NRIC VII

March 14, 2005

FOCUS GROUP 1B

Long Term Issues for Emergency/E9-1-1 Services

Network Architecture Properties in 2010 and Extending E9-1-1 to Satellites

Table of Contents

1. Results in Brief

1.1 Executive Summary

There is no doubt that lives can be saved through the incorporation of new 9-1-1 call [1] elements and functions. Before this can occur, however, changes will be required in the 9-1-1 infrastructure as it currently exists. This report is designed to provide a set of specific recommendations regarding future emergency communications network properties, and their capability by 2010 to support the exchange of voice, data, text, photographs and live video through the 9-1-1 to the PSAP (Public Safety Answering Point) and beyond. In addition, this revision of our report also considers universal access by people with disabilities to Enhanced 9-1-1 (E9-1-1); and E9-1-1 as it applies to satellite communications systems specifically.

Fundamental and significant change is required to move toward such an infrastructure that offers enhanced capabilities and increased change capacity to accommodate both current and future emergency services operations.

The existing 9-1-1 infrastructure is based on technologies and conventions that were established over 30 years ago. The communications industry has adapted the infrastructure to business needs over time but has not been able to implement more advanced capabilities. Thus the infrastructure will not readily adapt to emerging communication products. Because the communications industry is moving toward packet data versus circuit switched communications the existing infrastructure is a barrier to creating an integrated national emergency call management infrastructure. The business models of emerging communications require innovative technology solutions and the 9-1-1 network must be able to adapt quickly in order to harness the added values these innovations offer for emergency response improvement.

We are already seeing emerging technologies push the emergency response envelope. The disconnected nature of local networks on a national scale, or alternatively, the lack of a fully inter-connected national 9-1-1 network, creates unique challenges for various types of emergency calls, e.g. those initiated from a federal agency, a remote call center or via a dial-up to a remote VPN. A new approach is required to accommodate the many ways that emergency services can be requested and the response provided by the emergency service community. The role of the public safety answering point (PSAP), responders and related entities is expected to expand beyond traditional 9-1-1 services with higher levels of interaction, managed situational intelligence, enhanced capabilities, and more comprehensive communication and coordinated response services.

Another area of concern is access by people with disabilities including those disabilities that become more common as we age. Text plays the same role as voice for many people who are deaf, hard of hearing or have speech disabilities. The recent development of text captioning of telephone calls is now helping people who can hear, but not hear well, to understand voice calls. In addition, video on broadband networks can allow blind callers to use sign language relay in the same way that deaf users use TTY relay.

Satellite systems have historically been treated differently from wireline and wireless networks with regard to E9-1-1 requirements. Some systems, notably MSS systems that provide conventional switched voice calling services, are now obligated to support 9-1-1 through call centers. Ultimately, we believe that all satellite systems that support services that may reasonably be expected to support 9-1-1 calls should be able to support such calls with location and call back information as do other networks. The reality is, however, that retrofit of existing systems to accommodate such capabilities is not practical. Furthermore, there is a wide range of mechanisms and services that are provided over satellites and a uniform standard for all satellite systems would not be appropriate.

1.2 Future Reports

Future 1B reports to the Council will include:

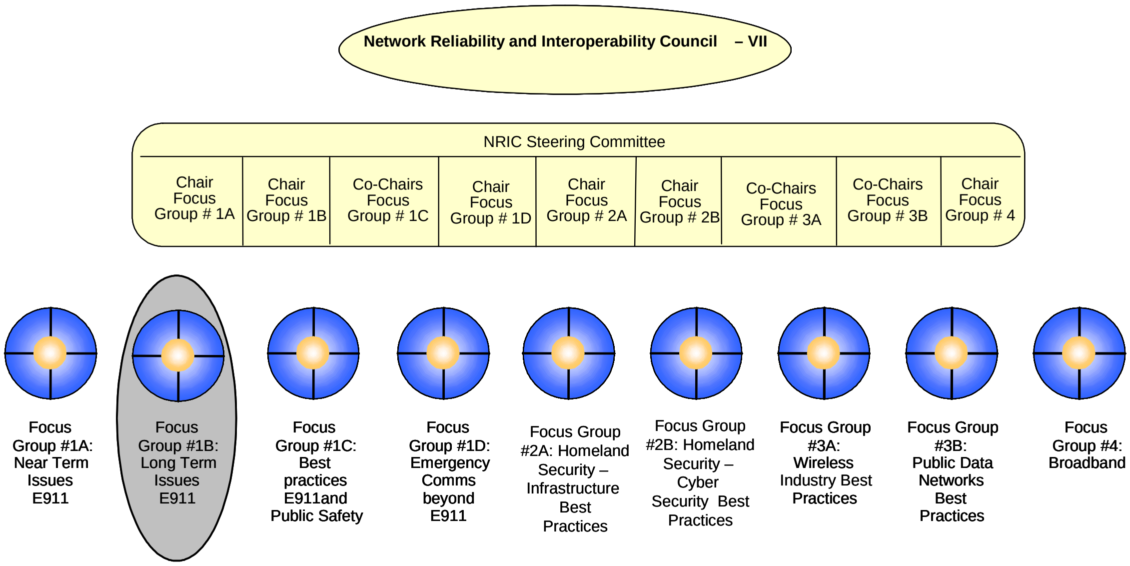
- Recommendations for generic network architectures for E9-1-1 that can support the transmission of voice, real-time text, pictures (e.g., from cellular telephones), data, location information, paging information, hazardous material messages, etc, including how IP technology should be used.
- Identification of the transition issues for the recommended generic network architectures and how the methods of accessing PSAPs should be modernized.
- Proposed resolutions of transition issues along with recommended time frames for their implementation.
- Conclusions on the feasibility and advisability of extending E9-1-1 to Multi-Line Telephone Systems and of having a National/Regional PSAP and how the existing PSAP structure should be altered.

2 Introduction

This report documents the efforts undertaken by the Network Reliability and Interoperability Council (NRIC) VII Focus Group 1B with respect to the properties that network architectures should meet by the year 2010 and to extending E9-1-1 to satellite telephony.

2.1 *Structure of NRIC VII*

The structure of the Network Reliability and Interoperability Council is as follows:



2.2 *Focus Group 1B Team Members*

The Focus Group members listed below participated in the development and editing of this report.

Bikash Saha, Ericsson Inc
Bill Ball, OnStar
Bill Chapman, Mobile Satellite Ventures
Bob Montgomery, Nextel
Bob Sherry, Intrado
Brian Deobald, Mobile Satellite Ventures
Brian Rosen, Emergicom
Brye Bonner, Motorola
Carey Spence, Intrado
David Jones, Spartanburg, SC
Dean Brenner, Qualcomm
Diana Borash, APCO
Donna Bethea-Murphy, Iridium Satellite
Doug Rollander, Lucent Technologies
Greg Arnold, Nokia
Greg Welenson, Vonage
Gregg Vanderheiden, University of Wisconsin-Madison
Henning Schulzrinne, Columbia University
Jamal Boudhaouia, Qwest
Jasmine Jijina, OnStar
Jeng Mao, NTIA
Jim Goerke, The Melcher Group
Jim Nixon, T-Mobile USA
Jim Propst, Sprint
John Healy, FCC
Joslyn Read, HNS
Judy Harkins, Gallaudet University
Kamil Grajski, Qualcomm
Mark Frederiksen, Mburst, Inc
Mark Lewis, Nortel
Mark Neibert, Intelesat
Mary Boyd, Intrado
Martin Dolly, AT&T
Michael Kennedy, SBC Public Safety
Michael Nelson, Intrado
Mike Kozlowski, Globalstar
Olga Madruga-Forti, Iridium Satellite
Peter McHale, Verizon Wireless
Rick Kemper, CTIA
Roger Hixson, NENA
Ron Trerotola, Technocom
Stephen Meer, Intrado
Stu Goldman, Lucent Technologies
Stuart Fankhauser, Iridium Satellite
Tim Barry, AT&T 9-1-1 Planning
Tom Breen, BellSouth
Tom Hicks, Intrado
Jean-Michel Rousseau, Nokia
Wanda McCarley, APCO
Yucel Ors, APCO

3 Objective, Scope, and Methodology

3.1 *Objective*

The objective of this document is to identify the properties that network architectures should meet by the year 2010, including the access requirements and service needs for emergency communications by the year 2010, and to extending E9-1-1 to satellite telephony.

3.2 Scope

The scope of this document is the communications network between people needing help, and the communications centers who are the coordinators of that help: the PSAPs. Our scope includes the networks within the PSAP, but does not include those that extend from the PSAP out to the responders[1], which are the subject of Focus Group 1D. It also addresses the satellite and terrestrial communications networks between people needing help and the PSAPs.

3.3 Methodology

To develop the contents of this report, the Focus Group was initially split into subcommittees, with a chair appointed for each. The areas of focus for these subcommittees were: Current Requirements, Policy and Governance, Future Requirements, Network Requirements, and Data Requirements. These subcommittees held weekly meetings to examine their specific areas of focus through brainstorming, review and sharing of existing documentation, and working towards consensus on the recommendations.

On a regular basis, the full Focus Group met to assimilate the results from all of the subcommittees. In addition to offline revisions made to the document, two in-person meetings were held to develop and finalize the document.

When we considered satellite communications the entire committee worked on this report as a single body.

4 Background

4.1 PSAP and 9-1-1 System Characteristics

Today, nearly half of the calls coming to 9-1-1 call centers (Public Safety Access Points, PSAPs) are from wireless subscribers (although only a small fraction of these would be via mobile satellite systems). Despite seven years of work towards deployment of advanced wireless 9-1-1 features only 31%[2] of the PSAPs have been upgraded to receive callback and location information with the 9-1-1 calls. While public safety authorities are struggling with funding and implementing advanced wireless 9-1-1 technologies, newer and more challenging communication services are knocking on PSAP doors for access into the “traditional and native 9-1-1 call delivery path”. Emerging mobile, satellite, VoIP and other IP enabled communications services do not fit into public policy

[1] It is understood that both functions may occur on a common network

[2] NENA estimate for number of PSAPs receiving Phase II location data from at least one wireless carrier as of 8/18/04. As of 2-7-05 this number has increased to 40.5%.

requirements that set out 9-1-1 governance, funding and access to the 9-1-1 networks for the delivery of callback and location information.

Accessing the 9-1-1 network for newer advanced services is not the only issue affecting PSAPs nationwide. The existing E9-1-1 infrastructure has many less desirable and limiting characteristics. The existing infrastructure limits the potential models for handling emergency calls and does not extend to handling emergency situations on a broad geographic scale. The existing infrastructure may be viewed as a barrier to advancing emergency service capabilities and creating a national response capability. However, the existing infrastructure has many positive capabilities that must be preserved or reproduced in future networks.

The existing infrastructure does not extend beyond the local jurisdictional focus under which it was developed. It is based on communications switching technology that does not adapt to transporting information with the emergency service request and does not extend to support enhanced information types such as (non-real-time) text, images, and video. It is generally not possible to transfer a call with Automatic Location Identification (ALI) between two PSAPs that are not supported by the same infrastructure elements. PSAPs are often connected to the Public Switched Telephone Network (PSTN) with CAMA trunk technology that is relatively slow and antiquated, with limited data transmission capability. Call congestion management is based on local switch interconnections, locally available call takers, limited to regional switching complexes and does not give communities broad enough options in directing calls to alternate PSAPs. The existing infrastructure simply does not have the basic capabilities to gracefully expand to meet future needs.

Advancing emergency services within the United States requires establishing an infrastructure that allows integration of communication, emergency management, and emergency response capabilities across the country. This future infrastructure will be flexible and capable of handling varying public access communication technology. It will provide local communities with the options to run their emergency response efforts effectively and according to their special needs, while also integrating with regional, state, and national infrastructures, emergency response capabilities, and information intelligence services. The future emergency service infrastructure needs to be made up of an Internetwork[3] of emergency service networks to achieve manageability and to be engineered to withstand attacks and abuse.

[3] We use the term "internetwork", as is it used in the NRIC VII Focus Group 1d report to refer to a collection of managed networks which are interconnected, often at multiple points. While these interconnected networks are not part of the public Internet, they may be connected to it through carefully managed firewalls.

As with most current generation communications networks, the 9-1-1 system currently has two separate but coordinated networks, a voice network (which includes real-time text via TTY) and a data network. The data network is presently limited to implementing the location determination mechanism, although it is agreed that much more data is really needed. As with most networks, convergence of the voice plus real time text (voice+text[4]) and data networks will occur, and work is underway in NENA, ATIS, and the IETF to provide the standards required to fully converge voice+text and data into one network, based on IP.

It should be noted that the current system functions very well in the normal day-to-day handling of emergency calls. It is important to not give up any of the good characteristics of the current system as we evolve it to the future. Additionally, telecommunications systems are rarely upgraded rapidly; they evolve relatively slowly. In the timeframe of this report, up to 2010, we are unlikely to have upgraded all systems and it will be necessary to maintain backwards compatibility with the existing systems for a significant time beyond 2010.

4.2 Current Wireline and Wireless Network Design

The current 9-1-1 system is based on a series of telephone switches called "Selective Routers" (S/R). Wireline calls to 9-1-1 are detected at the local central office serving the caller, and are directed to a specific S/R. The S/R uses the telephone number of the caller to look up in a database which PSAP should receive the call. The call is then routed to a trunk in the designated trunk group for that PSAP. Within the PSAP, calls are sometimes queued in a switch, often a traditional enterprise PBX, and directed to a call taker using mechanisms common in any call center. When the call is answered, the phone number of the caller is automatically looked up in an "Automatic Location Identification" (ALI) database that responds with the address associated with the caller. This address and other related information is then displayed to the call taker. In addition, the ALI textually identifies the police, fire and EMS responders that serve the caller's address and the actual TN transfer numbers are stored in the S/R. If necessary, the Selective Router is used to transfer the call to another PSAP or another emergency assistance agency (e.g. poison control).

The carrier serving the customer provides the contents of the ALI-DB. The address data is validated before being placed in the ALI by comparing it against a Master Street Address Guide (MSAG), which is maintained with all of the

[4] Voice+text is a term representing conversational communication. Voice+text conversation can occur in voice alone or real-time text alone, or in a mixed format. On the PSTN this is accomplished with voice and TTY over the voice channel. In IP, it would be VoIP and IP text.

known street address ranges for a given set of communities. The MSAG determines an emergency service zone, which maps to the primary PSAP to receive the call, and the emergency service transfer points (typically police, fire, and medical). Where data is provided in civic (street address) form, it should be validated against a version of the Master Street Address Guide. In the present system, the Master Street Address Guide is a database that lists all valid address ranges, along with other information about those addresses such as a code for the PSAP and responders that serve it. Currently the boundary described by an MSAG typically conforms to community or PSAP jurisdictional boundaries, which may be maintained at a state, county or city level, etc. Sometimes MSAG boundaries are maintained at the level of the E9-1-1 System Service Provider (E9-1-1 SSP)[5].

Wireless systems use somewhat different mechanisms. Location of a wireless caller is measured, either by having GPS receivers in the handsets, or by using triangulation of the radio signal from multiple towers. Sometimes both methods are combined to perform location determination. The location is determined using latitude & longitude rather than a street address. An entity called a Mobile Positioning Center is the interface between the mobile network and the PSAP. The MPC uses the reported location to compare against a database of service areas for PSAPs to determine which PSAP services the area of the caller. The MPC assigns a key Emergency Services Routing Key (ESRK) to the call to be used instead of a telephone number to route the call to the correct PSAP. Calls are introduced into the same Selective Routers, but with the ESRK as the key to the routing database. The MPC also uses a specialized interface to a mapping database to provide the actual location of the caller that can be pulled by the PSAP when the call is answered.

The current 9-1-1 infrastructure is based on several basic concepts that will exist in some form in any future emergency call services infrastructure.

- *Call delivery*
  Calls and data are delivered by an access network to the emergency services network. After someone has called 9-1-1, an emergency call center will be notified of their call back number and location information, even if the caller disconnects before the call rings at the PSAP.

- *Call location determination (static and mobile)*
  Wireline caller location is determined based on a static relationship

[5] An E9-1-1 System Service Provider (SSP) is an entity contracted by the local 9-1-1 system administrators to manage a portion of the 9-1-1 system, most often including the Selective Router and Master Street Address Guide.

between the telephone number and the service address. Mobile telephony introduced a fundamental change where location is based on geographic coordinates as determined by the communications service provider. Additional services, such as VoIP and satellite telephony, have yet to finalize how location (which may change during the call) will be determined in all possible scenarios.

- *Call back number determination*
  Determining the call back number is usually routine. However, to accommodate mobile telephony, the delivery of the call back number may require additional steps at a PSAP.

- *Address validation*
  The address is known and valid such that services could be dispatched to the given location. Current communications service providers (primarily the emergency services infrastructure provider) work with communities to define a Master Street Address Guide that contains all the valid street names and address number ranges for a given area. This form of address validation is based on a static relationship between the location and a given address for wireline users, and for wireless cell tower locations. Wireless networks deliver location information as longitude & latitude geospatial coordinates validated by the wireless carrier as being authentic.

- *PSAP selection algorithm*
  Calls are routed to the correct PSAP based on various parameters such as caller location, PSAP ability to receive the call, and possible alternate call taker sites that could receive the call.   For wireline callers, an extension of the MSAG is used to facilitate PSAP selection. The MSAG contains an Emergency Service Number (ESN) that maps a given address range to a primary PSAP and a set of emergency service providers (police, fire, medical, etc.). For wireless callers, the wireless communications carrier assigns an ESRK appropriate to select the correct PSAP which can be based on the cell tower location or latitude & longitude.

- *Routing of call to the PSAP*
  Once a PSAP has been selected to receive the emergency call request, the network must route the call to the PSAP. After the call is sent to the appropriate call center, the PSAP may utilize automatic call distribution (ACD) products to balance call load

across their available call takers. Today's selective router switches use the caller's telephone number to determine the ESN, and then use the ESN to determine the PSAP, and then the SR selects the appropriate communications trunks on which to route the call.

- *Automatic Number Identification (ANI) delivery*
  The telephone number of the caller, or an identifying key, is delivered to the PSAP over the voice or data channel and that number is used to retrieve location information.

- *Automatic Location Identification (ALI) delivery*
  ALI information is delivered over a separate data channel. For fixed location wireline telephones this is simply a database record retrieval based on the phone number. For mobile telephony an electronic message is sent to the mobile communications service provider's equipment so that geographic coordinates (latitude and longitude) can be determined.

- *Emergency service provider selection (police, fire, medical, poison control, etc.)*
  Calls are often transferred (especially in metro areas) to a different call taker for dispatch of emergency services. The choice of emergency service provider is usually based on the location of the caller, but it is expected that future implementations may add other parameters.

- *Call transfer to the emergency service provider (police, fire, medical, poison control, etc.)*
  Calls are sometimes transferred to another call taker and the caller's call back number and location information is displayed at the subsequent entity. Preferably, call taker notes are also transferred from the originating PSAP to the subsequent entities, but today that can only occur when those entities are interconnected and are using the same call-handling product. In many cases, the original call taker stays on the call to provide additional support.

These capabilities, listed above, exist in the current 9-1-1 infrastructure. However, they were designed and built in an era with much different challenges than we face today. These capabilities were put in place to support fixed location landline telephones provided by a ubiquitous communications service provider. The current capabilities are insufficient to meet many of today's and tomorrow's needs. As an example, the ALI & SRs have inherent limitations exacerbated by number portability. Current systems have been designed based on many assumptions about area codes and exchange codes that are no longer valid, or will not be valid in the future.

Wireless networks present serious challenges to the PSAP because the location of a caller is not fixed. The solution which has evolved is to query the wireless network for the current location of the caller. In addition, the wireless network may be queried for an updated location if there is a possibility that the caller has moved. Mobile location for Phase 2 is reported in latitude & longitude rather than street address form. This has necessitated creation of Geographical Information Systems that can display the location on a map, and in some circumstances, translate from geodetic to civic form for dispatch.

4.2.1 Challenges

The public safety community is faced with a number of challenges that cannot easily be overcome with the current system design. They include:

- The nature of communications is changing. While a voice+ real-time text channel is essential, and will remain essential for emergency communications, there are a myriad of other information sources and media streams that are useful to the PSAPs and the responders. These sources cannot traverse the public switched telephone network, and particularly cannot be accommodated by the selective routers, PBXs and other voice-centric equipment in the current network.

- Routing of emergency calls needs to be greatly improved. Current systems have very limited ability to route calls to alternate locations, and they assume that alternate routes will be relatively local to the original destination. The characteristics of richer communications networks such as Voice over IP and telematics call centers require that routing of calls be made by many more entities and be more flexible and interoperable across geography. These entities need access to the routing databases. An increasing number and variety of communication devices need the ability to deliver calls to the emergency services network, have the call directed to an appropriate PSAP, and provide corresponding location and caller information to the PSAP.

- Caller location determination and verification of the location information is not uniform between existing and emerging communication technologies. Past methods of determining location do not extend to future situations such as mobile VoIP and satellite. In many situations, a new method is required for determining a caller's location and validating the location information such that it can be trusted for emergency service dispatch.

- Existing call congestion and call distribution methods across PSAPs is limited in geography and existing TDM interoffice trunks. While future technologies could deliver an almost unlimited number of calls toward a PSAP or the emergency services network in general, this creates a significant challenge for the design and coordination of call centers with limited resources.[6] This leads to many aspects of change, in both technology and procedural arenas, that warrant further investigation in the areas of geographic remote communication between PSAPs, dispatch centers, and emergency service providers.

- Caller mobility presents various challenges. Callers can move before they initiate an emergency request and they can move during the call. Previous techniques and approaches that assumed fixed location devices do not readily extend to a mobile world. In addition to determining the initial location at the time of an emergency request, technology should be able to determine the location of the caller as needed to support emergency service response. The appropriate emergency services need to be determined based on the location of the caller when services are dispatched and not necessarily the location of the caller when the emergency call was initiated.

- Given mobility capabilities, geographic information systems (GIS) technology is expected to play more prominent roles in future emergency services infrastructures. Conversion techniques between civic location and geographic coordinate location information will need to be consistent between processing elements. Base maps or land maps should provide accurate representation of location characteristics, emergency service capabilities, and mapping of geographic coordinates. A PSAP may get more than one representation of location and could receive multiple, possibly conflicting, addresses for a given emergency call. The PSAP will need sophisticated tools to determine appropriate responses.

- Accepting calls from networks other than the PSTN, as well as the interconnection of the PSTN to computers on the Internet opens the emergency call system to more “hacker” attacks as well as more routes for more organized attacks to infiltrate the system. Yet, the public is increasingly deploying devices that are more vulnerable. These devices should have access to full 9-1-1 services while protecting the emergency networks through appropriate firewalls and other active defenses.

---

[6] The ultimate goal is to provide the caller with meaningful assistance and local coordination of the congestion control process is critical to this goal.

- The pace of change of the emergency calling network is very slow relative to the rest of the communications networks today. It is not uncommon to wait 10+ years from first deployments to having most systems upgraded for new capabilities. Indeed there are some areas of the country that do not yet have 9-1-1 systems at all.

4.2.2 Efforts to Address Shortcomings

The National Emergency Number Association, NENA, has an active effort to define new architectures for the emergency calling network, evolving from their "Future Path Plan" for generic improvements to E9-1-1, through current work on Migratory interface to current E9-1-1 and then evolution to Long Term IP-based E9-1-1. Documentation and position papers are available on their web site, www.nena.org.

NENA has put out a position paper on how VoIP calls should interact with the PSAP.

The Internet Engineering Task Force defines the IP standards. IETF has active efforts on multimedia sessions, and has a small group working on emergency call requirements and solutions.

The ComCare Alliance's EPAD effort is a directory service to provide notification of emergency events to affected agencies.

The Alliance for Telecommunications Industry Solutions(ATIS) has working groups created to define next generation telecommunications networks that include capabilities of and interconnection with emergency services networks.

4.3 Current Satellite Architecture

4.3.1 Mobile Satellite System (MSS) Architecture

Even without 9-1-1 service enhancements, satellite phones can be an indispensable and invaluable tool in an emergency, because they are most often used where no other telecommunications option is available. The FCC acknowledged how this service differs from terrestrial wireless systems and considered its unique technological and economic factors when it exempted satellite services from the current E9-1-1 rules for terrestrial wireless. Any new rules or regulations should balance the economic viability of the industry with the needs of subscribers to obtain enhanced emergency services.

Based on current spectrum allocations, MSS systems can not provide high speed data services due to their lower bandwidths and (resulting) system designs. They do not now provide SMS or other multimedia services.

Additionally, LEO, GEO and MEO systems have significantly different architectures, technologies, and life expectancies for the current and future satellite networks. Thus, one unified satellite 9-1-1 recommendation can not be made in this report.

Because major changes to the orbiting elements of satellite systems are not easily or frequently made, grandfathering the existing systems for varying periods of time may be necessary. It should be noted that the estimates for implementation of a second generation satellite systems is based primarily on the life expectancy of existing satellites and may not necessarily coincide with the year 2010, which is the scope of this report. Grandfathering may continue be required beyond 2010, dependant up the actual useful life of current systems. Next generation systems may include new satellite phone designs, as well, which might facilitate E9-1-1 capabilities; however, compared to terrestrial wireless handsets, satellite phones are much more expensive and their turnover is historically much lower.

4.3.2 Fixed-Satellite Systems (FSS) Architecture

Fixed-Satellite Services spacecraft owner/operators typically lease or sell their satellite capacity to third party entities that configure the capacity for onward sale to end-users, or that use the capacity for their own corporate needs. These services simply lease transponder capacity, rather than provide a complete access network.

Most FSS network services providers employ Very Small Aperture Terminals ("VSATs") which are the user antennas (remotes) that range in size from 0.74 to 1.8 meters in diameter and are generally mounted at fixed locations on the end-user premises. VSATs communicate through an FSS satellite and large hubs (which often measure 4 to 30 meters in diameter) that in turn "switch" communications to other VSATs within a corporate network, into the Internet, or to other service providers.

VSATs allow for one- or two-way data or video transmissions between geographically-disparate VSAT locations, usually within a defined VSAT network. Today, VSATs are heavily used by retailers, restaurants, gas stations, automotive manufacturers, financial institutions and other closed-user groups such as large and multinational corporations. Services provided via FSS include heavy trunking applications, credit and debit card approval, inventory control, electronic funds transfer, and other enterprise support services. In addition, video distribution companies (e.g., ABC, CNN) acquire capacity to distribute video programming to cable head-ends and broadcasting centers. In recent years, residential Internet services have also begun development in the United States.

Some satellite ground stations do not directly connect to end users. Rather, a wireline access network is interposed between the user and the satellite network. This is significant to 9-1-1 because when the distance between the satellite terminal and the end user is large, responsibility for determination of location shifts from the satellite link to the wireline link.

FSS systems are further complicated by the diversity of business relationships that complicate assigning responsibility to support emergency calling and location determination for emergency calls that operate over an FSS link.

4.3.3 Current Support of E9-1-1 by satellite systems

In October, 1994, the FCC issued its *Big LEO Report and Order* promulgating technical, licensing, and operational rules for the Big LEO Mobile Satellite Service (MSS).[7] At that time, these systems had already progressed in design and the first MSS satellites were launched in 1995. Up to that point, there had been no major consideration by the FCC of E9-1-1 service for MSS, because the agency was still working on establishment of the service for terrestrial wireless systems. The current, operational MSS satellite systems required billions of dollars to implement. Much of the infrastructure of the MSS systems is in orbit, was placed in operation before the FCC issued E9-1-1 rules, and is largely inaccessible for technical modification. MSS Satellite operators have already deployed PSAP database call centers for routing 9-1-1 traffic.

FSS systems do not currently have any requirements to support E9-1-1.

---

[7] Amendment of Section 2.106 of the Commission's Rules to Allocate the 1610-1626.5 MHz and the 2583.5-2500 MHz Bands for Use by the Mobile-Satellite Service, Including Non-geostationary Satellites, *Report and Order*, 9 FCC Rcd 536 (1994), *modified by* 10 FCC Rcd 3196 (1995).

5 Conclusions

5.1 Discussion of Network Architecture by 2010

As with many other networks, we foresee convergence of data, voice, text, and video networks, based on ubiquitous packet transports and using standard Internet Protocols. While 2010 will not see the end of the older TDM based equipment, we advocate that the country should have IP-based E9-1-1 capability established nationwide, have IP-based services fully integrated with E9-1-1, and be well along the path of transition for the older TDM based services wherever technically feasible and commercially reasonable. Immediate action will be required on the policy, funding and operational issues identified in this document[8].

We believe that PSAPs should and will deploy IP networks within the PSAP, between the PSAP and the sources of calls coming into the system and between the PSAP and other responders and emergency service agencies. This communication infrastructure serving the PSAPs will comprise an Internetwork (federation) of managed and secured Emergency Service IP Networks. We anticipate that such networks will mirror the 9-1-1 system authority level. In most areas, that would equate to a county or large city, but in some cases it would be an entire state, and in other cases a single large PSAP. The Emergency Services Network should in turn be interconnected to neighboring jurisdictions for mutual aid assistance, and the Internetwork formed by such connections would be aggregated at state or groups of states and further interconnected such that information can be sent reliably between any entities within this Internetwork across the country. National agencies, such as DHS, would connect to this Internetwork and thus would be able to both provide and access information on it. Many of those agencies do not have ready access to the emergency communications systems (E9-1-1 PSAPs) today. Allowing them to join this wider network will bring added value to the common cause of providing the best assistance possible in times of emergencies.

There must be a system of assigning multiple levels of priority to IP communications on the emergency services network both based on content and the identity of the sender. All elements of the Internetwork will have to honor

---

[8] The recent NENA SWAT Initiative and associated analysis noted that at the current pace of implementation, ". . .less than 50% and less than 70% [of PSAPs] will be Phase II capable by 2005 and 2007 respectively" (NENA SWAT, Monitor Group analysis, "Analysis of the E9-1-1 Challenge", December 2003).

The 2007 figure represents less than 80% of the nation's population, and only reflects national progress associated with enhanced wireless 9-1-1 service, let alone the many other needs described in this report. Much of what complicates this process and the broader challenges ahead relate to policy, funding and operational issues that have to be expeditiously addressed.

the priority of the data. Existing IP standards such as DiffServ[9] can be used to implement this priority mechanism, but standards will need to be created to specify how to classify the data, precisely how to mark it, and precisely how the network should treat the different levels. "Barge-In[10]" facilities for all real time media streams should also be uniformly implemented

The networks will need to interoperate with legacy technologies to achieve specific functional behavior (e.g., selective transfer). Forward looking interfaces and capabilities will be defined, but many legacy systems will need protocol converters and gateways to operate with the newer protocols (i.e., MPC E2 to PSAP location information delivery). Interactions between emergency services networks will be governed by local policy, and should consider security vulnerabilities in the connections between networks. Locally managed firewalls may implement these policies. Since some calls will originate on the Internet, the access networks bringing calls into the PSAP should deploy firewalls capable of withstanding sustained, deliberate attacks on the infrastructure between the PSAP and other networks.

By 2010, those PSAPs that have upgraded to IP should deploy equipment with SIP as the call setup protocol. Calls using other call setup protocols should employ gateways or protocol converters. For calls originating on the PSTN, gateways between the origin central office and the PSAP access network should route calls much as they do now, but with improved routing and congestion control mechanisms. Additional protocols and conventions will emerge to facilitate advanced inter PSAP communication and services, as well as allowing PSAPs to connect to other entities and other information services.

Newer call sources such as VoIP and telematics call centers will originate calls directly on an IP network. These call sources will interact with an emergency service IP network through a native IP interface and through gateway services. PSAPs will be able to accept calls with voice, video, interactive text, instant messaging, short messaging, images (photos), multimedia messages, etc, and be flexible enough to handle new kinds of media as it evolves.

Newer data sources, such as surveillance video, camera phones, hazardous material data, alarm data, etc., should be delivered via IP, following standards developed jointly by relevant standards bodies cognizant of the data source and NENA, APCO and other appropriate organizations. Methods will be available to determine the availability of such information, and provide it when requested. PSAPs should be able to request notification of some emergency events based on

[9] Differentiated Services is a mechanism in IP networks to provide different levels of Quality of Service treatment to different packets.
[10] The ability of management to break into a call

predefined rules. In general, all data sources should allow the PSAP and responders to pull data when they want it, in real time, directly to the call takers, dispatchers and responders as appropriate. Advanced interactive data services may allow the PSAP to update the incident record with supplemental information.

The Emergency Services Networks will evolve beyond simply providing interfaces to PSAPs. These networks will bridge together PSAPs, emergency service providers, jurisdictional oversight, management functions and others. Controlled access points or gateways should be deployed where entities do not reside on the Emergency Services Network itself but still need to collaborate, observe, and influence events within the network. Mechanisms should be defined and implemented to associate a given emergency service event across multiple service providers and across processing functions. Information should be provided to aggregating and analytical processing engines that implement broader and higher level functions.

The Emergency Services Network should accommodate a flexible services infrastructure where applications can be defined and introduced without requiring major overhauls to existing network service providing elements. Capabilities should include the ability for regional and national interests to monitor, impact, and participate in emergency events or emergency preparedness.

5.1.1 Location and its central role in Emergency Calls

Location information is the key element of the emergency call. The location of the incident, the location of nearby resources or hazards, and the location of responders all affect how public safety responds. The first major upgrade of the existing E9-1-1 system delivered the location of the caller to the call taker automatically, rather than relying on the ability of the call taker to elicit the caller's location verbally. Countless lives have been saved because the location of the caller is delivered to the PSAP automatically. Location also determines which PSAP gets the call and which responders are dispatched.

Determining the location of the caller is not a simple matter. In general, location is either measured (such as by a GPS receiver) or manually entered into some system by a human. Location for today's system is derived from a manual entry database kept by a local carrier who owns the wire plant, or, in the case of wireless, by a measuring system (GPS, or triangulation on the radio channel). In the PSTN, the carrier that owns the wire plant supplies the voice+text service, and thus can also supply the 9-1-1 system with the location information of the caller, associated with the phone number.

With newer systems, such as VoIP, the association of telephone number to a specific location breaks down. The Access Infrastructure Provider (AIP[11]) is not necessarily the communications service provider (CSP). Indeed, there need not even be a CSP, and even if there is one, it may not be local, and thus not subject to local regulation. CSPs located in foreign countries can supply communications service identical to that of a domestic service provider, and are not subject to FCC, state or local regulations.

We observe that the AIP can almost always determine where an endpoint is; either by tracing the wire, or by deploying a measurement technique. While they may not be providing voice services (they may not even be supplying data services; the wire may be leased to another provider who does), their infrastructure is being used to deliver emergency calls. They are the only ones who can determine location of the caller.

We advocate that every[12] Access Infrastructure Provider, wireline or wireless, supply location information. Where the AIP is the voice service provider, the information can be supplied directly. Where the AIP is not the voice service provider, but is the data provider (the "Internet Service Provider" or equivalent), it can supply endpoints with location, and the endpoints can provide this location on the call signaling when placing an emergency call. Where the AIP is neither the voice or data provider, it would need to have a relationship with the party who was, so they can supply location data to that provider. Note that PSTN and wireless telephony providers would meet this requirement already.

In every case, the FCC should consider the technical feasibility and commercial reasonableness of retrofitting existing deployed systems to meet new requirements. In many cases, such upgrades can reasonably be made in a relatively short time. In others, they may have to wait for significant system upgrades. We wish to emphasize that no AIP should be exempt; although the timeline for compliance may vary widely.

We recommend that an accuracy goal be established by the emergency service community, working together with industry technical experts that reflect the actual need, balanced by technical realities. This goal should reflect the nature of the structure where the emergency exists. For example, it may be sufficient to resolve to a single family house in a neighborhood of such houses, but it might be required to resolve to an apartment within a multistory residence. Altitude accuracy (which floor) may be more important than latitude & longitude. All

[11] An Access Infrastructure Provider is the wire plant owner or the wireless radio access network provider, including enterprises.

[12] Local authorities may exempt enterprises below some size from the requirement of deploying a location determination method

systems should be required to meet this accuracy within the limits of available technology and without arbitrary regulatory deadlines.[13] We recognize the difficulty in reconciling goals, technical feasibility and financial impact, and we recommend the establishment of a process to resolve such issues reasonably and timely. NENA has considered this issue and made some recommendations.

The original source of location determines the form in which it is supplied (geo or civic). The network needs to convert in some cases. For example, dispatch is always in civic, so if a geo is supplied, it must be converted to civic. Data is often best displayed on a map, and if civic is supplied, it must be converted to a geo for display on a map. Conversion requires a database, a Geographical Information System (GIS), and the advent of wireless has led many PSAPs to deploy GIS systems. Only a small percentage of systems have deployed GIS systems. Further, there are often several GIS systems deployed by various municipal entities, which are incompatible with each other. The GIS systems deployed by the emergency calling networks need to be especially accurate to reliably dispatch.

If upstream entities that supply location (either a caller's location or location associated with other resources of interest to an emergency call) convert before transmitting the location, we are concerned about the accuracy of the conversion database. We therefore recommend that all location data be sent in its original form. Of course, it would be preferable for any governmental agency or group of agencies to have or contract for a common GIS base map, shared by all users, with accuracy sufficient for the emergency services network.

Whenever possible, the initial location should be delivered in the signaling with the call. If a call is transferred to another PSAP or a responder, location should always be sent with the call. As some devices are completely mobile, location might have to be updated, sometimes frequently. Location reporting mechanisms should support tracking of moving callers if needed. Some measurement mechanisms do not create a "first fix" location in a timely manner. Often coarse-grained information (serving tower location for example) is the only information available with the call, with more accurate location arriving later. PSAP systems should accommodate such situations with more flexibility than they can now; for example, they should be able to bridge a call from the original PSAP, to the PSAP actually serving the current location of the caller, and then to the responder without disruption. Moving the call to the responders will be addressed more fully by Focus Group 1D.

[13] Accuracy goals should be set with industry input and should be reasonably achievable based on available technology at the time when such goals are established.

As with the current system, when location is provided in civic form, it must be validated prior to use for emergency calls. The validation data should be widely accessible, and the architecture should be deployed in a geographically diverse, fault tolerant manner. Some restructuring of the current verification databases (MSAG) will be required in order to achieve uniform national coverage, accessible by all of the numerous entities which have a need to verify location.

Location data should be secure, managed and trusted such that data integrity is maintained. This is challenging in an environment such as VoIP where the location data must pass between multiple entities, some of which are not trusted and thus could modify the data in transit. Techniques such as digital signatures and other cryptographic techniques should be deployed. Nevertheless, it is unlikely that such techniques will be foolproof against a determined attacker.

The level of service achieved by the U.S. 9-1-1 infrastructure is highly dependant on the quality of the information upon which the foundation is built. Mechanisms need to exist to support continuous improvement processes, including the identification, tracking, and resolution of data quality issues. In order to support such a continuous improvement process, the address information provided to a PSAP should identify the source provider of the information and the authority and mechanism used to validate address information. Location information sources should provide a means by which they can be contacted to be informed of inaccurate or otherwise insufficient location information. Quality metrics and change control tracking mechanisms should be in place to determine performance of a location information provider and these metrics should be available to PSAPs. During an emergency situation, location information providers may need to be contacted immediately to clarify location information that was provided to a PSAP.

5.1.2 Congestion Control

There are several circumstances when PSAPs will have more calls placed towards them than they have call takers to answer them. Disasters and deliberate attacks are two examples. When a PSAP is presented with more calls that it has call takers, the network should have a variety of responses it can provide, which must always be determined by local policy. Choices for handling these calls should include combinations of:

- Queuing calls for call takers
- Rerouting calls to pre-arranged alternate call centers who are able to effectively service the calls
- Connecting callers to Interactive Voice+text Response systems [14]

[14] Wherever automatic messaging is given to callers, which includes Interactive Voice Response as well as ACD messaging, both voice and real-time interactive text must be supplied, so that persons with disabilities can understand what is happening to their call.

- Returning busy

IP based emergency services networks offer new capability to call centers to handle unusual events. When disasters occur, response resources are overloaded – there are not enough call takers or responders, especially early in a disaster incident, to respond to the number of calls directed towards the call centers. Today, in most cases, a relatively small number of calls would reach the call centers, and most callers would get a busy indication. Busy is now considered a "good" response, indicating that the caller is not going to get any help. Their only choice is to fend for themselves without assistance, or hang up and try again. The callers who do get through represent a cross section of callers because the current system is designed to block calls early in the network, and thus the likelihood of a call getting through which is not related to a disaster is better than a call related to the disaster. This is a relatively good result. However, when calls are blocked early, the emergency services network is unable to extract any useful information from the call attempts – it is not even aware they were placed. The responders have limited resources, but they can more effectively deploy their limited resources where they will do the most good if they have a better understanding of where help is needed.

Networks should be engineered such that policy dictates what happens to calls rather than bandwidth or routing limitations of the network. It is recognized that all networks have capacity limits and effective congestion control measures must be deployed at all possible congestion points in the network[15]. Data associated with the call should be captured and forwarded[16] to the appropriate entity in the Emergency Services Network even if the calls cannot all be answered.

Using public IP networks as one of the routes into the emergency services network is of particular concern because of the threat of deliberate attack on the 9-1-1 system. Networks should be engineered to best current practice to protect the emergency services network including deploying firewalls between the public IP networks and the emergency services network.

5.1.3 Routing

The new networks should have much more flexible routing mechanisms. The basic concept that location determines the proper PSAP to receive the call, and location is further used within the PSAP to route the call to the proper responders should remain, but the mechanisms must be flexible and modifiable

[15] NENA has recommendations for current PSTN based congestion control mechanisms
[16] Some system elements may not be able to forward to such information in real time

by jurisdictional authorities based on situational need such as night shutdown, overflow conditions, congestion control, response to major incidents, and response to disasters, etc.

Specifically

- Routing data for calls should be widely accessible, and the architecture should be deployed in a geographically diverse, fault tolerant manner
- Routing must be controllable by PSAP management to handle call overflow. Choices may include: route calls based on location to alternate PSAPs, supply prerecorded announcements with Interactive Voice+text Response[17], supply busy indication. Combinations of the above should be possible, subject to local policy.
- Routing for normal events ("night mode") should be possible to any PSAP which accepts such calls
- Routing during disasters must accommodate shifting of calls to PSAPs who, by prearrangement, are able to effectively service the calls.
- While in the future network, the condition of "ANI failure" will be mitigated by the use of an end-to-end digital network, it still will be desirable to specify default routing to a designated default PSAP. This PSAP may be chosen based upon where in the network the routing failure appears. Default routing is also required because of the shift to using location based routing concepts, rather than ANI based routing. When the location isn't known, or isn't believed to be accurate enough to use for routing purposes, a default decision will be needed. Routing failures may result in the wrong PSAP getting the call. In such circumstances it should be possible to transfer the call to the correct PSAP with all relevant data.

Origination of emergency calls and routing to the appropriate PSAP is currently limited by the geography of call origination and the disconnected nature of local 9-1-1 networks. Entities (e.g., individual callers, alternate call centers, PSAPs) today cannot originate calls remotely into distant 9-1-1 networks as a second party. Enhanced capability that would permit remote 9-1-1 network access would enable use cases such as the following:

- Telematics, Hazmat or call center dials 9-1-1 and wishes to reach the 9-1-1 dispatch center located near the vehicle that originated the call, not the one located near the alternate call center.
- Individual is on the phone with a relative across the country on a non-emergency call, when emergency occurs. The individual wishes to reach the 9-1-1 dispatch center in the vicinity of the relative, not the individual caller.

[17] NENA & ESIF have both rejected "dynamically modifiable" recorded announcements

5.1.4 *Connecting Calls and Data from PSAPs to Responders*

Emergency service response will be determined at the time of service dispatch or predicted location versus today's static determination based on the entry in the ALI. Directory functions[18] will assist PSAPs in contacting, collaborating, and engaging others within their jurisdictional IP network boundary or across boundaries. The Directory functions will evolve to allow bi-directional and asynchronous emergency event communications. Where typically only police, fire and EMS services are directly associated with a location, we expect to gather and provide a great deal of information on locations.

We envision that integrated information on locations will be compiled by all the emergency services including PSAPs and responders. Interior building layouts, hazardous material storage information, surveillance camera locations, alarm locations, building construction details, security contact data, etc is but a small list of possible data that is tied to location. This data may be stored in Emergency Services databases, or it may be held by property owners and tenants, with pointers to such data stored in Emergency Service databases or directories. PSAPs and responders will all have access (authenticated and authorization permitting) to such data.

Similarly, in some circumstances, we envision subscriber based supplemental information, about callers to be available. VoIP phones and mobile phones have a concept of registration where it is possible to determine the subscription that is "logged in" to a phone. Data may be associated with the subscription and made available to the PSAP and responders, such as medical data, family members to be notified in emergencies, etc.

As we expect responders to share the same Emergency Services networks as the PSAP, we expect to be able to connect callers directly to responders when appropriate. All available media streams and data should be capable of being forwarded (or directly accessed) by responders assigned to an incident.

Although we see the convergence of voice+text and data for emergency communications on a single network, there is sometimes a natural dichotomy of treatment of these media. By the very nature of emergency response, voice+text communications are constrained to being sequential in nature (For example, a call taker answers calls sequentially. Also an EMS responder would answer a call if necessary only after it has been processed in voice+text by a PSAP.) Data on the other hand, can be transferred simultaneously to all relevant entities that requested to receive data on emergency incidents in their area. This inherent

---

[18] In this context, a directory is a managed entity that lists agencies and or resources that can be used by other agencies to discover what resources are available and how to get them.

distinction between voice+text and data should be leveraged to maximize efficacy of response. For example, PSAPs may find it useful to view location and emergency type for emergency calls currently in queue, as they make decisions to answer calls. Calls could be routed to PSAPs and responders that specialize in specific types of emergencies without having to resort to call transfers. For example, a Hazmat call would best be answered by an agent trained in hazmat or bio-terrorism response. Entities further down the information chain, e.g. responders and hospital staff would prefer to receive data (in advance of voice+text communications) on emergency patients headed their way.

5.1.5 Security

A uniform, comprehensive, cryptographically based security system must be deployed throughout the emergency communications system. Such systems should be based on ubiquitous authentication, authorization, integrity protection and privacy controls. No network elements should be deemed "secure"; rather, all elements should employ crypto uniformly. Such security mechanisms should be designed into the system in the first place, and not added on later.

Each authorized data provider should be responsible for accurate entry and update of their data into the system. Authorization for read or write privileges for any data element should be explicit and defined by common system-wide mechanisms. In addition, business rule logic should be developed to define synchronization and edit override priorities for disparate authorized editors.

Emergency calls that originate as IP should deploy the protections specified in the relevant standards. For example, SIP, the IETF call control protocol for voice+text, video and instant messaging should deploy the TLS security suite between all elements. It is not feasible to reliably authenticate all endpoints; such a problem would require a national Public Key Infrastructure, which is still an unsolved problem. However, all other elements can reasonably deploy some level of meaningful authentication, and all elements within the emergency service network can have strong authentication. For this purpose, we recommend that appropriate national public safety agencies deploy a strong PKI for their constituencies, probably using a chain of "Certificate Authorities" with strong state and county agency participation to assure only bona fide agencies receive credentials.

All communications between endpoints, routing elements and emergency service elements should employ strong integrity protections. Where private data is transferred, such as location, medical data, etc., encryption of the data should be deployed. In most cases, the media streams should be encrypted.

5.1.6 *Supporting Callers with Disabilities*

The evolution of the Emergency Services Network, if properly implemented, can improve the services Public Safety can offer to people with disabilities. Terrestrial VoIP provides a greatly superior capability for alternate complementary media streams such as interactive text.

As all data initially associated with the call can be transferred with the call, employing relay services without losing location or other data could be possible. Video capability should allow sign language interpreters to be bridged into a call. Relay operators or interpreters could be bridged with call takers and responders to maintain communications between a disabled person and all participants in an incident.

For these reasons, we recommend that efforts be expended to offer persons with disabilities the opportunity to use newer IP based communications technologies for both direct and relayed E9-1-1 communication, wherever broadband is available. Widespread availability of wireless networks and other broadband services will make such systems widely increasingly deployable.

Of course, backwards compatibility with existing TTY services will continue to be required until they are no longer in service. TTYs are still the only mechanism that works on the PSTN which is still relied upon by many people and geographic locations.

5.1.6.1 Real-time interactive text transmission for Emergency Communications on IP

Real-time interactive text, where a character appears on the opposite screen shortly after it is typed on the keyboard, is an essential mechanism for tele-conversation for a large and growing population including people who are deaf, who are hard of hearing, and who have speech disabilities. This use of text parallels voice and is different from messaging, email, document transmission, and other uses of text in communications. Messaging and other similar forms of asynchronous text communication are not sufficient for 9-1-1 and emergency responder communication (although, as discussed below, we advocate support for messaging when voice or real-time-text is not available).

Some limitations of messaging for 9-1-1 use include:

- No ‘real time connection’
- Uncertain message delivery (delays and dropped)
- Doesn’t allow interjections on timely basis without confusion.
- Can result in crossed messages and answers (especially if person doesn’t reply immediately or types slowly.)

A reliable method for real-time interactive text therefore, that does not involve perpetuating the use of analog TTY signals on IP network needs to be established. It needs to be as interoperable and reliable as voice under emergency/crisis load conditions, and it must be able to travel freely wherever user voice travels. For this reason we refer to this user communication as voice+text rather than voice in this report and we recommend this terminology in general to preserve this relationship in network engineering. We also recommend a single real-time interactive IP text format be adopted for use so that all of the E9-1-1 and related services do not have to deal with multiple real-time text formats to ensure receipt and avoid interoperability issues with callers.

At the current time at least some satellite systems do not have provisions for connection and transmission of TTY signals and some do not have built in text or text messaging capabilities. As a result, it might be difficult to retrofit these existing satellite technologies with text communication capability in order to allow them to be usable by individuals who are deaf. However, where the systems can be easily adapted to transport text this should be done. Whenever the systems are retrofitted or updated to provide IP transmission of information, real time conversational text capabilities should be built in subject to technical and commercial feasibility and taking into account spectrum constraints. Support for video conversational communication should be built in whenever the bandwidth of the phones increases to the point necessary to support it.

5.1.6.2 Messaging

Although messaging technologies have the disadvantages noted above and would not eliminate the need for real time voice or text, messaging can serve as an important method for communication when voice and or real time text are not available or cannot be used. For voice callers who do not have real time text – it can allow silent communication. For text users, it can act as an important method for communication on technologies that do not yet support real time interactive text (e.g. cell phones, PDAs etc). Currently messaging is the only widespread method for text communication on mobile technologies for people who are deaf.

5.1.6.3 Video & Text Relay and E9-1-1

Video Relay Services are now available that allow people who communicate primarily or exclusively in sign language to be able to communicate with voice telephone users over the phone. Text Relay, both current TTY Relay and real time interactive text over IP relay services, are relied upon by many deaf and hard of hearing persons for communications assistance. It is important for the FCC to specify that a person who uses Video or Text Relay Services can make a

9-1-1 call through their Relay that would automatically go to the correct PSAP with the Relay in the loop (including video/text pass-through to the PSAP). Also important is that location information be provided both to the 9-1-1 center and the Relay Service automatically.

5.1.6.4 Use of text entry on telephones with 10 key pads

Individuals who are deaf currently have to carry around special devices in order to make a text phone call. In emergencies they often do not have such devices with them. Today most all IP phones have some type of display of 12 characters or more. Such phones could, with the addition of minimal code and no hardware, be designed to display any incoming IP text (in the standard IP text format – see below). This would allow any people who are deaf but can speak to use any phone with a display to communicate in speech (out) and text (in). In addition, any 12 key telephone keypad can be used to send text using simple and standard routines. This would allow emergency outgoing text communication for those who cannot speak (due to speech impairment or deafness). Finally, individual who are blind can use any phones with physical keypads where they can tactilely locate and differentiate the number keys. Phones available to the public for use should contain these features to allow people with disabilities to use them for emergency communication in the standard formats described in this report.

5.1.7 Reliability, Maintainability, Serviceability, Traceability

The emergency calling system should be designed to minimize service interruptions by employing management and continuous monitoring that detects anomalies immediately and generates alarms to the appropriate technicians, managers and service providers. These capabilities should detect outages, inability to communicate and invoke services, and other error conditions. Maintenance personnel should have access to both automatic and manual diagnostic tools that facilitate the isolation and repair of problems within the network and the access points to the network. Components of the network should be capable of being upgraded and removed for normal maintenance without disruption of service to PSAPs or other service entities. All elements of the network should be exercised periodically to assure their readiness for service if the need arises, including nominal processing and recovery processing functions. Management workstations should be provided to oversee the operation of the PSAP. Operations management staff should be able to allow supervisors to monitor calls as well as overall system state. Some PSAPs may choose to outsource some or all of these network management responsibilities

The Emergency Services Network should be designed such that no single failure or interruptive incident (i.e. a cable cut) will create a system outage. Redundancy and duplication should be augmented by distributing cooperating network elements and transport facilities in a geographically dispersed manner. Management and security functions will be integrated with core operations and services functions providing robust regional infrastructures that integrate at the national level.

Unlike current systems, with the new IP based communications it is feasible to provide complete end-to-end test capability for each endpoint. It should be possible for each endpoint to periodically determine that it can signal a call to a PSAP, transfer media in all the forms it is capable of, and get an indication of the location reported for the device.

Every event that occurs in a PSAP relative to an incident should be recorded, with traceability to the source. This includes external events and data, responses, data changes, and all media streams in and out. All data should be time stamped, and tagged so that it cannot be repudiated.

Event/Media recording systems should be integrated so that PSAP management and subsequent legal investigations can get a complete picture of the incident and what occurred. Since we will be dealing with many new kinds of data and media, recording systems will have to evolve rapidly.

Each source of data must be traceable to its originator. The identities of the originator should be positive, and wherever possible, authenticated. Where data is handled by intermediaries, each intermediary must be traceable, with a positive identity, and in almost every case, authenticated.

5.2 Satellites

NRIC VII Focus Group 1B recommends that the next generation MSS satellite communications systems be connected to the emergency services network and support a number of the properties associated with today's cellular emergency services. Satellite systems operators should explore technologies necessary to provide similar capabilities as any other terrestrially transported source of 9-1-1 calls as they roll out next generation satellite systems or significantly update current systems, where technically feasible and commercially reasonable.

We recognize the widely varying technical characteristics of MSS systems. We conclude that the FCC should evaluate each system individually to determine under what could be achieved per the carrier's plans for existing and next generation systems. Therefore, NRIC VII Focus Group 1B recommends that each system operator should be required to prepare a detailed E9-1-1 feasibility and implementation plan for FCC review. The criteria for review should consider both the technical feasibility and commercial reasonability of meeting the properties that are detailed in this report for other services.

Because of the inability to change the satellites in orbit, as well as the relatively small turnover of handsets and ground systems, E9-1-1 upgrades should be considered for next generation satellite upgrades, and thus may only be deployed beyond 2010. No further requirements beyond the existing Order should be placed on current systems.

Fixed systems present even more difficulties to make recommendations because of widely varying service models. The owner/operators of FSS satellite systems generally, if at all, do not provide ground station services, and therefore, to that extent, FSS spacecraft owner/operators should be exempt from providing enhanced 9-1-1 services.

Ground station operators (where there is not a substantial wireline connection between the ground station and the user) and service providers who provide services over fixed satellite systems where the services could reasonably be expected to supply E9-1-1 capability should be obligated to evolve their systems to provide them.

As FSS ground technology evolves and is updated, FSS satellite systems and network service provision should look to develop the technology necessary to provide similar capabilities as other terrestrially transported source of 9-1-1 calls where technically feasible and commercially reasonable. Again, we foresee each system operator be required to develop a plan, for FCC review, that shows how they will meet the requirements outlined in this report. Plans should be required of systems operators who provide IP services and end point terminals termination (who should be required to support location determination as do all other Access Infrastructure Providers), as well as operators who provide "switched" voice/video/text services (who will be responsible for providing interconnection to the E9-1-1 system, call back provisions, etc.) Again, we do not advocate fixed deployment deadlines, but encourage operators to incorporate E9-1-1 upgrades as their systems are upgraded.

At the current time at least some satellite systems do not have provisions for connection and transmission of TTY signals and some do not have built in text or text messaging capabilities. Whenever the systems are retrofitted or updated to provide VoIP services, real time conversational text capabilities should be built in subject to technical and commercial feasibility and taking into account spectrum constraints. Support for video conversational communication should be built in whenever the bandwidth of the phones increases to the point necessary to support it.

5.3 Governance and Policy

Emergency communications and response is ultimately a public safety service—a service that depends upon the effective, timely and coordinated interaction of a variety of public and private sector stakeholders. Features of the above not only include the technical delivery and quality of the service itself, but also the governmental and public policy structure within which the service is provided, and ultimately funded.

9-1-1 has evolved in the US through various public policy structures, which established planning bodies, funding models and technological solutions that deliver information into the PSAP from wireline and wireless communication devices. The majority of the States have some form of 9-1-1 legislation that either establishes statewide 9-1-1 deployment programs, or enables local governmental agencies to establish dedicated funding mechanisms for the deployment of 9-1-1. These state statutes often contain confidentiality and limitation of liability protections applicable to the parties involved in delivering emergency services. Historically the policy models established government stakeholders as planners, and wireline and wireless companies as commercial stakeholders through the definition of 9-1-1 Service Provider. This definition assumes services providers are either regulated through State Public Utility Commissions (PUC) or the Federal Communications Commission (FCC). This definition, combined with PUC or FCC regulations determines a company's ability to participate in the 9-1-1 network infrastructure and it also, in many cases, regulates the 9-1-1 network, database and PSAP equipment.

The current 9-1-1 public policy does not sufficiently accommodate any new, advanced communications companies that do not meet the definition of 9-1-1 Service Provider; therefore, potentially the new companies cannot access the 9-1-1 networks, nor are they afforded any participation in formal 9-1-1 governmental program. Further, in the current regulatory environment 9-1-1 Service Providers have insufficient incentive to fund and deploy advanced architecture.

The convergence of an aging infrastructure, new technologies, changing market dynamics, and national priorities has created a situation where telecommunications, emergency services, and regulatory oversight must change. Policy must be adapted to meet the new evolution of technology and ensure that we retain the high quality of 9-1-1 service that is expected by the American public, as well as allow for the creation of additional emergency services features and capabilities. We advocate that the successful implementation of highly integrated locally controlled networks that cross political boundaries for the realization of the advantages it offers be an overriding policy objective. Ultimately, the desire for local control must be balanced against the need for some degree of national interconnection. The regulatory and legislative frameworks should be technology neutral and should encourage companies that provide communications to become “good 9-1-1 citizens” by allowing them access to advanced 9-1-1 networks. Additionally, the policy framework should encourage infrastructure companies, through beneficial financial models, to deploy advanced architecture to enable 9-1-1 service on the new communication service devices.

5.3.1 Policy

As 9-1-1 service has grown in its universality (capped by the 1999 Wireless Telecom Act which made its universality official), the public has come to expect that their 9-1-1 calls are not only answered by an appropriate PSAP, but that appropriate information is also automatically communicated to help facilitate emergency response. With this public expectation, comes the assumption that any telecommunications device accessing the PSTN should function within a standard 9-1-1 environment.

Historically, consumers have not been afforded the opportunity to personalize or manage data or information used for these purposes. However, with the technical opportunity to functionally utilize greater and different types of data (medical data, special needs information, contacts to be called in case of emergency, etc.) to foster more positive outcomes to emergency incidents, public expectation is changing and should be recognized as a matter of public policy.

In order to satisfy the kind of public expectation described above, along with the demands of new technology, new communications and data services providers need advanced 9-1-1 architectures in order to deliver the minimum data elements required on a 9-1-1 call. Ideally, any device the public can reasonably expect to be used to summon help in an emergency situation should be capable of accessing 9-1-1 and delivering critical data. Companies providing emergency services should be allowed interconnection to the 9-1-1 network to deliver these services independent from any other regulatory classification. The idea of being a “good 9-1-1 citizen” should be extended to all new communications technologies that provide consumers with the ability to summon help.

In order for public safety to function in a telecommunications world with no boundaries and respond to emergency calls being placed with new technologies that could be provided through national and international companies, 9-1-1 policy and regulation needs to be examined. The following sections of Governance and Policy will provide insight into the future of 9-1-1.

5.3.1.1 Funding

A new funding/financial model should be found. The existing one will not meet the needs of the future E9-1-1 environments. Indeed, in many instances the current model has difficulty supporting the current 9-1-1 system. Several new paradigms are being investigated, and all levels of government should support those activities as a means of identifying a nationally acceptable funding model that will be able to meet the needs of the E9-1-1 environment for many years into the future.

While funding is the most critical financial issue, it will likely not be the only financial issue that must be considered for the future. How the 9-1-1 governmental entity PSAPs will be charged for any services on the PSAP side must be considered in light of existing and future demarcation points between the providers and the PSAPs and future industry trends, regulations, and standards. For example, PSAPs and 9-1-1 system providers have historically been impacted by industry changes or practices over which the PSAP has little or no control (e.g., telephone deregulation, Local Number Portability, wireless E9-1-1, VoIP, agreements between providers, and industry practices). Changes to 9-1-1 funding mechanisms have typically lagged behind these industry changes.

Furthermore, how providers handle issues within their control as a matter of practice or industry standard may have an impact on PSAPs costs. For example, currently some providers may automatically put a record in the 9-1-1 database for each Direct Inward Dialing (DID) number associated with Primary Rate Interface (PRI) service or program their end office switches to send all the DID numbers as Automatic Number Identification (ANI). On the other hand, other providers may not automatically put all the DID records in the 9-1-1 database or may program their switches to send only the main billing number as ANI instead of all the DID numbers. Whichever of these current practices is used by the providers may have a financial impact on 9-1-1 governmental entity PSAPs that currently pay for their 9-1-1 database services on a per "record" basis. This nexus between the industry and PSAP costs will likely continue into the future. The establishment of any funding mechanisms should consider what services will be needed by the PSAPs, how the PSAPs will be charged for the needed services, and what industry regulations or standards may be needed to ensure any adopted funding mechanism is sufficient to cover the costs associated with the services.

Additionally, the new funding/financial structure should encourage investment by the private sector in the 9-1-1 network, as well as provide a business model that affords them a financial opportunity to attain a reasonable return on investment. In order to ensure the development of an advanced 9-1-1 architecture that is able to deliver the minimum data elements required on a 9-1-1 call, such incentives are required to make the transition to the next generation a reality.

5.3.2 *Governance*

9-1-1 in the United States has evolved through the implementation of specific governmental policies at the local, state and federal levels. The following information provides insight into these 9-1-1 governing bodies.

5.3.2.1 Federal

Prior to 1996, the Federal Government had minimal governing regulations for 9-1-1 service delivery. Upon the adoption of the FCC's Order in Docket 94-102 in 1996 and the passage of Senate Bill 800 (Wireless Communications and Public Safety Act of 1999), the FCC now maintains responsibility for 9-1-1 oversight of wireless deployments throughout the country. The Federal Government has continued to respect states' rights and local control to manage fund and deploy 9-1-1 services. However, some consideration should be given at the federal level to influencing the advancement of next generation architecture for 9-1-1. As such, federal policy bodies could encourage the establishment or adoption of industry standards for minimum service levels, or service and coordination related standards that would help insure the maintenance of fundamental elements.

To achieve even a fraction of the goals outlined in this document, a national coordinating body should take responsibility for organizing all of the stakeholders, and supplying resources and guidance to the state and local 9-1-1 authorities. While we see only a very limited management role which continues to honor states' rights, coordination is vital to achieve the vision we present here. If this could be done at a National level, it would greatly improve the consistency of service across the nation. In addition, limited federal involvement in setting 9-1-1 policy would ensure that emerging communications technologies are proactively reviewed, 9-1-1 issues are anticipated and the appropriate state and local governing bodies are engaged to adopt the most effective 9-1-1 policies at all levels.

5.3.2.2 State

In 2004, thirty-three (33) states have a statewide coordinating body that has facilitated deployment of 9-1-1, reacting to the specific needs of their citizens. The concept of at least a State level (no lower than State) administrative authority should be seen as a highly desired organizational structure. This State structure should still allow for local control (9-1-1 system authority) and the day-to-day operations of the PSAPs. But funding and technology decisions work best when they are at least coordinated through a focal point at a state level. In most cases this will allow for a more cost effective operational model than exists today. That type of centralized oversight will support the desired goal of ensuring that there is no degradation of fundamental elements that are essential to a highly reliable E9-1-1 system. It may also enable less populated areas to enjoy modern E9-1-1 call handling technologies that they may otherwise not be able to afford on their own, under today's typical funding paradigms.

5.3.2.3 Local

Some state laws enable local jurisdictions to establish planning and deployment of 9-1-1 without the coordination of the state governing bodies. In states where this form of 9-1-1 policy exists exclusively, these jurisdictions are left without a statewide implementation, which primarily affects those citizens in the rural populated areas and potentially leaves them without either basic 9-1- 1 or E9-1-1 service.

It is very important to note that in the majority of the country, local government does retain ultimate responsibility for the management of all PSAP operations and response to 9-1-1 emergency calls for assistance. The only exception to this rule occurs in the states of Rhode Island and New Hampshire. In these areas, the state coordinating body is also the 9-1-1 answering center.

5.3.3 Planning & Deployment

Initiating the planning, deployment and funding of 9-1-1 emergency communication systems historically has been the responsibility of State or Local government. However, the private sector partners play critical roles as stakeholders through the delivery of network, database and equipment service providers and should be equally represented as contributing members.

5.3.4 Government Stakeholder Roles & Responsibilities

As early as 1979, The US Department of Transportation, along with the US Department of Commerce, recognized the need for effective state presence in the deployment of 9-1-1. In a federal guide designed to assist State's with understanding the need for assuming the responsibility of planning and implementing 9-1-1, the two federal agencies noted:

> *It is the interest of the citizens of a State to see that a single emergency telephone number is established which a person anywhere in the State can call to report an emergency. Nor can a State rely on the voluntary efforts of local governments to make 9-1-1 a universal emergency number*

throughout the State. In many cases, local governments and institutions cannot be counted on to provide the impetus for establishing 9-1-1 service in their communities. The State is the logical source for the guidance and impetus necessary to bring local agencies together in developing and implementing 9-1-1 service. In order for the State's executive branch to play this role, the State legislature must first give it the authority to do so.

Because implementation of 9-1-1 is a matter of statewide concern, guidance for it would be most effective if it came from State government level. Telephone companies cannot be expected to undertake central office modifications needed to implement 9-1-1 until agreements can be made among the State and local governments and their public safety agencies as to requirements. Legislation provides a firm base for articulating the State's 9-1-1 policy and specifying planning steps for policy implementation. . . . It calls for 9-1-1 planning at the State and local levels, places responsibility for 9-1-1 implementation in a "communications division" at the State level, deals with jurisdictional boundary problems, and addresses possible funding methods.[19]

Twenty-five years after the above document was published the US is still waiting for a number of State governments to assume responsibility for planning, implementing and funding 9-1-1. Existing State 9-1-1 policy should be re-examined and updated so that it is adaptable to current and future telecommunication trends. States without ubiquitous planning and deployment efforts should consider evaluating existing, successful State planning models and structure public their own policy that affords all people access to 9-1-1 and emergency response.

5.3.5 PSAP Operations

In the United States today there are currently in excess of 6100 primary and secondary PSAPs.[20] Whether that is too many or too few, the number does reflect the state and local nature of 9-1-1 and emergency response. Recognizing that the nature of these critical public safety services are changing and evolving, PSAP service arrangements will have to be continually examined to insure that they best support the nature of emergency response today, tomorrow and into the future. Ultimately, the desire for state and local control must be balanced against the need for effective service delivery across traditional jurisdictional boundaries.

[19] The Emergency Telephone Number. 1979 USDOT NHTSA; USDC NTIA

[20] Based on the most current figures maintained by the National Emergency Number Association, 5413 of the 6176 PSAPs, are primary in nature.

Much, if not most, emergency response service will continue to be local in nature. With that in mind, individual PSAPs should retain responsibility for managing their centers and their service areas. That includes appropriate operational redundancy and backup in cases of planned outages, equipment failure, major incidents or disasters. That also includes establishing appropriate arrangements for the routing of calls from and to other PSAPs when operationally necessary.

PSAP managers should be able to supervise call takers, control access authorization of PSAP employees to data and controls, and receive notices of events, outages and incidents that may be, or might, become relevant to it. Some PSAPs may choose to outsource some or all of these network management responsibilities.

Based on the overall technical capabilities envisioned in this report, the PSAP operational environment will be greatly different in tomorrow's world. How that change will be facilitated and managed is an issue of critical importance. So is training and education, which will be critical stepping stones in the change process. Responsibility for the latter will need to be identified, along with the resources to accomplish it. Many PSAPs are struggling to meet current challenges, let alone those on the horizon. Getting them past the immediate challenges and helping them meet the upcoming challenges will potentially be one of the difficulties we foresee.

5.3.6 Industry Stakeholder Roles & Responsibilities

Public policy today, from the FCC to state and local government, has generally been founded on the principle that any telecommunications service that can be used to dial 9-1-1 and request emergency assistance is, in fact, a "service provider" contributing to 9-1-1 services. To the extent technologically possible, all service providers should be required to adhere to all rules/laws/policies in place to provide for a highly dependable publicly available system for handling emergency calls in an effective manner. Theoretically, the regulatory status of any entity should not be sufficient reason to exempt them from providing their customers/tenants/employees with substantially equivalent E9-1-1 services. Certainly that is the public's expectation.

How you achieve that goal, however, is the challenge in today's (and certainly tomorrow's) emerging communications arena (VoIP being an example). Faced with the specter of service providers located outside of the United States—providers not subject to US national, state or local rules and regulations—we must explore new ways to insure consistent and standardized 9-1-1 service.

To make this reasonable, the communications system must make it easy to comply. The requirements for devices and service providers must be straightforward, easily understood, and easily implemented. This argues for minimizing requirements on actual telecommunication service providers to the extent operationally feasible. Location reporting, as an example, should be ubiquitously passed from the access infrastructure provider to the data provider to the media service provider. Routing should be simple, well understood, and only dependent on publicly available databases. That in turn, though, generates technical challenges that must be addressed. And, the latter requires time and expense. Ultimately "ease of compliance" is a factor that should be considered in those technical solutions developed to address the challenges involved. Obviously, it will be impossible to build compliant devices unless and until the public policy requirements are established.

5.3.7 Data

There will be a myriad of data that could be made available to the PSAP and responders. This data will come from a great many sources, some of which are directly part of the telecommunications system, and others who are not connected at all. All data providers should have confidence that the information they provide will be kept confidential when appropriate within the Emergency Services Network, and will only be used for emergencies or for supporting or enhancing the provision of emergency services. This principal should be supported by legislation where applicable and appropriate.

Where entities have an obligation to provide data, they should be able to provide the required information efficiently, securely, and timely. Standards should be developed that allow data to be provided as a consequence of other automated systems' activity, and the emergency services agencies should make an effort to use existing standards, or develop new standards in close cooperation with the data providers to maximize the efficiency and minimize errors in providing such data. We expect that at least some of this data may be collected over the Internet, with suitable security safeguards. Other data will be collected over the same privately managed network infrastructure used for carrying calls and their related data.

There will be a need for databases of various kinds in the future. For each database, we need to:

- Identify who will own the data, who will collect the data and who will maintain the data
- Determine how we will evolve from the current data to the new data arrangements

As with many of the functions of the 9-1-1 system, entities that have responsibility for collecting and/or maintaining data may contract with a competent service provider to fulfill such responsibilities.

Appropriate Governance and Policy structures must be identified. That may range from a local (e.g. County) focus, to state and/or multi-jurisdictional regions of the state, or federal as appropriate and necessary. Regardless of where the lines of ownership and management are drawn, they will need to be drawn to prevent scattered pockets of unmanaged databases, or at worst databases that are managed to differing levels of quality and/or performance standards.

5.3.8 Network

Each element in the Emergency Services Network should have an owner who is responsible for continuous reliable operation of that element. The network itself must be managed. Management can be directed by a government agency or, within the context of acceptable and appropriate standards, it can be contracted to a service provider. The network manager should publish a "Service Level Agreement" to its users that should be suitable for their use.

6 Recommendations

6.1 Assumptions Regarding Recommended Properties

NRIC VII Focus Group 1B has a clear expectation that the emergency services network of 2010 will still support all of the desirable properties associated with today's existing emergency services network. In other words, nothing that is widely deemed desirable today will cease to exist on the emergency services network of 2010, so this list does <u>not</u> try to enumerate those commonly known and understood properties associated with today's emergency services networks.

With that understanding, below are the properties we recommend that network architectures must meet by the year 2010. They are categorized by network properties, access requirements, and service needs.

6.2 Network Properties

- We advocate that the country should have IP-based E9-1-1 capability established nationwide, have IP-based services fully integrated with E9-1-1, and be well along the path of transition for the older TDM based services. IP on satellites has not yet been tested or proven.
- Include as a basic function the exchange of voice+ text, other forms of text, data, photographs and live video into the 9-1-1 or emergency communications management center and to responders.

- Provide for real-time text transmission and handling wherever there is voice transmission and handling.
- Operate through the use of standard Internet Protocols among entities that are members of a federation of managed and secured Emergency Service IP Networks.
- Use SIP as the preferred call setup protocol including the ability to initiate use of the text channel in the midst of all voice channel connections. Calls using other call setup protocols should employ gateways or protocol converters.
- Interoperate with legacy technologies. This includes provision of transcoding gateways from TTY to real time interactive IP text.
- Use a single or small number of standard video formats for Video Relay Services that are supported by ECMC and Responders so that Video Relay calls can be forwarded or shared with ECMC and Responder personnel
- Be engineered to adopted "best practices" (that are yet to be identified), for example, deploying firewalls between the public IP networks and the emergency services network to protect the emergency services network from degradation.
- Have very large bandwidth capabilities, but still be able to manage congestion control to levels that allow calls to be effectively handled by PSAPs.
- Have a uniform, comprehensive, cryptographically based security system, based on ubiquitous authentication, authorization, integrity protection and privacy controls.
- Accommodate a flexible services infrastructure where applications can be defined and introduced without requiring major overhauls to existing network service providing elements.
- Rely on the Access Infrastructure Provider (AIP), wireline or wireless, to supply location information.
- Have much more flexible routing mechanisms (see 3.3 for details).
- Evolve to allow bi-directional and asynchronous emergency event communications.
- Be designed to minimize service interruptions by employing management and continuous monitoring that detects anomalies immediately and generates alarms to the appropriate technicians, managers and service providers.
- Be designed such that no single failure or interruptive incident (e.g. a cable cut) will create a system outage.
- Provide complete end-to-end test capability for each endpoint.

6.3 *Access Requirements*

- Support the Public Internet as one of the sources of calls coming into the 9-1-1 system.
- Allow any device the public can reasonably expect to be used to summon help in an emergency situation to be capable of accessing 9-1-1 and delivering critical data (including voice+real-time text if applicable), including calls originated via satellite technology where technically feasible and commercially reasonable.
- Use a single industry standard for real-time IP text that provides for reliable (low error) transmission even under crisis load conditions (works reliably as long as voice works).
- Allow people who are blind, or have speech or hearing disabilities to use any public use VoIP telephones to call E9-1-1 using the standard phone keypad (or keyboard if one is provided).
- Be engineered to allow incorporation of all FCC approved Video and Text Relay Services in E9-1-1 calls without loss of E9-1-1 functionality (including location) and with video and text pass-through to the PSAP.

6.4 *Service Needs*

- Be in compliance with the NENA Future Path Plan.
- Support the use of NENA defined data formats.
- Deliver the initial location data in the signaling with the call (when possible).
- Be able to capture data associated with the call and forward (some system elements may not be able to forward such information in real time) it to the appropriate entity in the Emergency Services Network even if the calls cannot all be answered.
- Be designed so that each element in the Emergency Services Network will have an owner who is responsible for continuous reliable operation of that element. The network itself must be managed.
- Consist of highly integrated locally controlled networks that cross political boundaries where necessary to serve the public good.
- Be based on and built around a totally new funding paradigm. This will require immediate action on the policy, funding and operational issues identified in this document.

6.5 *Satellite Systems*

- Each MSS satellite system operator should be required to prepare detailed feasibility and implementation plan, to be evaluated by the FCC, considering how and whether it will be able to deliver calls, with location and call back information, to the appropriate PSAP where technically feasible and commercially reasonable.

- Satellite system operators should explore and implement technologies necessary to provide similar capabilities as any other terrestrially transported source of E911 calls as they plan their next generation satellite systems where technically feasible and commercially reasonable.
- FSS based service providers who provide packet services should prepare a plan, to be evaluated by the FCC, detailing how and when it will be able to meet the requirements (where technically feasible and commercially reasonable) of delivering location to endpoints as does any Access Infrastructure Provider.
- FSS based service providers of “switched”[21] voice/text/video call services should prepare a plan, to be evaluated by the FCC, detailing how and when it will be able to meet the requirements (where technically feasible and commercially reasonable) of delivering calls, with location and call back information, to the appropriate PSAP.
- In most cases, this is expected to be completed coincident with next generation FSS upgrades, and thus may be beyond 2010. No further requirements should be placed on current FSS systems.
- Current MSS systems who deliver calls to PSAPs via administrative PSTN lines should, technically feasible and commercially reasonable, migrate their E9-1-1 call centers to technology which delivers such calls to Selective Routers or equivalent VoIP E9-1-1 call termination.

[21] While IP based voice/video/text systems are not “switched” systems in the conventional sense, we include them in this category, but exclude service providers who simply provide transport of audio or video for TV/Radio networks and similar services where there is no reasonable expectation of E9-1-1 services

7 Appendix I—References

"The NENA 9-1-1 Future Path Plan – Target for 9-1-1 Evolution",
http://www.nena.org/9%2D1%2D1techstandards/future%5Fpath%5Fplan.htm

"NENA's position on E9-1-1 and PSAP Connectivity with VoIP / Internet based Emergency Communications",
http://www.nena.org/VoIP_IP/NENA%20position%20on%20VoIP%208-4-2004,%20for%20publication.pdf

"Emergency Provider Access Directory", ComCare Alliance.
http://www.comcare.org/projects/epad.html

"Analysis of the E9-1-1 Challenge", NENA SWAT, Monitor Group analysis, December 2003

"NENA Technical Information Document on Model Legislation Enhanced 9-1-1 for Multi-line Telephone Systems",
http://www.nena.org/9-1-1TechStandards/TechInfoDocs/MLTS_ModLeg_Nov2000.PDF

"NENA Standards for E9-1-1 Call Congestion Management", NENA 03-006,
http://www.nena.org/9-1-1TechStandards/Standards_PDF/NENA%2003-006.pdf

"Security Considerations for Voice Over IP Systems", NIST_SP800-58-040502
http://csrc.nist.gov/publications/drafts/NIST_SP800-58-040502.pdf

The Emergency Telephone Number. 1979 USDOT NHTSA; USDC NTIA

8 Appendix II – Acronyms

AIP: Access Infrastructure Provider
ALI: Automatic Location Identification
ALI-DB: Automatic Location Identification Data Base
ANI: Automated Number Identification
APCO: American Public-Safety Communications Officials
ATIS: American Telecommunications Industry
CAMA: Centralized Automatic Message Accounting
CBN: Call back number
CLEC: Competitive Local Exchange Carrier
CONUS: Continental United States

CSP: Communications Service Provider
DHS: Department of Homeland Security
DoS: Denial of Service Attack
E9-1-1 SSP: E9-1-1 System Service Provider
EMS: Emergency Medical Services
ESIF: Emergency Services Interconnection Forum
ESN: Emergency Services Number (code for the PSAP)
ESRK : Emergency Services Routing Key
FCC: Federal Communication Commission
GIS: Geographical Information System
GPS: Geo Positioning System
HAZMAT: Hazardous Material
IETF: Internet Engineering Task Force
ILEC: Incumbent local exchange carrier
IP: Internet Protocol
ISP: Internet Service Provider
ITCO: Independent Telephone Company
IVR: Interactive Voice Response
MLTS: Multi-line telephony system
MPC E2: Mobile Positioning Center (J-STD-036 network topology)
MSAG: Master Street Address Guide
NENA: National Emergency Number Association
pANI: pseudo Automated Number Identification
PBX: Public Branch Exchange
PKI: Public Key Encryption
POI: Points of Interest
PSAP: Public Safety Access Point
PSTN: Public Switched Telephone Network
SIP: Session Initiation Protocol
S/R (SR): Selective Router
TDM: Time Division Multiplex (trunks)
TN: Telephone Number (speed dial list)
TSP: Telecommunication Service Provider
TTY: Telephone Devices for the Deaf based on the old TTY codes (Baudot)
VoIP: Voice over Internet Protocol
VoP: Voice over Packet
VPN: Virtual Private Network
WiFi: Wireless infidelity (industry organization promoting 802.11 wireless networks

9 Appendix III – Key Definitions

Following are definitions of key terms referred to throughout the document. While most of these are not complex terms, it is important to understand how the Focus Group defined these terms in order to understand the context and scope of our recommendations.

- ***Access Infrastructure Provider (AIP)*** - Wire plant owner or the wireless radio access network provider including enterprises
- ***Access Requirements -*** are technological and operational methods that are expected to be supported by the emergency service network and utilized by any service provider to deliver their customers emergency calls into the emergency service network.
- ***ANI failure*** - Unroutable call to a PSAP
- ***Call center*** - Public Safety Access Point, Communication Center
- ***Call -*** includes short message service, VoP, packet data, streaming data, etc., using PSTN, internet, satellite, etc.
- ***Crypto*** - cryptographic
- ***Diffserv*** - a Quality of Service mechanism used in IP networks to provide differentiated services often using a priority mechanism
- ***Directory*** - a managed entity that lists agencies and or resources that can be used by other agencies to discover what resources are available and how to get them.
- ***Emergency Services Network (ESN)*** -Trunks, routers, databases and other elements dedicated to 9-1-1 use
- ***Endpoint -*** a device with which one or more communication services may be accessed
- **FET**: Fixed Earth Terminal means fixed user satellite terminal.
- **FSS**: Fixed Satellite Service means satellite service to fixed earth terminals. These systems can be in any orbit.
- **GEO**: Geostationary Earth Orbit means an orbit 22,300 miles above the equator where satellites can maintain a stationary position in relation to the earth.
- ***Infrastructure*** - Hardware and software supporting public communications networks
- ***Internetwork*** - collection of managed networks which are interconnected
- ***IP Text -*** text encoded as text characters (Unicode) in a standard manner for transmission over an IP network.
- **LEO**: Low Earth Orbit means an orbit 100 to 1,000 miles above the surface of the earth.
- **MEO**: Middle Earth Orbit means an orbit 6,000 to 12,000 miles above the surface of the earth.

- **MET**: Mobile Earth Terminal means mobile user satellite terminal.
- **MSS**: Mobile Satellite Service means satellite service to mobile earth terminals. These systems can be in any orbit.
- ***Network Architecture -*** The overall design of the public and Emergency Services Networks
- ***Properties*** – "characteristics" that are the prominent, inherent features that are essential to the proper functioning of the emergency services network we (collectively) envision being in place by 2010. Such as the use of Internet Protocol.
- ***Real-time text*** – Generic term for continuous character by character conversational text. Includes TTY in analog networks but is used primarily in this report to refer to conversational text in IP networks.
- ***Softphone*** - a computer program that emulates the function of a telephone
- ***Voice+text*** – a term representing conversational communication. Voice+text conversation can occur in voice alone, or real-time character-by-character text alone, or a mixture of voice and text together. On PSTN this is accomplished with voice and TTY over the voice channel. In IP, it would be VoIP and IP text.

10 Appendix IV - Alternatives for Congestion Control

For a caller, busy is never a satisfactory result; it gives them one bit of information -- they aren't going to get help from this call attempt. This appendix describes a possible scenario that affords PSAPs the option, governed by local policy, to mutually assist each other so that, except in very widespread disasters, all calls to 9-1-1 are answered. We do not necessarily advocate this concept. It is provided as an illustration of what might be possible.

Emergency responders have a well established procedure called "triage" that they would like to apply to requests for help. They want to have requests classified such that they attend to the greatest need first. Furthermore, responders want to communicate instructions to callers. They may order evacuations, for example, or they may request that people stay in place and not go outside. Finally, call takers may be trained to be able to offer some first aid instructions[22] to callers that can be used in some circumstances to aid callers to render help to themselves or others.

All of these are only possible if the call is answered. With 6000 PSAPs, there are perhaps 25,000[23] on duty call takers at any time, and with call-outs for off duty people and standby workstations, many call centers could probably double the number of available call takers nationwide in tens of minutes. It is well within the capabilities of the kinds of networks advocated in this report to route calls in a disaster to any such call center. Prior arrangements would have to be made to do this of course. There could be large associations or groups of PSAPs who agree to assist each other in disasters. Such groups would publish procedures so that call takers could be trained to handle such contingencies.

Calls taken by a call taker far from the disaster would:

1. Extract the data associated with the call: location, telematics data, etc.
2. Confirm identity, location and nature of the call
3. Classify the call according to predetermined criteria to allow responders to triage
4. Provide instructions to callers provided by emergency management officials in the disaster area which could be communicated to the answering PSAP via the directory functions
5. Provide first aid instructions as appropriate

[22] Not all responders are trained, and in some jurisdictions, certification is required before call takers may give out first aid instructions

[23] There are no definitive studies of how many on duty call takers there are in the United States at any time. This figure is simply a guess based on an average of 4 call takers per PSAP.

6. Provide a realistic expectation to the caller of what response is likely, also provided by emergency management officials in the disaster area.

Of course, the most important service rendered by the answering call taker, whether they are in the area, near it, or across the country, is the human to human connection that is so desperately desired by the caller. As we learned so poignantly on 9/11, even when no help is forthcoming, knowledge, sympathy, and compassion make a tremendous difference.

Disasters know no bounds. Real systems do. 50,000 call takers facing millions of callers for a widespread earthquake might overwhelm every PSAP in the country. But consider that at 10 minutes a call, and 50000 call takers, a million calls can be completed in three hours. It still may be necessary to return busy in some circumstances, but it should only be when no humans are realistically available anywhere to answer.

The data collected by the call takers can be sent to the primary PSAP where it can be used by responders to best manage their resources. Call back numbers can be used to re-contact callers if circumstances dictate. Callers can be "tracked" if they call again, with call takers given the data extracted from prior calls.

Finally, consider using the same idea when a deliberate attack is launched on an emergency services network. While firewalls should be able to detect and stop most attacks, new vulnerabilities will be discovered continuously, and it is likely that some attacks will succeed for the time it takes to determine an attack signature and build a filter for the attack into the firewalls. In the intervening period, which may be a few minutes, a few hours or a day, bogus calls will be mixed with real calls in a way that cannot be separated. By spreading out calls to all available call takers, the good calls can be separated from the bad ones, and the good ones can be bridged back to the primary PSAP they were directed towards. Bogus calls can be detected by the call takers very quickly, and thus a deliberate attack can be effectively mitigated in many cases by using this technique. Again, it is always conceivable to overwhelm any real system.

11 Appendix V E9-1-1 Technical Considerations for Satellite Systems

11.1 MSS Systems Overview

Satellite communications present unique technical challenges for E9-1-1 that must be carefully considered when codifying E9-1-1 requirements. For example, a significant portion of existing MSS network hardware is inaccessible for upgrading. This inaccessibility places obvious constraints on an operator's ability to roll out network-wide upgrades for current generation systems.

This inaccessibility obviously applies to the space segments (satellites) which have already been placed in orbit. However, since most MSS subscribers seldom, if ever, replace their subscriber hardware (owing to their large prices relative to CMRS handsets), this inaccessibility also extends to a substantial percentage of the user equipment.

In addition, satellite systems are, by design, multi-regional to global in nature. Therefore, as other countries seek to develop E9-1-1 service requirements, MSS operators may be faced with the requirement to support multiple, incompatible national standards. These conflicting design requirements may prove extremely burdensome for an industry currently struggling to regain its financial standing

Mobile Satellite System designs also differ in numerous material ways, including: frequencies of operation, altitude of the operational satellites (LEO, MEO and GEO), the number of satellites in the system architecture as well as the number simultaneously in view, the inter-connectivity of the satellite nodes (e.g., crosslink interconnectivity versus space-to-ground only), and the design of the satellite payloads (e.g., transponding designs versus on-board processing designs). Given these significant design variations, the implementation of E9-1-1 features in MSS systems will be presented with system-unique design constraints and issues.

Another distinct E9-1-1 implementation challenge pertains to ANI and ALI. Most satellite operators do not have access to either ANI or ALI information. In addition, the current generation MSS air-interfaces do not support the encapsulation and transport of the high accuracy ALI required to support E9-1-1 services.

Additional implementation challenges pertain to the mobile equipment terminals (METs). Satellite phones are sold regionally or globally through service providers and are not "kept" by the satellite operator data base. A satellite handset can cost one or two thousand dollars compared to the one or two hundred dollar price of a typical terrestrial handset. In addition, satellite handsets are three to four times larger and heavier than the typical terrestrial mobile handset. Due to these factors, satellite handsets are not used in the same manner as terrestrial or landline phones by consumers, nor are they exchanged for newer models.

Furthermore, the incorporation of simultaneous, in-call, GPS receive functionality into MSS handsets may create difficult technical design challenges due to the low-level of the current generation GPS signals coupled with the close proximity of many of the MSS systems to the GPS downlink frequencies.

Satellite systems, like more conventional mobile systems, are increasingly provided with data capabilities. Unlike more conventional terrestrial mobile systems, the data transmission rates for satellite systems are low. These systems do not provide video services, nor do they anticipate doing so in the future due to international and domestic frequency restrictions.

11.2 FSS Systems Overview

Key features of FSS satellites and FSS service networks are:

1. Generally, FSS satellite owner/operators sell or lease capacity to others to develop services and service networks. FSS spacecraft are not used to provide services directly to members of the public, and therefore by definition, the spacecraft themselves are not enabled to provide enhanced 9-1-1 services.

2. FSS VSATs are not equipped with location determination capabilities. Such capabilities are not required for FSS network operation.

3. The majority of FSS-based networks are not interconnected to the public switched telephony network, and do not provide public telephony or other public communications services.

4. Where public satellite Internet services are provided, fixed VSAT sites communicate with the Internet without changes to the VSAT network and using normal Internet delivery protocols.

5. VOIP service providers using FSS satellite infrastructure manage their public end-user services without intervention by the satellite network provider. FSS VSATs are not equipped with telephone numbers.

6. Access to FSS services, and information about FSS customers and FSS VSATs, are not directly accessible by PSAPs or any entity outside the defined FSS network.

7. Most Fixed-Satellite System VSATs are in fixed sites and are not re-locatable to emergency locations. There are a limited number of VSATs that are mounted on vehicles or specially designed to be deployed as transportables in emergency situations. The services provided by a transportable FSS VSAT network, and the other VSAT communication points configured to operate with that network, are generally defined by the entity contracting for FSS network services, such as a state emergency management agency.

8. FSS satellite service provision is transparent to and does not impact end-user personal computer or other communications equipment which persons with disabilities already have available to them. FSS satellite services are generally delivered to an indoor modem which in turn communicates with the fully-equipped customer premises equipment.

For the reasons and system architecture described above, the FCC has not placed any rules or obligations on FSS satellite systems or FSS networks to provide 9-1-1 connectivity.

11.3 Location Determination by Current Generation MSS Systems

The current generation of Mobile Satellite Systems were conceived, designed, developed, launched and commenced commercial service during the period from the late 1980s to the late 1990's. During that timeframe the technical capabilities and policies for MSS E9-1-1 did not exist. As such, the currently deployed and operational MSS systems (and in particular those serving the US) were not designed with the capability to perform Location Determination of user terminals to an accuracy level necessary to provide meaningful support to E9-1-1 services.

Depending on the design details of the current MSS systems (e.g., orbital altitude, number of satellites simultaneously in view, service link air-interface, etc.), these systems have RMS location errors that range from 30km to over a thousand miles. In addition, the current generation MSS air-interfaces do not support the encapsulation and transport of the high accuracy geo-location information necessary to support E9-1-1 services.

Regulatory E9-1-1 requirements levied on existing MSS systems must consider the service life of these systems. In particular, given that the current generation MSS systems were deployed in the mid-to-late 1990's, they will be reaching the end of their useful satellite lifetime(s) during the 2010-2014 timeframe (note: the dates vary by system – depending on the exact system and may be off by +/- several years).

Furthermore, as a result of the significant cost of MSS user terminals, MSS systems are differentiated from other wireline and wireless services by their low equipment replacement rates. That is, unlike CMRS users, the vast majority of MSS users have (and will in the future) continue to use their originally purchased equipment until such time as they discontinue service or the systems/services are decommissioned.

11.4 Issues Associated With Modifying Current Generation MSS to Launch an Industry-Wide E9-1-1 Solution

***Reviewing Wireless Industry Solutions*:**

- Terrestrially Based Network Solutions (Terrestrial Triangulation)
  - Satellites cover every part of CONUS, and in some cases the world; therefore, it is infeasible for satellite operators to deploy triangulation towers CONUS-wide due to costs, terrain, and local zoning and environmental regulations.

- GPS Based Handset Solutions
  - MSS handset/terminals cost thousands of dollars and operators do not update each model more than a few times during the ten to twenty year life of the satellite network.
  - The upgrade costs required to embed GPS functionality into current generation MSS systems would be apportioned across a very small number of new satellite telephony subscribers (measured in the thousands in the post-2010 period). This apportioned cost impacts must be compared to the tens of millions of CMRS subscribers that currently support CMRS E9-1-1 upgrades.

- As such, the per-user cost structure associated with designing and developing a new generation of handsets/terminals, and simultaneously upgrading the air-interfaces and Gateway infrastructures with embedded GPS functionality, would be prohibitive for current generation MSS systems
- Positioning a user with GPS while they are actively in a call may be difficult, or impossible, due to the proximity of some MSS operational frequency bands to GPS frequencies, causing insufficient transmit/receive isolation.

11.5 Satellite Based Solutions – Current Generation Systems

- The current generations of MSS and FSS systems are unique in nearly every aspect of their system design (e.g., the number of satellites in the network, the amount of service link spectrum, their specific frequency bands, their air-interfaces, etc.). As such, it is not possible to implement a solution that is consistent across all operators.
- No satellite operator that serves the US is planning on replacing their current satellites with one-for-one replacements, or anything like a nominally equivalent replacement.
- It is financially infeasible for MSS operators to make the necessary large scale changes to current MSS systems that would be required to significantly change the existing air-interfaces, satellites, handset and gateways required to provide a high accuracy, GPS-like, ranging functionality directly by the current MSS satellites.
- Given the above, there is little possibility of upgrading current generation MSS satellite hardware to support E9-1-1 functionality.

11.6 Possibilities for Next Generation MSS System

Overview of Next Generation MSS Systems

- Currently, the only next-generation MSS systems licensed by the FCC for deployment are GEO-based systems (e.g., Inmasat-4, MSV, Boeing, TMI, Iridium, etc.).
- These licenses cover all of the existing MSS bands (L-Band, the Big-LEO band, and the newer S-Band MSS allocations).
- For the reasons outlined in the following sections, location determination solutions that are limited to measurements solely from the GEO MSS

satellites can not provide the accuracy necessary to support E9-1-1 services,.

11.7 Satellite-Only Solutions from GEO-Based MSS Systems

11.7.1 LD Solutions Based on Direct Ranging from GEO MSS Satellites

GEO-based MSS systems can only provide single-point ranging or possibly two-point ranging, as determined by their constellation size and orbital spacing. By their geometric design, these GEO system architectures can not support location determination with the accuracies required for E9-1-1.

- In current GPS LD solutions, nearly simultaneous ranging is performed from three to four (or more) locations (satellites) using high bandwidth, extremely stable satellite signals.
- At a minimum three-dimensional ranging is required to provide unambiguous location determination (hence the term *triangulation)*. Additional ranging points provide both additional LD accuracy, and improved spatial diversity to increase the availability of LD estimates.
- In an MSS context, ranging from (sparsely populated) GEO constellations can not provide accurate, or even unambiguous, location determination, as is required for E9-1-1 services
- To the extent that a satellite operator deploys a system architecture that allows simultaneous visibility to several satellites, LD based on satellite-only ranging may provide 10-50 km uncertainty regions.

11.7.2 Location Determination Based Solutions Based on Received Signal Strength - in MSS-Only Coverage Areas

It is important to differentiate

- In next-generation GEO MSS systems the "cells" (i.e., space-to-ground service beams) will measure in excess of 100 miles wide.
- These beam sizes represent the state-of-the art in satellite antenna technology (consistent with antenna apertures on the order of 20 meters).
- Near the beam center, fractional parts of a dB in relative signal strength equate to tens of miles in location uncertainty.
- Therefore handset or satellite implemented Location Determination as implemented via signal strength measurements alone (whether satellite or

handset based) would be limited to accuracies of approximately 20-25 miles (at best).

In light of the above considerations, Location Determination functionality over GEO based next-generation MSS systems would include (in all likelihood) an external augmentation – and this augmentation must be CONUS-wide. This is true whether the LD is used to support E9-1-1 or commercial location dependent services/features.

11.8 Handset/ Terminal GPS-Based Solutions for Next-Generation MSS Systems

Current generation MSS satellite systems were not designed with sufficient excess link margin to operate in dense urban or suburban areas. Similarly, GPS-only solutions are also known to not work well in these areas. As such, the CMRS industry has initiated development of several versions of Augmented GPS (A-GPS) solutions that typically provide augmentation signals to CMRS handsets. These augmentation signals are often designed to reduce the GPS signal search space, thereby allowing a more rapid synchronization and operation at reduced signal-to-noise ratios. Noteworthy, however, is the fact that these GPS augmentation signals are typically transmitted by the extensive CMRS infrastructure.

Migration of these approaches to next-generation MSS systems is an avenue that is worth further exploring. Notionally, the augmentation signals currently provided by the CMRS infrastructure could potentially be transmitted by the MSS satellites. It is important to note that, however, that the technical feasibility of this MSS A-GPS approach has not been examined in detail.

11.9 Other MSS Design Considerations

Ancillary Terrestrial Component

A few satellite systems may implement an ancillary terrestrial component (ATC) in their next generation of satellites. In these systems, the GPS augmentation signals may be supplied by the ATC infrastructure in those limited areas where ATC is implemented. However, outside of the ATC coverage area the augmentation signals would not be available.

11.10 Call Back Number

Modifications to current MSS infrastructure are often difficult, if not impossible, to implement, because there are only a few operators in the global market. Moreover, the few existing operators have different network components. Most of the current components of these operators' systems were built in the early to mid-1990s, and vendors for replacement components either no longer exist or no longer produce a similar product. Additionally, because the few existing networks are so different, hiring a new vendor to design one-off components can be prohibitively expensive.

11.11 ALI

If geolocation coordinates of the subscriber's MET were available, in order to be able to pass them on to the PSAP, the MSS industry would first have to locate an MET vendor and then participate in the 12-24 month design and development stages as well as raise the many millions of dollars to support the effort.

Additionally the ground segment side (gateway) would require a similar 12-24 months of a design and development stage as well as millions of dollars and additional internal resources to support the effort.

11.11.1 ALI and the MT

If GPS could be embedded in the handset, due to legacy H/W restrictions along with space and interfacing issues for the S/W, the industry would need to physically open up and replace H/W components and load new S/W on all existing user equipment. Due to the fact that the subscriber handset usage characteristics and behaviors regarding handset churn are completely different from current cellular consumers, i.e. MSS subscribers don't exchange their handsets for a new model, this option quickly becomes impractical for currently deployed MSS systems.

11.11.2 ALI and Wireless Interface

If the ALI were available, the MSS industry would need to embed the geo-locate information in the message traffic (signaling channel).

The resulting ripple effect of this new geo-location information in the message traffic and subsequently throughout the wireless side of the MSS network will require tremendous amounts of code to be written and / or modified- in the space segment (constellation) and the ground segment (gateway).

11.12 ANI and the GWS Switch

Current switching subsystems in Satellite Network ground segments (gateways) do not support PSAP level routing due to the size of the location cell area. However, in some cases it may be possible in CCS7 signaling to send ANI via terrestrial link. A long lead time would be required to redesign the appropriate subsystem HW and SW to accommodate the data storage requirements for the small location cell area. If vendors can support such required augmentations, they would need to build different switch software which would take substantial development and investment.

11.13 Voice over IP

Recognizing the growing market acceptance of Voice over Internet Protocol (VoIP) for communications, as well as the opportunity and desire to incorporate this technology into the PSAP architecture, it is necessary that existing wireline-based connectivity into the PSAPs remain an optional connection mechanism for MSS providers beyond the 2010 date. This date does not coincide with satellite operators' projections of "end of life" for their systems. Some satellite systems are projected to operate as late as 2014/2015.

In addition to the existing design limitations of MSS systems with respect to Enhanced 9-1-1 data capabilities, unless significant improvements are made to the VoIP architecture and technology by 2010, MSS subscribers attempting to connect to emergency services through VoIP infrastructure will be hindered by several factors.

Voice communications over satellite links introduce a significant amount of variable latency into the bandwidth utilization. Consistent latency can be addressed by applying QoS features to VoIP; however, even without consistent latency, VoIP voice quality suffers. Additionally, current VoIP switches are designed around broadband capabilities. MSS deployed network architectures are based on narrowband technology and operate at relatively low baud rates. While MSS subscribers familiar with these system constraints quickly adapt their conversations to accommodate the inherent delays, low bandwidth, coupled with variable latency, may render most VoIP conversations unintelligible. In fact, calls may drop. Under the stress of an emergency situation, callers could become frustrated or panic due to their inability to communicate effectively with the PSAPs.