Maintaining Public Safety Communications in Disaster Situations

Key Requirements for Uninterrupted, Interoperable Communications

Abstract

A disaster situation requires an immediate coordinated response by multiple public safety agencies. To address the needs of personnel on the ground and in command centers, an effective emergency communications network should allow public safety agencies to maintain multiple levels of communications connectivity during an entire operation: local connectivity among first responders on scene, wide area connectivity between in-field personnel and command and control centers, and between all personnel at all levels with private and public wide area networks. A dedicated wireless broadband network that can be easily deployed and configured as needed, provides the ideal solution for any disaster response effort.
Table of Contents

The Need for Ubiquitous, Uninterrupted Communications ................................................................. 4

Maintaining Critical, Real-time Communications Links ........................................................................ 5
  Key Criteria for the Ideal Network ..................................................................................................... 6

Building an Effective Disaster Response Communications Network ................................................ 7
  Leverage Mesh Technology ................................................................................................................ 8

Harness LTE ........................................................................................................................................ 9

Extend Coverage with Satellite ............................................................................................................ 9

The General Dynamics Rapidly Deployable Network Solution ................................................................ 11
  Deployable Wi-Fi Mesh Networks ....................................................................................................... 11

Integrated Broadband Network ........................................................................................................... 11

Advanced Tactical Communications .................................................................................................... 12

Next-generation Network Radios ........................................................................................................ 13

Conclusion ........................................................................................................................................... 14

Acronyms ............................................................................................................................................ 15
List of Illustrations

Figure 1: Three key elements for an effective disaster response communications network.........................5

Figure 2: A communications network optimized for disaster response....................................................7

Figure 3: Extending public safety networks with wireless mesh networking.............................................8

Figure 4: A complete, rapidly deployable, disaster response communications network..........................10

Figure 5: A fully-deployed General Dynamics LTE Network In A Box......................................................12
The Need for Ubiquitous, Uninterrupted Communications

Public safety agencies know that when disaster strikes effective, uninterrupted communications is the key to containing any situation, protecting citizens, and saving lives. Continuous communications between first responders on site and command and control centers ensures that everyone at all levels has the most accurate information available to properly assess a situation, make operational decisions, and adjust response efforts by fire, police, and emergency medical teams. In these situations, a reliable, fully-operational communications network is critical. It provides the vital link between personnel in the field and their colleagues, and with forward and central command centers.

But although public safety communications networks are designed and built with a high level of reliability, they are not 100 percent disaster proof. Therefore, maintaining that vital link in a disaster situation is often not possible. Often, these networks may be compromised and not capable of providing the full functionality required to support the complete portfolio of public safety voice, video and data communications services and applications. Sometimes, the network infrastructure may not be available at all because the power grid that enables it has been damaged. Or when the networks are available, they may not be able to provide coverage in all affected areas.

In these situations, using commercial wireless broadband networks is not an option. These networks were not originally deployed with first response use in mind. They were not designed to support the mission-critical applications public safety agencies need for uninterrupted, real-time communications. In addition, they are not optimized to prioritize public safety traffic in disaster situations. Since public networks that survive a disaster may be overloaded with commercial traffic, public safety operations may be compromised because they cannot ensure first responder communications takes priority over commercial traffic.

To fulfill their mandate in these situations, public safety agencies need communications networks they can rely on to support any operational requirement. If the network goes down, operations teams should be able to easily re-establish communications services with network solutions that ensure in-field personnel and command centers can continue to communicate at all times. These networks should support regular devices, so that first responders do not have to adapt to new equipment in the field, while trying to manage disaster response operations.

A dedicated wireless broadband network that can be easily deployed and configured as needed, provides the ideal solution for any disaster response effort. Ideally, that network should support the frequency bands designated for public safety and first responders, such as 700 MHz LTE and 4.9 GHz, to leverage current investments and comply with any existing regulatory requirements. Plus, it should take advantage of ad-hoc networking solutions for rapidly deployable systems that can work in standalone mode and connect back to wider area networks.
Maintaining Critical, Real-time Communications Links

A disaster situation requires an immediate coordinated response by multiple public safety agencies. In these situations, communication and coordination among first response teams is critical for the success of the operation. To be effective, all teams arriving on a scene need a communications network that enables instant collaboration between in-field personnel, with central command, and with other agencies. That network must support the deployment of emergency communications network elements in remote areas. It must easily scale from a small, on-site, ad-hoc network to a larger multi-site network, if required. And it must easily interconnect with similar networks, as needed.

Public safety networks based on these requirements are usually built on three key elements during a disaster situation (Figure 1):

- **Transportable network infrastructure elements** in the form of Cell On Light Truck (COLT) and Cell On Wheels (COW), which allow equipment to be placed directly in the disaster area. These network elements are typically scaled down versions of similar components in a permanent network infrastructure. They enable disaster response teams to establish a Mobile Command Post (MCP) on site to coordinate all disaster response efforts. The MCP gathers the most up-to-date information of the incident, coordinates the response locally and with a central command and control center, dispatches first responders, and provides in-field personnel with situational awareness information they can use to effectively respond to the incident.

- **A peer-to-peer network**, which enables the MCP to share mission critical information with all first responders on the scene. An MCP typically includes all the equipment required to create a small standalone wireless network and the associated command and control operation, making it a self-contained operation center. The wireless network can be a private cellular network, a Wi-Fi® hotspot or a Wi-Fi mesh over which first responders can use their regular wireless devices, or specialized first responder devices, such as push-to-talk radios.

- **A communication link** back to a central command and control center, which provides a way for first responders to access private and public IP networks for any additional communications support services and applications they need. The MCP links to IP network and a central command and control center via this backhaul link.

**Figure 1: Three key elements for an effective disaster response communications network.**
Unfortunately, the ability of public safety agencies to create these networks in disaster situations is hampered by the limitations of the Land Mobile Radio (LMR) systems that form the backbone of most public safety communications networks. This technology makes poor use of the frequency spectrum and is limited to voice communication only.

Typically, most public safety agencies rely on analog LMR systems operating on reserved frequencies. These systems were purchased independently by each agency to support that agency’s communications needs. There was no requirement to ensure interoperability with the LMR systems used by other agencies. As a result, today’s agencies are equipped with incompatible or aging communications equipment, which is adequate for communicating within that agency’s network during normal operations, but is not optimized to support in-field personnel and MCPs during disaster situations.

In addition, because LMR networks are voice oriented, most data applications used by public safety agencies are usually supported over separate leased networks, or over commercial networks during normal operations. But in emergency situations, data communications over these networks may be unavailable, and if it is available, it may be limited and unreliable. Although advances in trunked radio technology brought in some limited messaging capabilities, they fell short of the modern day communications needs of public safety agencies.

**Key Criteria for the Ideal Network**

To address the needs of public safety personnel on the ground and in command centers during a disaster, an effective emergency communications network should support existing LMR technology and offer new functionality.

Ideally, it should enable first response teams to use their LMR systems, as well as a variety of communications applications that leverage video surveillance cameras and unattended sensors, which can enhance the ability of in-field personnel to gather situation intelligence in real time.

Built to address these requirements, the network will allow public safety agencies to maintain multiple levels of communications connectivity during an entire operation. It will enable local connectivity among first responders on scene, which will allow in-field personnel to share information in real time and establish accurate situational awareness. It will also enable wide area connectivity, which will allow first responders to supply real-time reports and assessments to a command and control center. And it will allow all personnel at all levels to access critical information over a wide area or public network, such as building blueprints that may be stored on remote servers.

1 See the General Dynamics white paper “Advanced Mobile Networks for Public Safety Applications: Leveraging LTE for Interoperable Mission-Critical Communications”
Building an Effective Disaster Response Communications Network

An effective disaster response communications network must be easy to configure and deploy, without extensive planning. Regardless of the communications technology used, the network elements that enable continuous communication at all levels should require minimal user intervention and configuration. Therefore, the entire network should be pre-configured or self-configured with a quick power on to operation time.

The network should also provide the throughput and capacity needed to support real-time streaming of voice, data and video situational information to multiple MCPs and to in-field personnel. In this way, it can ensure all personnel have visibility to all relevant situation intelligence and are always aware of any changes that may affect their efforts to contain the disaster and save lives.

Support for frequency bands designated for public safety and first responders, such as 700 MHz LTE and 4.9 GHz is essential. This will enable public safety agencies to maximize their existing investment in devices that leverage this frequency spectrum, and comply with any regulatory requirements for interoperable public safety networks.

Of course, access to the incident response communications network and all traffic flowing through the network should be fully protected from intruders and unauthorized users using standard high-grade security and encryption. And all equipment should be ruggedized and capable of withstanding harsh environmental conditions that may be present at an incident response site.

A communications network optimized to address the needs of public safety agencies in this way can be created with three key network elements (Figure 2):

- A rapidly deployable wireless mesh network
- A 4G LTE Cellular data network
- A satellite link modem

Figure 2: A communications network optimized for disaster response.
Leverage Mesh Technology
Mesh networking offers the flexibility, scalability and functionality needed for a rapidly deployable, wireless local area network infrastructure that can support public safety communications requirements in a disaster situation.

A wireless mesh is a self-forming and self-healing networking solution particularly suited to public safety applications where information is shared wirelessly among a close group of users in an incident area. The mesh consists of a number of mesh points configured to automatically connect with each other. Access to an external Internet Protocol (IP) network and to a command and control center is achieved via one or more hops of mesh points linked to a broadband cellular network, such as LTE. This provides users with broadband access to command center networks and application servers on a private or public IP network (Figure 3).

Figure 3: Extending public safety networks with wireless mesh networking.

Wireless mesh networking based on Wi-Fi technology has been successfully adapted for military applications. This same technology can be used to extend the reach of public safety networks into remote or disaster-stricken areas. A mesh network built on Wi-Fi technology can be created with self-forming portable or mobile Wi-Fi network nodes that provide the high bandwidth necessary to support the communications needs of an incident response team. In addition, these nodes can be pre-configured to provide communications security through carrier-grade authentication and encryption protocols that protect the integrity of all communications travelling over the mesh infrastructure. Once the network is established, authorized Wi-Fi devices automatically connect to the mesh to enable immediate communications.
Harness LTE
The link to a wide area public safety network and to public networks can best be achieved with LTE cellular technology.

As the foundation of next-generation mobile networks, LTE offers a flat architecture built on the same packet-based IP technology used by today’s commercial Internet applications and services. It offers enhanced capacity and speed with lower latency, and with the flexibility and capability to support a wide variety of advanced multimedia applications and services. These characteristics make LTE ideal for the type of real-time services needed by public safety agencies in disaster situations.

By leveraging LTE, public safety organizations have the opportunity to take advantage of the economies of scale of a commercial technology, while creating networks that remain exclusive for private small- to medium-sized deployments. They can leverage today’s advanced commercial multimedia applications to enhance situational and mission-critical communications, while providing backward compatibility with existing devices. This includes video applications, such as video surveillance, live video capture and display, chat messaging, voice calls and voice communications, as well as field access to a host of day-to-day applications that require simple access to servers and databases to operate. They can also leverage the capabilities of current commercial-grade hardware, such as tablets and smartphones, to enable these applications and go beyond the capabilities of current LMR systems.

Adopting industry standard LTE also facilitates roaming to commercial wireless networks since the chipset and radio in public safety LTE devices support multiple LTE standard bands and provide backward compatibility with 3G networks, if required.

Extend Coverage with Satellite
Finally, to ensure in-field personnel can communicate with each other and command centers wherever a disaster occurs, the coverage capabilities of the wireless mesh can be enhanced with satellite communications. Satellite service provides almost worldwide coverage and is extremely useful to public safety agencies in disaster response efforts. For these applications, satellite allows response teams to go beyond the reach of LTE network services into areas with limited or no network coverage. This allows in-field personnel to maintain their communications link with command centers wherever they are.

In these situations, small, hand-carry and battery operated satellite terminals offer the only means of establishing a network link. Therefore, the terminal must be able to support video, voice and data applications. Plus, it must have an integrated local routing capability to make the most efficient use of the relatively low data bandwidth available over a satellite link.

By using satellite to complement the coverage of the local mesh and the wide area LTE network, public safety agencies responding to a disaster situation have a complete network they can rely on to enable an effective operation (Figure 4). And because the network is independent from commercial infrastructures, it can be relied upon to provide multiple levels of communications to support any operational requirement.
Figure 4: A complete, rapidly deployable, disaster response communications network.
The General Dynamics Rapidly Deployable Network Solution

General Dynamics addresses the disaster response communications needs of public safety agencies with integrated, rapidly deployable networking solutions optimized to maintain the vital links between in-field personnel, and between those personnel and command centers. Built on extensive experience delivering tactical networking and communications solutions for military applications worldwide, General Dynamics public safety networking solutions exploit current and emerging technologies to enable integrated multimedia communications in any situation.

Deployable Wi-Fi Mesh Networks

Local area communications for disaster response teams are enabled by General Dynamics in-field mesh networking solutions based on General Dynamics FastPath Mesh™ technology. This ad-hoc, Wi-Fi mesh networking technology for rapidly deployable wireless mesh infrastructures is well suited to disaster response applications. It enables mesh point nodes to create a secure, self-forming, self-healing, and path-optimizing wireless mesh network for voice, data and video communications. As a result, disaster response teams can quickly deploy a reliable wireless communications network to support any operation, in environments with no available infrastructure.

General Dynamics tactical networking mesh points equipped with FastPath seek out other nodes, establish connections, and form routing paths without any user intervention. When a mesh point leaves the network, adjacent nodes re-configure the mesh and re-optimize routing paths automatically. In addition, all General Dynamics mesh points can be configured as Wi-Fi hotspots to enable authorized devices to access the network and communicate with other devices in the mesh. Plus, the mesh nodes are programmed to continuously monitor mesh link quality and availability and automatically reconfigure the network topology for optimal performance.

The General Dynamics mesh point portfolio includes:

- **ES210 Tactical Mesh Point**, a rugged, wearable system for use by in-field personnel
- **ES520 Deployable Mesh Point**, a dual-radio wireless Local Area Network (LAN) system
- **ES820 Vehicle Mesh Point**, a dual-radio, size, weight and power (SWaP)-optimized system
- **ES2440 High Capacity Infrastructure Mesh Point**, a quad-radio system

Integrated Broadband Network

Wide area networking capabilities for a General Dynamics mesh network are enabled by the General Dynamics LTE Network In A Box (NIAB), a compact, integrated, and easily transportable unit specifically designed for rapid deployment. The LTE NIAB contains all essential LTE network components:

- **An integrated Evolved Packet Core (EPC)**, which provides the Packet Data Network Gateway (PDN-GW), Serving Gateway (S-GW) and Mobility Management Entity (MME) functions
• **Subscriber Management Platform (SMP)**, which contains the Home Subscriber Server (HSS) that provides user authentication, and Policy and Charging Rules Function (PCRF) that manages user policies and priorities definitions

• **One or more V6 eNodeB LTE base stations**, which provide LTE radio coverage

This complete, integrated system is designed for ease-of-use. In-field personnel only need to connect power and backhaul cables, and attach the base station to antennas to establish a fully functional LTE network (Figure 5).

Figure 5: A fully-deployed General Dynamics LTE Network In A Box.

---

**Advanced Tactical Communications**

To enable public safety agencies to leverage the local and wide area network in any disaster situation, General Dynamics provides the Smart Tactical Communications System (STACS). This small, lightweight product is engineered to enable in-field command and control communications from any location. It is a rugged, Wi-Fi hotspot that supports Bring Your Own Device (BYOD) for IP network access and voice communications by compatible voice over IP (VoIP) phones. Plus the built-in Broadband Global Area Network (BGAN) satellite modem and LTE modem provide reach-back capabilities to existing infrastructure via satellite and 4G terrestrial wireless links.
Next-generation Network Radios

Of course, to get the full benefits of this advanced infrastructure in-field personnel must be able to access the network and communicate using portable, handheld devices. The complete General Dynamics portfolio includes next-generation network radios designed to take full advantage of wireless mesh and LTE technologies to enable two-way, real-time voice and data communications in any disaster situation.

The General Dynamics Pathmaker™ Network Radio is a lightweight, battery powered, voice and data two-way wireless radio. It enables ad-hoc networking communication without reliance on network infrastructure. Once deployed, Pathmaker Radio users become their own network. This makes the radios ideal for use in remote locations where no infrastructure exists or where the infrastructure has been destroyed or overloaded. Where legacy network infrastructure exists, the Pathmaker Network Radio System can take advantage of the network by acting as a gateway, thereby increasing the network’s footprint and reach.

With a maximum of 32 radio users per network, in-field personnel can form traditional squad communications groups, or extend range and coverage by connecting to multiple networks. The radio allows users to communicate privately (one to one), as a group (one to many), or over multiple private and group communications sessions.

The flexibility of the Pathmaker radio makes it the ideal complement to the complete, integrated network solution offered by General Dynamics for first response and disaster response situations.
Conclusion

Coverage, ease-of-use, reliability, and scalability are the key to an effective public safety communications network for disaster situations. Engineered properly, the ideal communications network will enable public safety agencies to maintain multiple levels of communications connectivity to support the exchange of information between in-field personnel, between these personnel and command centers, and between everyone in a disaster site with existing private and public networks.

Therefore, an effective disaster response communications network must be easy to configure and deploy, without extensive planning. Regardless of the communications technology used, the network elements that enable continuous communication at all levels should require minimal user intervention and configuration.

Wireless mesh networking, supported by LTE broadband, and backed by satellite coverage capabilities offers the flexibility, scalability and functionality needed for a rapidly deployable, wireless local area network infrastructure that can support public safety communications requirements in a disaster situation. Built with these elements, the network will allow all agencies to establish and maintain vital communications links that enable the continuous exchange of situation information required for an efficient and effective disaster response effort.

The General Dynamics solution for disaster response communications leverages the capabilities of wireless mesh, LTE and satellite to deliver a rapidly deployable networking solution that exploits current and emerging technologies to enable integrated multimedia communications in any situation.
### Acronyms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGAN</td>
<td>Broadband Global Area Network</td>
</tr>
<tr>
<td>BYOD</td>
<td>Bring Your Own Device</td>
</tr>
<tr>
<td>COLT</td>
<td>Cell On Light Truck</td>
</tr>
<tr>
<td>COW</td>
<td>Cell On Wheels</td>
</tr>
<tr>
<td>EPC</td>
<td>Evolved Packet Core</td>
</tr>
<tr>
<td>HSS</td>
<td>Home Subscriber Service</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>LMR</td>
<td>Land Mobile Radio</td>
</tr>
<tr>
<td>LTE</td>
<td>Long Term Evolution</td>
</tr>
<tr>
<td>MCP</td>
<td>Mobile Command Post</td>
</tr>
<tr>
<td>MME</td>
<td>Mobility Management Entity</td>
</tr>
<tr>
<td>NIAB</td>
<td>Network In A Box</td>
</tr>
<tr>
<td>PDN-GW</td>
<td>Packet Data Network Gateway</td>
</tr>
<tr>
<td>PCRF</td>
<td>Policy Charging Rules Function</td>
</tr>
<tr>
<td>S-GW</td>
<td>Serving Gateway</td>
</tr>
<tr>
<td>STACS</td>
<td>Smart Tactical Communications System</td>
</tr>
<tr>
<td>VoIP</td>
<td>voice over IP</td>
</tr>
</tbody>
</table>