A National Plan
for Migrating to IP-Enabled 9-1-1 Systems

The National E9-1-1 Implementation Coordination Office

September 2009

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1 EXECUTIVE SUMMARY

In the *New and Emerging Technologies 911 Improvement Act of 2008 (NET 911 Improvement Act)*, Congress tasked the National E9-1-1 Implementation Coordination Office (ICO) to develop "a national plan for migrating to a national [Internet Protocol] IP-enabled emergency network capable of receiving and responding to all citizen-activated emergency communications and improving information sharing among all emergency response entities."[1] The ICO, managed jointly by the Department of Commerce's National Telecommunications and Information Administration (NTIA) and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA), drew upon three years of research and development on Next Generation 9-1-1 (NG9-1-1) technologies, available industry resources and feedback from emergency communications stakeholders in preparing this plan. As stated in the statute (see Appendix A), the contents of the plan should:

> ***(A) outline the potential benefits of such a migration;***
> ***(B) identify barriers that must be overcome and funding mechanisms to address those barriers;***
> ***(C) provide specific mechanisms for ensuring the IP-enabled emergency network is available in every community and is coordinated on a local, regional, and Statewide basis;***
> ***(D) identify location technology for nomadic devices and for office buildings and multi-dwelling units;***
> (***E) include a proposed timetable, an outline of costs, and potential savings;***
> ***(F) provide specific legislative language, if necessary, for achieving the plan;***
> ***(G) provide recommendations on any legislative changes, including updating definitions that are necessary to facilitate a national IP-enabled emergency network;***
> ***(H) assess, collect, and analyze the experiences of the public safety answering points and related public safety authorities who are conducting trial deployments of IP-enabled emergency networks as of the date of enactment of the New and Emerging Technologies 911 Improvement Act of 2008;***
> ***(I) identify solutions for providing 9-1-1 and enhanced 9-1-1 access to those with disabilities and needed steps to implement such solutions, including a recommended timeline; and***
> ***(J) analyze efforts to provide automatic location for enhanced 9-1-1 services and provide recommendations on regulatory or legislative changes that are necessary to achieve automatic location for enhanced 9-1-1 services.***[2]

Moreover, the ICO should:

> ***"...consult with representatives of the public safety community, groups representing those with disabilities, technology and telecommunications providers, IP-enabled voice service providers, Telecommunications Relay Service providers, and other emergency communications providers and others it deems appropriate."***[3]

Background

Trends in personal communication technologies are accelerating the obsolescence of the current 9-1-1 system. The current circuit-switched infrastructure of the 9-1-1 network cannot receive digital data (e.g., text messages, photographs, and video) from the communication devices

[1] P.L. 110-283, Sec. 102(3)(d)(1),
[2] *Id*. at (d)(2).
[3] *Id.* at (d)(3).

commonly used by the public. Because these outmoded networks cannot provide the public with access to 9-1-1 services from newer technologies and devices, 9-1-1 networks and call centers must change. Based on recent technology assessments by the U.S. Department of Transportation (USDOT) and others, it was concluded that IP-enabled systems provide the optimal technical solution for future 9-1-1 networks. There are no insurmountable technology barriers. There are costs associated with transitioning to NG9-1-1, but compared with current maintenance costs of existing PSAP infrastructure, there are no significant, long term cost increases associated with migrating to IP-enabled emergency networks. Service providers, leading emergency communications associations and standards development organizations all support the adoption of IP-networks as the foundation of future 9-1-1.

There are, however, challenges to overcome. People expect the same level of access to 9-1-1 service regardless of which town, county or State the caller is in. Yet, even with the devices that can access 9-1-1 now – landline, wireless, and voice-over-IP (VoIP) phones – service is inconsistent across the United States. Without concerted national leadership and coordination, this disparity will only grow as consumers adopt new voice, text and video applications and local 9-1-1 Authorities cobble together solutions to access the antiquated 9-1-1 system one technology at a time. Funding, institutional and technical issues must be addressed if anything more than isolated and fragmented pockets of IP-enabled 9-1-1 capabilities are to be deployed.

The primary long-term goal for migrating to IP-enabled emergency networks is to allow the general public to make a 9-1-1 "call' from any communication device in any mode (e.g., voice, text, or video) and potentially to furnish additional incident information (e.g., photo, crash data). This requires a fundamental change from the voice-oriented, circuit switched networks that currently exist as the only conduit into 9-1-1 centers. These outmoded networks must be replaced by equally secure and reliable IP-based digital networks before 9-1-1 can become a 21st century service. Along with new policies and procedures, such networks can be combined within an interconnected system providing true interoperability across county, State, and international borders and among disparate emergency response and disaster management agencies.

This document addresses the ten requirements[4] specified in the *NET 911 Improvement Act* and provides additional information to identify and analyze 9-1-1 system migration issues and assess potential options to resolve them. It draws heavily from the USDOT NG9-1-1 Initiative work and findings. This plan serves as a roadmap for implementing policy decisions; it is not a "deployment plan" with prescribed design, timeline and budget requirements, but rather is an attempt to identify and analyze 9-1-1 system migration issues and assess potential options to resolve them consistent with the requirements of the *NET 911 Improvement Act*. Consistent with available resources, more work is needed to complete a more detailed, comprehensive plan.

The ten requirements are summarized in this Executive Summary; detailed information and references can be found in the following sections of this document.

(A) Outline the potential benefits of such a migration

The benefits of migrating from a circuit switched to IP-enabled emergency communications network are clear:

Similar Costs. Based on a study prepared using the Value Measuring Methodology (VMM), the ICO determined that NG9-1-1 offers significantly higher value and similar costs compared with today's 9-1-1 technologies, regardless of the level of coordination and cost sharing included as part of its deployment. Even after adjusting costs to account for the risks inherent in the upgrade to an NG9-1-1 system, deployment scenarios for NG9-1-1 have total lifecycle costs that are within the range of the current 9-1-1 environment's lifecycle costs ($66B-$94B, see Table 4 7). This

[4] *Id*. at (d)(2).

makes choosing between NG9-1-1 and today's 9-1-1 largely a function of the value provided by each.

Public Access. NG9-1-1 has a greater potential to meet the public's expectations for accessibility than the current 9-1-1 environment. Today, all calls to 9-1-1 must go through the telephone network to the Public Safety Answering Point (PSAP), thereby limiting access to a handful of technologies. The wireline E9-1-1 network currently provides rudimentary support for interconnected VoIP services and the Internet-based video and texting services used by the deaf, hard-of-hearing, and speech-impaired communities. This support, however, relies on the user to manually register his location, which is particularly sub-optimal for those with disabilities whose reliance on these services requires access to be highly mobile. A major benefit of IP-enabled 9-1-1 is that it would enable location information to be updated dynamically and delivered automatically. Moreover, this same technology would similarly benefit today's VoIP users and ultimately benefit all highly-mobile users of IP-enabled voice, text and video communications.

PSAP Capability. Migration to IP-enabled emergency networks would also increase the capabilities and efficiencies at 9-1-1 call centers. Through 9-1-1 call centers, police, fire and emergency medical responders could receive useful and actionable information about emergencies. For example, transmission of an image of a highway crash scene or medical data from a personal alert device could lead to more efficient and effective responses.

PSAP Connectivity and Interoperability. NG9-1-1 has greater scalability and flexibility than the current 9-1-1 environment. NG9-1-1 also has a greater potential to increase public and responder safety through interconnectivity and interoperability than the current 9-1-1 environment. With IP-enabled 9-1-1, the physical location of a PSAP becomes immaterial. IP-enabled technology will allow callers to reach 9-1-1 call takers, regardless of the PSAP location or virtual location. It will allow PSAPs to transfer and share information with other call centers or response agencies more quickly and with greater accuracy, regardless of location, and to deliver access to crucial data at a level rarely available today. The ability to transfer 9-1-1 calls within and among jurisdictions along with all collected data provides resilience that currently does not exist, but that may be essential in the event of call overload or PSAP damage.

Potential Long Term Cost Savings. NG9-1-1 provides greater opportunities for long term cost savings and increased operational efficiencies than the current 9-1-1 environment. NG9-1-1 has the potential to provide significantly greater value than current 9-1-1 technology by maximizing efficiency, reducing cost, and promoting systems that foster resource sharing and efficiency and information sharing.

(B) Identify barriers that must be overcome and funding mechanisms to address those barriers

Although each State, 9-1-1 Authority, and PSAP faces specific challenges when implementing NG9-1-1, some issues will need to be resolved regardless of specific circumstances or the transition approach. Through extensive stakeholder engagement efforts and analyses, the USDOT NG9-1-1 Initiative identified a set of overarching issues in five areas: governance and policy; funding; operations; standards and technology; and education.

Governance and Policy. As NG9-1-1 deployment begins, current roles and responsibilities among all entities involved in providing 9-1-1 services will change and the existing legal and regulatory environment will likely not effectively accommodate new technologies and arrangements. The deployment of NG9-1-1 will require increased coordination and partnerships among government and public safety stakeholders, 9-1-1 Authorities, service and equipment providers, and PSAP Administrators in planning and implementing NG9-1-1. A new infrastructure will require a new delineation of roles and responsibilities among the parties, defined by common practices and statutes. Coordination with the general public will also be important to address concerns and to manage expectations. As a result, legislative and regulatory arrangements and demarcation points at every level of government may need to be reexamined and some modified to effectively support NG9-1-1 deployment.

Funding. Today, 9-1-1 is typically funded by subscriber fees on telephone services, an approach that will be insufficient in the future. Many areas of the country are already experiencing a decline in 9-1-1 revenues, as consumers have stopped using land lines and adopted new telecommunications services not covered under current State and local 9-1-1 laws.[5] New funding models and mechanisms that are technology-neutral and dedicated for 9-1-1 services will be essential for sustaining IP-enabled 9-1-1 systems.

Even when collected, subscriber fees are often diverted by State government to pay for programs and projects unrelated to 9-1-1. 9-1-1 Authorities cannot procure necessary equipment enabling the transition to NG9-1-1 unless 9-1-1 fees are preserved.

Operations. To achieve the true potential of NG9-1-1, the operation of 9-1-1 Authorities and PSAPs will require significant change:

- New expectations and responsibilities of call takers and dispatchers. The increased quantity of available multimedia data will enhance and expand existing call-taking functions. It may also extend the time it takes to process 9-1-1 calls, increase the workload of the call taker, and significantly change the call taker's experience (e.g., seeing the incident versus hearing the incident). Revamped introductory training, as well as continuing education (retraining in some cases) for experienced staff, will be critical to the success of any NG9-1-1 implementation. Training programs, properly designed, can enable PSAP managers and supervisors to effectively prepare dispatchers and call takers to respond to the needs of an IP-enabled system, while maintaining the level of service expected by the public.
- Broader operational responsibilities for 9-1-1 Authorities. 9-1-1 Authorities will confront the challenge of managing a wider set of shared resources (potentially including shared Land Mobile Radio (LMR) and PSAP support technology resources to facilitate the delivery of multi-discipline Public Safety response) than is typical in the current system, enhancing and expanding capabilities while ensuring personnel, including call takers, can expeditiously and correctly handle the new workload. Responsibilities will likely expand, particularly with regard to configuring and managing the NG9-1-1 system.

Standards and Technology. Standardization is essential to achieve national interoperability and to share data among geographically dispersed PSAPs and other emergency response agencies. The underlying concept of IP-enabled 9-1-1 is an open architecture that relies on many different technical standards to support its requirements. To date, many communications, networking, and telephony standards that will affect IP-enabled 9-1-1 are still in development or need to be selected and accepted before the system can be implemented. However, public safety and industry standards organizations have arrived at a consensus on the technical architecture of an NG9-1-1 system needed to meet the needs of IP-enabled 9-1-1 systems.[6] Until baseline standards are developed, selected, fully vetted, and ultimately adopted, uncertainty among 9-1-1 decision-makers and service and equipment providers may hinder migration to IP-enabled 9-1-1.

[5] National Emergency Number Association, *A Policy Maker Blueprint for Transitioning to the Next Generation 9-1-1 System*, September 2008, p.11, http://www.nena.org/sites/default/files/NG9-1-1PolicyMakerBlueprintTransitionGuide-Final_0.pdf.

[6] The consensus on an NG9-1-1 technical architecture is documented in the interlocking standards principally from the Internet Engineering Task Force (IETF), Alliance for Telecommunications Industry Solutions (ATIS), Third Generation Partnership Program (3GPP), and the National Emergency Number Association (NENA). The relationship among these organizations is described in *NENA Functional and Interface Standards for Next Generation 9-1-1 Version 1.0*, December 2007, http://www.nena.org/sites/default/files/08-002%20V1%2020071218.pdf.

Migration to IP-enabled networks along with new modes communication access to 9-1-1 bring new security challenges that will need to be addressed through standards, technology and operational practices. The IP-enabled 9-1-1 system, like other mission critical systems, will continually encounter attempts at illegal access, including concerted malicious attacks (e.g., denial of service and virus or worm transmission). Therefore, to mitigate security risks and control access to the NG9-1-1 system, security controls (i.e., redundant/alternate route/alternate service) and certification and authentication mechanisms need to be developed to identify and determine the access methods, rules, and controls by which users and systems are allowed to access the 9-1-1 system in a prescribed and standardized manner.

Education and Awareness. There is widespread agreement that all 9-1-1 stakeholders—PSAPs and 9-1-1 Authorities, the public safety community, services and equipment providers, policymakers, and the public —need to know more about and be kept informed of IP-enabled 9-1-1 technologies and how they will affect emergency communications. Education is critical to the effectiveness of all aspects of NG9-1-1 and deserving of significant investment to increase the level of understanding about NG9-1-1 by all stakeholders.

(C) Provide specific mechanisms for ensuring the IP-enabled emergency network is available in every community and is coordinated on a local, regional, and statewide basis

Achieving ubiquitous IP-enabled 9-1-1 service in the United States requires not only new 9-1-1 infrastructure, but new institutional frameworks as well. It will involve, to various degrees, actions by 9-1-1 Authorities, State and local governments, Federal agencies, non-governmental organizations, communication service and equipment providers, and emergency response organizations. Specific options and mechanisms to address the barriers and issues noted above include:

Governance and Policy
- Clarify jurisdictional frameworks and responsibilities and identify the coordination required at each level of government to make IP-enabled 9-1-1 possible;
- Consider developing model State legislation that would address update of regulations, legislation, and other policies to reflect modern communications and IP-enabled 9-1-1 system capabilities;
- Assign clear responsibility and authority for ensuring the availability of 9-1-1 within specific geopolitical boundaries by statute or administrative rule; and
- Factor IP-enabled 9-1-1 network considerations in national broadband planning, especially as it relates to extending high-speed Internet access to currently underserved areas.

Funding
- Ensure IP-enabled 9-1-1 upgrades are considered a fiscal priority for States and local jurisdictions and the Federal grant programs;
- Change outdated funding mechanisms to be more technology-neutral; and
- Ensure 9-1-1 funds are preserved for 9-1-1.

Operations
- Prepare and train call takers and other personnel to handle increased quantity and quality of information available with IP-enabled 9-1-1 calls;
- Prepare 9-1-1 Authorities to handle IP-Enabled 9-1-1 system administration, including configuration management, database management, quality assurance, and standard operating procedures; and
- Prepare 9-1-1 Authorities and PSAP Administrators to handle contingency planning and use of virtual PSAPs.

Standards and Technology

- After completing gap analysis of existing standards, complete and accept IP-enabled 9-1-1 open standards and understand future technology trends to encourage system interoperability and emergency data sharing;
- Establish routing and prioritization protocols and business rules;
- Determine the responsible entity and mechanisms for location acquisition and determination;
- Establish system access and security controls to protect and manage access to the IP-enabled 9-1-1 system of systems; and
- Develop a certification and authentication process to ensure service providers and 9-1-1 Authorities meet security and system access requirements.

Education and Awareness

- Encourage private and public policy stakeholders to support and promote change through effective education programs;
- Reduce barriers for IP-enabled 9-1-1 through education programs;
- Educate PSAP and 9-1-1 Authority personnel regarding their role in IP-enabled 9-1-1; and
- Develop effective public education and awareness programs.

(D) Identify location technology for nomadic devices and for office buildings and multi-dwelling units

Outside of the wireline common carriers, wireless carriers, and the interconnected VoIP providers mandated by the Federal Communications Commission (FCC) to deliver 9-1-1 calls, few service providers are consistently providing location information at the level of accuracy that is necessary for responders to locate callers. Location information currently available to new devices and services (e.g., mobile wireless VoIP) may be adequate for routing 9-1-1 calls to the appropriate PSAP, but there are technological and regulatory challenges to ensuring highly accurate positioning in buildings or outdoors.

There are, however, a growing range of methods to improve location determination indoors as well as outdoors. Some require incorporation of additional technology and infrastructure and some require enhancements to existing technology (See Table B-1 in Appendix B for details). There is activity in some standards organizations to establish provisions in various protocols for fixed and wireless systems to enable both location determination and proper routing of emergency calls. Although there are liaison activities underway among standards development groups, there are issues with using several different types of technologies in heterogeneous networks (i.e., connecting a WiFi access point to a cellular modem). These are complicated issues to address and are currently affected by the maturity of a draft standard and its status in the approval process. For example, two IEEE groups are addressing the provision of emergency services (IEEE 802.11 Task Group u-Interworking with External Networks and IEEE 802.21 to address handover and interoperability between heterogeneous networks.)

As IP-enabled 9-1-1 services are rolled out and implemented, it is essential that the public understands how, where, and when IP-enabled 9-1-1 services are available, and more importantly, where and when they are not available. Devices and services that can deliver 9-1-1 in one region may not be available in another. Moreover, even when the user is aware of what devices can be used in his region, the ability of any particular device to determine its location or even access 9-1-1 at all may depend on the particular network to which it is connected, and how it is connected. One future solution may be that all devices and applications with which people could "reasonably expect" to call for help display real-time 9-1-1 access status simply, clearly, and consistently to their users.

Demand for location capabilities is growing in conjunction with social networking and other applications. There are technologies available or in development for locating calls from nomadic or mobile devices and for providing specific addressing within buildings (see Appendix B for details).

(E) Include a proposed timetable, an outline of costs, and potential savings

A timetable for full, national deployment of NG9-1-1 is difficult to estimate due to a lack of:

- Consistent funding for NG9-1-1 implementation (due to reduction in and/or diversion of surcharges)
- Complete standards; and
- Coordinated planning and implementation efforts by stakeholders at all levels.

For the purpose of the Cost, Value and Risk Analysis conducted as part of the USDOT NG9-1-1 Initiative, a 10-year implementation period was used, and was based on resolution of the above three issues and an assumed lifecycle of 20 years.

As part of the NG9-1-1 Initiative, USDOT analyzed the value, cost, and risk associated with migrating to an IP-enabled 9-1-1 national framework. USDOT also compared the 20-year lifecycle costs for today's 9-1-1 system and two NG9-1-1 scenarios and found that public sector deployment and operation of IP-enabled 9-1-1 would likely cost about the same as maintaining the status quo (between 87 to 130 percent of today's expenses). The IP-enabled 9-1-1 infrastructure – PSAP upgrades, IP-networks, and corresponding data centers – would cost an estimated $12 billion, which is comparable to the $10-15 billion estimates for the corresponding components of the nationwide circuit-switched 9-1-1 system over the same period. This conservative analysis did not consider possible savings from organizational changes such as consolidating PSAP operations into fewer facilities or cost-sharing for supporting technologies nor did it account for concurrent expenses during the transition periods.

USDOT developed a rating scale to assess the relative values (i.e., measures of the non-monetized benefits) of these deployments, concluding that IP-enabled 9-1-1 would deliver significantly more value (between 73 and 80 percent) than today's circuit-switched 9-1-1 system. More specifically, it provides better opportunities for cost savings and increased operational efficiencies than the current 9-1-1 environment; increased potential to meet the public's expectations for accessibility; greater scalability and flexibility; and better potential to increase public and responder safety through interconnectivity and interoperability.

Continuing to adapt the current wireline E9-1-1 network to more calling devices and services would deliver significantly less value at a greater cost than migrating to the NG9-1-1 infrastructure. Moreover, many other government and commercial communications systems have or are transitioning to IP-networks.

(F) Provide specific legislative language, if necessary, for achieving the plan; and
(G) Provide recommendations on any legislative changes, including updating definitions that are necessary to facilitate a national IP-enabled emergency network

Without effective policy development in conjunction with technical and operational NG9-1-1 system development, the best designs and system architectures will be just that—designs and architecture that do not come to fruition. To actually implement NG9-1-1 systems, laws and regulations may require changes in order to facilitate and legalize all aspects of NG9-1-1. If properly enabled by technology and policies, an effective governance structure can be implemented. Governing 9-1-1 authorities, emergency response agencies, call takers, emergency responders and communications service providers will need to have the appropriate governance, policies and mechanisms to provide a coordinated and appropriate response in an NG9-1-1 environment.

The range of options spans from encouragement and guidance to regulation and legislation, and involves government agencies, non-governmental organizations, Originating Service Providers[7] (OSP), network providers and the general public. While not exhaustive, the following regulatory issues are raised to emphasize their importance in deploying a national NG9-1-1 system. Specific legislative language is not provided.

Responsibility and authority for ensuring the availability of 9-1-1 within specific geopolitical boundaries should be clearly assigned by statute or administrative rule. Many existing laws and regulations define a specific role for specific 9-1-1 Authorities, but general responsibility for providing 9-1-1 services is not clear in most jurisdictions. While callers use 9-1-1 to access "essential government services" such as law enforcement, fire departments or emergency medical services, 9-1-1 is not defined as an essential government service by State constitution, law or administrative rule. Many current statutes do not define which level of government is responsible for ensuring the provision of 9-1-1 services.[8] This is a deficiency that leaves open questions about what responsibilities fall to State, county and local governments in assuring at least minimal 9-1-1 operations. These responsibilities need to be defined and enforced to avoid a future crisis in the availability of 9-1-1 to some communities. As jurisdictions implement NG9-1-1 and are able to interconnect with other PSAPs regardless of location, identifying clear roles and points of contact is essential. Responsibility and authority for ensuring the availability of 9-1-1 within specific geopolitical boundaries should be clearly assigned by statute or administrative rule.

Public sector 9-1-1 institutions will need sufficiently broad authority to deploy and operate an IP-enabled system. Many existing laws and regulations define a specific role for specific 9-1-1 Authorities, limiting their jurisdiction and function to specific activities, such as the collection and disbursement of 9-1-1 surcharges. Moreover, many existing laws, regulations and tariffs specifically reference older technologies or system capabilities and consequently prohibit the implementation or funding of IP-enabled 9-1-1.[9] The deployment of IP-enabled 9-1-1 will greatly increase the number of new types of services and providers and change the roles of existing 9-1-1 system stakeholders. Public sector 9-1-1 institutions will need sufficiently broad authority to deploy and operate IP-enabled systems.

Some consolidation and centralization of 9-1-1 institutional responsibilities will be essential to avoid excessive administrative burdens as well as provide uniform, high quality 9-1-1 Authority functions. For example, current policies regarding which OSP can connect to 9-1-1 trunk lines are generally set by each local PSAP or its corresponding 9-1-1 Authority. Today, an OSP that delivers 9-1-1 calls must establish service level agreements separately with each 9-1-1 Authority in its service area. With the deployment of NG9-1-1, this may mean dozens of agreements for any single 9-1-1 Authority, and may entail thousands of agreements for carriers with nationwide coverage. With the thousands of IP-based OSPs that would be able to deliver 9-1-1 calls in an IP-enabled environment, this administrative model will become untenable for local 9-1-1 Authorities in the future. Some consolidation and centralization of 9-1-1 institutional responsibilities will be essential to avoid excessive administrative burdens as well as provide uniform, high quality 9-1-1 Authority functions, such as ensuring call routing and security mechanisms are in place. Most of these call routing and security functions are presently delegated to incumbent local exchange carriers or similar 9-1-1 system providers.

[7] "Originating service provider" encompasses landline and mobile phone common carriers, VoIP operators, and other communications application and service providers that will deliver "calls" to the 9-1-1 system.
[8] 9-1-1 Industry Alliance, *Health of the US 9-1-1 System*, 2008, pp. 43-46, http://www.911alliance.org/9IA_Health_of_US_911%20_2_.pdf (last accessed July 2, 2009).
[9] U.S. Department of Transportation, *Next Generation 9-1-1 Initiative Transition Plan*, February 2009, p.43, http://www.its.dot.gov/ng911/pdf/NG911_Transition_PlanFinal.pdf.

Examination of roles and responsibilities to be shifted from local to regional to State to National-level coordination should be conducted. Providing 9-1-1 services has traditionally been the role of local, regional and State government. As the infrastructure of 9-1-1 migrates to a digital, IP-based model, an examination of roles and responsibilities should be conducted on an ongoing basis, to identify those functions that should shift to a higher level of government. For example, as PSAPs are able to transfer calls to other distant PSAPs through a nationwide interconnection network, accessing a national database of IP addresses will be necessary to facilitate call transfers. While the response to emergencies will always be a local responsibility, some administrative and data security functions may be better served by shifting to a State or national (or international) model.

Laws and regulations for 9-1-1 should be updated to be technology-neutral. Many existing laws, regulations and tariffs specifically reference older technologies or system capabilities and consequently prohibit the implementation or funding of IP-enabled 9-1-1. For example, by statute, some locations only permit access to PSAPs via the telephone network. Laws and regulations for 9-1-1 must be updated to be technology-neutral, to facilitate 9-1-1 access for the communication devices already used by the public and those on the horizon of technology.

Consistent, long-term funding for 9-1-1 is essential. Laws and regulations affect how State and local governments fund 9-1-1 infrastructure and operations; for example, surcharge rates often differ depending on the service type (e.g., wireless, prepaid wireless, wireline or VoIP) and the jurisdiction for which the fee is being collected. With NG9-1-1, PSAP costs will be distributed over many more “carrier surcharges.” The administrative cost of collecting all of these differing fees is likely to substantially reduce net revenues. Whether through statutory changes or other policies, consistent, long-term funding for 9-1-1 is essential. New funding models for 9-1-1 should be developed and considered for adoption, and 9-1-1 Authorities may wish to identify opportunities to offset the cost of IP-enabled 9-1-1 by sharing infrastructure, resources and services with, or simply interconnecting with, other public safety, non-public safety government or private sector entities.

One of the most important policy decisions for IP-enabled 9-1-1 will be establishing responsibilities for generating and delivering accurate, real-time location information. Unlike today’s wireline and wireless telephone service, the OSP and network provider will no longer be the same entity or as closely-linked. For example, access to communications services such as instant messaging or VoIP do not depend on the particular network used to access the Internet. While the OSPs may ultimately continue to be responsible for delivering information accurate enough to enable an emergency response, there are network-based mechanisms that would permit any IP-enabled 9-1-1 call to be routed to the most appropriate PSAP, regardless of the capability of the devices or application service to determine its own location. One of the most important policy decisions for IP-enabled 9-1-1 will be establishing responsibilities for generating and delivering accurate, real-time location information. The FCC currently regulates the provision of 9-1-1 caller location information by service providers, but in the NG9-1-1 model, responsibility for providing location information for 9-1-1 calls made from additional forms of communication has not been established.

Updating definitions. Adopting consistent definitions will facilitate true interoperability in establishing an interactive “system-of-systems” for emergency communications. A mechanism to promote the use of consistent definitions by Federal agencies involved in emergency communications such as the USDOT, the FCC and the Department of Homeland Security, will support coordination of efforts by the adoption of common terminology and operating procedures.

(H) Assess, collect, and analyze the experiences of the public safety answering points and related public safety authorities who are conducting trial deployments of IP-enabled emergency networks as of the date of enactment of the NET 911 Improvement Act

As of the date of enactment of the NET 911 Improvement Act, a few State and local agencies (Vermont, Indiana and Galveston County, Texas) have implemented IP components within their 9-1-1 systems. To date, efforts have primarily focused on procuring IP-enabled equipment that supports operations within the PSAP. As of the date of enactment, no State or local agencies accepted calls delivered directly in IP-format. The ICO is currently establishing a 9-1-1 Technical Assistance Center to serve as a clearinghouse for 9-1-1 information of a technical, operational and institutional nature. The ICO plans to make information available on early adopters of IP-based technology through the 9-1-1 Technical Assistance Center. Although activities could be performed under current DOT and DOC authority, the long term role of the ICO is uncertain as the ICO's legislative authorization expires on October 1, 2009.[10]

Trial deployments of IP-enabled emergency networks include a Proof-of-Concept (POC) test and demonstrations conducted as part of the USDOT NG9-1-1 Initiative. The POC project leveraged past work from the public safety and standards communities and built on the requirements, architecture and initial system design developed under the NG9-1-1 Initiative.

The USDOT designed and implemented a standalone and secure POC network that connected three laboratory facilities, four PSAPs (Rochester, New York; King County, Washington; St. Paul, Minnesota; and Helena, Montana) and one statewide PSAP network (the State of Indiana). The NG9-1-1 POC demonstration was not an operational demonstration, although the facilities and staff of the five PSAPs were used during the testing. At no time during the tests were real calls used nor did the test system interrupt the operations of the current 9-1-1 system. The NG9-1-1 POC focused on the three main components of emergency calling: call origination, call support/processing and call termination at a PSAP. The POC tested legacy telephones, cellular telephones (both voice and texting), third-party call centers (e.g., telematics systems) and laptops, IP telephones and IP wireless devices.

At the five PSAPs, professional call takers, dispatchers and supervisory personnel were trained to assist with the POC testing. The NG9-1-1 POC was evaluated with basic pass/fail criteria for each test. During the PSAP-based testing, 273 functional requirements were tested, with 241 (88 percent) successfully passing. While no industry benchmarks exist that gauge IP-enabled emergency service network implementations, the team believed it successfully demonstrated a significant portion of the NG9-1-1 concepts during the POC. The following functions were successfully tested:

- Ability to send and receive voice, video, text (Instant Messaging (IM), Short Messaging Service (SMS)) and data;
- Increased deaf/hearing-impaired accessibility via text messaging and video relay services;
- Caller's location identification for landline, wireless and VoIP calls;
- Call routing based on caller's location;
- Transmission of telematics data; and
- Transfer of calls from PSAP to PSAP, with collected data.

Challenges were experienced with text messaging as there is currently no method for guaranteed message delivery and some SMS failed to be delivered or were significantly delayed in arriving at the PSAP. Location data for an SMS-based call is not currently commercially available, but some industry development and testing is underway.[11] In addition, issues arose with bandwidth and video streaming methods that caused initial video-based calls to fail.

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[10] P.L. 108-494, Sec. 104, (e)(2) codified as 47 U.S.C. §942 (e)(2).

[11] *See* Fox Business, *Iowa 9-1-1 Call Center First in Nation to Successfully Trial 9-1-1 Text Messaging*, June 9, 2009, http://www.foxbusiness.com/story/markets/industries/health-care/iowa----center-nation-successfully-

(I) Identify solutions for providing 9-1-1 and enhanced 9-1-1 access to those with disabilities and needed steps to implement such solutions, including a recommended timeline

The solution for providing emergency communications access to those with disabilities is to enable the devices that disabled people use every day to connect to the 9-1-1 system. The communications services used by individuals with disabilities have improved dramatically with new consumer devices. Internet-based video and text relay service now support PSAP routing and automatic location information delivery that is functionally equivalent to interconnected VoIP E9-1-1. Telecommunication Device for the Deaf/Teletypewriter (TDD/TTY) via Public Switched Telephone Network (PSTN) landlines is still widely retained because of the high reliability and location accuracy of wireline E9-1-1. Although mobile phones are the source of more than 50 percent of 9-1-1 calls in some areas, those devices are not yet a good option for emergency access by the deaf, hard-of-hearing and speech-impaired communities, which rely heavily on the text messaging capabilities of mobile phones and handheld devices.[12]

Increasingly, hearing-impaired individuals have abandoned TDD/TTY in favor of texting or video relay services. Texting access through various IP-devices and third party video conferencing (which may be needed to support sign language interpretation) were successfully tested in the NG9-1-1 proof of concept, demonstrating that access to 9-1-1 is feasible using these applications. Streaming video and cell phone texting (i.e., short message service) were also successfully demonstrated, but with shortcomings. Some SMS were not delivered or delivered to the default PSAP many hours later. Real-time texting, which does not have the shortcomings of SMS, was successfully demonstrated. Also during the proof of concept, the video call stream would lock up after several minutes of use due to bandwidth issues.

Migration to IP-enabled 9-1-1 systems in general represents the critical path for meeting the needs of people with disabilities. This report does not lay out a deployment timeline, which depends strongly on the existence of standards, consistent funding and nationwide coordination. Assuming these three factors, a 10-year rollout period for full deployment of network, data centers and PSAP infrastructure is feasible and was used as the basis for cost estimation.

(J) Analyze efforts to provide automatic location for enhanced 9-1-1 services and provide recommendations on regulatory or legislative changes that are necessary to achieve automatic location for enhanced 9-1-1 services

One of the most important policy decisions for IP-enabled 9-1-1 will be establishing responsibilities for generating and delivering accurate, real-time location information. Unlike with today's wireline and wireless telephone service, the OSP and network provider will no longer be the same entity or as closely-linked in an IP environment. For example, access to communications services such as instant messaging or VoIP do not depend on the particular network used to access the Internet. While the OSPs may ultimately continue to be responsible for delivering information accurate enough to enable an emergency response, there are network-based mechanisms that would permit any IP-enabled 9-1-1 call to be routed to the most appropriate PSAP, regardless of the capability of the devices or application service to determine

trial----text-messaging/ (last accessed July 13, 2009); *see also* Luke Meredith, *Northeast Iowa county set to receive 911 texts*, Chicago Tribune, June 10, 2009, http://archives.chicagotribune.com/2009/jun/10/health/chi-ap-ia-emergencytexting (last accessed July 13, 2009).

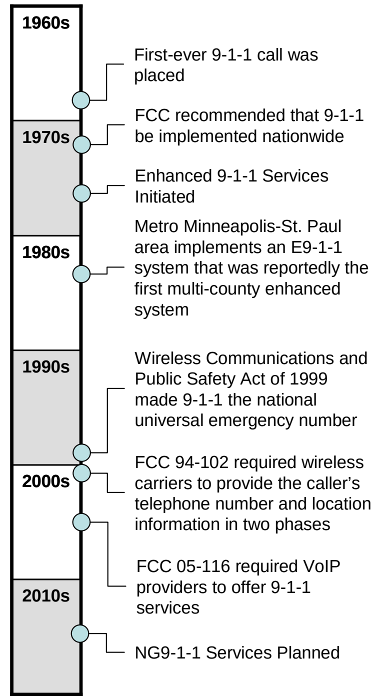
[12] TDD/TTY can also connect via most wireless phones, but is an impractical mobile solution. Georgia Institute of Technology has demonstrated a mobile phone that emulated TTY signaling, eliminating the need for a separate TTY device. *See TTY phone: direct, equal emergency access for the deaf*, http://portal.acm.org/citation.cfm?id=1414471.1414536#abstract.

its own location. One of the most important policy decisions for IP-enabled 9-1-1 will be establishing responsibilities for generating and delivering accurate, real-time location information.

As noted in Requirement (D) above, trends in communications services have implications for 9-1-1 automatic location. The decoupling of originating service providers from network operators will make the delivery of real-time, automatic location information more challenging. For example, the trend in the wireless industry toward “convergence” – enabling a single device to operate using multiple, different networks – will make for inconsistent location determination. Since most location methods derive some assistance from the network when the device switches from one type of network to another, it will temporarily (or longer) lose support for location and the support it ultimately receives may be markedly different. Mobile devices may have to incorporate multiple methods for location determination.

Location technology impacts 9-1-1 calls at two points: first, to route the call to the appropriate PSAP and second, to provide information to locate the caller. While location information currently delivered may be adequate for routing 9-1-1 calls to the appropriate PSAP, there presently is no single technology or simple hybrid system that will provide location information from mobile devices on converged networks that is adequately accurate for first responders to locate callers.

2 INTRODUCTION



For more than three decades, the 9-1-1 system has been a public service success story. 9-1-1 has extremely strong "brand" recognition and people in 96 percent of U.S. counties have access to police, fire and emergency medical services via this universal telephone number. Now, however, that service is changing. The public is rapidly adopting mobile communications devices that do not use traditional telephone networks and is finding that many of these devices connect poorly -- or not at all -- to the current 9-1-1 system. To prevent the degradation of emergency services, as well as take advantage of the text, data and imaging features of these consumer devices, the 9-1-1 system must migrate from a voice-oriented circuit-switched infrastructure to one that also incorporates advanced digital services (e.g., IP-enabled networks).

Congress recognized that our 9-1-1 call centers – known as Public Safety Answering Points (PSAPs) – would need guidance and assistance in upgrading their facilities and networks. The *Ensuring Needed Help Arrives Near Callers Employing 911 Act of 2004* (*ENHANCE 911 Act*)[13] called for the Assistant Secretary of Commerce for Communications and Information, U.S. Department of Commerce, and the Administrator of the National Highway Traffic Safety Administration (NHTSA), U.S. Department of Transportation, to create an E9-1-1 Implementation Coordination Office (ICO, which has also become known as the National 9-1-1 Office) to provide a focal point for national 9-1-1 leadership and to assist PSAPs in upgrading to accept calls from location-capable cellular devices. More recently, the *New and Emerging Technologies 911 Improvement Act of 2008* (*NET 911 Improvement Act*) encourages the rapid deployment of IP enabled 9-1-1 services and requires the ICO to develop "a national plan for migrating to a national IP-enabled emergency network capable of receiving and responding to all citizen-activated emergency communications and improving information sharing among all emergency response entities."[14] This report responds to the *NET 911 Improvement Act* requirements.

9-1-1 Background

The Nation's 9-1-1 system architecture, built in the 1970s, is based on a decades-old, circuit-switched network technology. Early 9-1-1 call processing was basic, using three-digit dialing and circuit-based transmission to PSAPs, and neither Automatic Number Identification (ANI) nor Automatic Location Identification (ALI) functions were available. The calls were received and processed through the public switched telephone network (PSTN) infrastructure to the PSAP. As new technologies were introduced, modifications were made to establish connections to this basic 9-1-1 infrastructure. "Enhanced" 9-1-1 (E9-1-1) enabled the functionality to route calls to appropriate PSAPs based on the location of the caller using selective routing equipment, as well as provide PSAPs with the number (ANI) and address information associated (ALI) with the caller.

In the mid-1990s, with the proliferation of wireless technologies, the 9-1-1 system faced new challenges—receiving 9-1-1 calls from cell phones and identifying the location of the caller. The Federal Communications Commission's (FCC) Order 96-264[15] established requirements and

[13] P.L. 108-494.
[14] P.L. 110-283, Sec. 102.
[15] Federal Communications Commission, In re Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, *Report and Order and Further Notice of Proposed*

deadlines in two phases, requiring that all wireless carriers provide the caller's telephone number and location information to the PSAPs. In 2005, with the growth of Voice over Internet Protocol (VoIP) telephony, the FCC issued Order 05-116[16] requiring interconnected VoIP providers to offer 9-1-1 services to all subscribers. VoIP is technology supporting voice communications over IP networks such as the Internet or other packet-switched networks. Most commercial VoIP services provide an interface to the PSTN allowing calls to traditional telephones. Wireless and VoIP technologies required additional, individual modifications to the previous 9-1-1 infrastructure – within thousands of 9-1-1 networks across the country – to enable 9-1-1 calls to connect to PSAPs.

The growing consumer market penetration of both wireless and VoIP telephony, and the increasing use of advanced technologies they represent, has underscored the limitations of the current 9-1-1 infrastructure and funding mechanisms. The Nation's 9-1-1 system, based on decades-old technology, cannot process video, text, images and other data that are increasingly common in personal communications. The pace of change in technology will not slow. To ensure that the general public has access to 9-1-1 from new and emerging devices that have multiple ways of communicating, the 9-1-1 infrastructure must be upgraded to accommodate new technologies. If left unchanged, the current 9-1-1 system will face a multitude of pressures as society and technology continue to advance. For example—

- More than one in five households have discontinued wireline service (or chosen not to use it) and rely solely on wireless communications as their primary telephone service; [17]
- Of those, an estimated 12 percent are prepaid customers;[18]
- 110.4 billion SMS messages were sent in December 2008 alone; and[19]
- Approximately 30 million households will be using a VoIP service as either a primary or secondary telephone line by the end of 2011.[20]

Current 9-1-1 System Deficiencies

For a member of the public making an emergency call from a traditional wireline telephone, the 9-1-1 system usually works as designed. However, in many communities, nearly half of 9-1-1 calls are placed from wireless telephones.[21] In addition, a small, but growing, number of telephone users have acquired VoIP service. Wireless and VoIP service users often do not have traditional wireline telephone service in their homes or offices. As a result, the 9-1-1 system is contending with growing challenges from this segment of the public. In addition, the current system cannot incorporate the multiple types of data transmitted by new communications devices, and therefore, cannot unlock the potential for better emergency service delivery that these data types (e.g., texting, video, crash notification) represent.

Rulemaking, RM-8143, adopted June 12, 1996, http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-96-264A1.pdf (last accessed July 13, 2009).

[16] Federal Communications Commission, In re IP-Enabled Services; E911 Requirements for IP-Enabled Service Providers, *Report and Order and Further Notice of Proposed Rulemaking*, FCC 05-156, adopted May 19, 2005, http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-05-116A1.pdf (last accessed July 2, 2009).

[17] Centers for Disease Control and Prevention, *Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July-December 2008*, May 6, 2009, http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless200905.pdf.

[18] According to a 2007 TracFone presentation to the National Association of State 9-1-1 Administrators (NASNA).

[19] CTIA Wireless Quick Facts, Year End Figures December 2008, http://www.ctia.org/media/industry_info/index.cfm/AID/10323 (last accessed July 13, 2009).

[20] Cellular-News, *VoIP-Connected Households to Grow by 8.5 Million by 2011*, October 15, 2008, http://www.cellular-news.com/story/34147.php?source=newsletter (last accessed July 13, 2009).

[21] *Id*.

The communications and computing technology available to the public has advanced and continues to advance faster than the 9-1-1 system can change to meet consumer needs.[22] In particular, technology has allowed 9-1-1 callers and their communications devices to be mobile. This creates a major challenge for the current 9-1-1 service delivery model, which relies on accurate callback and location data for every 9-1-1 call. It has now been more than a decade since the FCC required that all wireless carriers provide the telephone number and location information of voice callers to the PSAPs, yet some PSAPs still have not upgraded and requested this information from wireless carriers.[23] With the advancement of technology, the emergency communication networks are continuing to become less efficient, less technologically advanced and, as a result, less able to provide the public with 9-1-1 services on newer technologies and devices.

In addition, the deaf, hearing impaired and speech-impaired segments of the population have been historically underserved by 9-1-1. Current regulations require PSAPs to provide direct and equal access to their services to all citizens, regardless of disability.[24] As a result, PSAP operators employ Telecommunication Device for the Deaf/Teletypewriter (TDD/TTY) equipment to communicate with the deaf and hearing-impaired, and assistive technologies to aid speech-impaired individuals. However, although the technology used by individuals with disabilities has improved dramatically (e.g., text messaging and video relay services), access to 9-1-1 has not notably improved. Few mobile devices support TDD/TTY and other texting and video options cannot access 9-1-1 at all. The deaf, hearing-impaired and speech-impaired population has become effectively more underserved by the Nation's 9-1-1 systems.

The U.S. DOT Next Generation 9-1-1 Initiative

The Next Generation 9-1-1 (NG9-1-1) Initiative is a research and development project funded by USDOT Intelligent Transportation Systems Joint Program Office[25] to define the framework and plan to deploy IP-based emergency communications across the nation. It is based on the premise that a technological and operational transition to IP-enabled 9-1-1 is essential for the Nation's public safety emergency communications networks to adapt to the public's increasing use of wireless communications and digital and IP-based devices that can transmit text, images, and video. The NG9-1-1 project leveraged work from USDOT's earlier Wireless E9-1-1 Initiative and built on the IP-related 9-1-1 work at other organizations. These included the FCC Network Reliability and Interoperability Council (NRIC), the National Emergency Number Association (NENA) the Internet Engineering Task Force (IETF), and the Alliance for Telecommunications Industry Solutions Emergency Services Interconnection Forum (ATIS-ESIF) among others. USDOT's core vision for NG9-1-1 is that the new IP network will provide the foundation for public emergency services in an increasingly mobile and technologically diverse society and ultimately enable 9-1-1 calls from most types of communications devices. Envisioned as an emergency call[26] delivery and response system (or "system-of-systems"), the USDOT IP-enabled 9-1-1

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[22] As a *New York Times* article observed: The 9-1-1 "system has not kept pace with the nation's rapidly changing communications habits. As it ages, it is cracking, with problems like system overload, understaffing, misrouted calls, and bug-ridden databases leading to unanswered calls and dangerous errors." Shaila Dewan, *An SOS for 911 Systems in Age of High-Tech,* New York Times, April 6, 2007, http://www.nytimes.com/2007/04/06/us/06phone.html (last accessed July 13, 2009).

[23] Federal Communications Commission, In re Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, *Report and Order and Further Notice of Proposed Rulemaking*, RM-8143, adopted June 12, 1996, http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-96-264A1.pdf.

[24] For more information, please consult the U.S. Department of Justice, Civil Rights Division, *Americans with Disabilities Act: Access for 9-1-1 and Telephone Emergency Services,* http://www.usdoj.gov/crt/ada/911ta.pdf.

[25] For more information, see RITA, Intelligent Transportation Systems (ITS), http://www.its.dot.gov/index.htm (last accessed July 13, 2009).

[26] The term "call" is used in this document to indicate any real-time communication—voice, text, or video—between a person needing assistance and a PSAP telecommunicator. This term also includes

concept would capitalize on advances in information and communications technologies and provide the following benefits—

- Quicker delivery of more robust information to responders from a 9-1-1 call;
- Better and more useful forms of information (text, images and video) from any networked communications device;
- Transfer of 9-1-1 calls between geographically dispersed PSAPs (and from PSAPs to remote public safety dispatchers), if necessary;
- Transfer of 9-1-1 calls and data between PSAPs and other geographically dispersed emergency entities; and
- Capability to share data and resources to improve emergency response via IP-enabled networks built on flexible, robust platforms with built-in security to mitigate system risks.

The project developed a concept of operations, functional requirements and system architecture; it demonstrated components from the architecture in a proof-of-concept test, and analyzed migration barriers and issues, as well as the costs, values and risk for IP-enabled 9-1-1 system implementation. The following is a list of the key reports with findings from the NG9-1-1 Initiative; these and other documents, used primarily for the basis of this Migration Plan, are available, for more information, on the USDOT website:[27]

- Concept of Operations;
- System Description and Requirements Document;
- Proof of Concept Deployment Plan;
- Architecture Analysis Report;
- Proof of Concept Final System Design Report;
- Proof of Concept Testing Report;
- Transition Plan; and
- Analysis of Cost, Value, and Risk.

About This Report

Much of the material in this Migration Plan draws on the technical, institutional and economic research of the NG9-1-1 Initiative noted above, conducted between December 2006 and February 2009. Further, the development of this plan was contingent upon the resolution of final results and recommendations for key issues developed within the NG9-1-1 Initiative, such as the NG9-1-1 Transition Plan in February 2009. Subsequently, they were included herein.

This report addresses the ten specific requirements provided in the *NET 911 Improvement Act*. The layout of this report does not correspond directly to the requirements in the *NET 911 Improvement Act,* as many of these requirements have multiple, overlapping scopes. For example, Requirements (D), (I) and (J) all address location technology issues. The report is structured around major topical issues of concern for migrating to a national IP-enabled emergency network that were identified in the NG9-1-1 Initiative rather than by the order of the statutory requirements. To link the statutory requirements with the specific text within the document, they are designated in the document by bolded references (e.g., **REQUIREMENT A**) with the corresponding pages listed in Table 2-1. Table 2-1 also identifies those requirements that were drawn from the results of the NG9-1-1 Initiative.

The *NET 911 Improvement Act* requires that stakeholders be consulted during the development of the Migration Plan. USDOT worked closely with public and private 9-1-1 stakeholders during the three-year NG9-1-1 Initiative. The NG9-1-1 Initiative was consistent with the stakeholder

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non-human-initiated automatic event alerts, such as alarms, telematics or sensor data, which may also include real-time communications.

[27]RITA, ITS, Next Generation 9-1-1 Publications and Presentations, http://www.its.dot.gov/ng911/ng911_pubs.htm (last accessed July 13, 2009).

consultation requirement[28] of the *NET 911 Improvement Act* and included, for example, State and local 9-1-1 and public safety and emergency management agencies; telecommunications, information technology and emergency service industries; Federal departments and the standards community. Further, the ICO afforded the stakeholder community an opportunity to provide input and feedback prior to the publication of this Migration Plan. These groups were consistent — and similar to those participants in the NG9-1-1 Initiative — with those stakeholders identified in the *NET 911 Improvement Act*. A draft of this document was circulated in June 2009 among various stakeholder groups for review and feedback. That feedback has been incorporated into this final document appropriately.

This report can serve as a roadmap for implementing policy decisions. It is not a "deployment plan" with prescribed design, timeline and budget requirements, but rather is an attempt to identify and analyze 9-1-1 system migration issues and assess potential options to resolve them consistent with the requirements of the *NET 911 Improvement Act*. It describes migration scenarios, identifies benefits and barriers and other implementation issues, and provides results from recent trial deployments and cost-value-risk analyses. It highlights the key milestones that must be achieved and identifies legislative issues that must be considered if widespread IP-enabled 9-1-1 is to become a reality. Finally, location technologies and associated advantages and disadvantages are discussed. This report, consistent with available resources, may serve as the basis for an additional and more detailed comprehensive plan and deployment strategy.

Table 2-1. NET 911 Improvement Act Requirements

Requirement	Page
(A) Outline the potential benefits of such a migration.[i]	4-11
(B) Identify barriers that must be overcome and funding mechanisms to address those barriers.[i]	5-1
(C) Provide specific mechanisms for ensuring the IP-enabled emergency network is available in every community and is coordinated on a local, regional, and statewide basis.[i]	3-1, 5-1
(D) Identify location technology for nomadic devices and for office buildings and multi-dwelling units.	6-10, B-1
(E) Include a proposed timetable, an outline of costs, and potential savings.[i]	4-11, 5-1, 5-15
(F) Provide specific legislative language, if necessary, for achieving the plan.	5-16
(G) Provide recommendations on any legislative changes, including updating definitions that are necessary to facilitate a national IP-enabled emergency network.	5-16
(H) Assess, collect, and analyze the experiences of the public safety answering points and related public safety authorities who are conducting trial deployments of IP-enabled emergency networks as of the date of enactment of the *NET 911 Improvement Act.*[i]	6-1, 6-9
(I) Identify solutions for providing 9-1-1 and enhanced 9-1-1 access to those with disabilities and needed steps to implement such solutions, including a recommended timeline.[i]	6-6, B-1
(J) Analyze efforts to provide automatic location for enhanced 9-1-1 services and provide recommendations on regulatory or legislative changes that are necessary to achieve automatic location for enhanced 9-1-1 services.	6-1, 6-11, B-1

[i] The contents for this requirement contained in the Plan were derived from the efforts of USDOT's NG9-1-1 Initiative.

[28] P.L. 110-283, Sec. 102(3)(d)(3).

3 MIGRATION SCENARIOS

REQUIREMENT C: Provide specific mechanisms for ensuring the IP-enabled emergency network is available in every community and is coordinated on a local, regional, and statewide basis

As part of the NG9-1-1 Initiative, USDOT identified several likely implementation paths to IP-enabled 9-1-1. Those migration scenarios and the corresponding analyses are presented here as a contextual basis for subsequent sections of this Migration Plan.

Transition to IP-enabled 9-1-1 will be an evolutionary process, involving technological, economic and institutional change. As with any transition, there will be challenges as we progress from a circuit switched network to IP-enabled technologies. The paths and schedules for delivering IP-enabled 9-1-1 services to the public will depend on how local, regional and State jurisdictions plan to coordinate, deploy and operate their systems. Transition to future 9-1-1 services will also depend on the ability of originating service providers and underlying networks to locate IP-enabled 9-1-1 calls and route them appropriately. Regardless of the specific evolutionary steps, it is expected that public sector infrastructure implementation will stem from a combination of two general deployment environments described below, which reflect two extremes in existing 9-1-1 institutional and service delivery arrangements around the country:

- **Coordinated, Intergovernmental Implementation.** Planned and coordinated deployments, facilitated by statewide 9-1-1 authorities, regional authorities or informal mechanisms that enable a collaborative environment.

- **Independent, Unilateral Implementation.** Decentralized deployments of 9-1-1 capabilities by local jurisdictions.

Presently, only a handful of States consistently represent one or the other of the two implementation environments statewide. Most States exhibit a hybrid or combination of the two delivery arrangements, with some degree of coordination and planning in many locations[29] although the coordination is often limited to only certain types of 9-1-1 calls such as those from wireless devices.[30] Consequently, it is likely that the migration path to IP-enabled 9-1-1 will be vary from location to location, and at least initially, the IP-enabled emergency communications services offered to the public will also differ by location. The broadband infrastructure programs in the American Recovery and Reinvestment Act[31] may have implications for statewide planning and implementation that could benefit migration to IP-based 9-1-1.

Through an extensive series of stakeholder workshops and individual interviews, the USDOT NG9-1-1 Initiative identified a broad range of perspectives on the role of the emergency response community, industry, decision-makers and the general public, as well as some important planning

[29] For example, this could be a large metropolitan area in a relatively rural State. The complex institutional environment of the metropolitan area may foster (or even require) some degree of planning and coordination to maximize consistent service delivery across the region, while the balance of the State may not have the same factors or impetus.

[30] *See* "Model State Plan," National Association of State 9-1-1 Administrators, July 2008. It notes that "[w]hile many States across the country have established State-level 9-1-1 programs, there continues to be a great deal of diversity in the nature and organization of those programs. Some States have established programs by statute, and the programs involved are comprehensive in both geography and program scope; while other States have done the same in a less formal way, or program scope may be more limited. Beyond that, there are several States that have no State 9-1-1 focus or coordination mechanism at all."

[31] P.L. 111-5. The ARRA provides $4.7 billion for a Broadband Technology Opportunities Program (BTOP) to be administered by NTIA and $2.5 billion for broadband grant and loan programs at the Rural Utilities Service of the U.S. Department of Agriculture.

and coordination constraints on IP-enabled 9-1-1. While there is no single best approach to coordinating IP-enabled 9-1-1 implementation at the local, State or national level, stakeholders within each 9-1-1 community will need to weigh options to meet that jurisdiction's specific needs and unique circumstances.

Described below are the key elements of these environments and their underlying assumptions, as well as an analysis of the transition and implementation issues. It is expected that several common migration issues will need to be resolved, regardless of the specific deployment approach. These are addressed in the next section (Migration Barriers, Issues and Options).

Implementation in a Coordinated, Intergovernmental Environment

In a coordinated, intergovernmental 9-1-1 service environment, planned deployments of IP-enabled 9-1-1 capabilities most likely will be governed by statewide 9-1-1 Authorities, regional authorities or informal mechanisms that enable a collaborative deployment. Over time, many States have developed intergovernmental or inter-jurisdictional mechanisms to coordinate, plan and help guide the delivery of 9-1-1 services. These mechanisms range from regional and metropolitan coordination frameworks to statewide programs vested in State government. Although State legislation enables most of these efforts, in some cases local 9-1-1 Authorities have worked out other, less formal ways to address coordination and joint planning.

IP-enabled 9-1-1 systems could be implemented in several ways within a coordinated, intergovernmental environment. They vary in institutional arrangements, support and authority based on a variety of factors related to the historical relationship of State and local government regarding emergency services. Generally, this approach would take one of three forms:

- **Single Statewide 9-1-1 Authority.** Where such authorities exist, they are usually created by statute or executive order, or operate as a function of existing authority (such as a State utility commission, for example). Authority generally covers both funding and implementation, although the latter ranges from Statewide systems and outright authority over PSAP service migration and enhancement, to limited powers of encouragement, coordination and guidance of the same.

- **Regional Authorities without a Statewide Authority.** Some States have not established State-level 9-1-1 Authorities; rather, they authorize local governments to join together in regional efforts to coordinate service delivery and share resources. That authorization occurs through specific enabling legislation (directed toward 9-1-1) or as a by-product of existing joint powers or local cooperation initiatives.

- **Informal Mechanism, Locally Initiated Coordination.** Generally, local initiatives coordinate 9-1-1 services and enhancement across traditional jurisdictional boundaries where more formal mechanisms do not exist. These efforts vary from endeavors focused on metropolitan regions, to statewide initiatives. Normally they are more informal (e.g., conducted through regional and State associations, and other cooperative endeavors) but can be quite effective, depending on the organizations involved.

Assumptions and Key Dependencies of Deployment in a Coordinated, Intergovernmental Environment

The common theme among these forms of implementation is a desire for consistent emergency response and maximized available resources. Such coordination may be as simple as working together in a structured, cooperative way, to employing higher level entities with the authority to ensure that coordination occurs. This process may take longer since goals, priorities and decisions are shared to some extent. On the other hand, the process provides the opportunity to share resources and deploy new and enhanced multijurisdictional services such as transferring 9-1-1 calls among jurisdictions and providing backup and mutual support. This model is inherent in multiuse broadband backbone systems.

Migration Issues in a Coordinated, Intergovernmental Environment

Because of the level of complexity and the opportunities that are available with this approach, several migration issues must be addressed:

- **Governance and Policy.** Underlying this kind of implementation is the need for coordination among multiple 9-1-1 Authorities. The roles and responsibilities and intergovernmental arrangements for the IP-enabled 9-1-1 system will need to be defined across jurisdictional boundaries and within new partnerships. This is more complicated than the independent, unilateral style of deployment because of the potential need to determine entity responsibilities, how to share different components of IP-enabled 9-1-1 and how to address liability and confidentiality protection across jurisdictional boundaries (assuming that liability and confidentiality protection might be different for each jurisdiction).

- **Standards and Technology.** New standard processes and procedures will be needed to ensure system security as greater numbers of PSAPs, 9-1-1 Authorities, responder agencies and third-party call centers connect to the IP-enabled 9-1-1 network. In addition, protocols and business rules for call routing and prioritization will be different and/or potentially more complicated because of the number of interconnected PSAPs and the total jurisdictional area of coverage. These protocols must have built in mechanisms that ensure E9-1-1 traffic (regardless of whether the traffic is voice or data) is given priority. This will enable E9-1-1 traffic to reach intended first responders under all circumstances regardless of network congestion. This also provides the opportunity to consolidate or streamline 9-1-1 Authority functions, such as service level agreements and certification of the OSPs that would deliver calls to the 9-1-1 network.

- **Funding.** Coordinating the implementation of 9-1-1 service delivery enables many 9-1-1 Authorities and PSAP Administrators to share various components of the IP-enabled 9-1-1 system. This may provide opportunities for cost sharing and shared services among the 9-1-1 Authorities or other entities involved. But it also adds the challenge of delineating funding responsibilities among the jurisdictions.

- **Awareness.** The coordinated approach will require a more extensive education program than the independent, unilateral approach. It is inherently more complex, involving a greater number of organizations and agencies to implement. In turn, that requires that the 9-1-1 Authorities, legislative and policy officials, State organizations and other entities involved receive targeted, consistent, and coordinated messages.

Implementation in an Independent, Unilateral Service Environment

In an independent, unilateral 9-1-1 service environment, migration to IP-enabled 9-1-1 involves a decentralized deployment of system capabilities by local jurisdictions through unilateral or independent initiatives. The basis for this approach is that historically, 9-1-1 services have been largely a local or municipal governmental responsibility. That may be difficult to change even as the need for larger scale geographical coordination and planning continues to grow.

Consequently, a unilateral deployment framework may be used in States with a 9-1-1 statutory environment that places 9-1-1 implementation responsibility solely on local jurisdictions (e.g., at the township, city or county/parish level). This type of situation can also be used where there is no State or regional governmental entity responsible for 9-1-1 services or where 9-1-1 statutes explicitly provide funding and implementation responsibility and authority to the local governments involved.

Assumptions and Key Dependencies of Deployment an Independent, Unilateral Service Environment

In an independent, unilateral deployment environment, it is assumed that no other inter-jurisdictional coordination mechanism or initiative exists, and that efforts to migrate to IP-enabled 9-1-1 will be limited to separate initiatives by local jurisdictions.[32] While the authorities may migrate to the IP-enabled 9-1-1 system independently or unilaterally, such improvements are limited to their jurisdiction and involve little if any service or infrastructure sharing or interconnection with neighboring entities (or, for that matter, with any other jurisdiction). Consequently, implementation primarily depends on local initiative and resources and does not require time or effort to coordinate with a third party. Priorities can be set and migration managed as the jurisdiction best sees fit.

As with coordinated deployment, the general public will be able to make a 9-1-1 call from a wider range of devices and call takers at the involved PSAPs will be able to take advantage of other IP-enabled 9-1-1 system functionality, including access to additional information and data. Infrastructure and resource sharing would be limited to the local public safety jurisdiction. While the authority may be able to implement new operational approaches such as a virtual PSAP,[33] arrangements involving other jurisdictions (e.g., coordinated incident management, support and backup, emergency response) are necessarily limited to the willingness of the jurisdictions to work together. Thus, the independent, unilateral approach to implementation does not enable full IP-enabled 9-1-1 functionality—the PSAP or PSAPs involved are still an island, albeit an IP-enabled one.

Migration Issues in an Independent, Unilateral Service Environment

Because of the level of complexity and the opportunities that are specific to this approach, several migration issues will need to be addressed:

- **Governance and Policy.** In this environment, it is expected that the 9-1-1 Authority responsible for a specific local jurisdictional area will remain the same, which means that governance and existing policies may either remain unchanged or only slightly changed to accommodate its version of IP-enabled 9-1-1.

- **Standards and Technology.** If individual 9-1-1 Authorities upgrade to IP-enabled 9-1-1 without consideration for neighboring jurisdictions and without common standards, it may be more complicated to coordinate call treatment processes and response efforts. The call routing process and other standard operating procedures may not exist or take into account neighboring jurisdictions to support coordinated call and data handling.

- **Funding.** Funding may be limited because of the low priority of 9-1-1 upgrades and outdated funding models and allocation mechanisms. Moreover, there may be additional costs during the transition while some jurisdictions maintain dual systems. Consequently, implementing IP-enabled 9-1-1 independently without the ability to share costs may make it difficult to identify sufficient funding to fully upgrade to IP-enabled 9-1-1.

- **Awareness.** Often, agencies are unable to identify sufficient funding to support education, training and public awareness needs. Consequently, call takers may not have compatible capabilities across neighboring agencies.

[32] The definition of IP-enabled 9-1-1 calls for interconnected systems. So, technically, the full nature of IP-enabled 9-1-1 could not be implemented in this kind of environment. However, as described, some functions of IP-enabled 9-1-1 could be deployed, and that ultimately might be a policy decision by the 9-1-1 and PSAP authorities involved.

[33] A "virtual facility" (e.g., emergency command vehicle, backup facility or other ad hoc location) equipped and staffed to receive 9-1-1 calls that augments an existing municipal or county emergency communications center or 9-1-1 call center that directs 9-1-1 or other emergency calls to appropriate police, fire, and EMS agencies and personnel.

Options for Coordination and Implementation at the National Level

The vision for IP-enabled 9-1-1 is for an interconnected, nationwide implementation. This vision implies some degree of national leadership for the deployment of IP-enabled 9-1-1, especially when compared with the implementation of wireless E9-1-1 nationwide over the last decade. In the *ENHANCE 911 Act of 2004*, Congress states, "Enhanced 9-1-1 is a high national priority, and it requires national-level leadership, working in cooperation with State and local governments and with the numerous organizations dedicated to delivering emergency communications services."[34] Without focus and leadership at a national level, the vision for IP-enabled 9-1-1 won't be realized. The *ENHANCE 911 Act* will expire on September 30, 2009 effectively ending ICO activities unless further funding action is taken. Without the ICO, it remains unclear which national entity or entities will fill this leadership role in FY 10 and beyond.

There is no single best national approach to coordinating IP-enabled 9-1-1 implementation. Potential stakeholders and expert agencies include USDOT, NTIA and the FCC, and national associations like the National Association of State 9-1-1 Administrators (NASNA), the National Emergency Number Association (NENA), Association of Public Safety Communications Officials (APCO) and others. The *ENHANCE 911 Act* requires that NHTSA and NTIA jointly establish and maintain the Federal Implementation Coordination Office (ICO). Pursuant to this legislation, the ICO's mission is defined as ". . . [providing] leadership and coordination of comprehensive and technologically-enhanced [9-1-1] services." Specific responsibilities include improving coordination and communication among Federal, State and local emergency communications systems, emergency personnel, public safety organizations, telecommunications carriers and telecommunications equipment manufacturers and vendors. Other responsibilities include development, collection and dissemination of information concerning practices, procedures and technology used in implementation of E9-1-1 services.

The Federal Government also has a stakeholder interest in the connection between 9-1-1 and Federal programs and services, including subject areas such as public safety radio interoperability, transportation safety and incident management. Beyond that, organizations such as NENA, APCO and NASNA, have national association member interest in improving 9-1-1 services and migrating to next generation systems. All of this activity would benefit from some degree of national governmental leadership, coordination, and oversight.

[34] P.L. 108-494.

4 ANALYSIS OF COST, VALUE AND RISK

The decision to deploy IP-enabled 9-1-1 systems is not a simple one and is affected by many complex factors related to institutional and service arrangements, equipment and infrastructure, and funding. As part of the NG9-1-1 Initiative, USDOT analyzed the value, cost and risk associated with migrating to an IP-enabled 9-1-1 national framework. The scope of this analysis included PSAPs and the IP-enabled emergency network; it did not address new value, cost or risk implications for voice, text and video devices and the corresponding service provider networks. The USDOT study identified key values and risks inherent in three deployment scenarios and compared the risk-adjusted lifecycle costs and values of each scenario. This section leverages the previous efforts of the NG9-1-1 Initiative and summarizes those results. The complete analysis is documented in the *Next Generation 9-1-1 Final Analysis of Cost, Value, and Risk*.[35]

Methodology

The *Final Analysis of Cost, Value, and Risk* was prepared using the Value Measuring Methodology (VMM) instead of traditional cost-benefit analysis.[36] Cost-benefit analysis based on anticipated marginal public safety benefits of transitioning to NG9-1-1 would have required 9-1-1 and response data on outcomes that is currently unavailable or not standardized. VMM provides a holistic and structured approach for examining a broader range of values/benefits, costs and risks than those considered in a traditional cost-benefit analysis (e.g. value of increased access to 9-1-1 callers, contribution toward achieving political and/or strategic goals, benefits to society and/or key stakeholders). VMM is based on a scalable and flexible approach for estimating and analyzing value, cost and risk and evaluating the relationships among them, while allowing the calculation of non-financial value that might be unaccounted for in traditional financial metric calculations. It evaluates both quantitative and qualitative value and allows rigorous comparison of alternative scenarios. The objective of VMM is to capture the full potential range of values and costs provided by a particular scenario while considering project risks that might decrease value or increase cost. This approach complies with guidance from the Office of Management and Budget (OMB) and incorporates public and private sector analytical best practices. The VMM framework approach is presented in Figure 4-1.

[35] *See* http://www.its.dot.gov/ng911/pdf/USDOT_NG911_4A2ES_FINAL_FinalCostValueRiskAnalysis_ExecSum.pdf; *see also* http://www.its.dot.gov/ng911/pubs/NG911-Task4A2-FinalCostValueRiskAnalysis_files/v3_document.htm (last accessed July 13, 2009).
[36] CIO Council, Best Practices Committee, Value Measuring Methodology, http://www.cio.gov/documents/ValueMeasuring_Highlights_Oct_2002.pdf (last accessed July 13, 2009).

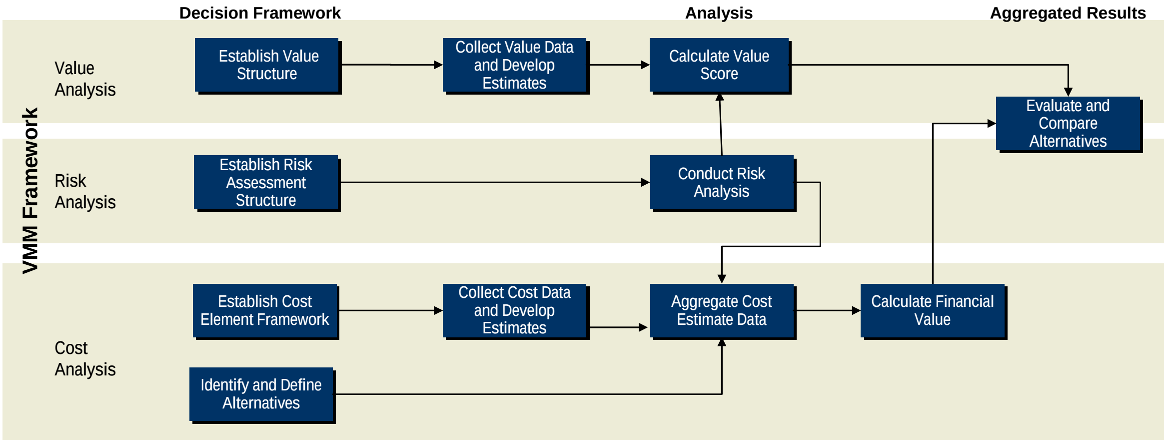

Figure 4-1. VMM Framework Approach

The major steps used in the USDOT analysis were:

- **Value Analysis**—Non-financial value measures were identified and evaluated in a structured decision framework. For the non-financial analysis, the project team established weighted value measures for use in estimating the ability of each scenario to meet key criteria.
- **Cost Analysis**—A Rough Order of Magnitude (ROM) cost estimate for each scenario was developed using a cost element structure that segmented costs into the different stages of a national deployment program lifecycle—planning, acquisition and implementation, and operations and maintenance. Operational lifecycle costs for each scenario were estimated in constant dollars, and inflated and discounted using OMB-approved factors. Discounted (Present Value in 2007 dollars) estimates were used for comparison purposes. A cost uncertainty analysis was conducted to capture how overall costs might change given potential differences in key cost inputs (e.g., wages, hardware, software).
- **Risk Analysis**—Risks were identified based on input from stakeholder representation, Subject Matter Experts (SME), and secondary research findings. The probabilities of occurrence and degree of impact of these risks were evaluated and assessed for cost and non-financial value. Risk impacts were then determined and applied to develop risk-adjusted costs and a risk-adjusted value score.

Key findings regarding the best alternative to pursue were based on integration of the value, cost and risk analysis for each defined alternative scenario.

Scenario Descriptions

The deployment scenarios used in the analyses are based on the ones described in Section 3, Migration Scenarios. As presented in Section 3, it is expected that NG9-1-1 system implementation within the public sector will stem from one of the two general deployment scenarios described below, which largely reflect existing institutional and service delivery arrangements around the country:

- **Coordinated, Intergovernmental Implementation.** System services generally reflect planned and coordinated deployments of 9-1-1 capabilities, facilitated by statewide 9-1-1 authorities, regional authorities or informal mechanisms that enable a cooperative environment.
- **Independent, Unilateral Implementation.** System services generally reflect decentralized deployments of 9-1-1 capabilities by local jurisdictions through an environment featuring independent initiatives.

However, actual deployment across the country is likely to reflect a hybrid or combination of the coordinated, intergovernmental and independent unilateral implementation approaches, with various degrees of coordination and independence. Based on this discussion, two high-level IP-Enabled deployment scenarios were identified for analysis—Uniform and Hybrid—along with the Baseline (current environment) representing today's level of 9-1-1 technology:

- **Scenario 1—Baseline (Low and High Cost):** Scenario 1 is a total cost scenario projected from the current 9-1-1 operations given the current state of technology, people and processes. Due to variations in studies of costs of the current 9-1-1 system, a Baseline Low Cost estimate derived from NG9-1-1 SME input and a Baseline High Cost estimate using the high end cost estimates from recent studies were developed.
- **Scenario 2—NG9-1-1 Uniform Deployment:** Scenario 2 is a total cost scenario for a standardized national deployment of the NG9-1-1 system that correlates to a fully coordinated, intergovernmental implementation. The Uniform deployment scenario is assumed to occur over a 10-year period, with the majority of PSAP units deploying in years five (5) and six (6). For nationwide deployment, a standardized "Unit" was defined as a general population of 625,000 served by 32 call takers. The total number of PSAP units deployed in this scenario was 508, with each being implemented over a two-year time period. The total number of 9-1-1 Data Center/Networks required to support the NG9-1-1 PSAPs was 50 (with redundancy). Each data center and network supported a population of 6,250,000 (or 10 PSAP units).
- **Scenario 3—NG9-1-1 Hybrid Deployment:** Scenario 3 is a total cost scenario for a variable-scaled national deployment of the Hybrid NG9-1-1 system that included a combination of deployment approaches by different segments of the nation, including a large-scale network and data center operations (serving 35 percent of the population), the uniform deployment approach discussed above (serving 60 percent of the population), and a small portion of deployments with an independent, unilateral implementation approach (serving five (5) percent of the population). This Hybrid Deployment scenario was assumed to occur over a 10-year period.

The analyses were based on a theoretical plan for implementing NG9-1-1 across the United States and took into account various geographic considerations, but do not reflect the specific situation of any actual State or region. The approach was designed to provide insights from a national, holistic perspective.

Value, Cost and Risk Analysis

USDOT applied a structured approach to examine the alternative scenarios. Each component of the analysis—value, cost and risk—was examined in detail to develop a comparative understanding of each scenario.

Value Analysis

The VMM approach provided a means to calculate non-financial value/benefits that might be unaccounted for in traditional cost benefit or return-on-investment calculations, allowing for a more complete comparison of alternatives. For 9-1-1, there were important benefits that were difficult or impossible to monetize. As the absolute value of a 9-1-1 emergency response system is not at issue, the lack of monetized benefit data was not an impediment. The analysis examined the relative ability of each scenario to deliver critical benefits to the full range of 9-1-1 system stakeholders.

The value of each scenario was calculated by identifying and estimating benefits within four value factor categories representing the viewpoints across key stakeholders. These value factors and the stakeholder groups they encompass are presented in Table 4-1.

Table 4-1. Summary of Value Factors & Stakeholder Groups They Encompass

Value Factor	Definitions
Direct User	Value to all direct users of the network, including all callers, the hearing and sight impaired, system operators and organizations that use 9-1-1 systems and processes to exchange information in emergencies
Operational / Foundational	Value associated with current Federal, State and local government 9-1-1 operations, the order of magnitude improvements realized in current 9-1-1 operations and processes, and in laying the groundwork for future initiatives
Strategic / Political	Contributions to achieving both public (Federal, State and local governments) and private sector strategic goals and priorities
Social	Value related to non-direct users (i.e., those not immediately involved in specific 9-1-1 incidents), communities of stakeholders, the larger economy, and society as a whole

Key value elements of the 9-1-1 system overall and their relative weights of importance were identified through a series of facilitated discussions with selected 9-1-1 system stakeholders and stakeholder representatives. Of the 17 measures considered in this analysis, the five (5) with the highest priority across all stakeholders were—

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

USDOT defined performance and effectiveness metrics for each of the key value measures. The various deployment scenarios were then scored using these measures. Performance estimating was conducted at a high level by rating how each of the scenarios would perform given the defined metric on a scale of one (1) to five (5). The current environment was ranked as an "average" indicator of three (3) given that national 9-1-1 metrics are typically not normalized and aggregated on a nationwide basis. The NG9-1-1 scenarios were assessed against this average performance measure. Stakeholder representatives and SMEs conducted the evaluation across scenarios based on these metrics to arrive at a value score for each deployment scenario. Value analysis findings are presented in Table 4-2. The NG9-1-1 Uniform and Hybrid deployment scenarios consistently scored higher values than the current 9-1-1 environment, especially on measures such as accessibility, reliability of service and general public safety. Although security and privacy measures in the NG9-1-1 environment scored lower than the current environment, these ratings are driven by the issues associated with moving to an IP-based system where data are potentially more accessible—a factor, in itself, that supports the value of being able to access new and additional data that may be beneficial to response and incident outcomes. Providing the opportunity for the more effective acquisition and application of new information and data, in turn, potentially increases the opportunity for misuse. Also, some of that information and data may be accessed across the public Internet, which generates commensurate security challenges. Privacy, confidentiality of information and network functional security are all issues for NG9-1-1 systems and applications. Consequently, data rights management is an important systems administration function, as pointed out in the NG9-1-1 High Level Requirements and Detailed Requirements reports.[37] The largest point differentials in favor of NG9-1-1 came in the measures of Accessibility and Reliability of Service, reflecting the increasing number of ways in which the 9-1-1 network can be accessed and the high value of PSAP-to-PSAP linkages in an NG9-1-1 deployment scenario.

Table 4-2. Value Analysis Results

		9-1-1 Baseline	NG9-1-1 Uniform	NG9-1-1 Hybrid
Value Factors and Measures	**Weight**	**Score**		
Direct User Value	**34%**	**17.1**	**33.7**	**32.1**
Accessibility	29%	4.9	9.8	9.0
Call Taker Timeliness	25%	4.2	7.8	8.1
Reliability of Service	27%	4.6	9.3	8.1
Ease of Use	20%	3.4	6.8	6.8
Foundational/Operational Value	**29%**	**14.5**	**21.6**	**20.6**
Scalability & Adaptability of System Functionality & Usage	24%	3.5	7.0	7.0
Information Accuracy	24%	3.4	4.3	4.3
Data Management & Sharing	15%	2.2	4.4	3.8
Operational Efficiency	18%	2.6	5.2	4.9
Security and Privacy	19%	2.8	0.7	0.7
Strategic / Political Value	**18%**	**9.2**	**17.7**	**16.6**
Alignment of Strategic Goals	16%	1.5	2.2	2.2
Technology Standards, Laws & Regulations	25%	2.2	4.5	4.2
Coordination Between PSAPs at Local, State and International Levels as well as with Other Public Services	28%	2.6	5.2	4.8
Strategic Use of Resources and Data	19%	1.8	3.5	3.1
Value to Industry	12%	1.1	2.3	2.3
Social Value	**18%**	**9.2**	**17.2**	**17.3**
Public Safety	43%	4.0	6.9	6.9
Safety to Responder	41%	3.7	7.4	7.4
Energy & Environment	16%	1.5	2.9	2.9
Total	**100%**	**50.0**	**90.2**	**86.6**

Note that the Hybrid NG9-1-1 deployment scenario scored slightly lower than the Uniform NG9-1-1 deployment scenario in a number of value factors and measures. This difference reflects the slight decrease in value that results when a portion of the population adopts a different NG9-1-1 solution path than was found in the Uniform deployment scenario. An important benefit of NG9-1-1 is the opportunity it provides to coordinate resources (within the PSAP as well as

[37] *See* RITA, ITS, Next Generation 9-1-1 Publications and Presentations, http://www.its.dot.gov/ng911/ng911_pubs.htm (last accessed July 13, 2009).

resources of all first responders) and share incident-related information and data—all with the intent to maximize efficiency, minimize cost and promote positive incident outcomes. To the extent that deployments are unilateral or uneven, that opportunity is compromised.

In summary, based on the value analysis, the NG9-1-1 Uniform deployment scenario is expected to deliver more than **73 percent** additional value over the current operating environment. The Uniform scenario would result in greater overall value because it assumes that all networks are based on the same standards, whereas the Hybrid scenario would result in five (5) percent of the 9-1-1 system adopting proprietary standards.

Cost Analysis

High-level cost range estimates were developed based on the NG9-1-1 *Concept of Operations, High Level Requirements* and *Architecture Analysis* research studies, input collected from industry experts, project team input, industry benchmarks and project team intellectual capital. As shown in Figure 4-2, the three primary components that were combined to form the NG9-1-1 architecture and therefore were analyzed in the cost analysis are the NG9-1-1 Network, the NG9-1-1 PSAPs and the NG9-1-1 Data Services. All cost elements were segmented by planning, acquisition and implementation and operations and maintenance for the defined scenarios. Note that the number of call taker positions per population served is assumed to remain constant across the scenarios.

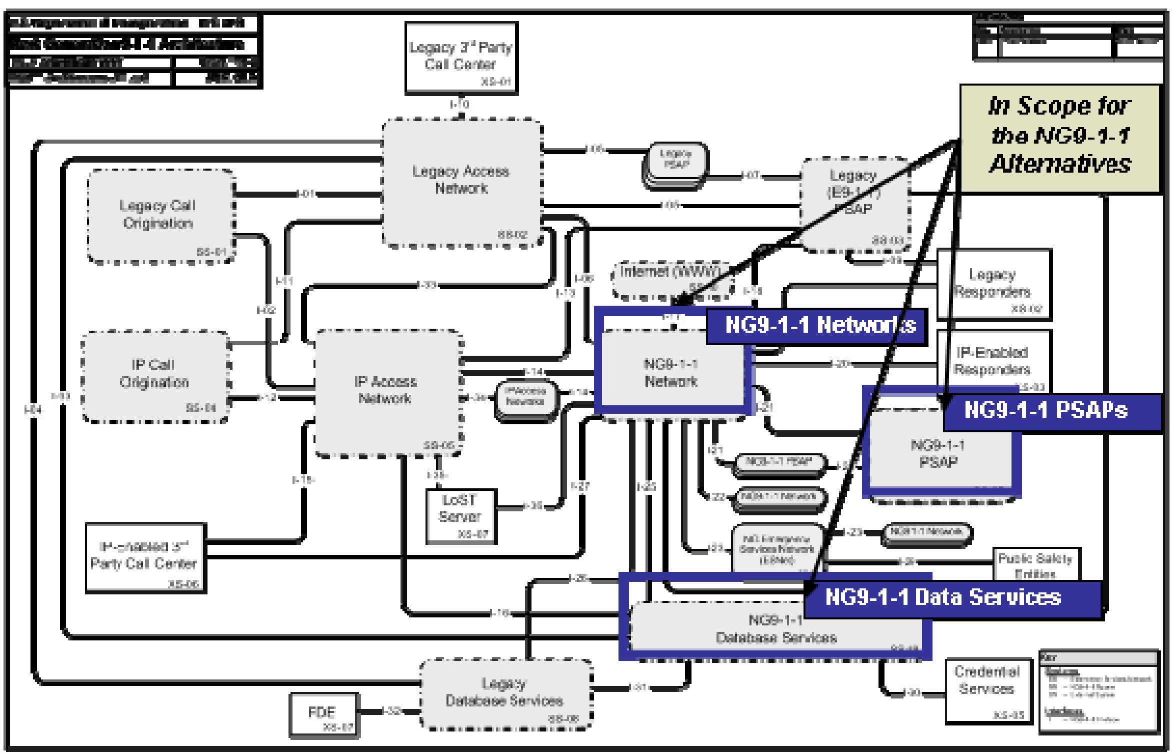

Figure 4-2. Portion of NG9-1-1 Reference Architecture Addressed in Analysis

The project team found that published estimates of aggregate national 9-1-1 operational costs range widely, due to large variations in staffing, level of automation, and number of managers and support personnel. To address this limitation, they estimated the lower (Baseline Low) and upper (Baseline High) costs for the baseline 9-1-1 environment. The Baseline Low costs were calculated through a detailed build of baseline component costs—leveraging SME input and segmenting by population and current 9-1-1 system technology levels. To establish the Baseline

High upper end of the range, a conservative estimate was made of today's "cost per call" for PSAPs.

For the next generation alternatives, costs were also calculated through a detail build of components. The basis for the total NG9-1-1 costs was a theoretical rollout strategy for nationwide deployment of the system.

To address uncertainty in future economic and other cost variables, a cost uncertainty analysis was incorporated into the analysis of each scenario. The analysis was based on Cost Estimating Guidance from the Association for the Advancement of Cost Engineering International. For the uncertainty analysis, a -25 percent to +50 percent range was applied to: personnel salaries, NG9-1-1 hardware, NG9-1-1 software and labor costs for installation and operations and maintenance of the system. For each scenario, 500 trials/iterations were carried out to determine the range of its potential future costs. The midpoint values were then taken as the expected costs for the scenario.[38]

The results of the cost analysis across all scenarios, presented in both nominal and discounted dollars, are summarized in Table 4-3.

Table 4-3. Lifecycle Cost Analysis (20-Year Lifecycle)

($ Billion, Nominal)	9-1-1 Baseline		NG9-1-1 Uniform	NG9-1-1 Hybrid
	Low Cost	High Cost		
Planning	N/A	N/A	$0.2	$0.2
Acquisition and Implementation	$9.2	$13.2	$8.7	$9.1
Operations and Maintenance	$46.4	$65.8	$51.1	$49.1
Total Lifecycle Cost	**$55.6**	**$79.0**	**$60.0**	**$58.4**

Each lifecycle cost aspect summarized in Table 4-3 represents a 20-year total cost estimate for the activity listed in the left-hand column. For example, for the Baseline 9-1-1 (Lower Range) scenario, the total cost over 20 years for the continued acquisition and implementation of replacement circuit-switched 9-1-1 systems is estimated to be $9.2 billion for national deployment. This is greater than the comparable NG9-1-1 infrastructure costs. Operations and maintenance costs over that same period are estimated to be $46.4 billion, for a total cost of $55.6 billion. The analysis is based on the assumption that the labor used and the number of PSAPs remain consistent with those already in existence. The overall costs resulting from NG9-1-1 implementation, regardless of deployment strategy over the 20-year period, fall within the cost range of continuing with current circuit-switched 9-1-1 systems.

Risk Analysis

The NG9-1-1 project team factored in the risk inherent to each scenario as a means of adjusting cost and value over the lifecycle. The four steps of this risk analysis process are:

- **Develop Risk Structure**—Risks were identified using multiple sources, including a literature review, industry sources, SMEs and stakeholder representatives.
- **Assign Probability**—For each risk, the probability of occurrence was estimated for each scenario (High, Medium, Low, None).

[38] There is a confidence level of 95 percent that these values fall within one standard deviation of the mean.

- **Assign Cost and Value Impact**—For each risk, the potential impact on cost and value was estimated (High, Medium, Low, None).
- **Risk Adjust Costs and Value**—The product of the probability and impact of the risks identified was used to risk adjust (increase) the costs associated with the alternative. Likewise, the product of the probability and value impact score was also used to risk adjust (decrease) the value scores for the scenario. The result of this analysis was a risk-adjusted cost and value score for each scenario.

Seventeen key risks, across eight categories, were identified as applicable to both the current and NG9-1-1 environments. Table 4-4 presents the risk structure.

Table 4-4. Risk Structure

Risk Category	Risk Definition
Program Resources	Increasing costs or incomplete/untimely design and standards owing to monopolies in the supply chain
Technology	Inability of system to meet functional requirements and address new failure modes
	Use of proprietary standards (open standards not developed)
	Failure of vendors' systems to keep pace with required system goals, use of workarounds that prevent system development and evolution
Security and privacy	Loss of public confidence over time because of inadequate security levels due to bandwidth limits, internal controls or degradation of security performance
	Loss of public confidence over time as result of unauthorized access to confidential information
Political / Strategic	Inadequate Federal, State and local legislative or regulatory support
Organizational and Change Management	Minimal stakeholder adoption of new technologies and processes
	Increased call processing time because of volume and complexity of incoming data
	Loss of human capital
	Unwillingness of jurisdictions to set aside traditional or historical parochial interests to collaborate with one another
Business / Industry	Lack of vendor 9-1-1 expertise
	Unwillingness or inability of current private sector service providers to keep up with changing service level requirements
Funding	Unwillingness to share costs (e.g., backbone, interfaces) with other jurisdictions
	Inability of funding models to meet project needs because of surcharge assessment and remittance inadequacies
	Inequity in service resulting from urban-rural funding disparities
Public	Lack of public knowledge and awareness of 9-1-1 system capabilities and functionality

The probability (high: 50%, medium: 30%, low: 10% or none: 0%) of each risk occurring in each scenario was then determined based upon inputs from the SMEs. Once the probability was assessed, the potential impact (High, Medium, Low, None) was evaluated to determine an impact factor for each cost element (1.0 Planning, 2.0 Acquisition and Implementation and 3.0 Operations and Maintenance) and value factor (direct user, operational/foundational, strategic/political and social). The impact factors used are shown in Table 4-5.

Table 4-5. Value and Cost Impact Factors[39]

Cost Impact Scale

Scale	Cost Impact
High	10%
Medium	5%
Low	2%
None	0%

Value Impact Scale

Scale	Value Impact
High	-10%
Medium	-5%
Low	-2%
None	0%

Finally, overall risk factors were calculated by multiplying the probability of risk occurrence by the impact factors for each value and cost element. These risk factors were incorporated into a risk analysis for each scenario. The results of this analysis are presented in Table 4-6 and Table 4-7.

Table 4-6. Risk-Adjusted Value Analysis

	9-1-1 Baseline	NG9-1-1 Uniform	NG9-1-1 Hybrid
Estimated Value Score	50.0	90.2	86.6
Risk Adjusted Value Score	32.8	59.6	57.2

Note: "Estimated Value Scores" are totals from Table 4-2 (above).

Table 4-7. Risk-Adjusted Lifecycle Cost Summary (20-Year Lifecycle)

Costs in $B, Nominal	9-1-1 Baseline		NG9-1-1 Uniform	NG9-1-1 Hybrid
	Low Cost	High Cost		
Lifecycle Cost (Unadjusted)	$55.7	$79.0	$60.0	$58.4
Lifecycle Cost Adjusted for Expected Risk Level	$66.1	$94.2	$86.3	$82.0

Note: "Lifecycle Costs (Unadjusted) are totals from Table 4-3 (above).

Once risks were applied to the prospective costs and values of each scenario, the IP-enabled system continued to have significant value above the current 9-1-1 environment, while the total lifecycle costs remain within the upper and lower bounds for continuing with today's system. This is shown graphically in Figure 4-3 below. Accounting for risks increases the overall cost estimate of a scenario, while the estimated value provided under that scenario declines. For example, the overall value for both of the NG9-1-1 scenarios (Uniform and Hybrid) is higher than that of the 9-1-1 Baseline environment. However, because transition to a new system is perceived as presenting significantly more risk overall than continuing with the current one, the overall risk adjustment is greater for the NG9-1-1 Uniform and Hybrid deployment scenarios than it is for the 9-1-1 Baseline environment**. These results indicate that NG9-1-1 would deliver significantly more value (between 174 and 182 percent of today's value) than today's 9-1-1 environment. Over a 20-year lifecycle, NG9-1-1 would roughly**

[39] Program categories were determined by Subject Matter Expert focus groups and the risk factor values were based on Association for the Advancement of Cost Engineering International Cost Estimating Guidance. The probability and risk values are included in Appendix C of the Next Generation 9-1-1 Program Final Analysis of Cost, Value and Risk.

cost about the same as maintaining the status quo –from 87 to 129 percent of today's capital and operating expenses.[40]

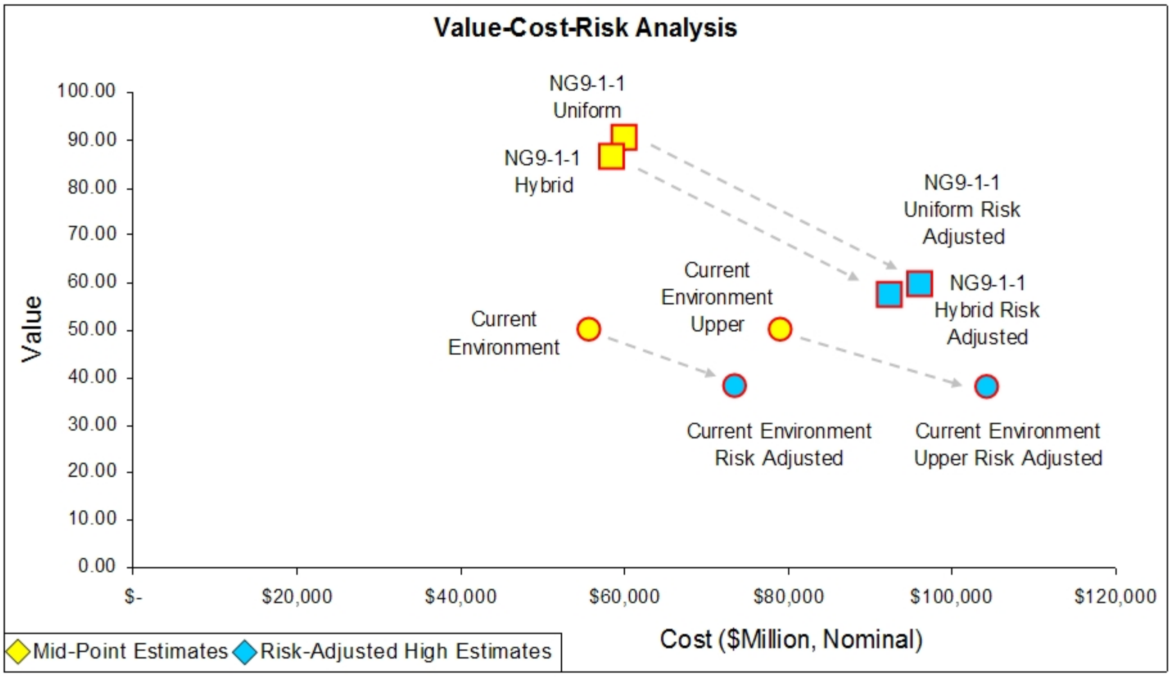

Figure 4-3. Results of Value-Cost-Risk Analysis

While the analysis described above focused on the total cost of implementation, it is likely that various components of next generation systems will be shared at various levels—shared not only with other non-9-1-1 services, but also with non-public safety applications. It is the nature of IP networking that those functions that make such networking possible can be grouped or "layered" by purpose, some of which are generic to those applications resident on the network involved. Thus, common infrastructure that is transparent to specific applications that make 9-1-1 work can be "shared" by all benefiting from the functions these common elements provide.[41] Sharing can occur in different ways. 9-1-1 and broader public safety functions can be shared among multiple jurisdictions for broad public safety purposes. A State may use a statewide backbone network to support both statewide 9-1-1 system connectivity and other non-public-safety State services, providing there is sufficient priority and security for 9-1-1 calls. The costs of the common network elements can thus be shared across all functions and applications.

Analysis indicates that, while additional risks may need to be mitigated to factor in the benefit of this approach, the relative cost incurred by the 9-1-1 community will no doubt be reduced. **It is projected that, through joint development and sharing of the data centers and networks inherent to the deployment scenarios defined, cost sharing could reduce the total lifecycle costs to the 9-1-1 authorities by $5.2 billion to $5.7 billion for the Uniform Deployment scenario and between $3.2 billion and $4.1 billion for the Hybrid Deployment scenario.** However, it should be noted that this analysis did not consider any additional costs or risks that may result from establishing and governing more complex cost-sharing systems.

[40] The risk-adjusted infrastructure costs (based on the Acquisition and Implementation Costs from Table 4-3) are in the $11-13 billion range.
[41] For example, these may include the physical, switching and transport functions that any such network must provide.

REQUIREMENT A: Outline the potential benefits of such a migration
REQUIREMENT E: Include a proposed timetable, an outline of costs, and potential savings

The content of the Migration Plan includes the benefits, timetable, costs and savings from such a migration. Leveraging the efforts of the NG9-1-1 work, the results of the value, cost and risk analysis are:

Public Access. NG9-1-1 has greater potential to meet the public's expectations for accessibility than the current 9-1-1 environment (e.g., texting, photographs, Video Relay Services). Today, all calls to 9-1-1 must go through the telephone network to the PSAP, limiting access to a handful of technologies. The wireline E9-1-1 network currently provides rudimentary support for interconnected VoIP services and the Internet-based video and texting services used by the deaf, hard-of-hearing, and speech-impaired communities. This support, however, relies on the user to manually register his location, which is particularly sub-optimal for those with disabilities whose reliance on these services requires access to be highly mobile. A major benefit of IP-enabled 9-1-1 is that it would enable location information to be updated dynamically and delivered automatically. Moreover, this same technology would similarly benefit today's VoIP users and ultimately benefit all highly-mobile users of IP-enabled voice, text and video communications.

PSAP Capability. Migration to IP-enabled emergency networks would also increase the capabilities and efficiencies at 9-1-1 call centers. Through 9-1-1 call centers, police, fire and emergency medical responders could receive useful and actionable information about emergencies. For example, transmission of an image of a highway crash scene or medical data from a personal alert device could lead to more efficient and more effective responses.

PSAP Connectivity and Interoperability. NG9-1-1 has greater scalability and flexibility than the current 9-1-1 environment. NG9-1-1 also has greater potential to increase public and responder safety through interconnectivity and interoperability than the current 9-1-1 environment. With IP-enabled 9-1-1, the physical location of a PSAP becomes immaterial. It will allow PSAPs to transfer and share information with other call centers or response agencies more quickly and with greater accuracy, regardless of location, and to deliver access to crucial data at a level rarely available today. The ability to transfer 9-1-1 calls within and among jurisdictions along with all collected data provides resilience beyond the 9-1-1 system's current limitations, a function that may be essential in the event of call overload or PSAP damage.

Potential Long Term Cost Savings. NG9-1-1 has the potential to provide significantly greater value than current 9-1-1 technology by maximizing efficiency, reducing cost and promoting systems that foster resource sharing and efficiency and information sharing.

- After adjusting for the risks inherent in the upgrade to an NG9-1-1 system, all NG9-1-1 deployment scenarios have total lifecycle costs that are within the range of the current 9-1-1 environment's lifecycle costs. This makes choosing between NG9-1-1 and today's 9-1-1 largely a function of the value provided by each. This favors either of the NG9-1-1 deployment scenarios.
- NG9-1-1 networks, data centers and PSAP infrastructure could be deployed within the next 10 years and have the potential to provide significantly greater value than current 9-1-1 technology by maximizing efficiency, minimizing cost and promoting positive incident outcome through systems that foster resource sharing and efficiency, information sharing and new call type applications that support new and more varied ways of communicating and requesting emergency response. This report, however, does not lay out a specific deployment timeline, which depends on the existence of consistent funding, a full set of standards and national coordination.

- While the Hybrid deployment scenario adopts multiple approaches and strategies for deployment, additional cost savings ($4.3 billion in comparison to the Uniform scenario) may still be realized from the creation of larger networks and data centers that can create economies of scale by providing service to larger populations overall.
- NG9-1-1 infrastructure – PSAP upgrades, IP-networks and corresponding data centers – would cost in the range of $11-13 billion in nominal, risk-adjusted dollars.

5 MIGRATION BARRIERS, ISSUES AND OPTIONS

There are overarching issues that States, 9-1-1 Authorities and PSAPs will need to resolve regardless of the specific migration path or implementation approach they choose. Strategic issues and options for progressing toward IP-enabled 9-1-1 deployments are identified in this section. They are drawn from the extensive stakeholder engagement efforts and analyses conducted by USDOT under the NG9-1-1 Initiative and presented in the *NG9-1-1 Transition Issues Report* [42] and *NG9-1-1 Transition Plan.*[43] The migration barriers and issues are categorized into five areas -- funding, operations, standards and technology, governance and policy, and education and awareness. Multiple options are provided for addressing these barriers and issues; these options are complementary and not mutually exclusive.

REQUIREMENT B: Identify barriers that must be overcome and funding mechanisms to address those barriers

REQUIREMENT C: Provide specific mechanisms for ensuring the IP-enabled emergency network is available in every community and is coordinated on a local, regional, and statewide basis

REQUIREMENT E: Include a proposed timetable, an outline of costs, and potential savings

Funding

Despite emerging requirements for IP-enabled emergency communications services, 9-1-1 Authorities and PSAPs throughout the nation may struggle to finance new systems while continuing to operate their current systems.[44] Moreover, many areas of the country are experiencing a decline in 9-1-1 revenues because consumers have abandoned older communication devices and adopted new telecommunications services and technologies not covered under current 9-1-1 funding laws.[45] The concept of a 9-1-1 subscriber fee on telephone services remains virtually unchanged today from its inception, despite reductions in landline users and increasing numbers of prepaid wireless and VoIP users. In addition, there is little consistency among and within States on 9-1-1 surcharge rates, which often differ based on the service type (e.g., wireless, prepaid wireless, wireline or VoIP) and the jurisdiction for which the fee is being collected.[46] As a result, a steadily decreasing number of consumers are subsidizing the cost of providing 9-1-1 service to a growing consumer market.

These and other considerations make the funding environment for IP-enabled 9-1-1 complex. Recognizing and addressing these factors will be key to the successful migration to IP-enabled 9-1-1. For example, the transition period will involve operating the legacy system and the IP-enabled 9-1-1 system side-by-side. Careful planning will be needed to assure adequate funding throughout the transition. In an IP-enabled 9-1-1 environment, allocating costs will be an institutional and administrative challenge, especially those related to shared networks, system interfaces and shared facilities and resources.

[42] http://www.its.dot.gov/ng911/pdf/NG911_TransitionIssuesReport_FINAL_v1.0.pdf (last accessed July 13, 2009).
[43] http://www.its.dot.gov/ng911/pdf/NG911_Transition_PlanFinal.pdf (last accessed July 13, 2009).
[44] The E-911 Grant Program provides more than $40 Million in grants for the implementation and operation of Phase II E-911 services and for migration to an IP-enabled emergency network. Further, NENA suggests that the NTIA/RUS broadband initiative offers a significant opportunity to foster the migration to next generation, IP broadband-based emergency networks. *See* NENA Comments to American Recovery and Reinvestment Act of 2009 Broadband Initiatives, http://www.ntia.doc.gov/broadbandgrants/comments/797D.pdf.
[45] NG9-1-1 Transition Plan, *supra* note 43, p.19.
[46] *See*, *e.g.*, NENA 9-1-1 user fees by State, http://www.nena.org/sites/default/files/9-1-1UserFees3_1.doc (last accessed July 13, 2009).

Options to Address Funding Barriers and Issues

The USDOT NG9-1-1 Initiative identified three strategic options to address funding issues:

- **Funding Option 1—Ensure IP-enabled 9-1-1 upgrades are considered a fiscal priority for States and local jurisdictions and Federal grant programs through outreach and education.** Current economics and competing priorities at all levels of government present major challenges in making migration to IP-enabled 9-1-1 a fiscal priority. Gaining that commitment requires 9-1-1 Authorities and others to convince decision-makers and the public of the essential connection between 9-1-1 funding and the public's continued access to lifesaving public safety services[47].

  One of the key lessons learned from past E9-1-1 implementations is the effective role of statewide coordination in focusing priorities for funding and support of the 9-1-1 services. By applying this lesson to IP-enabled 9-1-1 at the State level, governors could lead statewide implementation of IP-enabled 9-1-1 by designating a single point of contact for deployment. The State coordinator could have authority to oversee implementation statewide and coordinate the allocation of resources, particularly during the transition period. The Federal Government could encourage coordination and expansion of existing Federal public safety grant program funds to include 9-1-1 services. This could relate to multiple grant programs administered by the U.S. Department of Homeland Security, the U.S. Department of Justice and others.

- **Funding Option 2—Transform current 9-1-1 funding and cost recovery mechanisms** to address the diminishing revenue base, shared resources and provider cost recovery. Current revenue mechanisms and funding distribution will likely limit migration to IP-enabled 9-1-1. As more consumers abandon their wireline services and move to wireless, prepaid wireless and VoIP technologies for their primary communications, overall revenues from the current funding model are decreasing. Consequently, changes are needed to sustain existing services while also advancing toward an IP-enabled 9-1-1 system. Options for consideration include legislation establishing technology-neutral revenue mechanisms that accommodate all current and future devices and services capable of accessing 9-1-1 (e.g., text messaging, prepaid wireless, sensors and alarms).[48]

  Cost recovery and cost allocation models for IP-enabled 9-1-1 will also vary by implementation approach. IP-enabled 9-1-1 involves moving away from closed and dedicated networks to a system with shared networks, databases and applications in which costs related to the system could be shared among the participants. State governments and regulators could encourage shared services while also examining funding and cost recovery mechanisms and options. States may wish to identify opportunities to offset the cost of IP-enabled 9-1-1 by sharing infrastructure, resources, and services with, or simply interconnecting with, other public safety, non-public safety government, or private sector entities. The broadband infrastructure programs under the American Recovery and Reinvestment Act may provide support to some of these cooperative efforts.

  One example of cost sharing is provided by the Galveston County Emergency Communications District (GCECD), which has implemented an IP-enabled network of

[47] Statewide bodies (e.g., Statewide Interoperable Governing Bodies, 9-1-1 Boards and Commissions) may provide support.

[48] As an example, the Louisiana Legislature has passed a bill (HB 782) that would require retail stores to collect a 2% tax on prepaid telephone cards to help fund 9-1-1 emergency services. The tax is expected to generate $4.16 million in revenue annually. *See* Marsha Shuler, *House Backs Revised Cell-Phone Fee Bill*, 2theadvocate.com, Legislature and Politics, June 24, 2009, http://www.2theadvocate.com/news/politics/48967456.html (last accessed July 13, 2009).

PSAPs in the State of Texas. All eight PSAPs (21 dispatch positions) in the GCECD, along with the La Marque Police Department, the Galveston County Sheriff's Department and the Galveston Police Department are using the IP-enabled call handling system.[49] Another example is provided by the State of Vermont, where 9-1-1 calls are delivered using its Emergency Services Network (ESINet). Using this network, the State of Vermont 9-1-1 System consists of eight diverse locations collectively serving as one Statewide PSAP.[50]

Funding Option 3—Ensure 9-1-1 funds are preserved for 9-1-1 The diversion of funding for 9-1-1 implementation is an ongoing issue that is not solely related to IP-enabled 9-1-1 implementation. States and local governments that collect funds for 9-1-1 and restrict the use of those funds solely for the purposes for which they were collected will likely achieve IP-enabled 9-1-1 more rapidly than those that continue to divert these funds. In July 2009, in response to Section 101 of the *NET 911 Improvement Act*, the FCC published its "Report to Congress on State Collection and Distribution of 911 and Enhanced 911 Fees and Charges" providing preliminary information on diversion of 9-1-1 funds by the States[51].

Congress established a 9-1-1 grant program under the *ENHANCE 911 Act* and has prohibited Federal 9-1-1 grant monies to any State or political subdivision that "obligates or expends designated E–911 charges for any purpose other than the purposes for which such charges are designated or presented. . . ."[52] It also requires the U.S. Government Accountability Office (GAO) to monitor and report on States' collection and usage of 9-1-1 funds, including information regarding the diversion of 9-1-1 funds from intended purposes.[53]

To bolster long term 9-1-1 funding viability, Congress may wish to consider expanding and strengthening Federal incentives that encourage State and local 9-1-1 Authorities to use 9-1-1 funds, surcharges and fees solely for costs attributable to 9-1-1 operations, services and equipment. Additional guidance regarding what constitutes minimum 9-1-1 features and functions that are appropriate uses of 9-1-1 revenues may be needed.

Operations

IP-enabled 9-1-1 will increase capabilities to receive and disseminate information, change some roles of 9-1-1 Authorities, call takers, and other PSAP personnel and expand training requirements. Consequently, some PSAP operating practices, procedures and resource allocations will need to be modified accordingly. For example, PSAP operations will face new challenges associated with the increase in different types of real-time multimedia information—text, still images or video in addition to voice—passing between a person needing assistance or a sensor/automated device and the various routing end-points, including the call taker. The increased quantity of available multimedia data, for example, from automated crash notification systems in automobiles, will enhance and expand existing call-taking functions. It may also extend the time it takes to process 9-1-1 calls, increase the workload of the call taker, and significantly change the call taker's experience (e.g., seeing the incident versus hearing the incident). Receiving calls from IP-based communications devices will require administrators to

[49] *First VoIP E911 Call-Handling Solution in Texas*, VoIP Monitor, May 1, 2006, http://www.voipmonitor.net/2006/05/01/First+VoIP+E911+CallHandling+Solution+In+Texas.aspx (last accessed July 13, 2009).
[50] Vermont's 9-1-1 System, State of Vermont, http://e911.vermont.gov/vermont_911 (last accessed July 13, 2009).
[51] P.L. 110-283, Sec 101(2), codified as 47 U.S.C. §615a-1(f)(2). The FCC's first annual report is available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-292216A2.pdf.
[52] P.L. 108-494, Sec. 104, codified as 47 U.S.C. §942(c)(3).
[53] P.L. 108-494, Sec. 105(b). The report is available at http://www.gao.gov/new.items/d06338.pdf .

establish appropriate processes and procedures, including training and staffing levels that ensure call takers' ability to maintain efficient and effective response to emergency situations.

In addition to its impact on PSAP operations, the functions inherent to IP-enabled 9-1-1 will influence how 9-1-1 Authorities support PSAP operations and administration and how they coordinate with other nearby 9-1-1 Authorities. IP-based communications create the potential for resource, workload and data sharing among formerly distinct PSAPs and 9-1-1 Authorities. 9-1-1 Authorities, especially those overseeing multiple PSAPs, will need to manage a wider set of shared resources than is typical in the current system. 9-1-1 Authorities will likely have considerably more responsibility for database functions, along with system and network management in a multi-PSAP environment and have more options for solving problems (e.g., call overload, translation services and cost-of-shared services).

At the local level, responsibilities of PSAP Administrators[54] will likely expand, particularly with regard to configuring and managing the IP-enabled 9-1-1 system for their respective PSAPs. Although PSAP Administrators may receive support and guidance from governing 9-1-1 Authorities, at the local level, these individuals will be on the front line for ensuring their specific facilities, staff and resources meet the requirements and expectations necessary for implementing IP-enabled 9-1-1. For example, new IP-enabled 9-1-1 technologies may require new hiring and training, compensation and curricula development methodologies as IP-enabled 9-1-1 systems are introduced. Revamped introductory training, as well as continuing education (retraining in some cases) for experienced staff, will be critical to the success of any IP-enabled 9-1-1 implementation. In addition to operational staff, technical and support staff will need the skills to configure, maintain and troubleshoot advanced networks, systems and components. Likewise, public and private call taker and dispatcher certification programs will need to be updated to account for the new responsibilities and skill sets required of PSAP employees to fully use the capabilities of an IP-enabled 9-1-1 system.

Options to Address Operational Barriers and Issues

The USDOT NG9-1-1 Initiative identified three strategic options to address operational issues:

- **Operations Option 1—Prepare and train call takers and other personnel to handle increased quantity and quality of information available with IP-enabled 9-1-1 calls.** Although future 9-1-1 systems will likely include automated tools to assist call takers in answering and processing call data, they will still need to make decisions regarding the appropriate response and may still need to analyze and make decisions regarding what information should be transferred to the dispatchers and responder agencies. Consequently, in the IP-enabled 9-1-1 environment, call takers should be trained to address call-handling activities, such as answering multiple text messages from different callers during the same time period, and to understand text message forms, such as the use of abbreviations, symbols and short word sets. Today, many TTY/TDD 9-1-1 calls are not differentiated from voice 9-1-1 calls in terms of how they are distributed among the call takers. However, with the IP-enabled 9-1-1 system, incoming voice, text message or TTY/TDD calls can be automatically distinguished so that an assigned set of PSAPs or call takers within a PSAP would handle text-based calls, while others would handle voice calls.

  To address these needs, professional associations could develop guidelines for personnel skills and qualifications and effective training programs, including model

[54] The PSAP Administrator directs the overall operation of a PSAP and is responsible for the direct supervision, training, and administration of the PSAP's staff. The PSAP Administrator may be responsible for the maintenance of PSAP call-taking equipment and supporting peripherals, as well as the PSAP's budget and staff support. *USDOT NG9-1-1 System Description and Requirements Document,* Oct. 10, 2007, http://www.its.dot.gov/ng911/pdf/NG911_HI_RES_Requirements_v2_20071010.pdf (last accessed July 13, 2009).

curricula, educational standards, protocols and standard operating procedures. Training programs, properly designed, can enable PSAP managers and supervisors to effectively prepare dispatchers and call takers to respond to the needs of an IP-enabled system, while maintaining the level of service expected by the public. These efforts could be supported through State and 9-1-1 Authority training guidelines and approved training programs. Because PSAP Administrators will ultimately be responsible for implementing training and ensuring compliance, their participation and feedback in the educational material development is crucial. There will likely be additional costs to PSAPs in providing necessary training.

- **Operations Option 2—Prepare 9-1-1 Authorities to handle IP-Enabled 9-1-1 system administration, including configuration management, database management, quality assurance and standard operating procedures.** Much of the traditional 9-1-1 infrastructure is part of the existing telecommunications network, and its maintenance, upkeep and oversight are typically handled by the dominant wireline telephone service provider in the region. Within an IP-enabled 9-1-1 framework, the responsibility for the infrastructure, including its maintenance, upkeep and oversight will likely fall under a 9-1-1 Authority at the local, regional or State level (or a combination thereof). Consequently, as IP-enabled 9-1-1 is deployed, 9-1-1 Authorities will need to adjust and adapt to a broader set of responsibilities inherent in managing more complex technology systems.

  Many existing laws and regulations define a specific role for specific 9-1-1 Authorities, but general responsibility for providing 9-1-1 services is not clear in most jurisdictions. While callers use 9-1-1 to receive the essential government services such as law enforcement or fire departments, 9-1-1 is not defined as an essential government service. Many current statutes do not define which level of government is responsible for ensuring the provision of 9-1-1 services. This is a deficiency that leaves open questions about what responsibilities fall to State, county and local governments in assuring at least minimal 9-1-1 operations. These responsibilities need to be defined and enforced to avoid a future crisis in the availability of 9-1-1 to some communities. As jurisdictions implement NG9-1-1 and are able to interconnect with other PSAPs regardless of location, identifying clear roles and points of contact is essential. **Responsibility and authority for ensuring the availability of 9-1-1 within specific geopolitical boundaries should be clearly assigned by statute or administrative rule.**

  Current policies regarding which OSPs can connect to 9-1-1 trunk lines are generally set by the local PSAP or its corresponding 9-1-1 Authority. Today, an OSP that delivers 9-1-1 calls must establish service level agreements separately with each 9-1-1 Authority in its service areas. Although this may mean dozens of agreements for any single Authority, it may entail thousands of agreements for carriers with nationwide coverage. And with the thousands of IP-based OSPs that would be able to deliver 9-1-1 calls in an IP-enabled environment, this administrative model will become untenable for 9-1-1 Authorities in the future. Some consolidation and centralization of 9-1-1 institutional responsibilities will be essential to avoid excessive administrative burdens as well as provide uniform, high quality 9-1-1 Authority functions, such as ensuring call routing and security mechanisms are in place. Most of these call routing and security functions are presently delegated to incumbent local exchange carriers or similar 9-1-1 system providers.

  To ensure 9-1-1 Authorities are able to support and manage networks and system resources that are shared across PSAP service areas, it will be important for national and Federal entities to develop necessary tools and guidance. In some cases, these tools may be best practices for system configuration and administration. 9-1-1 Authorities must establish the mechanisms and structure to manage the database and network functions necessary to support the IP-enabled 9-1-1 enterprise.

- **Operations Option 3—Prepare 9-1-1 Authorities and PSAP Administrators to handle contingency planning and use of virtual PSAPs.** IP-enabled 9-1-1 permits virtual PSAPs – an operational concept that makes the physical, geographic location of a PSAP immaterial – permitting flexible management of day-to-day operations and for disasters and major events. In a virtual PSAP arrangement, 9-1-1 equipment could serve multiple PSAPs, with each PSAP having its own privileges but using a global administrator. These multiple PSAPs could be part of an intrastate or even interstate region. Virtual PSAPs could also be configured with multiple geographically dispersed call takers, operating as a single logical PSAP, rather than being situated in a single building. Consequently, in an IP-enabled 9-1-1 environment, where physical geographic location is no longer a limiting factor, virtual PSAPs and networks of PSAPs provide additional potential resiliency to support contingency planning.

  To address these issues, 9-1-1 Authorities and professional associations will need to develop requirements for virtual PSAPs and contingency planning. Authorities must hold regular combined training exercises to test the contingency plans and work to ensure continuity of operations. They must also develop appropriate educational materials and implement appropriate training programs for all personnel affected by virtual PSAP capabilities. A national coordinating entity could assist by obtaining PSAP operations best practices and lessons learned and sharing them among 9-1-1 Authorities and PSAPs[55]

Standards and Technology

The underlying concept of IP-enabled 9-1-1 is an open architecture that relies on many different technical standards to support its requirements. Standards for interoperability, call routing, location and security will need to be established or refined. To date, many communications, networking and telephony standards that will affect IP-enabled 9-1-1 are still in development or need to be selected and accepted before the system can be implemented. However, public safety and industry standards organizations have arrived at a consensus on the technical architecture of an NG9-1-1 system needed to meet the needs of IP-enabled 9-1-1 systems.[56] Until baseline standards are developed, selected, fully vetted and ultimately adopted, uncertainty among 9-1-1 decision-makers and service and equipment providers may hinder migration to IP-enabled 9-1-1. (See Box 5-1 on standards development activities underway.)

In the IP-enabled 9-1-1 environment, call routing and prioritization will be challenging because the open architecture of the IP-enabled 9-1-1 system will enable routing of 9-1-1 calls throughout the Nation (and even internationally) instead of current local limitations. It is expected that 9-1-1 calls will continue to be routed based on location as the initial factor; however, other factors, such as call type or the need for translation services and other data items, must be identified for use in routing and prioritizing the calls. Moreover, acquiring and delivering location data will be

[55] We note that the FCC in February 2009 conducted an outreach program with 9-1-1/E9-1-1 stakeholders on NG9-1-1 deployment and operational issues. *See* Deployment and Operational Guidelines for Next Generation 9-1-1/E9-1-1 Systems at http://www.fcc.gov/pshs/summits/. We also note that the *NET 911 Improvement Act* requires that FCC "shall work cooperatively with public safety organizations, industry participants, and the E-911 Implementation Coordination Office to develop best practices" in specified areas to better promote consistent standards in connection with IP-enabled service provision of E9-1-1 service. *See* P.L. 110-283, Sec. 101.

[56] The consensus on an NG9-1-1 technical architecture is documented in the interlocking standards principally from the Internet Engineering Task Force (IETF). Alliance for Telecommunications Industry Solutions (ATIS), Third Generation Partnership Program (3GPP), and the National Emergency Number Association (NENA). The relationship among these organizations is described in *NENA Functional and Interface Standards for Next Generation 9-1-1 Version 1.0*, December 2007, http://www.nena.org/sites/default/files/08-002%20V1%2020071218.pdf (last accessed July 13, 2009).

challenging in new ways in the IP-enabled 9-1-1 environment. There will be many more types of devices that will be capable of calling 9-1-1 and they will do so via associated services, infrastructure, and access providers that presently possess no role in 9-1-1. Although there are growing numbers of location determination technologies (see Appendix B), roles and responsibilities for generating and delivering the location information is a major issue yet to be resolved.

The 9-1-1 system, like other mission-critical systems, will continually encounter attempts at illegal access, including concerted malicious attacks (e.g., denial of service, virus or worm transmission). With the connection between multiple PSAPs and 9-1-1 authorities, the control of system access and security may be more difficult to manage because of the number of entities involved. Therefore, to mitigate security risks and control access to the IP-enabled 9-1-1 system, prescribed, standardized security controls and certification and authentication mechanisms must be developed that define the access methods, rules, and controls by which users and systems access the system. In addition, standards must be developed related to backup, restoration and redundancy.

Box 5-1: On-going Standards Development Activity Related to IP-Enabled 9-1-1

Several standards development organizations, including the Internet Engineering Task Force (IETF), the National Emergency Number Association (NENA) and the Association of Public-Safety Communications Officials International (APCO), are developing IP-enabled 9-1-1 related standards.

NENA's work to conceptualize, on what is now known as NG9-1-1, began in 2000 with active technical development beginning in 2003. NENA's 08-002 [IP] *Functional and Interface Standards for NG9-1-1* (`i3') Technical Standard Document identifies standards and requirements for various components of the NG9-1-1 System Architecture. NENA's geospatial and NG9-1-1 data standards, system operations, and PSAP operations standards are forthcoming.[a]

The IETF Emergency Context Resolution with Internet Technologies (ECRIT) working group has developed the Location to Service Translation Protocol (LoST) to route IP-enabled 9-1-1 calls to the most appropriate PSAP. In addition, IP-enabled 9-1-1 relies on an IP-based infrastructure that allows the transmission of voice, video, images, and data using different protocols.[b] For example, voice calls will use the Session Initiation Protocol (SIP), which is the focus of one of the IETF's working groups.

The Organization for the Advancement of Structured Information Standards (OASIS) Emergency Management Technical Committee currently promotes data interoperability standards, and several organizations, including NENA, are collaborating on a suite of specifications called the Emergency Data Exchange Language (EDXL). EDXL is an Extensible Markup Language (XML)-based model intended to create an integrated framework for a wide range of data exchange standards to support emergency operations.

The Alliance for Telecommunications Industry Solutions' (ATIS) Emergency Services Interconnection Forum (ESIF) has developed the Emergency Network Interface (ESNI)[d] Standards suite that defines interfaces between PSAPs and Emergency Services Networks (ESNets), access to services within or external to ESNets and interconnection and exchange of services between ESNets. They also have current work items for an Ingress SIP Interface specification and a protocol specification to address the requirements of the Location Information Server (LIS) architecture.

The 3rd Generation Partnership Project (3GPP) and the related 3GPP2 are global standardization efforts for 3G mobile phone systems, GSM and CDMA2000, respectively. The 3GPP2 has published Wireless Features Description: Emergency Services (S.R0006-529-A) and the 3GPP is developing support for IP Multimedia Subsystems emergency calls in Release 9 of its Technical Specifications

[a] A current working list of NENA standards, completed, in progress, and pending, can be found at: http://www.nena.org/ng911-project/strategic-planning (last accessed July 8, 2009).

[b] Issues unique to emergency communications must be solved. These include the ability for IP to transmit background sounds on which call takers may rely. This is not a capability used in commercial VoIP calling, but can be critical for 9-1-1 calls. Another requirement is that text messages must be handled as interactive conversations in NG9-1-1 system design.

[c] More information about the OASIS Emergency Management Technical Committee is available at: http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=emergency (last accessed July 2, 2009). For more information on EDXL see: http://xml.coverpages.org/edxl.html (last accessed July 2, 2009).

[d] ATIS standards are available via https://www.atis.org/docstore/.

Options to Address Standards and Technology Barriers and Issues

The USDOT NG9-1-1 Initiative identified four strategic options to address standards and technology issues:

- **Standards Option 1—After completing gap analysis of existing standards, complete and accept IP-enabled 9-1-1 open standards and understand future technology trends to encourage system interoperability and emergency data sharing.** The IP-enabled 9-1-1 system will rely on open, non-proprietary standards for an architectural framework that promotes system interoperability and emergency data sharing. All appropriate stakeholders should be represented in the standards development process to ensure those standards meet the needs of the 9-1-1 community. National leadership may be needed to encourage stakeholders to identify standards to be developed and implemented. One option is to promote and support a standard coordinating entity with dedicated attention to the development of standards and technologies considered essential to IP-enabled 9-1-1.

- **Standards Option 2—Determine routing and prioritization protocols and business rules.** Accurately routing 9-1-1 calls to the appropriate PSAP will be more complex in the IP-enabled 9-1-1 environment because of the amount of data that can potentially be used to route and prioritize IP-enabled 9-1-1 calls. For example, an IP-based call could be tagged based on the language of speaker. When the call is received by the 9-1-1 system, software would query a business rules database to determine which PSAP and call taker is best suited to receive the call. To ensure that the protocols and business rules developed for routing meet the needs of the 9-1-1 community, Standards Development Organizations (SDOs) should collaborate with the public and private 9-1-1 stakeholders, including service providers and emergency response entities, to identify what information is important and how the call should be routed.

- **Standards Option 3—Determine the responsible entity and mechanisms for location acquisition and determination.** As new devices become available that are capable of calling 9-1-1, challenges will arise to determine and acquire the location of the caller and device, especially if the device is transportable. There are many new location approaches (see Appendix B) now available or under development to serve non-emergency needs such as social networking and product inventory control for indoor and outdoor applications. Whether any of these will be suitable for response-quality 9-1-1 location has not yet been tested.

  Moreover, location information for call routing and location information for emergency response are separable requirements that can be, but need not be, the responsibility of the same provider for a given emergency call. The network and increasingly, the calling device, can independently determine caller location (to various degrees of accuracy). Location accuracy for call routing need not be nearly as precise as location required by the emergency responders.[57] For example, most landline and cellular 9-1-1 calls are routed based on the call's network access point – to a landline switch or cell tower – requiring a much lower level of accuracy than the exact location of the caller, which is delivered to the PSAP separately.

  In an IP-enabled environment, the OSP can, and most often will, be separate from the network provider. There are several network protocols established (see Appendix B) that enable network providers to determine caller location information sufficient for 9-1-1 call-routing and to deliver that information to OSPs. With network-provided location, any IP-

[57] To route a call today, what is needed is the caller's location in the PSAP's region, an area that typically corresponds to a city- or county-scaled region. Response information, typically a street address, needs to be much more precise.

enabled 9-1-1 call, regardless of the capability of the device or application service to determine its own location, would be routed to an appropriate PSAP.

The trend in the wireless industry toward “convergence” – enabling a single device to seamlessly interoperate with multiple different networks – may make for inconsistent location measurements. Most location methods derive some assistance from the network in the form of location monitoring units, location assistance servers or the actual computation of the location. When the device switches from one type of network to another, it will temporarily (or longer) lose support for location determination. Mobile devices may have to incorporate multiple methods for location determination.

- **Standards Option 4—Establish system access and security controls to protect and manage access to the IP-enabled 9-1-1 system of systems.** The security of and authorized access to the IP-enabled 9-1-1 system is critical to ensuring that the IP-enabled 9-1-1 system of systems is secure from security breaches and illegal users to prevent disruption of the delivery of a 9-1-1 call and public safety response to emergencies. Government authorities, State utility commissions, and SDOs can play a role in ensuring that 9-1-1 Authorities and service providers have standards for meeting the security controls and system access requirements. National-level leadership is necessary to identify and leverage defense and homeland security solutions, standards, and best practices to determine an appropriate level of security for the IP-enabled 9-1-1 system. Moreover, a national coordinating entity could consider identifying a certification and authentication process to ensure service providers and 9-1-1 Authorities meet the security and system access requirements. In addition, State utility commissions could modify existing regulations that limit architectural content of and access to the 9-1-1 system, and determine a certification and authentication process to ensure service providers and 9-1-1 Authorities meet security and system access requirements.

Governance and Policy

Many existing laws, regulations and tariffs specifically reference older technologies or system capabilities that may inadvertently inhibit the migration to IP-enabled 9-1-1. Types of regulatory and statutory issues that may need to be updated include, but are not limited to, collection and eligible use of 9-1-1 funds; State 9-1-1 program authority; 9-1-1 system definition, technology, and interconnection requirements; rules concerning access and sharing of 9-1-1 related databases; authority to implement shared emergency service IP networks to replace dedicated 9-1-1 telephony systems; rules concerning which devices and services may connect to 9-1-1; privacy protection; and liability.

Although there are significant variations among regions, the current 9-1-1 environment supports a structured process with relatively clear delineation regarding roles and responsibilities among the parties as defined by common practices and statutes. The existing legal and regulatory environment, however, will not effectively accommodate new technologies, coordination and partnerships among government and public safety stakeholders, 9-1-1 Authorities, service and equipment providers, and PSAP Administrators implementing IP-Enabled 9-1-1 systems. While the Federal Government establishes 9-1-1 requirements for wireless and VoIP services, State and local government have always played an important role in determining 9-1-1 system service arrangements, costs and funding mechanisms. An appropriate Federal-State-regional-local balance will need to be established for IP-enabled 9-1-1 as well. Differences in the service delivery environment inherent in future 9-1-1 environments may require commensurate changes in legislative and regulatory policy. Current State and Federal laws were written in an era when IP capabilities did not exist. To foster the migration to IP-enabled 9-1-1, State and Federal legislatures and regulatory bodies will need to review current laws and regulations to keep pace with the rapidly changing 9-1-1 marketplace. These may include, but are not limited to:

- Collection and eligible use of 9-1-1 funds;
- State 9-1-1 program authority;
- 9-1-1 system definition;
- Technology and interconnection requirements;
- Rules concerning access and sharing of 9-1-1 related databases;
- Authority to implement shared emergency service IP networks to replace dedicated 9-1-1 telephony systems;
- Rules concerning which devices and services may connect to 9-1-1;
- Privacy protection; and
- Liability.

The *NET 911 Improvement Act* provides liability protection for PSAPs, service providers, and their vendors consistent with existing State liability laws.[58] This protection applies to all communications services that are required by the FCC to provide 9-1-1/E9-1-1 (today and in the future). This protection also applies to services that voluntarily provide information to PSAPs, in the absence of an FCC requirement, with approval from the appropriate State or local 9-1-1 governing authority. Thus, State liability protection laws can now cover communications to PSAPs from new types of services possible with IP-enabled 9-1-1.[59] This should encourage the entry of new service providers and provision of innovative data that could result in more effective emergency response services.

However, other liability issues may still need to be addressed through State or Federal statutes. For example, IP-enabled 9-1-1 is expected to increase choices and opportunities to empower 9-1-1 governing authorities and PSAP Administrators to design 9-1-1 systems that enable the sharing and receipt of information consistent with local needs. One region may choose to receive all possible information (voice, text, images and video) from all devices. Another area may choose to filter and limit receipt of certain information and to route calls differently based on unique local capabilities and needs. Differing 9-1-1 system policies and structures, enabled by standards-based IP-enabled 9-1-1, is an advantage of IP-enabled 9-1-1. However, it could also raise possible liability concerns if individual PSAPs choose not to receive all information (e.g., direct video communications) despite the technical availability of such information. Such policy decisions would also be counter to the goal of consistent, ubiquitous 9-1-1 coverage nationwide.

Options to Address Governance and Policy Barriers and Issues

The USDOT NG9-1-1 Initiative identified two strategic options to address governance and policy issues:

- **Governance Option 1—Clarify jurisdictional frameworks and responsibilities and identify the coordination required at each level of government to make IP-enabled 9-1-1 possible.** The Nation's experience with the rollout of wireless E9-1-1 services demonstrated that lack of coordination among the many public and private entities delays deployment.[60] Compared with wireless E9-1-1 implementation, the rollout of IP-enabled 9-1-1 will be more complex because of the much larger number of new types of services and service providers and the changing roles of existing 9-1-1 system stakeholders. Federal, State and local government leadership roles will need to be further defined to facilitate the deployment and operation of the IP-enabled 9-1-1 system.

  Coordinated approaches and partnerships among 9-1-1 Authorities, PSAPs, emergency responders, service and equipment providers and government officials (elected or appointed) will be essential to take full advantage of the next generation opportunities

[58] P.L. 110-283, Sec. 201.
[59] USDOT, *Transition Plan*, February 2009, p. 44, http://www.its.dot.gov/ng911/pdf/NG911_Transition_PlanFinal.pdf.
[60] *Id.* at 45.

and capabilities. Defining roles and responsibilities for regional and statewide coordination will also be important to provide accountability and guidance. States will likely need to designate a central coordinating body and/or mechanism for IP-enabled 9-1-1 implementation and to assign appropriate entities the authority and responsibility for determining certification requirements for telecommunications services and service providers that may access the IP-enabled 9-1-1 system.

- **Governance Option 2—Consider developing model legislation that would address update of regulations, legislation and other policies to reflect modern communications and IP-enabled 9-1-1 system capabilities.** Typically, 9-1-1 telecommunications service providers and the services they offer are regulated through State public utility commissions and the FCC. Because current 9-1-1 services are, in part, provided by regulated telecommunications companies, new non-local exchange carrier (LEC) service providers with alternative technologies may be unable to participate in 9-1-1 service delivery in some jurisdictions. For example, many jurisdictions permit only the incumbent LEC to connect to PSAPs, thereby restricting, by statute, the delivery of IP communications.[61] Although the FCC has mandated that wireless carriers and VoIP service providers have access to the 9-1-1 network, the current 9-1-1 governance environment does not always allow access for new, advanced communications technologies.[62] Policymakers could use several legislative options to address regulatory shortcomings and ensure increased competition in the 9-1-1 marketplace in a technologically neutral manner. In particular, Federal and State authorities can ensure that rules and regulations governing the transition from the legacy system to IP-enabled 9-1-1 are neutral in all respects, including issues such as technology platforms, interconnection, system pricing, funding mechanisms, and certification. For example, laws that prohibit the transmission of non-human initiated calls to a PSAP (e.g., hazardous chemical, flood level or vital sign sensors capable of transmitting data and/or initiating a voice call to a PSAP without human initiation) will need to be updated.

  Similarly, current policies are inconsistent concerning the disclosure of customer-specific information by telecommunications providers to government agencies for the delivery of emergency services. This inconsistency has resulted in delays in providing emergency response during real emergencies and can adversely affect 9-1-1 database access. At the Federal and State level, legislators could examine these issues and make the relevant statutory provisions consistent in how new and expanded personal information available with IP-enabled 9-1-1 should be handled and treated.

  Lastly, liability protection will be needed for communications services that seek to connect to IP-enabled 9-1-1, but are not yet required by the FCC to provide 9-1-1/IP-enabled 9-1-1 service. For example, some State laws prohibit the use of location information for call routing beyond those covered under traditional 9-1-1 (e.g., other N-1-1 entities and 800-type emergency provisioning, such as poison control centers and suicide hotlines).[63] Under the *NET 911 Improvement Act*, such protection can occur with approval from the appropriate State or local 9-1-1 Authority.[64] To ensure that future service providers are treated equally, the Federal Government could consider exploring what criteria authorities should use in granting approval.

[61] National Emergency Number Association, *A Policy Maker Blueprint for Transitioning to the Next Generation 9-1-1 System*, September 2008, p.11, http://www.nena.org/sites/default/files/NG9-1-1PolicyMakerBlueprintTransitionGuide-Final_0.pdf.
[62] USDOT, *Transition Plan*, p. 45.
[63] *Id.* at 47; *see also,* P.L. 110, 283, Title II, Sec 201(b)(9)(B).
[64] *Id.* at 47.

Education and Awareness

Education has been an integral part of discussions on how to accelerate IP-enabled 9-1-1 implementation. There is widespread agreement that all 9-1-1 stakeholders—public and private—need to know more about and be kept informed of IP-enabled 9-1-1 technologies and how they will affect emergency communications.[65] Public awareness is critical to the effectiveness of all aspects of IP-enabled 9-1-1, including funding, operations, standards and technology, and governance and policy.

Federal agencies and stakeholder organizations have made progress in increasing awareness of IP-enabled 9-1-1 capabilities and issues. The USDOT's NG9-1-1 Initiative has been the major activity engaging stakeholders on IP-enabled 9-1-1 topics. Many stakeholder organizations and associations have recognized the need for IP-enabled 9-1-1; NENA, APCO, NASNA and the 9-1-1 Industry Alliance have published reports about the need for IP-enabled 9-1-1 and incorporate IP-enabled 9-1-1 topics in many of their activities.[66]

Currently, the ICO is developing a Technical Assistance Center to support stakeholder awareness and understanding of IP-enabled 9-1-1. The Technical Assistance Center will offer a number of educational services, including a Clearinghouse for 9-1-1, a user-friendly website, a deployment profile for IP-enabled 9-1-1, and technical and operational information to States, 9-1-1 Authorities, and PSAPs.[67] The ICO coordinates efforts with other Federal agencies to explore how IP-enabled 9-1-1 will affect future 9-1-1 services and related emergency communications services. Coordination among agencies will be required as IP-based systems are developed. Plans are now being formulated to ensure that all government agencies involved in emergency communications and emergency response are aware of progress toward IP-enabled 9-1-1 and their potential role in making it happen.

As IP-enabled 9-1-1 systems are deployed, the general public will want to know what, how, and when next generation services will be available in their area. The public will likely have questions regarding IP-enabled 9-1-1 system capabilities and limitations. The government may need to examine the effect IP-enabled 9-1-1 deployment has on the elderly, deaf and hard of hearing, disabled and non-English speaking populations. Consequently, keeping the public informed and involved throughout the planning and deployment of IP-enabled 9-1-1 will be important to its ultimate success. Also, managing expectations of the public and correcting misconceptions about the capabilities of 9-1-1 services will be important as 9-1-1 continues to evolve toward complete IP-enabled 9-1-1 deployment. As no education campaign can ever reach all the public and convey all the intricacies and potential differences in 9-1-1 services from region to region and State to State, consumer devices and services may need to indicate their 9-1-1 capabilities directly to users.

Options to Address Education and Awareness Barriers and Issues

The USDOT NG9-1-1 Initiative identified four strategic options to address education and awareness issues:

- ***Option 1—Encourage stakeholders to embrace change through effective education programs.*** Enabling the creation of an IP-enabled 9-1-1 system will require buy-in from numerous and varied stakeholder groups. Educating them about IP-enabled 9-1-1 and corresponding service improvements is the first step toward building a consensus among decision-makers and agents of change.

  These stakeholder groups will not all share the same roles or responsibilities during the transition to IP-enabled 9-1-1 or after its implementation. For this reason, a

[65] *Id.* at 51.
[66] *Id.* at 53.
[67] NHTSA will continue to operate the Technical Assistance Center (as funds permit).

"one-size-fits-all" approach to educating the various parties is not recommended. Instead, strategies must be crafted to address the concerns and areas of responsibility of each individual stakeholder group.

- ***Option 2—Reduce barriers for IP-enabled 9-1-1 through education programs.*** Creating a culture of awareness regarding the robust capabilities of an IP-enabled 9-1-1 system will expedite the transition and implementation process immensely. Providing decision-makers at all levels of government, as well as within the public safety community, with information on the necessity and benefits of IP-enabled 9-1-1 will create an atmosphere more amenable to providing funding, creating and updating legislation, and addressing other issues that could potentially impede the transition.

- ***Option 3—Educate PSAP and 9-1-1 Authority personnel regarding their role in IP-enabled 9-1-1.*** In an IP-enabled 9-1-1 environment, almost all employed in the emergency communications field will be expected to take on new and/or altered responsibilities. Once IP-enabled 9-1-1 systems go live, the public will continue to expect timely and effective emergency response. PSAP and 9-1-1 Authority personnel will be a key target audience for education programs promoting full use and awareness of IP-enabled 9-1-1 system's expanded capabilities.

- ***Option 4—Develop effective public education and awareness programs.*** Public awareness has always been important to 9-1-1; most 9-1-1 programs include a public education component. As text messaging and the use of camera telephones increase, expectations and misperceptions of what can and cannot be delivered to a 9-1-1 call taker increases. As services continue to change and become more mainstream, more and more consumers will be frustrated and confused about why the devices they use daily do not work when they need to call 9-1-1. The public expects 9-1-1 centers to keep up with technological change and that the IP-enabled 9-1-1 system will deliver at least the accustomed level of service. As IP-enabled 9-1-1 services are rolled out and implemented, the public must understand how, where, and when next generation services are available.

Educating the public about IP-enabled 9-1-1 should be done in two phases. First, the public should be educated about the benefits of IP-enabled 9-1-1 to create a groundswell of support for its implementation. Once transition is nearing completion, the public must also be educated about the IP-enabled 9-1-1 system's expanded capabilities for receiving information and about how they can best use these new options for contacting emergency services.

But even in an environment of uniform, consistent IP-enabled 9-1-1 systems deployed across the nation, public confusion and uncertainty will not be eliminated. Some IP-applications, because of security, quality of service or other reasons, will not be suitable for emergency calling and will not be permitted to access the 9-1-1 system. Other applications certified for 9-1-1, such as current wireless phone service, may have critical limitations in access or response information depending on where the caller is positioned during the call. This could become a significant problem in the future as "converged" mobile devices become more widespread. By design, converged devices smoothly switch across disparate networks. The implication for 9-1-1 service is that while most communication applications will use some form of network assistance for location determination, location capabilities may vary widely for any given user traversing multiple networks.

Ultimately, users need to know in real time what the "9-1-1 status" is of their device/application. It is not uncommon today for people to have multiple communication devices or applications readily available; choosing the best option in an emergency could be crucial in saving lives or property. Under the IP-enabled 9-1-1 architecture concept developed by USDOT, applications accessing emergency services must include location data in the call setup to support call routing and response. Consequently, the user device or application, based on the source and methods for generating positioning data, will be aware of its "9-1-1 status" (i.e., whether it is suitable for precise response). Such devices or applications could be designed to display that 9-1-1 status information simply, clearly, and consistently to their users. Various visual, audio or haptic indicators could be used, but the goal would be to convey whether 9-1-1 access is feasible at all and whether or not response-quality location information is available with that device.

REQUIREMENT E: Include a proposed timetable, an outline of costs, and potential savings

NG9-1-1 is a complex issue with many variables as described in previous sections. Needless to say, an accurate presentation of a timeline for national, ubiquitous deployment and implementation presents major challenges. Based upon the extensive work of USDOT's NG9-1-1 Initiative, it is concluded that a timetable for full, national deployment of NG9-1-1 is difficult to estimate due to a lack of:

- Consistent funding for planning, training, deployment and implementation;
- Complete set of standards and time required to develop them; and
- Coordinated planning and implementation efforts by stakeholders at all levels (e.g., government, industry, OSPs, standards organizations).

Progress is being made. Funding mechanisms have been identified in previous sections. Pilot projects have begun and have demonstrated the viability of IP networks. While several SDOs are currently developing standards, these are by no means indicative of a national deployment estimate, but rather the beginning of a long transition period. With that said, for the purpose of the Cost, Value and Risk Analysis conducted as part of the USDOT NG9-1-1 Initiative, a 10-year implementation period was used, and was based on resolution of the above three issues, and an assumed lifecycle of 20 years.

As part of the NG9-1-1 Initiative, USDOT analyzed the value, cost, and risk associated with migrating to an IP-enabled 9-1-1 national framework. USDOT also compared the 20-year lifecycle costs for today's 9-1-1 system and two NG9-1-1 scenarios and found that public sector deployment and operation of IP-enabled 9-1-1 would likely cost about the same as maintaining the status quo (between 87 to 130 percent of today's expenses). The IP-enabled 9-1-1 infrastructure – PSAP upgrades, IP-networks, and corresponding data centers – would cost an estimated $12 billion, which is comparable to the $10-15 billion estimates for the corresponding components of the nationwide circuit-switched 9-1-1 system over the same period. This conservative analysis did not consider possible savings from organizational changes such as consolidating PSAP operations into fewer facilities or cost-sharing for supporting technologies.

USDOT assessed the relative values (i.e., measures of the non-monetized benefits) of these deployments, concluding that IP-enabled 9-1-1 would deliver significantly more value (between 174 and 182 percent) than today's circuit-switched 9-1-1 system. More specifically, it provides better opportunities for long term cost savings and increased operational efficiencies than the current 9-1-1 environment; increased potential to meet the public's expectations for accessibility; greater scalability and flexibility; and better potential to increase public and responder safety through interconnectivity and interoperability.

Continuing to adapt the current wireline E9-1-1 network to more calling devices and services would deliver significantly less value at a potentially greater cost than migrating to the NG9-1-1 infrastructure. Moreover, many other government and commercial communications system have or are transitioning to IP-networks.

REQUIREMENT F: Provide specific legislative language, if necessary, for achieving the plan

REQUIREMENT G: Provide recommendations on any legislative changes, including updating definitions that are necessary to facilitate a national IP-enabled emergency network

Without effective policy development in conjunction with technical and operational NG9-1-1 system development, the best designs and system architectures will be just that—designs and architecture. To actually implement NG9-1-1 systems, laws and regulations may need to be adopted or changed to facilitate and make legal all aspects of NG9-1-1. If properly enabled by technology and policies, an effective governance structure can be implemented. Governing 9-1-1 authorities, emergency response agencies, call takers, emergency responders and communications service providers will need to have the appropriate governance, policies, and mechanisms to provide a coordinated and appropriate response in an NG9-1-1 environment.

The range of options spans from encouragement and guidance to regulation and legislation, and involve government agencies, non-governmental organizations, OSPs, network providers and the general public. While not exhaustive, the following issues are raised to emphasize their importance in deploying a national NG9-1-1 system. Specific legislative language is not provided.

Responsibility and authority for ensuring the availability of 9-1-1 within specific geopolitical boundaries should be clearly assigned by statute or administrative rule. Many existing laws and regulations define a specific role for specific 9-1-1 Authorities, but general responsibility for providing 9-1-1 services is not clear in most jurisdictions. While callers use 9-1-1 to access “essential government services” such as law enforcement, fire departments or emergency medical services, 9-1-1 is not defined as an essential government service by State constitution, law or administrative rule. Many current statutes do not define which level of government is responsible for ensuring the provision of 9-1-1 services. This is a deficiency that leaves open questions about what responsibilities fall to State, county and local governments in assuring at least minimal 9-1-1 operations. These responsibilities need to be defined and enforced to avoid a future crisis in the availability of 9-1-1 to some communities. As jurisdictions implement NG9-1-1 and are able to interconnect with other PSAPs regardless of location, identifying clear roles and points of contact is essential. Responsibility and authority for ensuring the availability of 9-1-1 within specific geopolitical boundaries should be clearly assigned by statute or administrative rule.

Public sector 9-1-1 institutions will need sufficiently broad authority to deploy and operate IP-enabled systems. Many existing laws and regulations define a specific role for specific 9-1-1 Authorities, limiting their jurisdiction and function to specific activities, such as the collection and disbursement of 9-1-1 surcharges. The deployment of IP-enabled 9-1-1 will greatly increase the number of new types of services and providers and change the roles of existing 9-1-1 system stakeholders. Public sector 9-1-1 institutions will need sufficiently broad authority to deploy and operate IP-enabled systems.

Some consolidation and centralization of 9-1-1 institutional responsibilities will be essential to avoid excessive administrative burdens as well as provide uniform, high quality 9-1-1 Authority functions. For example, current policies regarding which OSPs can connect to 9-1-1 trunk lines are generally set by each local PSAP or its corresponding 9-1-1 Authority. Today, an OSP that delivers 9-1-1 calls must establish service level agreements separately with each 9-1-1 Authority in its service area. With the deployment of NG9-1-1, this may mean dozens of agreements for any single 9-1-1 Authority, and may entail thousands of agreements for carriers with nationwide coverage. With the thousands of IP-based OSPs that would be able to deliver 9-1-1 calls in an IP-enabled environment, this administrative model will become untenable for local 9-1-1 Authorities in the future. Some consolidation and centralization of 9-1-1 institutional responsibilities will be essential to avoid excessive administrative burdens as well as provide uniform, high quality 9-1-1 Authority functions, such as ensuring call routing and security mechanisms are in place. Most of these call routing and security functions are presently delegated to incumbent local exchange carriers or similar 9-1-1 system providers.

Examination of roles and responsibilities to be shifted from local to regional to State and National-level coordination. Providing 9-1-1 services has traditionally been the role of local, regional and State government. As the infrastructure of 9-1-1 migrates to a digital, IP-based model, an examination of roles and responsibilities should be conducted on an ongoing basis, to identify those functions that should shift to a larger level of government. For example, as PSAPs are able to transfer calls to other distant PSAPs, a national database of IP addresses will be necessary to facilitate call transfer. While the response to emergencies will always be a local responsibility, some administrative functions may be better served by shifting to a national (or international) model.

Laws and regulations for 9-1-1 must be updated to be technology-neutral. Many existing laws, regulations, and tariffs specifically reference older technologies or system capabilities and consequently prohibit the implementation or funding of IP-enabled 9-1-1. For example, by statute, some locations only permit access to PSAPs via the telephone network.[68] Laws and regulations for 9-1-1 must be updated to be technology-neutral, to facilitate 9-1-1 access for the communication devices already used by the public and those on the horizon of technology.

Consistent, long-term funding for 9-1-1 is essential. Laws and regulations affect how State and local governments fund 9-1-1 infrastructure and operations. For instance, surcharge rates often differ depending on the service type (e.g., wireless, prepaid wireless, wireline or VoIP) and the jurisdiction from which the fee is being collected. Whether through statutory changes or other policies, consistent, long-term funding for 9-1-1, derived from all users based on their usage or potential usage of the system, is essential. New funding models for 9-1-1 should be developed and considered for adoption, and 9-1-1 Authorities may wish to identify opportunities to offset the cost of IP-enabled 9-1-1 by sharing infrastructure, resources and services with, or simply interconnecting with, other public safety, non-public safety government or private sector entities.

One of the most important policy decisions for IP-enabled 9-1-1 will be establishing responsibilities for generating and delivering accurate, real-time location information. Unlike with today's wireline and wireless telephone service, the OSP and network provider may no longer be the same entity or as closely-linked in an IP environment. For example, access to communications services such as instant messaging or VoIP do not depend on the particular network used to access the Internet. While the OSPs may ultimately continue to be responsible for delivering information accurate enough to enable an emergency response, there are network-based mechanisms that would permit any IP-enabled 9-1-1 call to be routed to the most appropriate PSAP, regardless of the capability of the devices or application service to determine its own location. One of the most important policy decisions for IP-enabled 9-1-1 will be establishing responsibilities for generating and delivering accurate, real-time location information.

Updating definitions. Adopting consistent technical, operational and institutional definitions will facilitate true interoperability in establishing an interactive "system-of-systems" for emergency communications. A mechanism to promote the use of consistent definitions by Federal agencies involved in emergency communications, such as the USDOT, the FCC, and the Department of Homeland Security, will support the coordination of efforts by adopting the use of common terminology.

[68] NENA, *Policy Maker Blueprint*, pp. 10-11.

6 TRIAL DEPLOYMENTS

Congress tasked the ICO with analyzing the experiences of 9-1-1 organizations that had conducted trial deployments of IP-enabled emergency networks as of July 23, 2008.[69] This section contains an assessment of USDOT's NG9-1-1 proof-of-concept demonstration carried out from May through July 2008 and a status report on operational deployments of IP-enabled 9-1-1 components.

REQUIREMENT H: Assess, collect, and analyze the experiences of the public safety answering points and related public safety authorities who are conducting trial deployments of IP-enabled emergency networks as of the date of enactment of the *NET 911 Improvement Act*

REQUIREMENT J: Analyze efforts to provide automatic location for enhanced 9-1-1 services and provide recommendations on regulatory or legislative changes that are necessary to achieve automatic location for enhanced 9-1-1 services

The NG9-1-1 Initiative Proof-of-Concept Deployment

The NG9-1-1 Proof-of-Concept (POC) Deployment was the culmination of the technical work of the USDOT Initiative. The POC project leveraged past work from the public safety and standards communities and built on the requirements, architecture and initial system design developed under the NG9-1-1 Initiative.

POC Overview

The POC system design relied on Commercial Off-the-Shelf (COTS), open source and common telecommunications and networking products used throughout the industry. Because of the limited project scope, the POC system design did not include all the components listed in the architecture (i.e., legacy systems); however, it did represent virtually all of the "next generation" system design elements. During the POC demonstration, little of the legacy technology (such as selective routers) was demonstrated because those systems are in place today. However, it is important to recognize that in future operational deployments, legacy and IP-enabled systems will likely need to run concurrently until the legacy systems can be replaced or retired.

The NG9-1-1 POC demonstration was not an operational demonstration, although the facilities and staff of five PSAPs were used during the testing. At no time during the tests were real calls used nor did the test system interrupt the operations of the current 9-1-1 system. This configuration allowed a demonstration of the NG9-1-1 architecture in a controlled environment with professional call takers.

The NG9-1-1 POC demonstrated selected features of the NG9-1-1 requirements and system design, focusing on the three main components of emergency calling: call origination, call support/processing and call termination at a PSAP. Because IP-based calling is a key factor for NG9-1-1, the POC used IP devices and systems in addition to more traditional methods (e.g., wireline and wireless telephones).

To demonstrate the networking features of NG9-1-1, a standalone and secure POC network was designed and implemented. The network connected three laboratory facilities (Booz Allen Hamilton, Texas A&M, and Columbia Universities), four PSAPs (Rochester, New York; King County, Washington; St. Paul, Minnesota; and Helena, Montana) and one statewide PSAP network (the State of Indiana). Each of these entities was connected via secure Generic Route

[69] P.L. 110-283, Sec. 102(3)(d)(2)(H).

Encapsulation tunnels over the Internet2 network and a mix of AT&T's Commodity Internet and Multi-Protocol Label Switching network.

A number of system-wide decisions were made during the design of the POC in areas where there are not yet formal 9-1-1 standards. For example, the POC used Session Initiation Protocol (SIP) as the signaling protocol for call set up, routing and termination. Although other signaling protocols exist, SIP was chosen because of its wide industry acceptance, support and open source status. Also, SIP gateways were used as interfaces to the NG9-1-1 POC network to demonstrate a modular architecture corresponding to a more realistic deployment scenario. These decisions helped control the scope of the POC to maintain a tight implementation schedule.

Call Origination

During the POC, a variety of call origination scenarios were tested, including legacy PSTN telephones, cellular telephones (voice and SMS texting), third-party call centers (telematics systems) and IP User Agents (UA), including laptops with SIP clients, IP telephones, and IP wireless devices). These devices successfully demonstrated call initiation as the first step in the overall call delivery process. A mix of simulated and actual originating service providers were used to show the various routes a call could take to reach the NG9-1-1 system.

Demonstration of call origination devices helped identify areas for future research, including conference server and video compression technology for multiparty conferencing to support the needs of video interpreting services for the deaf or those who have hearing or speech disabilities. In addition, the demonstration showed that SMS texting was an inferior technology for emergency calling because it does not provide callers' location information and it cannot guarantee timely delivery or receipt of messages. On a positive note, telematics testing demonstrated the maturity of that commercial technology and provided positive results that may be demonstrated in pilot tests before a full rollout of NG9-1-1.

IP Access Network

The POC's IP access network provided location acquisition and validation, network routing and SIP signaling functions. To simulate an IP access network, the test laboratory implemented devices to dynamically assign IP addresses, translate host names to IP addresses, acquire locations for test calls and provide network security for the POC network and devices.

POC test calls entered the IP access network as native IP calls or through telephony gateways (and were converted to SIP). Once within the IP access network, the calls accessed location acquisition and call routing services. The call's location was used to route the call, and it was forwarded out of an edge/ border gateway and onto the NG9-1-1 network.

NG9-1-1 Network

The primary function of the NG9-1-1 network was to identify the appropriate PSAPs based on the call origination information and to efficiently and accurately route the call while maintaining data integrity. Simulated databases of NG9-1-1 data were used to ensure that appropriate business rules were applied prior to routing the calls to the POC PSAPs. In an operational NG9-1-1 network, the data would likely be decentralized and geographically distributed to maximize the stakeholders' needs for reliability, availability, scalability and serviceability.

One of the main components of the NG9-1-1 network was the Location to Service Translation (LoST) discovery protocol. LoST matches geographic regions with services (in this case, emergency services providers.) During the NG9-1-1 POC, LoST was used to resolve which PSAP an IP-based calling device should contact for emergency services. The LoST server used its database to provide the identification and contact information for the requested service based on the caller's location.

NG9-1-1 PSAP

The primary role of the NG9-1-1 PSAP in the POC was to receive simulated 9-1-1 calls generated from a variety of call origination devices. As part of the POC, PSAP equipment and infrastructure were deployed at several real PSAPs that provide 9-1-1 emergency services within their city, county or State. The project team ensured that the daily operations of the PSAPs were not disrupted while conducting the POC tests. POC equipment deployed at the PSAPs was isolated from the operational environments and while call takers participated in the testing, no real 9-1-1 calls were taken using POC equipment.

As part of the POC, graphical user interface software was developed to support typical call taker functions. In the NG9-1-1 environment, the amount and types of data displayed were dramatically increased; however, the call taker participants were able to quickly adapt to the new software with only minimal orientation. The call taker's console contained functionality for call takers to receive multimedia calls (i.e., video/interactive video, static images and text messages). Call takers were able to view and interact with this multimedia data by using pop-ups displays designed to present this information, and easily adapted to their use in call processing.[70]

POC Test Findings

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 five PSAPs, 26 professional call takers, dispatchers and supervisory personnel were trained to assist with the POC testing. 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 performance of IP-enabled emergency service network implementations, the team believed it successfully demonstrated a significant portion of the NG9-1-1 concepts and use cases during the POC. The test results are summarized in Table 6.1.

[70] There are two project documents that specifically describe research into the call taker's HMI, including: *NG9-1-1 Call Taker Human Factors Issue Report,* November 2007, *available at* http://www.its.dot.gov/ng911/NG911_HMI_2007FINAL.htm (last accessed July 13, 2009); and *NG9-1-1 Human Machine Interface Display Design Document,* January 2008, *available at* http://www.its.dot.gov/ng911/pdf/NG911_HMI_Display_Design_FINAL_v1.0.pdf (last accessed July 13, 2009).

Table 6-1. Summary of POC Test Results

High-Level Functional Component	Initial Finding
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 carriers or equipment. Upgrades and technological improvements will be needed at multiple levels.
Increased deaf/hearing-impaired accessibility	Successfully Tested. Live streaming video from a mobile device to PSAPs is not currently supported by the carriers or devices. Upgrades and technological improvements will be needed at multiple levels.
Caller location identification	Successfully Tested. Various location acquisition and identification processes were used.
Call routing based on caller location	Successfully Tested. First use of ESRP and LoST servers and a business rules database in a real application environment.
Telematics data delivery, including speed, vehicular rollover status and crash velocity	Successfully Tested. Demonstrated the ability to automatically transfer important data associated with a vehicle accident.
IP networking and security in an emergency communications environment	Successfully Tested. Not included in the POC because of scope limitations, Identify and Access Management (IdAM) system will need to be tested and evaluated.

The decisions made in the system design and the reasons for them will assist individuals and entities as they implement IP-enabled solutions. Those key findings and lessons-learned are outlined below.

Standardization on SIP

The POC used SIP as the signaling protocol for call establishment, routing, and termination. Although signaling protocols such as IP Multimedia Subsystem (IMS), Signaling System 7 (SS7) and H.323[71] are available, SIP was chosen for a number of reasons. SIP enjoys a wide industry acceptance, readily-available support and open source status.

The flexibility of the SIP standard to support a variety of multimedia communications sessions was consistent with the need to deliver multimedia-based calls over IP networks. The POC successfully demonstrated the use of SIP to deliver voice, video conferencing, instant messaging and real-time texting, as well as provide essential, supportive and supplemental data.

SIP was selected for its ability to invite participants to already existing sessions, such as multicast conferences. One of the NG9-1-1 requirements is to automatically enable conferencing for a variety of situations, including the need for language interpreting services. Similarly, SIP supports the ability to add (and remove) media from existing sessions. As demonstrated during the POC, SIP provided the ability to add transport of text, video and other data, simultaneously with established voice channels. The resulting calls were media-rich and offered multiple sources of data input for the call taker.

Use of Reference Links

One element of the IP-Enabled 9-1-1 concept is to make available significant amounts of data associated with the call at all stages of the call session. However, there are real concerns about

[71] Specified in International Telecommunications Union-Telecommunications (ITU-T) specification H.323, the specification for transmitting multimedia (voice, video, and data) across a network, and is used in some VoIP architectures.

exceeding limits on message length. Specifically, one benefit of limiting the message size would be to avoid fragmenting IP packets (which could lead to data loss, as well as some denial-of-service attacks that have been attributed to fragmented packets).

The POC incorporated location by reference[72] and other reference link methods to permit access to data sets much larger then the maximum field or header lengths allowed. In this manner, links or pointers were included in the standard message fields by using a Uniform Resource Identifier (URI) that pointed to another service or database. Although the message did not contain the complete set of data, it indicated that the information exists and provided the definitive source for obtaining the data.

This method of providing a link to the necessary information helps solve potential technical issues and introduces the opportunity to enhance security protection of that data. Varying levels of access to subsets of the data are necessary throughout the duration of a 9-1-1 call. For example, a call taker must have immediate access to the caller's location, but may not need access to next-of-kin information associated with a medical-alarm activation. However, the dispatchers and emergency responders may need that contact information to gain access to the home of someone experiencing a medical emergency. In this manner, the call stream message would indicate the availability of this contact information and business rules would specify which users or entities are authorized to access the data in question. This would support preservation of proper data access, in accordance with privacy and data protection laws and regulations (e.g., Privacy Act of 1974[73] and the Health Insurance Portability and Accountability Act) [74] currently in place.[75]

Use of Hierarchical LoST Server Architecture

One of the key features of the LoST protocol[76] architecture is its ability to be implemented in a distributed, scalable and highly resilient infrastructure. This addresses the need to be able to route calls from widely mobile callers to the appropriate PSAP given that "authoritative knowledge" about the relationship between geographic locations to emergency services is "distributed among a large number of autonomous entities that may have no direct knowledge of each other."[77] As part of the POC effort, the LoST servers were configured in a hierarchical and distributed manner. A similar configuration would be likely as part of an operational IP-Enabled 9-1-1 implementation as it provides the maximum flexibility and control for 9-1-1 Authorities.

The POC demonstrated the ability to have large regionalized LoST servers (e.g., Western U.S. and Eastern U.S.) that could connect to statewide, regional or local LoST servers. Deploying LoST for future IP-enabled 9-1-1 systems could be accomplished in a similar way. Some organizations may wish to deploy their own local or regional LoST servers (a bottom-up approach), which would eventually lead to nationwide coverage. Another way would be for some large, authoritative systems to implement LoST at a nationwide, multi-state or large regional area, allowing further coverage to grow over time. Most likely, there will be a hybrid of approaches initially creating a patchwork of coverage.

Overall Security Concerns

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[72] For more information about the Location by Reference Requirements, visit the IETF's GEOPRIV Working Group for their current draft: http://www.ietf.org/html.charters/geopriv-charter.html (last accessed July 13, 2009).
[73] P.L. 93-579, 5 USC § 552a .
[74] P.L. 104-191, *Health Insurance Portability and Accountability Act.*
[75] For more information on health information privacy, see the Department of Health and Human Services reference materials at http://www.hhs.gov/ocr/privacy/index.html (last accessed July 13, 2009).
[76] IETF ECRIT Working Group, *LoST: A Location-to-Service Translation Protocol* [RFC5222], http://tools.ietf.org/html/rfc5222 (last accessed July 13, 2009).
[77] IETF ECRIT Working Group, *Location-to-URL Mapping Architecture and Framework*, http://tools.ietf.org/html/draft-ietf-ecrit-mapping-arch-03 (last accessed July 13, 2009).

Security of future IP-enabled 9-1-1 systems is critically important and one of the leading concerns raised by stakeholders. With today's 9-1-1 system primarily consisting of legacy technology and closed networks, security risks are mostly known and manageable. However, an IP-based system, more widely connected across multiple networks and systems, faces more opportunity for security compromises. The situation remains manageable through the use of best current practices within the IT and public safety community.

IT-based systems require a solid security foundation, which is multifaceted and implemented at multiple levels. For mission-critical applications such as IP-enabled 9-1-1, the importance of restricting access to only authorized users becomes even more crucial. High levels of protection are not new to IP-based enterprise networks and systems, such as those used in national defense, intelligence, and banking communities. While not a panacea, lessons-learned and best practices within those environments are one method of leveraging existing knowledge to assist in developing comprehensive security solutions for IP-enabled 9-1-1.

Commercial Off the Shelf (COTS) Hardware and Software

COTS typically refers to technology that is commercially available and does not require specialized support throughout its lifecycle. In the context of the NG9-1-1 POC, the use of COTS demonstrated that stakeholders are able to employ components developed by vendors for which they have a particular comfort level or experience without losing features or functionality. Legacy 9-1-1 components historically have been proprietary and not COTS due to the relative small size of the 9-1-1 market and the perceived need for specialized equipment to operate those systems.

Some benefits of using COTS include cost savings and more widespread understanding of the technical limitations and issues associated with the product. Operations and maintenance of COTS hardware is frequently easier and less expensive than customized solutions, as replacement parts are usually more readily available.

REQUIREMENT I: Identify solutions for providing 9-1-1 and enhanced 9-1-1 access to those with disabilities and needed steps to implement such solutions, including a recommended timeline

Migration to IP-enabled 9-1-1 systems in general represents the critical path for meeting the needs of people with disabilities. This report does not lay out a deployment timeline, which depends strongly on the existence of standards, consistent funding and nationwide coordination. Assuming these three factors, a 10-year rollout period for full deployment of network, data centers and PSAP infrastructure is feasible.

Access for People with Disabilities

The POC included specific test scenarios for addressing the needs of the deaf or hearing-impaired. The biggest gap between the technologies used for daily communication and those that can access 9-1-1 services is that for the deaf and people with hearing or speech impairments. These communities use various texting or video applications for communicating, but only decades-old analog TTY/TDD can connect to today's PSAPs. Texting access through various IP-devices and third-party conferencing (which may be needed to support sign language interpretation) were successfully demonstrated. Recognizing the importance of, and need for, alternate forms of communication for people with disabilities, streaming video and cellphone SMS texting were also successfully demonstrated, but with key shortcomings. Real-time texting, which does not have the shortcomings of SMS, was successfully demonstrated.

Streaming Video for Emergency Calling

The ability to transmit and receive video streams as part of a call was one of the primary NG9-1-1 concept and POC requirements. Emerging technology (in the form of handheld wireless devices with a screen and camera) is now making portable streaming video possible. While the POC focused on fixed, PC-based web cameras to demonstrate this functionality, these mobile concepts were successfully tested as well. For the POC, open source technology was selected (in keeping with the project's design parameters) and due to various limitations of the technology, mixed results were found. The conferencing server used to support streaming video distribution did not support multiple parties (although there are commercial products available that support this capability). Multiple party conferencing is needed so that a deaf or hard-of-hearing caller, a sign language interpreter and the emergency call taker can all communicate in concert to obtain the necessary information quickly and efficiently.

Due to the current limitations of cellular carriers' networks, transmitting compressed video, with the quality needed to deliver an intelligible sign language conversation, is not yet readily available in the United States. Research into new encoding techniques is currently underway,[78] and with improvements in the cellular networks, may provide the ability to transmit video to the PSAP.

Inclusion of SMS Technology

The POC tested SMS text messages as a method of call origination as this technology is in widespread use; increasingly, people attempt to send text messages to 9-1-1 and are surprised to learn that it is not a feature of today's system. While some in the emergency communications field believe that SMS has its merits and should be supported in future 9-1-1 systems, many others have concluded that SMS is an inferior technology for emergency calling due to its fundamental inability to support identification of callers' location information. Although the POC created an "SMS Positioning Center" system to support SMS location acquisition, there are no commercial systems available that identify the SMS sender's location. There would need to be significant changes made to the technology and devices to support location acquisition and delivery. Other problems with SMS exist as well, as it does not provide the call taker with an easy method of caller interrogation and because SMS technology was never designed to guarantee message delivery or receipt.

From an operational perspective, the POC permitted only a single SMS conversation at a time. It is expected that in IP-enabled 9-1-1, call takers will need to interact with multiple, simultaneous SMS messages (from different callers). For the call taker, this introduces risks associated with talking to multiple callers all at the same time, something that is not typically done in today's 9-1-1. Limiting the call taker to respond to a single SMS at a time may strain the limited resources of a typical PSAP. NENA has a working group addressing these operational issues, but more research must be performed to reduce risk and decrease the chance of introducing a potentially serious system design flaw.[79]

While the technology was successfully demonstrated, there may be better technology options for both emergency callers and call takers over that of SMS. For example, development or modification of a real-time texting (similar to instant message or chat) application, could support delivery of caller's location, improve the ability for the call taker to quickly obtain additional critical information during their interrogation and eliminate the 140 character limitation of SMS. Real-time texting was successfully demonstrated in the POC.

[78] MobileASL is a research project at the University of Washington, seeking to enable sign language conversations on cell phones. More information is available at Mobile ASL, http://mobileasl.cs.washington.edu/ (last accessed July 13, 2009).
[79] *See* NENA, Non-Traditional Technical Committee, http://www.nena.org/technical-committee-nontraditional (last accessed July 13, 2009).

Selection of Databases for POC Testing

A number of databases were included in the POC testing and demonstrations. The POC used actual master street address guide data from the participating PSAPs in the development of other location-oriented databases. Some databases that support functions critical to future IP-enabled systems – business rules, identity and authentication management, data rights management and dispatch/response routing – were also not included due to limitations in POC resources and scope. Initial work was done to identify requirements for a business rules database. In particular, there are two types of business rules: rules that affect call routing (e.g., factor other than location of the caller); and rules that affect how a call and data are presented to call takers. Detailed requirements were not available in time for the POC. More work is needed; and NENA's Technical and Operational committees and others are presently working to establish business rules for the transition to IP-enabled 9-1-1.

Identity and authentication management databases are key to overall IP-enabled 9-1-1 system security; however, implementing such a system within the resource and time constraints of the POC was not possible. Dispatch/response routing was also not included as the POC focused on call origination, delivery and termination at a PSAP; hand-off to a dispatch organization was outside the scope of the project as well.

User Interface

The Human-Machine Interface (HMI) was designed specifically for the POC and was not intended for live, operational use. The nature of the POC testing required multiple features in the HMI, including automatic call distribution and the ability to record caller detail information. In an IP-enabled 9-1-1 system, this functionality may be provided by a single system or multiple, tightly-integrated systems. Some data displayed to the call taker was done to aid the testing and demonstration process and would not normally be displayed to the end user. For example, in the telematics demonstration, all 130+ data elements associated with crash notification were displayed. In future operational 9-1-1 systems, it is expected that only the few data elements or just an indication of crash severity and likelihood of injury would be shown to assist the call taker in making a response decision.[80]

Additional research into the content, format and layout of the HMI will be necessary by the vendors who will provide future call-taker equipment. Previous work done for the NG9-1-1 Initiative[81] may assist in the development of those future user interfaces.

Telematics Service Provider Integration

Throughout the project, the team worked closely with OnStar, a major Telematics Service Provider (TSP). Integration of a telematics call was an important requirement for the POC. Prior to the NG9-1-1 Initiative, USDOT had conducted a test in Minnesota where OnStar was able to deliver crash data directly to PSAPs. An updated version of the Vehicular Emergency Data Set (VEDS)[82] standard used in the earlier test was used in the POC to successfully deliver crash notification "calls" originating from OnStar's laboratory.

[80] Mortality and Morbidity Weekly Review, *Guidelines for Field Triage of Injured Patients Recommendations of the National Expert Panel on Field Triage*, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Recommendations and Reports, January 23, 2009, 58 (RR01); 1-35, http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5801a1.htm (last accessed July 13, 2009).

[81] *NG9-1-1 Human Machine Interface Display Design Document,* January 2008, *available at* http://www.its.dot.gov/ng911/pdf/NG911_HMI_Display_Design_FINAL_v1.0.pdf (last accessed July 13, 2009).

[82] VEDS is an XML-based standard, used to transmit telematics data to PSAPs. More information is available at: http://www.comcare.org/veds.html (last accessed July 13, 2009).

Although important to demonstrate on its own merits, the knowledge gained testing telematics is directly applicable to development, integration and testing of other non-human-initiated automatic event alerts, such as alarms or sensors. For example, the Association of Public-Safety Communications Officials International (APCO) has helped to develop a standard data exchange method to transmit data between alarm monitoring companies and PSAPs.[83]

Other Trial Deployments

REQUIREMENT H: Assess, collect, and analyze the experiences of the public safety answering points and related public safety authorities who are conducting trial deployments of IP-enabled emergency networks as of the date of enactment of the *NET 911 Improvement Act*

In addition to the NG9-1-1 POC, some State and local agencies have implemented elements of an IP-Enabled 9-1-1 system. To date, efforts have primarily focused on procuring IP-enabled equipment that supports operations. No State or local agency, however, is accepting calls delivered in IP-format (VoIP calls are converted to the existing circuit-switched network before they are forwarded to PSAPs). Described below are State and local agencies' efforts to develop and implement IP-enabled 9-1-1 network components that were on-going or completed by July 23, 2008; testing activities and deployments after this date are not reported here.

<u>State of Vermont</u>

In February of 2007, the Vermont Enhanced 9-1-1 Board activated the first statewide next generation 9-1-1 system. The system delivers 9-1-1 calls from the PSTN to a PSAP using VoIP over its Emergency Services Network (ESINet). Currently, the State of Vermont 9-1-1 System consists of eight diverse locations collectively serving as one Statewide PSAP; 9-1-1 calls are initially routed to one of these answering points based on the originating caller's location.[84]

Many of the characteristics of the Vermont system likely match or reflect national NG9-1-1 concepts and methods. Vermont is arguably the most advanced IP based 9-1-1 process in the country. However, its PSAPs are not yet accepting IP calls or other data. Following the implementation of the system, two sites were decommissioned based on the economy of scale provided by Vermont's virtual statewide PSAP.

<u>The Galveston County Emergency Communications District</u>

The Galveston County Emergency Communications District (GCECD) has implemented an IP-enabled network of PSAPs in the State of Texas. All eight PSAPs (21 dispatch positions) in the GCECD, along with the La Marque Police Department, the Galveston County Sheriff's Department and the Galveston Police Department, are using the IP-enabled call handling system. Functionality that will eventually be enabled by the system includes the ability to accept VoIP calls, ability to receive automatic crash notification data, on-demand conferencing, group paging capabilities, remote log-in and encryption of all 9-1-1 calls for increased privacy.[85]

[83] The Association of Public-Safety Communications Officials International, *Alarm Monitoring Company to Public Safety Answering Point (PSAP) Computer-aided Dispatch (CAD) External Alarm Interface Exchange*, http://www.apcointl.org/new/commcenter911/documents/APCO-CSAA-ANS2-101-1web.pdf (last accessed July 13, 2009).
[84] Vermont's 9-1-1 System, State of Vermont, http://e911.vermont.gov/vermont_911 (last accessed July 13, 2009).
[85] *First VoIP E911 Call-Handling Solution in Texas*, VoIP Monitor, May 1, 2006, http://www.voipmonitor.net/2006/05/01/First+VoIP+E911+CallHandling+Solution+In+Texas.aspx (last accessed July 13, 2009).

In addition, the GCECD has constructed an IP-based mobile PSAP that can be taken to any location that has broadband Internet access. This will allow dispatchers to travel to a safe location, log in at their position, and begin taking 9-1-1 calls. This call will also be possible with stand-alone VPN phones without the mobile PSAP.

State of Indiana

Prior to being selected as a participant in the USDOT NG9-1-1 POC demonstration, the State of Indiana began developing a diverse IP-based "network" that delivers 9-1-1 voice and ALI data. The Indiana network (IN911) enables most of the 9-1-1 PSAPs to transfer a cellular call, along with its associated location information, to any other PSAP that is connected to the IN911 network.

IN911 was not initially developed to handle certain types of communications or protocols from cellular or other wireless devices such as telematics, SMS, text messaging, still images, video images or video relay. The operator of the IN911 network has plans to include transit, routing and delivery for these types of messages in 2009.[86]

Hamilton County, Ohio

In December 2007, Hamilton County, Ohio Department of Communications officials successfully routed an enhanced 9-1-1 call using a selective router infrastructure completely based on IP technology. The call was initiated from an IP-enabled telephone, traveled over a dedicated, end-to-end IP-network, and was delivered natively into the PSAP on premise call-handling equipment.[87]

Greensboro, North Carolina (Guilford Metro 9-1-1)

In August 2007, Guilford Metro 9-1-1 (Greensboro, NC) completed the center's first IP-based call. The call included voice, ANI and ALI functionality. The call was generated in a test lab using a VoIP device and was routed across the country using an IP-based Next Generation network. On arrival at Guilford Metro 9-1-1, the call was routed through the onsite network servers and delivered to the PSAP as a 9-1-1 call with voice, ANI and ALI. The call used a randomly-selected address within Guilford County, which included the latitude and longitude of the "caller."[88]

REQUIREMENT D: Identify location technology for nomadic devices and for office buildings and multi-dwelling units

Outside of the wireline common carriers, wireless carriers, and the interconnected VoIP providers mandated by the FCC to deliver 9-1-1 calls, few service providers are consistently providing location information at the level of accuracy that is necessary for responders to locate callers. Location information currently available to new devices and services (e.g., mobile wireless VoIP) may be adequate for routing 9-1-1 calls to the appropriate PSAP, but there are technological and regulatory challenges to ensuring highly accurate positioning in buildings or outdoors.

There are, however, a growing range of methods to improve location determination indoors as well as outdoors. Some require incorporation of additional technology and infrastructure and some require enhancements to existing technology (See Table B-1 in Appendix B for details). There is some activity in some standards organizations to establish provisions in various

[86] *Indiana Statewide 9-1-1 Plan*, December 2008, http://www.in.gov/tos/e911/files/Indiana_Statewide_9-1-1_Plan_-_Final_121108.pdf (last accessed July 13, 2009).
[87] Intrado, *Project summary: Next Generation 9-1-1 Success Story,* (July 20, 2008).
[88] Personal communication, Joe Hernandez, Intrado. *Intrado and Guilford Metro 9-1-1 Team to Complete Successful IP-Based 9-1-1 Call,* (January 10, 2008).

protocols, for fixed and wireless systems, to enable both location determination and proper routing of emergency calls. Although there are liaison activities underway among standards development groups, there are issues with using several different types of technologies in heterogeneous networks (such as connecting a WiFi access point to a cellular modem). These are complicated issues to address and are currently affected by the maturity of a draft standard and its status in the approval process.

As IP-enabled 9-1-1 services are rolled out and implemented, it is essential that the public understands how, where and when IP-enabled 9-1-1 services are available, and more importantly, where and when they are not available. Devices and services that can deliver 9-1-1 in one region may not be available in another. Moreover, even when the user is aware of what devices can be used in his region, the ability of any particular device to determine its location or even access 9-1-1 at all may depend on the particular network to which it is connected, and how it is connected. One possible solution may be that all devices and applications with which people could “reasonably expect” to call for help display real-time 9-1-1 access status simply, clearly and consistently to their users.

Demand for location capabilities is growing in conjunction with social networking and other applications. There are technologies available (or on the horizon) for locating calls from nomadic or mobile devices and for providing specific addressing within buildings (see Appendix B for details).

REQUIREMENT J: Analyze efforts to provide automatic location for enhanced 9-1-1 services and provide recommendations on regulatory or legislative changes that are necessary to achieve automatic location for enhanced 9-1-1 services

One of the most important policy decisions for IP-enabled 9-1-1 will be establishing responsibilities for generating and delivering accurate, real-time location information. Unlike today’s wireline and wireless telephone service, the OSP and network provider will no longer be the same entity or as closely-linked in an IP environment. For example, access to communications services such as instant messaging or VoIP do not depend on the particular network used to access the Internet. While the OSPs may ultimately continue to be responsible for delivering information accurately enough to enable an emergency response, there are a variety of network-based mechanisms that would permit any IP-enabled 9-1-1 call to be routed to the most appropriate PSAP, regardless of the capability of the devices or application service to determine its own location. One of the most important policy decisions for IP-enabled 9-1-1 will be establishing responsibilities for generating and delivering accurate, real-time location information.

As noted in Requirement D above, trends in communications services have implications for 9-1-1 automatic location. There is increased demand for location services and technologies, yet at the same time, the decoupling of originating service providers from network operators will make the delivery of real-time, automatic location information more challenging. For example, the trend in the wireless industry toward “convergence” – enabling a single device to operate using multiple, different networks – will make for inconsistent location determination. Since most location methods derive some assistance from the network when the device switches from one type of network to another, it will temporarily (or longer) lose support for location and the support it ultimately receives may be markedly different. Mobile devices may have to incorporate multiple methods for location determination.

Location technology impacts 9-1-1 calls at two points: first, to route the call to the appropriate PSAP and second, to provide information to locate the caller. While location information currently delivered may be adequate for routing 9-1-1 calls to the appropriate PSAP, there presently is no single technology or simple hybrid system that will provide response-quality location information for mobile devices on converged networks.

7 CONCLUSION

Although the 9-1-1 system has been a success for 40 years, changes in the public's use of technology, the saturation of the mobile market and the spread of VoIP telephony over broadband are contributing to greater expectations than the current system can address. Because text, data, images and video are increasingly common in personal communications, users expect the 9-1-1 system to accommodate highly mobile, dynamic communications modes. The architecture of these advanced communications modes is inconsistent with the fundamental structure of the current 9-1-1 system.

Trends in personal communication technologies are pushing the current 9-1-1 system toward obsolescence. There is no question that 9-1-1 networks and call centers must change; it is just a matter of how and when. Based on recent technology assessments by USDOT, NENA, IETF, FCC's NRIC and others, a conclusion can be made that IP-enabled 9-1-1 systems provide the optimal technical solution. There are no insurmountable technology barriers. There are costs associated with transitioning to NG9-1-1, but compared with existing networks, there are no significant, long term cost increases associated with migrating to IP-enabled emergency networks. Service providers, leading emergency communications associations and standards development organizations all support the adoption of IP-networks as the foundation of future 9-1-1.

The benefits of IP for emergency networks are real: greater access, more capabilities, interoperability and cost savings. Despite them, barriers such as funding, standards, and need for education exist; however, there are mechanisms that have been identified to help overcome these obstacles. The bottom line is that nationwide IP-enabled 9-1-1 is achievable. Additionally, there are a large number of operational, economical, and institutional issues that must be addressed and reconciled to successfully implement the NG9-1-1 system across the Nation. Implementing NG9-1-1 will likely be a complicated process, requiring the effective, timely and willing cooperation of an array of stakeholders. Although the rationale for deploying NG9-1-1 is compelling, the extent to which all 9-1-1 stakeholders move toward IP-enabled 9-1-1 will be affected by how they resolve or mitigate the institutional issues.

This National Plan for migrating to a nationwide IP-enabled emergency network can serve as an agenda for action and as a foundation for 9-1-1 stakeholders in planning and deploying NG9-1-1. It can serve as a roadmap for implementing policy decisions. The contents of this Plan are consistent with, and based largely upon USDOT's previous efforts, findings, and recommendations from the NG9-1-1 Initiative. It is not a "deployment plan" with prescribed design, timeline and budget requirements, but rather is an attempt to identify and analyze 9-1-1 system migration issues and assess potential options to resolve them consistent with the requirements of the *NET 911 Improvement Act*. This report, consistent with available resources, may serve as the basis for an additional and more detailed comprehensive plan and deployment strategy.

APPENDIX A: THE "NATIONAL PLAN" SECTION OF THE NET 911 IMPROVEMENT ACT

SEC. 102. MIGRATION TO IP-ENABLED EMERGENCY NETWORK.

Section 158 of the National Telecommunications and Information Administration Organization Act (47 U.S.C. 942) is amended--

(1) in subsection (b)(1), by inserting before the period at the end the following: 'and for migration to an IP-enabled emergency network';

(2) by redesignating subsections (d) and (e) as subsections (e) and (f), respectively; and

(3) by inserting after subsection (c) the following new subsection:

'(d) Migration Plan Required-

'(1) NATIONAL PLAN REQUIRED- No more than 270 days after the date of enactment of the New and Emerging Technologies 911 Improvement Act of 2008, the Office shall develop and report to Congress on a national plan for migrating to a national IP-enabled emergency network capable of receiving and responding to all citizen-activated emergency communications and improving information sharing among all emergency response entities.

'(2) CONTENTS OF PLAN- The plan required by paragraph (1) shall--

'(A) outline the potential benefits of such a migration;

'(B) identify barriers that must be overcome and funding mechanisms to address those barriers;

'(C) provide specific mechanisms for ensuring the IP-enabled emergency network is available in every community and is coordinated on a local, regional, and statewide basis;

'(D) identify location technology for nomadic devices and for office buildings and multi-dwelling units;

'(E) include a proposed timetable, an outline of costs, and potential savings;

'(F) provide specific legislative language, if necessary, for achieving the plan;

'(G) provide recommendations on any legislative changes, including updating definitions, that are necessary to facilitate a national IP-enabled emergency network;

'(H) assess, collect, and analyze the experiences of the public safety answering points and related public safety authorities who are conducting trial deployments of IP-enabled emergency networks as of the date of enactment of the New and Emerging Technologies 911 Improvement Act of 2008;

'(I) identify solutions for providing 9-1-1 and enhanced 9-1-1 access to those with disabilities and needed steps to implement such solutions, including a recommended timeline; and

'(J) analyze efforts to provide automatic location for enhanced 9-1-1 services and provide recommendations on regulatory or legislative changes that are necessary to achieve automatic location for enhanced 9-1-1 services.

'(3) CONSULTATION- In developing the plan required by paragraph (1), the Office shall consult with representatives of the public safety community, groups representing those with disabilities, technology and telecommunications providers, IP-enabled voice service providers, Telecommunications Relay Service providers, and other emergency communications providers and others it deems appropriate.'

APPENDIX B: LOCATION TECHNOLOGIES

The following sections describe some of the basic techniques for locating emergency callers, primarily from mobile and portable devices. These techniques can be used to determine location for calls originating on Internet Protocol (IP)-based networks. Each technique has its own advantages and disadvantages; and these are summarized in Table B-1 and discussed below. Specific technology comparisons or cost analyses were not made.

The following requirements from the *NET 911 Improvement Act* are addressed in this section:

REQUIREMENT D: Identify location technology for nomadic devices and for office buildings and multi-dwelling units

REQUIREMENT I: Identify solutions for providing 9-1-1 and enhanced 9-1-1 access to those with disabilities and needed steps to implement such solutions, including a recommended timeline

REQUIREMENT J: Analyze efforts to provide automatic location for enhanced 9-1-1 services and provide recommendations on regulatory or legislative changes that are necessary to achieve automatic location for enhanced 9-1-1 services

Table B-1. Sample Basic Location Techniques

Technique	Who Uses	Advantages and Disadvantages
Triangulation	Existing Cell phones	Uses provider's existing infrastructure/ requires 3 base stations in range of subscriber
AFLT	Existing CDMA-Based Cell phones	Uses provider's existing infrastructure/ works only for synchronous systems with 3 base stations in range of subscriber
A-GPS	Existing Cell Phones	High accuracy/ requires connection to infrastructure, network support, and has limitations indoors
B-GPS	Research stage	Similar to A-GPS but does not always require connection to infrastructure and network support/in development
Pseudolites	Aviation, indoor navigation and robotics research	Provides highly accurate location augmentation to GPS where coverage is poor/ requires new infrastructure installations
Signal Strength	Hybrid location systems	Simple to implement; accuracy is problematic
RF Mapping	iPod iTouch, social networking applications	Can provide good accuracy both outdoors and indoors in areas with significant WiFi coverage/ requires extensive surveying and periodic updates.
RFID	Public safety, inventory control, access control systems	Can provide precise location/ requires significant infrastructure due to short range
Signals of Opportunity	DoD research, several new products	Can provide improved coverage and accuracy; requires additional receivers

The primary technical challenge for emergency response is determining the location of mobile or nomadic devices. As these devices can operate in a variety of environments, most location products use a combination of techniques (hybrid) and often incorporate proprietary methods and algorithms. The trend toward "convergence" – the wireless industry term for devices that can operate seamlessly across multiple, diverse networks – will introduce new technical issues for precisely locating mobile devices. These techniques are presented to underscore their capabilities and limitations and illustrate why vendors chose the particular mechanisms to incorporate in their products.

Several new products have emerged since the FCC required E9-1-1 Phase 2 accuracy for Commercial Mobile Radio Services (CMRS) and there are some new techniques to improve location determination indoors. Many of these techniques are still in the research phase. There is not, however, a single technology or simple hybrid system on the horizon that will provide response-quality location information for mobile devices in even the common operational scenarios on converged networks expected for IP-enabled 9-1-1 services. In particular, there are no commercial systems yet available that identify a SMS sender's location.

Basic Wireless Location Techniques

Triangulation

Angle of Arrival. Angle of arrival is a technique that is based on classic radio direction finding. Using a highly directional antenna (either fixed or an electronically steered array), a line of bearing is determined between a base station and a subscriber. If lines of bearing from two base stations cross at an acute angle, an estimate of position can be made. As shown in Figure B-1, three or more base stations are normally required to provide acceptable accuracy. The station being located must be line of sight; a measurement from a reflected signal would provide an erroneous angle which can introduce significant location error.

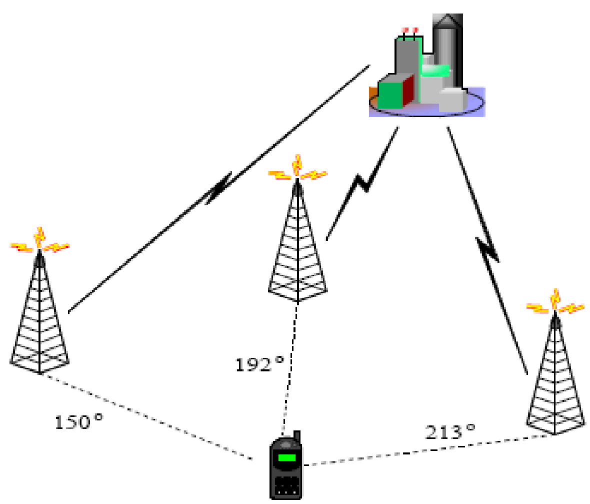

Figure B-1. Angle of Arrival

Time of Arrival. The time of arrival (TOA) method for locating handsets relies on the ability to estimate how long it takes a transmission to reach a base station. Since radio waves travel at the speed of light, the distance (d) from a base station can be estimated from the transmission delay. This, however, locates the handset as being on a circle with a radius d, with the base station at the center of the circle. If the estimate is made from three base stations, there will be three circles that intersect at the handset, as shown in Figure B-2.

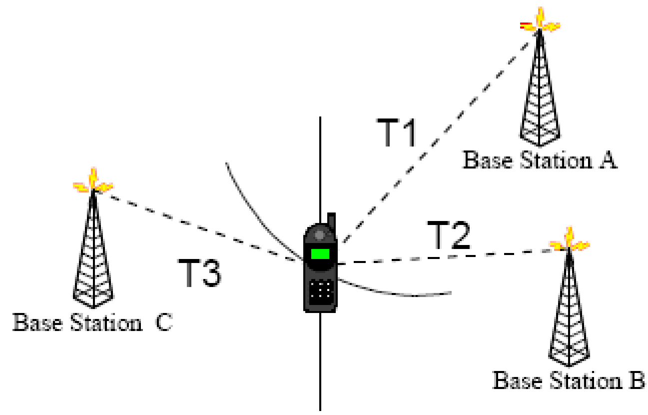

Figure B-2. Time of Arrival

Time Difference of Arrival. Time difference of arrival (TDOA) is similar to TOA, however pairs of base stations compare the difference they measure in time of arrival of the same handset signal. The difference of arrival time defines a hyperbola with the loci at the two base stations. If three base stations are used, there are three sets of difference times, creating three hyperbolic equations that define a single solution. TDOA is sometimes preferred to TOA because, in most implementations, there is less data that needs to be exchanged over the air (communications load). The computation of TDOA can be performed at a central processor. If additional accuracy is needed and there are sufficient base stations within range of the handset being located, a base station can instruct the handset to hand off, which will cause it to transmit a new registration message. This registration message gives the base station a new set of data to make a second estimate. TOA and TDOA estimates normally need at least three base stations to make a meaningful estimate of location. There must also be a common time base exchanged so the units can be synchronized. An advantage of TDOA is that only the base stations need tight synchronization to be able to make the computation. This method, which relies on the base stations, is often referred to as Uplink TDOA (U-TDOA) and is commonly used by Global System for Mobile communications (GSM)-based cellular networks.

An alternate method based on TDOA is called Enhanced Observed Time Difference (E-OTD). In this method, the handset measures the time difference of arrival of signals from several base stations. The handset performs the calculation and reports its position back to the base station.

Advanced Forward Link Trilateration. Advanced Forward Link Trilateration (AFLT) is used primarily by cellular telephone systems that are based on Code Division Multiple Access (CDMA) technology. The CDMA-based systems are synchronous systems that require precise timing throughout the network to operate properly. AFLT uses this feature to triangulate on base stations in the network using ranging measurements based on the time delay of the arrival of the signal. The handsets measure the phase delay between pairs of signals from 3 base stations. A location server in the network associates the measurements with the specific tower positions in a base station almanac database. Trilateration is used to turn the tower positions and cellular system pilot signal measurements into a GPS-like ranging solution. The cellular carriers recognized that GPS-based location determination had limitations both indoors and in urban canyons. If the signals from three base stations are available, AFLT can be used to estimate location. AFLT is part of a hybrid system used to meet the FCC’s E9-1-1 Phase II mandate.

Radio Frequency (RF) Time-of –Flight. RF Time-of-Flight (TOF) is a variation of time of arrival that is incorporated into mesh networks, ad-hoc networks, and sensor systems. This is a form of time of arrival, using a transmitted signal for ranging purposes to estimate relative location among the nodes of the network. There is some recent research in this area using a roundtrip signal between pairs of stations to remove any differences in the internal time base of the stations to compute relative position without tight synchronization. If some of the network nodes have a known position, it is possible to convert the relative position of a node into an absolute position. There have been some proposed applications using RF TOF with wideband signals to locate police and firefighters, primarily indoors.

Signal Strength. The signal strength method uses the received power level to estimate the distance from a base station. If the transmit power is known, either a handset or a base station can, using radio frequency path loss equations, estimate the distance from each other using a measurement of the received power. If the distance from three base stations is estimated, the location of the handset can be determined. This technique will not work with systems that use adaptive power control. For example, cellular systems using CDMA, such as the current systems from Verizon and Sprint, can carry the greatest amount of voice traffic if all handsets appear to be equal distance from the closest base station (called the near-far problem). Handsets that are very close automatically reduce their power, while handsets that are far away will increase their power. If signal strength measurements are used for locating handsets for E9-1-1, the devices would need to be designed to automatically go to full power when emergency calls are made. This would decrease the communications capacity of the cell, but only on the occasions when 9-1-1 call are in progress.

Global Navigation Satellite Systems (GNSS)

There are several potential Global Navigation Satellite Systems (GNSS) that might be used to locate emergency callers. The United States operates the Global Positioning System (GPS). Russia operates a similar system called GLONASS. This system fell into disrepair and is in a restoration phase. There are additional systems in development; Europe is developing a system called Galileo. Both China and India have regional systems that might be expanded into global coverage.

Global Positioning System (GPS) Satellites. Use of GPS receivers is the most straightforward, accurate method of determining location, and is the basis for E9-1-1 location in CDMA2000-based cellular telephones. GPS signals are modulated with a data signal that includes satellite almanac data, ephemeris, and data and clock error information. The receiver starts searching for GPS signals, and once acquired, extracts the information from the navigation signal. If a receiver can see at least three (3) satellites of the 24 in the constellation, it can resolve the transmission time from each satellite and compute a position that can be accurate to the centimeter range. If a fourth satellite is available, altitude can also be computed.

There are several fundamental problems using GPS as the only means of locating a 9-1-1 call. One problem is the caller is frequently shielded from the GPS satellites; many calls are made from an indoor location. Another problem stems from the “time-to-first-fix.” When a user device is first turned on and an attempt is made to make a 9-1-1 call, it takes a relatively long time for the GPS receiver to calculate the location (60 seconds or longer depending on the receiver design). Also, the GPS receiver uses extra battery power to do a full computation of the location, which is counter to consumer demands for tiny devices (therefore, small batteries) and long times between recharges.

Network-Assisted GPS (A-GPS). GPS receivers have several functions to perform before they can compute a location. The first thing the receiver needs is information about where in the current transmission cycle (epoch) the satellite signal is located. GPS satellites transmit a carrier modulated by a pseudo-random code 1023 chips[89] long and a 50 bit per second navigation signal. The navigation signal tells the receiver what is needed to use the carrier as a ranging signal, including the current location of the satellites (ephemeris), the time of week count for the most recent transmission subframe, and the number of epochs elapsed since the beginning of the subframe. The problem is when the receiver is indoors the signal can be attenuated up to 30 dB, and the receiver cannot demodulate the navigation signal. Also, a significant part of the time to first fix is spent acquiring the satellites in view and demodulating the navigation signal information.

In Network-Assisted GPS, shown in Figure B-3, this work is done by GPS receivers, called location measurement units, placed either at the base stations or at strategic locations throughout the network. These receivers acquire the satellites in view, demodulate the navigation signals, and provide the handsets with the required navigation information including timing, which satellites are in view, estimates of Doppler shift, and differential corrections from the Nationwide Differential Global Positioning System (NDGPS) service. (This service uses ground reference stations to determine the differential between the GPS solution and the true solution and helps improve accuracy.) All the caller's handset has to do is track the carrier phase, which can be done at a significantly lower power level and may be available indoors or in urban canyons.

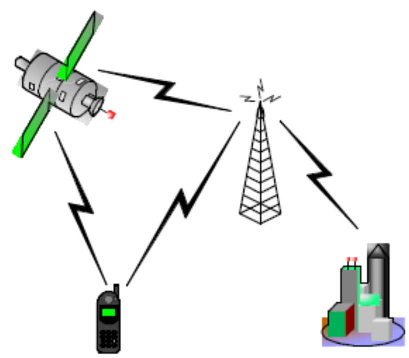

Figure B-3. GPS and A-GPS

Another improvement for Network-Assisted GPS is in receiver design. The satellite transmits at a known frequency (1575.42 MHz), which is altered (delayed) by frequency shifts due to satellite motion (Doppler), handset motion, and error from the local oscillator in the receiver. The receiver has to search a range of delays, and, at each delay, it has to correlate a locally-generated version of the 1023 bit code with the 1023 bit code used by the satellite. Each delay-code combination is called a bin, and the longer the receiver dwells on a bin, the greater the receiver sensitivity. This creates a tradeoff between time to calculate a fix and the ability to use a very weak indoor signal. The new receivers use the navigation information received from the base station to reduce the delay search window and incorporate thousands of correlators on a single chip to perform the code searches in parallel. This reduces the number of bins by several orders of magnitude, reducing the time-to-first-fix and allowing the receiver to track a much weaker signal. The end result is a cell phone that can be located to some extent at indoor locations, in urban canyons, and in parking garages. The signal is usually marred by multipath reflections in these environments, but the reduced accuracy derived from the reflected signals is still within the handset accuracy standards established by the FCC.[90]

[89] In spread spectrum technologies such as CDMA, chip rate is the number of bits per second (chips per second) used in the spreading signal.

[90] FCC, Fact Sheet, *FCC Wireless E911 Requirements,* January 2001, http://www.fcc.gov/pshs/services/911-services/enhanced911/archives/factsheet_requirements_012001.pdf (last accessed July 13, 2009).

B-GPS. A new approach to using GPS to achieve instant positioning, B-GPS (called "B" because it is a follow-on to "A"), overcomes the main shortcomings of A-GPS -- the need for a network connection and transfer of satellite information over the network. When a GPS receiver is first turned on, if it doesn't know its last position, doesn't know the approximate time, or does not have the satellite almanac (which is derived from the navigation signal), it can take anywhere from 60 seconds to 12 minutes to get the time-to-first-fix. This is known as a cold start. A-GPS uses what is known as a hot start. The receiver gets the almanac, current ephemeris data, and accurate time from the network and can get a fix in less than 6 seconds (typically one or two seconds). It can ignore the navigation signal which contains the data provided over the network (and requires a much stronger signal to be able to extract the information, thus the ability to find weak signals in indoor locations) and can focus on just finding the time mark in the GPS signals to resolve ambiguities in the position.

B-GPS has two significant differences from A-GPS. The first difference is that it does not need a continuous network connection because it stores ephemeris data. These data can be predicted in advance and can be downloaded to the user's device. The device needs a network connection to update the information perhaps once or twice a week, and this can be done over the Internet. Some researchers feel that this interval could be extended to perhaps once a month in the future. The second difference is the use of a "signal snapshot." It uses special algorithms to retrieve the time of transmission in real time without reading the navigation message; it uses a single "snapshot" of the data. This second step can be computationally intensive, and will affect the cost and power consumption of device. B-GPS is currently in a prototyping phase and experiments are being performed. With advances in microelectronics, this may be an affordable enhancement for future 9-1-1 capable devices.

Pseudolites. A pseudolite is a source that transmits GPS-like signals intended to aid in locating nearby users where GPS signals are either too weak or unavailable. When pseduolites can operate on the same frequency as GPS, they can be used by standard GPS receivers with some firmware modifications. In effect, pseudolites act as additional satellites in the GPS system. Used indoors, pseudolites can provide positioning with the same user equipment enabling a device to go from an area with good satellite visibility to an area where the signal is obstructed, such as indoors or in a parking garage, and be able to perform an accurate location determination. One important drawback to the use of pseudolite transmitting in the same band as the GPS satellites is the risk of in-band interference with GPS signals. Widespread use can cause enough interference that a separate RF band might be necessary. Even though location errors using pseudolites can increase significantly due to multipath signal reflections, especially indoors, they may be useful at selected critical locations where other techniques will not work.

RF Mapping

RF mapping is a category of techniques that require widespread surveying and mapping of transmitters to be used for determining location. Unlike land mobile radio or cell phone towers, where the precise location is registered with the FCC, these sources are usually unlicensed devices where there is no publicly available source of information concerning their location. The following is a description of two types of RF mapping: transmitter surveying and RF fingerprinting.

Transmitter Surveying. One method used to develop an RF mapping system is to have crews physically survey transmitter locations and create a database. Using cars equipped with various types of radio receivers and GPS units, locations, signal types and signal strengths can be logged. Some transmitters will include an identifier in their transmissions. For example, current Wi-Fi transmitters normally transmit a unique service set identifier in their beacon frame (however, this feature can be hidden if the owner chooses to when they configure their access point). The transmitter-related information gathered by the survey crew is compiled in a data base. A device can be located by reporting the signals it sees to the network server with the database, and there are various analytical techniques to estimate the device's location. If the transmitters in the database are likely to be moved, relocated, or upgraded, the service provider would have to periodically re-survey and update the database. An alternate method is to encourage the owners of transmitters, such as Wi-Fi access points, to volunteer the information to a service provider. This is a method popular for enabling location information for social networking applications.

Another term used for transmitter surveying is RF profiling. It is essentially the same principal, but the term usually refers to real time location systems that operate indoors using existing infrastructure systems such as Wi-Fi.

RF Fingerprinting. RF signals reflect off of objects including the ground, buildings, and terrain. The reflected signals (multipath) combine in patterns of constructive and destructive interference. At a particular location, the specific pattern can be unique. These multipath patterns (RF fingerprints) can be surveyed and a data base consisting of a grid of locations and their corresponding patterns can be used as a basis for estimating location. A device can report the "fingerprint" to a location server. Using various computational techniques (including pattern matching), a location estimate can be made. Similar to RF mapping, the survey would have to be periodically updated for locations where significant construction has occurred or the RF transmitter population has changed. This is also a technique that can be tailored, with careful calibration, to locate devices indoors.

RFID/IR

The term Radio Frequency Identification (RFID) refers to a system consisting of at least three elements; a tag, a reader, and a computing device to run software for an application. Using radio frequency transmissions, tags can be "read" and information can be transferred between readers and tags, depending on the specific technology used, over distances from a few inches to several hundred feet. The information on the tag can be as simple as a unique identifier, essentially the equivalent of a bar code, or can be more sophisticated and contain several kilobytes of information in the tag's memory. By linking a tag's unique identifier to other sources of information, such as an owner's financial account, RFID can be used for applications such as paying for gasoline (Mobil SpeedPass), paying for tolls (E-ZPass), or paying for public transit (contact-less farecards). Integrating RFID with GPS satellite receivers and wide area communications devices enable the implementation of systems capable of tracking and locating items worldwide. The design goal is to make the tags small and cheap enough to be considered disposable. This makes them economical to use in identification badges, contact-less smart cards, automotive ignition keys, and on containers, pallets, and stocked items on a shelf. They have been installed in cell phones (primarily in some Asian countries) to allow people to pay for items such as food from a vending machine simply by having the machine exchange the payment information with the phone via the short range RFID link and having the phone connect to a debit account.

RFID tags installed in nomadic devices and readers installed at strategic locations can be programmed to communicate their exact location, such as a specific office in a building. This technology could be installed in locations where either GPS or wireless signals for triangulation are not available. Also, for buildings that already have RFID-based security systems (e.g., employee badge readers), they could also be used to communicate with RFID-enabled phones to provide location information.

In addition to the traditional active and passive tags that operate in frequency bands allocated by the FCC specifically for RFID use, there are now tags based on both Ultra-Wideband (UWB) technology and Wi-Fi technology. The UWB-based signals have the unusual property of being able to pass through most common (non-metallic) building materials, but have a typical range of 30 feet or less. The Wi-Fi based tags have a much longer range.

Fixed Network Techniques

When an application or network provider implements a location technology, such as A-GPS in cellular systems, the location of the device can be used to route the call to the proper PSAP. However, there are many cases where the calling device does not have a “calculated” location, such as a VoIP device that can connect to any one of several fixed or wireless networks. Currently, that location information must be manually updated by the user.

There are several network protocols that can be configured to facilitate emergency call routing to the proper PSAP. Some network protocols inform connected devices about the services supported and convey information related to where a device is connected, what services the device is requesting, and what quality of service is needed.

DHCP. Dynamic Host Configuration Protocol is a protocol for assigning IP addresses to devices on a network. Addresses can be static (fixed) or dynamic. With dynamic addressing, a device can have a different IP address every time it connects to the network, and in fact can even change during a connection. This protocol is implemented in a server connected to a network, and is used to manage the devices that connect to it.

DHCP has a Relay Agent Information Option that can pass port and agent information to a central DHCP server and can indicate where an assigned IP address physically connects to the network. The protocol also has a provision for the server to provide this information to the device itself. This location information can be used to make decisions on where to route the session based on where the request came from or which user is making the request. For example, on an Ethernet-based network, the physical location can be a port on a switch. In other networks, this might be a wireless modem. If a device makes an emergency call on a network with a DHCP server, this information could be used to route the call to the correct PSAP.

LLPD-MED. The Link Layer Discovery Protocol (LLDP) allows a network device to advertise its identity and capabilities on the local network and discover what devices are connected. An extension to the protocol, LLDP-Media Endpoint Devices (MED) is a protocol used to communicate between switch ports and end devices and provides a way for the network to keep track of what the device is and what it does. It can also tell the device what its location is on the network and can detect if a device has moved to a different node on the network. The protocol can be used to differentiate between what types of service the device requests, for example, voice or video, and can configure the connection with the correct quality of service and location information for 9-1-1 call routing.

HELD. HTTP Enabled Location Delivery (HELD) is a protocol that enables a device to retrieve its location from a Location Information Server (LIS) on a network. It can be used by devices that cannot determine their own location or otherwise need some network assistance to determine their location. The LIS can be operated by the originating service provider or network provider. The device can get the information either as a specific value, or as a reference. The reference can be an association with a PSAP for emergency calling. The method used for building the database in a LIS differs from network to network. For example, a wire map of a fixed Ethernet can be used to describe the location of a specific port on the network. Location information associated with that port can be stored in the database and queried by the device. This protocol does not specify how the location on the server is determined.

Wi-Fi Amendments (802.11). The Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards development group has recognized that emergency calls may be attempted from devices connecting through any Wi-Fi access point, but the network the access point connects to may or may not support emergency services. One of the IEEE task groups has added a frame to the protocol that can be used to “advertise” to connected devices whether the network supports emergency services. There is also a frame that has provisions for requesting the location of an access point and an indicator for the relative accuracy of the location. Having the network inform a user about available services, as in the case of the 802.11 amendments, raises the issue of how callers should be alerted about the status of 9-1-1 availability (which implies the call can be routed to the correct PSAP) and to the quality of the location information for response purposes.

New Products and Service Providers

The following are some examples of newer approaches for locating subscribers for E9-1-1, social networking, real-time location systems, and product accountability/inventory control both indoors and outdoors. This list is representative, not exhaustive, and is not an endorsement or recommendation for any specific product or approach. The descriptions found here are provided to illustrate how the basic techniques described earlier in this section are being incorporated into various products that are targeting the segments of the location-based technologies market. Several of these technologies are used either alone or with other technologies as part of a hybrid system.

Rosum Technologies. Rosum uses a form of time of arrival triangulation to locate subscribers by making ranging measurements from television signals. There are several components to the system. A regional monitor measures the clock timing and timing offsets from TV signals in a metropolitan area, and sends information to a server on the network. The subscriber's device locks on to the television's station synchronization code, and with assistance from the network server, computes location. The subscriber's unit needs a television tuner and a baseband television module built into the mobile device.

This product leverages a signal of opportunity (multiple television signals are widely available in populated metropolitan areas) that are broadcast at significant power levels (tens to hundreds of kilowatts) in a frequency range that penetrates well indoors and in urban canyons. The weaknesses in this system would be rural areas where television coverage can be sparse, and in certain metropolitan areas where several stations tend to congregate their broadcast antennas at the same lucrative location ("broadcast hill"). In the latter case, there are suitable television sources, but they lack the special diversity to give an accurate location. Rosum has a hybrid product that couples the television based location technique with A-GPS to provide more comprehensive coverage for location determination.

It should be noted that there has been research in using other signals of opportunity for location determination such as AM radio. The Air Force Research Laboratory has funded experiments for non-GPS location techniques, including the use of AM radio, to determine location of military personnel and assets in locations where GPS signals are not available or reliable.

WirelessWERX. This company has a product called siteWERX that is designed specifically for locating Bluetooth-enabled mobile devices (including cell phones) indoors. Their main emphasis is providing location down to the specific office level. It uses sensors similar to RFID tags, installed at and programmed with a specific location (building, floor, room number), that communicate with mobile devices via a Bluetooth wireless connection. It requires installation of a network of nodes in the building. Client software must be installed in the mobile device and two servers are needed to manage the network and queries from 9-1-1 centers. With sensors located at every office, calls can be tracked as they move throughout the building. The company claims the system provides 10-meter accuracy. This is due primarily to the nominal range of the existing Bluetooth technology, which has a maximum transmission design range of ten (10) meters. When a PSAP queries the server, it is provided with the building name, the floor number, the room number and the time of call. If the server is programmed with building blueprints, the PSAP can view a graphical representation of the location.

Skyhook Wireless. Skyhook Wireless is another example of using signals of opportunity (Wi-Fi signals) to locate mobile subscribers. They use a combination of transmitter mapping and signal strength to locate a device. Skyhook is used in the location application on the iPod iTouch.

Wi-Fi access points (APs) transmit unencrypted beacons that contain a Service Set Identifier (SSID), which identifies a particular local area network, and in most cases, identifies a specific AP on the network. Most laptops, for instance, have a utility that will show what networks are visible, what the relative signal strength is, the SSID of the AP and whether it is encrypted. Skyhook has employed people to drive extensively through populated areas with a monitoring receiver and a GPS unit that looks for this information. They have built an extensive data base of Wi-Fi APs by logging the location and SSID, and the relative signal strength of every AP the monitor receiver can find. When a mobile device needs its location, it sends a Skyhook server a list of all the APs it sees, their SSIDs, and their signal strengths. The Skyhook server uses a set of algorithms and their database to compute a location and return it to the mobile device. Since most APs are installed indoors, this particular location method should have fairly good indoor accuracy, particularly if there are several APs in the building, or nearby. The caveat with determining specific floor locations (which is true for any personal area or local area radio signal) is that the signals can propagate in all directions, and a signal close by an AP on a different floor can be confused with a signal farther away on the same floor.

NAVIZON Virtual GPS. NAVIZON uses a technique similar to Skyhook Wireless. The main difference is that NAVIZON does not perform the transmitter mapping survey. The entries in their server database come from volunteers and system users. They have an "earn and redeem points" incentive for the volunteers. NAVIZON users with GPS-enabled devices provide the mapping information related to where they find APs. NAVIZON uses proprietary triangulation algorithms in conjunction with their database.

Ubisense. Ubisense has an RFID-based system that uses UWB transmissions. This system consists of battery operated tags, sensors placed at various points within a factory, warehouse or building, and a software-based real-time location tool. There are several types of location determination that are possible depending on the level of accuracy required. The most comprehensive version of the product combines the information from the sensor locations, angle of arrival computations, and time difference of arrival computations to obtain centimeter level accuracy as well as a 3 dimensional representation of location.

Cisco Wireless Location. Cisco is an example of one of several companies that have developed methods for locating Wi-Fi client devices. Cisco has three separate options in their system. They can determine the closest access point, which will locate a device within the transmission range, it can triangulate based on received signal strength, and it can locate a device based on RF fingerprinting. For RF fingerprinting, Cisco has an RF fingerprinting location tool that predicts how the signal will likely interact with the building. With RF fingerprinting, factors affecting the signal including reflection, attenuation, and multi-path are considered. The location tracking system populates the database with information about selected locations and how each access point views that location. When a transmission is received, the information on the signal characteristics of the device is matched with entries in the database to estimate the most likely location.

Ekahu. Ekahu has a product that uses a combination of RF fingerprinting and Wi-Fi enabled devices including RFID-style tags designed to communicate with WiFi APs. They have a site survey product that maps the RF environment created by the existing WiFi APs in any building or work area (it typically takes an hour for every 10,000 sq. ft.). It generates a map showing signal strength by Wi-Fi node, network coverage, and signal to noise ratio. They have a positioning engine that combines signal strength along with their site mapping/calibration to display positions on a map of the workspace. It shows the position of any device connected to the Wi-Fi network by using a radio finger printing-based technique using the characteristics of the signal source, the

IP address of the signal source, and the signal characteristics of the source itself as well as the characteristics of the Wi-Fi access points collected by the site survey.

Difficult Location Determination Situations: Indoors, Urban Canyons, Parking Structures

GNSS upgrades. There are several trends in GNSS that should improve location capabilities for NG9-1-1. One trend is the development of better receivers (High Sensitivity GPS (HSGPS)) that can detect significantly weaker signals. There is also some advanced signal processing research that may result in techniques to improve indoor accuracy. This will enable user devices to use techniques such as A-GPS and B-GPS with better indoor coverage. Another improvement is satellite transmission power. Newer satellites are transmitting the signals at a higher power level, and in the case of GPS, there is a new civilian signal that will be available. Also, new GNSS systems such as Galileo should be available in the next few years, and used in conjunction with GPS, should improve location accuracy and availability. Additionally, the accuracy of GPS-based location determination may be further improved using differential corrections obtained from the High Accuracy-Nationwide Differential Global Positioning System (HA-NDGPS). HA-NDGPS is currently undergoing a research and development phase. It will provide greater accuracy to a GPS-derived location than currently available through DGPS.[91]

Research in the Military Community. One research area that bears watching is the Defense Advanced Research Projects Agency Robust Surface Navigation (RSN) program. This program is developing technologies to provide the U.S. military with the ability to determine location and be able to navigate in areas where GPS signals are degraded, denied, or unavailable. The RSN program is examining alternative ranging signals, including beacons and any signal of opportunity including satellites-based signals, cellular telephone signals, and terrestrial television when GPS signals are not fully available. Results from this program may have applicability to location and tracking of 9-1-1 calls.[92]

Use of Inertial Navigation Devices (MEMS-based). Another research area that may yield improvements in locating devices is Micro-Electromechanical Systems (MEMS)-based inertial measurement units and barometers. MEMS can be used to construct very small gyros and accelerometers that can perform inertial measurements and small devices that can make barometric measurements. An Inertial Measurement Unit can measure orientation change and acceleration in three dimensions. This can be used as part of a hybrid system to be used to provide precise positioning when gaps in availability or coverage of a primary location system, such as one based on a RF or GPS signal occurs. The use of miniature MEMS barometers can be used to estimate a height component to aid in determining altitude, or in the case of indoor location, a specific floor. Also, the use of height information (height fixing) increases the accuracy of HSGPS indoor location determination.[93]

Use of Signals of Opportunity. Wireless E9-1-1 location has been based primarily on a hybrid of using A-GPS and a triangulation method based on the cellular carrier's own signals. As described in the new products, other signals can be used. The types that have been most extensively investigated are Wi-Fi, Television, and several forms of RFID. These all have the capability of improving location determination in areas where traditional hybrid methods do not work well; indoors and in urban canyons. Techniques using these signals, with the exception of RFID-based ones, leverage off of existing infrastructure.

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[91] *See* Federal Highway Administration, Nationwide Differential Global Positioning System, http://www.tfhrc.gov/its/ndgps/ (last accessed July 13, 2009).
[92] *See* Defense Advanced Research Projects Agency, Robust Surface Navigation, http://www.darpa.mil/sto/space/rsn.html (last accessed July 2, 2009).
[93] Lachapelle, Gérard, *GNSS Indoor Location Technologies*, Journal of Global Positioning Systems, 2004, Vol. 3, No. 1-2: 2-11, *available at* http://www.gmat.unsw.edu.au/wang/jgps/v3n12/v3n12p01.pdf.

Network Enhancements. As noted above, there is significant work going on in various standards development organizations to address the development of protocols for advertising, forwarding, and retrieving location of devices connected to any portion of an IP network, whether it is fixed or wireless. The IETF and IEEE 802 are addressing some of these issues in several different working groups. However, some of these groups lack a firm set of requirements and are modifying various protocols using best estimates of what features and enhancements should be included in a particular standard.

Technology Trends Affecting Location Determination

Convergence

The term "convergence" is used in the wireless industry to describe enabling a single device to seamlessly interoperate with multiple heterogeneous networks. In the broadest sense, it is the ability for a user to access any content on any device on any network at any location. The current E9-1-1 location methods require support from the network owned or operated by a specific carrier. For the most part, they have significant control over the network and the devices that use it. There are products being introduced that are breaking with this paradigm; they are capable of operating in more than one mode and can easily change their point of attachment in a network, and between different networks. For example, there are devices that can connect with Wi-Fi, Fixed Ethernet, and Cellular data networks. There is also research into seamless handover for wireless devices that travel between heterogeneous networks but there are several issues when location services are required. Most of the location methods employed require some form of assistance from the network, either in the form of location monitoring units, location assistance servers or the actual computation of the location. When the device changes attachment from one type of network to another, it will lose the network infrastructure support for location determination. Devices may have to incorporate multiple methods for location determination, but there may be a limit in terms of computational power, battery life, and size of a device.

There are also issues with locating callers within fixed systems when multiple technologies or providers are traversed in the emergency call route. Accurate caller location may rely on accurate wiring diagrams of local area networks within an enterprise, otherwise it might only be possible to locate a demarcation point in the network, such as a DHCP server. These issues are only compounded when devices, such as WiFi APs and femtocells, are attached to the fixed network by the subscriber, so the calling device is no longer connected at the physical "wall jack" itself. Accuracy in determining location of a caller will depend on how well devices can be equipped to determine location through a "daisy chain" of devices and networks between the caller and the PSAP.

Communications and Coverage Enhancements

All of the network-based techniques described suffer from a lack of accuracy for several reasons. Wireless systems deployed in populated areas consist of many base stations with relatively close spacing. Ideally, the systems are engineered so that user devices should be heard by only one or two base stations so as not to interfere with other users (which would reduce system capacity). Although this is good communications design practice, this does not provide good radio-location accuracy, since many methods rely on three or more base stations to determine location. Also, the base stations were originally placed for maximizing communications capacity, not performing radio location. In rural areas and along major highways, much of the coverage is linear. The base stations are laid out in a "string of pearls" arrangement. This provides good communications coverage where the majority of calls are expected to be made, but provides poor accuracy for network-based location techniques.

In an effort to increase system capacity and coverage, there are several new capabilities being standardized for wireless communications systems, and these may add a layer of complexity to the ability to locate devices using the network. IEEE 802.16, the standard for WiMAX, is being amended to incorporate relay operation. The relay stations will be able to fill in coverage gaps in a network, but end stations will no longer be communicating directly with a base station. This will have an impact on network-based location methods. The same is true for networks that operate in a mesh or ad-hoc mode, especially if the nodes in the network are mobile. IEEE 802.11 has a task group developing a mesh network version of Wi-Fi.

Another new capability being pursued by the cellular industry is the use of femtocells. These are compact base stations that can be installed in any location that has internet access. They are designed primarily for residences and small businesses where coverage is a concern. The use of femtocells increases both coverage and capacity for the network, but interference with the main network needs to be controlled. Femtocells can be portable, and can be comparable in size with Wi-Fi access points. Deploying femtocells where coverage is poor implies that network-based triangulation methods will not work. However, some cellular networks need to know the location of a femtocell to effectively control interference on the network. In these instances, the location of a caller can be estimated to be within the range of the femtocell. Recently, there was an announcement that one manufacturer was incorporating Rosum Technology products for locating the femtocell.[94] The FemtoForum plans to address standards for locating the wireless user's device for E9-1-1.

Summary

There are three basic methods currently in use for wireless location determination in commercial mobile radio systems: A-GPS/AFLT hybrid, U-TDOA, and manual entry (for VoIP service). CDMA-based systems (such as Verizon Wireless and Sprint) use a hybrid of A-GPS and AFLT. GSM-based systems (such as T-Mobile and AT&T) use U-TDOA. Both wireless implementations require the use of servers and computational assistance from the network provider. The primary method is A-GPS, which, when available, gives the most accurate location. The triangulation-based methods using the carrier's own signal are used when GPS signals are too weak or unavailable. However, these methods do not provide good accuracy in areas where reception by three or more base stations may not be available.

Many service providers are planning on changing the base technology for their next generation systems. Sprint and Clearwire have already begun implementing WiMAX as their 4th Generation (4G) system. Verizon and AT&T are migrating to a transmission scheme called Long Term Evolution (LTE). Each of these 4G technologies is based on Orthogonal Frequency Division Multiplex (OFDM) modulation. This will likely change the way the carriers are performing location determination. In the case of Clearwire, the 4G service is marketed as a broadband wireless service, and the voice service is an implementation of VoIP. Currently, subscribers are required to register their location manually as a condition for obtaining E9-1-1 service when using this new network.

There are many changes occurring in the provision of IP-based services. Control by a single network provider may rarely be the case in the future. Devices may not be able to rely on current methods of network-provided assistance. New capabilities and methods to enhance coverage and capacity are being deployed, but these have the overall impact of making location determination more difficult. Also, wireless devices that can be attached by the user to other wireless or fixed networks are also making accurate location determination more challenging.

There are alternative methods to improve on location determination. Some require incorporation of additional technology and infrastructure (such as RFID) and some require enhancements to existing technology (B-GPS or advanced high sensitivity receiver technology). There is some

[94] Rosum press release, *2Wire to Incorporate Rosum TV+GPS Timing and Location Technology into New Femtocell Products*, March 31, 2008, http://www.rosum.com/2Wire_Chooses_Rosum_for_Femtocell_Location_and_Timing.pdf (last accessed July 13, 2009).

activity in various standards organizations to establish provisions in various protocols, for both fixed and wireless systems, to enable both location determination and proper routing of emergency calls. Although there are liaison activities underway among standards development groups, there are issues with using several different types of technologies in heterogeneous networks (such as connecting a WiFi access point to a cellular modem). These are difficult issues to address adequately and depend on the maturity of a draft standard and where it is in the approval process.

APPENDIX C: LIST OF COMMON ACRONYMS

ACRONYM	DEFINITION
3GPP	3rd Generation Partnership Project
3GPP2	3rd Generation Partnership Project 2
A-GPS	Network-Assisted GPS
AFLT	Advanced Forward Link Trilateration
ALI	Automatic Location Identification
ANI	Automatic Number Identification
AP	Access Point
APCO	Association of Public-Safety Communications Officials
ASL	American Sign Language
ATIS-ESIF	Alliance for Telecommunications Industry Solutions Emergency Services Interconnection Forum
B-GPS	(The follow-on to A-GPS)
CDMA	Code Division Multiple Access
CMRS	Commercial Mobile Radio Services
COTS	Commercial Off the Shelf
DGPS	Differential GPS
E-OTD	Enhanced Observed Time Difference
E9-1-1	Enhanced 9-1-1
ECRIT	Emergency Context Resolution with Internet Technologies
EDXL	Emergency Data Exchange Language
EMS	Emergency Medical Services
ESINet	Emergency Services IP Network
FCC	Federal Communications Commission
GCECD	Galveston County Emergency Communications District
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HA-NDGPS	High Accuracy-Nationwide Differential GPS
HELD	HTTP Enabled Location Delivery
HMI	Human Machine Interface
HSGPS	High Sensitivity GPS
HTTP	HyperText Transfer Protocol
ICO	National E9-1-1 Implementation Coordination Office
IEEE	(formerly, Institute of Electrical and Electronics Engineers)
IETF	Internet Engineering Task Force
IM	Instant Messaging
IP	Internet Protocol
IT	Information Technology
ITS	Intelligent Transportation System

ACRONYM	**DEFINITION**
JPO	Joint Program Office
LEC	Local Exchange Carrier
LIS	Location Information Server
LoST	Location-to-Service Translation Protocol
LTE	Long Term Evolution
LLDP	Link Layer Discovery Protocol
MED	Media Endpoint Devices
MEMS	Micro-Electromechanical Systems
NASNA	National Association of State 9-1-1 Administrators
NDGPS	Nationwide Differential GPS
NENA	National Emergency Number Association
NG9-1-1	Next Generation 9-1-1
NHTSA	National Highway Traffic Safety Administration
NRIC	Network Reliability and Interoperability Council
NTIA	National Telecommunications and Information Administration
OFDM	Orthogonal Frequency Division Multiplex
OSP	Originating Service Provider
OMB	Office of Management and Budget
POC	Proof of Concept
PSAP	Public Safety Answering Point
PSTN	Public Switched Telephone Network
RF	Radio Frequency
RFID	Radio Frequency Identification
ROM	Rough Order of Magnitude
RSN	Robust Surface Navigation
SDO	Standards Development Organization
SIP	Session Initiation Protocol
SME	Subject Matter Expert
SMS	Short Message Service
TDOA	Time Difference of Arrival
TOA	Time of Arrival
TOF	Time-of-Flight
TDD/TTY	Telecommunications Device for the Deaf / Teletypewriter
TSP	Telematics Service Provider
UA	User Agents
U-TDOA	Uplink Time Difference of Arrival
URI	Uniform Resource Identifier
USDOT	U.S. Department of Transportation
UWB	Ultra-Wideband
VEDS	Vehicular Emergency Data Set
VMM	Value Measuring Methodology

ACRONYM	**DEFINITION**
VoIP	Voice over Internet Protocol
XML	Extensive Markup Language