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**The use of International Mobile
Telecommunications for broadband public
protection and disaster relief applications**

M Series
**Mobile, radiodetermination, amateur
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REPORT ITU-R M.2291-0

The use of International Mobile Telecommunications for broadband public protection and disaster relief applications

(Question ITU-R 229-3/5)

(2013)

1 Introduction

This Report addresses the current and possible future use of international mobile telecommunications (IMT) including the use of long term evolution (LTE)¹ in support of broadband public protection and disaster relief (PPDR) communications as outlined in relevant ITU-R Resolutions, Recommendations and Reports. The Report further provides examples for deploying IMT for PPDR radiocommunications, case studies and scenarios of IMT systems to support broadband PPDR applications such as data and video.

Public protection and disaster relief (PPDR) is defined in Resolution **646 (Rev.WRC-12)** through a combination of the terms “public protection radiocommunication” and “disaster relief radiocommunication”. The first term refers to “radiocommunications used by responsible agencies and organizations dealing with maintenance of law and order, protection of life and property and emergency situations”. The second term refers to “radiocommunications used by agencies and organizations dealing with a serious disruption of the functioning of society, posing a significant widespread threat to human life, health, property or the environment, whether caused by accident, natural phenomena or human activity, and whether developing suddenly or as a result of complex, long-term processes”. A number of studies of PPDR radiocommunications have been carried out within the ITU, based on Resolution **646 (Rev.WRC-12)** and Report ITU-R M.2033 [1], as well as in external agencies [2] [4] [5] [6].

2 Background

IMT specifications and related systems have drastically changed the global mobile communications landscape, in particular for commercial markets, where the general consumer in many countries has gained broadband access to new advanced applications making use of information databases, media and general Internet capabilities.

In the past public safety radiocommunications and other governmental mission critical communications have used narrow band systems. However, the demand for mobile radiocommunications of video and high bit rate data has increased considerably, and the emerging trend towards “voice-over-Internet protocol (IP)” (VoIP), with the result that the mobile broadband capabilities are becoming increasingly important to public safety organizations.

To respond to the mobile broadband networks increasing data demand, an increase in capacity by including more spectrally efficient advanced radio technologies is foreseen by public safety operators. If broadband PPDR applications are based on IMT systems, then there may be a benefit from increased economies of scale and more rapid technology evolution.

¹ LTE and LTE-Advanced also known as Evolved Universal Terrestrial Radio Access Network (E-UTRAN) is an IMT terrestrial radio interface in Recommendation ITU-R M.1457 §§ 5.1 and 5.3 and Recommendation ITU-R M.2012, Annex 1.

It is also useful to understand how IMT-based specifications and standards can play a vital role by enabling broadband PPDR applications. PPDR communications are predominantly mission critical because these aid in the protection and safety of the life or property on a day-to-day basis as well as in response, rescue, and recovery efforts before, during, and after emergencies and disasters. The ability of PPDR agencies to react quickly, inter-communicate and work together in close coordination with each other, as well as their ability to communicate with resources that are farther away, will heavily influence the outcome of an emergency, whether it be a forest fire, a traffic accident or a terrorist threat. With the ever-increasing scale of responses to emergency situations and increased number of responding agencies and authorities, administrations have increasingly recognized how new PPDR applications based on IMT systems may be able to serve or support broadband PPDR communications. The use of IMT for broadband PPDR applications could open up new ways of working, increase the effectiveness of emergency management and improve interaction within and across PPDR organizations. Section 3 details the existing and planned capabilities of IMT that support broadband PPDR applications.

PPDR applications could be supported on commercial IMT networks to either complement the dedicated PPDR networks in certain areas where dedicated networks may not be economically viable or directly integrate PPDR applications, so as to reduce the overall cost of deploying a dedicated PPDR network. See § 4 on approaches for supporting broadband PPDR applications using IMT.

3 Existing and planned capabilities of IMT that support broadband PPDR applications

IMT supports higher data-rates, reliability, resiliency, and capacity of mobile networks in comparison to legacy communications networks. The term IMT encompasses IMT-2000 and IMT-Advanced.² This section focuses on the capabilities of IMT which will allow the introduction of PPDR applications.

In particular, LTE systems have attractive capabilities of providing a broadband Internet Protocol (IP)-based network supporting voice, data and video services as an IMT radio interface. This section describes capabilities and key features of LTE as an example of an IMT system for supporting broadband PPDR applications.

Other IMT radio interfaces described in Recommendation ITU-R M.1457 and Recommendation ITU-R M.2012 may also support PPDR applications.

3.1 Capabilities of IMT systems to support broadband PPDR

Annex 1 contains examples of LTE capabilities which can be used as a base to develop broadband mission critical applications. It shows a correlation between Report ITU-R M.2033 requirements and the LTE-based system capabilities including those incorporated in the IMT-2000 and IMT-Advanced radio interfaces.

It should be noted that the LTE specifications are continually being enhanced. New capabilities or enhancements to existing capabilities may be under consideration that could enhance the capability and/or performance of LTE when utilized in a PPDR application.

Annexes 2 to 5 provide case studies and example scenarios of using IMT to support broadband PPDR applications.

² Resolution ITU-R 56-1, "Naming for International Mobile Telecommunications".

3.2 Advantages of LTE systems for PPDR agencies

The following features and benefits make LTE particularly suitable for PPDR applications as compared to traditional PPDR systems and provide unprecedented capabilities for public safety.

3.2.1 Better performance

The numerous technology advances of LTE bring better overall performance. End users will certainly notice an improved experience, and the technology itself will be more reliable. Multiple-input multiple-output (MIMO) technology, for example, is used with LTE.

MIMO puts several antennas – rather than one – on a single tower and on the devices. With more antennas working for the same communication, performance (coverage and capacity) is significantly improved without the need for additional bandwidth or increased transmitting power. Recently, studies have been initiated on 3D MIMO. This additional ability for the network to detect elevation may also enhance the existing location services in IMT to provide a z-axis element to public safety. This would greatly enhance the ability to locate first responders at an incident scene.

Orthogonal frequency division multiple access (OFDMA) is another technology that is used with LTE. It maximizes the use of available spectrum far better than previous technologies. This is a key attribute because there is a finite amount of spectrum available for use. The improved spectral efficiency lets the system optimize bandwidth data capacity, number of users, and user experience.

For public safety a new category of UE that has higher output power is also an example of how end user may experience improved performance.

What this means for public safety agencies: Improved situational awareness

Two-way voice (PTToLTE, VoLTE), real-time high-definition video, device to device (D2D) and large data file distribution integrated with incident management databases, including Geographic Information Systems (GIS), provide for immediate, dependable communications during incident response. With LTE, voluminous amounts of information can be exchanged from anywhere, instantly, in many ways. Collaboration utilizing these tools ensures effective sharing of information in task force operations.

3.2.2 Simplified, IP-based architecture

The all-IP architecture of an LTE network requires fewer elements, which reduces complexity and results in lower capital expenditure (CAPEX) and operational expenditure (OPEX) as well as lower latency. LTE is also extremely scalable, which makes it easy to accommodate a significant number of users. All-IP architecture is also more flexible, making it easy to inter-connect nodes, build pathways between nodes for increased resiliency and availability, and automatically change the logical paths between nodes if needed.

In today's commercial marketplace, operators are reducing network complexity and cost by leveraging a common IP architecture for their fixed and mobile needs. Public safety agencies can benefit from the same efficiencies. Best of breed technologies and solutions from the commercial sector – augmented with public safety specific features, such as ruggedized devices for first responders – will provide reduced cost, reduced complexity, and superior service for the public safety market. The IP architecture that may be deployed will be also capable of extensions for specific operator needs such as SON.

What this means for public safety agencies: Unified communications and enhanced day-to-day operations

Voice, video, and data on one end-to-end IP network results in reduced complexity and lower costs through greater efficiency. LTE supports telemetry and remote diagnostics, which means information may be sent automatically to mobile devices and analysed remotely. As a result,

personnel have instant remote access to databases to access vehicle records or suspect's files, for example, or to submit reports electronically. Public safety personnel can be more effective when paperwork and waiting times are reduced.

3.2.3 Low latency and low packet loss

Low latency and low packet loss are particularly important for services such as conversational voice (including VoIP and Push to Talk), conversational video (including live streaming) and real time interactive applications with fast call set up.

The LTE architecture has been designed to provide for low latency, and low packet loss. It additionally includes quality of service (QoS) management with up to nine service classes defining a wide range of priority, budget and error loss rates to support these and other applications. Also see § 3.2.7.

With LTE users typically experience a low latency in certain defined QoS classes applicable to the services indicated above. Too much latency degrades the quality of service and application performance and can frustrate the end user.

What this means for public safety agencies: Streaming video

LTE gives new meaning to the phrase “a picture is worth a thousand words”. Seeing what's happening at an incident scene – while the situation is unfolding – is much more helpful than hearing about it. LTE provides real-time transmission of high-definition video, as well as detailed images of crime and disaster scenes, suspects, and more.

If an officer is not responding by radio, a dispatcher can instruct the squad car to activate and/or remotely control a camera and autonomously transmit video to the dispatcher.

3.2.4 Greater interoperability

LTE has a number of advantages related to roaming partner network interoperability: commercially standardized protocols and interfaces mean that more public safety personnel can talk to one another, agencies and individuals can be on the same communications platform, and there is support for an open device ecosystem.

What this means for public safety agencies:

- enhanced cooperation and lower costs;
- move away from “special” or proprietary and expensive technologies;
- allow roaming onto commercial networks when necessary, facilitating broad partnerships between public safety and commercial carriers;
- communicate seamlessly with other emergency responders. When other first responders join on a public safety LTE network, inter-agency communications is greatly enhanced;
- leverage growing amounts of information – text, images, and video – received by Public service answering points (PSAPs) from the public through mobile devices.

3.2.5 Security

LTE makes use of some of the most advanced mechanisms available for air interface and network security. Air interface security features and capabilities protect the LTE device, network elements, and traffic from attacks originating over the air interface. Network security features and capabilities protect the LTE network elements and traffic from security attacks generated in the wireline transport network and external devices connected to the Evolved Universal Terrestrial Radio Access Network (E-UTRAN) and the evolved packet core (EPC) network.

End-to-end security is achieved with strong data encryption in the devices and network. This includes encryption at the base stations which provides over-the-air ciphering and integrity validation as well as security over land lines connecting the base stations to the EPC using IPsec. Mutual authentication between the network and devices ensures system integrity.

If further security enhancements are required, LTE could accommodate them.

What this means for public safety agencies:

- communicate securely and reliably;
- enables secure communication;
- enables security between network elements for an end-to-end security policy;
- eliminates tampering with over-the-air information;
- throughput capability enables implementation of additional end-to-end security layers, if needed;
- mutual authentication means rogue devices will not jeopardize operations;
- provides the basis for a secure and reliable communication between devices and data centres.

3.2.6 Network sharing

The concurrent use of the network by multiple entities with distinct functions and roles means asset-sharing must be done in a manner amenable to all parties. Standard network-sharing methods are available to ensure multiple entities have access to their fair share of resources without hindering each other's operations.

What this means for public safety agencies: Share resources

- spectrum resources can be concurrently used;
- spectrum-sharing can be tailored based on mutual agreements;
- distinct encryption levels can be provided;
- traffic can be segregated.

3.2.7 Quality of service and prioritization

With its all-IP architecture, the LTE network must rely on QoS controls to handle different types of services and prevent congestion. In that regard, QoS functions are spread across the whole LTE network domain, including the user equipment (UE), base station, EPC, and IP/multiprotocol label switching (MPLS) backhaul/backbone segments. LTE standards define a comprehensive framework to support end-to-end QoS – from the terminal to the edge of the EPC. Each user and each application per user can be translated into a set of QoS parameters (data rate, latency, packet loss rate and priority) to enable guaranteed and differentiated delivery of each individual application end-to-end. Further, LTE introduces priority mechanisms, including pre-emption, to distinguish between higher and lower priority sessions and UEs. In the event of congestion, this enables the network to prioritize the most critical services/users by pre-empting resources from less critical applications/users. Finally, the rules of QoS can be changed dynamically, ensuring for instance that a group assigned to an incident will have priority over other first responders that may also be in the incident area but that are not part of the response team. QoS continuity when roaming is ensured subject to local policies.

What this means for public safety agencies:

- assure QoS for mission-critical activities;
- intelligent sharing of air resources and network capacity;

- traffic prioritization, especially critical during incidents;
- enable quality of experience.

3.2.8 Bandwidth flexibility

LTE can be flexibly deployed with a wide range of channel sizes, or carrier bandwidths. These can range from 1.4 MHz wide up to 20 MHz. LTE works well at any level within this range. In the future evolution of LTE (LTE-Advanced, first defined in 3GPP Release 10), it is possible to aggregate multiple bandwidths to achieve transmission bandwidth in excess of 20 MHz (up to 100 MHz).

What this means for public safety agencies:

- flexibility and scalability;
- flexibility to fit in existing but disparate spectrum slices (e.g. at 400 MHz);
- system performance scalability as additional spectrum becomes available.

3.2.9 Simultaneous use of multiple applications and grade of service

IMT systems will allow operators to modify their networks for a variety of unique services. For example, voice services require low latency and jitter unlike bandwidth-hungry data and video streaming media applications. Because IMT systems tightly control latency and jitter on links used for voice, while appropriately adjusting for various other types of data, IMT has the ability to deliver both voice and data services on the same network infrastructure. On the downlink, the base station directly controls the scheduling of traffic and the allocation of network resources and through appropriate scheduling the operator can optimize use of the downlink bandwidth. On the uplink, there are several scheduling methods available to the operator, depending upon the QoS requirements for the service flow.

3.2.10 Coverage and spectrum usage/management

Multiple-input multiple-output (MIMO) is a technique for multi-antenna communication systems that relies on the presence of multiple, independent radio-frequency chains and antenna, both at the base station site, and on the subscriber device. For a given bandwidth and overall transmission power, MIMO technology provides a significant increase in throughput and range. In general, MIMO technology increases the spectral efficiency of a wireless communication system and exploits environmental phenomena. For example, MIMO systems exploit multipath propagation to increase data throughput and range and reduce bit error rates. Experts consider MIMO to be a form of smart antenna technology. MIMO and single-input single-output (SISO) are both supported in IMT systems. SISO employs a single antenna on the mobile set and at the base station. MIMO can facilitate the deployment of networks that meet the high coverage and reliability requirements of PPDR.

3.2.11 Capabilities (e.g. talk group configuration)

LMR systems use a broadcast method for talk groups, where multiple mobile stations share a common downlink channel. Multicasting, a similar capability, has been defined for IMT systems to support video and audio conferencing, gaming, and other applications. This type of transmission permits multiple mobile stations in a network to share a common downlink channel.

3.3 Other IMT capabilities

LTE supports Public Warning System (PWS), which enables the public to receive timely and accurate alerts, warnings and critical information regarding disasters and other emergencies. As has been learned from disasters such as earthquakes, tsunamis, hurricanes and wild fires, such a

capability is essential to enable the public to take appropriate action to protect their families and themselves from serious injury, or loss of life or property.

LTE operates in a number of frequency bands, particularly in some of the bands listed for PPDR in Resolution **646 (Rev.WRC-12)**. For one of these bands, a high power UE capability is being defined to meet the needs of PPDR agencies in this band.

4 Approaches for supporting broadband PPDR applications using IMT

4.1 IMT offers a high degree of flexibility for supporting broadband PPDR applications. In particular, there are a number of different approaches in relation to accommodating the broadband communications needs of PPDR agencies including:

- deployment of a dedicated PPDR network owned and operated by the PPDR agency or controlling entity, based on IMT systems;
- deployment of a dedicated PPDR network owned and operated by a commercial entity under negotiated contract arrangements for the PPDR organization, based on IMT systems;
- a combination of a dedicated PPDR network owned and operated by the PPDR agency (or entity) and commercial network services, based on a common IMT system, to facilitate roaming where the PPDR agency as a preferential subscriber with suitable assigned priority, under negotiated contract arrangements;
- integrating PPDR as an application on a public network, either sharing the commercial IMT network operator's IMT infrastructure as a closed/private sub-network (e.g. as a virtual private network (VPN)) under specific contract arrangements, or as a preferential subscriber with suitable assigned priority.

4.2 There may also be a need for ruggedized IMT user devices and other special arrangements to meet various PPDR deployment situations.

4.3 During disaster situations, some infrastructure may be affected, but others may still be operational. The surviving infrastructure can be important to support PPDR operations. In the case of IMT, the dynamic use of commercial infrastructure would be a great advantage of the harmonized use of commercial IMT technologies by PPDR systems. The traffic on a PPDR network is likely to be higher at times of emergency such as natural disasters and major public disorder than at 'normal times'. At these times, it is possible to add extra IMT channels to the PPDR network or increase the width of channels already in use. This could, for example, enable spectrum to be used for PPDR at times of emergency that cannot be made available on a permanent basis.

5 Case studies of applications of IMT to broadband PPDR

5.1 Case studies of approaches in various countries are outlined in Annexes 2 and 3.

5.2 An example scenario of using LTE for PPDR at a chemical factory fire is given in Annex 4.

5.3 A case study of a PPDR deployment utilizing partitioning of the service capacity on a national IMT network is given in Annex 5.

6 Summary

This Report has considered how the use of IMT, and LTE in particular, can support current and possible future PPDR applications. The broadband PPDR communication applications are detailed in various ITU-R Resolutions, Recommendations and Reports; and this Report has assessed the LTE system capabilities to support these applications. This Report has also considered the benefits

that can be realized when common radio interfaces technical features, and functional capabilities, are employed to address communications needs of public safety agencies.

This Report describes the features and benefits that make LTE particularly suitable for PPDR applications as compared to traditional PPDR systems. These features and benefits include:

- greater economies of scale;
- enhanced interoperability;
- better performance;
- simplified IP-based architecture;
- low latency;
- enhanced security;
- enhanced network sharing;
- enhanced quality of service and prioritization;
- bandwidth flexibility;
- simultaneous use of multiple applications; and
- enhanced spectrum efficiency.

In addition, case studies have been provided in Annexes 2 to 5 that offer real-world examples of ways in which administrations are employing IMT to support broadband PPDR applications.

7 Acronyms, abbreviations

3GPP	Third Generation Partnership Project
BS	Base station
CAPEX	Capital expenditure
CAD	Computer aided dispatch
D2D	Device to device
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
EMC	Electromagnetic compatibility
EPC	Evolved packet core
GIS	Geographic Information Systems
HAZMAT	Hazardous materials
IMT	International Mobile Telecommunications (includes IMT-2000 and IMT-Advanced)
IP	Internet protocol
IPSec	Internet protocol security
LMR	Land mobile radio
LTE	Long term evolution
MIMO	Multiple-input multiple-output
MPLS	Multi protocol label switching
MS	Mobile station
OAM	Operation, administration and maintenance

OFDMA	Orthogonal frequency division multiple access
OPEX	Operational expenditure
PPDR	Public protection and disaster relief
PSAP	Public service answering points
PTToLTE	Push to talk over LTE
PWS	Public Warning System
QoS	Quality of service
SISO	Single-input single-output
SON	Self-organizing network
UE	User equipment
VoLTE	Voice over LTE
VoIP	Voice-over-Internet protocol
VPN	Virtual private network

8 References

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Annex 1

Examples of LTE technology capabilities which can be used as a base to develop mission critical applications as currently supported by narrowband PPDR technologies and services

Tables 1 and 2 provide examples of LTE technology capabilities which can be used as a base to develop mission critical applications as currently supported by narrowband PPDR technologies and services.

Table 1 lists the envisioned applications with particular features and specific PPDR examples. The applications are grouped under the narrowband, wideband or broadband headings to indicate which technologies are most likely to be required to supply the particular application and their features. Furthermore, for each example, the importance (high, medium or low) of that particular application and feature to PPDR is indicated. This importance factor is listed for the three radio operating environments identified in Report ITU-R M.2033-0 (2003), Annex 2, § 2.1 “Day-to-day operations”, § 2.2 “Large emergency and/or public events”, and § 2.3 “Disasters”, represented by PP (1), PP (2) and DR, respectively.

TABLE 1
PPDR applications and examples

Application	Feature	PPDR Example	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
			PP (1)	PP (2)	DR	
<i>1. Narrowband</i>						
Voice	Person-to-person	Selective calling and addressing	H	H	H	Supported
	One-to-many	Dispatch and group communication	H	H	H	Proposals being considered in 3GPP for this capability in LTE
	Talk-around/direct mode	Groups of portable to portable (mobile-mobile) in close proximity without infrastructure	H	H	H	Proposals being considered in 3GPP for this capability in LTE
	Push-to-talk	Push-to-talk	H	H	H	Proposals being considered in 3GPP for this capability in LTE

TABLE 1 (continued)

Application	Feature	PPDR Example	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
			PP (1)	PP (2)	DR	
	Instantaneous access to voice path	Push-to-talk and selective priority access	H	H	H	Proposals being considered in 3GPP for this capability in LTE
	Security	Voice encryption/scrambling	H	H	M	Supported
Facsimile	Person-to-person	Status, short message	L	L	H	Supported
	One-to-many (broadcasting)	Initial dispatch alert (e.g. address, incident status)	L	L	H	Supported
Messages	Person-to-person	Status, short message, short e-mail	H	H	H	Supported
	One-to-many (broadcasting)	Initial dispatch alert (e.g. address, incident status)	H	H	H	Supported
Security	Priority/instantaneous access	Man down alarm button	H	H	H	Supported
Telemetry	Location status	GPS latitude and longitude information	H	M	H	Supported
	Sensory data	Vehicle telemetry/status	H	H	M	Supported
		EKG (electrocardiograph) in field	H	H	M	Supported
Database interaction (minimal record size)	Forms based records query	Accessing vehicle license records	H	H	M	Supported
		Accessing criminal records/missing person	H	H	M	Supported
	Forms based incident report	Filing field report	H	H	H	Supported

TABLE 1 (continued)

Application	Feature	PPDR Example	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
			PP (1)	PP (2)	DR	
<i>2. Wideband</i>						
Messages	E-mail possibly with attachments	Routine e-mail message	M	M	L	Supported
Data Talk-around/direct mode operation	Direct unit to unit communication without additional infrastructure	Direct handset to handset, on-scene localized communications	H	H	H	Proposals being considered in 3GPP for this capability in LTE
Database interaction (medium record size)	Forms and records query	Accessing medical records	H	H	M	Supported
		Lists of identified person/missing person	H	H	H	Supported
		GIS (geographical information systems)	H	H	H	Supported
Text file transfer	Data transfer	Filing report from scene of incident	M	M	M	Supported
		Records management system information on offenders	H	M	L	Supported
		Downloading legislative information	M	M	L	Supported
Image transfer	Download/upload of compressed still images	Biometrics (finger prints)	H	H	M	Supported
		ID picture	H	H	M	Supported
		Building layout maps	H	H	H	Supported
Telemetry	Location status and sensory data	Vehicle status	H	H	H	Supported
Security	Priority access	Critical care	H	H	H	Supported
Video	Download/upload compressed video	Video clips	M	L	L	Supported
		Patient monitoring (may require dedicated link)	M	M	M	Supported
		Video feed of in-progress incident	H	H	M	Supported

TABLE 1 (continued)

Application	Feature	PPDR Example	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
			PP (1)	PP (2)	DR	
Interactive	Location determination	2-way system	H	H	M	Supported
		Interactive location data	H	H	H	Supported
<i>3. Broadband</i>						
Database access	Intranet/Internet access	Accessing architectural plans of buildings, location of hazardous materials	H	H	H	Supported
	Web browsing	Browsing directory of PPDR organization for phone number	M	M	L	Supported
Robotics control	Remote control of robotic devices	Bomb retrieval robots, imaging/video robots	H	H	M	Supported
Video	Video streaming, live video feed	Video communications from wireless clip-on cameras used by in building fire rescue	H	H	H	Supported
		Image or video to assist remote medical support	H	H	H	Supported
		Surveillance of incident scene by fixed or remote controlled robotic devices	H	H	M	Supported
		Assessment of fire/flood scenes from airborne platforms	M	H	M	Supported

TABLE 1 (*end*)

Application	Feature	PPDR Example	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
			PP (1)	PP (2)	DR	
Imagery	High resolution imagery	Downloading Earth exploration-satellite images	L	L	M	Supported
		Real-time medical imaging	M	M	M	Supported

⁽¹⁾ The importance of that particular application and feature to PPDR is indicated as high (H), medium (M), or low (L). This importance factor is listed for the three radio operating environments: “Day-to-day operations”, “Large emergency and/or public events”, and “Disasters”, represented by PP (1), PP (2) and DR, respectively.

NOTE 1 – The term “supported” as utilized in the new column in the Table (*LTE system capability*) includes not only the inherent capabilities of the radio technology and related 3GPP system but also the ability to support a varied range of “applications” that could provide the indicated service/capability. Some new capabilities may be under consideration for development in 3GPP and others may be the subject of work to improve or enhance the capability and/or performance.

NOTE 2 – This is based strictly on a review of Report ITU-R M.2033 and does not address any specific performance requirements or operational thresholds that might be announced by relevant PPDR entities.

NOTE 3 – A “blank” indicates that further study would be needed in order to respond.

TABLE 2

User requirements

Requirement	Specifics	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
		PP (1)	PP (2)	DR	
1. <i>System</i>					
Support of multiple applications		H	H	M	Supported
Simultaneous use of multiple applications	Integration of multiple applications (e.g. voice and low/medium speed data)	H	H	M	Supported
	Integration of local voice, high speed data and video on high speed network to service localized areas with intensive on-scene activity	H	H	M	Supported

TABLE 2 (continued)

Requirement	Specifics	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
		PP (1)	PP (2)	DR	
Priority access	Manage high priority and low priority traffic load shedding during high traffic	H	H	H	Supported
	Accommodate increased traffic loading during major operations and emergencies	H	H	H	
	Exclusive use of frequencies or equivalent high priority access to other systems	H	H	H	
Grade of service	Suitable grade of service	H	H	H	Supported
	Quality of service	H	H	H	Supported
	Reduced response times of accessing network and information directly at the scene of incidence, including fast subscriber/network authentication	H	H	H	Supported
Coverage	PPDR system should provide complete coverage within relevant jurisdiction and/or operation	H	H	M	Supported
	Coverage of relevant jurisdiction and/or operation of PPDR organization whether at national, provincial/state or at local level	H	H	M	Supported
	Systems designed for peak loads and wide fluctuations in use	H	H	M	Supported
	Enhancing system capacity during PP emergency or DR by techniques such as reconfiguration of networks with intensive use of direct mode operation	H	H	H	Proposals being considered in 3GPP for this capability in LTE
	Vehicular repeaters (NB, WB, BB) for coverage of localized areas	H	H	H	Supported
	Reliable indoor/outdoor coverage	H	H	H	Supported
	Coverage of remote areas, underground and inaccessible areas	H	H	H	Supported
	Appropriate redundancy to continue operations, when equipment/infrastructure fails	H	H	H	

TABLE 2 (continued)

Requirement	Specifics	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
		PP (1)	PP (2)	DR	
Capabilities	Rapid dynamic reconfiguration of system	H	H	H	
	Control of communications including centralized dispatch, access control, dispatch (talk) group configuration, priority levels and pre-emption	H	H	H	
	Robust operation, administration and maintenance (OAM) offering status and dynamic reconfiguration	H	H	H	Supported
	Internet Protocol compatibility (complete system or interface with)	M	M	M	Supported
	Robust equipment (hardware, software, operational and maintenance aspects)	H	H	H	Supported
	Portable equipment (equipment that can transmit while in motion)	H	H	H	Supported
	Equipment requiring special features such as high audio output, unique accessories (e.g. special microphones, operation while wearing gloves, operation in hostile environments and long battery life)	H	H	H	Supported
	Fast call set-up and instant push-to-talk operation	H	H	H	
	Communications to aircraft and marine equipment, control of robotic devices	M	H	L	
	One touch broadcasting/group call	H	H	H	Proposals being considered in 3GPP for this capability in LTE
	Terminal-to-terminal communications without infrastructure (e.g. direct mode operations/talk-around), vehicular repeaters	H	H	H	Proposals being considered in 3GPP for this capability in LTE
	Appropriate levels of interconnection to public telecommunication network(s)	M	M	M	Supported

TABLE 2 (continued)

Requirement	Specifics	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
		PP (1)	PP (2)	DR	
2. Security	End-to-end encrypted communications for mobile-mobile, dispatch and/or group calls communications	H	H	L	Supported
3. Cost related	Open standards	H	H	H	Supported
	Cost effective solution and applications	H	H	H	Supported
	Competitive marketplace	H	H	H	Supported
	Reduction in deployment of permanent network infrastructure due to availability and commonality of equipment	H	H	L	Supported
4. Electromagnetic compatibility (EMC)	PPDR systems operation in accordance with national EMC regulations	H	H	H	Supported
5. Operational					
Scenario	Support operation of PPDR communications in any environment	H	H	H	Supported
	Implementable by public and/or private operator for PPDR applications	H	H	M	Supported
	Robust OAM offering status and dynamic reconfiguration	H	H	H	Supported
	Rapid deployment of systems and equipment for large emergencies, public events and disasters (e.g. large fires, Olympics, peacekeeping)	H	H	H	Supported
	Information to flow to/from units in the field to the operational control centre and specialist knowledge centres	H	H	H	Supported
	Greater safety of personnel through improved communications	H	H	H	Supported
Interoperability	Intra-system: Facilitate the use of common network channels and/or talk groups	H	H	H	Proposals being considered in 3GPP for this capability in LTE
	Inter-system: Promote and facilitate the options common between systems	H	H	H	

TABLE 2 (continued)

Requirement	Specifics	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
		PP (1)	PP (2)	DR	
	Coordinate tactical communications between on-scene or incident commanders of the multiple PPDR agencies	H	H	H	
6. <i>Spectrum usage and management</i>	Share with other terrestrial mobile users	L	L	M	
	Suitable spectrum availability (NB, WB, BB channels)	H	H	H	Supported
	Minimize interference to PPDR systems	H	H	H	
	Efficient use of spectrum	M	M	M	Supported
	Appropriate channel spacing between mobile and base station frequencies	M	M	M	Supported
7. <i>Regulatory compliance</i>	Comply with relevant national regulations	H	H	H	Supported
	Coordination of frequencies in border areas	H	H	M	Supported
	Provide capability of PPDR system to support extended coverage into neighbouring country (subject to agreements)	M	M	M	Supported
	Ensure flexibility to use various types of systems in other Services (e.g. HF, satellites, amateur) at the scene of large emergency	M	H	H	
	Adherence to principles of the Tampere Convention	L	L	H	Supported
8. <i>Planning</i>	Reduce reliance on dependencies (e.g. power supply, batteries, fuel, antennas, etc.)	H	H	H	Supported
	As required, have readily available equipment (inventoried or through facilitation of greater quantities of equipment)	H	H	H	Supported
	Provision to have national, state/provincial and local (e.g. municipal) systems	H	H	M	Supported

TABLE 2 (*end*)

Requirement	Specifics	Importance ⁽¹⁾			LTE system capability (See Notes 1, 2, 3)
		PP (1)	PP (2)	DR	
	Pre-coordination and pre-planning activities (e.g. specific channels identified for use during disaster relief operation, not on a permanent, exclusive basis, but on a priority basis during periods of need)	H	H	H	
	Maintain accurate and detailed information so that PPDR users can access this information at the scene	M	M	M	Supported

⁽¹⁾ The importance of that particular application and feature to PPDR is indicated as high (H), medium (M), or low (L). This importance factor is listed for the three radio operating environments: “Day-to-day operations”, “Large emergency and/or public events”, and “Disasters”, represented by PP (1), PP (2) and DR, respectively.

NOTE 1 – The term “supported” as utilized in the new column in the Table (*LTE system capability*) includes not only the inherent capabilities of the radio technology and related 3GPP system but also the ability to support a varied range of “applications” that could provide the indicated service/capability. Some new capabilities may be under consideration for development in 3GPP and others may be the subject of work to improve or enhance the capability and/or performance.

NOTE 2 – This response from 3GPP is based strictly on a review of Report ITU-R M.2033 and does not address any specific performance requirements or operational thresholds that might be announced by relevant PPDR entities.

NOTE 3 – A “blank” indicates that further study would be needed in order to respond.

Annex 2

Case study – An example of deployment of a dedicated PPDR network owned and operated by a PPDR agency or controlling entity, based on IMT in the United States of America

On February 22, 2012, the United States Congress enacted the Middle Class Tax Relief and Job Creation Act of 2012 (Spectrum Act), containing landmark provisions to create a much-needed nationwide interoperable broadband network that will help police, firefighters, emergency medical service professionals and other public safety officials to safely and effectively perform their mission.

- The spectrum act allocated mobile broadband spectrum in the 700 MHz band for use for a nationwide public safety broadband network based on commercial technologies (i.e. LTE) [3].
- The nationwide entity charged with the deployment and operation of this network is the First Responder Network Authority (FirstNet), an independent entity with the National Telecommunication and Information Administration within the U.S. Department of Commerce.
 - i) Holds the single public safety licence for the nationwide network.
 - ii) Form the FirstNet Board by August 20, 2012.
- FirstNet must ensure “the establishment of a nationwide, interoperable public safety broadband network” and that network must be based on a single national network architecture. See sections 6202 (a) and (b).
- Up to USD 7 billion dollars were allocated to the Public Safety Trust Fund in order to construct this nationwide public safety broadband network.
- Under the Spectrum Act, federal law enforcement (e.g. Customs and Border Patrol, the Drug Enforcement Agency and the FBI), as well as state and local emergency responders will be able to utilize this network.
- In order to ensure that this network is cost-effective, FirstNet is authorized to lease capacity on its network under “covered leases” via a public private partnership with non-public-safety uses, including commercial services, on a secondary basis.

Annex 3

Case study – Broadband wireless communications for public safety in Japan

In Japan, spectrum has been allocated for public safety broadband wireless communication systems in 2011 following conversion of VHF/UHF band analogue TV broadcasting service to digital format. Since this system consists of a portable base station (BS) and multiple mobile stations (MS), it can be operated when and where it is needed. It is capable of providing several Mbit/s transmission data rate within the communication area of several km from the BS. One representative use case is high quality video image transmission from a disaster area to the local emergency headquarters. Technical specifications [7] for the system have been standardized in ARIB STD-T103 based on IEEE Standard 802.16-2009, and elements introduced in ARIB STD-T103 have been incorporated in the new VHF mode of the IEEE P802.16n draft [9]. An overall introduction of the public safety broadband system can be found in [8]. The specifications of ARIB STD-T103 are closely related to the specifications of ARIB STD-T105 which is the ARIB transposition of the IMT technology Wireless MAN-Advanced.

Annex 4

Case study – An example scenario of using LTE for PPDR at a chemical factory fire

1 Introduction

This example scenario of use of LTE considers a chemical plant fire and a typical response sequence based on the number of responders, as well as the utility of broadband resources throughout the duration of the incident. All of the data traffic supporting this response is assumed to be served by a wide area, mobile broadband network.

2 Summary of the incident

In a major suburban industrial township, an explosion occurs at 8:30 p.m. on a Friday evening at a major chemical plant producing insecticides. The fire is spreading fast, a number of people are injured, and still more than 10 persons are trapped in the building (Fig. 1). The factory is situated in an industrial area just outside the city. The buildings on fire are about 100 metres from a gas tank containing the highly toxic methyl isocyanate and the connected production facility for this gas at the plant. The tank is located directly behind the building on fire and the fire is spreading fast towards the tank area (Fig. 2).

FIGURE 1
Picture showing front side of the factory on fire



FIGURE 2
Picture showing the back of the factory and the gas tank



3 The incident time line

Table 3 below provides a summary of the incident and various events and their start times. Deployment of various communications resources is shown in Fig. 3.

TABLE 3
Summary of various events

Event identity number	Time T+ (minutes)	Time	Event description
A1	0	8.30 p.m.	Incident start
A2	15	8.45 p.m.	Fire trucks arrive and secure perimeter, save trapped workers
A3	60	9.30 p.m.	Special chemical fire response team arrives
A4	65	9.35 p.m.	Special chemical fire response team deploys
A5	90	10.00 p.m.	Deploy large unmanned crane; clear connecting area
A6	120	10.30 p.m.	Remote high res. camera deployed
A7	125	10.35 p.m.	Methyl isocyanate gas tank emptying process begins
A8	240	0.30 a.m.	Gas storage tank shut down process starts
A9	245	0.35 a.m.	Gas storage tank shut down
A10	600	6.30 a.m.	Incident ends

Each of these events is summarized in the following paragraphs:

3.1 Event A1

Incident start (Time T=0)

8.30 p.m. Friday evening an explosion occurs on a major chemical plant producing insecticides on the outskirts of a metro city. The fire is spreading fast, a number of people are injured, and more than 10 persons are trapped in the building.

8.33 p.m. First call received at the fire operations control centre.

8.35 p.m. First call received at police operations room. First responders dispatched.

8.35 p.m. Two fire tenders dispatched from nearest locations.

8.36 p.m. Fire operations control centre receives the alert from the police dispatch centre.

8.37 p.m. Fire operations control centre received calls from public as well as alerts from the control room of the chemical plant (CP).

8.37 p.m. Incident verified and entered into the computer aided dispatch (CAD) system and the location of the incident is displayed on GIS maps. CAD officer made recommendation of responding units based on capabilities, proximity and availability. CAD operator accepted recommendation and pushed the incident to the first responders. Information and details of the incident transmitted to LTE multimedia data terminals in the first responder vehicles and the portable handsets. First responder equipped with LTE devices received multi-media information including video clips, floor plans and HAZMAT info. Dispatcher tracks the movement of the first responders on the GIS maps. Fire operations control centre monitoring live video feed from the incident commander vehicle as it speeds towards the incident site.

8.40 p.m. Video feeds of the CCTV from chemical plant are piped into the fire operations control centre. Due to the severity of the incident, fire operations control centre supervisor escalated the incident and informed the fire operations control centre commander. Being Friday evening, the fire operations control centre commander was away from office so he was reached on his ruggedized LTE public safety handheld device.

8.40 p.m. Citizens called fire operations control centre with MMS and video messages, sharing photos and videos on various social media such as facebook, etc.

8.40 p.m. Five additional fire tenders dispatched.

8.40 p.m. Video feeds from chemical plant streaming in the police and fire operations control centre's video wall. Live video images from chemical plant are streaming directly to the Fire Commander's LTE handset.

3.2 Event A2

Fire fighters arrive and deployment begins to save trapped workers (Time = T+15)

8.45 p.m. First fire officer "Incident Commander" arrives at the incident scene. Fire operations control centre commander, who is still driving towards the scene, calls the incident commander to get a first-hand update on the status from the incident scene ("ground zero"). Fire operations control centre commander also calls the incident commander from his LTE handset. Officers determine that special chemical response units will be required to further proceed with the situation. Upon awareness of the incident, public safety LTE system resources and capacity have already been dynamically prioritized for the responding officers. Non-essential users on the system are automatically down prioritized, and where necessary the network engages user pre-emption. Necessary safeguards ensure that critical system resources are focused on the emergency and will stay in effect throughout the entire response.

FIGURE 3

Deployment of various resources



8.46 p.m. Chemical HAZMAT response unit alerted.

9.00 p.m. Police officers establish an outer perimeter, and evacuate anyone in harm's way. A police command post is also established. Fire control helicopter arrives on scene and transmits a high-resolution video stream to video control at the network data centre. The video stream from the helicopter is prioritized on the public safety LTE mobile network and multicast from the video control centre at 1.2 Mbit/s to the on-scene responders. Situational updates begin from the command post. The fire team main focus is to evacuate factory workers trapped in the upper level

of the building complex in the front area. However, the fire in that area is very strong and applying the high ladder to reach that area directly so far has been unsuccessful.

9.05 p.m. Fire team lands on the upper level and start the victim search and rescue teams successfully enter the room where 10 factory workers are trapped, guided by experts using remote video feeds that have access to the building plans downloaded from the Municipal authority database.

9.15 p.m. The trapped persons rescued from the fire are brought down using ladders and are transferred to the ambulances. Due to severe burns, doctors from a city hospital are getting live videos and are guiding the paramedics for the necessary first aid. Out of trapped persons, two have severe fire injuries and need to be transferred to the helicopter with remote biometric monitoring and support guidance from remote doctors using LTE handsets.

3.3 Event A3

Special chemical fire response team arrives (Time = T+60)

9.30 p.m. The Hazmat Chemical response team arrives on scene. A HAZMAT command post is positioned nearby to host the HAZMAT command staff. The growing number of on-scene responders generates an increased number of video streams to choose from. By securely multicasting the video streams and data updates, the additional responders are also able to receive information without further loading the system capacity. Real-time video intelligence optimizes LTE capacity by adjusting video content to available bandwidth and device screen size. The team starts checking nearby buildings to observe and gather intelligence to ensure that no hazardous chemicals are stored near the buildings on fire.

The Hazmat team immediately noticed the gas tank containing Methyl isocyanate at the plant that produces carbonyl, an insecticide. In case the fire reaches near to this tank, the increased temperature inside the tank could cause it to explode and release highly toxic gas. In addition, the heat from the fire could also cause the pressure in the tank to increase and trigger the safety valves, which could result in a large amount of toxic gases being released into the environment. The gas therefore must be safely transferred from the tank into a tanker and taken away. The team calls for a safe HAZMAT tanker which is expected to arrive by 10.30 p.m. The temperature around the tank was already building up due to the heat from the fire. Therefore the Hazmat commander informs the fire team commander to dispatch pumpers to location in order to cool the tank as much as possible. The expert who has knowledge of the gas and how to transfer it to the tanker safely is away at a marriage party on the other side of the city some 50 kilometres away. The HAZMAT team contacts him on his LTE smartphone but he cannot reach the site before 11.30 p.m. The HAZMAT team decides to work with him using high resolution Video from High resolution cameras in order to manage the transfer of the gas. The HAZMAT team decides to send a fast dispatcher to the location of the expert with LTE-based devices so that he could guide the team through the process.

3.4 Event A4

Special chemical fire response team deploys (Time = T+65 minutes)

9.35 p.m. HAZMAT unit starts to deploy the necessary monitoring equipment to transmit data on gas levels directly to their control centre and local commanders. The commanders are ready to evacuate all non-essential, non-protected personnel if gas levels reach hazardous conditions. The HAZMAT team has also immediately deployed high resolution cameras to keep watch on the toxic methyl isocyanate gas storage facility. The Fire commander estimates that unless the fire is controlled, the wind will carry the fire to the storage facility in about one hour. The team monitoring the toxic methyl isocyanate gas storage facility is collectively transmitting to the video control centre with two full resolution video feeds focused on the tank and two low-resolution video

feeds for the area between the factory fire and tank. Select video streams from helicopter and fire teams are made available through secure multicast to the appropriate incident responders. Temperatures in the area are becoming increasingly difficult to work and Hazmat commander has decided to pull back the previously deployed fire crews. Therefore the HAZMAT team decides to deploy two large cranes, each equipped with a video camera and claw to clear the space between the factory and the storage tank to prevent the fire from reaching the tank. Intense heat in the area does not allow humans to work there, even with their fire suits.

3.5 Event A5

Deploy large unmanned crane (Time = T+90 minutes)

10.00 p.m. HAZMAT team deploys large cranes, each equipped with a camera and a claw to clear away various items clogging the space between the factory and the tank. Video streams from the cranes are transmitted to the command post through the video control centre. Responders are able to receive secure multicast video streams from the helicopter, toxic chemical expert teams and the cranes.

3.6 Event A6

Remote high resolution camera deployed (Time = T+120 minutes)

10.30 p.m. HAZMAT team deploys remote high resolution cameras at 3 500 kbit/s to monitor the gas tank and also share the details of the gas tank with the remote experts. These camera-equipped “eyeballs” provide additional video streams for situational awareness. Based on consultations with remote experts, the HAZMAT team tactically decides to transfer the gas from the tank to a mobile tanker. For this purpose, they are able to secure a tanker parked in the factory complex for emergency use.

3.7 Event A7

Methyl isocyanate gas tank emptying process begins (Time = T+125 minutes)

10.35 p.m. The mobile gas tanker vehicle arrives and establishes its position. High resolution cameras guide the HAZMAT experts through voice command using LTE handsets on the key precautions in transferring the highly toxic methyl isocyanate gas to the mobile tanker. The remote expert who has knowledge of the gas and how to transfer it to the tanker safely is connected on his LTE smartphone and uses the high resolution video feeds to guide the team. The HAZMAT team decides to work with him using high resolution video from high resolution cameras to manage the transfer of the gas.

The time-consuming process of safely transferring the highly toxic methyl isocyanate gas is expected to take about 2 hours. The fire team has to make sure that during this time the fire will not move to this area and the temperature around the tank is kept low. The support team utilizes incoming video feeds to offer advice, monitor progress and ensure that the primary activity of cooling this area and transferring the gas continues at necessary pace as needed.

3.8 Event A8

Gas tank shut down process starts (Time = T+240 minutes)

0.30 a.m. As soon as the process of transferring the highly toxic methyl isocyanate gas is completed and the tanker moves away, the expert from the factory needs to shut down the safety valves on the gas producing mechanisms. For this, he needs access to two high resolution cameras to isolate the gas tank from the rest of the factory by intricate valve settings. This is accomplished with the help of two high resolution cameras mounted directly across the various controls connected

to the LTE network. This process is extremely complex and dangerous as the residual gas in the tank could be equally dangerous. During this time also the fire team has to make sure that the fire will not move to this area and the temperature around the tank is kept low. The support teams continue to utilize incoming video feeds to offer advice, monitor progress and ensure the primary activity of cooling this area.

3.9 Event A9

Storage tank shutdown (Time =T+245 minutes)

0.35 a.m. The storage tank has been successfully shut down and the focus now shifts to controlling the fire in the main building. All focus has now shifted to extinguishing the fire.

3.10 Event A10

Incident ends (Time =T+600 minutes)

6.30 a.m. Finally the fire has been brought under control after 10 hours of extremely hazardous work and the team starts moving various equipment and cameras, etc. and writing necessary reports. All videos of the events are archived and transferred to the main data centre.

Annex 5

Case study: PPDR deployment strategy utilizing partitioning of the service capacity on a national IMT network

This case study describes an arrangement in which an existing national IMT network(s) uses the ability of an LTE system to partition the service capacity (either by the assignment of dedicated spectrum blocks for PPDR and public users or by assignment of dedicated capacity apportionment amongst PPDR and public users) coupled with the ability in certain situations to dynamically adjust the service capacity with prioritization to the PPDR.

An alternative approach to implementation of a dedicated network or a build-own-operate network, utilizes the ability of IMT networks to “partition” designated spectrum blocks for exclusive use by certain user-groups, such as PPDR agencies – while sharing the remaining network coverage, capacity, switching/routing core, backhaul, and radio base-station infrastructure. Using QoS ‘priority’ features available within the IMT technology, and in IP transport layers, a more affordable and effective strategy is available for delivering seamless emergency-grade mobile broadband services over a larger area. The key considerations underlying this strategy include:

- PPDR coverage must be widespread – ideally, PPDR operational coverage should be nationwide for maximum operational effectiveness. While day-to-day public safety events are mostly focused in populated (urban/suburban) areas, natural disasters such as cyclones/tornadoes, tsunamis/floods, volcanic eruptions, earthquakes and forest fires can strike anywhere – often in regional/rural zones. Public networks may already provide national coverage – but further extending and ‘hardening’ an existing public network may be easier, faster and cheaper than building an entirely new “dedicated” network of similar scale. However, the resilience and quality of service may be limited to that provided by the public network unless additional measures are implemented.
- PPDR functionality must be transparently delivered everywhere – irrespective of geographic location, the full PPDR functionality should be readily/seamlessly available to authorized users. Reflecting the urgency of emergency events and disasters, minimal access delays and latency is critical for ensuring effective response by PPDR agencies. This suggests need for an integrated network approach. Reliance on simple roaming to another network is unlikely to satisfy PPDR users in critical situations expecting a fast and seamless experience.
- Mobile broadband networks require significant capital resources to build and operate – the resource requirements of building a near-nationwide IMT network, with high availability and capacity, can be prohibitive – and the ongoing operations and maintenance costs (along with periodic technology upgrades) can be a significant burden.
- Sharing public network infrastructure will result in greater efficiencies by avoiding the direct need for duplicating core network, backhaul systems, site access/infrastructure, and operational support systems (OSS), as well as leveraging the public network operator’s procurement scale, the incremental capital resource needs of delivering broadband PPDR are considerably reduced. There are significant savings and a better user experience, through more seamless functionality over a homogenous coverage footprint, for PPDR agencies using an integrated network scenario.
- Enhancing public network resiliency (hardening) may be simpler than building an equivalent new network – while some aspects of a public network may need to be further ‘hardened’, the capital needs associated with localized upgrades will always be lower compared to deployment of a dedicated PPDR network. Such upgrades may include: increased site back-up power; backhaul link and node redundancy; additional physical and

electronic intrusion detection; and other protective measures. In contrast, some aspects of public network planning offer greater resiliency than traditional PPDR networks: for example, typical public network deployment planning includes overlapping sector-coverage arrangements (coverage “depth”) to minimize outage due to loss of a sector – in contrast to the ‘thin’ single-layer coverage typically associated with traditional PPDR network planning. However, geographical coverage objectives of public networks may differ from those of traditional PPDR networks.

- Leveraging public network infrastructure may also facilitate a faster PPDR deployment – since the majority of network infrastructure is already in place, especially in urban and populated areas, PPDR services can be put into active service (over a relatively large coverage area) sooner – even if further network ‘hardening’ and coverage extension work is still proceeding.

This case study also considered several other aspects to be attractive, including: i) The availability of skilled resources for planning, building and operating an IMT broadband wireless network within an existing network operator; ii) technology obsolescence and need for regular upgrades to keep the network fit-for-purpose is the responsibility of existing network operator; and iii) retention and training of specialist technical staff, support vehicles and equipment, shifts to the network operator.

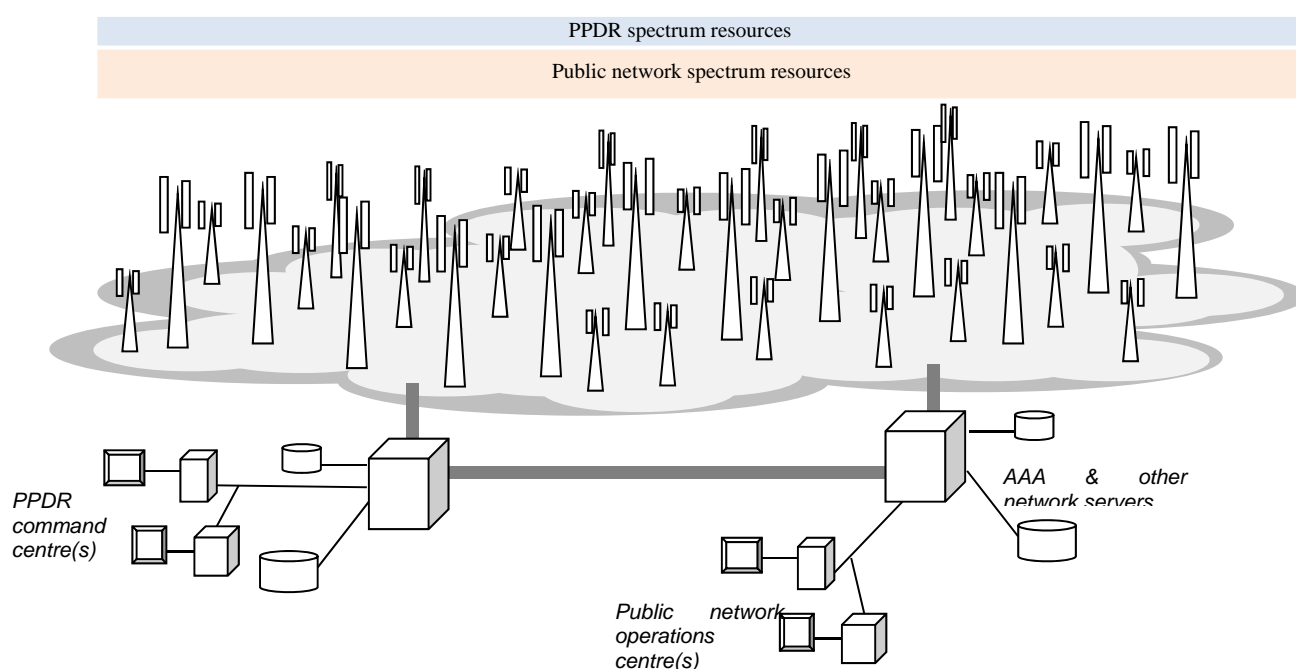
Public networks can efficiently and seamlessly accommodate the needs of mission-critical PPDR users within a nationwide IMT network by implementing a combination of:

- spectrum partitioning, to quarantine spectrum segments to specified users or user-groups;
- enabling differential QoS attributes; and
- enabling dynamic intra- and inter-band ‘carrier aggregation’ of spectrum resources.

This integrated approach to implementing a national broadband PPDR system is illustrated in concept in Fig. 4.

FIGURE 4

Integrated IMT PPDR/public network – based on shared Radio Access Network (RAN), duplicated core, distributed OSS, and configured for partitioned PPDR spectrum and dual HSS/AAA



Delivering an integrated broadband PPDR system

Delivery of emergency-grade mobile broadband services using dedicated PPDR spectrum resources and seamless integration with a public IMT network in this case study is based on a three-stage deployment plan:

- Stage 1 – Deploy the PPDR spectrum as a dedicated resource within a common Radio Access Network (RAN) on existing public network base-station sites, for exclusive use by emergency services.
- Stage 2 – Introduce “priority access” and preferential service levels for PPDR users, to facilitate priority access (‘overflow’) to the public network capacity in times of need (e.g. major event or disaster).
- Stage 3 – In parallel, progressively enhance the resiliency of the public IMT network in accordance with PPDR agency priorities, for more robust operation in times of emergency and disasters.

The concept of ‘partitioned’ spectrum is achieved via two alternative methods: distinct spectrum bands or distinct sub-bands – as illustrated below:

FIGURE 5
Example of cross-band partitioning

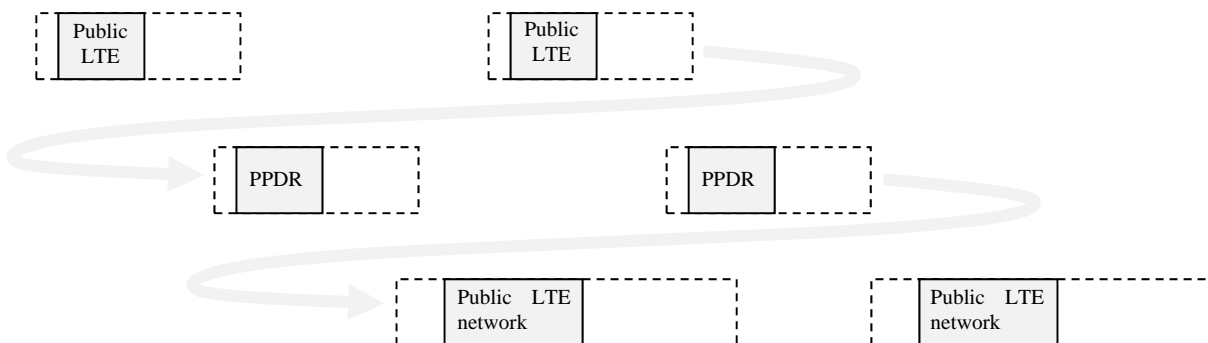


FIGURE 6
Example of sub-band partitioning



Such spectrum partitioning is intended to provide PPDR agencies with sufficient certainty in regard to network coverage and capacity, to support all day-to-day operational requirements and many emergency events and local disasters.

In the case of an integrated host network employing either cross-band or sub-band partitioning, the use of “carrier aggregation” and “priority access” to the public IMT network spectrum enables

additional resources to be seamlessly and immediately made available should PPDR traffic needs exceed the dedicated spectrum block threshold capacity. In the event of a major disaster, this effectively provides PPDR agencies with immediate, seamless and transparent access to considerably greater network capacity – while avoiding valuable spectrum otherwise largely lying idle/under-utilized, as might be the case for a dedicated PPDR network.

Network capability and resilience

To be fully effective, a host IMT network must provide PPDR users with sufficient coverage reach, availability, and overall resilience. These three key attributes are inextricably associated with the architecture and configuration of the deployed network, and will involve:

- sufficient radio base station sites deployed to not only meet coverage objectives, but also to ensure suitable ‘depth’ of coverage in all priority regions;
- sufficient capacity in base stations to cope with increases in demand that may occur in certain areas during major emergency events;
- sufficient base-station site physical security and back-up power to maintain operations despite adverse natural events and human attack;
- backhaul and core network systems configured for redundancy to mitigate any conceivable single-point-of-failure;
- sufficient security measures and encryption to block unauthorized access or tampering with relevant network servers and routers; and
- 24/7 network status/health monitoring and proactive capacity management to ensure that network issues are immediately addressed before they impact performance or user experience.

All of these protective measures are equally important irrespective of the preferred approach to implementing a broadband PPDR network.

Device and terminal considerations

A rich eco-system of access devices and user terminals for public/commercial IMT (LTE) systems is already emerging in the global market. This eco-system includes a wide range of hand-portables, vehicle-mounted devices, and OEM modules.

However, the PPDR sector has traditionally sought ruggedized user terminals, and a variety of special application versions (e.g. for helicopter/aircraft, motorcycle, and covert use). Such requirements will continue – not necessarily for all PPDR users – so vendors of ruggedized devices will continue to play a vital role in this market segment. But, special PPDR user devices have typically involved higher development costs, and a higher sales price, due to their unique design requirements and the relatively small market size. To alleviate such costs, greater harmonization of PPDR spectrum arrangements on a regional (or semi-global) basis is being sought – with harmonization of a key objective of Resolution ITU-R 646.

With the wider take-up of mobile broadband services, “smart” phones/devices and tablets will also play a greater role in day-to-day PPDR operations – inevitably encouraging the emergence of new functions, applications, and methods of working.

Case study conclusions

In this case study, it was found that the integrated approach across spectrum and network infrastructure involving use of public IMT (LTE) network resources and systems – even with dedicated PPDR spectrum – offers an alternative method of delivering future mobile broadband services for PPDR agencies. The case study provides a view with regard to these aspects of PPDR deployment:

- early initial PPDR service availability/delivery;
- wide-area prioritized PPDR network access;
- seamless geographic coverage;
- dynamic additional capacity allocation for major events/disasters;
- seamless PPDR user experience across the entire coverage area;
- high levels of resilience;
- potentially lower cost of deployment; and
- opportunity for economies of scale.

The strategy outlined above allows national resources to be efficiently used – and financial investment to be directed toward network ‘hardening’, rather than duplication of existing infrastructure. This strategy also ensures that radio spectrum resources are fully exploited to deliver maximum economic and social benefit to national communities. It may enable a larger PPDR mobile broadband network to be brought into operation, in a relatively short time-frame, and with lower project and financial risk to administrations and PPDR agencies.

Leveraging the existing skills and experience of public IMT network operators may reduce costs, risks and delays associated with bringing advanced LTE mobile broadband technology to assist in enhancing the effectiveness of today’s PPDR agencies.
