



Intelligent Transportation Systems
U.S. Department of Transportation



Next Generation 9-1-1 (NG9-1-1) System Initiative



Proof of Concept Testing Report

Washington, D.C.

Version 1.0
September 17, 2008



DOCUMENT CHANGE HISTORY

Version Number	Date	Description
v 1.0	September 17, 2008	Final Version



Acknowledgements

The Next Generation 9-1-1 Initiative at the U.S. Department of Transportation gratefully acknowledges the contributions of all participants to the Proof of Concept. Without their time and expertise, the successful completion of the Proof of Concept would not have been possible.

Tom Brindle	Director	Kosciusko County, IN 911
Marlys Davis	E-911 Program Manager	King County (WA) E911 Program
Pete Eggimann	Director of 911 Services	Metropolitan Emergency Services Board, MN
Craig "C.J." Johnson	Deputy Director	Rochester/Monroe County (NY) Emergency Communications Department
Kenneth Lowden	Executive Director	Office of the Treasurer of Indiana, Indiana Wireless Enhanced 911 Board
John Merklinger	Director	Rochester/Monroe County (NY) Emergency Communications Department
Monica Ness	Assistant 9-1-1 Program Manager	State of Montana 911 Program Office
Ryan Olson	Assistant 9-1-1 Program Manager - Wireless	State of Montana 911 Program Office
Scott Williams	Director	Ramsey County, MN Emergency Communications Center

Public Safety Answering Point (PSAP) Personnel:

Karen Anderson	Seattle, WA Police
Jo Baumgartner	Washington State Police PSAP
Jean Best	King County, WA Sheriff's Office
Gary Bowman	Thurston County, WA 911
Theresa Bryant	Lake County, MT Sheriff's Office
Mark Deisenroth	Rochester/Monroe County (NY) Emergency Communications Department
Peggy Garcia	Seattle, WA Police
Rochelle Gardner	King County, WA Sheriff's Office
Andrea Garrett	City of Bluffton, IN 911
Joanna Hamilton	Ravalli County, MT 911
Wayne Hausburg	Rochester/Monroe County (NY) Emergency Communications Department
Jeremy Henshaw	Kirkland, WA Police
Daren Incashola	Lake County, MT Sheriff's Office
Mary Kassmer	Chouteau County, MT Sheriff's Office
Lecia Kelly	Chouteau County, MT Sheriff's Office
Khalid Khan	King County (WA) E911 Program
Tim Klutz	Thurston County, WA 911
Steve Lagreid	King County (WA) E911 Program
Kurt Larson	Chouteau County, MT Sheriff's Office
Aimie MacArthur	Missoula County, MT 911
Debi Michael	University of Washington PSAP
Loni Micheletto	Missoula County, MT 911



Patti Mooney	Kosciusko County, IN 911
Rita Noble	Valley Communications (South King County, WA)
Denise O'Leary	Ramsey County, MN Emergency Communications Center
Marsha Pacolt	Ramsey County, MN Emergency Communications Center
Michael Price	Kirkland, WA Police
Guy Priszner	Kirkland, WA Police
Brandon Pugliese	Rochester/Monroe County (NY) Emergency Communications Department
David Rosenberry	Kosciusko County, IN 911
Tracy Sheldon	University of Washington PSAP
Don Smiley	Ramsey County, MN Emergency Communications Center
Tara Smith	Kosciusko County, IN 911
Dan Stilwell	Seattle, WA Fire PSAP
Glenn Thorp	Thurston County, WA 911
Evelyn Torres	King County (WA) E911 Program
Yvonne Ublane	Washington State Police PSAP
Lora Uellanid	Valley Communications (South King County, WA)
Tim Viets	Helena, MT Police 911
Tom Walsh	Seattle, WA Fire PSAP
Matthew Yang	Kirkland, WA Police
Timothy Yauch	Rochester/Monroe County (NY) Emergency Communications Department
Milla Zinski	King County (WA) E911 Program

PSAP Facilities:

King County E-911 System, Seattle WA
State of Montana Public Safety Services Bureau, Helena MT
Ramsey County 911, St. Paul MN
Kosciusko County 911, Warsaw IN
Rochester – Monroe County Emergency Communications Department,
Rochester NY

Proof-of-Concept Laboratories:

Booz Allen Hamilton, Center for Network & Systems Innovation (CNSI)
Columbia University, Internet Real Time Laboratory
Texas A&M University, Internet2 Technology Evaluation Center

Next Generation 9-1-1 Initiative Project Team:

Booz Allen Hamilton
National Emergency Number Association
L. Robert Kimball & Associates
Texas A&M University Research Foundation



Vendors:

Cisco Systems
Emergent Communications
INdigital Telecom
OnStar
Pictometry International
RedSky Technologies
WirelessWERX



[This page left blank intentionally]

Table of Contents

1	Introduction.....	1
1.1	Overview.....	1
1.2	Scope.....	8
1.3	Document Overview	8
2	Methodology.....	10
2.1	Testing Process	11
2.2	Testing Resources	12
3	Test Site User Training	15
4	Initial Laboratory Site Testing.....	17
5	PSAP Site Testing.....	18
5.1	King County, Washington, PSAP Site Testing.....	18
5.2	Helena, Montana, PSAP Site Testing	19
5.3	St. Paul, Minnesota, PSAP Site Testing	20
5.4	Rochester, New York, PSAP Site Testing.....	21
5.5	Indiana PSAP Site Network-to-Network Testing.....	22
6	Total System Testing	24
6.1	King County, Washington, PSAP Site Testing.....	25
6.2	Helena, Montana, PSAP Site Testing	26
6.3	St. Paul, Minnesota, PSAP Site Testing	26
6.4	Rochester, New York, PSAP Site Testing.....	27
6.5	Indiana PSAP Site Network-to-Network Testing.....	27
7	Demonstration Testing.....	28
7.1	King County, Washington, PSAP Site.....	28
7.2	Helena, Montana, PSAP Site	29
7.3	St. Paul, Minnesota, PSAP Site	29
7.4	Rochester, New York, PSAP Site	30
7.5	Indiana PSAP Site.....	30
7.6	Texas A&M Laboratory Site	31
8	Lessons Learned and Future Research.....	32
8.1	Introduction.....	32
8.2	Operational Issues.....	33
8.3	Technical Issues	38
9	Compliance Matrix	44
	Appendix A—Acronyms	A-1
	Appendix B—Glossary.....	B-1
	Appendix C—Source References	C-1
	Appendix D—POC Testing Results	D-1
	Appendix E—POC Data Acquisition and Analysis Results.....	E-1



The following report contains the brand names of software and hardware used in the USDOT NG9-1-1 Proof of Concept, as well as the names of companies and agencies that participated. Their inclusion does not represent an endorsement of any kind.

1 Introduction

This report documents the methodology and results of the U.S. Department of Transportation (USDOT) Next Generation 9-1-1 Initiative (NG9-1-1) Proof of Concept (POC) testing. It describes in detail the NG9-1-1 POC test results and provides a baseline for future testing of NG9-1-1 systems.

The NG9-1-1 POC demonstration provided a realistic implementation and served as the culmination of previous NG9-1-1 efforts including—

- NG9-1-1 Concept of Operations (CONOPS)
- High-Level Requirements document
- Interim System Design Document
- Human Machine Interface Display Design Document
- POC Deployment Plan
- POC Testing Plan
- POC Data Acquisition and Analysis Plan.

These documents were used as a basis for planning, executing, and testing the NG9-1-1 POC system. These documents are available for download at the USDOT NG9-1-1 website: <http://www.its.dot.gov/ng911>.

1.1 Overview

The following subsections provide brief overviews of the NG9-1-1 project, the POC, and the POC testing performed.

1.1.1 Overview of the NG9-1-1 Project

The NG9-1-1 Initiative is a USDOT research and development project that was established to help define the concept of operations, functional requirements, and system architecture and to develop a transition plan that considers responsibilities, costs, schedule, and benefits for deploying Internet Protocol (IP)-based emergency services across the Nation. To accomplish these goals, USDOT has worked closely with public and private 9-1-1 stakeholders throughout the public safety community.

Trends in telecommunications mobility and convergence have put the 9-1-1 system at a crossroads. The growing market penetration of both wireless and Voice-over-Internet-Protocol (VoIP) telephony, and the increasingly nomadic and mobile world they reflect, has underscored the limitations of the current 9-1-1 infrastructure. The Nation's 9-1-1 system, based on 1960s technology, cannot handle the text, data, images, and video that are increasingly common in personal communications and critical to future transportation safety and mobility advances. Although improvements to 9-1-1 technology have occurred over the last four decades to enhance the data provided to the call taker (e.g., Enhanced 9-1-1 [E9-1-1], Wireless 9-1-1, and VoIP), the core 9-1-1 technology remains unchanged. The limitations of today's 9-1-1 infrastructure prevent the easy transport of

data, critical sharing of information, and enhanced awareness that ultimately reduces decision-making ability and quality of service provided to emergency callers.

USDOT views the NG9-1-1 project as a transition enabler, further assisting the public to make a 9-1-1 “call”¹ from any wired, wireless, or IP-based device, and allowing the emergency services community to take advantage of enhanced call delivery and advanced functional and operational capabilities through new internetworking² technologies based on open standards. By enabling the public to access 9-1-1 services through virtually any communications device, the NG9-1-1 system provides a more direct ability to request help or share critical data with an emergency services provider from any location. In addition, call takers at the Public Safety Answering Points (PSAP) will be able to transfer emergency calls to other PSAPs and forward the location and other critical data, such as text messages, images, and video, with the call.

The intent of the USDOT NG9-1-1 project is to provide leadership, guidance, and resources to work with the public and private 9-1-1 stakeholders, and lay out a path to achieve a phased migration of nationally interoperable³ emergency service networks.

1.1.2 Overview of the NG9-1-1 Proof of Concept

The NG9-1-1 POC provided the opportunity to develop and deploy software and network components that demonstrate the desired capabilities of the NG9-1-1 system. These included—

- Call origination using—
 - IP User Agents (UA) such as laptop computers, IP telephones, IP wireless devices, and Session Initiation Protocol (SIP) clients (audio, data, text, and streaming video)
 - Cellular devices (audio, Short Message Service [SMS], Instant Messaging [IM])
 - Third-party call center (audio and telematics data)
 - IP and Video Relay Services (VRS) for the deaf and hard-of-hearing community (real-time text and video).
- Call support and processing using—
 - Standard IP access networks
 - NG9-1-1 network components such as Emergency Services Routing Proxy (ESRP) and data gateways

¹ The term “call” is used in this document to indicate any emergency real-time communication—voice, text, or video—between a person or sensor and a Public Safety Answering Point (PSAP) call taker.

² “Internetwork”—to go between one network and another; a large network made up of a number of smaller networks.

³ The emergency services internetwork will be interoperable in that the networks and systems that comprise the NG9-1-1 architecture system of systems will have the ability to work together using standard formats and protocols.

- NG9-1-1 databases such as Business Rules, Location-to-Service Translation Protocol (LoST), Enterprise Location Information Server (LIS), and Call Record.
- Call termination at the PSAPs using—
 - IP Automatic Call Distribution (ACD) systems
 - IP telephones and workstations
 - Human machine interface (HMI).

To add a realistic perspective to the POC testing and demonstration, USDOT approached the PSAP community to participate in the POC effort. Three test laboratories and five selected PSAPs hosted the infrastructure for the NG9-1-1 POC demonstration. The three laboratory facilities that housed a majority of the NG9-1-1 infrastructure were—

- Booz Allen Hamilton Center for Network & Systems Innovation (CNSI), located at the One Dulles office in Herndon, Virginia
- Texas A&M Internet2 Laboratory, located in College Station, Texas
- Columbia University Next Gen Laboratory, located in New York, New York.

After completion of configuration and testing at the test bed locations, equipment and software was installed at the selected PSAP locations. The five PSAP locations were—

- City of Rochester—Emergency Communications Department, Rochester, New York
- King County E-911 System, Seattle, Washington
- Metropolitan Emergency Services Board—Ramsey County Emergency Communications Center, St. Paul, Minnesota
- State of Montana—Public Safety Services Bureau, Helena, Montana
- Kosciusko County 911, Warsaw IN.



1.1.3 Overview of the Testing Performed

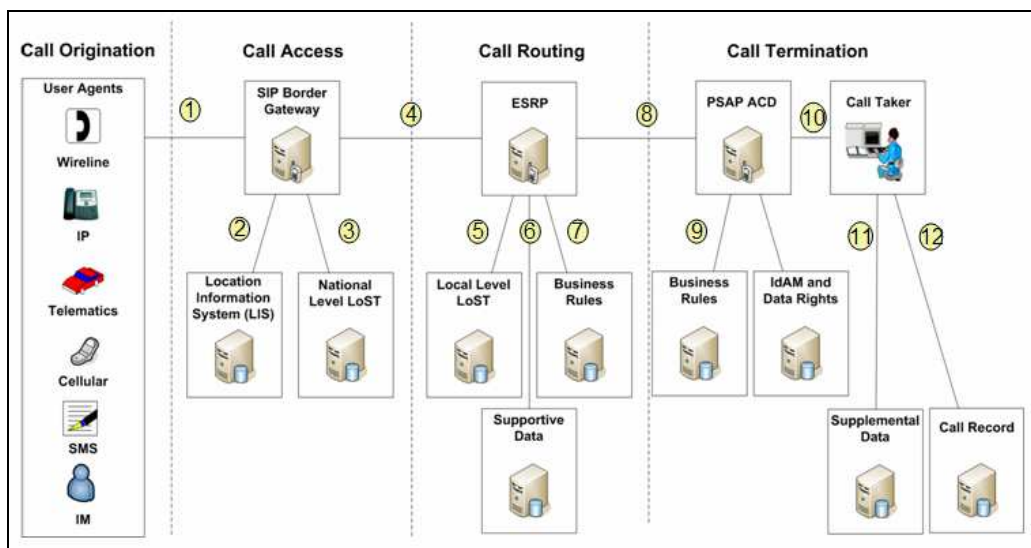
The testing process was based on the NG9-1-1 requirements document using the Tier 1 requirements. The requirements tested are grouped into two main segments: System Operations and PSAP Operations. The POC Test Plan was created to describe the detailed test processes to validate the functional requirements. By employing “use cases” or scenarios, the requirements have been integrated into industry-standard testing methodologies, which were applied to the laboratory test bed environment, the PSAP environment, and an end-to-end system test.

Segment	Use Cases Covered	Description
System Operations	Authenticate Call	Checks for the appropriate credential information against an authorization list
	Recognize Originating Location	Validates the location of the caller
	Recognize Call Type	Identifies the classification of calls (e.g., telematics, wireless, silent alarms, etc.).
	Route Call to PSAP	Routes a call to one or more appropriate PSAPs
	Provide Network Bridging Services	Conferences and shares data as appropriate and beneficial to call treatment, processing, and incident management
	Record Call	Captures call data in real time
PSAP Operations	Answer Call	Allows a call taker to respond to an indication of an incoming call
	Determine and Verify Location of Emergency	Queries caller about the location of the emergency
	Update Mobile Caller's Location Information (if caller is mobile)	Obtains more accurate location information for a mobile caller
	Determine Nature of Emergency	Obtains necessary information to route caller to the proper person/agency
	Identify Appropriate Responding Agency or Service	Identifies the appropriate agencies for incident response
	Obtain Supportive or Supplemental data post call delivery	Accesses Supportive (e.g., Automatic Crash Notification [ACN]) or Supplemental data (e.g., medical history, telematics, geospatial) after the call has been delivered to the PSAP
	Establish Conference Call	Establishes conference session with other entities as required or transfers caller
	Initiate Callback	Allows a call taker to attempt to reestablish contact with a caller
	Transfer Call with detailed Call Record Information	Transfers or forwards all media associated with an emergency call (voice, video, data) to authorized entities electronically

To accomplish testing, all tests used POC equipment, systems, and test data, and at no time, were live calls handled on the POC system or were the test calls sent to live 9-1-1 systems. To accommodate the sheer number of tests and limited testing staff, the testing occurred in phases. The most complicated components were housed at the various laboratory sites, and as a result, they were tested first by the project team. Subsequently, the individual PSAPs were tested, using trained participants from the host agency or organization.

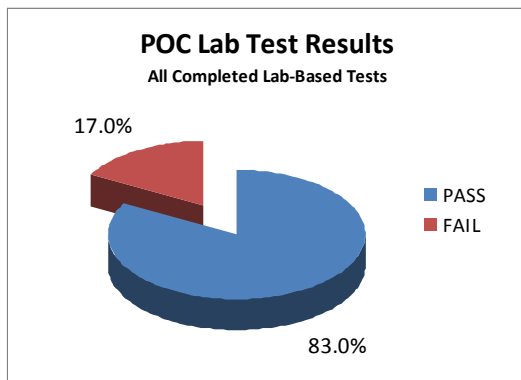
During the testing phases, each technology type (wireline, cellular, SMS, telematics, and IPUA) was used to deliver a call to the system. Call origination typically occurred from the laboratories, but due to the flexibility of the POC system configuration and the physical location of the testers, some calls were generated directly from the PSAP locations.

Regardless of technology being used, the Test Call followed the same general Call Flow. A call was originated from a lab or PSAP onto some form of access network (Step 1 in figure below). Within the access network, the location of the caller was acquired and additional call stream parameters were added, if these data elements were not already provided by the end user device (Steps 2,3). The system then used the location and call stream parameters to route the call through the NG9-1-1 system to the appropriate PSAP based on various NG9-1-1 business rules (Steps 4-8). If needed, additional call information could be obtained from external supportive data sources while the call was in transit (Step 6). The call was then terminated at a PSAP Automatic Call Distributor (ACD) where its call stream parameters were analyzed and subsequently the call was routed to the most appropriate Call Taker based on the Call Taker's availability and capabilities (Step 9-10). Once the call was terminated with a Call Taker, additional external supplemental data sources could be queried for further information and a comprehensive call record was created and stored to a Call Record database (Step 11, 12). For further details on the system architecture and design refer to the POC System Design Document.



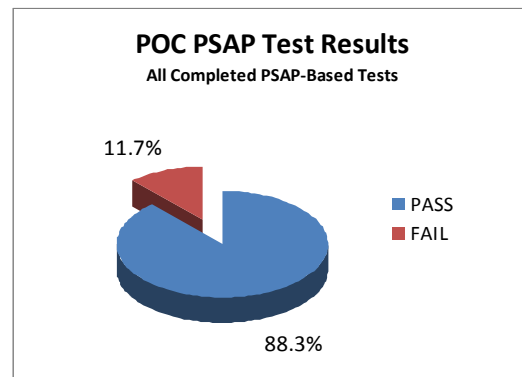
The NG9-1-1 POC was evaluated on several levels, both objectively and subjectively. Based on basic pass/fail criteria for each test, the system was graded to determine how it performed in a functional and operational manner. From a subjective perspective, feedback and input from the end users was recorded to provide for avenues of future study and investigation. Performance data was stored to measure how the NG9-1-1 POC system responded to the testing and can be used to identify opportunities to review and/or optimize future networks or systems.

The three laboratory sites were tested at the beginning of the POC, prior to any PSAP-based testing. Although the three laboratories housed the equipment, logically they operated as a single system. Seven use cases were tested at the laboratories, and testing



was completed by placing test calls to a workstation at the Booz Allen laboratory. During these initial tests, 47 requirements were tested, with 39 (83 percent) successfully passing. This lower pass rate can be attributed to the limited maturity of the POC software at the time of testing. The laboratory tests focused on the call setup and routing of calls, while the individual PSAP-based testing focused more on the call termination and handling.

At the 5 PSAPs, 26 professional call taker, dispatch, and supervisory personnel were trained to assist with the POC testing. Involving end users in the testing process provided a valuable benefit to the overall effort. These users were able to provide subjective feedback about functionality which someday they will come to depend on. Their input about their needs and the difficulties currently faced in today's 9-1-1 environment will help ensure that current problems are addressed by emerging NG9-1-1 technology. During the PSAP-based testing, 273 functional requirements were tested, with 241 (88.3 percent) successfully passing. While no industry benchmarks exist that gauge the success of emergency service network implementations, the team felt accomplished in having successfully demonstrated a significant portion of the NG9-1-1 concepts and use cases during the POC.



Based on the goals of the NG9-1-1 POC, the following summarizes the initial results—

High-Level Functional Component	Initial Finding
Ability to send and receive voice, video, text (Instant Messaging [IM], SMS), and data	Successfully Tested. The ability to receive and locate an SMS-based emergency call is not currently supported by the carriers, equipment, or technology. Upgrades and technological improvements will be needed at multiple levels.
Increased deaf/hearing-impaired accessibility	Successfully Tested. Streaming video from a mobile device is not currently supported by the carriers or devices. Upgrades and technological improvements will be needed at multiple levels. Ability to send video from a handheld device is important for the deaf/hearing-impaired community.
Caller's location identification	Successfully Tested. A number of different location acquisition and identification processes were used that helped demonstrate the functional capabilities to locate emergency callers. Other efforts already underway within the community will need to continue to identify best practices and standards for this critical function.
Call routing based on caller's location	Successfully Tested. Use of an ESRP and LoST servers, along with a Business Rules database, is a first in a real application environment. The POC results will help other organizations as they implement early NG-like solutions.
Transmitting telematics data (Advanced ACN), including speed, vehicular rollover status, and crash velocity	Successfully Tested. Working with a telematics service provider, the POC was able to demonstrate the ability to easily and automatically transfer important data associated with a vehicle accident. Display of all the data is a concern for end users, and efforts underway to leverage a small, distinct subset of the data to perform predictive injury analysis will provide a dramatic benefit for PSAPs and emergency responders to make both quicker and better decisions.
IP networking and security in an emergency communications environment	Successfully Tested. Although the use of industry-accepted best practices will be strongly encouraged for any NG9-1-1 system, much work is still needed to ensure the integrity of the network and system. While not included in the POC because of scope limitations, the use of an Identify and Access Management (IdAM) system should be vetted.

Overall, very positive feedback was received from the POC participants, both those involved in the testing and in the demonstrations. The POC helped to “de-mystify” NG9-1-1 by calming fears and answering pressing questions. The 9-1-1 community generally recognizes that a fundamental transformation of the way 9-1-1 calls are originated, delivered, and handled is slowly underway. The POC helped create a sense of urgency and movement within the community to get more involved and to start discussing the issues. The POC generated new discussions among stakeholder organizations—a key process to the success of NG9-1-1—and one that often does not occur today.

1.2 Scope

Limitations in available time and funding made it necessary to limit the technical scope of the POC. As a result, the project team focused its efforts on the 9-1-1 call from origination to delivery and handling by a public safety call taker. While recognizing that the needs of an emergency caller do not stop with the call taker, dispatch and field operations that support the emergency response were deemed outside the scope of the project. The scope limitations also narrowed the number of requirements tested as part of the POC.

A number of requirements require further evaluation, testing, and possible revision. In addition, it was necessary to simulate certain components of the POC, including—

- Integration with Emergency Providers Access Database (EPAD)
- Business Rules Database
- Integration with dispatch and responder agencies (e.g., computer-aided dispatch systems).

The scope of this document is limited to the process and results of testing the Tier 1 functionality of the USDOT NG9-1-1 system requirements. The testing took place during June and July 2008. Testing occurred in a manner consistent with the *POC Test Plan*, and results were recorded during the test process. Data was gathered during the testing process and later analyzed for recommendations and conclusions, which are presented in subsequent sections of this document.

1.3 Document Overview

This NG9-1-1 POC Test Report is organized into the following numbered sections:

- **1 Introduction**—This section presents an overview of the project and POC.
- **2 Methodology**—This section outlines the process and logistics of the POC testing.
- **3 Test Site User Training**—This section describes the training that was delivered to the test sites.
- **4 Initial Laboratory Site Testing**—This section outlines the testing that was conducted at each of the three laboratory sites.
- **5 PSAP Site Testing**—This section outlines the PSAP testing that was conducted at each of the selected PSAP sites.
- **6 Total System Testing**—This section outlines the testing that was conducted with the total system.
- **7 Demonstration Testing**—This section outlines the demonstrations that were conducted during the public demonstration phase.
- **8 Lessons Learned**—This section contains a description of lessons learned during the testing.

- **9 Compliance Matrix**—This section contains a summary of the test results in table format.
- **Appendix A—Acronyms**—This appendix contains acronyms used in the test plan document.
- **Appendix B—Glossary**—This appendix contains a glossary of terms used in the test plan.
- **Appendix C—Source Documents**—This appendix lists the documents used as references to develop the test plan.
- **Appendix D—POC Testing Results**—This appendix details the testing results from each test site.
- **Appendix E—POC Data Collection Results**—This appendix contains the results from the data collection detailed in the *Data Acquisition and Analysis Plan*.

2 Methodology

The POC testing was designed to test the high-level (Tier 1) requirements as developed and documented in the *NG9-1-1 Concept of Operations (CONOPS) and High-Level Requirements* documents. These requirements should not be considered an exhaustive list of all NG9-1-1 functional requirements but rather a fundamental set of requirements that form the baseline for future NG9-1-1 systems.

The NG9-1-1 POC system development lifecycle generated several documents that outline the functions of an NG9-1-1 system. As part of the development process, the NG9-1-1 team developed a set of use cases that covered the basic functions of an NG9-1-1 system. Each of these use cases was further decomposed into a set of requirements. These were documented in the *System Description and High-Level Requirements Document*. Based on these requirements, the *NG9-1-1 POC Test Plan* was developed.

The *NG9-1-1 POC Test Plan* lists each use case with its associated requirements. A test was then developed for each requirement. Each test associated with a requirement is described, along with the test procedure. For each requirement, the plan provided the following information—

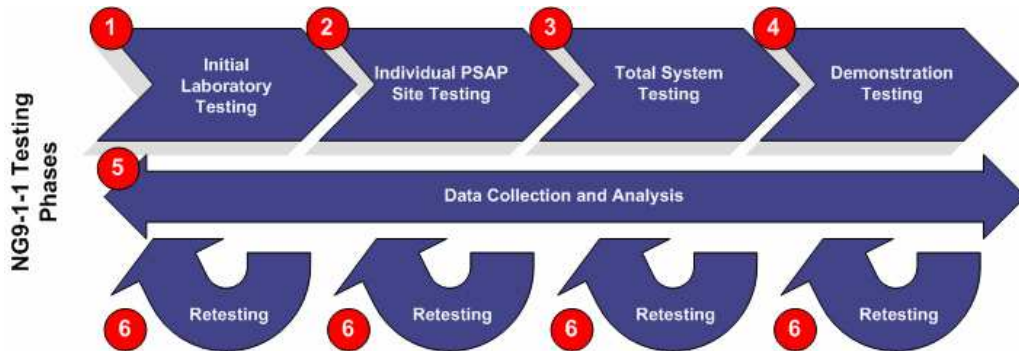
- **Test Description**—Brief overview of the test
- **Test Procedures**—Required test steps
- **Expected Results**—What was expected to happen
- **PASS/FAIL**—General indicator of success or failure of the test
- **Results**—Documentation of the test outcome.

While the plan provides a set of test steps associated with each requirement, there is considerable interrelationship among the requirements. Consequently, a single test call was often used to test more than one requirement at a time.

Since the System Test Plan was written before all development had completed, occasionally the test procedures did not accurately reflect the proper operation of the system. However, in many cases the actual functional requirement was still met by the software. When this occurred, the functional requirement received a PASS, and the details of how the requirement was met were added to the notes section of the test case in Appendix D.

Each test was rated as a PASS, FAIL, or NOT TESTED: PASS was assigned if the system was able to fully meet the requirement; FAIL was assigned if the system did not meet the requirement in its entirety; and NOT TESTED was used if no testing was conducted or the functionality was not developed in time for the functionality to be tested.

2.1 Testing Process



The testing proceeded in six phases using a top-down approach. Major NG9-1-1 POC functionality housed in the laboratories at Booz Allen Hamilton, Columbia University, and Texas A&M was tested first. Next, more detailed aspects of the call origination process were strategically tested at the five PSAP locations. Finally, the entire end-to-end system was comprehensively tested to ensure all Tier 1 functionality had been provided by the software development team. Once end-to-end testing was complete, the team conducted demonstration tests at the five PSAP locations. During all testing phases, the team also acquired data on the operation and performance of the NG9-1-1 POC system. Time was built into the testing process for retesting. As software issues were discovered, the software development team would fix bugs and release new versions of the software. The test team would then conduct basic acceptance testing of the new software release to ensure the problem had been resolved and that no new issues had arisen with the previously validated functionality. The following subsections (2.1.1–2.1.6) give an overview of testing process and its various phases. The subsequent sections (3–8) then go into further detail about each phase and discuss the findings and issues that were discovered during that specific phase of testing.

2.1.1 Initial Laboratory Site Testing

The laboratories were tested as a group to ensure that the main NG9-1-1 infrastructure they housed worked as intended. The seven most significant use cases were tested to ensure basic operation of the POC system. The Texas A&M and the Booz Allen CNSI laboratories originated calls using each technology type. Calls were answered using the call taker workstation located at the Booz Allen CNSI laboratory, which simulated the infrastructure that would eventually be housed at each of the five PSAPs.

2.1.2 Individual PSAP Site Testing

Each PSAP was tested individually as a separate operating entity. The equipment housed in the PSAPs was intended to work independently and was tested as such. In addition, no conference or transfer functionality was built into the software during this initial phase of PSAP testing. Nine use cases were tested at each PSAP. The test team went to each PSAP and conducted the tests for a 2-day period. The test team usually consisted of two team personnel and members of the PSAP staff. A development and support team was also located at the laboratory sites as support for call origination. During this phase, the

network-to-network connections were also demonstrated at the Indiana state system. All tests used POC equipment, systems, and test data. At no time were live calls handled on the POC system or were the test calls sent to live 9-1-1 systems.

2.1.3 Total System Testing

The total system was tested as a unit. The testing scripts developed for the *POC Test Plan* were modified for the actual testing with specific technologies and additional steps. Seven tests were developed and tested. During the 2-day test period, test team and PSAP personnel were present at each of the five PSAP locations, and the development and support team was located at the three laboratories.

2.1.4 Demonstration Testing

At the completion of testing, demonstrations were held to allow input from a variety of 9-1-1 stakeholders regarding the processes and systems of the NG9-1-1 POC. A demonstration was prepared that included graphical (animated) slides describing the processes that each call source used. These slides were used to visualize and explain the processes that occur prior to and following placement of the test call. Over a period of 3 weeks, seven demonstrations were conducted, one at each of the five PSAP locations, one at the Texas A&M Laboratory, and one at the Booz Allen Hamilton CNSI Laboratory.

2.1.5 Data Collection

Data for the POC were collected in accordance with the *Data Acquisition and Analysis Plan*. The details of the data acquisition during the POC and the analysis that was conducted are discussed in Appendix E of this document.

2.1.6 Retesting

The POC was a research and development project. Consequently, a series of software versions and changes to the systems were developed and integrated cyclically during the testing process. To support the demonstration timelines, retesting occurred in an ad hoc manner during the complete testing process and whenever key features were released by the software development team. Given the sheer number of changes to the software after PSAP testing, retesting was completed prior to moving into the end-to-end system testing or demonstration testing.

2.2 Testing Resources

The testing personnel, software versions, and schedules are described in the following paragraphs.

2.2.1 Testing Personnel

The testing personnel consisted of three groups of personnel:

- **The Testing Team** consisted of seven people who performed the testing at the various sites. One of the testing team staff was at the Booz Allen laboratory site to assist the test teams in the field for most of these tests. In general, during the

PSAP testing, two test team personnel were present at each site during the tests. During system testing, there was usually only one person at each site.

- **The PSAP Staff** was critical to the success of the testing. This staff operated the call taker workstation and provided feedback regarding the systems and processes during the testing.
- **The Development and Support Team** was available during the testing to troubleshoot problems and provide answers to technical questions. The development staff also made frequent updates to the systems and software as problems were discovered. The support staff also assisted by generating calls to the systems as needed to initiate or complete a test.

2.2.2 Software Revisions Tested

Several revisions and releases of the Call Taker HMI software occurred during the testing process. The table below outlines these revisions.

Revision Date (2008)	Changes Included
January 31	<ul style="list-style-type: none"> • Initial version <ul style="list-style-type: none"> – Basic HMI – Basic call handling (incoming INVITE/BYE/CANCEL)
February 14	<ul style="list-style-type: none"> • User interface (UI) upgrade <ul style="list-style-type: none"> – Text messaging
February 27	<ul style="list-style-type: none"> • Caller location handling
March 14	<ul style="list-style-type: none"> • Major UI upgrade • LoST query for responder lists • Call taker status handling • Basic call transfer
April 9	<ul style="list-style-type: none"> • UI upgrade (added popup screens) • SIP registration bug fix
April 11	<ul style="list-style-type: none"> • Video integration
April 15	<ul style="list-style-type: none"> • Google map integration
April 16	<ul style="list-style-type: none"> • Emergency location handling
April 23	<ul style="list-style-type: none"> • Call back function
April 24	<ul style="list-style-type: none"> • Real-time texting • Hold function
May 9	<ul style="list-style-type: none"> • UI upgrade <ul style="list-style-type: none"> – Timer (Call setup/duration/hold time) – Dial pad buttons – Speed dial buttons
May 13	<ul style="list-style-type: none"> • Links buttons for external materials • Telematics data handling • Fetching a call in call queue
May 30	<ul style="list-style-type: none"> • Emergency types, notes handling

Revision Date (2008)	Changes Included
June 3	<ul style="list-style-type: none"> • SMS with location • Pictometry integration • Standard operating procedure (SOP)/script based on emergency type
June 4	<ul style="list-style-type: none"> • Call transfer/conference with data
June 14	<ul style="list-style-type: none"> • Emergency location editing • Webpage link for call record, call recording, caller history, and call queue status
June 15	<ul style="list-style-type: none"> • Call transfer/conference with data
June 16	<ul style="list-style-type: none"> • SMS message recording
June 20	<ul style="list-style-type: none"> • Dial plan feature for external numbers • Call queue alerting
June 20	<ul style="list-style-type: none"> • WirelessWERX integration for cellular calls
June 24	<ul style="list-style-type: none"> • Rebid for SMS
June 28	<ul style="list-style-type: none"> • Video program crashing fixed
July 1	<ul style="list-style-type: none"> • Improve auto answering
July 9	<ul style="list-style-type: none"> • Final release <ul style="list-style-type: none"> – Location rebid fix

2.2.3 Scheduling

Given the research-oriented nature of the project, the *POC Test Plan* schedule was designed to allow for flexibility. The final testing schedule provided ample yet stringent timelines for the test team to travel to the various sites, test the NG9-1-1 infrastructure and its associated functionality, and then document the findings.

Test Site/Area	Planned Dates	Actual Dates
Booz Allen Laboratory (Test Team Training)	May 2008	May 13–15, 2008
Laboratory Site	May 2008	June 3–6, 2008 July 9, 2008
Individual PSAP	June 2008	June 16–17, 2008 June 19–20, 2008 June 23–24, 2008
Total System	June 2008	June 25–26, 2008
Demonstrations	July 2008	July 7–23, 2008
Data Collection	June 2008	June / July 2008
Retesting (If needed)	July 2008	Included in above testing dates

3 Test Site User Training

In preparation for the POC testing, the staff from each PSAP received a 4-hour block of training to use the call taker software. During this training, the PSAP staff provided feedback. The software was then revised based on the feedback. The training covered—

- USDOT NG9-1-1 Initiative Overview
- NG9-1-1 POC Overview
- POC Testing Logistics
- POC Software Overview
- POC Software Demonstration.

The following table lists the training dates, number of attendees, and comments from each site.

Site	Date (2008)	Number of Attendees	Feedback/Comments
King County, Washington	June 2	9	<ul style="list-style-type: none"> • How would abandoned calls be handled? • Shortcut keys would be helpful. • Transfers, when developed, should be a one-step process. • SMS calls give no indication to the call taker that the message was received by the caller. • Call taker was not able to call back wireless caller.
Helena, Montana	May 30	3	<ul style="list-style-type: none"> • Appears to be user friendly and intuitive. • Cannot close some additional information tabs. • Should add a “close all tabs” button. • Text does not clear after call. • Callback feature not working. • Video not received.
St. Paul, Minnesota	May 28	4	<ul style="list-style-type: none"> • Invitation template for the POC demonstrations would be helpful. • Because of connectivity problem, the software was not demonstrated.
Rochester, New York	May 28	6	<ul style="list-style-type: none"> • A telematics call was made and delivered voice and call data. However, supportive data were not sent. • When one of the Additional Info buttons was depressed, the system closed (call taker screens closed—went to log-on screen). • Add a pop-up screen when user releases a call—“Are you sure you want to release?” • Call Taker Status is too small on Telephone Controls Section screen.

Site	Date (2008)	Number of Attendees	Feedback/Comments
Indiana PSAP	May 30	4	<ul style="list-style-type: none"> • Indiana provided shape files which hold geospatial boundary information for the associated counties; Is the format compatible? Can they be used? • The system timed out, and the first few calls had audio problems. • On the cellular call, the screen blinked but the call did not connect. According to support staff, Indiana has an extra hop that may have caused the problem. A successful wireless call was made. • After releasing one call, the call duration time continued to add up. • Text message: <ul style="list-style-type: none"> – Could not send a text message during training but that feature did work during morning network test. – During retest, a successful call was made but Class of Service was "unknown." According to support staff, this occurred because an older version of the software had to be used to get the text to work. – During this test, the text screen had to be uncovered to see it. It did not pop up. • Additional info buttons were not linked to any file. • Telematics came in with audio and call data. The call mapped successfully, and supportive data was also delivered.

4 Initial Laboratory Site Testing

At the laboratory sites, seven use cases were used for testing. All three laboratory sites were tested at the same time. The requirements associated with the use cases below were tested from a workstation at the Booz Allen CNSI laboratory. The table and narrative below summarize the activities. Detailed test results are included in Appendix D of this report.

Use Cases Tested	Number of Requirements	PASS	FAIL	Not Tested
Identify Appropriate Responding Agency or Service [CP-IDRES]	11	5	3	3
Obtain Supportive or Supplemental Data Post Call Delivery [CR-OSSDT]	9	7	0	2
Recognize Originating Location [CT-ROLOC]	3	3	0	0
Recognize Call Type [CT-REGCT]	8	6	0	2
Route Call to PSAP [CT-RTPSP]	14	8	3	3
Provide Network Bridging Services [CT-PNWBS]	11	8	2	1
Call Authentication [CT-CAUTH]	2	2	0	0

June 4–5, 2008

On the scheduled testing dates, the software was not fully completed. The testing team used the testing time to familiarize itself with the software and systems to be used for the POC. The team reviewed the test scripts and determined items that needed to be completed. These tests were not documented on the test scripts; rather, input was provided to the development team for further refinement of the systems and software.

June 12, 2008

The testing team began the testing by updating the Call Taker HMI software to the June 6, 2008, 10:24:12 p.m. version. The testers then reviewed the latest version of software and placed initial test calls to familiarize themselves with the functionality. The test scripts were completed. A few areas of the software testing was not completed:

- Bridging was not fully implemented.
- Video errors caused the video calls to freeze.
- Call queuing was not working.
- Some data was not being saved to the call detail record.

July 9, 2008 Retesting

The testing team began the testing by reviewing the software and initial test calls. The Sipcalltaker software version tested was July 3, 2008, 7:03:08 p.m. This testing completed the tests that had not been completed in prior test sessions. There were some problems during the testing with slow response from services on the network, and therefore, the testing was completed with the Booz Allen firewall removed.

5 PSAP Site Testing

Each of the five PSAP test sites was tested with a set of test scripts. These scripts were detailed in the *POC Test Plan*. This section summarizes the activities and results. The detailed test results are included in Appendix D of this report.

5.1 King County, Washington, PSAP Site Testing

At the King County PSAP site, the requirements associated with the nine use cases listed below were used for testing. During testing, the PSAP staff was involved and performed many of the tester functions.

Use Cases Tested	Number of Requirements	PASS	FAIL	Not Tested
Obtain Supportive or Supplemental Data Post Call Delivery [CR-OSSDT]	9	4	0	5
Answer Call [CA-ANSCL]	12	7	3	2
Initiate Callback [CA-INTCB]	2	2	0	0
Determine Nature of Emergency [CP-DTNAT]	5	5	0	0
Determine and Verify Location of Emergency [CP-VFLOC]	4	2	1	1
Update Mobile Caller's Location Information [CP-UCLOC]	7	1	0	6
Establish Conference Call [CP-ECONF]	8	3	0	5
Record Call [CP-RCCAL]	20	18	0	2
Transfer Call Records [CR-TRCIN]	0	0	0	0

The test equipment was located in the offices of the King County E9-1-1 Program Office. The various PSAPs in the King County system provided dispatch staff to operate the call taker workstation during the testing.

PSAP testers provided significant feedback, including—

- The screen refreshed inappropriately after a call was automatically received.
- Call details did not update after HOLD was activated.
- The call queue was not under the active call screen.
- Sound volume for recorded calls of people on HOLD was too low.
- Sipcalltaker reused the last touched Internet Explorer© window to update the map information rather than using a dedicated application instance.
- There did not seem to be an indication to the call taker when the caller dropped the call from his/her end.
- Each time a note in the call detail report was generated, it re-displayed all previous information in the screen, whereas call takers would expect a simple timestamp and the new note entry.

- When location information was updated for the call, another location table was created in the log detail area rather than appending changes to one location table.
- A unique identifier for each call should be attached to the call so two people can ensure they are talking about the same thing when looking at logs or playback.
- More hyperlinks should be enabled from the call detail report, such as a map of the location information.
- In the future, call takers should have the ability to check databases, such as the National Law Enforcement Telecommunications System (NLETS), National Crime Information Center (NCIC), or local databases, regarding the reporting party or subjects.

5.2 Helena, Montana, PSAP Site Testing

At the Helena PSAP site, the requirements associated with the nine use cases listed below were used for testing. During testing, the PSAP staff was actively involved and performed many of the testing functions.

Use Cases Tested	Number of Requirements	PASS	FAIL	Not Tested
Obtain Supportive or Supplemental Data Post Call Delivery [CR-OSSDT]	9	4	0	5
Answer Call [CA-ANSCL]	12	8	3	1
Initiate Callback [CA-INTCB]	2	2	0	0
Determine Nature of Emergency [CP-DTNAT]	5	5	0	0
Determine and Verify Location of Emergency [CP-VFLOC]	4	2	1	1
Update Mobile Caller's Location Information [CP-UCLOC]	7	7	0	0
Establish Conference Call [CP-ECONF]	8	4	1	3
Record Call [CP-RCCAL]	20	17	0	3
Transfer Call Records [CR-TRCIN]	0	0	0	0

The test equipment was located in an equipment room of a telecommunications provider. The PSAPs in the area provided staff to operate the call taker workstations during the testing and provided feedback.

June 19, 2008

The software version built on June 18, 2008, at 10:43:03 p.m. was used. An initial conference bridge was established with the Rochester NY PSAP test site and the Booz Allen CNSI laboratory. A cellular telephone was used because there was no wireline conference bridge telephone at the Helena site. A brief overview of the POC, the screen, and the various available functions and features was conducted.

PSAP testers provided feedback on call taker software functions, including—

- A recommendation was made to provide functionality that would automatically take a call off hold if it had been on hold for defined time (such as 2 minutes).
- The call taker should be able to enter answers when going through the scripts (POC did not have this feature).
- Stakeholders commented that all of the provided data might not be relevant for the call taker or medical first responders—call takers would process call in the same manner. The stakeholders questioned why some data was listed.
- It was suggested that call takers should be able to use the appropriate telematics-provided data to run inquiries via state NLETS-related systems. Moreover, it would be helpful to be able to use supportive/supplemental data to run inquiries to other external/internal databases.
- Call takers wanted to know whether POC NG9-1-1 software could send a reply message to a text message initiator indicating that a text message was received. Consensus of the group was that this should be possible for all calls.

June 20, 2008

The software version built on June 20, 2008, at 2:19:41 a.m. was used. An initial conference bridge was established with the Rochester NY PSAP test site and the Booz Allen CNSI laboratory. Cellular telephones were used because there was no wireline conference bridge telephone at the Helena site.

PSAP testers provided feedback on call taker software functions, including—

- Outgoing calls from the PSAP were not stored in call records.
- Color could be improved so data (such as caller location, etc.) would stand out better. Background color could be improved in the data area associated with a call, and buttons/toggles should change colors when the cursor is passed over them and when the buttons/toggles are in use. (Different colors would be better than just shades of a single color.)
- It was suggested that call takers should have the ability to change the latitude/longitude to another view than that delivered; this would aid those who use other display methods for latitude/longitude in other systems (such as the degree/minute/second measurement system that some Global Positioning System [GPS] units use).

June 25, 2008

The software version built on June 24, 2008, at 11:57:27 p.m. was used. Retesting took place to complete tests not previously conducted.

5.3 St. Paul, Minnesota, PSAP Site Testing

At the St. Paul PSAP site, the requirements associated with the nine use cases listed below were used for testing. During testing, the PSAP staff was involved and performed many of the tester functions.

Use Cases Tested	Number of Requirements	PASS	FAIL	Not Tested
Obtain Supportive or Supplemental Data Post Call Delivery [CR-OSSDT]	9	5	0	4
Answer Call [CA-ANSCL]	12	8	3	1
Initiate Callback [CA-INTCB]	2	2	0	0
Determine Nature of Emergency [CP-DTNAT]	5	5	0	0
Determine and Verify Location of Emergency [CP-VFLOC]	4	2	1	1
Update Mobile Caller's Location Information [CP-UCLOC]	7	0	0	7
Establish Conference Call [CP-ECONF]	8	5	3	0
Record Call [CP-RCCAL]	20	17	0	3
Transfer Call Records [CR-TRCIN]	0	0	0	0

The test equipment was located on the PSAP's dispatch floor. The PSAP provided staff to operate the call taker workstation during the testing and provided feedback.

June 16, 2008

The software version built on June 15, 2008, at 9:52:17 p.m. was used. Feedback included the following:

- Requirement D.8.10 should be reworded to indicate that the call taker screen should be refreshed, not the call detail record.
- Requirement D.11.2 should be reworded. The system automatically placed the initial caller location information into the emergency location fields of the HMI screen, but the emergency location was added to the call detail record only if the information was changed on the screen. The changed information entered by the call taker did not appear to update the call stream as shown by the SIP message tool.
- The read-only fields were grayed out. It was suggested that users tend to ignore items that are grayed out.

June 17, 2008

The software version built on June 15, 2008, at 9:52:17 p.m. was used. Feedback included the following:

- Call Detail Records should display with the most current record first.
- Address/Location entry box should be formatted in a logical manner.

5.4 Rochester, New York, PSAP Site Testing

At the Rochester PSAP site, the requirements associated with the nine use cases listed below were used for testing. During testing, PSAP staff was involved and performed many of the tester functions.

Use Cases Tested	Number of Requirements	PASS	FAIL	Not Tested
Obtain Supportive or Supplemental Data Post Call Delivery [CR-OSSDT]	9	5	0	4
Answer Call [CA-ANSCL]	12	10	2	0
Initiate Callback [CA-INTCB]	2	2	0	0
Determine Nature of Emergency [CP-DTNAT]	5	5	0	0
Determine and Verify Location of Emergency [CP-VFLOC]	4	2	1	1
Update Mobile Caller's Location Information [CP-UCLOC]	7	7	0	0
Establish Conference Call [CP-ECONF]	8	7	1	0
Record Call [CP-RCCAL]	20	17	2	1
Transfer Call Records [CR-TRCIN]	0	0	0	0

The test equipment was located in the Training/Emergency Operations Center (EOC) room at the Rochester PSAP. The PSAP provided staff to operate the call taker workstation and provided the following feedback:

- The ability to automatically see calls in queue would be preferred. Tester had three calls in queue but no data in Call Queue. On a second attempt, after two calls were made, the Call Queue refreshed and two calls were listed in queue.
- Additional calls in queue could not be answered until the first call was released.
- Audio and video recorded the caller while the call was “on busy” and on hold.
- Call takers suggested the system should display a pop-up screen asking “Are you sure?” before a call was released.
- Call taker “Ready” or “Available” status was too small.

5.5 Indiana PSAP Site Network-to-Network Testing

At the Indiana PSAP site, the requirements associated with the nine use cases listed below were used for testing. During testing, PSAP staff was involved and performed many of the tester functions.

Use Cases Tested	Number of Requirements	PASS	FAIL	Not Tested
Obtain Supportive or Supplemental Data Post Call Delivery [CR-OSSDT]	9	3	0	0
Route Call to PSAP [CT-RTPSP]	14	4	3	7
Answer Call [CA-ANSCL]	12	9	3	0
Initiate Callback [CA-INTCB]	2	2	0	0
Determine Nature of Emergency [CP-DTNAT]	5	5	0	0
Determine and Verify Location of Emergency [CP-VFLOC]	4	2	1	1



Use Cases Tested	Number of Requirements	PASS	FAIL	Not Tested
Update Mobile Caller's Location Information [CP-UCLOC]	7	2	1	4
Establish Conference Call [CP-ECONF]	8	7	1	0
Record Call [CP-RCCAL]	20	17	1	2
Transfer Call Records [CR-TRCIN]	0	0	0	0

The test equipment was located in the Training/EOC room at the Kosciusko County PSAP in Warsaw, Indiana. The PSAP provided staff to operate the call taker workstation and provided the following feedback:

- The provided mapping information could not be used on the call taker workstations during testing.
- After an SMS message was received, Call Taker Status had to be manually changed to “available.”
- Caller heard music in background on IP UA calls.

6 Total System Testing

After completion of the component testing in the laboratory and PSAP testing phases, the total system was tested. This testing consisted of processing calls through the complete system and recording the results. During the testing, the PSAP staff was involved and operated the call taker workstation. This testing took place on June 25–26, 2008.

On June 26, 2008, the test sites were offered the opportunity to invite local agencies to observe the testing. Several sites took advantage of this chance to showcase the testing that was occurring at their respective PSAPs.

To cover all of the possible scenarios, the PSAPs were configured to use the following answer types and transfer points. A PSAP whose Answer Type was designated as “Manual” relied on Call Takers to physically acknowledge and accept incoming calls. Alternatively, a PSAP also had the option of designating an “Automatic” Answer Type in which the IP ACD and Call Taker Software worked autonomously to acknowledge and answered incoming calls and then direct them to the appropriate Call Taker.

PSAP	Answer Type	Transfer to:
King County, Washington	Manual	Helena, Montana
Helena, Montana	Manual	St. Paul, Minnesota
St. Paul, Minnesota	Automatic	Rochester, New York
Rochester, New York	Automatic	Indiana
Indiana	Manual	King County, Washington

The basic scripts were broken down into three sections:

- Call Setup
- Call Handling
- Data Handling.

These sections of the test scripts were developed to cover each of the Tier 1 requirements. The use cases covered in each section of the test script are listed below.

Test	Use Cases Covered
Call Setup	<ul style="list-style-type: none"> • Call Authentication • Recognize Originating Location • Recognize Call Type • Route Call to PSAP
Call Handling	<ul style="list-style-type: none"> • Answer Call • Determine and Verify Location of Emergency • Determine Nature of Emergency • Identify Appropriate Responding Agency or Service • Establish Conference Call • Provide Network Bridging Services

Test	Use Cases Covered
Data Handling	<ul style="list-style-type: none"> • Update Mobile Caller’s Location Information (if caller is mobile) • Record Call • Obtain Supportive or Supplemental Data post call delivery • Initiate Callback • Transfer Call Record

The specific test scripts that were used for each use case were changed from those described in the test plan. The table below summarizes the technologies tested. The detailed test results are included in Appendix D of this report.

Technologies Tested
Process Wireline Call
Process Cellular Call
Process Intelligent IP Call (Voice, Video, & Text)
Process SMS Text Message
Process Telematics Call
Process Extended Transfer of Calls
Business Rules Test

During the second day of total system testing, the system was used by all five PSAP locations as well as the three laboratory sites. This did put stress on the systems, and some problems were experienced, which are described below.

Network Response Time Extended

Call takers began to report that the call taker workstation software took a second or more to refresh the screen with the caller’s information when they answered a call. They also noticed some of the other screens (Map, Call Detail Record) were slow to open.

Loss of SMS Calls

Several SMS calls were not delivered or delivered to the default PSAP many hours later. Troubleshooting was done to debug these issues. During the demonstration testing, further information was gathered to assist in the resolution. This is discussed in the demonstration testing section.

6.1 King County, Washington, PSAP Site Testing

POC site testing took place on June 23–25, 2008, at the King County facility. Total system testing was held on June 26, 2008, at the same facility.

Execution of test scripts for the total system went well. However, network problems slowed the testing. On one day of testing, calls could not be processed at the start of morning testing. The development team was contacted, and the IP ACD software at the

PSAP was shut down and restarted. During IP User Agent (IPUA) device calls, the video call stream would lock up after several minutes of use.

There were no further problems with the testing. Testing continued normally the rest of the time at the site and training was conducted successfully.

During the testing a different group of attendees participated each day. Each group attending was given an overview of the USDOT POC and a PowerPoint description of how the systems operate before the attendees spent some hands-on time taking test calls. The reaction by all groups attending was positive.

6.2 Helena, Montana, PSAP Site Testing

Execution of test scripts for the total system testing went well. However, network problems slowed the testing, as well as the coordination of the testing with the five PSAP and two laboratory sites that were actively involved in the testing. Testing was completed by the testing staff; no PSAP staff members were scheduled to participate on these test days.

The testing workstation used the software build of June 24, 2008, 11:25:27 a.m.

No PSAP demonstrations were held at this site during the system testing.

6.3 St. Paul, Minnesota, PSAP Site Testing

On June 25, 2008, there was no connectivity for the system in St. Paul at the start of testing. Support staff worked to establish connectivity. The steps taken can be summarized as follows:

- Upon arrival at the St Paul Center on June 25, staff looked at the local router and found the T1 leased line was dead. At about 8:30 a.m., they reported the bad circuit to the TMAC (AT&T dedicated State of Texas trouble desk.). A ticket was opened with ASI (AT&T national backbone network group), which isolated it to a Qwest local loop in St. Paul. A Qwest trouble ticket was opened and a local technician was dispatched. (The router and network management system [NMS] logs indicated that the St Paul T1 had gone down at about 1:00 p.m. on Tuesday.)
- At about 1:00 p.m., the Qwest technician arrived and opened the line at the Central Office, performed a set of time domain reflectometer tests and found the incoming wire pair to be good. He reconnected the line but the circuit still did not come up. He then did a visual inspection of the connection in the local cross-connect box because he suspected a bad connection. After reconnecting the local block, the circuit came up and tested error free.
- The link was reestablished at about 2:15 pm.

There were four visitors at the Ramsay County PSAP on June 25 from 1:30 to 3:00 p.m. Three were from the Fargo North Dakota PSAP, and one was from the Metropolitan

Emergency Services Board. The visitors arrived just as total system testing commenced and viewed the testing as it progressed through the scripts. They asked many next generation concept questions while the test team worked with the PSAP call taker on the system testing scripts. They were pleased with what they saw of the system testing.

6.4 Rochester, New York, PSAP Site Testing

On 6/25/2008 test calls were transferred from the Rochester PSAP to Seattle, then to Montana, then to Indiana, and finally back to Rochester. The notes that were added to the call on the cellular and IP UA device tests were not received. On the wireline call, Seattle and Montana successfully added and passed notes to the other PSAPs.

On June 26, 2008, at 1:00 p.m., approximately 30 invitees were given a short PowerPoint presentation on the USDOT NG9-1-1 POC project and the POC software overview, followed by a software demonstration (Total System Test).

After the presentation, the test team made two successful outbound calls. The tester called a telephone on the system and a cellular telephone not on the system.

6.5 Indiana PSAP Site Network-to-Network Testing

Execution of the test scripts for the total system testing went well. However, network problems slowed the testing, as well as the coordination of the testing with the five PSAP and two laboratory sites that were actively involved in the testing. Testing was completed by the testing and PSAP staff.

No PSAP demonstrations were held at this site during the system testing.

7 Demonstration Testing

The demonstration tests were similar to the total system tests but limited in number. Only seven technologies were demonstrated, and testing consisted of processing calls through the complete system. During the testing, the PSAP staff was involved and performed many of the tester functions.

Technologies Tested
Process Wireline Call
Process Cellular Call
Process Telematics Call
Process SMS Text Message
Process Intelligent IP Call (Voice, Video, & Text)
NG9-1-1 Transfer of Voice and Data
Override Rules

Site	Date (2008)	Number of Attendees
King County, Washington	July 15	58
Helena, Montana	July 11	12
St. Paul, Minnesota	July 17	> 22
Rochester, New York	July 8	~30
Indiana PSAP	July 10	22
Texas A&M Laboratory	July 23	~25
Booz Allen CNSI Laboratory	TBD	~30

7.1 King County, Washington, PSAP Site

July 15, 2008

The demonstration kicked off with a short introduction by the King County Executive. There were 58 people in attendance, including representatives from 3 local television stations and 1 newspaper. Two members of the Washington Office of the Deaf and Hard of Hearing were also in attendance. Press packets were distributed by King County.

The prepared slides were presented in two sections—the NG9-1-1 overview and the call flow of the demonstration calls. All live presentations functioned correctly and were received well by the audience. The three television stations recorded the event.

Several questions were raised and responded to after the presentation:

- When asked if this POC would be the standard for NG9-1-1, the test team stated that this was a proof of concept to illustrate what was possible. Other organizations would be responsible for setting standards.
- There were inquiries about several NG9-1-1 features that were not part of the POC, including receipt of still pictures from cellular telephones. The test team stated that these features were not currently included in the POC. The team

restated that this was a proof of concept and that these features would have to be studied and integrated into production systems of the future.

The audience enjoyed the presentation.

After completion of the demonstration, the two representatives from the Office of the Deaf and Hard of Hearing had several specific questions about the video and texting applications as they pertained to NG9-1-1 and which organizations were involved in setting the standards. The test team answered their questions through an interpreter for about an hour.

7.2 Helena, Montana, PSAP Site

July 11, 2008

There were 12 attendees at the demonstration, including the Lieutenant Governor of Montana who introduced the demonstration. Also in attendance were staff from the Governor's office, state and local public safety departments, and one television station.

The prepared presentation reviewed the NG9-1-1 project and described the call flow of the call types that were demonstrated. Two testing team members presented the information and fielded questions from the audience. A Helena PSAP staff member operated the call taker workstation during the presentation.

The local television reporter recorded the presentation and demonstration and held interviews with selected people.

7.3 St. Paul, Minnesota, PSAP Site

July 17, 2008

There were 22 people attending the presentation and demonstration representing the Governor's office, U.S. House of Representatives, State Senate, State House, State Patrol, Minnesota Department of Public Safety, Metropolitan Emergency Services Board, Ramsey County Board, and Ramsey County PSAP.

The prepared presentation reviewed the NG9-1-1 project, and described the call flow of the call types that were demonstrated. Two testing team members presented the information and fielded questions from the audience. A Ramsey County staff member operated the call taker workstation during the presentation.

The local CBS TV affiliate sent a reporter and cameraman who recorded the presentation and demonstration and held interviews with selected people. A report was to be presented on a local newscast in the next couple of weeks.

7.4 Rochester, New York, PSAP Site

July 8, 2008

Prior to the demonstration, the test team ran the system and successfully tested all devices, including several video calls. At approximately 11:00 a.m., the PSAP had a generator malfunction that cut off all power to the room where the demonstration was to be held. Power was restored, and the POC workstations were brought back on line.

At 1:00 p.m., the POC demonstration was held, with approximately 30 attendees and representatives from the television and print media.

After the NG9-1-1 PowerPoint presentation, tests were conducted on all the communication devices. Successful calls were made with a wireline telephone. The cellular telephone call, which included location data updates that simulated a mobile cellular call, was successfully tested. A telematics call was successfully completed. The IP UA device delivered voice communication but video and text calls were not delivered. There seemed to be a problem with the network.

Many of the attendees expressed interest in the next step after the USDOT POC.

7.5 Indiana PSAP Site

July 10, 2008

The demonstration took place in Warsaw, Indiana (Kosciusko County). More than 22 people attended, including Indiana governmental and public safety personnel, as well as several press representatives. The latter included representatives from television channels 15, 21, and 33 (all major networks) from Fort Wayne, and the Fort Wayne and Warsaw newspapers.

Major governmental attendees included the Chairman of the Indiana Utility Regulatory Commission (IURC), several other IURC leaders, a State Senator, the Indiana Chief Deputy Treasurer, and the Indiana State 9-1-1 Coordinator. A number of County 9-1-1 directors, police chiefs, and sheriffs attended.

After the overview of the USDOT NG9-1-1 project, all demonstration use cases were successfully performed for the audience, including text and video communication. Because Indiana has implemented a statewide IP network (currently supporting cellular E9-1-1 service), many of the attendees were aware of IP networking in general and, more specifically, its role as the base for future NG9-1-1. There were few questions from the audience.

Several project team members were interviewed by television and press representatives, resulting in at least a 2-minute story on TV 15 Fort Wayne, and newspaper coverage. After the demonstration, several attendees offered opinions that the demonstration went smoothly and was effective in information delivery.

7.6 Texas A&M Laboratory Site

July 23, 2008

The demonstration was performed at Texas A&M laboratory site in College Station, Texas. There were approximately 25 attendees, including a member of the state legislature, the Texas 9-1-1 Alliance Director, several County 9-1-1 directors, representatives from the project team agencies, and members of the press.

All calling use case examples were successful, with the exception of SMS text test. Involvement of the Texas A&M Internet2 Technology Evaluation Center in the USDOT NG9-1-1 project was emphasized, as well as related IP emergency communications development in Texas.

Project team members were interviewed by television and press representatives.

8 Lessons Learned and Future Research

8.1 Introduction

The USDOT NG9-1-1 initiative was one of the first federally funded studies that attempted to comprehensively define and document a future vision for 9-1-1 systems. Its goal was to provide a framework for future 9-1-1 systems that would allow any person access to emergency services from any device, anytime, anywhere. The NG9-1-1 initiative followed the complete system development lifecycle from CONOPS, to system requirements, to implementation. While the NG9-1-1 initiative successfully answered many pressing questions and proved out many futuristic concepts, as with any project, its scope was limited by time and money. This section documents many of the issues and lessons learned from the POC and hopefully provides a starting point for future NG9-1-1 efforts.

Before actually discussing the numerous lessons learned from this project, it is important to highlight that one of the most significant findings of the POC was how diverse and complex the 9-1-1 community is and how much work there is to still be done. The USDOT NG9-1-1 project team worked with a variety of organizations, including emergency service personnel (i.e., dispatchers, responders, etc.), industry vendors, and standards development organizations (SDO). All stakeholders shared a common bond stemming from the importance of their mission and their desire to help people in their time of need. However, hampering this mission is the community's overall lack of effective ways to communicate and collaborate. The USDOT initiative made significant headway by actively seeking the input of all of these groups to the project, sharing its efforts on an Internet website, and attending numerous meetings and conferences to conduct updates on the project.

It is imperative that this concept of information sharing continue to flourish and grow in the 9-1-1 community. There is definitely a need for a common location where stakeholders can collaborate and share information from past, present, and future NG9-1-1 efforts. Whether it be a repository, wiki, or combination thereof, all this information should continue to be open and available to all stakeholders. Providing a platform for communication will guarantee an increase in information sharing, leading to decreased cost and increased quality and interoperability of 9-1-1 systems. It will provide a place of recognition and scrutiny for all NG9-1-1 efforts and ensure that the 9-1-1 stakeholder community does not repeat past difficulties. At the conclusion of the NG9-1-1 Initiative, all results transition to the E9-1-1 Implementation Coordination Office (National 9-1-1 Office), which is charged by Congress with multiple responsibilities, including that of an information clearinghouse. The promotion of USDOT efforts toward NG 9-1-1 will continue through the National 9-1-1 Office.

8.2 Operational Issues

Over the course of the POC the following operational issues were raised or discovered by the various NG9-1-1 stakeholders and project team. For a successful transition to NG9-1-1 technology and systems all these issues will need to be addressed.

Lesson Learned / Issue Identified:	Process for Handling Abandoned, Lost, and Dropped Calls
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Government and Regulatory Administrations • Academic Research communities • Telecommunication Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

Regardless of the safeguards put in place, no system will operate 100-percent reliable all of the time. However, given the time-sensitive nature and importance of 9-1-1 services, there must be processes and procedures put into place when a system operates unexpectedly. As a call traverses an NG9-1-1 system, it must interact with an increased number of system components. These multiple components provide advanced functionality but also increase the risk of an abandoned, lost, or dropped call. To mitigate this risk, further research must be done regarding ways of logging calls as they traverse the system and informing call takers when unexpected behavior occurs within the system.

Lesson Learned / Issue Identified:	Call Taker Interactions with SMS Messaging
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • Government and Regulatory Administrations • Telecommunication Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

SMS has proliferated as a preferred method of mobile communication. Given NG9-1-1’s mission and objective of “any device anywhere anytime,” it is desirable to provide call takers with the ability to receive SMS emergency calls. However, SMS’ unreliable and connectionless properties raise new issues when considering the process by which call takers handle SMS emergency calls.

- Which call taker handles the call?
- What type of lexicon is used?
- Does SMS tie up call taker resources like a traditional call?
- Can a call taker handle multiple SMS calls at one time?
- When is call taker finished with an SMS emergency call?
- Can SMS become a reliable service through the use of acknowledgements?

These, as well as a variety of other issues, must be vetted in the community before this technology can be successfully handled in the PSAPs of the future.

Lesson Learned / Issue Identified:	Concept of Operations for Business Rules, Policy-Based Routing, and NG9-1-1 System and Software Configuration
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Government and Regulatory Administrations • NG9-1-1 Network and System Designers • National 9-1-1 Organizations (NENA, APCO, etc.)

The *NG9-1-1 Concept of Operations and Systems Requirements* documents identified a variety of functionality deemed “Business Rules.” Based on a review of the requirements documents, there are two types of Business Rule. A policy-based business rule is a decision the NG9-1-1 system makes when handling or processing a call. This, in turn, typically affects how a call is routed or queued within the system. A second type of business rule refers to the configuration of software and/or components within the NG9-1-1 system that affects how a call taker interacts with a call. These rules typically relate to the configuration properties of the call taker HMI and accessibility of data for the call taker. While this functionality can all fall under the umbrella of NG9-1-1 System Configuration, work must be done to detail these concepts and further define how the system is configured and how it routes calls. For the POC, the ability to override where a call terminates and the ability to route calls based on their call type were demonstrated. In addition, the call taker HMI had a preferences and configuration screen. More exhaustive work is needed to effectively define NG9-1-1 business rules and their associated functionality.

Lesson Learned / Issue Identified:	Integration of Telematics Automatic Crash Notification (ACN) Data and Criticality Metric Determination
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • Academic Research communities • Telematics and Third Party Data Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

The rapid integration of cutting-edge technology is one of NG9-1-1’s major benefits. The automotive industry is increasingly equipping their vehicles with more sophisticated systems and sensors. Given the number of trauma-related fatalities associated with the Nation’s highways, it is imperative that PSAP call takers be able to respond to automotive crashes in a timely and effective fashion. The NG9-1-1 POC demonstrated the ability to associate telematics data with an emergency call. However, more detailed research should be done in the field of telematics integration. The ability to determine the criticality of an accident while the call is in transit, route the call accordingly, adjust the priority level of the call if it is placed in queue, and automatically conference in EMS



staff are just a few of the capabilities that were identified but not expanded upon during the POC efforts.

Lesson Learned / Issue Identified:	Automatic Third-Party Conferencing
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Telematics and Third Party Data Service Providers • NG9-1-1 Network and System Designers • National 9-1-1 Organizations (NENA, APCO, etc.)

In NG9-1-1, additional data are associated with an emergency call that can enable new services for the caller and call taker. Occasionally, callers required specialized services to enable effective communication and rapid response time. A potential new feature of NG9-1-1 systems is the ability to automatically bring third parties into a call. This is vital for individuals in the deaf or hard of hearing community, those who require foreign language interpreters, or during times when a specialist is needed (i.e., medical, structural, psychological, managerial, etc.).

Lesson Learned / Issue Identified:	Effective Demonstration of Sensor Data Integration into PSAP Operations Centers
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • Telematics and Third Party Data Service Providers • NG9-1-1 Network and System Designers

NG9-1-1 provides the ability to accept emergency calls from both human and automated sensor systems. This can include medical devices, home alarms, building and bank security systems, weather sensors, etc. This raises a variety of operational issues because PSAPs are now able to accept an enormous amount of new data and call types. How these calls are handled and routed in the system, the data that are associated with these calls, and the responsible agency or authority must all be determined. The NG9-1-1 POC only scratched the surface in defining this use case. Further evaluation, demonstration, and implementation are necessary.

Lesson Learned / Issue Identified:	Definition of a Flexible, Authoritative Hierarchical Governance and Operation Model for Call Handling and Routing in NG9-1-1
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • Information standards development and professional organizations • Government and Regulatory Administrations • Telecommunication Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

The current 9-1-1 system has more than 6,600 PSAPs geographically spread across the country. For the most part, operations and authoritative decision making occurs at a local

or county level thus hampering interoperability and coordination. This grassroots operational model is not effective and does not utilize the functionality of an NG9-1-1 environment. Fundamentally, built into the NG9-1-1 architecture and technology is a hierarchical governance model. Using standards-based technology, local PSAPs will be able to interoperate with surrounding counties if they coordinate efforts. Those counties will be able to interoperate statewide, and all states will be able to interoperate at a national level, assuming the necessary coordination. Accomplishing this increased coordination, given the divergent 9-1-1 funding models, will be difficult; however, given the flexibility of the technology, it is still possible. The POC demonstrated a two-stage (Regional and Local) call processing model. Transition issues must be successfully addressed, to be incorporated into the realistic 9-1-1 environment today. The responsibility for infrastructure (national, regional, and local) and call handling and business rule policy at each level must be further defined.

Lesson Learned / Issue Identified:	Standards and Interoperability for Integrating External Systems and Services into NG9-1-1
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • Academic Research communities • Telematics and Third Party Data Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

One of the key capabilities of NG9-1-1, as defined in the CONOPS, is the ability to acquire supportive and supplemental data. Supportive data are data that are acquired initially during call generation, or while the call is in transit, that provide critical information to assist the NG9-1-1 system with call processing and call handling. Supplemental data are data that are acquired once a call is terminated at a PSAP and can assist the call taker in making more intelligent decisions regarding the nature of the call or how to respond to the situation. Interfacing with external systems, such as medical records systems or telecommunications provider customer record systems, will require standard protocols, interfaces, and datasets. Further work and cross-agency and industry surveys should be conducted to determine the standardization efforts that already exist.

Lesson Learned / Issue Identified:	Flexible HMI Software Architecture for Taking in New Data Sets
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Telematics and Third Party Data Service Providers • NG9-1-1 Network and System Designers • National 9-1-1 Organizations (NENA, APCO, etc.)

An NG9-1-1 system supports a number of different call origination technologies. Each technology will have its own media and data associated with the call. This information can be a combination of voice, video, and/or data. New call taker software must be designed with a flexible architecture and be standards based (IP, SIP, and XML) in order

to ensure interoperability and ease of upgrade as new data sets and technologies become available. Furthermore, interfaces for call takers must be user friendly and intuitive, creating uniform yet customizable views to cater to call taker preferences. Given a network-based approach, a call taker should be able to maintain a profile enabling a common operating picture (COP) regardless of where or how he or she accesses the system. This will create a much more useable framework for call taker software and provide “virtual PSAP” capabilities independent of geographic and physical location. Further research must continue to optimize the way call takers interact and configure the NG9-1-1 system.

Lesson Learned / Issue Identified:	Accreditation of NG9-1-1 Systems to Ensure Interoperability
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • Government and Regulatory Administrations • NG9-1-1 Network and System Designers • Telecommunication Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

Transitioning to NG9-1-1 will not occur overnight or be as easy as flicking a switch. More realistically, 9-1-1 systems will move to NG9-1-1 capabilities slowly based on available funding and priorities decided by state and local authorities. However, it is imperative that as existing legacy systems transition, there is increased local, state, and federal coordination to achieve full interoperability among 9-1-1 systems. One proposed method to ensure interoperability among systems is through accreditation. The POC did not address this issue; however, additional time, resources, and stakeholder input would be necessary in defining the feasibility of an accreditation system .

Lesson Learned / Issue Identified:	Operational Model and Technical Feasibility Study for Authority to Citizen Communication
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • Government and Regulatory Administrations • Telematics and Third Party Data Service Providers • NG9-1-1 Network and System Designers • Telecommunication Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

The POC dealt exclusively with citizen-to-authority and authority-to-authority communication. However, authority-to-citizen communication is just as important. The ability to quickly warn citizens of natural disasters, terrorist attacks or other state of emergencies through public communication systems must be addressed, especially as emergency services move to IP-based systems. Getting NG9-1-1 stakeholders involved with other agencies’ efforts, including the Department of Homeland Security’s Common



Alerting Protocol (CAP) and the Federal Emergency Management Agency’s Integrated Public Alert and Warning System (IPAWS) ensures standardization, interoperability, and acceptance of other federal authority-to-citizen communication efforts.

Lesson Learned / Issue Identified:	Interface with and Transfer of NG9-1-1 Information to Other Emergency Services (Fire, Police, EMS)
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • NG9-1-1 Network and System Designers • Telecommunication Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

Emergency response service requires a tight interaction among PSAPs, dispatch services, and first responders such as Police, Fire, and EMS. While calls typically come into a PSAP for initial screening, once the nature of the call is determined, the caller is usually transferred or conferenced in with various dispatch services. The NG9-1-1 POC identified the need to transfer to these services but did not demonstrate a method for effective handoff to these services. This is especially important given all the new data that NG9-1-1 make available with an emergency call.

In addition, PSAP call takers need a method of looking up the appropriate dispatch service. Although PSAP call takers are typically familiar with services in their local area, sometimes they require services from distant counties or even other states. EPAD is a federally sponsored effort and the desired future source for looking up emergency services for a given area. It would be beneficial if the NG9-1-1 POC demonstrated its ability to interface with this directory as its method of determining the optimal dispatch service to contact.

8.3 Technical Issues

Over the course of the POC the following technical issues were raised or discovered by the various NG9-1-1 stakeholders and project team. For a successful transition to NG9-1-1 technology and systems all these issues will need to be addressed.

Lesson Learned / Issue Identified:	Importance of Product Selection and Understanding the 9-1-1 Vendor Community
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • NG9-1-1 Network and System Designers

Product selection will be key to effective NG9-1-1 deployments. The POC demonstrated that technologies exist today that can support the requirements of an NG9-1-1 system. However, the POC also demonstrated that the industry is still in its infancy. There will be numerous integration challenges for NG9-1-1 system integrators moving forward. For the POC, one of the largest design flaws involved limitations related to the selection of an open source, free conference server. Because of product constraints, the conference



server limited the number of connections that could be made to a PSAP and limited video conferencing to two parties (not ideal when demonstrating handling of a deaf caller who used of a sign language interpreter). The NG9-1-1 vendor community is evolving and further efforts need to be made to drive this market, meet its needs and understand priorities of the key players in this industry.

Lesson Learned / Issue Identified:	Improved Network and System Management of NG9-1-1 Systems
Key Stakeholders:	<ul style="list-style-type: none">• 9-1-1 and public safety agencies• PSAP Call Takers• NG9-1-1 Network and System Designers

As 9-1-1 systems are moved to IP-based technology more control is returned to the PSAP. No longer do the telecommunications providers determine routing and call handling. Given the importance of the 9-1-1 mission and the user community it serves, the NG9-1-1 system must be a managed IP network with guaranteed reliable and robust service. Network management was not a key focus of the NG9-1-1 POC. However, standard best practices and advanced monitoring capabilities must be enabled in production NG9-1-1 systems to ensure proper operation of the network and its associated system components.

Lesson Learned / Issue Identified:	Extensions of Network Monitoring, Traffic Generators, and Packet Sniffers for Future Interoperability, Accreditation, and Performance Benchmarking of NG9-1-1 Systems
Key Stakeholders:	<ul style="list-style-type: none">• NG9-1-1 Network and System Designers

Although the NG9-1-1 system is standards based, it will still require extensive testing to ensure optimal network and system performance. The POC found that testing NG9-1-1 systems could be done at a basic level using commercial off-the-shelf test tools. However, to more accurately characterize and simulate NG9-1-1 traffic requires extensions to currently available test tools, network monitoring applications, traffic generators, and packet sniffers. The POC discovered test tools such as Wireshark and SIPStone are taking early steps to provide NG9-1-1 network and infrastructure testing capabilities. However, as NG9-1-1 systems and standards mature the testing tools will have to continue to keep pace with the technologies they are testing. These tools will prove invaluable to future NG9-1-1 interoperability, accreditation, and benchmarking work.

Lesson Learned / Issue Identified:	Best Practices in Security for NG9-1-1
Key Stakeholders:	<ul style="list-style-type: none">• 9-1-1 and public safety agencies• Academic Research communities• NG9-1-1 Network and System Designers• Telecommunications Service Providers• National 9-1-1 Organizations (NENA, APCO, etc.)

NG9-1-1’s basis on IP networking standards provides many advantages; however, it also exposes it to all of the associated vulnerabilities. Security will play a key role in NG9-1-1 and will have to protect the system against some of the same challenges and malicious acts found on the Internet today. The NG9-1-1 system will have to provide security policy for the network infrastructure and resources, as well as define access, authentication, and authorization for the users of the system. The critical nature of the services offered and privacy concerns of the data make this network attractive for misuse. The network must be highly controlled to ensure service yet flexible enough to provide open access. Security will be a huge challenge that experts are just now beginning to address. IP networks are not a new technology. If the Internet can exist today and remain available to the public, the NG9-1-1 system should be able to leverage some of its best practices and diverse vendor community to accomplish its mission.

Lesson Learned / Issue Identified:	Building Redundancy, Reliability, and Overflow into the NG9-1-1 Network
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • NG9-1-1 Network and System Designers • Telecommunications Service Providers

The NG9-1-1 system and emergency services it provides save lives on a day-to-day basis. There is no downtime for emergency service personnel, and thus there must be no downtime in the network or system. The only way to provide the level of service this system demands is to build redundancy and reliability into the network. This includes both redundancy in the network and in its associated system components. PSAP operators and authorities must build stringent quality and level of service agreements with their operational contactors and system integrators. NG9-1-1 systems must have 100-percent uptime. In addition, in the case of catastrophe, when system resources spike or are unavailable altogether, PSAPs must have appropriate overflow mechanisms built into their infrastructure to offload some of their burden yet still provide equivalent levels of service. Given the fact that the POC was not handling “real” 9-1-1 calls, the design did not have to take into account these stringent yet necessary requirements. Operational PSAPs must stress the importance of redundancy, reliability, and overflow, and ensure these services are built into their systems.

Lesson Learned / Issue Identified:	Study and Standardization of CODECs for Optimal Voice and Video Transmission
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • NG9-1-1 Network and System Designers • Telecommunication Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

A variety of voice and video CODECs exist in the market place today. Typically, they make tradeoffs among bandwidth, quality, and configurability. For the POC, an arbitrary CODEC was chosen for voice and video based on ease of procurement and integration into the POC software. Through the use of SIP, multiple CODECs can be used and supported. Native to the SIP is the ability to negotiate the media format and associated CODEC while the session is being set up. However, PSAPs should not have to support

all the CODECs that currently exist. It is recommended that the emergency response community be more proactive and conduct research to determine a list of acceptable CODECs that provide the necessary quality and performance for emergency communication. Only by driving standards and specifications will the emergency service community ensure interoperability among all the communication devices available today.

Lesson Learned / Issue Identified:	Optimization of Call Routing Based on Call Propagation Timing
Key Stakeholders:	<ul style="list-style-type: none"> • Government and Regulatory Administrations • NG9-1-1 Network and System Designers • Telecommunication Service Providers

As a call propagates through the NG9-1-1 system, it must interact with an increased number of system components. Gone are the days of a single selective router that decides how the call should be routed. NG9-1-1 adds new components with advanced capabilities like location determination, injections of supportive data, and policy-based call routing. Unfortunately, these advanced features also add overhead and can increase the propagation time of the call. In addition, they increase the risk of call failure and place external dependencies on the system. Typically, in today's systems, it takes 9-1-1 calls an average of 7–12 seconds to propagate end-to-end. An NG9-1-1 system should strive to provide the same level of quality. To ensure this quality, stringent timing constraints must be placed on NG9-1-1 systems. A system must be able to respond within a predetermined amount of time or the NG9-1-1 system should have a mitigation strategy if one of its system dependencies is unresponsive or underperforming against its performance metrics. The POC did not address this issue because it was not handling “live” emergency calls. However, determining these metrics and enforcing them on an operational NG9-1-1 system is vital to ensure all emergency calls are handled with the appropriate level of service.

Lesson Learned / Issue Identified:	Location Acquisition for All Forms of Emergency Communication
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • Government and Regulatory Administrations • Academic Research communities • Telematics and Third Party Data Service Providers • NG9-1-1 Network and System Designers • Telecommunication Service Providers • National 9-1-1 Organizations (NENA, APCO, etc.)

The NG9-1-1 system introduces an innovative paradigm for call routing. The NG9-1-1 system routes calls based on a variety of information, one of the most important elements being location. Unlike traditional 9-1-1 systems where the call is statically mapped to a PSAP and the location of the call is acquired after the call has terminated at the PSAP, NG9-1-1 differs in that it requires location up front to route the call appropriately through the system. Therefore, each call origination technology (legacy wireline, cellular wireless, telematics, SMS, IPUA, Sensor, etc.) must provide mechanisms for injecting or acquiring an emergency caller's location initially as the call is placed. This will require an

overhaul and upgrade of the location acquisition technology that currently exist today such as Automatic Location Identification (ALI), Mobile Positioning Center (MPCs) and Voice over IP Positioning Center (VPCs). In addition, the POC showed that some technologies, such as SMS, currently have no means of location acquisition. To effectively integrate these technologies into NG9-1-1, they must provide location and conform to the defined location data standards. Standards bodies such as the Emergency Context Resolution with Internet Technologies (ECRIT) are addressing some of these issues. Given the timelines of the POC and the inaccessibility to production location acquisition systems, many of the POC location acquisitions systems (ALI, MPC, VPC, LIS, SMS Positioning) were mocked up and simulated. Further work needs to be done to characterize these systems and demonstrate effective, standards-based methods for accessing these systems.

Lesson Learned / Issue Identified:	Provision of Imagery and Additional Supplemental Data to the Call Taker
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • Telematics and Third Party Data Service Providers • NG9-1-1 Network and System Designers

Many emerging communication devices provide advance methods of communication and support many different media types, including voice, video, texting, and data. Although the POC touched on many of these media types, it was not able to successfully demonstrate an effective method for PSAPs to consume imagery or video clips with a call. This is largely due to a lack of standardization within the industry on how multimedia content is shared and distributed using mobile devices. One technology that is offering this capability in a standard format is Multimedia Messaging Service (MMS). As this technology matures and telecommunications vendors begin to support this standard, further research should be done to ensure that MMS can meet the requirements of the emergency service community and ease the integration challenge of supporting multimedia in a PSAP environment.

Lesson Learned / Issue Identified:	Improved Geospatial Data Fusion for the PSAP and Call Takers
Key Stakeholders:	<ul style="list-style-type: none"> • 9-1-1 and public safety agencies • PSAP Call Takers • Information standards development and professional organizations • Academic Research communities • Telematics and Third Party Data Service Providers • NG9-1-1 Network and System Designers

Geospatial capabilities are important as PSAPs transition to NG9-1-1 systems. Moving to an IP-based network will allow advanced geospatial capabilities for the PSAP community and ease the integration with existing geospatial platforms and systems with NG9-1-1 software and infrastructure. Some groups, such as the GEOPRIV Working



Group, are already addressing some of the issues associated with geolocation in an emergency service context. The POC attempted to conform to industry standard geospatial solutions. It demonstrated the ability of NG9-1-1 systems to integrate with both open source solutions such as GoogleMaps, as well as proprietary, high-resolution solutions such as Pictometry. Further information and an overview of geospatial solutions for emergency services can be found at geopriv.googlepages.com.

9 Compliance Matrix

	Requirement	Laboratory Testing Pass/Fail	Rochester, NY Pass /Fail	King County, WA Pass /Fail	St. Paul, MN Pass /Fail	Helena, MT Pass /Fail	Indiana Pass /Fail
Wireline Call							
	Call Setup	Pass	Pass	Pass	Pass	Pass	Pass
	Call Handling	Pass	Pass	Pass	Pass	Pass	Pass
	Data Handling	Pass	Pass	Pass	Pass	Pass	Pass
Cellular Call							
	Call Setup	Pass	Pass	Pass	Pass	Pass	Pass
	Call Handling	Pass	Pass	Pass	Fail	Pass	Pass
	Data Handling	Pass	Pass	Pass	Fail	Pass	Pass
Intelligent IP UA Call							
	Call Setup	Pass	Pass	Pass	Pass	Pass	Pass
	Call Handling	Pass	Pass	Pass	Pass	Pass	Pass
	Data Handling	Pass	Pass	Pass	Fail	Pass	Pass
SMS Message							
	Call Setup	Pass	Pass	Pass	Pass	Pass	Not Tested
	Call Handling	Pass	Pass	Pass	Pass	Pass	Not Tested
	Data Handling	Pass	Pass	Pass	Pass	Pass	Not Tested



	Requirement	Laboratory Testing Pass/Fail	Rochester, NY Pass /Fail	King County, WA Pass /Fail	St. Paul, MN Pass /Fail	Helena, MT Pass /Fail	Indiana Pass /Fail
Telematics							
	Call Setup	Pass	Pass	Pass	Pass	Pass	Pass
	Call Handling	Pass	Pass	Pass	Fail	Pass	Pass
	Data Handling	Pass	Pass	Pass	Pass	Pass	Pass
Extended Call Transfer							
	Call Transfer	Pass	Pass	Pass	Pass	Pass	Pass
	Data Handling	Pass	Pass	Pass	Pass	Pass	Pass
Business Rules Test							
	Specific Call Type	Pass	Pass	Pass	Pass	Pass	Not Tested
	PSAP Override	Pass	Pass	Pass	Pass	Pass	Not Tested

Appendix A—Acronyms

Acronym	Definition
ACD	Automatic Call Distribution
ACN	Automatic Crash Notification
ALI	Automatic Location Identification
ANI	Automatic Number Identification
CAD	Computer Aided Dispatch
CAP	Common Alerting Protocol
CM	Configuration Management
CNSI	Booz Allen’s Center for Network & Systems Innovation at One Dulles (Herndon, VA)
CODEC	C oder / D ecoder
CONOPS	Concept of Operations
COP	Common Operating Picture
CPE	Customer Premises Equipment
E9-1-1	Enhanced 9-1-1
ECRIT	Emergency Context Resolution with Internet Technologies
EMS	Emergency Medical Service
EOC	Emergency Operations Center
EPAD	Emergency Providers Access Database
ESRP	Emergency Services Routing Proxy
GIS	Geographic Information System
GPS	Geographic Positioning System
HMI	Human Machine Interface
IM	Instant Messaging
IP	Internet Protocol
IPAWS	Integrated Public Alert and Warning System
IPUA	Internet Protocol User Agent
IURC	Indiana Utility Regulatory Commission
kbps	Kilobits per Second
LIS	L ocation I nformation S erver
LoST	Location-to-Service Translation Protocol
Mbps	Megabits per Second
MMS	Multimedia Messaging Service
MPC	Mobile Positioning Center
ms	Millisecond
NCIC	National Crime Information Center
NENA	National Emergency Number Association
NG9-1-1	Next Generation 9-1-1
NLETS	National Law Enforcement Telecommunications System
NMS	Network Management System



Acronym	Definition
NTP	Network Time Protocol
POC	Proof-of-Concept
PSAP	Public Safety Answering Point
RMS	Records Management System
SDO	Standards Development Organization
SIP	Session Initiation Protocol
SOP	Standard Operating Procedure
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SR	Selective Router
TBD	To Be Determined
UA	User Agent
UCD	User Center Design
UI	User Interface
USDOT	US Department of Transportation
VoIP	Voice over IP
VPC	Voice over IP Positioning Center
VRS	Video Relay Systems

Appendix B—Glossary

Term	Definition
9-1-1	A three-digit telephone number to facilitate the reporting of an emergency requiring response by a public safety agency.
Analog	Continuous and variable electrical waves that represent an infinite number of values, as opposed to digital.
Authentication	Determination or verification of a user's identity and/or the user's eligibility to access to a system, network, or data; measures to prevent unauthorized access to information and resources.
Automatic Call Distributor (ACD)	Equipment or application that automatically distributes incoming calls to available PSAP attendants in the order the calls are received or queues calls until an attendant becomes available.
Automatic Location Information (ALI)	The automatic display at the PSAP of the caller's telephone number, the address or location of the telephone, and supplementary emergency services information.
Automatic Number Identification (ANI)	Telephone number associated with the access line from which a call originates.
ANI key	A value that is used to correlate the number identified for the call with a query that determines the caller's location via Automatic Location Identification (ALI).
Bandwidth	Capacity of a network line to transfer data packets (includes speed of transfer and number of packets processed per second).
Call	For the purposes of this <i>NG9-1-1 Test Results Report</i> , any real-time communication—voice, text, or video—between a person needing assistance and a PSAP call taker. This term also includes non-human-initiated automatic event alerts, such as alarms, telematics, or sensor data, which may also include real-time communications.
Call Back	The ability to re-contact the calling party.
Call Delivery	The capability to route a 9-1-1 call to the designated selective router for ultimate delivery to the designated PSAP for the caller's Automatic Number Identification (ANI) key.
Call Detail Record	All system (including network) data accessible with the delivery of the call, and all data automatically added as part of call processing. This includes Essential Data (including reference key to network component and call progress records) and Supportive Data. Part of the Call Record.
Caller Location Information	Data pertaining to the geospatial location of the caller, regardless of whether the caller is a person or an automatic event alert system.



Term	Definition
Call Recording	The electronic documentation of the interactive communication (e.g., audio, video, text, image) between the caller, call taker, and any conferenced parties. Part of the Call Record.
Call Routing	The capability to selectively direct the 9-1-1 call to the appropriate PSAP.
Call Taker	As used in 9-1-1, a person (sometimes referred to as a telecommunicator) who receives emergency and non-emergency calls by telephone and other sources, determines situations, elicits necessary information, and relays essential information to dispatches, staff, and other agencies, as needed, using telephony and computer equipment.
Call Transfer	The capability to redirect a call to another party.
Call Type	Classification of a 9-1-1 call that indicates the call access method, which can affect call treatment, routing, and processing. Call types may include voice caller, short message service (SMS) text, Simple Mail Transfer Protocol (SMTP) text, multimedia, telematics data, ANI, silent alarms, etc.
Computer Aided Dispatch (CAD) system	A software package that uses a variety of displays and tools to allow call takers at the PSAP locations to dispatch emergency services (Police, Fire, Emergency Medical Services) to the identified emergency location. CAD uses a variety of communication types to dispatch a unit (paging, SMS, radio, etc.).
Customer Premises Equipment (CPE)	Communications or terminal equipment located in the customer's facilities; terminal equipment at a PSAP.
Dispatch Operations	The distribution of emergency information to responder organizations responsible for delivery of emergency services to the public.
Emergency Call	A telephone request for public safety agency emergency services that requires immediate action to save a life, to report a fire, or to stop a crime. May include other situations as determined locally.
Emergency Location Information	Data pertaining to the location of the emergency, which may be different from the caller location.
Emergency Medical Service (EMS)	A system providing pre-hospital emergency care and transportation to victims of sudden illness or injury.
Emergency Response	An effort by public safety personnel and citizens to mitigate the impact of an incident on human life and property.
Enhanced 9-1-1 (E9-1-1)	An emergency telephone system that includes network switching, database, and customer premises equipment (CPE) elements capable of providing selective routing, selective transfer, fixed transfer, caller routing and location information, and ALI.
Essential Data	Data that support call delivery and adequate response capability. These data, or references to them, are automatically provided as a part of call or message initiation. Examples include location, call back data, and call type.

Term	Definition
Human Machine Interface (HMI)	Method, software, and/or device that enables direct interaction between the end-user (human) and a system (computer, machine) via commands and inputs, and receives an output from the system based on specified criteria.
Human Machine Interface (HMI) Display	Graphical and visual user screen through which call takers (end users) are able to manipulate a system.
Geographic Information System (GIS)	A computer software system that enables the user to visualize geographic aspects of a body of data. It includes the ability to translate implicit geographic data (such as a street address) into an explicit map location. It has the ability to query and analyze data in order to produce the results in the form of a map. It also can be used to graphically display coordinates on a map (i.e., latitude/longitude) from a wireless 9-1-1 call.
IP Telephony	The electronic transmission of the human voice over IP Protocol, using data packets.
Internet Protocol (IP)	The set of rules by which data are sent from one computer to another on the Internet or other networks.
Interoperability	The capability for disparate systems to work together.
Interrogation Questions	Questions that call takers ask callers during an emergency call to obtain additional information.
Multimedia Communication Types	Communication media used to receive emergency requests from the public, including text, images, and video.
Navigation Menu	A tool used by a variety of computer systems that contains links to the features and applications available in the system, and allows end users to access the applications by selecting the feature. Generally is connected, via links/hyperlinks, to the application.
Nature of Emergency	Reason for a citizen's request for response from emergency services (e.g., heart attack, vehicle collision, burglary).
Network	An arrangement of devices that can communicate with each other.
Public Safety Answering Point (PSAP)	A facility equipped and staffed to receive 9-1-1 calls; a generic name for a municipal or county emergency communications center dispatch agency that directs 9-1-1 or other emergency calls to appropriate police, fire, and emergency medical services agencies and personnel.
Records Management System (RMS)	A computer software system that enables the storage or archival of data records related to public safety (e.g., 9-1-1 call logs, incident information, cases).
Router	An interface device between two networks that selects the best path to complete the call even if there are several networks between the originating network and the destination.



Term	Definition
Screen Aesthetics	Look and feel of the human machine interface; includes fonts, color schemes, and display layout.
Selective Routing (SR)	Direction of a 9-1-1 call to the proper PSAP based on the location of the caller.
Selective Transfer	The capability to convey a 9-1-1 call to a response agency by operation of one of several buttons typically designated as police, fire, and emergency medical services.
Service Provider	An entity providing one or more of the following 9-1-1 elements: network, customer premises equipment (CPE), or database service.
Short Message Service (SMS)	A text message service that enables messages generally no more than 140–160 characters in length to be sent and transmitted from a cellular telephone. Short messages are stored and forwarded at SMS centers, allowing their retrieval later if the user is not immediately available to receive them.
Supportive Data	Information beyond essential data that may support call handling and dispatch. The addition of this data to the call stream is triggered by one or more of the data or reference items in essential data for a given call type. An example is the Automatic Crash Notification (ACN) data “vehicle rollover.” Supportive data is acquired by the system prior to the call delivery to the PSAP or other emergency entity.
Supplemental Data	Information that may complement, but is not necessary for, call handling and dispatch or emergency response. Supplemental data are acquired after call delivery to the PSAP or other emergency entity.
Telematics	The system of components that supports two-way communications with a motor vehicle for the collection or transmission of information and commands.
User Centered Design (UCD)	Design principle that enable the development of a computer system based on the needs, wants, and limitations of the end user, including intuitive navigation, simplicity and consistency of information presentation, accessibility of information, visibility of key functional and navigational elements, and legible visual design.
Voice over Internet Protocol (VoIP)	A set of rules that provides distinct transfer of voice information in digital format using the Internet Protocol. The IP address assigned to the user’s telephone number may be static or dynamic.
Wireless	In the telecommunications industry, typically refers to mobile telephony and communications through handheld devices that make a connection using radio frequency (in particular frequency bands often reserved for mobile communications) for personal telecommunications over long distances.
Wireline	Standard telephone and data communications systems that use in-ground and telephone pole cables. Also known as landline or land based.

Appendix C—Source References

The following documents are primary sources of information used in this document.

1. *Next Generation 9-1-1 (NG9-1-1) System Initiative: Concept of Operations*. USDOT ITS JPO. April 2007. http://www.its.dot.gov/ng911/pdf/NG911ConOps_April07.pdf—This formal document provides a user-oriented vision of NG9-1-1 in the context of an emergency services internetwork that can be understood by stakeholders with a broad range of operational and technical expertise. It is intended to communicate the vision of this system to stakeholders so that they can be actively engaged in its development and deployment.
2. *Next Generation 9-1-1 (NG9-1-1) System Initiative: System Description and High-Level Requirements Document*. USDOT ITS JPO. July 2007. http://www.its.dot.gov/ng911/pdf/NG911_HighLevel_Requirements2007.pdf—This formal document provides a high-level overview of NG9-1-1 system operations.
3. *USDOT NG9-1-1 Architecture Analysis Report*. USDOT ITS JPO November 2007. http://www.its.dot.gov/ng911/pubs/NG911_FINAL_ArchAnalysis_v1.htm—This formal document provides a high-level architecture analysis of the NG9-1-1 system.
4. *USDOT_NG911_POC_RequirementTableTiered_11Sept2007.xls*. This internal document contains the requirements developed in previous work. This file contains the updated Tier 1 requirements.
5. *NG9-1-1 Interim System Design Document*. USDOT ITS JPO. February 2008. NOT POSTED—This formal document details the interim NG9-1-1 system design. This design was used in the preparation of the POC.
6. *Proof of Concept Deployment Plan*. USDOT ITS JPO. February 2008. http://www.its.dot.gov/ng911/pubs/NG911_proof_concept.htm—This formal document details the plan to deploy the proof-of-concept resources and to perform the POC.
7. *Human Machine Interface Design Document*. USDOT ITS JPO. January 2008. NOT POSTED—This formal document details the human machine interface. This design was used in preparation of the POC.
8. *NG9-1-1 Proof of Concept Testing Plan*. USDOT ITS. JPO June 2008. http://www.its.dot.gov/ng911/pubs/ng911_poc_testplan_final.htm—This formal document describes the testing of the NG9-1-1 POC.
9. *Data Acquisition and Analysis Plan*. USDOT ITS JPO. May 2008. http://www.its.dot.gov/ng911/pubs/data_acquisition.htm—This formal document describes the data collection plan and the plan to analyze the data collected.

Appendix D—POC Testing Results

[This appendix includes the specific details of each test conducted during the POC Testing. Due to the large number of pages, Appendix D will be made available in electronic format only and as a separate document.]

Appendix E—POC Data Acquisition and Analysis Results

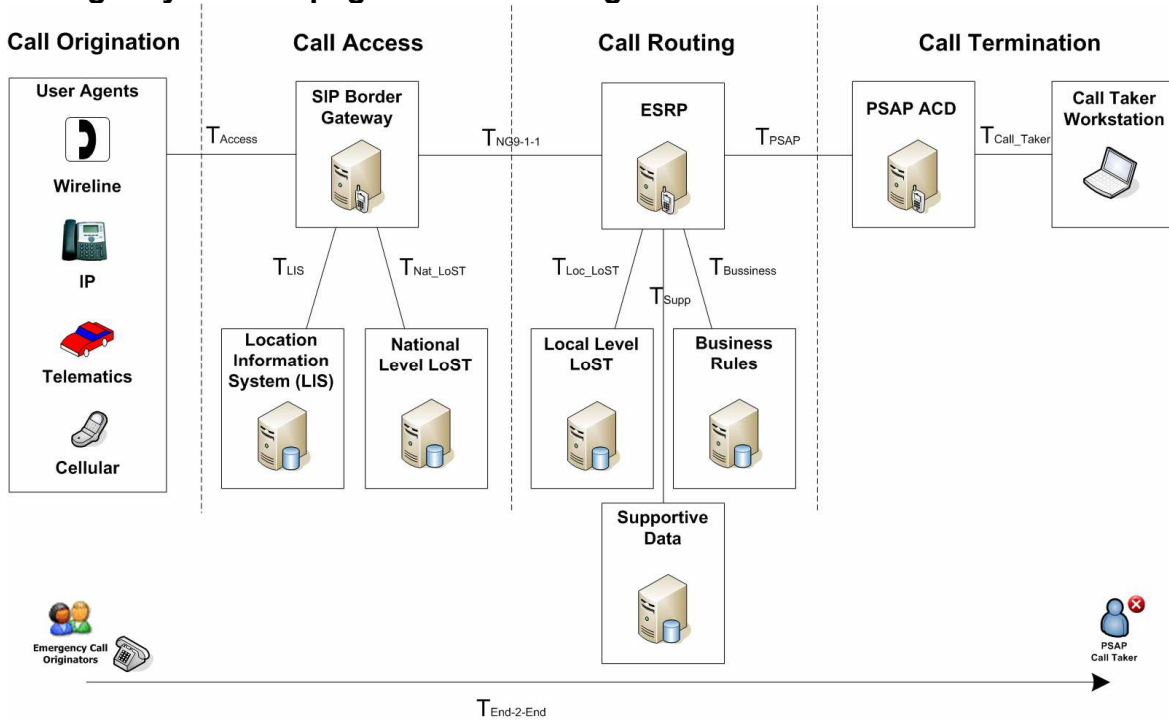
Overview

The Data Acquisition and Analysis task assisted the Next Generation 9-1-1 (NG9-1-1) Project Team and the U.S. Department of Transportation (USDOT) to evaluate the technical and operational success of the proof of concept (POC). It identified gaps and current issues with the technologies used to implement the NG9-1-1 POC system. The data acquired from the task will serve as benchmarks for future large-scale, production NG9-1-1 technology deployments and further assist in the refinement of the final NG9-1-1 transition plan. The data will facilitate the USDOT, Standards Development Organizations (SDO), industry vendors, the Public Safety Answering Point (PSAP) operational community, and future independent evaluators in defining measures of interest for Internet Protocol (IP)-based emergency calling. The subsequent subsections address the four main data analysis tasks of the NG9-1-1 POC:

- **Emergency Call Propagation and Timing**—This subsection examines the need for calls to be routed in an efficient, time-sensitive manner through the NG9-1-1 system.
- **Emergency Call Availability and Quality**—Two subsections investigate the effect of NG9-1-1 Component and Interface availability and IP network performances on the quality of voice and video calls.
- **Emergency Call Scalability**—This subsection explores the NG9-1-1 system’s ability to scale on a need-driven basis with convergence of different media types (voice, video, and data). It also looks at innovative NG9-1-1 call overflow mechanisms and their ability to improve overall system performance.

Each subsection gives an overview of the specific data analysis task, identifies the measures of interest that were collected and the tools used to collect that information, and then provides analysis and conclusions based on the data collected. For further details about how the data analysis task was conducted, refer to the *NG9-1-1 Data Acquisition and Analysis Plan*.

Emergency Call Propagation and Timing



Description: This activity evaluated the NG9-1-1 POC system’s ability to initiate, propagate, and terminate different types of emergency calls, including IP User Agent (IPUA), legacy wireline, telematics, and cellular. Currently, within the United States, a wireline emergency telephone call traverses from a call originator to a PSAP call taker in an average of 7 to 12 seconds. It is imperative that NG9-1-1 emergency calls are processed with at least the same level of performance as exists with current technology.

Measures of Interest: T_{Access} , T_{LIS} , T_{Nat_LoST} , $T_{NG9-1-1}$, T_{Loc_LoST} , T_{Supp} , $T_{Business}$, T_{PSAP} , T_{Call_Taker} , $T_{End-2-End}$

Measure of Interest	Description
T_{Access}	This parameter represents the time for an emergency call to traverse an access network and arrive at an NG9-1-1 border gateway. It spans the time frame from when a call originator initiates an emergency call to when the border gateway receives the SIP INVITE message.
T_{LIS}	This parameter represents the round trip time for a border gateway to query and receive location information for a call originator. Upon receipt of an emergency call, a border gateway inspects the call stream for location. If no location is present in the call stream, the border gateway queries a location information server (LIS) using a unique identifier. The LIS will then respond with the location of the call originator.

Measure of Interest	Description
$T_{\text{Nat_LoST}}$	This parameter represents the round trip time for a border gateway to acquire a location resolution from a National Location-to-Service Translation Protocol (LoST) server. Using the location of a call originator, the border gateway queries a National LoST server. The National LoST server uses the location information (civic or geospatial) to resolve to an ESRP uniform resource identifier (URI). The border gateway then forwards the call to the appropriate ESRP.
$T_{\text{NG9-1-1}}$	This parameter represents the time for an emergency call to traverse from a NG9-1-1 border gateway to an ESRP server. It spans the time frame from when the SIP INVITE leaves the border gateway to when ESRP receives the SIP INVITE.
$T_{\text{Loc_LoST}}$	This parameter represents the round trip time for an ESRP to acquire a location resolution from a Local LoST server. Using the location embedded within the call stream, the ESRP queries a Local LoST server. The Local LoST Server uses the location information (civic or geospatial) to resolve to a PSAP URI. The border gateway then forwards the call to the appropriate ESRP.
T_{Business}	This parameter represents the round trip time for an ESRP to acquire business rules from the business rules DB. The business rules DB can change the routing of an emergency call based on call stream parameters embedded within the emergency call. In addition, the business rules DB can designate supplemental and supportive data sources for the ESRP to contact. The business rules DB returns these modified routing and data source instructions to the ESRP.
T_{Supp}	This parameter represents the round trip time for an ESRP to acquire supplemental or supportive data. A variety of supplemental and supportive data sources can exist. This information can be passed by value or reference, depending on the criticality of the information.
T_{PSAP}	This parameter represents the time for an emergency call to traverse from an ESRP to a PSAP ACD. It spans the time frame from when the SIP INVITE leaves the ESRP to when PSAP ACD responds with a SIP OK.
$T_{\text{Call_Taker}}$	This parameter represents the time for an Emergency Call to traverse from a PSAP ACD to a call taker's workstation. It spans the time frame from when the call enters the PSAP ACD queue to when the designated PSAP call taker answers the telephone.
$T_{\text{End-2-End}}$	This parameter designates the time it for an emergency call to traverse the whole system from call origination to call reception. It spans the time frame from when a call originator initiates an emergency call to when the Call Taker picks up the telephone at the PSAP.

Data Collection Tools Used: Network Time Protocol (NTP) Server, Call Origination/Session Initiation Protocol (SIP) Border Gateway/Emergency Services Routing Proxy (ESRP)/PSAP Automatic Call Distribution (ACD) Software Event Logs, Network Protocol Analyzer

Analysis/Conclusions/Points of Interest:

- 1) The median time for $T_{\text{End-2-End}}$ for all call types was less than or equal to 10 seconds ($T_{\text{End-2-End}} \leq 10 \text{ sec}$). Therefore, the NG9-1-1 POC environment maintained the same level of response time as today's operational 9-1-1 system(s).
- 2) For the POC environment, most of the propagation time can be attributed to T_{PSAP} (T_{PSAP} was approximately 3–5 seconds for most calls). This is expected because a great deal of decision-making logic is built into the PSAP ACD. The PSAP ACD must

terminate the call and then analyze an emergency call's call stream data to determine the "most appropriate" call taker to handle the call. This is based on the availability and capabilities of the call takers. This advanced decision-making process adds latency to the call. Operational 9-1-1 systems would have to closely monitor this parameter and ensure those systems do not become overly complex. There is a fine balance between providing advanced call routing features and physically getting a person in the loop to determine the nature of the emergency and the appropriate response action. Therefore, this parameter should have a threshold to ensure that calls are handled in a timely fashion.

- 3) When larger amounts of time (> 10 seconds) were taken for the call to propagate through the system, T_{Access} was large and the most significant factor in the $T_{\text{End-2-End}}$ calculation.
- 4) Because of an external dependence on other systems outside the NG9-1-1 POC, T_{Supp} was not measured ($T_{\text{Supp}} = 0$ seconds). For operational NG9-1-1 systems, a detailed understanding of the external system must be known in advance. Dependence on external systems for routing and processing call can create bottlenecks in the system and severely affect the performance (response time) of the system.
- 5) Because the Business Rules Database resided on the same server as the ESRP, T_{Business} was negligible and not measured after a few initial trials (T_{Business} was assumed to equal 0 seconds). If the Business Rules Database was maintained as a separate system, this could add network latency to the routing of an emergency call. Operational 9-1-1 systems would have to closely monitor this parameter and ensure their systems did not become overly complex. There is a fine balance between providing advanced call routing features and physically getting a person in the loop to determine the nature of the emergency and the appropriate response action. Therefore, this parameter should have a threshold to ensure that calls are handled in a timely fashion.



Data Collection Results:

IP User Agent

Parameter (hh:mm:ss:ms)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
T_Access	00:00:00.373	00:00:00.194	00:00:00.819	00:00:00.764	00:01:01.071	00:00:00.267	00:00:00.474	00:00:00.113	00:00:00.455	00:00:00.020
T_LIS	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Nat_LoST	00:00:00.011	00:00:00.009	00:00:00.008	00:00:00.008	00:00:00.009	00:00:00.008	00:00:00.008	00:00:00.008	00:00:00.008	00:00:00.008
T_NG911	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_LOC_LoST	00:00:00.010	00:00:00.011	00:00:00.013	00:00:00.010	00:00:00.010	00:00:00.010	00:00:00.011	00:00:00.010	00:00:00.010	00:00:00.010
T_Business	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Supp	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_PSAP	00:00:03.608	00:00:03.340	00:00:11.827	00:00:03.842	00:00:04.196	00:00:02.425	00:00:02.637	00:00:02.886	00:00:03.532	00:00:03.150
T_Call_Taker	00:00:00.030	00:00:00.158	00:00:00.024	00:00:00.014	00:00:00.049	00:00:00.026	00:00:00.049	00:00:00.065	00:00:00.042	00:00:00.018
T_End-2-End	00:00:03.865	00:00:03.416	00:00:12.530	00:00:04.486	00:01:05.148	00:00:02.572	00:00:02.992	00:00:02.879	00:00:03.868	00:00:03.049

Parameter (hh:mm:ss:ms)	Mean	Minimum	Maximum	Std Dev
T_Access	00:00:06.455	00:00:00.020	00:01:01.071	00:00:19.192
T_LIS	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Nat_LoST	00:00:00.009	00:00:00.008	00:00:00.011	00:00:00.001
T_NG911	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_LOC_LoST	00:00:00.010	00:00:00.010	00:00:00.013	00:00:00.001
T_Business	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Supp	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_PSAP	00:00:04.144	00:00:02.425	00:00:11.827	00:00:02.753
T_Call_Taker	00:00:00.047	00:00:00.014	00:00:00.158	00:00:00.042
T_End-2-End	00:00:10.480	00:00:02.572	00:01:05.148	00:00:19.430



Legacy Wireline

Parameter (hh:mm:ss:ms)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
T_Access	00:00:00.24	00:00:00.78	00:00:00.76	00:00:04.63	00:00:03.94	00:00:02.30	00:00:03.26	00:00:03.96	00:00:01.95	00:00:02.94
T_LIS	00:00:00.34	00:00:00.34	00:00:00.34	00:00:00.11	00:00:00.11	00:00:00.11	00:00:00.34	00:00:00.34	00:00:00.34	00:00:00.34
T_Nat_LoST	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01
T_NG911	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
T_LOC_LoST	00:00:00.01	00:00:00.01	00:00:00.02	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.01
T_Business	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
T_Supp	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
T_PSAP	00:00:03.96	00:00:03.66	00:00:03.38	00:00:02.91	00:00:03.44	00:00:03.16	00:00:02.98	00:00:04.59	00:00:03.57	00:00:04.96
T_Call_Taker	00:00:00.03	00:00:00.14	00:00:00.04	00:00:00.13	00:00:00.02	00:00:00.11	00:00:00.07	00:00:00.01	00:00:00.04	00:00:00.04
T_End-2-End	00:00:04.42	00:00:04.67	00:00:04.38	00:00:07.54	00:00:07.37	00:00:05.45	00:00:06.47	00:00:08.77	00:00:05.74	00:00:08.13

Parameter (hh:mm:ss:ms)	Mean	Minimum	Maximum	Std Dev
T_Access	00:00:02.48	00:00:00.24	00:00:04.63	00:00:01.53
T_LIS	00:00:00.27	00:00:00.11	00:00:00.34	00:00:00.11
T_Nat_LoST	00:00:00.01	00:00:00.01	00:00:00.01	00:00:00.00
T_NG911	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
T_LOC_LoST	00:00:00.01	00:00:00.01	00:00:00.02	00:00:00.00
T_Business	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
T_Supp	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
T_PSAP	00:00:03.66	00:00:02.91	00:00:04.96	00:00:00.67
T_Call_Taker	00:00:00.06	00:00:00.01	00:00:00.14	00:00:00.05
T_End-2-End	00:00:06.29	00:00:04.38	00:00:08.77	00:00:01.60



Telematics

Parameter	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
T_Access	00:00:01.037	00:00:00.274	00:00:03.796	00:00:03.537	00:00:01.022	00:00:07.451	00:00:01.998	00:00:04.132	00:00:00.058	00:00:04.009
T_LIS	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Nat_LoST	00:00:00.090	00:00:00.094	00:00:00.089	00:00:00.085	00:00:00.089	00:00:00.088	00:00:00.087	00:00:00.089	00:00:00.088	00:00:00.182
T_NG911	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
T_LOC_LoST	00:00:00.087	00:00:00.091	00:00:00.092	00:00:00.088	00:00:00.088	00:00:00.090	00:00:00.085	00:00:00.087	00:00:00.087	00:00:00.086
T_Business	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Supp	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_PSAP	00:00:02.867	00:00:03.640	00:00:04.759	00:00:03.124	00:00:05.080	00:00:02.614	00:00:04.472	00:00:02.947	00:00:03.256	00:00:02.648
T_Call_Taker	00:00:00.090	00:00:02.047	00:00:00.324	00:00:00.077	00:00:00.064	00:00:00.067	00:00:00.072	00:00:00.074	00:00:00.324	00:00:00.108
T_End-2-End	00:00:03.945	00:00:03.963	00:00:08.599	00:00:06.698	00:00:06.141	00:00:10.106	00:00:06.505	00:00:07.118	00:00:03.353	00:00:06.789

Parameter	Mean	Minimum	Maximum	Std Dev
T_Access	00:00:02.732	00:00:00.058	00:00:07.451	00:00:02.289
T_LIS	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Nat_LoST	00:00:00.098	00:00:00.085	00:00:00.182	00:00:00.030
T_NG911	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
T_LOC_LoST	00:00:00.088	00:00:00.085	00:00:00.092	00:00:00.002
T_Business	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Supp	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_PSAP	00:00:03.541	00:00:02.614	00:00:05.080	00:00:00.910
T_Call_Taker	00:00:00.325	00:00:00.064	00:00:02.047	00:00:00.614
T_End-2-End	00:00:06.322	00:00:03.353	00:00:10.106	00:00:02.124

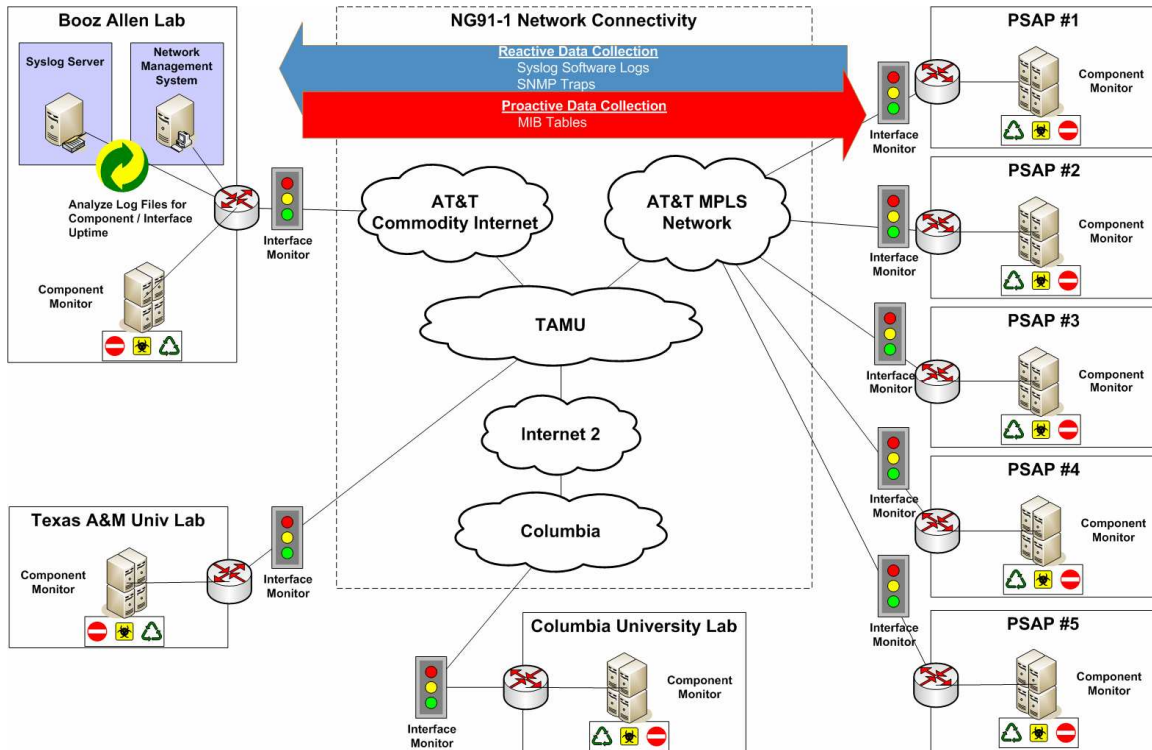


Cellular

Parameter (hh:mm:ss:ms)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
T_Access	00:00:01.604	00:00:01.095	00:00:01.119	00:00:01.345	00:00:01.153	00:00:02.780	00:00:00.169	00:00:01.697	00:00:09.131	00:00:09.398
T_LIS	00:00:00.194	00:00:00.106	00:00:00.105	00:00:00.106	00:00:00.106	00:00:00.105	00:00:00.105	00:00:00.105	00:00:00.105	00:00:00.106
T_Nat_LoST	00:00:00.001	00:00:00.012	00:00:00.012	00:00:00.012	00:00:00.016	00:00:00.013	00:00:00.012	00:00:00.030	00:00:00.013	00:00:00.015
T_NG911	00:00:00.083	00:00:00.084	00:00:00.083	00:00:00.084	00:00:00.083	00:00:00.081	00:00:00.081	00:00:00.082	00:00:35.034	00:00:00.050
T_LOC_LoST	00:00:00.012	00:00:00.012	00:00:00.012	00:00:00.012	00:00:00.012	00:00:00.012	00:00:00.012	00:00:00.030	00:00:00.012	00:00:00.012
T_Business	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Supp	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_PSAP	00:00:01.689	00:00:01.143	00:00:01.146	00:00:01.143	00:00:01.144	00:00:13.320	00:00:09.118	00:00:01.390	00:00:02.667	00:00:01.774
T_Call_Taker	00:00:00.282	00:00:00.307	00:00:00.330	00:00:00.079	00:00:00.285	00:00:02.546	00:00:00.391	00:00:00.532	00:00:08.588	00:00:01.453
T_End-2-End	00:00:03.583	00:00:02.452	00:00:02.478	00:00:02.703	00:00:02.514	00:00:16.312	00:00:09.498	00:00:03.334	00:00:46.962	00:00:11.355

Parameter (hh:mm:ss:ms)	Mean	Minimum	Maximum	Std Dev
T_Access	00:00:02.949	00:00:00.169	00:00:09.398	00:00:03.391
T_LIS	00:00:00.114	00:00:00.105	00:00:00.194	00:00:00.028
T_Nat_LoST	00:00:00.014	00:00:00.001	00:00:00.030	00:00:00.007
T_NG911	00:00:03.575	00:00:00.050	00:00:35.034	00:00:11.054
T_LOC_LoST	00:00:00.014	00:00:00.012	00:00:00.030	00:00:00.006
T_Business	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_Supp	00:00:00.000	00:00:00.000	00:00:00.000	00:00:00.000
T_PSAP	00:00:03.454	00:00:01.143	00:00:13.320	00:00:04.237
T_Call_Taker	00:00:01.479	00:00:00.079	00:00:08.588	00:00:02.609
T_End-2-End	00:00:10.119	00:00:02.452	00:00:46.962	00:00:13.810

Emergency Call Availability



Description: This activity evaluated the NG9-1-1 component and interface availability. Over the course of the POC, a Network Management System was deployed to track the uptime of system components and interfaces. Proper operation of NG9-1-1 system components and interfaces is vital to an effective emergency response service. Operationally, an NG9-1-1 system must provide near 100-percent uptime. The POC is research oriented; therefore, no efforts were made to design a fully redundant or 100-percent available system.

Measures of Interest: Component Availability, Interface Availability

Measure of Interest	Description
Component Availability (Downtime/year)	Availability: 2 9's (99%) = downtime less than 87.6 hours per year 3 9's (99.9%) = downtime less than 8.8 hours per year 4 9's (99.99%) = downtime less than 53 minutes per year 5 9's (99.999%) = downtime less than 315 seconds per year
Interface Availability (Downtime/year)	See above
System Availability	See above

Data Collection Tools Used: Network Management Software (HP Openview)

Analysis/Conclusions/Points of Interest:

1) Components (servers, laptops, etc.) in the POC did not provide the level of availability expected for an emergency response system. Given the research-oriented nature of the POC, components were constantly being updated with software, restarted, and physically moved within the laboratories and at the PSAPs. Because there was no redundancy (i.e., only one workstation was used per PSAP), an unstable environment existed where, in effect, the PSAP was considered “down/unreachable” during maintenance and/or upgrades. For an operational system, much more care would have to be given to design the system to provide a more robust and reliable operating environment that could handle emergency calls 24/7/365. It is likely that a PSAP or governing authority would have to enforce a service contract requiring the desired level of availability (e.g., Five 9s) from the operations and maintenance (O&M) systems contractor.

2) During the POC, interface availability (i.e., network connectivity) was fairly robust. Network connections between the three labs and five PSAPs were stable and more reliable than the components that resided on the actual network. Leasing the connections from major telecommunications providers minimized the risk of losing network connectivity. However, as emergency response systems move to IP-based infrastructure, the results of the POC should not lead to underemphasizing the importance of a good Network Management System to ensure reliability and conformance to service level agreements. Although network connectivity and bandwidth are viewed as a commodity in today’s world, stringent IT redundancy, resiliency, and performance best practices should still be used to ensure 100-percent operational emergency response systems.

Data Collection Results:

Component Availability

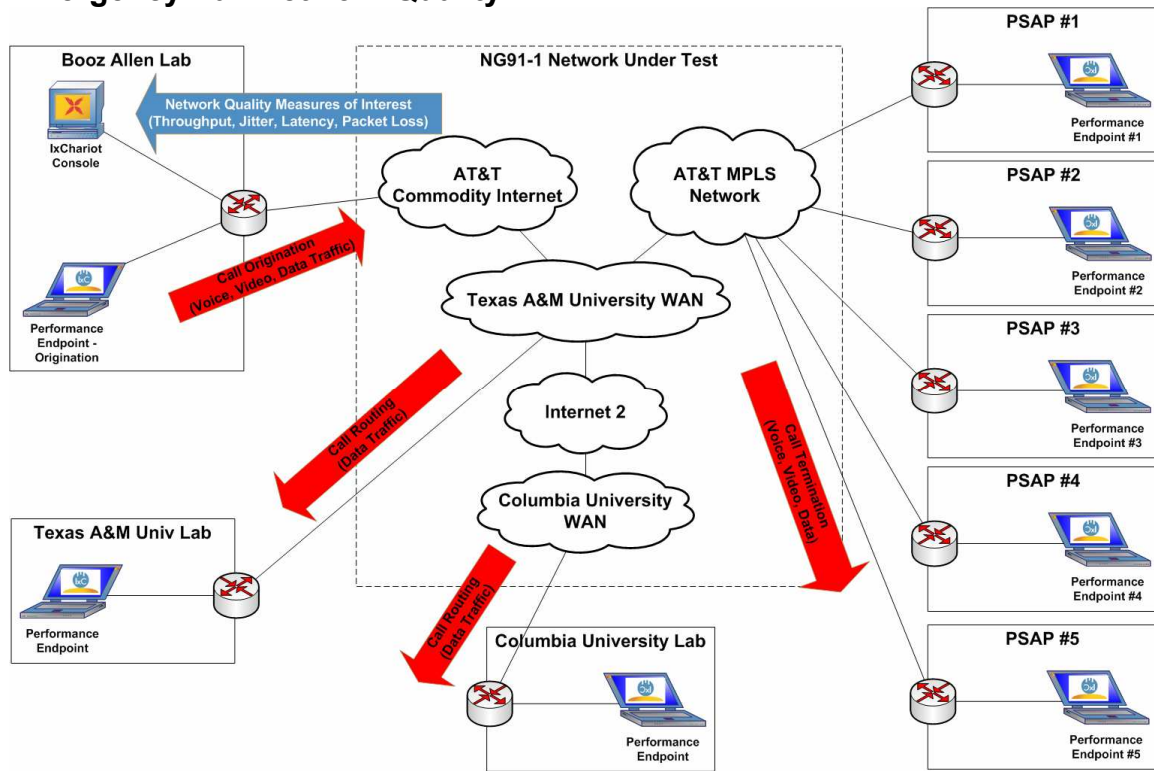
Location	Call Workstation IP Interface	Uptime (June/July 2008)
Booz Allen	12.43.248.90	76.00%
Columbia	165.91.168.216	100.00%
Rochester	204.56.204.54	94.5%
Ft. Wayne	66.249.247.7	100.00%
Seattle	204.56.204.30	14.79%
St. Paul	204.56.204.62	43.46%
Helena	204.56.204.46	96.25%

Interface Availability

Location	Router IP Interface	Uptime (June/July 2008)
Booz Allen	12.87.56.102	100.00%
Columbia	128.59.19.89	100.00%

Location	Router IP Interface	Uptime (June/July 2008)
Texas A&M	165.91.168.162	100.00%
Rochester	204.56.204.14	99.97%
Ft. Wayne	66.249.243.182	100.00%
Seattle	204.56.204.2	99.99%
St. Paul	204.56.204.18	99.97%
Helena	204.56.204.10	99.98%

Emergency Call Network Quality



Description: This activity evaluated the NG9-1-1 POC’s IP network quality. It is imperative that an optimized network exist to transport voice and video call streams, especially in an emergency response context. Voice and video traffic requires time-sensitive delivery of IP packets. Lost IP packets quickly degrade the quality of the voice and video streams, and retransmission is typically not an option. End points were configured to send a variety of voice, video, and data traffic across the network. Based on the traffic scenarios, network performance metrics were calculated.

Measures of Interest: Throughput, Packet Loss Latency, Jitter

Measure of Interest	Description
Throughput (Bandwidth)	The number of bits per unit of time forwarded to the correct destination
Jitter	The mean statistical deviation of packet inter-arrival times
Latency (Response Time)	The time needed to complete one request/response transaction
Packet Loss	Number of datagrams sent minus datagrams received

Data Collection Tools Used: Network Traffic Generator (appCritical, SimpleNets Simple Network Tester)

Analysis/Conclusions/Points of Interest:

1) The POC provided enough bandwidth to support the test cases and POC demonstrations. Lease lines were obtained to connect the three labs and five PSAPs. Both the commodity Internet and Internet2 networks were leveraged to use as transport for the POC emergency call traffic. Based on the testing, all leased lines supported at least 3 megabits per second (Mbps) of bandwidth. Those lines that leverage Internet2 for connectivity provided throughput of as much as 50 Mbps. Based on the selected video and voice CODEC, a single call was no greater than 150 kilobits per second (kbps) for video and 64 kbps for voice. Therefore, given the limited number calls placed during the POC, the IP network had little trouble supporting the traffic generated by the testing. In an operational network, more care would need to be taken to ensure that the network could provide adequate bandwidth to the PSAP even during peak loads and disaster situations. Best practices, such as dynamic network scalability, PSAP overflow, and call rerouting mechanisms, should be designed for and implemented in an operational network.

2) Based on current best practices, packet loss should be < 1 percent. The POC network met this constraint during all testing and POC demonstrations. Packet loss is typically an indication of an overly congested network. This scenario did not occur during operation of the POC. Operational 9-1-1 networks would need to monitor this metric using network management software and work with their network provider to ensure appropriate measures were put in place to handle network congestion.

3) Based on current best practices, latency should be < 100 milliseconds (ms) to support voice and video. The POC network met this constraint during all testing and POC demonstrations. Given the use of leased lines and small size of the network, there were only a limited number of hops that packets needed to take to traverse the system end to end. Operational 9-1-1 networks would need to work closely with their access and transport network providers to ensure latency is minimized.

4) Jitter should be < 50 ms for voice and video. The POC network met this constraint during all testing and POC demonstrations.



Data Collection Results:

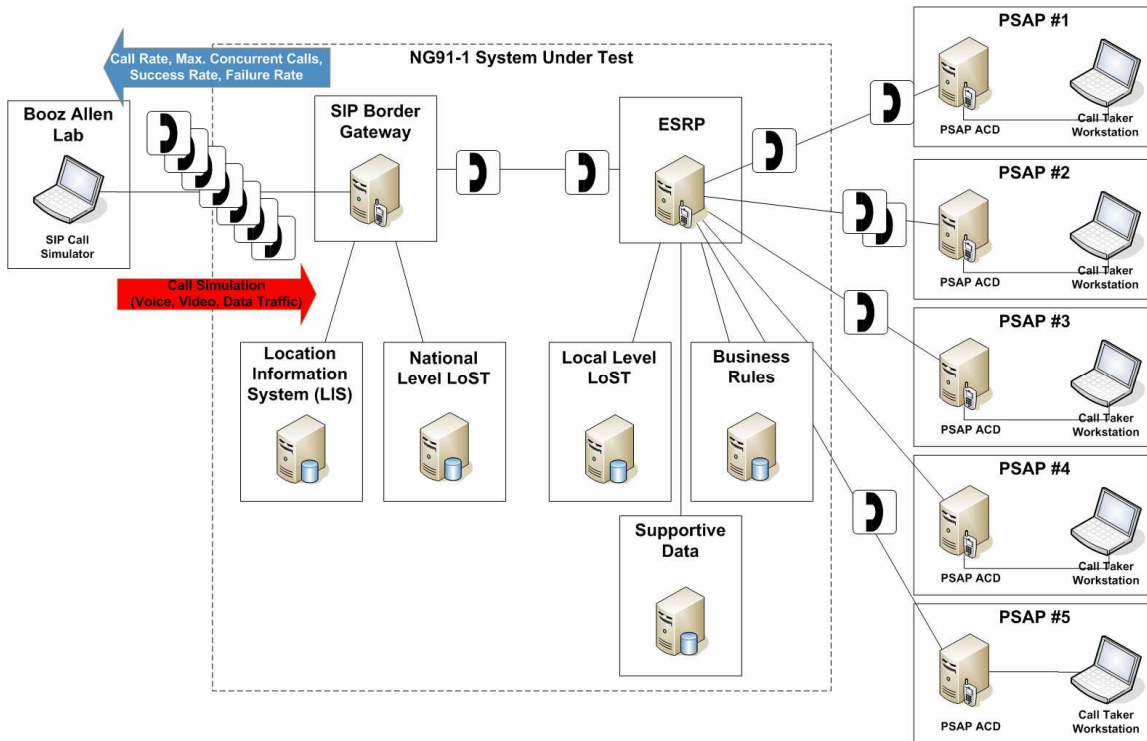
appCritical Results:

Location	Router IP Interface	Throughput (Mbps)	Packet Loss (%)	Latency (ms)
Booz Allen	12.87.56.102	2.93	0%	37.2
Columbia	128.59.19.89	54.2	<1%	25.9
Rochester	204.56.204.14	2.99	0%	24.4
Ft. Wayne	66.249.243.182	50.2	0%	22.8
Seattle	204.56.204.2	2.98	0%	33.1
St. Paul	204.56.204.18	2.99	0%	17.8
Helena	204.56.204.10	3	0%	33.3

SimpleNet's Simple Network Tester Results:

Location	Call Taker Workstation IP Interface	Run	Length (s)	Average Jitter (ms)
Booz Allen	12.43.248.90	1	30	8
	12.43.248.90	2	60	8
Columbia	165.91.168.216	1	30	8
	165.91.168.216	2	60	8
Rochester	204.56.204.54	1	30	8
	204.56.204.54	2	60	4
Ft. Wayne	66.249.247.7	1	30	4
	66.249.247.7	2	60	5
Seattle	204.56.204.30	1	30	8
	204.56.204.30	2	60	1
St. Paul	204.56.204.62	1	30	8
	204.56.204.62	2	60	8
Helena	204.56.204.46	1	30	1
	204.56.204.46	2	60	4

Emergency Call Scalability



Description: This activity evaluated the NG9-1-1 POC system’s ability to handle large call loads (call scalability). Designing scalability into an emergency response network is imperative for handling peak load and disaster situations. In an emergency response network, both the network and system components should be able to handle additional call load and dynamically scale according to need.

Measures of Interest: Call Rate, Maximum Concurrent Calls, Call Success, Call Failure

Measure of Interest	Description
Call Rate (Calls/sec)	Number of calls per second a system can handle
Maximum Concurrent Calls	The number of concurrent calls that can be simultaneously terminated
Call Success (%)	Number of successfully terminated calls divided by the total number of calls sent
Call Failure (%)	Number of failed calls divided by the total number of calls sent

Data Collection Tools Used: SIP Call Simulator (SIPStone SipP)

Analysis/Conclusions/Points of Interest:

1) The call failure rate is directly proportional to the number of concurrent calls placed in the system. For the testing, the team injected a number of different types of calls into the

system that simulated a combination of data, voice, and video emergency calls. For the POC environment, it was determined that as the number of concurrent calls increased, the probability of call failure also increased. This can be attributed to the bandwidth used by a call, the lack of quality of service (QoS) policy within the network, and the capabilities of the hardware/software used in the POC environment.

a) Limitations in bandwidth. Because the system leveraged leased line circuits at both the ingress and egress of the NG9-1-1 network, as the number of concurrent calls increased, the system began to saturate with voice and video packets. With no overflow or scalability capabilities, the system eventually could no longer support additional data packets injected in the system. The router queues began to fill, and eventually, packets began to drop. As new calls were injected into the system, their signaling data (setup and tear-down information) could no longer pass through the system. At this point, calls began to fail, thus increasing the failure rate. For operation systems, link budget analyses should be conducted prior to implementation to determine the desired number of concurrent calls that should be supported. Important factors include the theoretical bandwidth of the network links, the audio and video CODECs supported, and whether the signaling protocol operates in a centralized or peer-to-peer mode.

b) Lack of QoS Policy. Given scheduling and product constraints, a QoS policy was not implemented for the NG9-1-1 POC. A solid QoS policy would have given different priorities to certain IP packets. Therefore, despite the congestion in the network, signaling information could have passed through the network with priority over the voice and video traffic. This would have allowed the system to support more voice and video calls and alleviated some of the network bottlenecks that were created.

c) Limitation in Call Processing Hardware/Software. The POC environment was also limited as a result of some of the hardware and software selected. To support the transfer and conferencing of calls, a cheaper conference server was selected that supported only a maximum of 15 concurrent call streams. In addition, to expedite development of the POC, a design decision was made to pass all calls through the conference server even if only two parties (caller and call taker) would be involved in the call. This design decision, in conjunction with the conference server product selection, placed a hard limit of 14 concurrent calls on the system. In future work, it would be interesting to see how the system would scale if this constraint did not exist. This constraint emphasizes the importance of a thorough vendor analysis before the selection of any equipment in a production or operational system.

Data Collection Results:



Rochester, New York, PSAP

Call Scenario	Description	Call Rate (Calls / sec)	Maximum Concurrent Calls	Call Success (%)	Call Failure (%)
1	Data Traffic between Booz Allen Lab and PSAP #1 NY	0.194	8	100	0
		0.219	9	91	9
		0.216	10	95	5
		0.212	11	100	0
		0.228	12	91	9
		0.234	13	91	9
		0.243	14	87	13
6	Voice Traffic between Booz Allen Lab and PSAP #1 NY	0.188	8	82	12
		0.210	9	70	30
		0.204	10	85	15
		0.222	11	81	19
		0.225	12	85	15
		0.237	13	70	30
11	Video Traffic between Booz Allen Lab and PSAP #1 NY	0.246	14	75	25
		0.118	8	95	5
		0.123	9	95	5
		0.126	10	95	5
		0.144	11	85	15
		0.136	12	95	5
16	Voice/Video Traffic between Booz Allen Lab and PSAP #1 NY	0.156	13	85	15
		0.147	14	95	5
		0.118	8	95	5
		0.123	9	95	5
		0.126	10	95	5
		0.145	11	85	15
		0.134	12	100	0
		0.160	13	85	15
		0.195	14	70	30



Ft. Wayne, Indiana PSAP:

Call Scenario	Description	Call Rate (Calls / sec)	Maximum Concurrent Calls	Call Success (%)	Call Failure (%)
2	Data Traffic between Booz Allen Lab and PSAP #2 IN	0.191	8	100	0
		0.204	9	100	0
		0.210	10	95	5
		0.221	11	95	5
		0.228	12	95	5
		0.241	13	87	13
		0.266	14	82	18
7	Voice Traffic between Booz Allen Lab and PSAP #2 IN	0.119	8	95	5
		0.123	9	95	5
		0.126	10	95	5
		0.129	11	88	12
		0.149	12	85	15
		0.145	13	95	5
12	Video Traffic between Booz Allen Lab and PSAP #2 IN	0.135	8	75	25
		0.129	9	90	10
		0.127	10	100	0
		0.138	11	95	5
		0.138	12	95	5
		0.153	13	90	10
17	Voice/Video Traffic between Booz Allen Lab and PSAP #2 IN	0.125	8	90	10
		0.129	9	90	10
		0.143	10	90	10
		0.139	11	95	5
		0.149	12	90	10
		0.160	13	74	26
		0.148	14	95	5



Seattle, Washington PSAP:

Call Scenario	Description	Call Rate (Calls / sec)	Maximum Concurrent Calls	Call Success (%)	Call Failure (%)
3	Data Traffic between Booz Allen Lab and PSAP #3 WA	0.186	8	100	0
		0.188	9	100	0
		0.194	10	100	0
		0.210	11	95	5
		0.212	9	92	8
		0.220	13	95	5
		0.207	14	100	0
8	Voice Traffic between Booz Allen Lab and PSAP #3 WA	0.102	8	95	5
		0.120	9	95	5
		0.134	10	85	15
		0.124	11	95	5
		0.131	12	100	0
		0.148	13	90	10
8	Video Traffic between Booz Allen Lab and PSAP #3 WA	0.122	8	90	10
		0.116	9	95	5
		0.137	10	85	15
		0.129	11	100	0
		0.137	12	95	5
		0.142	13	95	5
13	Voice/Video Traffic between Booz Allen Lab and PSAP #3 WA	0.134	14	100	0
		0.117	8	90	10
		0.118	9	95	5
		0.123	10	95	5
		0.131	11	95	5
		0.135	12	95	5
		0.212	13	60	40
0.148	14	90	10		
0.200	20	80	20		

St. Paul, Minnesota PSAP:

Call Scenario	Description	Call Rate (Calls / sec)	Maximum Concurrent Calls	Call Success (%)	Call Failure (%)
4	Data Traffic between Booz Allen Lab and PSAP #4 MN	0.202	8	100	0
		0.225	9	90	10
		0.211	10	96	4
		0.223	11	100	0
		0.210	12	94	6
		0.263	13	85	15
		0.234	14	100	0
		0.470	20	60	40
9	Voice Traffic between Booz Allen Lab and PSAP #4 MN	0.119	8	95	5
		0.123	9	95	5
		0.134	10	90	10
		0.131	11	90	10
		0.124	12	96	4
		0.141	13	90	10
14	Video Traffic between Booz Allen Lab and PSAP #4 MN	0.142	14	89	11
		0.128	8	90	10
		0.130	9	90	10
		0.142	10	90	10
		0.132	11	95	5
		0.150	12	85	15
19	Voice/Video Traffic between Booz Allen Lab and PSAP #4 MN	0.162	13	85	15
		0.128	8	90	10
		0.125	9	100	0
		0.132	10	95	5
		0.139	11	90	10
		0.156	12	75	25
0.164	13	85	15		
0.168	14	85	15		



Helena, Montana PSAP:

Call Scenario	Description	Call Rate (Calls / sec)	Maximum Concurrent Calls	Call Success (%)	Call Failure (%)
5	Data Traffic between Booz Allen Lab and PSAP #5 MT	0.12	3	100	0
		0.16	4	100	0
		0.170	5	100	0
		0.166	6	100	0
		0.183	7	96	4
		0.185	8	100	0
		0.180	9	100	0
		0.193	10	100	0
		0.222	11	90	10
		0.223	12	90	10
		0.227	13	90	10
10	Voice Traffic between Booz Allen Lab and PSAP #5 MT	0.228	14	95	5
		0.110	8	90	19
		0.120	9	95	1
		0.127	10	90	5
		0.127	11	100	0
		0.128	12	100	0
		0.155	13	85	15
15	Video Traffic between Booz Allen Lab and PSAP #5 MT	0.144	14	95	5
		0.117	8	90	10
		0.120	9	95	15
		0.130	10	90	10
		0.212	11	90	10
		0.237	12	75	25
		0.195	13	76	24
20	Voice/Video Traffic between Booz Allen Lab and PSAP #5 MT	0.241	14	80	20
		0.193	8	90	10
		0.194	9	95	5
		0.200	10	95	5
		0.205	11	90	10
		0.223	12	86	14
		0.227	13	90	10
		0.241	14	85	15