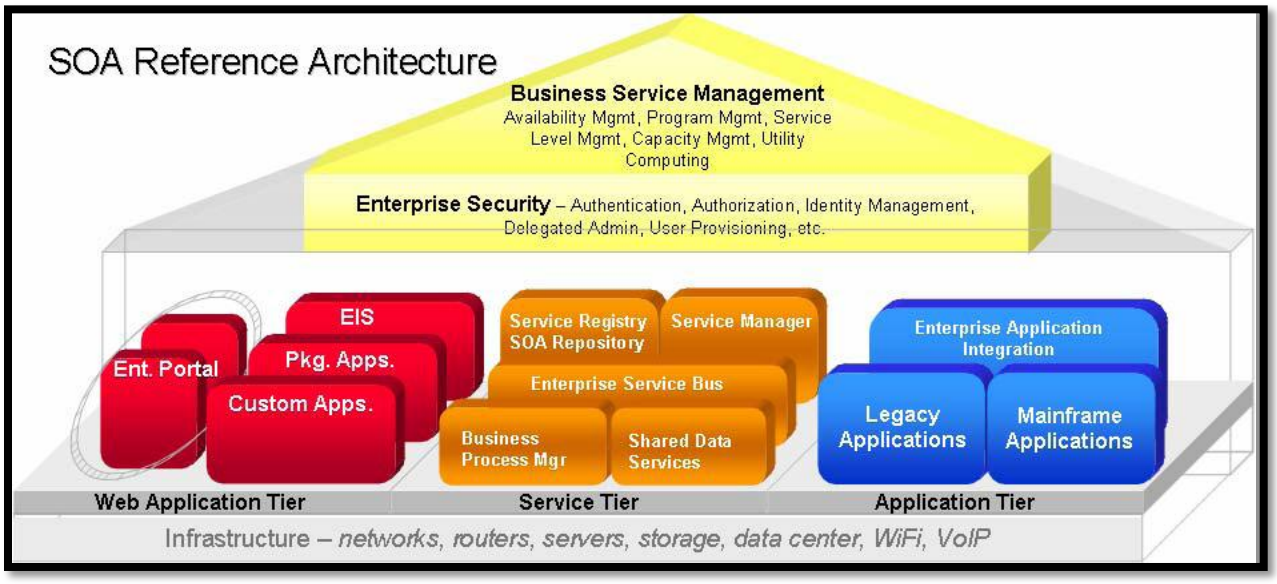


Figure 9: SOA Reference Architecture

There will be a need for new NG9-1-1 infrastructure components; key to this will be portal services-which will provide a consistent user interaction, which allow for the shared data services, logging services, and authentication. The PSAP will need to focus on utilizing business process automation to improve organization efficiency; the key to this is through instituting appropriate change management and monitoring policies-governance issues that demand further research, and are outside the scope of this case study.

Chapter 3 – Methodology

The researcher utilized the case study and its' qualitative research methodology and analysis emphasis. The objective behind using case study and qualitative research is to gain an understanding of the research data and reveal processes and systems. Researcher Robert K.Yin defines case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (Yin, 1984). The case study will allow the researcher to test the validity of certain theories in real-world context. The public safety answering point is a real-life context, and exemplifies the case study use and qualitative research methodology. The main focus of this case study is the evaluation of existing architectural infrastructure of the Colorado PSAP, and the feasibility of utilizing this architecture in implementation of next generation 9-1-1(NG9-1-1) technology will be utilized within the existing architecture. The research data will provide insight into the NG9-1-1 non-traditional communication processing concerns, and the existence of an IP-based architectural infrastructure, a key requirement in the implementation and deployment of NG9-1-1technologoes. Through qualitative research the prevalent trends in thought and opinion concerning governance and policy toward NG9-1-1 may be uncovered. Governance and policy extend beyond the scope of this case study, and are key requirements in the implementation of NG9-1-1, and qualify for further research. Secondary data analysis will be included in this case study through field observation and testing from the researcher's current PSAP and technology experience; this field study will explore the implementation of NG9-1-1 requirements, and the practical application of SOA methodology amongst three (3) PSAPs that are within 10 miles

proximity to each other; those PSAPs are; the West Metro Fire Protection District, the City of Wheat Ridge and the City of Lakewood.

A review of literature in the areas of service-oriented architecture (SOA) and next generation 9-1-1 (NG9-1-1) was required in order to better understand how these two concepts can coexist in moving forward with an effectual architecture for NG9-1-1 in the Colorado PSAPs. The National Emergency Number Association (NENA) has taken the lead on the and has written the i3 Functional and Interface Standards for Next Generation 9-1-1(NENA, 2006); this is a major step forward in creating standardization in an industry that historically promotes siloed technology solutions. The researcher saw an opportunity to expand on the standardization theme, as well as limiting the existing siloed technology, and promote the potential for technology interoperability amongst the PSAPs utilizing the SOA methodology.

The six case study techniques recommended by researchers Robert E. Stake (1995), Helen Simons (1980) and Robert K. Yin (1984) will be utilized for organizing and conducting the research:

1. Determine and define the research questions
2. Select the cases and determine data gathering techniques
3. Prepare to collect the data
4. Collect data in the field
5. Evaluate and analyze the data
6. Prepare the report

These six steps were utilized as a framework for the remainder of this research.

The goal of this research is to evaluate the numerous public safety answering points in the state of Colorado and determine if an effectual architecture can be deployed to support next generation 9-1-1 IP-based non-traditional communication. The research questions in this case study were designed to identify key systems that each PSAP utilizes to conduct daily 9-1-1 emergency services, and verify the platforms that are present, and gather as much infrastructure information as possible without specifics that could expose classified public safety functionality. Additional questions in the study address governance and policy, since these will be important to the migration to a NG9-1-1 infrastructure, these particular questions can be used for additional research in that area of NG9-1-1; that research is outside the scope of this case study.

The case studied for this research is the National Emergency Number Association and its' work on the *i3 Functional and Interface Standards for Next Generation 9-1-1 Version 1.0 (08-002), and the Technical Requirements Document (08-751).* The establishment of these standards will also assist in the development of the NG9-1-1 IP-based network- Emergency Service IP Network (ESInet); both of these projects are currently ongoing. This researcher's case study addresses the gap in the NENA research, which stops at the firewall of each public safety answering point's private network. This case study introduces the service oriented architecture adoption that will interface through a web portal to each participating PSAP allowing access to i3 referenced IP-based technologies, and the implementation of SOA web services for processing emergency 9-1-1 calls. This SOA implementation along with the NENA ESInet will allow for the creation of a common network that promotes true interoperability, shared services, and more efficient and effective emergency 9-1-1 call processing across the state of Colorado.

In preparation for data collection an online survey service (Survey Monkey) automatically distributes the survey link through email to the ninety-seven (97) PSAPs in Colorado. The survey service allows for preset cutoff date and time, maximum response count, along with a restriction of responses controlled by IP address. The online survey service provides security and privacy for the data collected. The online surveys also comply with US Federal section 508. The survey service provides data storage, and analysis of results with the option for creating charts and graphs. There is also a need for a case study database for survey questions that require individual interpretation, in particular the "other" option as a recorded question. Prior to the administration of the survey processes, all survey questions were submitted to the Regis University IRB Board for approval, and a copy of the acceptance letter is listed under Appendix B.

There is secondary data that will also be recorded in the case study database; referencing the NG9-1-1 & SOA pilot project between the three (3) local PSAPs identified earlier. The information that will be presented in this case study is available to the researcher from shared project documentation obtained during the deployment of the two joint PSAP projects; NICE 9-1-1 Call Logger and the Emergency Backup Center.

The researcher has been an active participant in the NG9-1-1 project for the state of Colorado PSAPs, observations made during data gathering will not be used in the survey data collection, and this is primarily for the evaluation of other PSAPs in Colorado. The researcher will provide data gathered in the field in relation to the three (3) PSAP NG9-1-1 pilot project; this project emphasizes interoperability and data sharing utilizing IP-based technologies, primarily VoIP telephony and digitized audio capture of emergency 9-1-1 calls, as well as a description of how SOA methodology can be implemented.

The PSAP NG9-1-1 survey consisted of nineteen (19) questions; each question had an option to select single or multiple answers, as well as an "other" category for responses that did not fit in the presented answers. Each question is listed with a brief description as to the intent of the question; the questions were kept "high-level" to protect public safety information.

1. Which of the following best describes your job role?
    - PSAP Director
    - PSAP Manager
    - 911 Authority Director
    - PSAP Supervisor
    - PSAP Operator
    - IT Manager
    - IT Technician

Question intent: NG9-1-1 will require upper management involvement, this project will take untold planning and resources to accomplish- it is critical to get upper management buy-in.

2. What obstacles exist for transitioning to NG9-1-1?

    Please select all that apply.

    - Financial
    - Political
    - Staffing
    - Knowledge (training)
    - Current 911 Phone System Limitations
    - Willingness to change to a new 911 system

Question intent: NENA research indicates that finance burden will be the greatest obstacle to the NG9-1-1 transition.

3. Which best describes your outlook concerning PSAP interoperability in the state of Colorado?
    - Very confident
    - Confident
    - Somewhat confident
    - Not confident at all

Question intent: Interoperability is a key to data sharing, and SOA methodology.

4. Think of your PSAP's current business strategy, to what extent is your organization focused on Next Generation 911?
    - Completely focused
    - Mostly focused
    - Somewhat focused
    - Not focused at all

Question intent: Are PSAPs concerned about expanding their current business model.

5. What are your PSAP's current tactics for preparing for NG9-1-1?
    - Actively researching technology solutions for NG9-1-1
    - Choosing IP enabled technology solutions
    - Choosing to establishing technology sharing with other PSAPs
    - Developing shared services intergovernmental agreements (IGAs)
    - Waiting for a NG911 vendor to tell you what to do

Question intent: Are PSAPs aware of the technological requirements, and supporting the new non-traditional communication technologies.

6. To what extent is each of the following important to your PSAP's ability to process NG9-1-1 non-traditional communications, such as texting, email, photos, & video?
    - Extremely Important
    - Important
    - Doesn't Matter Much

Question intent: More granular about non-traditional communications, and what is required by the NG9-1-1 PSAP.

7. What is the number of Dispatcher/Call-taker positions within your PSAP?
    - 1-5
    - 5-10
    - 10-15
    - 15-25
    - More than 25

Question intent: part of NG91-1 interoperability and data sharing will also involve regionalization of PSAPs, either physically or technologically. SOA intends to reuse and limit the need for additional technology.

8. What is the number of 911 CAMA trunks for your PSAP?
    - 1-5
    - 5-10
    - 10-15
    - 15-25

Question intent: More granular and targeting particular telephony systems; part of NG91-1 interoperability and data sharing will also involve regionalization of PSAPs, either physically or technologically.

9. Average number of 911 calls per day?
    - 1-25
    - 25-50
    - 50-100
    - 100-150
    - 150-200
    - More than 200

Question intent: More granular and targeting particular telephony systems; part of NG91-1 interoperability and data sharing will also involve regionalization of PSAPs, either physically or technologically.

10. What Computer Aided Dispatch (CAD) System does your PSAP utilize?
    - Intergraph
    - TriTech
    - New World Systems
    - Printrak/Motorola
    - Data911
    - Other

Question intent: More granular and targeting particular CAD systems; part of NG91-1 interoperability and data sharing will also involve regionalization of PSAPs, either physically or technologically.

11. Is your CAD web-services capable?
    - Yes
    - No
    - Not Sure

Question intent: CAD systems that are web-services enabled will support the IP-based NG9-1-1 and SOA methodology.

12. Does your PSAP have a CAD to CAD connection?
    - Yes
    - No
    - Not Sure

Question intent: CAD systems that can "talk" across IP networks are candidates for NG9-1-1 and SOA methodology. Also provides information about the vendor's technology limitations.

13. Does your PSAP utilize an IP-enabled radio system, such as P25?
    - Yes
    - No
    - Not Sure

Question intent: P25 will be the replacement radio system that allows for interoperability, and support for the NG9-1-1 model.

14. Does your PSAP utilize an IP-enabled logging recorder, such as NICE Freedom?
    - Yes
    - No
    - Not Sure

Question intent: IP-based technology solutions that support NG9-1-1 and SOA methodology.

15. Does your CAD system have a GIS mapping component?
    - Yes
    - No
    - Not Sure

Question intent: NG9-1-1 will utilize GPS/GIS technology for tracking 9-1-1 calls, an important component; again identifying CAD vendor involvement in technological advances.

16. Does your PSAP maintain a Geographical Information System (GIS) database?
    - Yes
    - No
    - Not Sure

Question intent: NG9-1-1 will utilize GPS/GIS technology for tracking 9-1-1 calls, an important component. PSAPs will be able to share GIS information through web services.

17. Does your PSAP share GIS information with other public safety agencies?
    - Yes
    - No
    - Not Sure

Question intent: Identify the level of GIS data sharing.

18. Does your PSAP have web access to other public safety, and government agency portals for interoperability and data sharing?
    - Yes
    - No
    - Not Sure

Question intent: Identify the PSAPs level of web involvement, and data sharing.

19. Has your PSAP reviewed the NENA 9-1-1 i3 standard and what percentage of your emergency call taking equipment is NG9-1-1 enables?
    - 75-100% enabled
    - 50-75% enabled
    - 25-50% enabled
    - Less than 25% enabled
    - Not sure

Question intent: Reinforcement for the IP-enable effectual architecture, and support for SOA reuse.

The "other" field was enabled as an answer option and cannot be automatically analyzed, it will require independent data analysis, and this information will be stored in the case study database.

During data evaluation and analysis, the researcher was guided by current developments in the field of NG9-1-1, and the work being conducted by the NENA organization in establishing IP-based standards for the shared Emergency Services IP Network (ESInet). By conducting in-depth data comparisons amongst the PSAPs in the state of Colorado it could be determined if the IP-based platforms required for the ESInet could also provide the web-based infrastructure that will allow for the adoption of SOA methodology to allow for PSAP shared services, and emergency systems interoperability. With the data collected the researcher can begin to identify relationships between various data, these relationships will drive the justification for the service oriented architecture deployment. The research questions were based on know technological requirements for the majority of the PSAPs in Colorado, this information guided the literature review and provided the rationale and context for the formulation of those questions.

The case study framework utilized requires a research report. Leedy & Ormrod (2005) identify five items that need to be incorporated in the research report:

1. A rationale for studying the case.
2. A detailed description of the facts related to the case.
3. A description of the data you collected.
4. A discussion of the patterns you found.
5. A connection to the larger scheme of things.

These five items are presented as a series of questions and answers which will bring a connection between the results and findings of this case study will shape the framework of the research report, and be further discussed in Chapter 4-Data Analysis and Results.

Chapter 4 – Data Analysis and Results

The goal of this research was to evaluate the public safety answering points within the state of Colorado and determine what architectural infrastructure and current technology is available for reuse and future promotion of the Next Generation 9-1-1 program. There are four primary technologies that are utilized by each PSAP and these are:

1. 9-1-1 telephone systems
2. Dedicated frequency radio systems
3. Computer-aided dispatch systems
4. Emergency call logging systems

This goal is a critical step in the promotion of the service oriented architecture as the vehicle for enabling fluid data sharing, interoperability between all 9-1-1 stakeholders, and alignment with the NENA i3 standards for future ESInet network integration. There are two key platforms that are part of the four technology systems listed previously that need to be identified in this survey; they are the IP-based platform and the geographical information system (GIS) platform. The IP-based platform will allow for interoperability, emergency call routing, location and security. The GIS platform is a core requirement that ensures spatial routing of emergency calls from any communication device, especially the non-traditional next generation IP devices.

In order to facilitate more direct answers to the research questions and to provide for more specific access to this study's results, the analysis was structured around the following research questions:

1. Does an IP-based effectual architecture infrastructure exist within the Public Safety Answering Points that can be leveraged for NG9-1-1, and a service-oriented architecture deployment?

2. What emergency services applications can be reused in service-oriented architecture?
3. How can web services be utilized for emergency services applications?
4. Given the results of the survey, can it be determined from a technology perspective that a SOA adoption plan can work in the PSAP environment?

Research Question1:

Does an IP-based effectual architecture infrastructure exist within the Public Safety Answering Points that can be leveraged for NG9-1-1, and a service-oriented architecture deployment?

The PSAP survey results indicates that there is evidence that 83% are selecting IP-enabled technology, 22% have web-enabled CAD systems-requiring IP-based protocol, 39% are utilizing an IP-based radio systems, 66.7% are utilizing an IP-based call logging recorder, and 55.6% of the PSAPs have enabled web portals for data sharing, again and IP-based protocol. The consensuses of those surveyed do have an existing IP-based effectual architecture infrastructure, which can promote an NG9-1-1 and SOA deployment.

Your PSAP and Next Generation 911 SurveyMonkey

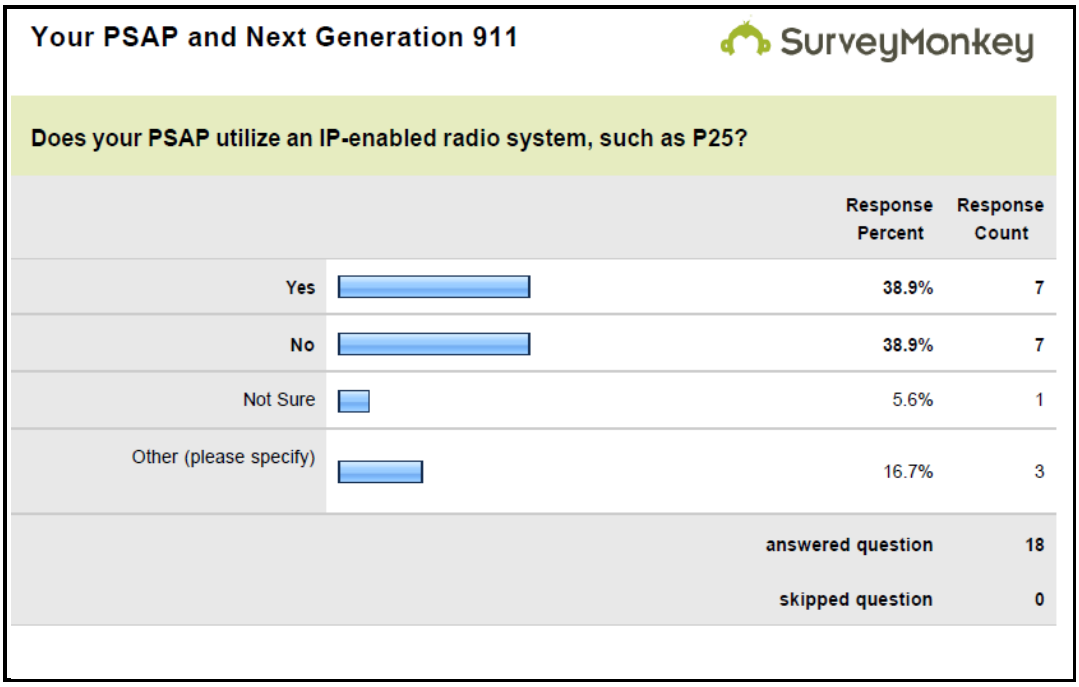
What are your PSAP's current tactics for preparing for NG 911? Please select all that apply.

	Response Percent	Response Count
Actively researching technology solutions for NG 911	61.1%	11
Choosing IP enabled technology solutions	83.3%	15
Choosing to establish technology sharing with other PSAPs	72.2%	13
Developing shared services intergovernmental agreements (IGAs)	61.1%	11
Waiting for an NG 911 vendor to tell you what to do	11.1%	2
Other (please specify)	0.0%	0
	answered question	18
	skipped question	0

Your PSAP and Next Generation 911 SurveyMonkey

Is your CAD system web-services capable?

	Response Percent	Response Count
Yes	22.2%	4
No	38.9%	7
Not Sure	27.8%	5
Other (please specify)	11.1%	2
	answered question	18
	skipped question	0

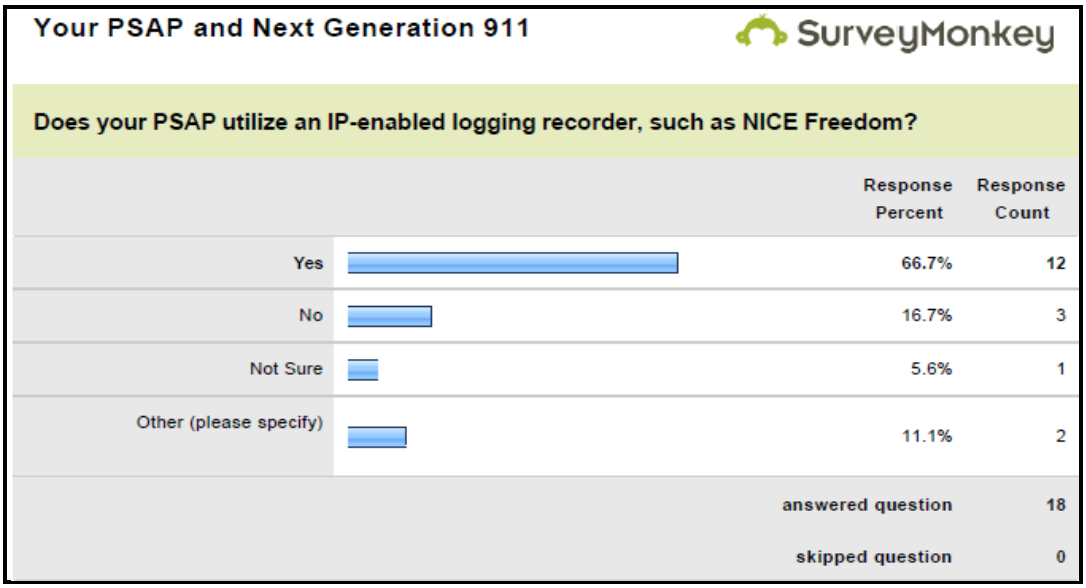


Your PSAP and Next Generation 911

SurveyMonkey

Does your PSAP utilize an IP-enabled radio system, such as P25?

	Response Percent	Response Count
Yes	38.9%	7
No	38.9%	7
Not Sure	5.6%	1
Other (please specify)	16.7%	3
answered question		18
skipped question		0

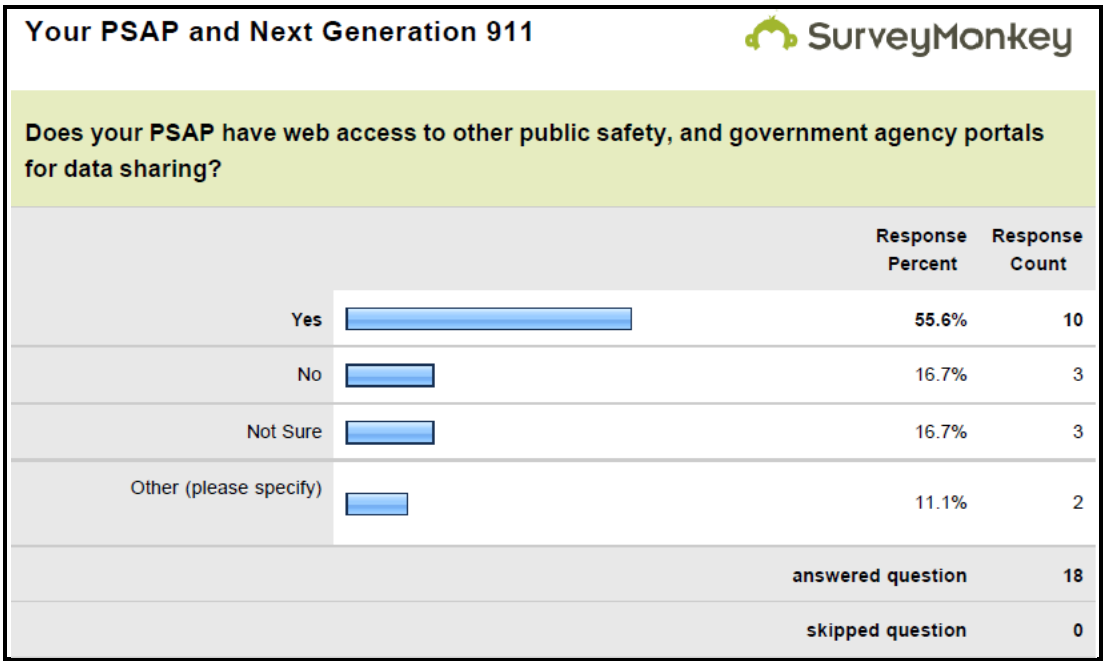


Your PSAP and Next Generation 911

SurveyMonkey

Does your PSAP utilize an IP-enabled logging recorder, such as NICE Freedom?

	Response Percent	Response Count
Yes	66.7%	12
No	16.7%	3
Not Sure	5.6%	1
Other (please specify)	11.1%	2
answered question		18
skipped question		0



Your PSAP and Next Generation 911

SurveyMonkey

Does your PSAP have web access to other public safety, and government agency portals for data sharing?

	Response Percent	Response Count
Yes	55.6%	10
No	16.7%	3
Not Sure	16.7%	3
Other (please specify)	11.1%	2
answered question		18
skipped question		0

Research Question2:

What emergency services applications can be reused in service-oriented architecture?

This question pertains to the four primary emergency 9-1-1 systems: IP-based 9-1-1 telephony, dedicated frequency radio, computer-aided dispatching (CAD), and 9-1-1 emergency call recording. The PSAP survey results indicates the researcher failed to specifically address IP-based 9-1-1 telephony, the only question in the survey that makes reference to this is question 5, which discusses the purchasing of IP enabled technology. The researcher's firsthand experience in the 9-1-1 arena can provide information concerning 9-1-1 telephony, and how the current telephony systems are outdated, and cannot be reused with an NG9-1-1 deployment. The PSAP survey results concerning the other three (3) key systems shows more promise concerning the reuse of technology. 66.5% of the PSAPs indicate that IP-based radio is available and ready for reuse; computer aided dispatching (CAD) also shows merit as a candidate for SOA and NG9-1-1, questions 11, 12, and 15 provide insight into some of the CAD capabilities for the

future migration. Questions 15, 16 and 17 all reference the importance of GIS in the NG9-1-1 deployment, a critical tool for improving first responder location for efficient and effective emergency responses.

Your PSAP and Next Generation 911 SurveyMonkey

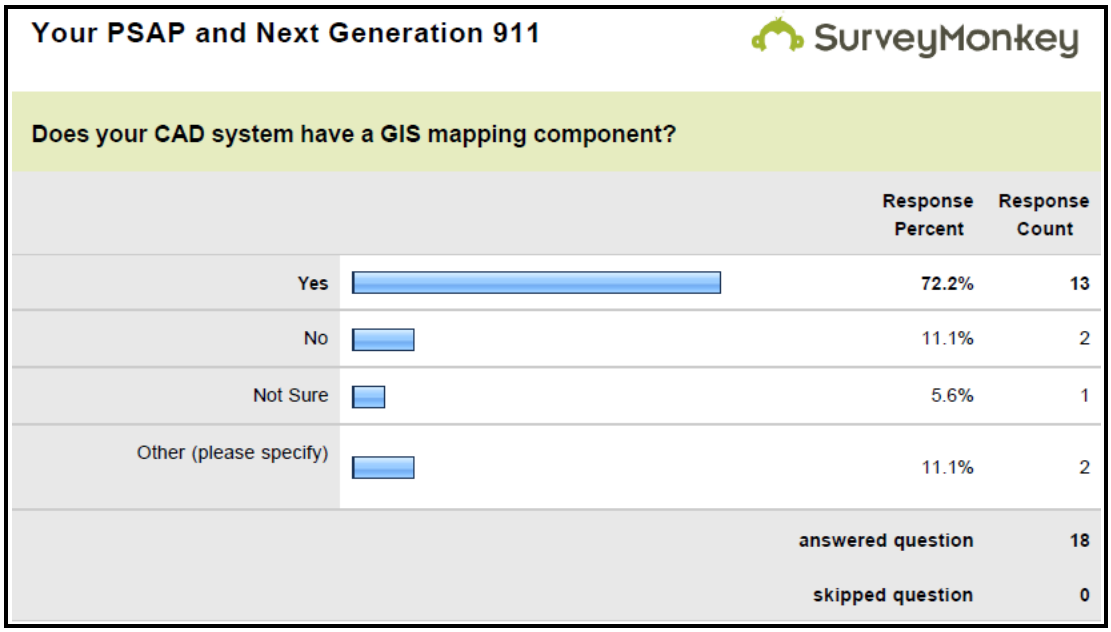
Is your CAD system web-services capable?

	Response Percent	Response Count
Yes	22.2%	4
No	**38.9%**	**7**
Not Sure	27.8%	5
Other (please specify)	11.1%	2
	answered question	**18**
	skipped question	**0**

Your PSAP and Next Generation 911 SurveyMonkey

Does your PSAP have a CAD to CAD connection?

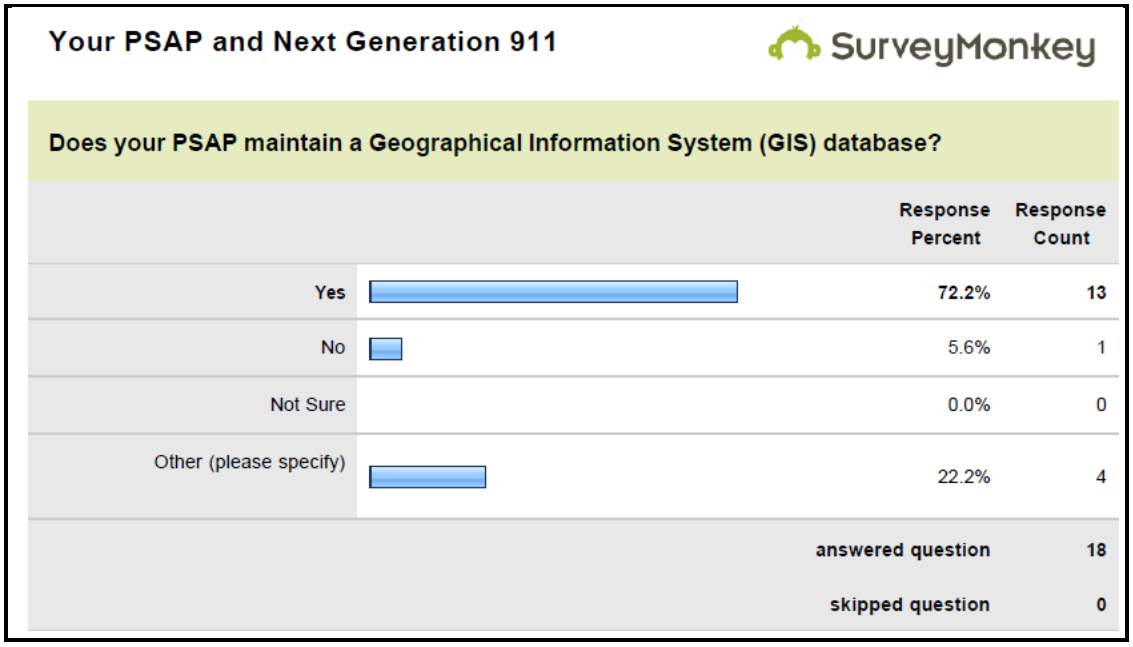
	Response Percent	Response Count
Yes	22.2%	4
No	**44.4%**	**8**
Not Sure	22.2%	4
Other (please specify)	11.1%	2
	answered question	**18**
	skipped question	**0**



Your PSAP and Next Generation 911 SurveyMonkey

Does your CAD system have a GIS mapping component?

	Response Percent	Response Count
Yes	72.2%	13
No	11.1%	2
Not Sure	5.6%	1
Other (please specify)	11.1%	2
answered question		18
skipped question		0



Your PSAP and Next Generation 911 SurveyMonkey

Does your PSAP maintain a Geographical Information System (GIS) database?

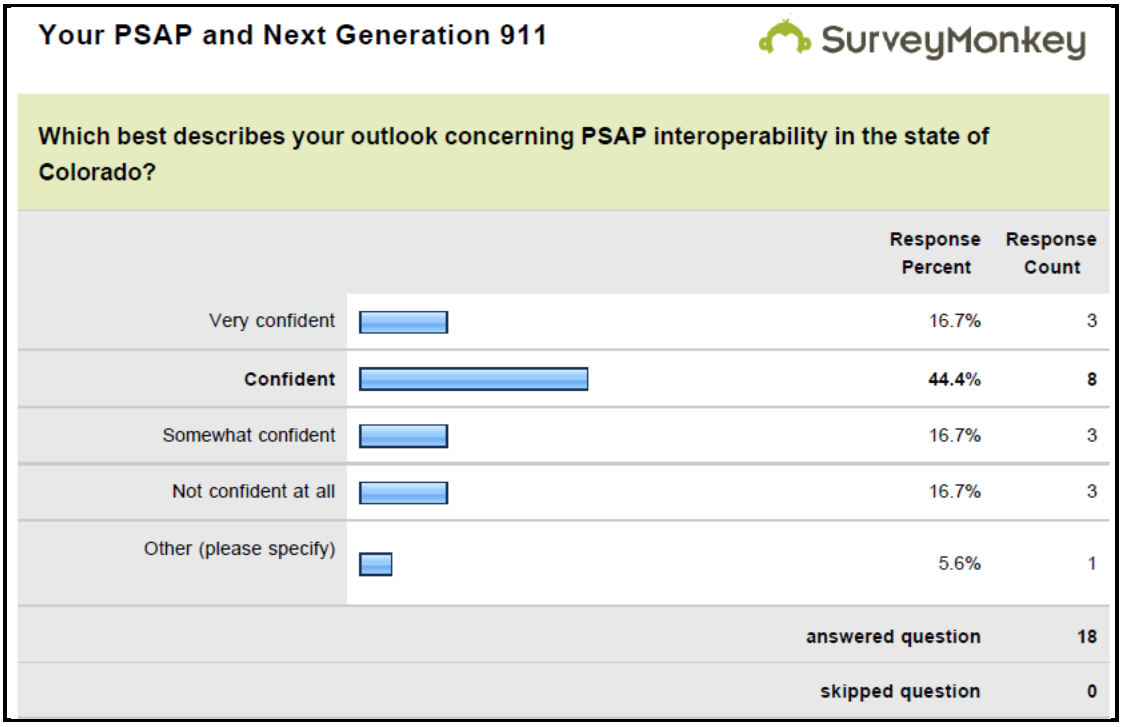
	Response Percent	Response Count
Yes	72.2%	13
No	5.6%	1
Not Sure	0.0%	0
Other (please specify)	22.2%	4
answered question		18
skipped question		0

Research Question 3:

How can web services be utilized for emergency services applications?

The National Emergency Number Association has the designed the i3 standards for the ESInet network which will allow for interoperability and data sharing on the network. Service oriented architecture will allow for the reuse of existing business applications by creating web

services and making them available through a private web portal. The action research example that follows is included in this case study is a working example of how emergency services can be deployed as a web service. The PSAP survey does indicate that the opportunity for interoperability is positive with a 44.4% confidence rating, 22.2% surveyed indicate that their CAD system is web enabled, 22.2% also indicate that they have a CAD to CAD IP-based connection, the IP-enabled P25 radio system emphasis is on boundary-less connectivity. Question 18 also highlights the fact that many of the PSAPs surveyed allow for interconnectivity to other public safety agencies, a plus for web enabled data sharing.

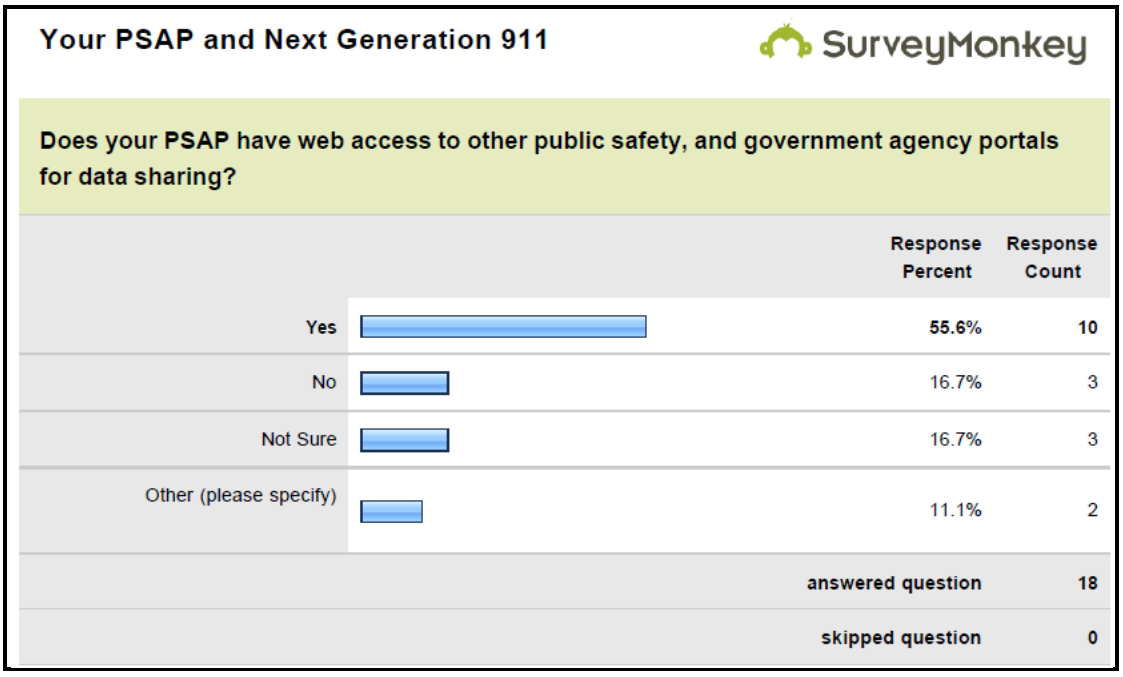


Your PSAP and Next Generation 911

SurveyMonkey

Which best describes your outlook concerning PSAP interoperability in the state of Colorado?

	Response Percent	Response Count
Very confident	16.7%	3
Confident	**44.4%**	**8**
Somewhat confident	16.7%	3
Not confident at all	16.7%	3
Other (please specify)	5.6%	1
	answered question	**18**
	skipped question	**0**



Your PSAP and Next Generation 911 SurveyMonkey

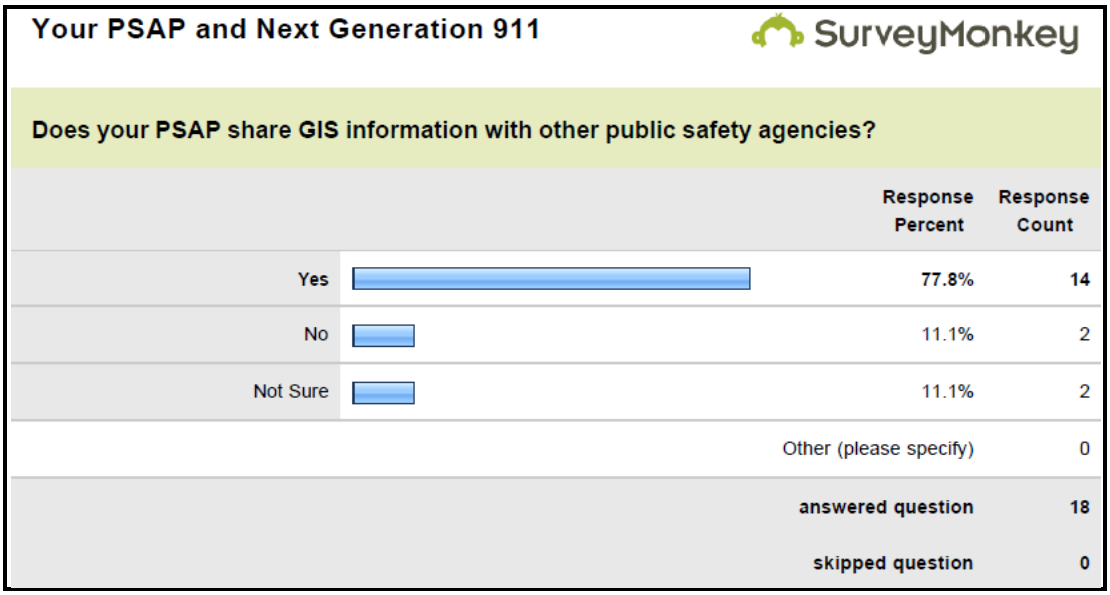
Does your PSAP have web access to other public safety, and government agency portals for data sharing?

	Response Percent	Response Count
Yes	55.6%	10
No	16.7%	3
Not Sure	16.7%	3
Other (please specify)	11.1%	2
answered question		18
skipped question		0

Research Question 4:

Given the results of the survey, can it be determined from a technology perspective that a SOA adoption plan can work in the PSAP environment?

SOA delivers on the promise of technology and business integration allowing for the reuse of current infrastructure architecture and applications into new business solutions. The PSAP survey indicates that IP-based technology solutions are important, and as indicated in the previous research questions, successfully being deployed in the Colorado PSAP today. The findings lead this researcher to believe that a SOA adoption plan can work for the Colorado PSAPs.



Your PSAP and Next Generation 911 SurveyMonkey

Does your PSAP share GIS information with other public safety agencies?

	Response Percent	Response Count
Yes	77.8%	14
No	11.1%	2
Not Sure	11.1%	2
Other (please specify)		0
answered question		18
skipped question		0

NICE Next Generation 9-1-1 Emergency Call Project

The following research addresses a pilot project between three (3) Colorado PSAPs currently sharing a private Internet connection for the purpose of technology and application interoperability. The NICE IP-based 9-1-1 Call Logger deployment demonstrates that an emergency application can be hosted by one PSAP and accessed by the two other PSAPs through a web portal. Without getting too technical figure 10 gives a high level overview of the NICE Logger web service design. The NICE Logger is hosted by West Metro Fire Rescue through a web portal, the other two PSAP have a standardized user interface, the application can also be accessed by the emergency backup center, all of this accessed through a secure IP-based fiber and wireless connection. Each PSAP has a utility that runs on their CAD which interfaces with NICE and the 9-1-1 telephony system for recording the emergency call. The cities of Lakewood and Wheat Ridge have VoIP 9-1-1 telephone systems, West Metro Fire Rescue (WMFR) has traditional circuit-switched PBX, for this reason the NICE Logger system was hosted by WMFR, the other agencies could push their 9-1-1 call information over the secure VPN on the public

internet, as well as point to point network connectivity on the private public safety network. At this time there has not been a need for the NICE application to be accessible to the mobile first responder, since this is a backend application, but being IP-based the capability is available. The NICE logger project emphasizes interoperability and data sharing utilizing IP-based technologies, primarily VoIP telephony and digitized audio capture of emergency 9-1-1 calls. The web portal and services with a single user sign-on, and standardized user interface promotes the effectual architecture design through service oriented methodology.

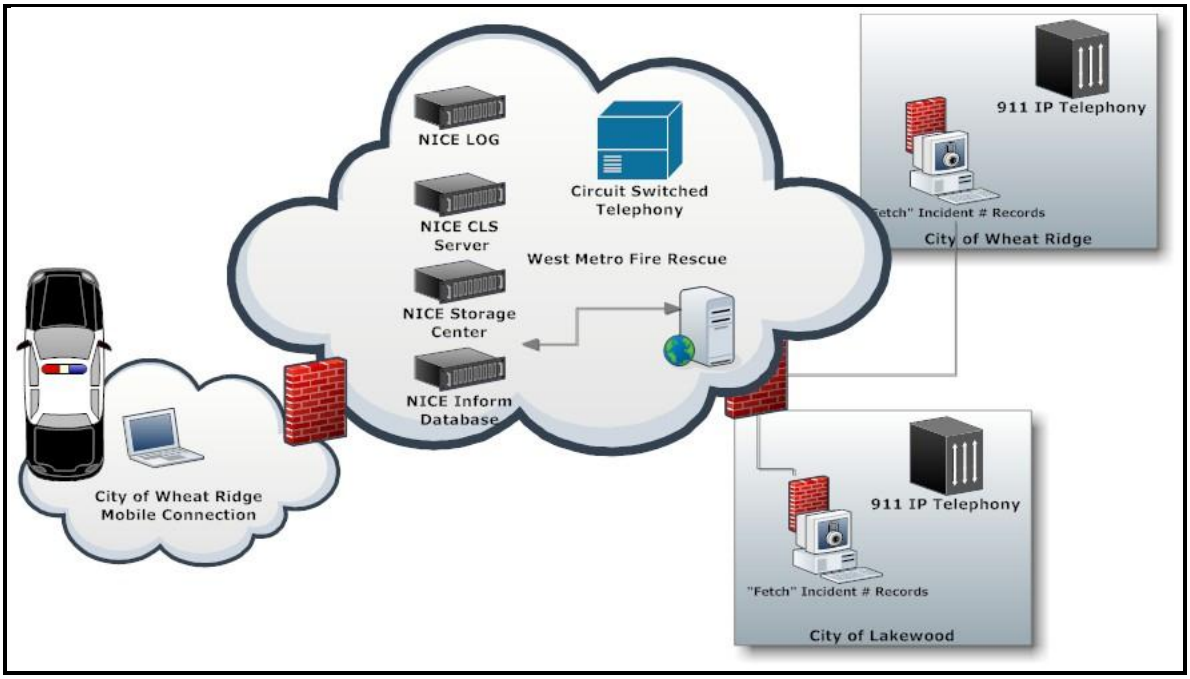


Figure 10: NICE 9-1-1 Logger Web Service

Chapter 5 – Recommendations and Conclusions

The analysis of the data collected from the various Colorado PSAPs concludes that there is the potential for the deployment of an effectual architecture for Next Generation 9-1-1. The research utilizing the National Emergency Number Association's i3 Standards as the reference for the deployment which emphasizes a system composed of managed IP-based networks, [applications and databases] that augment present-day E9-1-1 features and functions and add new capabilities. Inherent in that definition is a distinction between an Emergency Services IP Networks (ESInet) shared by emergency service agencies and the specific application environment that supports the delivery of a request for emergency services and represents NG9-1-1. The ESInet network will provide connectivity and interoperability with emergency response and other critical public safety stakeholders involved in incident management. Other application environments will also utilize the ESInet, supporting emergency response, incident management, and similar functions (e.g., computer-aided dispatch, radio interoperability, and responder communications). With ESInet as the framework it is conceivable that an effectual architecture can be supported with SOA methodology, the survey results and the NICE 9-1-1 call logger pilot project with the three Colorado PSAPs provides the proof to support this conclusion.

The PSAP's legacy architectural framework is outdated and needs upgrading to an effectual architectural framework that will allow for the acceptance and processing of non-traditional communication methods. The implementation of service-oriented architecture is also the key to interoperability, and data sharing amount the public safety community. The PSAP of tomorrow will need to incorporate these newer types of communication in order to meet the needs of the citizens.

The transition to the NENA IP-based 9-1-1 will be an evolutionary process, involving technological, economic and institutional change. The migration away from circuit-switched telephone networks to IP will be a joint venture that needs immense support from the 9-1-1 vendor community. The path for delivering IP-enabled 9-1-1 services to the public will depend on how local, regional and State jurisdictions plan and coordinate, deploy and operate their systems. The author has many years of experience in dealing with 9-1-1 PSAPs, and public safety in general, and governance will be required in order to create the NG9-1-1 for our future. The role of technology in the NG9-1-1design, indicates that technology will be the key to making this new 9-1-1 model work, the role of technology in SOA must be validated in partnership with people and processes, and ensure synergy by installing governance early in the NG9-1-1 initiative. In the Next Generation 9-1-1 Transition Policy Implementation Handbook created by NENA (2010), it states: "Transitioning our nation's legacy 9-1-1 system to a modern IP-based Next Generation 9-1-1(NG9-1-1) system must be a major policy objective at all levels of government. Demands from 9-1-1 leaders and the public to modernize 9-1-1 are increasing. Significant standards and technology developments are underway. However, without effective policy development in conjunction with technical and operational NG9‑1‑1 system development, the best system designs, architectures and plans will be just that—designs, architectures and plans. To actually implement an NG9‑1‑1 system requires effective overall policies, laws, and regulations that facilitate and fully support all aspects of NG9-1-1. In addition, stakeholders must work together to make sure that appropriate governance structures are in place to enable the effective implementation and operation of an NG9‑1‑1 system." (p. 1)

Chapter 6 – Areas for Further Research

As a result of the information gathered for this case study a significant factor became evident that the author believes will impact the development of the NG9-1-1 effectual architecture that being the governance topic, which is only touched upon and deserves additional research, the need to define IT and business governance will be instrumental in helping NG9-1-1 achieve success. The NG9-1-1 deployment will require buy-in from the leaders in both the IT and business camps of the PSAP industry, the researcher believes that there is a level of commitment to NG9-1-1; survey questions 1, 2, and others indicate that there is a commitment from key stakeholders, and that the Colorado PSAP is taking steps toward accepting NENA's NG9-1-1 i3 standards.

Further research can be conducted in the area of NG9-1-1 risks in relation to program resources, future technology, security and privacy and organizational and change management. Research concerning Cloud capabilities is well justified, especially the area of Service Oriented Cloud (SOC), this case study does touch on NG9-1-1 as a SOC, and this researcher proposes that the Colorado PSAP move their 9-1-1 emergency services to the Cloud. At present Colorado and the Nation will stay with internal deployment, and ownership of the information and communication technology systems. We can expect slow changes in the area, primarily because of governance issues. A prime example of the 9-1-1 emergency call taking changing and migrating can be demonstrated by current businesses practicing telematics- OnStar should come to mind. OnStar is a private business that accepts 9-1-1 emergency calls, and alerts, once they receive these calls a determination is made to contact a public safety answering point in order to initiate emergency services if appropriate. Prior to telematics all of this call processing occurred by circuit-switched telephone networks within the four walls of the PSAP.

References

A National Plan for Migrating to IP-enabled 9-1-1 Systems. (2004).

Bergen County, NJ and CODY Systems: partners for real-time information sharing. (2010). Hendon Publishing Company Online. Retrieved July 7, 2011, from http://www.hendonpub.com/resources/articlearchive/details.aspx?ID=208138

Davis, J. (2009). *9-1-1: The Next Generation Now.* Volume 24(6). Retrieved July 05, 2010, from the Radio Source Mission Critical Communications Website: http://www.radioresourcemag.com/highlights.

Durvasula S., et al. (2006). *SOA Practitioners' Guide Parts1-3: SOA Reference Architecture.* Retrieved January 02, 2010, from the SOA Blueprint Website: http://www.soablueprint.com/whitepapers/SOAPGPart1.pdf, http://www.soablueprint.com/whitepapers/SOAPGPart2.pdf, http://www.soablueprint.com/whitepapers/SOAPGPart3.pdf.

Erl, T. (2005). *Service Oriented Architecture: Concepts, Technology, and Design.* Upper Saddle River, NJ: Prentice Hall.

Evdemon, J. (2005). *Business Architectures and Standards, Microsoft Architecture Strategy Team. The Four Tenets of Service Orientation.* Retrieved January 02, 2010 from the BPM Institute Website: http://www.bpminstitute.org/articles/article/article/the-four-tenets-of-service-orientation.html.

Federal Communications Commission. (2010). *9-1-1 Service.* Retrieved June 14, 2010, from the Federal Communications Commission Website: http://transition.fcc.gov/pshs/services/911-services/.

Functional and Interface Standards for Next Generation 9-1-1 Version 1.0 (i3). (2006). National Emergency Number Association (NENA). Retrieved August 15, 2009, from the NENA Website: http://www.nena.org/standards/technical/voip/functional-interface-NG911-i3.

Gabhart, K., Bhattacharya, B. (2008). *Service Oriented Architecture Field Guide for Executives.* Hoboken, NJ: Wiley & Sons.

Hay, D. (2008). *UML as a Data Modeling Notation.* Retrieved December 1, 2010, from The Data Administration Newsletter Website: http://www.tdan.com/view-articles/8457.

Jones, Hinkle, Goerke, Sherry. (2007). *National Emergency Number Association (NENA). Next Generation Transition Planning Committee (NGTPC),* Retrieved July 5, 2010, from the NENA Website: http://www.nena.org.

Kunz, R. (2010). *SRPEDD Local Communities Join in Regional 911 Dispatch Feasibility Study.* Retrieved May 15, 2011, from the Southeastern Regional Planning and Economic Development District Website: http://www.srpedd.org/municipal_service/regional%20911%20feasibility%20study%20update%20may%202010.pdf.

Leedy, P.D., &Ormrod, J.E. (2005). *Practical Research: Planning and Design (8th Ed.).* Upper Saddle River, NJ: Pearson Education. Retrieved August 15, 2009, from http://www.netlibrary.com.dml.regis.edu/Reader/ page 89.

Moving Toward Credentialing Interoperability. (2010). SAFECOM Program. Retrieved January 02, 2011, from http://www.safecomprogram.gov/NR/rdonlyres/648C73A5-022C-4E1E-84EB-8DFEFCA0C382/0/2aMovingTowardsCredentialingInteroperability_7810.pdf

NG9-1-1 Project. (2010). National Emergency Number Association (NENA). Retrieved April 10, 2010, from http://www.nena.org/ng911-project.

People & Technology in the Workplace. (1991). Commission on Behavior and Social Sciences and Education, National Research Council, National Academy Press. Retrieved August 15, 2009, from, http://www.netlibrary.com.dml.regis.edu/Reader/ page 89.

Schulzrinne, H. (2004). *Emergency Services for Internet Telephony Systems.* Retrieved July 21, 2010, from the Columbia University Website: www.cs.columbia.edu/.../emergency.../draft-schulzrinne-sipping-emergency-arch-01.html

Simons, H. (1980). *Towards a science of the singular: Essays about case study in educational research and evaluation.* Norwich, UK: University of East Anglia, Centre for Applied Research in Education.

Stake, R. E. (1995). *The Art of Case Study Research.* Thousand Oaks, CA: Sage.

Ulrich, W. (2006). *The Role of SOA in Business / IT Architecture Alignment.* Retrieved January 02, 2010, from the SOA Institute Website: http://www.soainstitute.org/articles/article/article/the-role-of-soa-in-business-it-architecture-alignment.html.

U.S. Department of Transportation Research and Innovative Technology Administration (RITA). Next Generation 9-1-1. Prepared by: Intelligent Transportation Systems Joint Program Office. Retrieved on June 7, 2010, from http://www.its.dot.gov/ng911/

United States House of Representatives. (2008). *3403: NET 911 Improvement Act of 2008.* Retrieved on May 15, 2010, from http://www.govtrack.us/congress/bill.xpd?bill=h110-3403.

Valley Emergency Communication Center (VECC). (2011). *VECC had been Nominated for APCO's 2010 Horizon Award Honoring Technical Achievements.* From, http://vecc9-1-1.com/awards/nominated-for-apcos-2010-horizon-award-honoring-technical-achievements/

Yin, R. K. (2003). Case Study Research: Design and Methods (3rd ed.). Thousand Oaks, CA: Sage Publications

Appendix A

NG9-1-1Public Safety Answering Point Survey

IRB Informed Consent

You are being invited to participate in a research study about the implementation of Next Generation 9-1-1 (NG9-1-1) in the Public Safety Answering Points (PSAPs) within the State of Colorado.

This study is being conducted by Patrick Purdy and Charles Thies faculty advisor, from the School of Computer and Information Sciences at Regis University. The study is being conducted as part of a graduate student thesis.

You were selected as a possible participant in this study because you are an important member of the PSAPs of Colorado.

There are no known risks if you decide to participate in this research study. There are no costs to you for participating in the study. The information you provide will be used to compare infrastructure architecture and current business practices at various Colorado PSAPs in order to make a determination for the application of service oriented architecture for the main purpose of improving citizen's abilities to report emergency 9-1-1information through the use of non-traditional communications methods.

The questionnaire will take about 15 minutes to complete. The information collected may not benefit you directly, but the information learned in this study should provide more general benefits.

This study is confidential. Individuals from the Institutional Review Board (IRB) may inspect these records.

Should the data be published, no individual information will be disclosed.

Your participation in this study is voluntary. By completing the online survey through Survey Monkey.com, you are voluntarily agreeing to participate. You are free to decline to answer any particular you do not wish to answer for any reason.

If you have any questions about the study, please contact: Patrick Purdy, 5790 Cheetah Chase, Littleton, CO. 80124, (303) 790-4592 or email ppurdy1@me.com, or purdy343@regis.edu.

My thesis advisor Charles Thies may be reached at cthies@regis.edu , (228) 229-8626.

Your PSAP and Next Generation 911

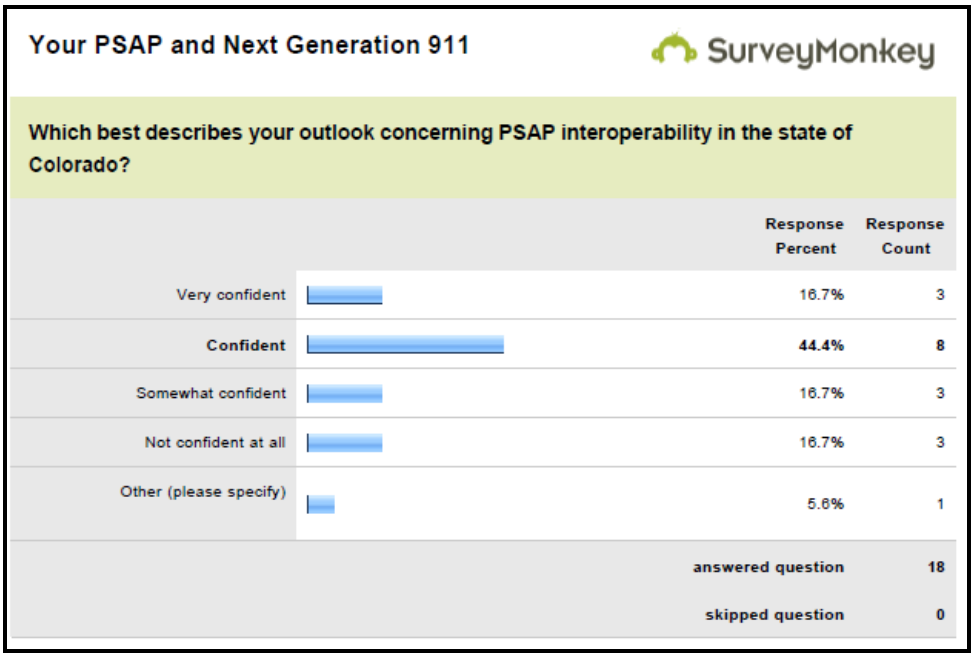
SurveyMonkey

Which of the following best describes your job title?

	Response Percent	Response Count
PSAP Director	0.0%	0
PSAP Manager	27.8%	5
911 Authority Director	11.1%	2
PSAP Supervisor	**33.3%**	**6**
PSAP Operator	0.0%	0
IT Manager	11.1%	2
IT Technician	5.6%	1
Other (please specify)	11.1%	2
	answered question	**18**
	skipped question	**0**

Page 2, Q1. Which of the following best describes your job title?

1	Tecnical Advisor	May 15, 2011 9:03 AM
2	Communications Center Project Manager	May 13, 2011 11:42 AM

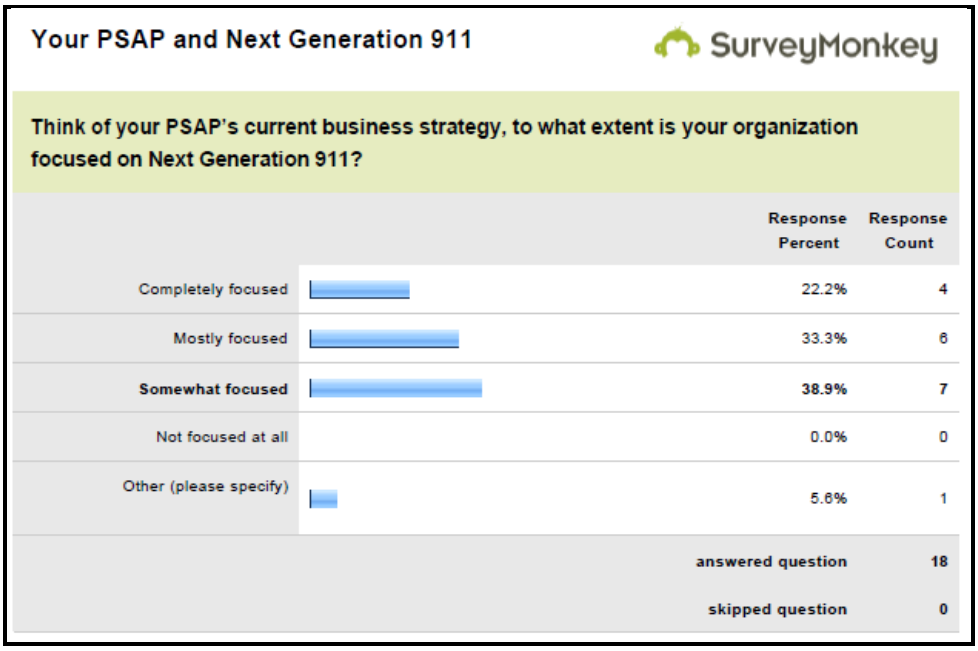


Your PSAP and Next Generation 911

SurveyMonkey

Which best describes your outlook concerning PSAP interoperability in the state of Colorado?

	Response Percent	Response Count
Very confident	16.7%	3
Confident	**44.4%**	**8**
Somewhat confident	16.7%	3
Not confident at all	16.7%	3
Other (please specify)	5.6%	1
	answered question	**18**
	skipped question	**0**

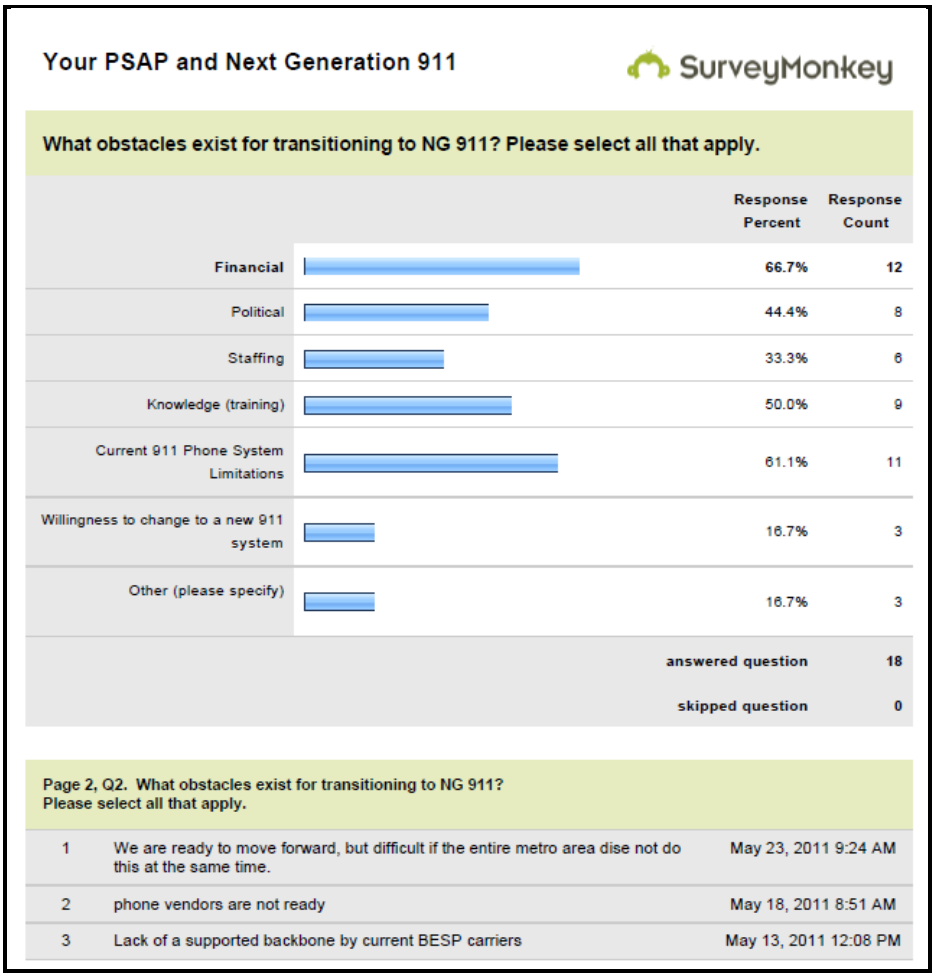


Your PSAP and Next Generation 911

SurveyMonkey

Think of your PSAP's current business strategy, to what extent is your organization focused on Next Generation 911?

	Response Percent	Response Count
Completely focused	22.2%	4
Mostly focused	33.3%	6
Somewhat focused	**38.9%**	**7**
Not focused at all	0.0%	0
Other (please specify)	5.6%	1
	answered question	**18**
	skipped question	**0**



Your PSAP and Next Generation 911

SurveyMonkey

What obstacles exist for transitioning to NG 911? Please select all that apply.

	Response Percent	Response Count
Financial	66.7%	12
Political	44.4%	8
Staffing	33.3%	6
Knowledge (training)	50.0%	9
Current 911 Phone System Limitations	61.1%	11
Willingness to change to a new 911 system	16.7%	3
Other (please specify)	16.7%	3
	answered question	18
	skipped question	0

Page 2, Q2. What obstacles exist for transitioning to NG 911? Please select all that apply.

1	We are ready to move forward, but difficult if the entire metro area dise not do this at the same time.	May 23, 2011 9:24 AM
2	phone vendors are not ready	May 18, 2011 8:51 AM
3	Lack of a supported backbone by current BESP carriers	May 13, 2011 12:08 PM

Your PSAP and Next Generation 911

SurveyMonkey

What are your PSAP's current tactics for preparing for NG 911? Please select all that apply.

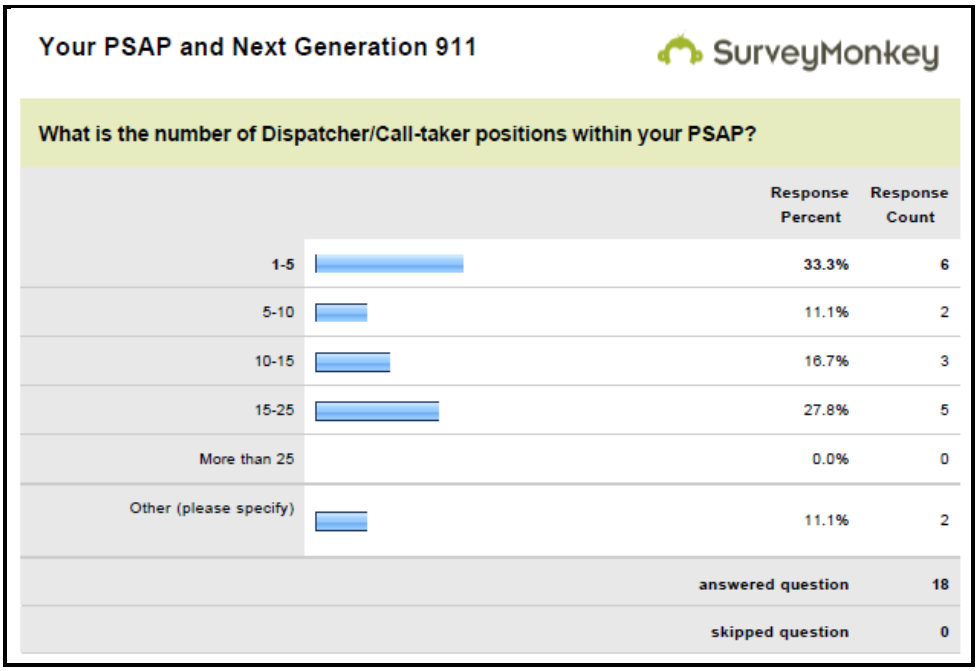
	Response Percent	Response Count
Actively researching technology solutions for NG 911	61.1%	11
Choosing IP enabled technology solutions	**83.3%**	**15**
Choosing to establish technology sharing with other PSAPs	72.2%	13
Developing shared services intergovernmental agreements (IGAs)	61.1%	11
Waiting for an NG 911 vendor to tell you what to do	11.1%	2
Other (please specify)	0.0%	0
	answered question	**18**
	skipped question	**0**

Your PSAP and Next Generation 911

SurveyMonkey

To what extent is each of the following important to your PSAP's ability to process NG 911 non-traditional communications?

	Extremely Important	Important	Doesn't Matter Much	Rating Average	Response Count
Texting	**44.4% (8)**	**44.4% (8)**	11.1% (2)	2.33	18
Email	16.7% (3)	**55.6% (10)**	27.8% (5)	1.89	18
Photos	27.8% (5)	**61.1% (11)**	11.1% (2)	2.17	18
Video	16.7% (3)	**72.2% (13)**	11.1% (2)	2.06	18
Voice over IP Telephone	**61.1% (11)**	33.3% (6)	5.6% (1)	2.56	18
			answered question		**18**
			skipped question		**0**

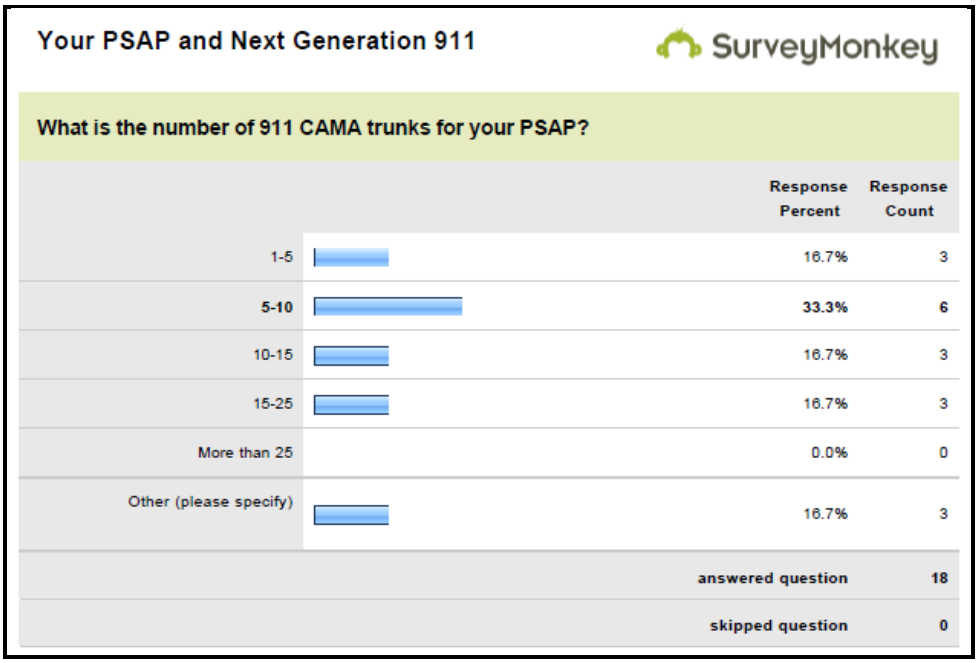


Your PSAP and Next Generation 911

SurveyMonkey

What is the number of Dispatcher/Call-taker positions within your PSAP?

	Response Percent	Response Count
1-5	33.3%	6
5-10	11.1%	2
10-15	16.7%	3
15-25	27.8%	5
More than 25	0.0%	0
Other (please specify)	11.1%	2
answered question		18
skipped question		0

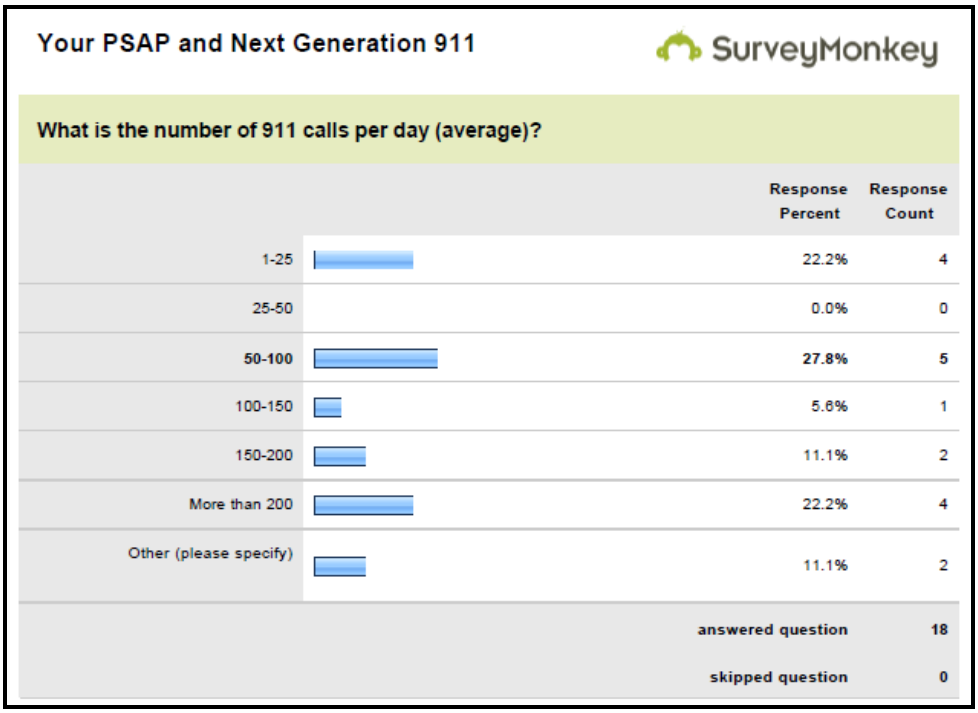


Your PSAP and Next Generation 911

SurveyMonkey

What is the number of 911 CAMA trunks for your PSAP?

	Response Percent	Response Count
1-5	16.7%	3
5-10	33.3%	6
10-15	16.7%	3
15-25	16.7%	3
More than 25	0.0%	0
Other (please specify)	16.7%	3
answered question		18
skipped question		0



Your PSAP and Next Generation 911

SurveyMonkey

What is the number of 911 calls per day (average)?

	Response Percent	Response Count
1-25	22.2%	4
25-50	0.0%	0
50-100	**27.8%**	**5**
100-150	5.6%	1
150-200	11.1%	2
More than 200	22.2%	4
Other (please specify)	11.1%	2
	answered question	**18**
	skipped question	**0**

Your PSAP and Next Generation 911

SurveyMonkey

What Computer Aided Dispatch (CAD) System does your PSAP utilize?

	Response Percent	Response Count
Intergraph	27.8%	5
TriTech	11.1%	2
New World Systems	11.1%	2
Printrak/Motorola	5.6%	1
Data911	0.0%	0
Other (please specify)	**44.4%**	**8**
	answered question	**18**
	skipped question	**0**

Page 2, Q10. What Computer Aided Dispatch (CAD) System does your PSAP utilize?

1	HTE	May 16, 2011 11:11 AM
2	can't afford CAD. Use pen and paper	May 16, 2011 8:40 AM
3	Sunguard - H.T.E.	May 16, 2011 8:35 AM
4	Tiburon	May 16, 2011 12:27 AM
5	Not Applicable	May 15, 2011 9:03 AM
6	Slueth	May 13, 2011 8:38 AM
7	authority funds 10 psaps, 6 different cads in use	May 13, 2011 7:55 AM
8	SunGard/HTE	May 12, 2011 5:09 PM

Your PSAP and Next Generation 911

SurveyMonkey

Is your CAD system web-services capable?

	Response Percent	Response Count
Yes	22.2%	4
No	**38.9%**	**7**
Not Sure	27.8%	5
Other (please specify)	11.1%	2
	answered question	**18**
	skipped question	**0**

Your PSAP and Next Generation 911 SurveyMonkey

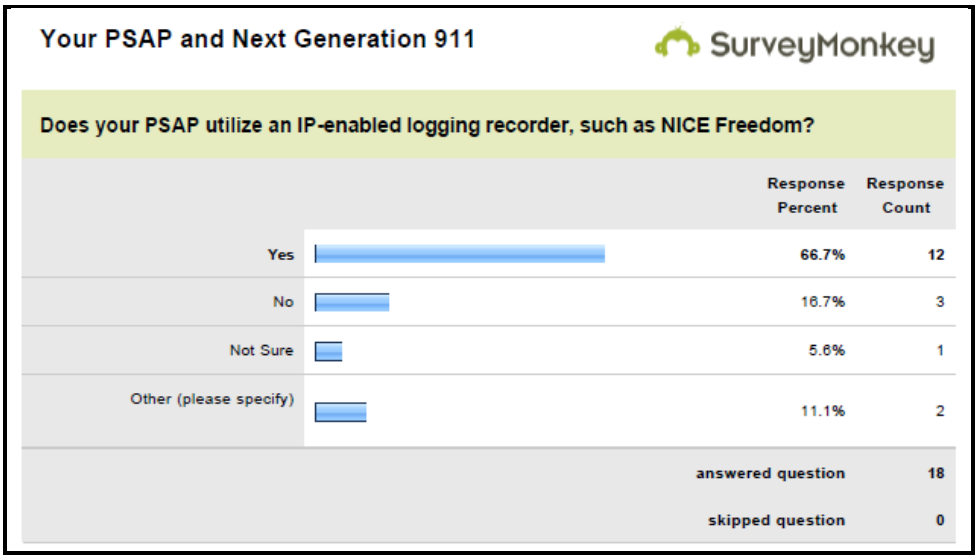
Does your PSAP have a CAD to CAD connection?

	Response Percent	Response Count
Yes	22.2%	4
No	44.4%	8
Not Sure	22.2%	4
Other (please specify)	11.1%	2
answered question		18
skipped question		0

Your PSAP and Next Generation 911 SurveyMonkey

Does your PSAP utilize an IP-enabled radio system, such as P25?

	Response Percent	Response Count
Yes	38.9%	7
No	38.9%	7
Not Sure	5.6%	1
Other (please specify)	16.7%	3
answered question		18
skipped question		0

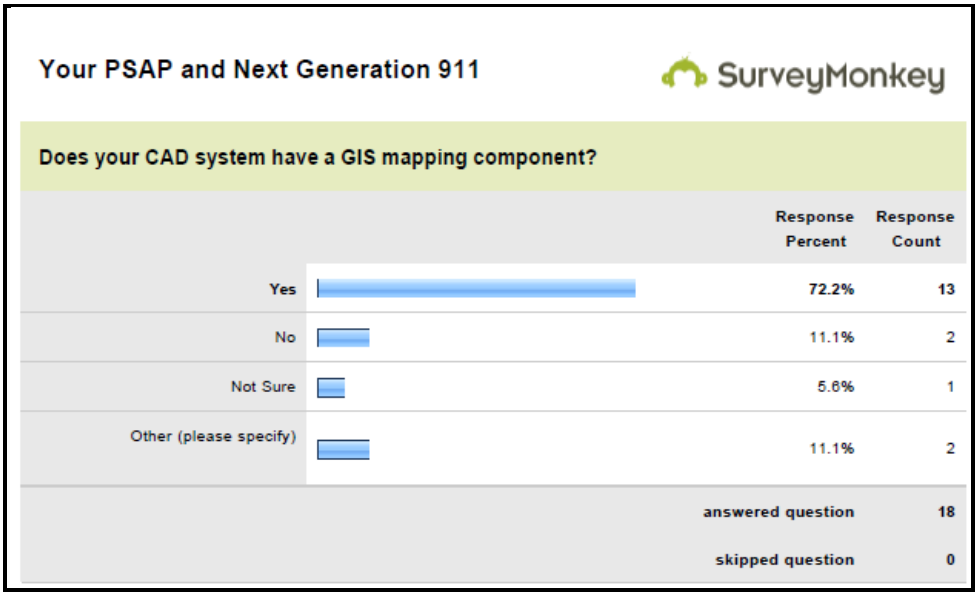


Your PSAP and Next Generation 911

SurveyMonkey

Does your PSAP utilize an IP-enabled logging recorder, such as NICE Freedom?

	Response Percent	Response Count
Yes	66.7%	12
No	16.7%	3
Not Sure	5.6%	1
Other (please specify)	11.1%	2
answered question		18
skipped question		0

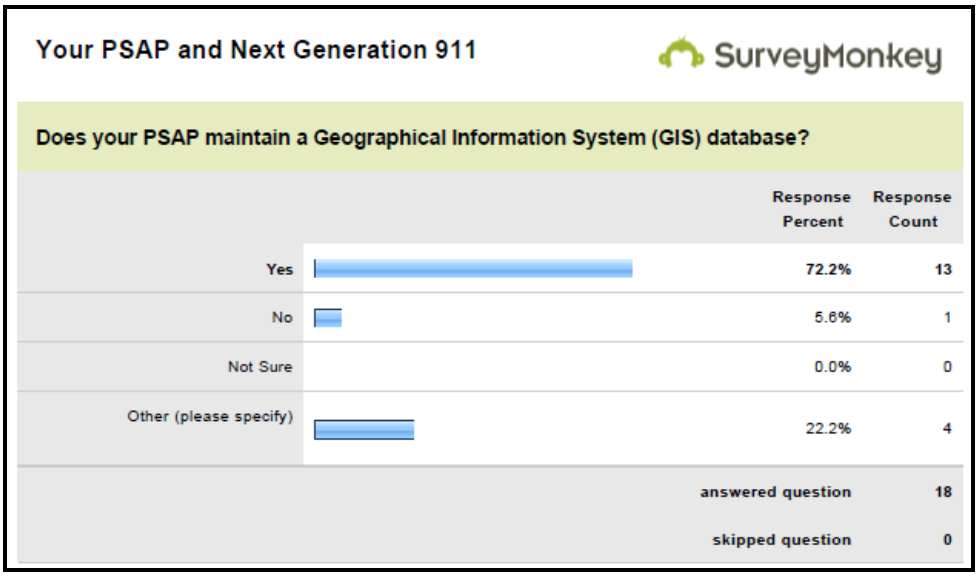


Your PSAP and Next Generation 911

SurveyMonkey

Does your CAD system have a GIS mapping component?

	Response Percent	Response Count
Yes	72.2%	13
No	11.1%	2
Not Sure	5.6%	1
Other (please specify)	11.1%	2
answered question		18
skipped question		0

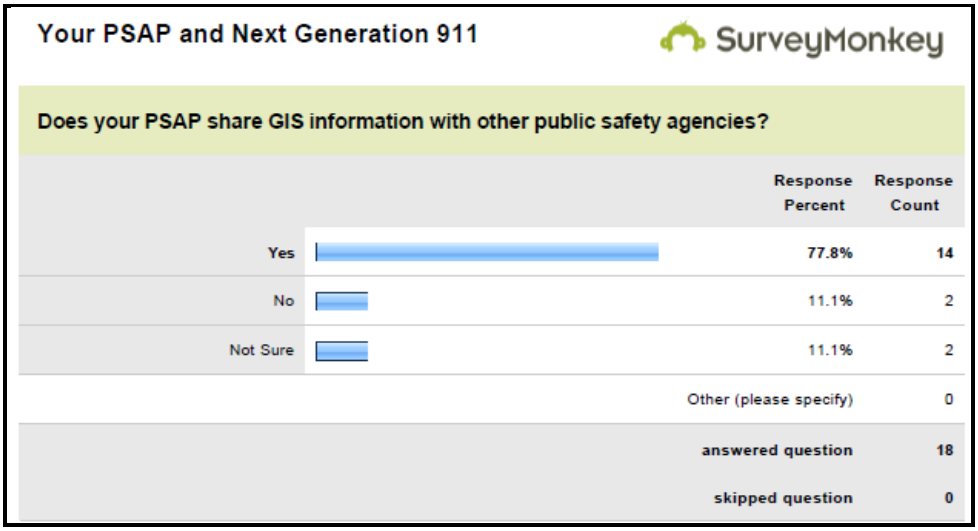


Your PSAP and Next Generation 911

SurveyMonkey

Does your PSAP maintain a Geographical Information System (GIS) database?

	Response Percent	Response Count
Yes	72.2%	13
No	5.6%	1
Not Sure	0.0%	0
Other (please specify)	22.2%	4
answered question		18
skipped question		0

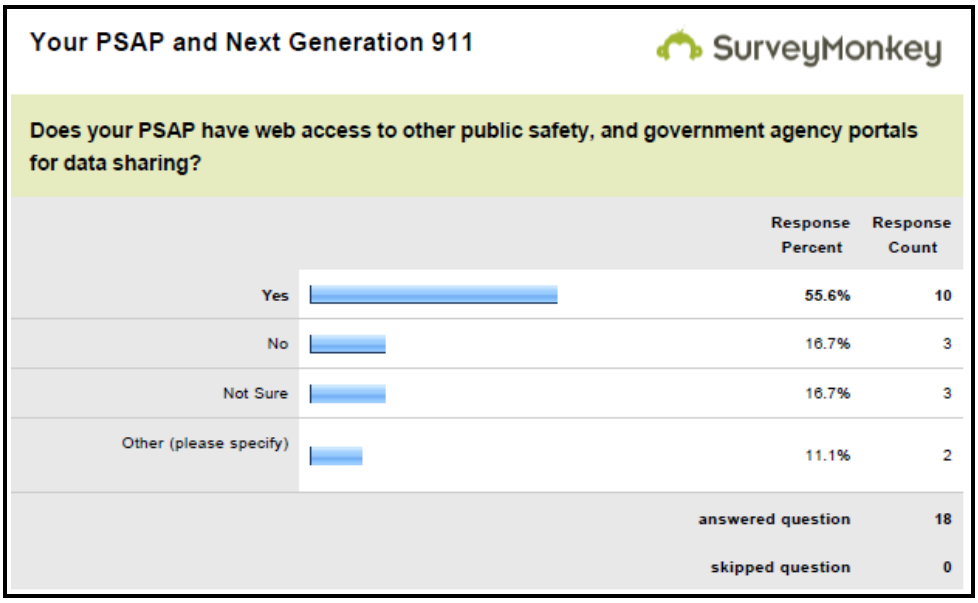


Your PSAP and Next Generation 911

SurveyMonkey

Does your PSAP share GIS information with other public safety agencies?

	Response Percent	Response Count
Yes	77.8%	14
No	11.1%	2
Not Sure	11.1%	2
Other (please specify)		0
answered question		18
skipped question		0

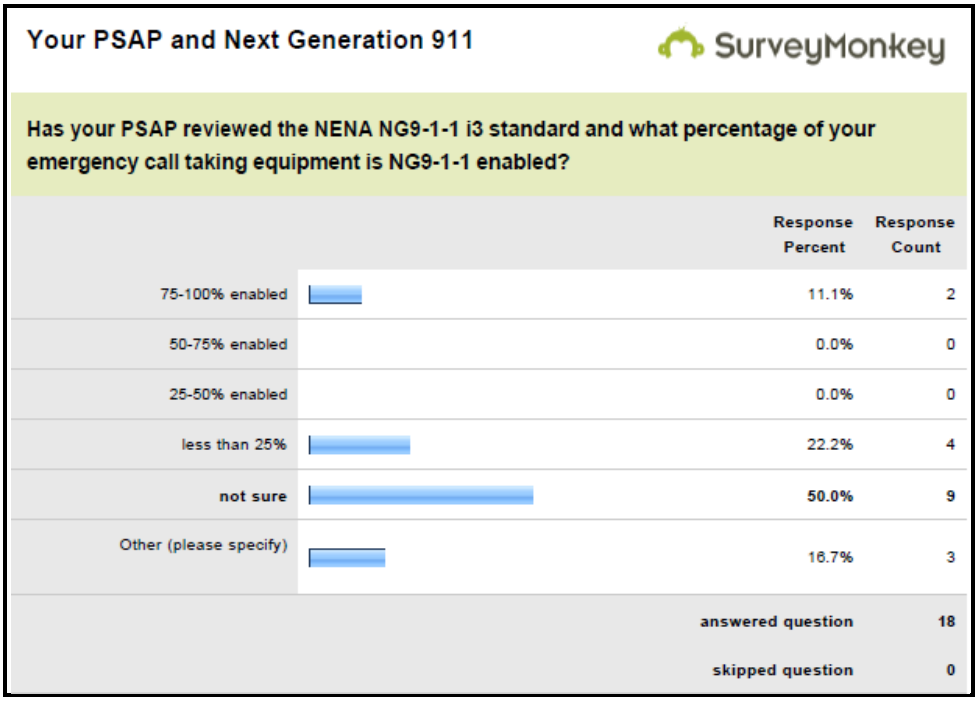


Your PSAP and Next Generation 911

SurveyMonkey

Does your PSAP have web access to other public safety, and government agency portals for data sharing?

	Response Percent	Response Count
Yes	55.6%	10
No	16.7%	3
Not Sure	16.7%	3
Other (please specify)	11.1%	2
answered question		18
skipped question		0



Your PSAP and Next Generation 911

SurveyMonkey

Has your PSAP reviewed the NENA NG9-1-1 i3 standard and what percentage of your emergency call taking equipment is NG9-1-1 enabled?

	Response Percent	Response Count
75-100% enabled	11.1%	2
50-75% enabled	0.0%	0
25-50% enabled	0.0%	0
less than 25%	22.2%	4
not sure	50.0%	9
Other (please specify)	16.7%	3
answered question		18
skipped question		0

Appendix B

REGIS UNIVERSITY

Academic Affairs
Academic Grants

3333 Regis Boulevard, H-4
Denver, Colorado 80221-1099

303-458-4206
303-964-3647 FAX
www.regis.edu

IRB – REGIS UNIVERSITY

April 28, 2011

Patrick Purdy
5790 Cheetah Chase
Littleton, CO 80124

RE: IRB #: 124-10

Dear Patrick:

Your application to the Regis IRB for your project "AN INQUIRY REGARDING THE DEVELOPMENT OF AN EFFECTUAL ARCHITECTURE FRAMEWORK SUPPORTING NEXT GENERATION 9-1-1" was approved as exempt on April 26, 2011.

The designation of "exempt," means no further IRB review of this project, as it is currently designed, is needed.

If changes are made in the research plan that significantly alter the involvement of human subjects from that which was approved in the named application, the new research plan must be resubmitted to the Regis IRB for approval.

Sincerely,

Edwin May
Director

cc: Charles Thies

Glossary

ANI: Automatic Number Identification corresponds to the subscriber's seven digit telephone number. The ANI displays at the PSAP on the digital ANI display console.

ANI Failure: Failure of the end office to identify the call and provide the ANI (telephone number) to the tandem office; or, an ANI failure between the tandem office and the PSAP.

ALI: Automatic Location Identification provides for an address display of the subscriber calling 911. With ALI, the PSAP receives the ANI display and an ALI display on a screen. The ALI display includes the subscriber's address, community, state, type of service and if a business, the name of the business. The PSAP will also get a display of the associated ESN information (police, fire, and rescue).

Alternate Routing: Alternate routing provides for a predetermined routing for 911 calls when the tandem office is unable to route the calls over the 911 trunks for a particular PSAP due to troubles or all trunks busy.

Anonymous Call: If a subscriber misdials and dials the seven digit number associated with the PSAP position, they will come in direct and ANI display as 911-0000 which will ALI as an anonymous call. The seven digit numbers associated with the PSAP positions are not published even to the PSAPs.

API: Application programming interface is asset of specifications that allow software programs to communicate with each other.

Call Detail Record: When the 911 call is terminated by the PSAP operator, the ANI will automatically print-out on the teletypewriter located at the PSAP. The printout will contain the time the call came into the PSAP, the time it was picked up by an operator, the operator number, the time the call was transferred, if applicable, the time the call was terminated and the trunk

group number associated with the call. Printouts of the ALI display are now also available, if the PSAP has purchased the required equipment.

CAD: Computer Aided Dispatch is a proprietary technological emergency incident and tracking hardware and software solution designed to increase the efficiencies of processing E911 emergency calls.

Default Routing: Provides for routing of 911 calls when there is an ANI failure. The call will be routed to the "default" ESN associated with the he NNX the caller is calling from. Default ESNs are pre-assigned in translations and are usually the predominant ESN for a given wire center.

E911: Enhanced 911: Features available include selective routing, selective transfer, fixed transfer, alternate routing, default routing, Automatic Number Display, Automatic Location Identification, night service, default routing, call detail record.

End Office: Telephone central office which provides dial tone to the subscriber calling 911. The "end office" provides ANI (Automatic Number Identification) to the tandem office.

ESInet: A network of Emergency Services IP Networks envisioned by NENA, an IP-based inter-network (network of networks) shared by all agencies, which may be involved in an emergency.

ESN: Emergency Service Number (XXX) that is assigned to the subscriber's telephone number in the tandem office translations The ESN represents a seven digit number by which the tandem office routes the call to the proper PSAP. PSAPs with ALI capabilities also receive a display of the ESN information which shows which police, fire and rescue agency serves the telephone number calling 911. An ESN is a unique combination of police, fire, and rescue service for purposes of routing the E911 call.

ESRP: Emergency Service Routing Proxy is a SIP proxy that routes incoming emergency calls to the appropriate emergency call center or public safety answering point.

GIS: A geographic information system **(GIS)** captures, stores, analyzes, manages, and presents data that is linked to location. Technically, a GIS is a system which includes mapping software and its application to remote sensing, and aerial photography.

GPS: Global positioning system

MSAG: The Master Street Address Guide ledgers are controlled by the municipality which has purchased the E911 ALI service, in that they assign which police, fire or rescue agency will serve a given street and number range. They do this by assigning an ESN to each street range, odd, even, community that is populated in the county or municipality served. These MSAGs are then used as a filter for service order activity into the E911 computer data base to assign ESNs to individual TN records. This insures that each customer will be routed to the correct agency for their particular address. In a non-ALI County, TAR codes are used by the Telephone company to assign ESNs to service conductivity and the County does not control the ESN assignment. TAR codes represent the taxing authority for the given subscriber which should correspond to their police, fire and rescue agencies. The MG method, of course, is more accurate because it is using the actual service address of the customer to route the call and provides the county with more flexibility in assigning fire and rescue district, etc. The Customer Services E911 Group maintains the E911 computer data base and interfaces with the County (customer) on all MSAG or data base activity.

Misroute: Any condition that results in the 911 call going to the wrong PSAP. A call can be misrouted if the ESN and associated routing information are incorrect in the E911 data base

and/or tandem data base. A call can also be misrouted if the call is an ANI failure, which automatically default routes.

N11 Assignments: The FCC has assigned several three-digit numbers for emergency and non-emergency access, and has posted a complete explanation on their Web site.

NENA: The National Emergency Number Association's mission is to foster the technological advancement, availability and implementation of a universal emergency telephone number system (9-1-1).

Night Service: Night service works the same as alternate routing in that the calls coming into a given PSAP will automatically be routed to another preset PSAP when all trunks are made busy due to the PSAP closing down for the night.

No ANI: This condition means the PSAP received a call, but no telephone number displayed on the ANI console. The PSAP should report this condition immediately to the SSC/MAC.

No Displays: A condition where the PSAP ALI display screen is blank. This type of trouble should be reported immediately to the SSC/MAC. If all screens at the PSAP are blank, it is an indication that the problem is in the circuits from the PSAP to the E911 computer. If more than one PSAP is experiencing no display, it may be a problem with the Node computer or the E911 computer. The SSC/MAC should contact the MMOC to determine the health of the HOST computer.

PSAP: Public Safety Answering Point, usually the police, fire and/or rescue groups as determined by the local municipalities. A "ring-in" will not have ANI or ALI capabilities, but just receives calls or transferred calls from another PSAP.

PSAP Not Receiving Calls: If a PSAP cannot receive calls or request retrievals from the E911 host computer, i.e., cable cut, the calls into that PSAP must be rerouted to another PSAP. The

Switching Control Center must be notified to reroute the calls in the tandem office E911 translations.

Tandem Office: Telephone central office which serves as a tandem (or hub) for all 911 calls. Must be a 1AESS type of central office. The tandem office translations contain the TN/ESN relationships which route the 911 call to the proper SAP. The tandem office looks up the ANI (TN) that it receives from the end office and finds the ESN (routing information) which corresponds to a seven digit number ringing in at a PSAP.

Record Not Found: If the host computer is unable to do a look up on a given ANI request from the PSAP, it will forward a Record Not Found message to the PSA ALI screen. This is caused by service order activity for a given subscriber not being processed into the E911 data base, or HOST computer system problems whereby the record cannot be accessed at that point in time

Selective Routing: The capability to route a call to the particular PSAP serving the address associated with the TN making the 911 call. Selective routing is achieved by building TN/ESN translations in the tandem central office. These translations are driven by the E911 data base which assigns the ESN to each telephone number based on the customer's address. Service order activity keeps the E911 data base updated. The E911 data base, in turn, generates recent change to the tandem office (through the SCC or RCMAC) to update the TN/ESN translations in the tandem data base.

Selective Transfer: Provides the PSAP with the ability to transfer the incoming 911 call to a fire or rescue service for the particular number calling 911 by pushing one button for fire or rescue. For example, if an incoming 911 call was reporting a fire, the PSAP operator would push the fire button on the ANI console; the call would go back to the tandem office, do a lookup for the seven digit number associated with fire department, for the ESN assigned to the calling TN, and

automatically route the call to that fire department. This differs from "fixed" transfer which routes every call to the same fire or rescue number whenever the fire or rescue button is pushed. The PSAP equipment is optioned to provide either fixed or selective transfer capabilities.

Spurious 911 Calls: Occasionally, the PSAP will get a call that is not associated with a subscriber dialing 911 for an emergency. It could be a subscriber who has not dialed 911, but is dialing another number, or has just picked up their phone and was connected with the PSAP. These problems are equipment related, particularly when the calls originate from electromechanical or step by step offices, and are reported by the E911 Center to Network Operations upon receipt of the PSAP inquiry reporting the trouble. The PSAP may get a call and no one is there; if they call the number back, the number may be disconnected or no one home. Again these are network troubles and must be investigated. Cordless telephones can also generate "spurious" calls in to the PSAPs. Generally, the PSAP will hear conversation on the line, but the subscribers are not calling 911. The PSAP may report spurious calls to repair if they become bothersome, for example, the same number ringing in continually.