The Next Generation 9-1-1 Guide for 9-1-1 Authorities

A NENA Resource Document

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Next Generation 9-1-1 Guide for 9-1-1 Authorities

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Reason for Issue/Reissue

NENA reserves the right to modify this document. Upon revision, the reason(s) will be provided in the table below.

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NENA-REF-005.1-2020	04/21/2020	Initial Document

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Forward

Chapter 1 Introduction to Next Generation 9-1-1

This document is an educational resource that provides guidance regarding what NG9-1-1 ***is***, and what it ***is not***, along with high-level explanations of the various components of NG9-1-1. This document is not intended to provide instructions on how to implement and maintain NG9-1-1. In addition, a recommended reading list of other NENA documents and standards is provided as Appendix B.

The evolution of emergency calling beyond traditional voice 9-1-1 calls highlights that current E 9-1-1 systems are no longer able to support the needs of the future. As each new communications method was introduced, the legacy 9-1-1 system struggled to accommodate them. Wireless, VoIP and text-to- 9-1-1 have all been backwards engineered to work within existing 9-1-1 systems. In NG9-1-1, IP networks referred to as an Emergency Services IP Network (ESInet), replace existing narrowband, circuit switched 9-1-1 networks which carry only voice, and very limited data. Existing E 9-1-1 networks do not support such things as real-time text messages for emergencies, images and video (including support for American Sign Language users), and easy access to additional data such as telematics, building plans and medical information, over a common data network.

NG9-1-1 Core Services provide the databases and location-based routing functionality that replace legacy automatic location identification (ALI) databases and selective routing. Seamless support of communications and data transfers requires a highly standardized system. The NG9-1-1 system enables interoperability across county, state, and international borders, as well as across emergency response professions and agencies,

> **ANALOGY**
>
> NG9-1-1 terminology relies on very technical concepts, which can be difficult for lay people to understand. An analogy may help in comprehension of some concepts which follow in this document. Think of NG9-1-1 as a transportation system. The ESInet is the roadway; the NG9-1-1 Core Services (NGCS) are the traffic control devices, rules and laws which govern traffic flow; and the vehicle occupants are the data being transported (calls, texts, call data, etc.).

including but not limited to traditional PSAPs, poison control centers, trauma centers, Coast Guard, and disaster management centers.

NENA's i3 workgroup (WG) defines those Core Services, or traffic control devices, as: Emergency Services Routing Proxy (ESRP); Emergency Call Routing Function (ECRF); Location Validation Function (LVF); Border Control Function (BCF); Bridging; Policy Store; Logging Services; and typical IP service such as Domain Name System (DNS) and Dynamic Host Configuration Protocol (DHCP). More information on these core services can be found in Chapter 3 Technology of this document.

A. Benefits of NG9-1-1

NG9-1-1 provides many benefits to 9-1-1. One important benefit is equal access for Deaf, hard of hearing or speech impaired individuals. With NG9-1-1, for the first time in history everyone will be able to access 9-1-1 in the same way.

NG9-1-1 allows PSAPs, especially smaller PSAPs that might not have had access to advanced services, to share services. For example, it may no longer be necessary for every PSAP to have its own logging and backroom 9-1-1 call handling equipment. Those applications may now be procured at a regional or statewide level and utilized by all PSAPs on the network because of the data sharing capabilities that NG9-1-1 introduces.

NG9-1-1 helps us meet the public's changing expectations of how they want to communicate with 9-1-1.

NG9-1-1 is software and data driven. This new approach to utilize data differently provides flexible access to valuable information about a call, caller, or location that was previously unavailable to PSAPs and First Responders. The presentation of the new types of information can be customized through software and the goal of using common off the shelf (COTS) hardware to meet an agency's specific needs. Understanding the purposes, interactions, and requirements of the NG9-1-1 databases allows agencies to make policy and quality control adjustments before moving into NG9-1-1.

NG9-1-1 technology allows 9-1-1 Authorities to program their systems (via policy routing rules), to support virtual PSAPs for disaster handling or overflow, if so desired.

For example, in the event of a natural disaster, calls could be routed to a pre-designated back-up PSAP. Smaller PSAPs, that may not operate 24 X 7, will have the ability to automatically send after hours calls to an alternate location.

NG9-1-1 technology also provides a scalable, flexible, mainstream platform that will more easily adapt to future capabilities and objectives. NG9-1-1 helps us meet the public's changing expectations on how it wants to communicate with 9-1-1. With NG9-1-1 we are no longer limited to a (nearly) voice only communications platform. The introduction of text, pictures, additional data and videos will result in improved call handling outcomes.

1. Primary System Benefits of NG9-1-1

Before NG9-1-1, routing 9-1-1 calls relied on either a static address within an ALI database using pre-determined routing (wireline case), or a proximate cell tower location for mobile calls. The cell tower location may be a considerable distance away from the caller or the appropriate PSAP, or in a different jurisdictional boundary, because cell phone coverage areas overlap. While NG9-1-1 doesn't promise to improve location accuracy of calls, it enables the use of more accurate location information provided by the wireless carriers. Despite any improvement in location accuracy, PSAPs must deploy NG9-1-1 systems and networks in order to take full advantage of the improved location information.

Location based routing, which is a fundamental tenant of NENA's NG9-1-1 design, enables a call to be routed to the appropriate PSAP for the location of the caller's device, once that position information is made available to the network. This will result in fewer misrouted calls and therefore a reduced need to transfer calls to a different PSAP, since the call was routed to the appropriate PSAP initially. Location based routing requires changes to where and how location is stored and acquired in the network. For end-to-end NG9-1-1, a location database within the access provider network, called a Location Information Server (LIS), is used in the NENA NG9-1-1 system to store and make available individual location information used with every emergency call. This LIS database provides location via new protocols, including hypertext transfer protocol (HTTP), in a standardized format called Presence Information Data Format – Location Object (PIDF-LO). For wireless emergency calls where the location of a wireless caller may change the IMS-based Originating Services Network may deploy a Location Retrieval Function (LRF) to make available location information of the wireless caller.

2. Specific Examples of Expected Benefits of NG9-1-1

a. Geospatial routing

Geospatial routing uses the location of a 9-1-1 caller to determine which PSAP should receive the call based on a map of jurisdictional boundaries. Today, the location of a caller using a wireless device is approximated using the cell tower and sector handling the subscriber's call. In areas where more than one PSAP has jurisdiction for the area in a cell site sector, this could result in the call being delivered to a neighboring PSAP necessitating a transfer to the appropriate PSAP once the actual location of the caller is determined. NG9-1-1 provides the opportunity to use the caller's device location to route the call to the appropriate responding PSAP once the wireless carriers are capable of providing the location in time for routing.

b. Policy Based Routing

When the appropriate PSAP to handle a call is unavailable either due to planned downtime (i.e. after hours) or an unplanned outage (i.e. evacuation), policy-based routing can divert calls to a designated backup and/or alternate PSAP(s) to handle the call. Policy based routing are rules that allow the delivery method of a call to be dynamically altered based on conditions that exist at the time of the call and information associated with the call. These conditions may include, but are not limited to:

- Network status
- PSAP status
- Location of the call
- Type of call (voice, multi-media, text)
- Language preference

For example, a PSAP that is open less than 24 hours a day would use a policy-based rule to reroute its calls when the PSAP is closed. Another example, if one PSAP in a county is handling all text-to- 9-1-1 calls, a policy would be utilized to send all texts to the appropriate PSAP.

The subscribers' preferred language and other subscriber and incident information can also be used to deliver the call to the PSAP in the best position to handle the call. For example, a NG9-1-1 call can include information on the subscribers' preferred language. If a region has determined that all calls from people whose first language is French should be handled by a single PSAP, the NG9-1-1 system can use the subscribers' preferred language to implement this call routing.

c. Interoperability

- Expanded interconnection options and call transfer capabilities
- Allows data sharing across agencies (virtually limitless)

d. Resiliency and Disaster Preparedness

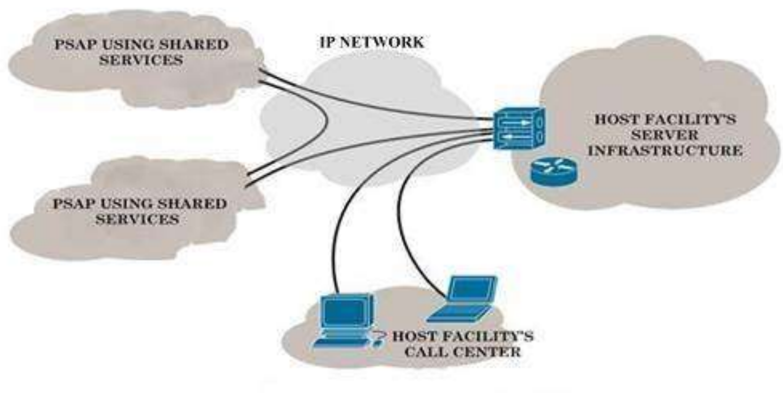
- Improved redundancy & reliability through more versatile network sharing and management, including, but not limited to virtual PSAPs (Appendix A: Glossary), which will allow a wide range of call handling possibilities.
- Mobile PSAPs
- Standardized architecture can allow a telecommunicator to go to another PSAP during a disaster and be able to receive & process their own PSAPs calls.

e. Shared Services

One of advantages of an NG9-1-1 network, is that it allows PSAPs to share services such as 9-1-1 call handling equipment, Radio, CAD and Records Management. In the past each PSAP purchased these systems individually and housed the servers in their own backrooms. In NG9-1-1, for example, by utilizing shared services, one agency or vendor can host CAD servers at its facility, where it can be upgraded and maintained as needed, and PSAPs on (or with access to) the network can share the same system. This sharing of backroom equipment allows multiple PSAPs to benefit from the services without having to incur the large capital expenditure of creating their own infrastructure. In this instance, other PSAPs can collaborate with the host agency or vendor, share expenses and data, and should be able to maintain their own end user look and feel.

In Figure 1 Shared Service Diagram below it is understood that the connectivity would be provided via a private managed network that is common to each of the depicted members or via a highly secured connection if the public Internet were used as the transport path.

FIGURE 1 SHARED SERVICE DIAGRAM



f. Multimedia, i.e. text, pictures, videos, and files (not just 'Text to 9-1-1')

NG9-1-1 allows PSAPs to receive text messages on their 9-1-1 call handling equipment in much the same manner as other 9-1-1 calls today. It also allows a PSAP to receive not only short message service (SMS) text messages converted to message session relay protocol (MSRP), but also Real-Time Text (RTT) messages. In addition, IP-based Originating Service Providers (OSPs) may send pictures, videos and attached files that may be viewed by the telecommunicator.

- RTT is much like TTY in a native IP environment, in that it allows a texter to communicate in near real time.
- J-STD-110 [24] describes an Interim SMS texting solution which became available in 2016. This standard allows SMS/multimedia messaging service (MMS) text to be interworked to NG9-1-1 PSAPs. The interim solution is described in greater detail in Section 5.2 of this document, and in J-STD-110.
- Additional data, i.e. telematics
  - Real time data will support being able to access emergency events interactively.

B. Common NG9-1-1 Myths (i.e., What NG9-1-1 is NOT)

Myth 1

- Upgrading a network or system with a piece of NG9-1-1 functionality equates to having a full NG9-1-1 system and network. Not true!

The transition to NG9-1-1 can be varied and may include deploying one element at a time. For example, if a region or PSAP procures and installs an i3 compliant call handling or CAD system, the call handling system on its own does not constitute NG9-1-1.

Users that have enabled text-to- 9-1-1 may be able to send text messages where the TCC connects directly to the PSAP or interworks to the PSAP via the ESInet. Yet having the text-to-9-1-1 capability on its own does not constitute NG9-1-1.

An ESInet is not by itself NG9-1-1. An ESInet is an IP network which meets reliability and Quality of Service (QoS) transport requirements to support the application environments that provide core NG9-1-1 functions and services.

Myth 2

- NG9-1-1 will provide more accurate location for 9-1-1 callers. Not true.

NG9-1-1 does not change or impact the information or accuracy of location being sent by the OSPs. Rather NG9-1-1 provides the ability for future expanded location information to be provided to 9-1-1 Authorities. While some devices may "know" their own locations and be able to report it, not all devices connected to an NG9-1-1 network will have this capability. In some cases, for example nomadic VoIP or some wireless calls, the location of the device may not be available.

Myth 3

- NG9-1-1 is going to be much cheaper than legacy 9-1-1. Not true.

NG9-1-1 will allow for increased sharing of resources and equipment which may result in some savings. This is particularly true when NG9-1-1 is simply replicating legacy automatic number identification (ANI)/ALI services. However, it may not cost less. The more advanced services which NG9-1-1 provides involve additional databases and servers and the cost of operating them. Also, during transition to NG9-1-1 it may actually cost more as the current legacy environment will need to be funded while the new system is being tested and installed.

C. Implementation Challenges

1. Funding Considerations

Funding is one of the biggest challenges to implementing NG9-1-1. The transition to NG9-1-1 is enhanced or facilitated with some level of statewide funding coordination. Statewide coordination can include one statewide NG9-1-1 system or multiple regional interconnected NG9-1-1 systems. If no statewide coordination is present, 9-1-1 Authorities should consider working together to form a regional NG9-1-1 system. Some of the options for defining regions might be state level NENA regions, state level Emergency Management Areas, Homeland Security Regions, or other predefined regions (councils of government, emergency management districts or radio districts). The newly defined region would need to determine how NG costs will be divided among the participating entities. See Agreement Between Stakeholders Section 3.2.2 below for information on formalizing the funding agreement between entities.

There is the option for individual 9-1-1 Authorities to move forward with purchasing NG9-1-1 as a service and funding it at the local level. Please note at some point in the future it will be necessary to interconnect with a statewide or regional network.

> Larger scale projects could reduce cost by allowing the initial investment to be lowered by riding on top of state IP networks or cost sharing with neighboring jurisdictions. The more entities involved, the lower the cost may be.

Larger scale projects could reduce cost by allowing the initial investment to be lowered by riding on top of state IP networks or cost sharing with neighboring jurisdictions. The more entities involved, the lower the cost may be.

In those states that provide grant funds to 9-1-1 Authorities; based on the State requirements, those grant funds could be utilized to pay for NG9-1-1 non-recurring or recurring costs. State funding sources may be set up via a State 9-1-1 Administrator or the state organization that collects 9-1-1 fees, depending upon the state.

Federal grants could be utilized to pay for a regional NG9-1-1 implementation, based on federal requirements and the agreement of the state 9-1-1 Authority to support the request. Some grants, for example the National 9-1-1 Program grant funds, are only available to a state 9-1-1 Authority. Federal funding is not as readily available as it has been in the past.

- The FCC now requires states to verify that 9-1-1 funds have not been used for non- 9-1-1 services.
- Some 9-1-1 Authorities may approach other entities within the state or county to help fund the purchase of the equipment.
- Other county entities may benefit with the NG9-1-1 system. For example, the data received via the NG911 system could be passed to responding agencies via FirstNet or other data transport provider.
- Grants could be available on the local (state) level to assist with cost. Also, depending on the state, Tribal Nations may have resources available for funding.
- County entities could pass a public safety tax/surcharge that is different than the 9-1-1 surcharge that could also help implement NG9-1-1.
- Counties may need to consider realigning their current budgets to fund NG9-1-1 utilizing current funding from the fees collected today.

2. Statutory and Administrative Environments

9-1-1 systems are administered differently across the county, so statutory and administrative requirements vary based on state, regional, and local requirements. It is recommended that 9-1-1 Authorities conduct a statutory analysis to determine if legislative changes are needed to accomplish NG9-1-1. Additionally, the statutory analysis should include a discussion of whether interlocal or regional agreements can be created for a shared NG9-1-1 system.

3. Interlocal or Regional Agreements

Regional agreements between participating 9-1-1 entities need to be formalized to ensure all parties are in alignment with responsibilities and governance. Agreements should include all elements of governance and operations of the shared NG9-1-1 system, e.g. how much funding each entity contributes, individual responsibilities in the implementation, ongoing management and security of the system, decision making authority, governance policies such as data management, data retention and policy routing rules. These elements should be clearly documented for all stakeholders.

Formalized agreements can also identify a primary management/oversight committee comprised of stakeholders that implementation staff would either directly report to or be tasked with providing periodic progress updates.

4. Governance

As the migration from legacy 9-1-1 systems to a new NG9-1-1 infrastructure occurs, the issue of governance and who makes major decisions must be addressed. As stakeholders consider the various issues, there may be situations where final decisions will have to be made. It is therefore incumbent on all participants that joint oversight committees be created to oversee and be involved in all aspects of system planning. As stakeholders adjust to the concept of regionalization and the migration to new technologies, an open dialogue that addresses the needs of both the public and emergency responders, and the effective delivery of emergency services must remain at the core of the various discussions and deliberations. Final decisions on any aspect of new systems therefore should be made as much as possible by consensus, with any final decisions made, and agreed to, by the established governance committee.

5. Planning

9-1-1 Authorities should develop an overall plan for the end state of the NG9-1-1 deployment that involves a communication plan. NG9-1-1 deployment plan should include realistic timelines for things like approval processes, legislative changes, certifications, etc. and consider some NG9-1-1 features that are not currently available.

Agreements between stakeholders should include detailed planning phases. A strategic plan should be developed containing clearly defined short- and long-term goals, along with resources and responsible parties. The plan should also include periodic reviews to gauge progress towards implementation.

6. Education

NG9-1-1 requires end-to-end education starting with 9-1-1 Authorities, PSAP personnel, First Responders, local, state and other elected officials, as well as the general public. Implementing NG9-1-1 systems requires a complete replacement of legacy systems and is the only solution to supporting new technologies and data. Solution providers, PSAP IT personnel, PSAP staff, administrators, and the general public need appropriate levels of education and training.

7. Training

NG9-1-1 requires training for various disciplines on an ever-evolving technology. It is important to ensure that all stakeholders have adequate training. For example, an IP network may be managed by a 9-1-1 Authority or it may be provided as a managed service from the vendor. If the 9-1-1 Authority is managing the network, network training will be required.

Telecommunicator training recommendations have been addressed at the national level, Recommended Minimum Training Guidelines for the Telecommunicator [6], was created with input from several entities including NENA. 9-1-1 Authorities should reference these guidelines, for recommended training topics which include:

- Roles and Responsibilities
- Legal Concepts
- Interpersonal Communications
- Emergency Communications Technology
- Call Processing
- Emergency Management
- Radio Communication
- Stress Management
- Quality Assurance
- On-The-Job Training

Below is an additional list of training that may be needed, but is not all inclusive:

- IT/Support Services personnel require training on how to maintain these systems and provide security in an NG9-1-1 environment.
- PSAP personnel need training on handling calls for service.
- GIS personnel need training on how map layers/GIS data will affect call routing processes and database management.

8. Integration/Interoperability

Hardware or software providers must with existing standards which have been developed, approved and implemented for use by the 9-1-1 industry so their offerings are universal and not restrictively proprietary. Because of the need for NG9-1-1 to interconnect across the nation, it is important for all hardware and software to be able to communicate with each other.

Interoperability is *"the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units."* Ensuring that any elements and/or applications that are deployed in NG9-1-1 use common standards may also help with long term management and costs. Systems that use proprietary protocols are difficult to upgrade and tend to be costlier in the long run.

9. PSAP Operational Impact

Deciding to progress to a NG9-1-1 environment is a universal decision involving public safety leaders working with governmental entities responsible for allocation of funding and resources, the local population, industry partners, and 9-1-1 agencies (PSAPs) both in the local area and on a regional or statewide basis. 9-1-1 Authorities must devise a long-term plan for implementation of NG9-1-1 while being fully cognizant of the needs for the daily operations and the additional impacts a NG9-1-1 environment has on infrastructure policy, call routing, training, systems and other considerations which may not have been reviewed previously in a legacy 9-1-1 environment. 9-1-1 Authorities must also be aware that by its nature NG9-1-1 involves other PSAPs, potentially in ways that are unfamiliar, as routing process, disaster planning, and redundancies are designed and implemented. Below are some additional impacts which should be considered:

- Partnering with service providers such as call handling equipment (CHE) vendors, local exchange carriers, Internet service providers, wireless carriers, etc. are needed for successful deployment of service.
- Working closely with local (contiguous) public safety entities, regional and state authorities to devise policies and plans which will be functional with the implementation is essential.

Beyond the issues and opportunities related to the technology and governance impacts of NG9-1-1 implementation, there will also be impacts on the Telecommunicators, Dispatchers, Certified Training Officers (CTOs) and Dispatch Supervisors working in the NG9-1-1 environment. The increase in data that will be available to 9-1-1PSAPs, along with the possibility of nearly global redundancy capabilities, will result in PSAP staff needing additional skill sets that are sometimes overlooked in today's 9-1-1 environment. Including:

- Data Analysis
- Principles of Disaster Recovery
- Video Processing
- Emergency Management
- Incident Command
- Remote Sensor Use and Management

- Advanced Incident Monitoring and Reconstruction using multiple systems and sensors
- Social Media Monitoring

Additional skill sets may be needed either within a PSAP IT department or at a 9-1-1 Authority level for:

- Video Analytics
- Social Media Monitoring

These items are only a partial list of the skills that telecommunicators in the PSAP may need to be effective in the PSAP environment that will be created through NG9-1-1 deployment. Beyond these, PSAPs need to address the increased likelihood that telecommunicators will answer and process 9-1-1 calls for incidents that could be far outside the normal service area. Traditionally, PSAPs have valued the local knowledge that telecommunicators utilize to answer calls and provide enhanced service to callers through their awareness of local geography and other information that may be of local interest. In a connected, integrated NG9-1-1 environment, it will be more likely that calls are routed to alternate PSAPs, which may impact the ability of telecommunicators to interact in the same localized manner with callers. PSAP managers should be aware of this and work with their personnel and industry partners to provide the appropriate support to minimize any negative impacts to call processing for those emergency calls which are answered by an alternate PSAP. PSAP managers should ensure that their personnel are fully trained on the steps to take to successfully process calls from other PSAPs, including the process necessary to dispatch the appropriate resources when the normal PSAP is unavailable for any reason [7].

The entirety of the NG9-1-1 PSAP environment, from the new technology, capabilities and job skill requirements, may potentially create a more stressful work environment for 9-1-1 professionals than the current environment. PSAP managers [10], stakeholders and the general public should be aware of this reality and the need to ensure that best practices regarding education, hiring, scheduling, staffing, wellness program, and human factors are understood [10] and followed. Introducing additional stress factors [10] into the 9-1-1 environment has the potential to further impact the existing problems of staffing and retention that many PSAPs experience. In addition, the evolving skill sets required of 9-1-1 personnel should be reflected in both minimum training guidelines [6], but also in the compensation and benefits packages provided to those in the 9-1-1 profession.

Telecommunicators previously have only dealt with voice communication during an incident. With NG9-1-1 features, it is possible that telecommunicators will now see photos and/or videos of an incident that may be disturbing. Having some type of Employee Assistance Program (EAP) or Critical Incident Stress Management (CISM) program in place will be necessary to assist with mental health of the telecommunicators.

In summary, the implementation of NG9-1-1 will require increased awareness and effort on the part of PSAP managers and stakeholders to the issues of telecommunicator performance and human factors. If managed properly, the introduction of NG9-1-1 should provide increased capability and effectiveness for 9-1-1 professionals, however this will not happen without effort on the part of those who manage these services.

10. Quality of Service

The NENA Master Glossary of 9-1-1 Terminology defines Quality of Service (QoS) as: "As related to data transmission, a measurement of latency, packet loss and jitter." QoS measures the quality of a network connection; QoS should not be mistaken for quality assurance (QA) or quality control (QC), which are methods used to improve customer service. QoS is solely about the network and network connections.

Several factors determine the QoS of a network. These factors are defined below:

- Service Level Agreement (SLA) Requirements/Consequences: SLA requirements are those items in a contract between a user and service provider which define the level of service to be expected from the service provider and received by the user/customer. SLAs generally allow for a certain amount of time a network can experience a maintenance window/period SLA consequence are what can be expected by a customer as a remedy when service providers fail to meet the SLA requirements.
- Packet Loss: Packet loss is defined as the failure of one or more transmitted packets to arrive at their destination. In an IP world, data are sent as packets, or groupings of information. Upon reaching their destination, packets are put back together to form a message, picture, video, etc. When packets are lost, the message will be incomplete, or errors may be produced. In 9-1-1, packet loss may result in loss of audio or unintelligible speech. Packet loss is typically caused by network congestion, inadequate signal strength, interference, or a combination of those and other factors. Packet loss is a metric used when determining system efficacy and performance.

- Jitter: The NENA Master Glossary defines jitter as packets arriving at a non-consistent rate due to a type of distortion caused by the variation of a signal from its reference that can cause data transmission errors, particularly at high speeds. Jitter can cause a blip or flicker of a monitor, clicks or other undesired effects, such as inconsistency, in audio, and loss of transmitted data. Jitter degrades the quality of communications. IT professionals and SLAs often group packet loss, jitter and latency together as a measure of network performance.
- Latency: In simplest terms, latency is the time interval between stimulation and response. In two-way communications, latency limits the maximum rate that information can be transmitted. In everyday life, this is often demonstrated on the news, where an anchor is interviewing a reporter in the field via a satellite connection. There is often a lag from when the anchor finishes asking his/her question and when the reporter begins to answer; this is due to latency. In terms of impact to 9-1-1, latency reduces efficiency of telecommunicators, increases call taking times and may result in inaccurate or incomplete information.
- Availability: Availability is the ability of a user to access data or a network via a specified location and in the correct format. For 9-1-1, the public expects a high-level of availability, i.e. the public expects to be able to access 9-1-1 and its services on a 24-hour basis.
- Uptime and Downtime: Uptime and downtime relate to availability. Basically, uptime refers to how often/long a network must function (or be available), while downtime is the amount of time a network can be down or not functioning.
- Network Availability: Network availability is generally measured as a percentage of reliability or uptime. In 9-1-1, network availability is generally measured to five 9s, or 99.999% reliable.

  For information on methods to ensure good QoS in NG9-1-1, refer to section 3.7 of NENA-STA-010.2 [4].

Chapter 2 Technology

A. Session Initiation Protocol

Perhaps the most important difference between the current 9-1-1 system and NG9-1-1 is the move to Session Initiation Protocol (SIP) [20]. All communications within the NG9-1-1 system utilize SIP. SIP, as the underlying Communications Protocol provides many of the benefits listed previously including:

- The ability to transport voice, text, data, photos, full motion video, and other forms of media
- Dynamic rerouting of calls around congestion and outages to achieve the required high availability
- Improved call setup times
- The ability to include information about the caller and the incident with the call. When provided by the OSP, these data blocks to the basic SIP standard can be used to route the call.

Perhaps the most useful information that can be passed to the NG9-1-1 system by the OSP is the location of the device. This is known as Presence Information Data Format Location Object (PIDF-LO). Instead of the course routing of wireless calls accomplished by using the caller's approximate location derived by determining the cell site and sector handling the call, the OSP can provide the actual location of the caller using GPS, proximity to Wi-Fi hotspots, barometric pressure, and a variety of sources of location available today and in the future. This more precise location can be used for dispatch but more importantly it can be used to route the call to the responsible 9-1-1 Authority the first time. This will reduce or eliminate the need to transfer calls especially in high density areas that may have multiple 9-1-1 Authorities responsible for a single cell site and sector.

Note that at this stage of the migration to NG9-1-1, most OSPs do not interface natively to NG9-1-1 systems. The majority of OSPs interface to NG9-1-1 systems via the legacy network gateway (LNG) utilizing legacy time division multiplexing (TDM) technology. Many of the

Session Initiation Protocol

Perhaps the most important difference between the current 9-1-1 system and NG9-1-1 is the move to Session Initiation Protocol (SIP). All communications within the NG9-1-1 system utilize SIP. SIP, as the underlying Communications Protocol provides many of the benefits listed previously including:

- The ability to transport voice, text, data, photos, full motion video, and other forms of media.
- Dynamic rerouting of calls around congestion and outages to achieve the required high availability.
- Improved call setup times.
- The ability to include information about the caller and the incident with the call. When provided by the OSP, these data blocks to the basic SIP standard can be used to route the call.

features and benefits of NG9-1-1 will not be fully realized until the OSPs migrate to IP-based architectures and fully implement the native NG9-1-1 interface.

The ESInet and NG9-1-1 Core Services described below are built on top of the basic SIP architecture and NG9-1-1 data blocks.

The NG9-1-1 Core Services (NGCS) is comprised of Functional Elements (FEs). A Functional Element (FE) does one or more jobs, or functions within the NGCS, and it has one or more interfaces to other FEs. All FEs work together to route a call from an OSP to the proper PSAP, based on caller's location that was provided by the OSP and obtain caller location and additional data information. An FE is a component of a system that does a specific job or set of jobs within the system. For example, a vendor may bundle multiple FEs into a piece of equipment that performs a broader range of functions in the overall NG9-1-1 architecture.

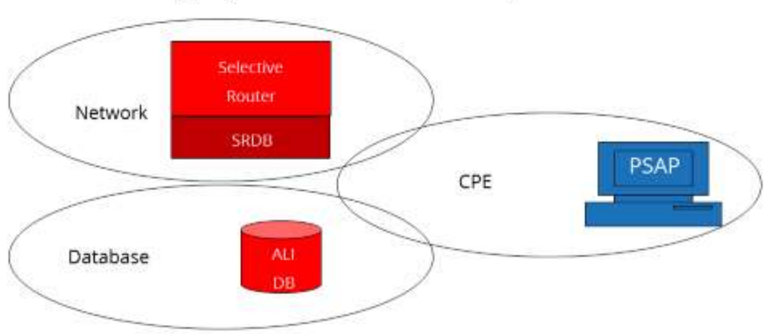
1. Call Flow Diagrams

NENA's NG9-1-1 i3 architecture defines many FEs, such as the Border Control Function (BCF), Emergency Services Routing Proxy (ESRP) FE, the Emergency Call Routing Function (ECRF) FE, LNG, and others. A service in the i3 architecture consists of one or more FEs that perform their functions in concert, as one entity. The i3 Logging Service is an example – it can consist of multiple (redundant) Logging Service FEs that function as a single Logging Service application.

a. Legacy Call Flow

A high-level example of the components of current legacy 9-1-1 systems is shown.

Legacy 911 Basic Components



The three basic components for legacy 911 call processing:
Network, Database, and CPE

1

FIGURE 2 *LEGACY 9-1-1 COMPONENTS*

An example of the legacy 9-1-1 network is illustrated below and followed by diagrams of the different types of E 9-1-1 calls: wireline, wireless and VoIP. In these examples, a call enters the 9-1-1 network from the Public Switched Telephone Network (PSTN), and then traverses the E 9-1-1 Selective Router/Tandem on its way to the designated legacy (not yet NG9-1-1) PSAP. The caller's ANI and audio are delivered to the PSAP via dedicated trunks/lines. PSAP equipment uses the ANI to query for the associated ALI information.

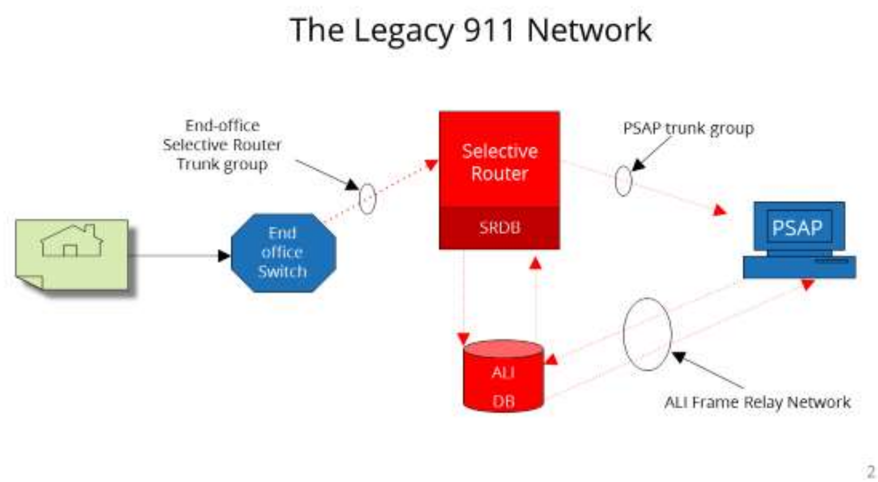


FIGURE 3 *LEGACY 9-1-1 NETWORK DIAGRAM*

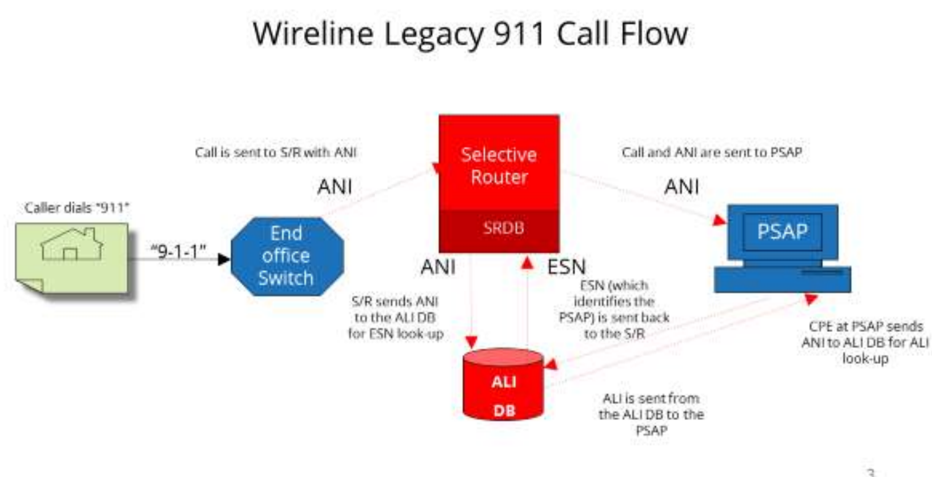


FIGURE 4 LEGACY 9-1-1 CALL FLOW DIAGRAM

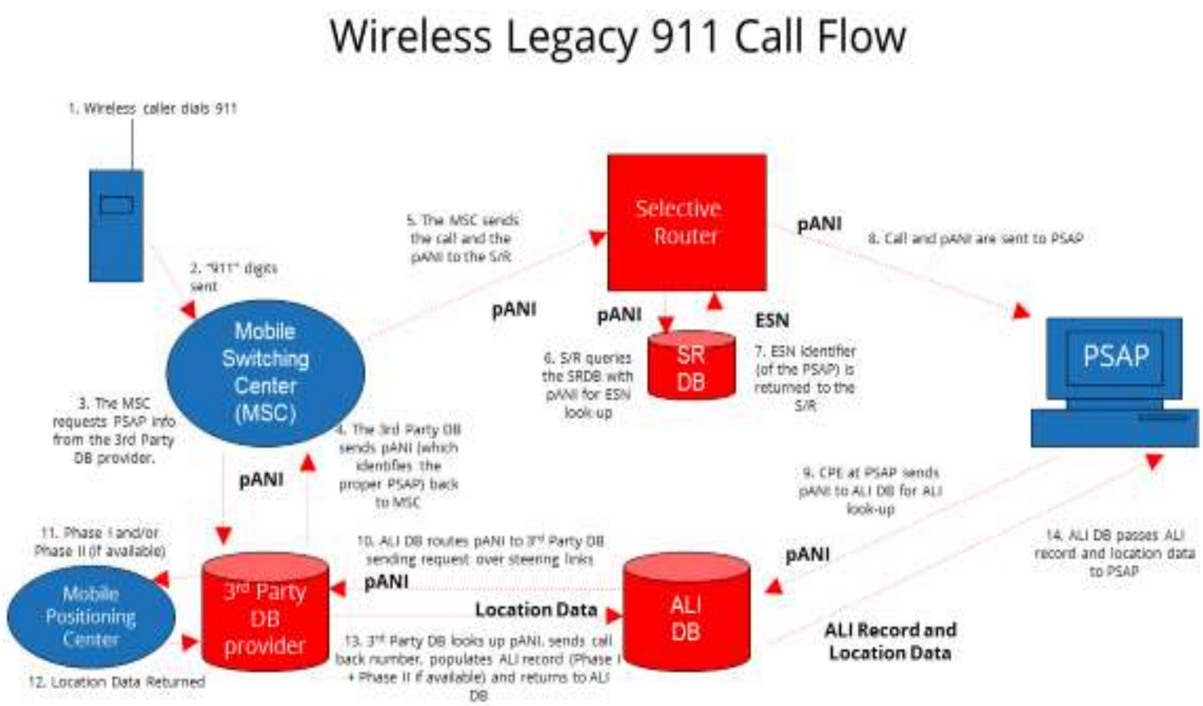


FIGURE 5 *LEGACY WIRELESS CALL FLOW DIAGRAM*

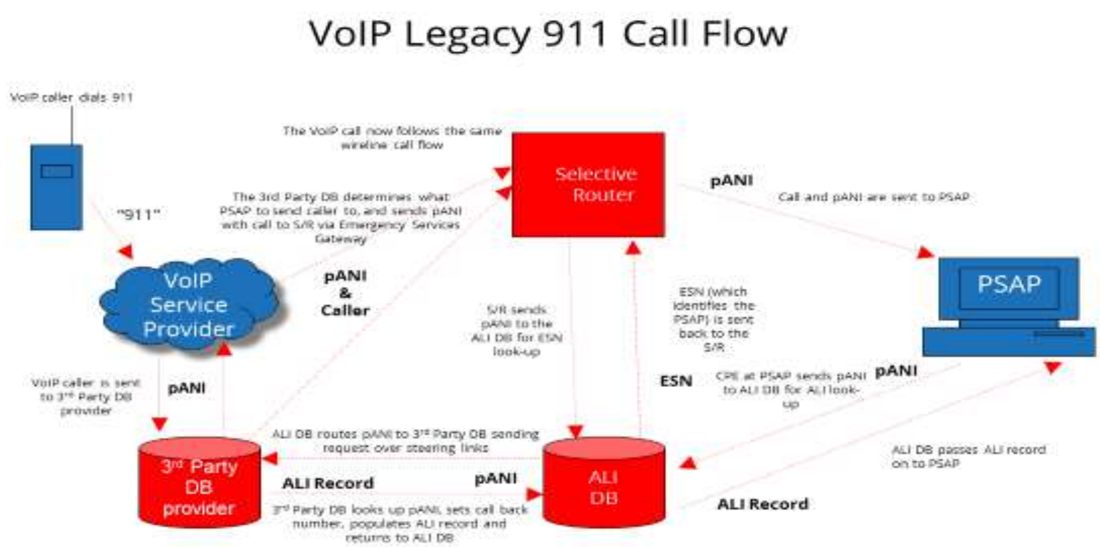


FIGURE 6 *LEGACY VOIP CALL FLOW DIAGRAM*

b. NG9-1-1 Call Flow

TRANSITIONAL STATE WITH LEGACY SELECTIVE ROUTER GATEWAY

As noted in the Task Force on Optimal PSAP Architecture (TFOPA) report, PSAPs in the foundational stage of the transition to full NG9-1-1 may be connected to an ESInet where legacy selective routing is still being used. The call flow diagram below depicts this scenario.

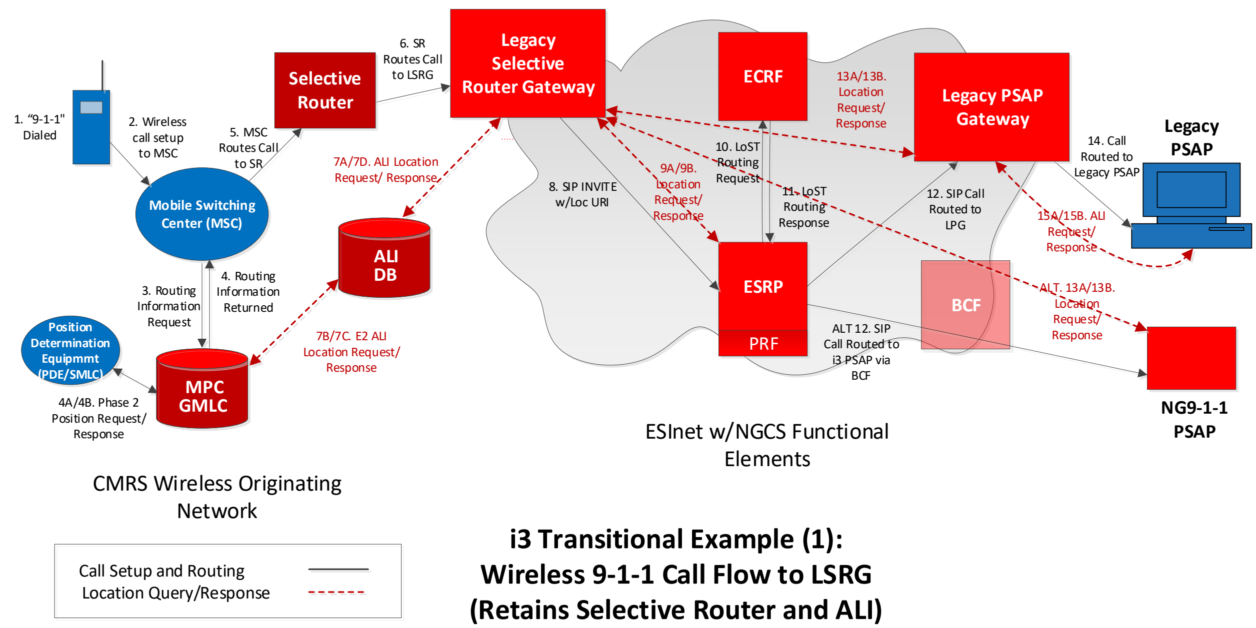


FIGURE 7 *TRANSITIONAL NG9-1-1 WITH LEGACY SELECTIVE ROUTER GATEWAY DIAGRAM*

In the diagram, the following call flow steps are numbered and correlate to the diagram above.

(1) Emergency call initiated by dialing 9-1-1

(2) The wireless carrier sends the call to the carriers' Mobile Switching Center (MSC)

(3) The MSC sends a query to the Mobile Positioning Center/Gateway Mobile Location Center (MPC/GMLC) for routing instructions

(4) The MPC/GMLC returns routing instructions including pANI (ESRK) back to the MSC

(4A) The MPC/GMLC sends a request for location to the Positioning Determination Entity/Serving Mobile Location Center (PDE/SMLC) (this happens simultaneous to step 4)

(4B) The PDE/SMLC returns the Phase II X/Y of the caller's device to the MPC/GMLC and stages it for the next ALI query (this step may take several seconds)

(5) The MSC forwards the call along with the pANI to the legacy Selective Router (SR)

(6) The SR, using information from the SRDB (not shown), routes the call to the Legacy Selective Router Gateway (LSRG)

(7A) The LSRG makes a location query to the ALI using the pANI (ESRK)

(7B) The ALI forwards the location query via the E2 interface to the MPC/GMLC to request initial location information

(7C) The MPC/GMLC returns location information along with Call Back Number (CBN) to the ALI

(7D) The ALI returns location information along with Call Back Number (CBN) to the LSRG for use in next hop routing within the ESInet/NGCS network

(8) The LSRG converts call signaling from analog TDM to SIP (constructing a SIP REQUEST URI in the process) and routes it to the ESRP

(9A) The ESRP sends a dereference request for location information to the LSRG, using the location URI provided by the LSRG in the previous step

NOTE: The LSRG uses stored information associated with the incoming location URI to make an ALI query for location information (repeat steps 7A through 7D)

(9B) Location information is returned from the LSRG to the ESRP in a PIDF-LO [4] [11] format

(10) The ESRP initiates a LoST query to the ECRF using the received location and service URN

(11) The ECRF returns the next hop route (URI) in the LoST response

Case 1: LEGACY PSAP Call Delivery

(12) The call is routed to the legacy PSAP gateway (LPG) based on the next hop route URI returned in the previous step, and includes the location URI

(13A) The LPG makes a dereference request using the location URI back to the LSRG

Note: To complete the location request all the way back to the MPC/GMLC, the LSRG repeats steps 7A through 7D, since location information is not cached

(13B) The LSRG returns the location information within a PIDF-LO, potentially containing both civic and geodetic location, if available

(14) The LPG caches location information, converts the call from SIP to TDM (analog) signaling, creates a pANI, and sends the call to the legacy PSAP call handling equipment

(15A) The legacy PSAP does an ALI query based on the pANI provided in the previous step

(15B) The LPG returns location information to the PSAP

Case 2: NG9-1-1 PSAP Call Delivery

(ALT 12) The call is routed from the ESRP through the BCF toward the NG9-1-1 PSAP

(ALT 13A) The NG9-1-1 PSAP requests location

Note: Steps 7A through 7D are repeated

(ALT 13B) Location information is returned to the NG9-1-1 PSAP

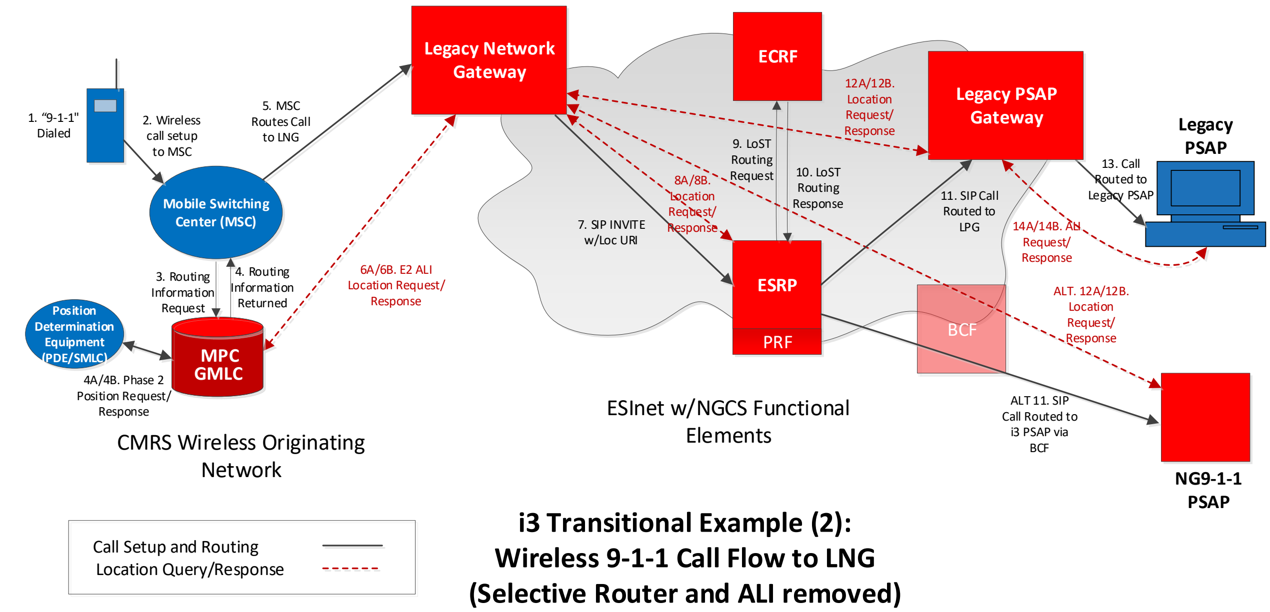


FIGURE 8 *TRANSITIONAL NG9-1-1 WITH LEGACY NETWORK GATEWAY DIAGRAM*

TRANSITIONAL STATE WITH LEGACY NETWORK GATEWAY

As noted in TFOPA, PSAPs in the transitional or intermediate stage of the transition to full NG9-1-1 may be connected to an ESInet where ingress call routing is not capable of being directly connected to the ESInet and requires an LNG. The call flow diagram below depicts this scenario.

In the diagram, the following call flow steps are numbered and correlate to the diagram above.

(1) Emergency call initiated by dialing 9-1-1
(2) The wireless carrier sends the call to the carriers' mobile switching center (MSC)
(3) The mobile switch sends a query to the mobile positioning center/gateway mobile location center (MPC/GMLC) for routing instructions
(4) The MPC/GMLC returns routing instructions including pANI (ESRK) back to the mobile switch

(4A) The mobile switch sends a request for location to the PDE/SMLC

(4B) The PDE/SMLC returns the Phase II X/Y of the caller's device to the MPC/GMLC and stages it for the next ALI query (this step may take several seconds)

(5) The MSC routes the call to the LNG

(6A) The LNG sends a location request to the MPC/GMLC

(6B) The MPC/GMLC sends location information back to the LNG

(7) The Gateway assigns a location URI based on the pANI used for the call through the BCF towards the ESRP using a SIP URI. This step is where the call signaling is converted from analog TDM to SIP.

(8A) The ESRP queries the LNG for location information

(8B) The LNG returns location information to the ESRP

(9) The ESRP makes a LoST request, including location information and a service URN

(10) The ECRF uses the location and service URN to find the next hop URI for the call and returns the URI to the ESRP

LEGACY PSAP CASE

(11) The ESRP routes the call to the legacy PSAP Gateway (LPG)

(12) The LPG converts the call from SIP to TDM (analog) signaling and sends it to the legacy PSAP call handling equipment, including a pANI with the call

(13) The legacy PSAP performs an ALI query based on the pANI provided in the previous step

(14A-B) The LPG queries for and receives location (includes steps 12A-B, and 6A-B)

i3 PSAP CASE

(11ALT) The call is routed through the BCF to the i3 PSAP call handling equipment

(12ALT) The i3 PSAP queries for and receives location (steps 12A-B, steps 6A-B)

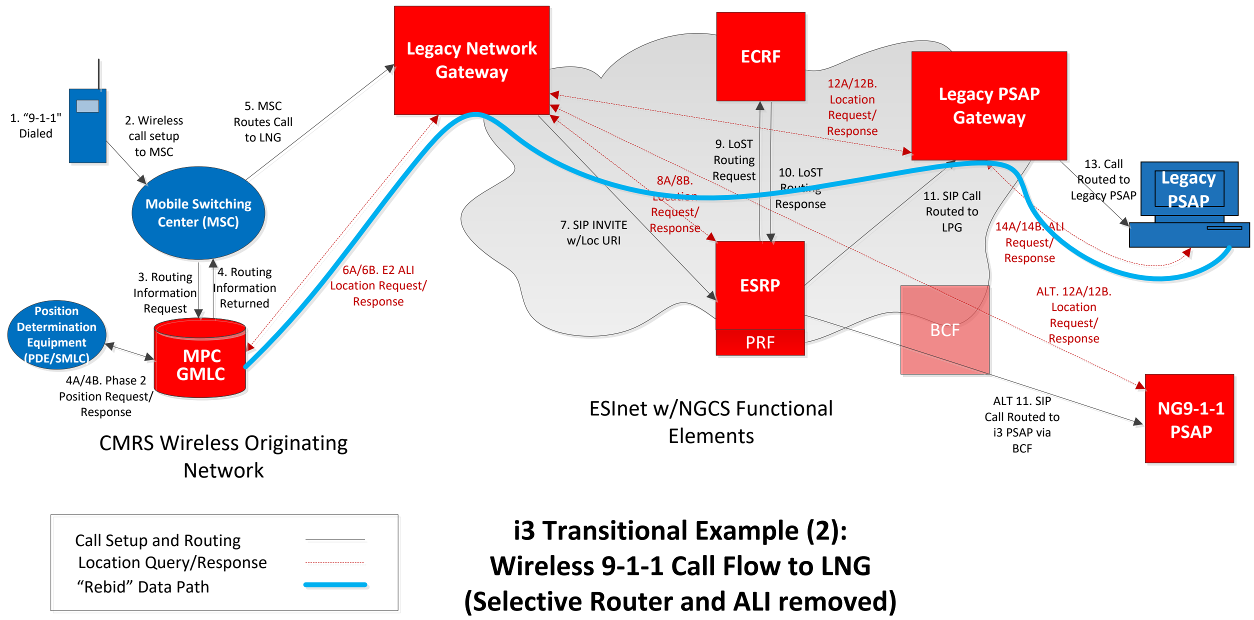


FIGURE 9 *TRANSITIONAL NG9-1-1 LEGACY PSAP WIRELESS REBID CALL FLOW DIAGRAM*

LEGACY PSAP LOCATION REBID

Note: The steps below are numbered sequentially and do not necessarily correlate to the diagram above.

1. Legacy PSAP rebids for updated location
2. The location request goes back to the LPG to the LNG (shown as step 14A)
3. The LPG sends the request to the LNG (step 12A)
4. The LNG queries the MPC/GMLC (step 6A)

    (step 4A) The MPC/GMLC requests updated location from the PDE/SMLC

    (step 4B) The PDE/SMLC returns Phase II X/Y coordinates (if available)

6. The MPC/GMLC returns the Phase II X/Y to the Legacy Network Gateway (step 6B)
7. The LNG sends the location to the LPG (step 12B)
8. The LPG provides the updated location response to the legacy PSAP (step 14B)

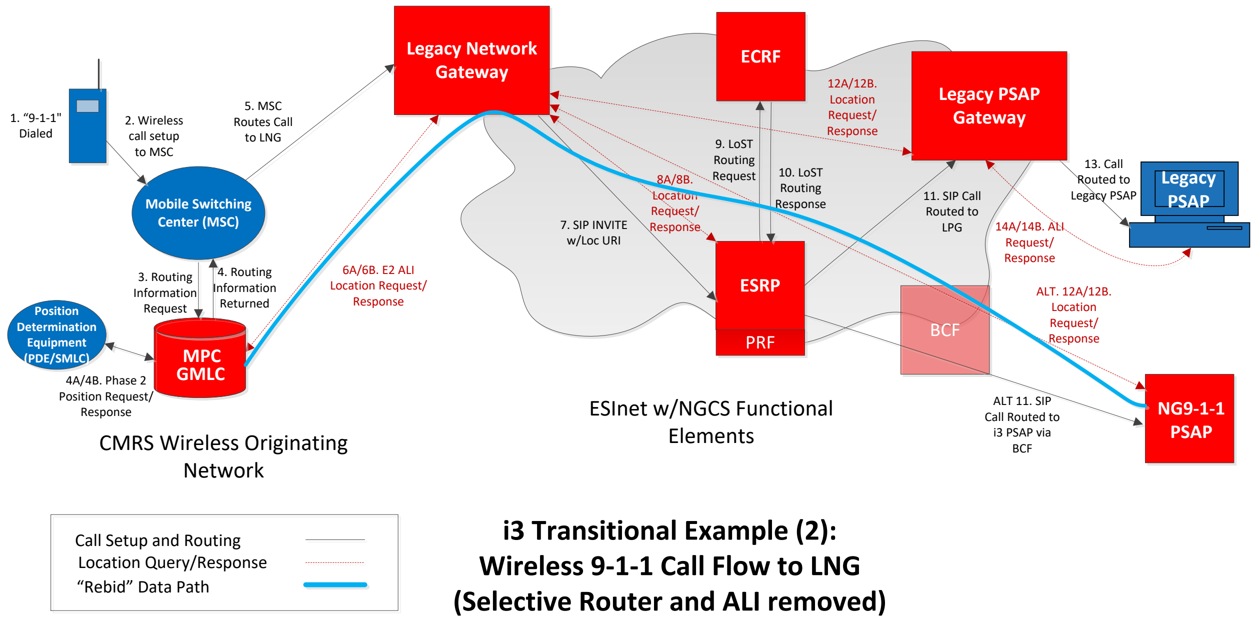


FIGURE 10 *TRANSITIONAL NG9-1-1 PSAP WIRELESS REBID CALL FLOW DIAGRAM*

i3 PSAP LOCATION REBID

Note: The steps below are numbered sequentially and do not necessarily correlate to the diagram above.

1. i3 PSAP rebids for updated location
2. The location request goes through the egress and ingress BCF to the LNG (step ALT 12A)
3. The LNG queries the MPC/GMLC (step 6A)
   (step 3A) The MPC/GMLC requests updated location from the PDE/SMLC
   (step 3B) The PDE/SMLC returns Phase II X/Y coordinates (if available)
4. The MPC/GMLC returns the Phase II X/Y to the LNG (step 6B)
5. The LNG sends the location through the egress/ingress BCF to the legacy PSAP (step ALT 12B)

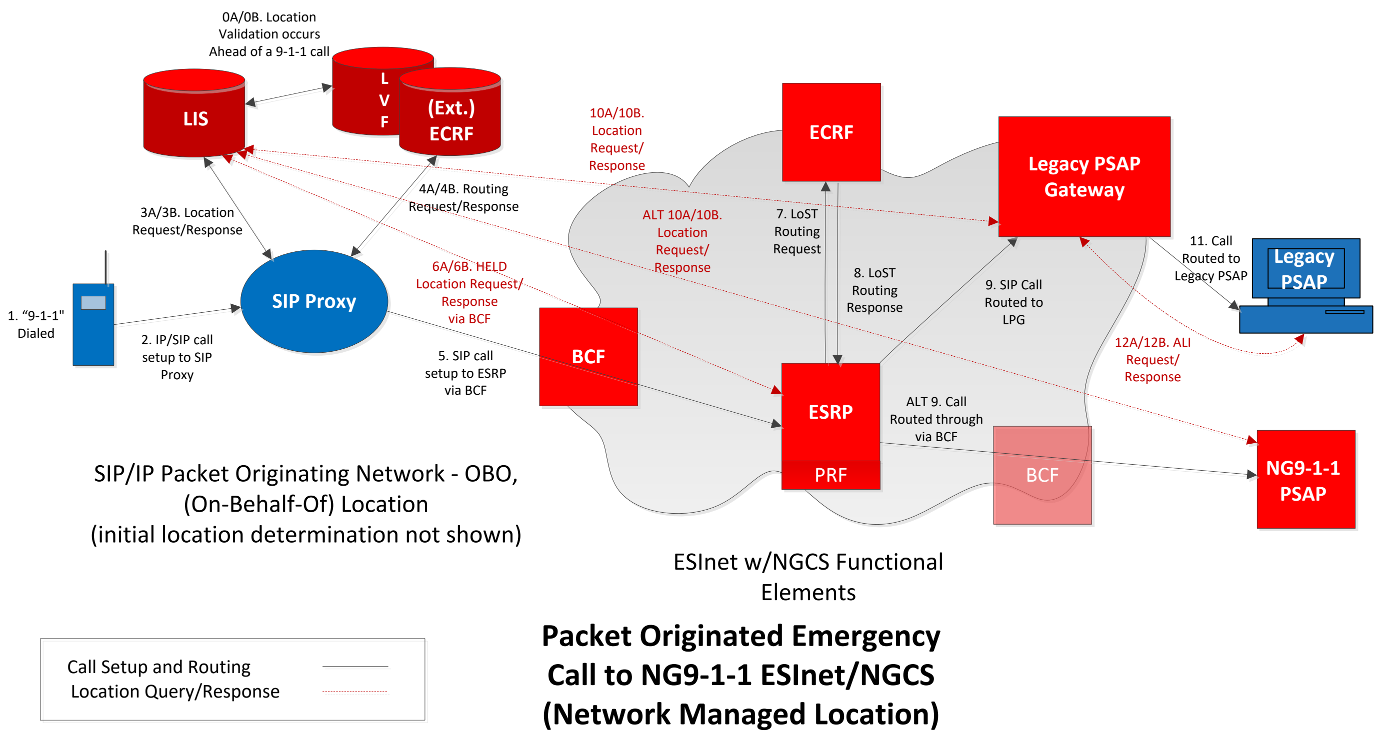


FIGURE 11 *NG9-1-1 CALL FLOW DIAGRAM*

In the diagram, the following call flow steps are numbered and correlate to the diagram above.

(0A) Validation request for stored location is sent from the LIS to the LVF (this step happens ahead of the emergency call)

(0B) LVF returns a location validation response to the LIS (this step happens ahead of the emergency call)

(1) Emergency call initiated by dialing 9-1-1

(2) The SIP/IP call is sent to the SIP service provider's SIP Proxy

(3A) SIP Proxy requests location for the caller's device from the LIS

(3B) LIS returns location and a location URI (for later dereferencing) to the SIP Proxy

(4A) SIP Proxy requests initial ESInet routing instructions from the external ECRF

(4B) External ECRF returns routing instructions (next hop URI) to the SIP Proxy

(5) SIP Proxy sends call to the ESRP via the BCF

(6A) ESRP requests location information from LIS

(6B) LIS returns location information to the ESRP

(7) The ESRP initiates a LoST query to the ECRF using the received location and service URN

(8) The ECRF returns the next hop route URI in the LoST response

Case 1: LEGACY PSAP Call Delivery

(9) The call is routed to the LPG based on the next hop route URI returned in the previous step, and includes the location URI

(10A) The LPG makes a dereference request using the location URI back to the LIS

(10B) The LIS returns the location information within a PIDF-LO, potentially containing both civic and geodetic location – if available

(11) The LPG converts the call from SIP to TDM (analog) signaling, creates a pANI, and sends the call to the legacy PSAP call handling equipment

(12A) The legacy PSAP does an ALI query based on the pANI provided in the previous step

(12B) The LPG returns location information to the PSAP

Case 2: NG9-1-1 PSAP Call Delivery

(ALT 9) The call is routed from the ESRP through the BCF toward the NG9-1-1 PSAP

(ALT 10A) The NG9-1-1 PSAP requests location

(ALT 10B) Location information is returned to the NG9-1-1 PSAP

B. What is an ESInet?

An ESInet, or Emergency Services IP network [12], is a managed IP network used for emergency services communications that is designed to be shared by all public safety agencies. The network must meet more stringent requirements for security and reliability service levels than a traditional IP network. The ESInet is *the network* that

> As explained in Chapter 1, if NG9-1-1 is a transportation system, the ESInet is the roadway; the NG9-1-1 Core Services (NGCS) are the traffic control devices, rules and laws which govern traffic flow; and the vehicle occupants are the data being transported (calls, texts, call data, etc.)

provides transport services for 9-1-1 related voice, signaling and other data. This network provides the IP transport infrastructure upon which independent application platforms and core functional processes can be deployed, including but not restricted to, those necessary for providing NG9-1-1NGCS. ESInets may be interconnected at local, regional, state, national and international levels to form an IP-based inter-network.

ESInets use broadband, packet switched technology capable of carrying voice plus large amounts of varying types of data using Internet Protocols and standards. ESInets are engineered, managed networks, and are intended to be multi-purpose, supporting extended public safety communications services in addition to 9-1-1. NG9-1-1 assumes that ESInets may be hierarchical, or a network of networks in a tiered design approach to support local, regional, state and national emergency management authorities.

Chapter 3 Building Blocks

This section describes on a high level, the building blocks to NG9-1-1NGCS. The building blocks include FEs, interfaces and protocols, databases, security and administrative processes.

A. Interfaces

Network interfaces between varying E 9-1-1 systems today are antiquated and are subject to end-of-life support issues, security vulnerabilities, low processing performance, and limited data that can be conveyed using them. NENA's i3 design approach to NG9-1-1replaces existing legacy TDM circuits and interfaces with IP based SIP and HTTP [21] styled protocols. New interfaces to convey signaling, media, logging, and additional data have been created using these protocols as defined in the i3 specifications.

1. Data Formats

NG9-1-1 leverages a new data format to convey information. The common format for conveying location in i3 is the PIDF-LO format, based on the NENA defined Civic Location Data eXchange Format (CLDXF) [11] standard and implemented using eXtensible Markup Language (XML). The following shows an example of location information encoded within a PIDF-LO XML format.

Example. Let's assume we want to encode a civic street address within a PIDF-LO document of the form, "123 Main Street, Morristown, PA, US 37815." The following XML representation shows a short extract of the standardized PIDF-LO form. (Note that country code of US is assumed.)

```
<civicAddress xml:lang="en-US"
 xmlns="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr">
 <country>US</country>
 <A1>PA</A1>
 <A3>Morristown</A3>
 <RD>Main</RD>
 <STS>Street</STS>
 <HNO>123</HNO>
 <PC>37815</PC>
</civicAddress>
```

B. Functional Elements

FEs are a set of software and/or hardware ***elements*** which perform tasks or ***functions*** within the i3 architecture. FEs perform various tasks, including but not limited to: conversion from legacy to NG9-1-1 signaling, security, call routing, and call handling. For databases and applications, FEs may GIS, additional call data, web or user interface functions, or other general location information. The functions performed by each FE are described in high level terms in this document.

FEs have well-defined interfaces and protocols in which to communicate or interact with other functional elements. Interfaces defined by i3 are connections to external elements or networks. Protocols are a set of procedures for handshaking and exchanging information between elements or networks. i3 standards and protocols are developed to help ensure interoperability between FEs and other NG9-1-1 systems across the network.

FEs do not necessarily need to interact or interface with every other FE in the i3 architecture. However, all FEs as a whole create an NG9-1-1 system or service, otherwise known as NG9-1-1NGCS.

Encryption will be critical in NGCS. With so many elements communicating and exchanging data, great care must be taken to ensure the information cannot be read while in transit (routed) or at rest (stored).

1. Border Control Function

The Border Control Function (BCF) is the security element located at each entrance/exit to the ESInet. It is comprised of two security functions, a Session Border Controller (SBC) and a firewall that sits between the ESInet and external networks, or other elements and services. The BCF provides a secure entry for emergency calls presented to the network and protects NGCS from various types of attacks. In addition to security, the BCF may be able to provide protocol interworking, translations, and interoperability between various FEs across different domains. The BCF is the first (ingress) and last (egress) element in any call flow for NGCS.

The BCF performs three major functions:

- Acts as a firewall for the ESInet
- Acts as a potential media anchoring element
- Acts as a session border controller

As a firewall, the BCF:

- Establishes a barrier between trusted, secure internal network, such as the ESInet, and other networks assumed not be secure or trusted
- Enforces network access control

- Controls, identifies, verifies, regulates and enforces incoming and outgoing traffic

As a media anchoring element, the BCF:

- May perform protocol conversion between dissimilar calling networks
- Supports transfers of emergency calls and acts as a conference bridge with interactive voice recognition
- Isolates media between networks

As a session border controller, the BCF:

- Controls and mediates signaling, encryption and media flow
- Governs call set-up, call exchange of media and call termination
- Provides security and interoperability during a session (call) in an IP network
- Provides call quality, availability, service level agreement (SLA) and other statistics

2. Emergency Call Routing Function

Though its name implies that it performs call routing functions or tasks, the Emergency Call Routing Function (ECRF) [13] provides a set of data in the data layer to allow or steer other elements to route calls at the communications layer. As described in the next section, the routing proxy queries the ECRF to determine where it should normally route a call.

The ECRF utilizes the location of the calling device and the service URN (e.g., urn:service:sos) to determine the correct path for the 9-1-1 call to reach the correct PSAP. When a 9-1-1 call is placed, the location of the calling device is known, and this location comes with the call. This location and the service URN being requested is sent to the ECRF by the ESRP. The ECRF utilizes internal GIS data to determine the appropriate destination and the ESRP routes the call to the appropriate PSAP.

To visualize this concept, imagine a call is received from 15 2nd Street in Figure 12 below. The top GIS layer depicts address points, indicated by the blue dots. The middle GIS data layer shows a street layer indicated by the black lines. The bottom GIS data layer is the PSAP Service boundary layer. The location of the call received from 15 2nd Street falls within the city PSAP boundary. The 9-1-1 call would be routed to the city PSAP, provided there was no overriding policy rules to change the routing.

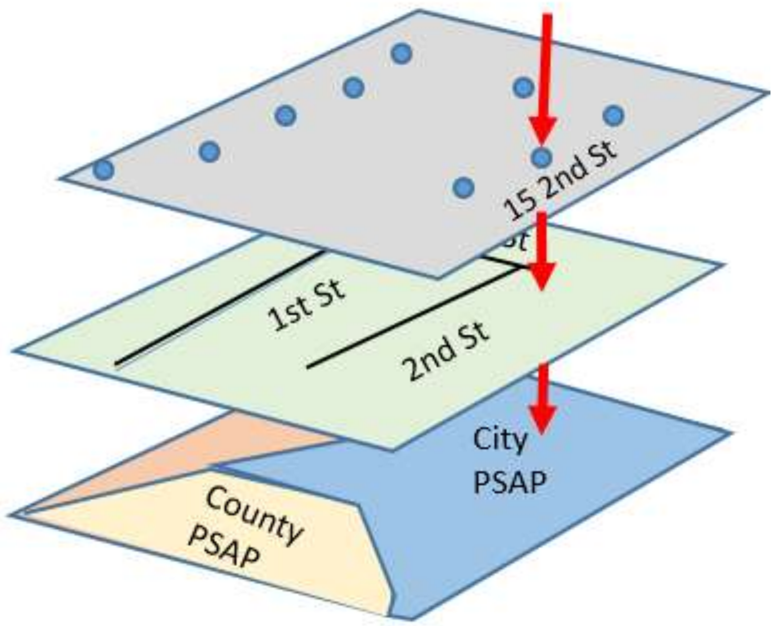


FIGURE 12 *GIS DATA LAYERS*

3. Emergency Services Routing Proxy

The ESRP contains a set of rules in order to route the 9-1-1 call. The ESRP works with the ECRF to determine which PSAP should receive the call based on location and policy routing. For example, the ESRP considers other factors, such as the availability of the destination PSAP to take calls, specific language requested, etc. If a PSAP is unavailable to accept calls for whatever reason, a preconfigured rule can be created that will cause the ESRP to route the call to a different PSAP. The logic used by the ESRP to make the routing decisions is called the Policy Routing Function (PRF), which is a configurable part of the ESRP. The PRF is configured with input from all stakeholders – PSAPs, regions, and state entities.

The ESRP performs several key tasks:

- The ESRP sends the caller's location and request for service to the ECRF. In response, the ECRF sends the destination of the requested service, generally the appropriate PSAP back to the ESRP.

- The ESRP uses the returned destination of the service to route the call to the correct PSAP or emergency agency.
- Before the ESRP connects the call with the returned destination service it evaluates the policies in the PRF, to determine if any policies are in place to override the destination of the call.

a. Policy Routing Function

The ESRP utilizes the PRF to determine the next hop in the delivery of a 9-1-1 call when the intended destination is unavailable. The PRF implements rules based on policies subject to agreements between 9-1-1 Authorities. The PRF utilizes the policy rules set by the 9-1-1 Authority to allow the rerouting of calls based on certain conditions or criteria. The ESRP utilizes policy rules within the PRF to modify the normal routing of a 9-1-1 call based on conditions including:

- Overload conditions such as the number of calls in a call queue
- Service state such as scheduled maintenance, scheduled upgrade, and network or equipment failure
- Available Telecommunicator skill sets, or
- Other criteria based on information associated with the call

4. Location Validation Function

The LVF, is an i3 Functional Element. In a full i3 implementation the LVF works with the LIS to validate the location of a civic address prior to a call being placed to 9-1-1. The functionality of the LVF within NG9-1-1 replaces the E 9-1-1 master street address guide (MSAG) validation in legacy 9-1-1 environments.

The civic location of the calling device is validated against the same GIS data used by the ECRF. During the validation process, if the civic location provided to the LVF is invalid, a discrepancy report is generated indicating the location validation was unsuccessful. When a discrepancy report is generated, notification is provided back to the entity identified within the GIS data as the agency to receive GIS data discrepancies. This agency will take responsibility for ensuring discrepancy resolution and may or may not be the same as the 9-1-1 Authority. For more information on discrepancy reporting please reference NENA-REQ-002 – NENA Next Generation 9-1-1 Data Management Requirements.

The LVF obtains the GIS data from the 911 Authority that flows through the Spatial Interface (SI). The SI provisions GIS data to both the LVF and the ECRF.

a. Location Information Server

After the civic location of the calling device is determined to be valid by the LVF, the location is then stored in the Location Information Server (LIS) in the OSP network. In

NG9-1-1, the LIS is designed to replace the ALI database that is used in legacy E 9-1-1, however, the LIS only contains location information but does not contain customer name, phone and related caller information, which is supplied by the additional data repository (ADR).

The LIS also provides location information at the time of call for IP-capable VoIP and other devices capable of contacting 9-1-1.

b. Additional Data Repository (ADR)

An ADR is a database that holds additional data about an emergency call, caller, or location related to an incident. A partial list of additional data content includes data about the network or service provider, the device, the caller's medical details, site structure floorplans, and on-site hazards. HTTP links to an ADR may be passed with the call. PSAPs use the link to retrieve the data using a standard HTTPS "GET" request. The ADR is defined in NENA-STA-010, along with a minimal set of data that must be provided. Originating networks and service providers are expected to provide at least this minimal set of data on every call, which is, at a minimum) basically equivalent to what is typically provided in ALI.

c. Identity Searchable -Additional Data Repository

Some ADRs allow the repository to be searched by identity. For example, personal medical data about the caller may be stored by a service trusted by the caller to keep such data. The Identity Searchable – Additional Data Repository (IS-ADR) provides a web service that returns the data when a PSAP system sends a request that provides the caller's identity, e.g., the telephone number. Additional details about the IS-ADR can be found in NENA-STA-010.

5. Legacy Network Gateway

The LNG converts older telephone network trunking (e.g., Signaling System 7) into an IP format. The LNG allows i3/ NG9-1-1 PSAPs to receive emergency calls from legacy networks and accesses location and additional data from legacy networks. The LNG is a signaling (request for service) and media (audio path) interconnection point between callers in legacy wireline/wireless originating networks and the i3 architecture. This function is on the ingress side of the ESInet and sends calls to the BCF. In this configuration, the traditional method of caller location information is parsed into the NG9-1-1 format by the LNG. The LNG appends the callers' location information into the IP output delivered to the ESInet and enables location information to accompany the call as it is routed to the NG9-1-1 PSAP. The LNG also converts i3 originating calls into E 9-1-1 formats for delivery from the ESInet to legacy PSAPs. As long as there are legacy originating service providers connected to the ESInet, there will be a need to have an LNG.

6. Legacy PSAP Gateway

The LPG performs a similar function to the LNG, in that the LPG converts between IP and non-IP protocols used by legacy PSAPs. The LPG is a signaling (call setup) and media (for example, voice, video, text) interconnection point between the ESInet and the legacy PSAP. And unlike the LNG, which is on the ingress side of the ESInet; this function is on the egress side of the ESInet and sends calls to the PSAP (in some implementations there may be a BCF prior the LPG serving the PSAP).

7. Call Handling Function

The Call Handling Functional Element (CHFE) within the PSAP includes interfaces, equipment and software applications necessary for agencies to receive and process incidents. As communications technology develops, call handling will need to process not only 9-1-1 voice calls, but also non-traditional methods of requesting emergency service, including text, video, automatic crash notifications, etc. Additionally, it will be necessary for each PSAP to not only have CPE capable of connectivity to an ESInet, but to have an interface for that connectivity [3]. In NG9-1-1 the call handling function for the PSAP may be physical equipment located at the PSAP or in a central location; or it may be cloud-based software with limited hardware on the premises.

8. Logging Service

In NENA's i3 standard for NG9-1-1 (NENA STA-010 [4]), logging functionality is provided by the Logging Service which is one part of the NG9-1-1NGCS, and therefore must not have any single point of failure and must be available to all elements in an ESInet, and in a PSAP. A PSAP can have its own Logging Service, which might include physical equipment located at the PSAP; or it can use a Logging Service in the serving ESInet or in another PSAP. If a PSAP has its own Logging Service, it may use an external Logging Service for redundancy. 9-1-1 Authorities should consider how Logging Service redundancy will be implemented to provide the high availability required.

The NG9-1-1 Logging Service differs from a legacy logging recorder in four key ways:

1. In addition to recording voice, it records video and text communications (including from automated devices and sensors)
2. It records call processing events from entry into the ESInet until the call ends, including call transfers
3. It records incident processing events from the beginning to the end of the response

4. It has standardized interfaces for searching and retrieving all recorded media and events

a. Event Logging

The NG9-1-1 Logging Service also logs call and incident processing events, each stamped with the time the event occurred. Event logging begins with the first element the call hits, in the first ESInet that receives it, and continues through the routing process, and through the call handling and incident processing that occurs in the PSAP. Each element that handles the call must log the start and end of its processing. Database queries and responses that occur along the way are also logged, as are all the SIP messages sent and received. Changes to the state of the call are logged (ringing, answered, on hold, etc.), and changes to an agent's state (waiting, on a call, in wrap-up, on break, etc.) are also logged. When incident data is sent from one system to another in an Emergency Incident Data Document (EIDD), that data is always logged. The Logging Service contains a great deal of detail about the call, the caller, incident location(s), and how the incident was processed. And all this event data is tied to the media recording by the unique NENA Identifiers.

b. Unique NENA Identifiers

The BCF assigns a NENA Call Identifier and a NENA Incident Tracking Identifier, prior to the start of the logging service. If the call is transferred to another PSAP or the incident is dispatched by another agency, these identifiers go along with it, and effectively tie everything together for a complete record.

c. Media Recording

The NG9-1-1 Logging Service must record all multimedia including text. The text media type includes Real Time Text (RTT) (a character at a time), Message Service Relay Protocol (MSRP) (chat or instant messages, also used to deliver SMS initiated text messages), and automated device data from sources like vehicle telematics, sensors of various types, and automated alerts of various types.

d. Search, Retrieval and Playback

The NG9-1-1 Logging Service has a standardized interface for search queries, and for retrieval and playback of media or text data. Standardized interfaces provide interoperability between different vendors' Logging Services and make it possible for an authorized 9-1-1 Authority to reconstruct the entire record of a call and/or incident, even if parts of the record exist on different vendors' platforms. And with the unique NENA Identifiers and the timestamped processing events, the record produced will give a fairly accurate picture of what was known at a given point in the processing of an incident.

It is important for the 9-1-1 Authority to ensure that the logging service procured allows PSAP personnel end users, such as the telecommunicator, dispatcher or call-taker to have easy, immediate access to recordings. This information must be readily available to PSAP personnel in order to assist in responding to 9-1-1 calls.

C. Interfaces and Protocols

As mentioned throughout in this document, NENA's i3 design approach to NG9-1-1replaces existing legacy TDM circuits and interfaces with IP packet-based interfaces with SIP and HTTP messaging protocols. NGCS as it is defined, is implemented over an ESInet, and comprises a number of FEs. Each FE does one or more jobs, or functions within the NGCS, and each FE has one or more interfaces that send and receive messages using a specific protocol to and from other FEs.

In NG9-1-1 an interface can be thought of as a pathway to support communication between FEs, and a protocol can be thought of as the agreed to language used across that pathway.

The protocols used for NG9-1-1 not only support a standardized means of exchanging data values, but also support the necessary signaling instructions to allow FEs to exchange data. Another way to explain protocols is to think of them as a set of pre-defined rules for handshaking and exchanging information between elements or networks. The NENA i3 design uses standardized protocols to help ensure interoperability between different FEs within an NG9-1-1 system and between other NG9-1-1 systems.

Examples of protocols used in NG9-1-1, and how they apply include:

- SIP – Session Initiation Protocol - an IETF defined protocol (RFC 3261) that defines a method for establishing multimedia sessions over the Internet. Used as the call signaling protocol in VoIP, i2, and i3.
  One example: SIP is used to setup the initial 9-1-1 call, and to convey various signaling requests between the caller and the PSAP, apart from the media (voice), throughout the call, for example, including the ability for the PSAP to terminate the call.

- HTTP – Hypertext Transfer Protocol – HTTP is a messaging protocol designed to send and receive data between two different FEs in an NG9-1-1 system.
- HELD (Deref) – HTTP-Enabled Location Delivery (Dereference) - HELD (Deref) is a protocol (RFC 6753 [21]) designed to request and convey location information via the HTTP protocol that it was built on top of. HELD (Deref) can be used to acquire location information (LI) from a LIS within an access network as defined in IETF RFC 5985.
- LoST – Location-to-Service Translation – LoST (RFC5222 [22]) is a protocol designed specifically to request and convey location information to and from a LoST server. In NG9-1-1 it is used generally for location-based call routing.

1. Databases

NG9-1-1 uses a set of database systems to house and provide management of the data content. NG9-1-1 databases include: location validation, routing control, policy/business rules, and system-wide detail call records. NG9-1-1 provides the mechanisms to access external sources of data via the ESInet, either automatically or manually, to support more knowledgeable and efficient handling of emergency calls/messages. External databases include: telematics/advanced automatic crash notification (AACN) data, hazardous material information, building plans, and medical information.

2. Security

NG9-1-1 provides extensive security methods at the hardware and software levels to replicate the privacy and reliability inherent in E9-1-1 services. It is highly recommended users reference the NG-SEC [15] standards and information documents to assist in writing RFPs and to aid in determining the security capability of their NG9-1-1 network.

3. Human process

NG9-1-1 as a service system involves a multitude of human procedures and system operations procedures to control and monitor the functionality and effectiveness of the systems and services that provide NG9-1-1. Examples include database establishment and maintenance procedures, IP network operations, security processes, troubleshooting procedures, database auditing and accuracy validation procedures.

Chapter 4 Expanding 9-1-1 Service toward NG9-1-1 Evolution

A. Interim SMS Text-to- 9-1-1

In 2012, the big four wireless carriers AT&T, Sprint, T-Mobile and Verizon, together with NENA and APCO reached an agreement to support an interim text-to- 9-1-1 solution. The interim short message service (SMS) text-to-9-1-1 solution is for the most commonly utilized texting technology. In addition, the agreement provides for a bounce back message to be delivered if a person attempts to send a text in an area where text-to- 9-1-1 is not supported. The bounce back message will explain that text is not available and to attempt to reach 9-1-1 with another method.

The wireless carrier will utilize a third-party network element referred to as a Text Control Center (TCC) to route the text messages to a PSAP, much like wireless carriers and VoIP providers use to route 9-1-1 calls today. The wireless carrier will recognize the short code of 9-1-1 and forward the text message to the TCC. The TCC will query the wireless carrier's commercial location server to determine a course location and utilize this information to route the call toward the correct PSAP. Unlike wireless 9-1-1 calls, text-to- 9-1-1 will be routed based on the commercial location services or fall back to the centroid of the cell sector. This is similar to wireless Phase I location information; however, it may not be the same in all cases. The solution provides the general location of the caller, similar to a wireless Phase I location. In some cases, more granular location information is available.

Currently, the solution will be deployed within the wireless carrier's home networks and is not supported when a customer is roaming. Unlike wireless calls to 9-1-1, the service will be limited to current wireless customers with a texting plan. A PSAP will not receive text messages from Non-Service Initialized (NSI) devices.

As a transitional solution, Interim SMS text-to- 9-1-1 allows the public to use existing SMS-based texting to text 9-1-1 when making a traditional call for help might place them in additional danger, such as in an active shooter or domestic abuse situation. It also provides individuals who are deaf, deafblind, hard of hearing or have a speech disability equal access to 9-1-1 for the first time in history!

The interim SMS solution was created to provide text access to all PSAPs through legacy options like a TTY interface or a web browser solution. As PSAPs transition to IP based call delivery the third option of the interim solution allows for IP delivery of a text integrated into the call handling equipment. The TCC may connect directly to the PSAP via an IP network or the TCC may connect to an ESInet, and the ESInet will route the call to the PSAP.

1. TTY Transition to Real Time Text

As communication technologies have become more advanced, individuals who are deaf, deafblind, hard of hearing or have a speech disability have begun using video calls and Real Time Text (RTT) in place of traditional TTY for communication. Wireless carriers, as well as Apple and Android mobile phones, are now including RTT as part of their operating systems. FCC 16-169 allows wireless providers and interconnected VoIP providers using wireless technology to move away from TTY support and replace it with RTT support. Where TTY technology remains in lieu of RTT, either with the OSP or at the PSAP, RTT will be converted to Baudot tones which may create conversion anomalies in the transmitted information (e.g. special characters, garbled messaging, etc.).

The initial deployment called for the delivery of RTT into the PSAP via TTY beginning December 31, 2017 for tier 1 wireless service providers, which chose to support RTT in lieu of TTY, on at least one device with one type of technology (native vs. application). These deployments supported Voice Carry Over (VCO) and Hearing Carry Over (HCO). By December 31, 2019, each wireless provider choosing to support RTT in lieu of TTY over IP facilities shall support RTT for all new authorized user devices. As OSPs migrate to i3-compliant IP networks, they will have the capability to deliver RTT natively to the ESInet. As ESInet and PSAP systems and technologies evolve, RTT originated by OSPs will be delivered directly to i3-compliant PSAPs without a transition to TTY. These native RTT calls will incorporate simultaneous audio which emulate VCO and HCO.

a. Analog-to-Digital Telephone Network Transition

Analog telephone lines are expensive to maintain, rely on switches and other parts that may no longer be manufactured, and do not always interface well with the newer technologies that still use old copper wires, especially in rural areas. Consequently, they are problematic in many VoIP implementations as most voice digitization and compression codecs are optimized for the representation of the human voice and the proper timing of the modem signals cannot be guaranteed in a connection-less network.

The incompatibility between analog and VoIP network may have an adverse impact on the usage of analog equipment such as TTY; data traveling across a computer network may fail to reach its destination during transmission which is known as a packet loss. This means that one can expect to exceed the one percent character error rate threshold recommended by the FCC when the packet loss rate is only 0.12%, an amount far below what is often regarded as acceptable for voice communication. Voice-optimized packet loss concealment algorithms are *not* able to trick a TTY into hearing a TTY tone (data bit) that was not received. If any one of the audio packets containing a TTY tone is lost, the receiving TTY will be unable to decode and display that character properly [25]. There appears to be no effort from TTY manufacturing companies to update TTYs to accommodate VoIP or digital phone systems.

The FCC is working on the biggest transformation in over a century of profound technological progress in communications: shutting down the analog telephone network. The big carriers have already started to sunset the Public Switched Telephone Network (PSTN) with reduction of support, increase in costs, and elimination of a replacement. These changes are a technological revolution.[1]

It is important to note that the current SMS text-to- 9-1-1 solution will **not** be replaced by RTT; but rather both solutions may be deployed at a PSAP[2].

B. Other Types of Media

Once central NG9-1-1 capability exists in a state or region, a major evolution step is the implementation of OSPs to incorporate IP-based architectures and interconnect native IP to the NG9-1-1 NGCS. Having IP end to end for NG9-1-1 enables various features and operational aspects of the NG9-1-1 design, including

- multi-media (various forms of text, pictures, video, certain additional data)
- future use of caller location, when available, sent literally with the 9-1-1 call or message, allowing more accurate routing and caller location display
- expanded additional data options
- ability for the caller and the PSAP to hold interactive text, voice, and video conversations

NENA's i3 architecture for NGCS is designed to deliver much more than phone calls to the PSAP. In addition to voice calls, the NGCS system supports video and text calls, and all calls are delivered with the device's location attached. Whatever the call type, other information about the call, the caller, or the caller's location (called additional data) can

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[1] https://www.fcc.gov/news-events/blog/2013/11/19/ip-transition-starting-now (Retrieved on November 15, 2013)

[2] https://sites.atis.org/insights/new-atis-standard-specifies-mobile-device-behavior-real-time-texting/

be delivered with, or during, the call. Examples would be a caller's medical data, or information about a building the caller is in, or near.

Two kinds of text calls are supported. One is RTT, which is delivered a character at a time, like TTY. RTT will replace TTY over time. The other kind of text call uses MSRP. MSRP delivers a whole message at a time, like traditional chat services, and can support multiple parties in a conversation. In NG9-1-1, SMS text messages are converted to MSRP by the service providers TCC and delivered to the ESInet.

Another type of call that the NGCS can deliver is referred to as a non-human-initiated call. This is a data-only call from some device or application. One example would be an automatic crash notification message sent by a vehicle. Another example would be a nuclear, biological, or chemical sensor. In the Internet of Things world that is evolving, there will likely be many sources of non-human-initiated calls that can alert a PSAP of an emergency without the help of a citizen. As service providers migrate to pure IP-based services, they will deliver more and more of the rich data that the NGCS supports, providing both the public and PSAPs with more enhanced emergency services. The transition will happen over a period of years, gradually for some technologies, and in leaps and bounds for other technologies. Public demand, funding, service providers, and governance and regulatory issues will all play a role in determining how, and how fast, NG9-1-1 evolves.

C. FirstNet and its relationship to 9-1-1

Signed into law on February 22, 2012, the Middle Class Tax Relief and Job Creation Act created the First Responder Network Authority (FirstNet). The law gives FirstNet the mission to build, operate and maintain the first high-speed, nationwide wireless broadband network dedicated to public safety. FirstNet will provide a single interoperable platform for emergency and daily public safety communications.[3]

This broadband network will fulfill a fundamental need of the public safety community as well as implement the last remaining recommendation of the 9/11 Commission. FirstNet will bring 21st century tools to millions of organizations and individuals that respond to emergencies at the local, state, tribal, and federal levels.

[3] About FirstNet https://www.firstnet.gov/

Congress established FirstNet as an independent government authority with a mandate to provide specialized communication services for public safety. Using nationwide 700 MHz spectrum, FirstNet may put an end to decades-long interoperability and communications challenges and help keep our communities and emergency responders safer.

The construction of the Nationwide Public Safety Broadband Network (NPSBN) by FirstNet will result in an IP network over which public safety responders will be able to access mission critical data, such as real-time video, pictures, documents, etc. Since the network will be dedicated to public safety, public safety will have priority and pre-emptive capabilities, applications may be developed to take advantage of the dedicated bandwidth to allow public safety to access data. Currently, first responders are unable to access next generation data due to the limitations of using commercial networks and sharing that bandwidth with commercial users. The NPSBN will create tremendous opportunities to enhance the abilities of first responders to perform their life-saving missions.

The opportunity exists for states to identify synergies between the two networks (NPSBN and ESInets) and how they may interface with each other to share data – in some cases, where common assets may be utilized by both networks. State and regional leaders of NG9-1-1 implementation should be actively engaged in the planning and execution of their state's FirstNet initiatives to advocate for the integration of the two networks. With this type of coordination, the state's ESInet may converge with the NPSBN to form a new IP based broadband communications platform to serve public safety from end to end.

NGCS and ESInets will allow citizens to provide not only voice and text to 9-1-1, but also other forms of data such as pictures and video. NG9-1-1 data will be delivered to the ESInet from the carrier's commercial network, processed by the NGCS and delivered to the PSAP via the ESInet. The PSAP will then be able to disseminate the data to first responders via the NPSBN. First responders may then be able to receive data from an incident in real time from citizens on scene, prior to their arrival, thus providing first responders with situational awareness never previously experienced. Photographs from a scene will allow PSAPs to coordinate the appropriate resources for responding to the incident, instead of reacting after responders arrive on scene. This functionality will provide first responders with the best information available to determine the most appropriate approach, such as the capability to launch pre-arrival tactics.

Appendix A: Glossary

See NENA-ADM-000, NENA Master Glossary of 9-1-1 Terminology, located on the NENA web site for a complete listing of terms used in NENA documents. All abbreviations used in this document are listed below, along with any new or updated terms and definitions.

Term or Abbreviation (Expansion)	Definition / Description
ASD (Acute Stress Disorder)	ASD refers to clinically significant (causing significant distress or impairment in social, occupational, or other important areas of functioning) symptoms more than two days but less than one month after exposure to a trauma, as defined above (may progress to PTSD if symptoms last more than one month).
FCC (Federal Communications Commission)	An independent U.S. government agency overseen by Congress, the Federal Communications Commission regulates interstate and international communications by radio, television, wire, satellite and cable in all 50 states, the District of Columbia and U.S. territories.
i3 PSAP (i3 Public Safety Answering Point)	A PSAP that is capable of receiving IP-based signaling for delivery of emergency calls and for originating calls and is conformant to NENA specifications for such PSAPs.
Virtual PSAP	An operational model directly enabled through NG9-1-1 features and/or network hosted PSAP equipment in which telecommunicators are geographically dispersed, rather than working from the same physical location. Remote access to the PSAP applications by the dispersed telecommunicators requires the appropriate network connections, security, and work station equipment at the remote location. Unified communications applications supporting voice, data, instant messaging, and video communications between telecommunicators may be used to enable the telecommunicators to work cooperatively from diverse locations. The virtual work place may be a logical combination of physical PSAPs, or an alternate work environment such as a satellite facility, or any combination of the above. Workers are connected and interoperate via IP connectivity.

Appendix B: Recommended Reading and References

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