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| **Radiocommunication Study Groups** |  |
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| “Public protection and disaster relief communications” | |

Editor’s Note: Align the title to the content at a later stage

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EDITORS NOTE: NEED TO CHECK THROUGHOUT THE DOCUMENT AND REPLACE THE WORD MUST IF IT IS USED INNAPPROPRIATELY.

# 1 Introduction

In recent decades, demand for global development and enhancement of Public Protection and Disaster Relief (PPDR) applications has shown a significant increase. There is a need to enable more efficient and more effective responses to natural and man-made disasters, as well as routine, daily emergencies. At the same time, mobile broadband technologies have advanced rapidly in terms of speed and throughput, with peak data rates in the order of 1 gigabit per second (Gbit/s) in the downlink and 500 megabits per second (Mbit/s) in the uplink.

Meanwhile, narrowband and wideband technologies for PPDR services and applications are still widely used in all three ITU Regions.

# 2 Scope

This report addresses:

– the categorization of technical and operational requirements relating to PPDR;

– the current use of narrow and wide-band PPDR;

– the mobile broadband PPDR services and applications including further developments and the evolution of PPDR through advances in technology;

– the needs of developing countries,

References, terminology and abbreviations, and an explanation of PPDR operations can be found in annexes 1 to 3 of this report. Applications, including examples and requirements can be found in Annexes 4 and 5. Further content of Annexes, related to broadband, is summarised in Section 6.2

Part 1 – generic PPDR radio communications

This part describes the objectives and requirements for PPDR services and applications that can be provided by all types of PPDR implementations (narrowband, wideband and broadband) and:

* summarizes the overall PPDR objectives and requirements, as provided by Administrations and the PPDR agencies and organisations;
* those requirements that are categorized as generic (to be met by NB, WB, and BB systems) and those additional requirements that are to be met by broadband systems only, with an explanation provided for a detailed listing as included in Annex 5;
* categorized requirements linked to the appropriate applications divided into narrow, wide and broadband in Annex 4.

Editor’s Note: We need to make sure that the Annexes and their referencing make sense and are logical.

# 3 Generic technical and operational objectives and requirements for PPDR services and applications

## 3.1 General objectives

PPDR radiocommunication systems have the following general objectives:

a) to provide radiocommunications that are vital to the achievement of:

– the maintenance of law and order;

– response to emergency situations and protection of life and property;

– response to disaster relief situations

b) to provide the services as identified above in item a) over a wide range of geographic coverage areas, including urban, suburban, rural and remote environments and areas with limited infrastructure

c) to support interoperability and interworking between networks, both nationally and for cross-border operation, in emergency and disaster relief situations, including interconnectivity with public networks

d) to allow international operation and roaming of mobile and portable units;

e) to make efficient and economical use of the radio spectrum, consistent with providing services at an acceptable cost;

f) to accommodate a variety of mobile terminals including a range of devices that are small enough to be carried on one’s person to those which are mounted in vehicles;

g) to encourage cooperation among countries for the provision of effective and appropriate humanitarian assistance during disaster relief situations;

h) to make available PPDR radiocommunications at reasonable costs in all markets and

i) to support the needs of developing countries, including the provision of low-cost solutions for PPDR agencies and organisations.

## 3.2 Technical and functional objectives

Systems for PPDR aim to achieve the following technical and functional objectives:

a) to support the integration of voice, data, video and image communications as part of a multimedia capability;

b) to provide additional level(s) of priority, availability and layered security associated with the source, destination and type of information carried over the communication channels used by various PPDR applications and operations; (e.g. authentication, air to air encryption, end to end encryption (Subscriber Device management and application security);

c) to provide each PPDR organization with user authentication (e.g., public key cryptography) among PPDR organizations and for their devices prior to granting access to their applications or network resources;

d) to support equipment that accommodates operation while wearing gloves, operation in adverse/adverse environments (heat, cold, dust, rain, water, shock, vibration, explosive and rough road, dust, extreme temperature, intrinsically safe environments and extreme electromagnetic environments, etc.) and long battery life;

dbis) to support robust equipment (e.g. hardware, software or in operational and maintenance aspects) required for PPDR systems. Equipment that functions while the user is in motion is also required. Equipment may also require high audio output (to cope with high noise environments), as well as unique accessories, which could include special microphones (e.g. lapel, in-ear);

e) to accommodate the use of repeaters for covering long distances between terminals and base stations in rural and remote areas and also for intensive on-scene localized areas;

f) to provide fast[[1]](#footnote-1) call set-up, one touch broadcasting (PTT to group) and group call features;

g) to provide for emergency calls, one-touch emergency alert, emergency voice PTTs, and emergency data PTTs (e.g. sending images, real-time video) during PPDR events;

h) to support information pull, push and subscription with prioritisation;

i) to provide for strong multi-national/multi-agency technical interoperability over multi‑network and device technologies in a seamless fashion;

j) to provide Localized Communication Services, such as DMO;

k) to provide for the ability of PPDR communication systems to interface with existing other dedicated PPDR and/or commercial systems;

l) to be scalable in order to suit small and large agencies, without sacrificing the ability to interoperate;

m) to provide for quick deployment of temporary infrastructure and services as well as recovery from failure;

n) to support continuous use basic PPDR services in case of infrastructure collapse or failure, e.g. backhaul link between base station and core network drops.

## 3.3 Operational objectives

Systems for PPDR aim to achieve operational objectives, including the following:

a) to provide security, including optional end-to-end encryption, and secure terminal/network authentication;

b) to enable communications management to be (fully or partly) controlled by PPDR agencies and organizations through such functions as, dispatch and incident management, instant/dynamic reconfiguration changes to talk groups, guaranteed access controls -- including device and application priority, pre-emption calls, groups or general calls -- spectrum resource availability for multiple PPDR agencies and organizations, and coordination and rerouting;

c) to provide group communications through the system/network and/or independent of the network (e.g. such as localized communication services, simplex radio and push‑to‑talk);

d) to provide customized and reliable coverage especially for indoor areas such as underground and inaccessible areas.

e) to allow for the extension of cell size or capacity in rural and remote areas or under severe conditions during emergency and disaster situations;

f) to provide full service continuity, high reliability and failure tolerance through measures such as redundancy for emergency operations, or support for isolated sites/stations working in case of backhaul loss, and the possibility to rapidly provide temporary coverage and capacity, e.g. when there is partial loss of infrastructure;

g) to provide high quality-of-service, including fast[[2]](#footnote-2) call set-up and dialling including push-to-talk, resilience under extreme load, very high call set-up success rate, etc.;

h) to take account of various PPDR applications;

i) to provide for multi-national/multi-agency interoperability at various levels of incident management and chain of command as well as with other, collaborating organizations and/or entities;

j) to have user handsets/devices that are easily useable and configurable with little need for technical expertise.

## 3.4 User requirements

This section covers both the generic and broadband only user requirements. The requirements categorized as generic are those that can be met by narrow, wide and broadband systems as included in Table A5-1 of Annex5. The additional requirements that can only be met by broadband systems are categorized in Table A5-2 of Annex 5.

### 3.4.1 System

#### 3.4.1.1 Support and integration of multiple applications

Systems providing for PPDR operations should be able to support and integrate a broad range of applications given in Table A4-1 in Annex 4 and according to the categorization in Table A5-1 of Annex 5.

#### 3.4.1.2 Simultaneous use of multiple applications

Communication systems and applications serving PPDR should be able to support the simultaneous use of several different applications with a range of bit rates.

In addition, Table A5-2 of Annex 5 shows that Systems providing for broadband PPDR operations are likely to have to accommodate high data throughput, with demands for several simultaneous applications running in parallel.

#### 3.4.1.3 Priority Access

Systems serving PPDR should have the ability to manage high priority traffic and possibly manage low priority traffic load shedding during high traffic situations. PPDR operations may require either the exclusive use of frequencies or equivalent high priority access to other systems   
or a combination thereof.

In addition, this could also mean giving priority access to certain public safety personnel or agencies when they connect to a given network either permanently or at pre-defined times. This is especially important in any scenario where the network supports a mixture of PPDR communications and ordinary commercial communications. Priority access may entail some sort of immediate pre-emption capability through the network (e.g. LTE priority access). One of the key requirements of the PPDR communications is the need to have dynamic priority management.

#### 3.4.1.4 Grade of service (GoS) requirements

A suitable grade of service should be provided for PPDR applications that support mission critical activities.

Editorial note: A definition of mission critical should be put in the appropriate section.

#### 3.4.1.5 Quality of Service

PPDR users may also require reduced response times for accessing the network and information directly at the scene of incident, including fast subscriber/network authentication.

Editorial note: Further work to identify difference between generic QOS and broadband only requirements need to done.

An overview of QoS definition is available in Appendix 1 to Annex 5

#### 3.4.1.6 Reliability

PPDR applications should be provided on a stable and resilient working platform. Reliability requirements should include a stable and easy-to-operate management system, offer resilient service delivery and a high level of availability[[3]](#footnote-3) (commonly achieved using redundancy and backup, fall‑back and auto-recovery, self-organization).

In the event of the network failure or loss of network coverage, Localized communication services such as isolated base stations, relayed mode of operation and Direct Mode Operation (DMO), off‑network communication or D2D communication (Device-2-Device) between PPDR users is required as an immediate solution for re-establishing communications. Localised communication services are also needed either through deliberate user action or as a result of devices leaving the network coverage. or may also be required at a local incident where the coverage does not extend inside a building. See table A5-3 for more detail on localised communication services.

Editorial note: A definition of the terms used above should be put in the appropriate section for definitions and vocabulary.

#### 3.4.1.7 Coverage

A PPDR system is typically required to provide complete geographic coverage[[4]](#footnote-4) for “normal” traffic within the relevant jurisdiction and/or area of operation (national, provincial/state or local level). This coverage is required 24 hours per day, 365 days per year. Systems supporting PPDR organizations are designed for peak loads, and wide fluctuations in use.

Additional resources for systems providing for PPDR -- enhancing either coverage, system capacity or both - may be employed during a PP emergency or DR event, through techniques such as reconfiguration of networks with intensive use of Transportable Base station sites, DMO, high power UE and vehicular repeaters), which may be required for coverage of localized areas. PPDR systems are not generally installed inside buildings. Urban PPDR systems are designed for highly reliable coverage of subscribers outdoors and indoors, using direct propagation through the buildings’ walls. Sub-systems may be installed in specific buildings and/or structures like tunnels, if coverage from external systems is insufficient. Traditionally, and in current practice, narrowband PPDR systems have tended to use larger radius cells and higher power mobile and personal radios compared to devices available in commercial service provider’s systems (for service to the public). Trade-offs of coverage, capacity and spectrum reuse against infrastructure costs will likely be a decision for each administration to consider. Some administration may favor a larger cell model for PPDR networks.

Editor’s note: The above Paragraph needs to looked at in detail to see what is broadband specific

With modern mobile broadband technologies such as LTE, the user equipment (UE) is designed to be able to reduce maximum transmit power and transmission bandwidth configuration in order to meet additional (tighter) unwanted emissions requirements. During emergency situations, there is a need to access the full UL transmission bandwidth configuration. All resource blocks at maximum power are required by PPDR user(s) to upload mission-critical information to their command and control centres with minimum delay. This function may not be required in all scenarios, but it should be achievable without the need to activate the additional power control mechanisms (e.g. NS\_0X/A-MPR function) which would require the UE to reduce its maximum output power.

Editor’s note: The above paragraph looks out of place in this section should it be moved or deleted?

#### 3.4.1.8 Capabilities

In addition to those capabilities shown in section 3.3 of this report the additional following capabilities may be considered. As the trend continues to move towards IP based solutions, PPDR systems may be required to be IP compatible or be able to interface with IP based solutions.

There may be additional requirements for simulcast (quasi-synchronous broadcast), receiver operating (in-bound path diversity) that have not been covered in Annex 5.

PPDR users also require communications with aircraft and marine vessels, control of robotic devices, and vehicular coverage extenders (deployable base stations, to extend network coverage to remote locations).

System capability for over-the-air programmability of field units is also extremely beneficial.

Editor’s note: Some editorial changes are needed in this section to make the text read properly.

### 3.4.2 Security related requirements

Efficient and reliable PPDR communications within a PPDR organization and between various PPDR organizations, which are capable of secure operation, may be required.

Notwithstanding, there may be occasions where administrations or organizations, which need secure communications, bring equipment to meet their own security requirements.

Furthermore, it should be noted that many administrations have regulations limiting the use of secure communications for visiting PPDR users.

Table A5-1 of Annex 5 shows that end to end encrypted communications for mobile to mobile, dispatch and group call communications are a generic requirement for all PPDR networks.

In addition Table A5-2 of Annex 5 shows that, broadband PPDR networks must provide a secure operational environment. Security requirements should include:

– encryption technology;

– support for domestic encryption algorithms;

– authentication for users, terminals and networks;

– user identification and location, air interface encryption and integrity protection ability;

– end-to-end encryption;

– support for third-party key management center;

– system authorization management; and

– over-the-air key updating.

In addition to these system-level requirements, suitable operational procedures should be developed to accomplish required levels of security for information being passed across the network.

### 3.4.3 Cost related

Cost-effective solutions and applications are extremely important to PPDR users. These can be facilitated by open standards, a competitive marketplace, and economies of scale. Furthermore, cost-effective solutions that are widely used can reduce the deployment costs of network infrastructure, as well as user devices and other equipment.

This includes compliance with open international standards, with technology exhibiting backwards compatibility and a smooth upgrade path. These requirements, together with a requirement for end‑user to end-user connectivity with existing networks used for PPDR communications should lead to a diversity of supply.

PPDR equipment should be manufactured at a reasonable cost, while incorporating various aspects specific to each country/organization. Administrations should consider the cost implications of procuring interoperable equipment; since this requirement should not be so expensive as to preclude implementation within an operational context (see also Table 5A-1).

It should be noted that PP networks may cost more than DR networks due to the more-stringent requirements of PP systems[[5]](#footnote-5). However, most of these costs are related to network design (power supply, redundant transmission etc.).

### 3.4.4 EMC

Systems supporting PPDR should be in compliance with appropriate regulations concerning electromagnetic compatibility (EMC), which may take into account not only interference but also protection from inadvertent electromagnetic pulse or surge effects. Adherence to national EMC regulations may be required between networks, radiocommunications standards and co located radio equipment.

### 3.4.5 Operational requirements

This section defines the operational and functional requirements for PPDR users and lists key attributes as provided in Table 5A-1 of Annex 5.

#### 3.4.5.1 Scenario

This section describes the operating environments by defining the scenarios that, from the radio perspective, may impose different requirements on the use of PPDR applications and their importance.

Greater safety of personnel can be accomplished through improved communications. Systems supporting PPDR should be able to operate in the various scenarios, as described in Annex 4.

Editor's note: Does Annex 4 refer to all of the scenarios in Annex 5

#### 3.4.5.2 Compatibility

PPDR networks should allow end-user to end user connectivity or be compatible with existing networks used for PPDR communications. Compatibility requirements may include diversity of supply, use of open international standards, backward compatibility and a smooth upgrade and evolution path.

The current, ongoing evolution of systems and technologies providing PPDR might alleviate most of the compatibility challenges.

#### 3.4.5.3 Interoperability

Interoperability is an important requirement for PPDR operations. PPDR interoperability is the ability of PPDR personnel from one agency/organisation to communicate by radio with personnel from another agency/organisation, on demand (planned and unplanned) and in real time.

This includes the interoperability of equipment internationally and nationally for those agencies that require domestic and international cross-border cooperation with other PPDR agencies and organizations.

Several options are available to facilitate communications interoperability between multiple agencies, networks and devices.

These include, but are not limited to:

a) adoption of a common technology and/or standards, such as those listed in Recommendation ITU-R M.2009;

b) the use of standardised equipment and harmonized frequency bands;

c) equipment and infrastructure supporting multiple modes (e.g. capability to provide services using different technologies in the same equipment);

c) utilising local, on-scene command vehicles/equipment/procedures;

d) communicating via dispatch centres/patches;

e) utilising technologies such as audio switches or software defined radios. Typically multiple agencies use a combination of options; or

f) interconnection with (via standard interface and open system infrastructure:

• narrow-/wide- and broadband PPDR systems;

• commercial communication networks (fixed and mobile);

• satellite communications networks; and

• other information systems.

How these options are used to achieve interoperability depends on how the PPDR organizations want to communicate with each other and at what level in the organization. Usually, coordination of tactical communications between the on-scene or incident commanders of multiple public protection and disaster relief agencies is required.

Regarding the technology element, there are a variety of solutions implemented either through pre‑planning activities or by using particular technologies, which could support and facilitate interoperability.

### 3.4.6 Spectrum usage and management requirements

Depending on national circumstances and regulatory options, PPDR users may need to share spectrum resources with other terrestrial mobile users. The detailed arrangements regarding sharing of the spectrum vary from country to country. Furthermore, there may be several different types of systems supporting PPDR operating in the same geographic area.

Communication systems and applications providing for PPDR operations need appropriate spectrum management provisions (e.g. in order to maintain the required Quality of Service). Depending on the national regulations, systems supporting PPDR may be required to use specific channel spacing between mobile and base station transmit frequencies.

As PPDR networks may be designed to provide wider coverage per site, site planning may be needed to avoid interference between high tower/low density PPDR sites and low tower /high density cellular sites.

### 3.4.7 Regulatory compliance

Systems supporting PPDR should operate in accordance with provisions of the Radio Regulations and comply with relevant national regulations. In cross-border areas and roaming situations, coordination of frequencies should be arranged between administrations (especially where DMO or D2D use may be required), as appropriate.

### 3.4.8 Planning

Planning and pre-coordination by PPDR agencies and organisations are essential to providing reliable PPDR communications. This includes ensuring that sufficient equipment and backhaul capacity is available (or can be rapidly called upon) to provide communications during unpredictable events and disasters, and ensuring that channels/resources, user groups and encryption keys are pre-allocated for seamless deployment. It is beneficial to maintain accurate and detailed information so that PPDR users can access this information at the scene.

Administrations may also find it beneficial to have provisions supporting national, state/provincial and local (e.g. municipal) systems.

### 3.4.9 Performance

PPDR networks must be able to support a range of performance requirements as given in Table A5‑1 of Annex 5 including high quality audio and intelligibility, secure communications (e.g. encryption, form /records query and report).

These requirements are supported by applications as contained in Table A4-1 and A4-2 of Annex 4.

In addition broadband requirements as described in Table A5-2 of Annex 5 support applications which are contained Table A4-3 of Annex 4.

A broadband PPDR system is expected to support various media, such as a flexible combination of multi-media capabilities (simultaneously and in real-time), data and narrowband voice. Such flexibility may be accomplished through reallocation of both, uplink and downlink rates (depending on the RAN technology), increasing spectrum efficiency, ergonomic design of terminals, very good signal coverage, high terminal performance, and mobility.

Editor’s Note: There is a proposal to move the text in section 3.5 below to the beginning of the user requirements.

## 3.5 General summary on requirements and applications

Annex 5 is a general summary of the generic user requirements (Table A5-1) and additional broadband requirements (Table A5-2). Furthermore, the importance (high, medium or low) of that particular requirement to PPDR is indicated. This importance factor is listed for the three radio operating environments identified in Tables A4-1 to A4-3 to Annex 4 “Day-to-day operations”; “Large emergency and/or public events”, and; “Disasters”, represented by PP(1), PP(2) and DR, respectively. The detailed choice of PPDR applications and features to be provided in any given area by PPDR is a national or operator specific matter. However, the capabilities of the service are affected by the requirements above.

# 4 Envisioned applications

The Table A4-1 of Annex 4 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.

However, Broadband technologies are expected to be able to supply all of the applications shown in the Table A4-2 of Annex 4.Broadband applications enable an entirely new level of functionality with additional capacity to support higher speed data and higher resolution images. The exact applications and particular features to be provided by the various PPDR organizations are to be decided by such organizations. Furthermore, for each example, the importance (high, medium or low) of that particular application and feature to PPDR is indicated.

Editor's Note: There was a proposal to move the text in sections 4 and 5 above the requirements section.

# 5 PPDR applications

As PPDR operations become more reliant on electronic databases and data processing, access to accurate and detailed information by professionals in the field, such as police, fire fighters and medical emergency personnel, is critical to improving effectiveness in resolving emergency situations. This information is typically held in office-based database systems and includes images, maps, architectural plans of buildings, and locations of hazardous materials systems.

In the other direction, the flow of information back from units in the field to operational control centres and specialist knowledge centres is equally important. Examples to note are the remote monitoring of patients and remote real-time video monitoring of civil emergency situations, including the use of remote-controlled robotic devices. More related examples are available in the Annex4.

Moreover, in disaster and emergency situations, critical decisions to be made by controlling authorities are often impacted by the quality and timeliness of the information received from the field.

These applications, in general, require higher bit-rate data communications than can be provided by narrowband PPDR systems. The availability of advanced applications is expected to be beneficial to PPDR operations.

The eventual availability of applications for PPDR may depend on various factors. These include the cost, the regulatory and the national legislative climate, the nature of the PPDR mandates, and the needs of the area to be served. The exact applications and particular features to be provided by the various PPDR organizations are to be decided by such organizations.

While voice communications will remain a critical component of PPDR operations, new data and video services will play a key role.

The challenge to be taken on board by the future evolution of applications and services providing for PPDR operation is to keep track with the changing demands and requirements of the PPDR community. The following, amongst others, should be considered by these activities:

- implementing advanced solutions enabling existing services to fulfil also broader future demands and requirements – e.g. to provide for higher data rates;

- wide availability of such advanced technology with interoperability to reduce cost and network rollout times, and – e.g. by using common standards;

- spectrum aspects of existing and future use – e.g. considering the pooling of PPDR usage.

The report provides in its Annexes 4 and 5 tables summarizing applications (Annex 4) and requirements (Annex 5) for narrow, wide and broadband systems. PPDR communications using applications (as depicted in Annex 4) providing PPDR services able to fulfil in future the related requirements (as requested in Annex 5) are considered sufficient to serve the needs of PPDR agencies and organizations also in the long term.

# 6 Spectrum considerations for PPDR

Resolution 646 (Rev.WRC-12) encourages administrations to consider the regionally harmonized frequency bands/ranges identified in that resolution or parts thereof when undertaking their national planning for public protection and disaster relief solutions. It is noted that the frequency bands/ranges identified in that Resolution are allocated to a variety of services in accordance with the relevant provisions of the Radio Regulations and that flexibility must be afforded to administrations to determine, at national level, what portions of the spectrum within the bands/ranges in this Resolution can be used by public protection and disaster relief agencies in order to meet their particular national requirements.

It is noted that the identification of these frequency bands/ranges for public protection and disaster relief does not preclude the use of these bands/frequencies by any application within the services to which these bands/frequencies are allocated and does not preclude the use of nor establish priority over any other frequencies for public protection and disaster relief in accordance with the Radio Regulations.

## 6.1 Frequency bands/ranges for PPDR

Resolution **646 (Rev. WRC-12)** encourages administrations, for the purposes of achieving regionally harmonized frequency bands/ranges for advanced PPDR solutions, to consider the frequency bands/ranges identified in that resolution, or parts thereof. Resolution **646 (Rev.WRC‑12)** also recognizes the frequency bands designated for existing PPDR operations. In addition Recommendation ITU-R M.2015 contains the Frequency arrangements for public protection and disaster relief radiocommunication systems in UHF bands in accordance with Resolution **646 (Rev.WRC‑12)**.

Editor’s Note: Hyperlinks to the resolution and the recommendation should be added above.

It should be noted that there is some variation in regard to frequency bands that are used for PPDR in different countries. In addition, while in most countries the bands used for public protection are the same as those used for disaster relief, in some countries separate bands are used.

## 6.2 Spectrum requirement calculations for PPDR

Editor’s Note: Some suitable introductory text is needed for this section.

Annex 6 (Narrow/Wideband technologies) and Annex 7 (Broadband technologies) provides examples of the estimation of the spectrum requirements for PPDR.

The spectrum calculation methodology employed follows the format of the generic methodology that was used in Recommendation ITU R M.1390, with the values selected for the PPDR applications taking into account the fact that PPDR utilizes different technologies and applications (including dispatch and direct mode).

Editorial note: The proponents who submitted spectrum calculations contained in Annex 6 and Annex 7 should indicate any deviation from Recommendation ITU R M.1390 in their calculations at the next meeting and introduce suitable amendments to the above paragraph as appropriate.

In addition to the above general considerations on spectrum for narrow, wide and broadband PPDR, administrations may find it helpful to consider the following parameters:

1 Total number of users per site during the peak hour.

2 Data rate requirements.

3 Applications types and call model.

4 Peak capacity during incident scenario.

5 Priority and QoS.

6 Reliability.

7 Cell edge performances.

8 Localized Communication Services.

Editor’s Note: The references shown below to the annexes containing the calculations carried over for spectrum requirements see Annex 6 and annex 7 should be updated/reviewed/verified.

Editor’s Note: To look at the Narrow/Wideband band only examples from M.2033 in Annex 6 with a request to review the need for these calculations, and if needed to contextualize why they are needed post 2010.

Examples of these Assessments of PPDR spectrum requirements have been done in a number of studies reflecting various environments, considering their unique environments and they are shown in Annex 6 to 11 of this Report.

Part 2 – Narrow/wideband PPDR communications

Radiocommunications is extremely important to PPDR organisations and in many countries narrowband/ wideband radiocommunications is the only form of communications that PPDR organisations can rely on in carrying out mission critical tasks. In order to provide effective communications, PPDR organisations have a set of objectives and requirements that include security, reliability, functionality and interoperability.

The following section is dedicated to narrow- and wideband PPDR communications only.

Specifically, it identifies objectives, applications, requirements, methodology for spectrum calculations, spectrum requirements and solutions for interoperability, which are not covered in general in Part 1 of this Report. It also discusses the evolution of narrow and wideband systems and applications serving for PPDR.

Recommendation ITU-R M.2009 identifies radio interface standards applicable for public protection and disaster relief (PPDR) operations in some parts of the UHF band in accordance with Resolution **646** **(Rev.WRC-12).**

# 7 Narrow / wideband PPDR communications

## 7.1 NB/WB applications

Editorial Note: need some introductory text for these bullets and this section.

a) Narrowband and wideband applications associated with the routine day-to-day and emergency operations for public protection applications as outlined in Tables A4-1 and A4-2 of Annex 4 could be offered.

b) Narrowband and wideband applications associated with disaster relief operations as outlined in Tables A4-1 and A4-2 of Annex 4 could be offered.

c) Applications for PPDR could be developed to support a variety of user terminals including handheld and vehicle-mounted.

## 7.2 Interoperability provided by narrow-/wideband systems and applications serving for PPDR

Editor’s Note: This section should be compared with the Generic Interoperability section 3.4.5.3

Interoperability is becoming increasingly important for PPDR operations. PPDR interoperability (as given in the definitions) is the ability of PPDR personnel from one agency/organization to communicate by radio with personnel from another agency/organization, on demand (planned and unplanned) and in real time. There are several elements/components which affect interoperability including, spectrum, technology, network, standards, planning, and available resources. Regarding the technology element, there are a variety of solutions implemented either through pre-planning activities or by using particular narrow- and wideband technologies, which could support and facilitate interoperability as described in the examples below.

## 7.3 NB/WB solutions of systems and applications serving for PPDR

Editor’s Note: This section should be compared with the Generic Interoperability section 3.4.5.3

A variety of the technologies with enhancements including developments in digital processing techniques could be applied to increase the data throughput of systems supporting PPDR. These technologies also support and enable dissimilar radios to be interoperable across different frequency bands and with different waveforms. Current advanced solutions could also satisfy some PPDR requirements by assisting the migration to new technology solutions. The below provides a general description of some of the historic and existing solutions which PPDR agencies and organizations employed in combination with the other key elements (spectrum, standards, etc.) required to facilitate interoperability.

### 7.3.1 Cross-band repeaters

Although less spectrum efficient, the cross-band repeater solution may provide interoperability, especially on a temporary basis. It is a viable solution when agencies, which need to interoperate use different bands and have incompatible systems (either conventional or trunked communications systems, using analogue versus digital modulation and operating in wideband versus narrowband mode). Currently, this solution is a practical approach for radio-radio interconnection because audio and push-to-talk (PTT) logic inputs and outputs are typically available. It requires little or no dispatcher involvement and is typically automated. Once activated, all broadcasts from one channel of one radio system are rebroadcast onto one channel of the second radio system. It also allows each user group involved to use its own subscriber equipment and allows subscriber equipment to have only basic features. The mobile radio implementation of cross-band repeaters is used, especially in mobile command vehicles, by public protection agencies to interconnect mobile users in different frequency bands. Using cross-banding repeaters is a method to solve spectrum and standards incompatibilities with a technology that exists today.

### 7.3.2 Radio reprogramming

Radio reprogramming to provide channel interoperability occurs between user groups operating in the same frequency band by allowing frequencies to be installed in all incident responders' radio equipment. Therefore, in order for this to be an effective solution, the radios should have this as a built-in capability. Radio reprogramming costs less than other interoperability solutions; it may or may not require additional infrastructure; it does not require coordinating and licensing of additional frequencies; and it can provide interoperability on very short notice. New techniques such as over the air reprogramming allow for instantaneous reprogramming to first responders in critical situations. This can be extremely useful in providing dynamic changes in a chaotic environment.

### 7.3.3 Radio exchange

Exchange of radios is a simple means to obtain interoperability. Radio exchange provides interoperability between responders with incompatible systems; it does not require coordinating and licensing of additional frequencies; and it can provide interoperability on very short notice.

### 7.3.4 Multi-band, multi-mode radios[[6]](#footnote-6)

Although the initial investment to purchase these radios is significant, it does provide several advantages:

– no dispatcher intervention is required;

– users can establish more than one simultaneous interoperability talk group or channel simply by having subscriber units switch to the proper frequency or operational mode;

– agencies need not change, reprogram, or add to the radio system infrastructure on any backbone systems;

– outside users can join the interoperability talk group(s) or channel(s) by simply selecting the right switch positions on their subscriber units; and

– no additional wireline leased circuits are needed. Multi-band, multi-mode radios can provide interoperability among subscriber units on the same radio system or on different systems. Equipment specifically designed and currently available that can operate on many frequency bands and in different voice and data modes. This also provides flexibility for users to operate independent systems in support of their missions with the added capability of linking different systems and bands on an as needed basis. Although this solution is not wide-spread due to the lack of software defined radios (SDRs), many public protection agencies use radios that operate in different frequency bands for interoperability.

SDR technology, for example, may permit interoperability without incurring other incompatibilities. The use of SDRs for commercial use, particularly for PPDR has potential advantages for meeting multiple standards, multiple frequencies, and the reduction of mobile and station equipment complexity.

### 7.3.5 Commercial services

The use of commercial services is effective in providing interoperability for by some extent PPDR organizations on an interim basis, particularly when administrative connectivity between disparate users is necessary. This interoperability solution is also beneficial in off-loading administrative or non-critical communications when the demand for the tactical system is greatest.

### 7.3.6 Interface/interconnect systems

Although a substantial investment is required to purchase interface/interconnect systems, they have proven to be effective in providing interoperability between different communications systems. These systems can simultaneously cross-band two or more different radio systems such as HF, VHF, UHF, 800 MHz, trunking, and satellite; or connect a radio network to a telephone line or a satellite. The ability to interface/interconnect different systems allows the users of different equipment in different bands the ability to utilize the type of equipment that best meets their requirements.

## 7.4 Existing solutions

For solving future bandwidth requirements, there are several existing technologies that are applied to increase the data throughput of PPDR systems which also reduces the amount of spectrum needed to support PPDR applications.

### 7.4.1 Adaptive antenna systems

Adaptive antenna systems could improve the spectral efficiency of a radio channel and, by so doing, greatly increase the capacity and coverage of most radio transmission networks. This technology uses multiple antennas, digital processing techniques and complex algorithms to modify the transmit and receive signals at the base station and at the user terminal. Commercial, private and government radio systems might obtain significant capacity and performance improvements from the application of adaptive antenna systems. The use of adaptive antenna systems in PPDR systems could increase the capacity of those networks within a limited bandwidth.

### 7.4.2 Cross-banding

Cross-banding is a solution that permits a radio operating on one frequency band to interoperate with another radio in a different frequency band is a technology that the PPDR community already uses and needs to use even more. Cross-banding can yield dividends because it permits operators to continue using existing frequencies and lets the translator do the work to accommodate the various users across different bands. If SDR technology is incorporated into the translator first, then legacy systems with their current waveforms can interoperate today, and these systems can be adaptable for tomorrow.

One other consideration with translators is the possibility of cross-moding, which could, for example, permit a UHF AM radio to interoperate with a UHF FM radio.

### 7.4.3 SDR (Software-Defined Radio)

Enhanced functions for the user are possible with SDR technology that uses computer software to generate its operating parameters, particularly those involving waveforms and signal processing. This is currently in use by some government agencies. Some companies are also starting to benefit by using SDR technology in their products. SDR’s systems have the ability to span multiple bands and multiple modes of operation and will have the capability in the future to adjust its operating parameters, or reconfigure itself, in response to changing environmental conditions. An SDR radio will be able to electronically “scan” the spectrum to determine if its current mode of operation will permit it to operate in a compatible fashion with both legacy systems and other SDRs on a particular frequency in a particular mode. SDR systems could be capable of transmitting voice, video, and data, and have the ability to incorporate cross-banding which could allow for the ability to communicate, bridge, and route communications across dissimilar systems. Such systems could be remotely controlled, and may be compatible with new products and backward compatible with legacy systems. By building upon a common open architecture, this SDR system will improve interoperability by providing the ability to share waveform software between radios, even radios in different physical domains. Further, SDR technology could facilitate public protection organizations to operate in a harsh electromagnetic environment, to not be readily detected by scanners, and to be protected from interference by a sophisticated criminal element. Additionally, this system could replace a number of radios currently operating over a wide range of frequencies and allow interoperation with radios operating in disparate portions of that spectrum.

## 7.5 Sum-up on still used and historic solutions

Because of each administration's ability to adopt and implement different standards and policies, harmonizing frequency bands on a global/regional basis for NB/WB PPDR solutions may not satisfy full interoperability with former existing equipment. The above solutions have historically been used to facilitate interoperability.

The services and applications described in this section are typically associated with emergency operations, disaster relief operations, public protection, and routine day-to-day operations. These are to be considered as examples only. The needed set of services and applications depends on the requirements in the respective PPDR organisation(s) at a certain time for a certain incident.

PPDR communications require:

– resilient and highly available infrastructure;

– reliable communication;

– secure communication; and

– group-addressable communication.

PPDR applications usually support advanced security mechanisms, such as authentication and end-to-end encryption.

In general, narrow- and wideband PPDR communication systems provide roaming, interoperability and interworking on domestic and international levels. Additionally, direct mode operation should be available.

## 7.6 Evolution of narrowband/wideband systems and applications serving for PPDR

### 7.6.1 Narrowband PPDR services and applications

Voice communication plays the dominant role in narrowband PPDR services and applications. The following voice services may be supported:

– group call with fast call set-up;

– broadcast call; and

– point-to-point call.

The following low-speed PPDR data applications may be supported:

– pre-defined status messages;

– transfer of location information;

– vehicle status;

– short messages; and

– access to databases (very small data volume only).

Internet protocol based services and applications are supported with very low transmission speed due to severe limitations of the bearer service. The services and applications have to be specially designed to cope with the speed, which is lower by several orders of magnitude than the speed provided by state-of-the-art IP networks.

### 7.6.2 Wideband PPDR services and applications

Wideband systems carry data rates of several hundred kilobits per second (e.g. in the range of 384‑500 kbit/s). With this speed, widely used application programs for IP based services can be used. Wideband services are therefore less limited than the narrowband service, while supporting the same voice services.

Examples of PPDR services and applications which may be supported in addition to the narrowband PPDR services and applications mentioned in section 6.2 include:

– E-mail;

– access to databases (medium data volume only);

– access to server based applications, including office applications and applications tailored to the needs of the specific organisation; and

– file transfer (e.g. picture, finger prints).

The servers providing those services typically reside in the IP networks of the respective PPDR agency or organisation, not in the public Internet, and the PPDR data bearer service provides access to this separate IP network without involvement of the public Internet. This gives the PPDR agency or organisation full control over security and availability. The PPDR network is typically designed for higher reliability, availability and security than the public Internet.

### 7.6.3 Harmonization of narrowband/wideband spectrum

Significant amounts of spectrum are already in use in various bands in various countries for narrowband PPDR applications, however, it should be noted that sufficient spectrum capacity will be required to accommodate future operational needs including narrowband, wideband and broadband applications. Since the adoption of Resolution 646 (WRC-03) experience has shown that the advantages of harmonized spectrum include economic benefits, the development of compatible networks and effective services and the promotion of interoperability of equipment internationally and nationally for those agencies that require national and cross-border cooperation with other PPDR agencies and organizations. Some of the benefits are:

– economies of scale in the manufacturing of equipment;

– readily available off-the-shelf equipment;

– competitive market for equipment procurement;

– increased spectrum efficiency;

– efficient planning and border coordination of land mobile spectrum due to globally/regionally harmonized frequency arrangements; and

– stability in band planning, that is, evolving to globally/regionally harmonized spectrum arrangements may assist in more efficient planning of land mobile spectrum; and

– increased effective response to disaster relief.

When considering appropriate frequencies for narrowband/wideband PPDR not identified in Resolution **646 (WRC-03)**, it should be recognized that the propagation characteristics of lower frequencies allow them to travel farther than higher frequencies, making low frequency systems potentially less costly to deploy in rural areas. Lower frequencies are also sometimes preferred in urban settings due to their superior building penetration. However, these lower frequencies have become saturated over time and to prevent overcrowding some administrations now use more than one frequency band in different parts of the radio spectrum.

Part 3 – Broadband PPDR radiocommunications

Editor’s Note: There needs to be a review of Part 2 to check for duplication with Part 1 and carry out a rationalisation process to make sure that the additional text is specific to broad band technologies.

This part of the Report is dedicated to mobile broadband PPDR radiocommunications.

Considering, for example, PPDR applications using IMT systems, it may be possible to leverage off commercial IMT networks in regions where it is not cost-effective or time-effective to deploy a dedicated network. IMT is intended for deployment in a wide range of environments, from rural to the densest urban areas. Commercial networks that are being deployed using IMT systems may not meet all of the identified needs for PPDR. However, the use of these systems can be considered, particularly in terms of the potential associated savings and advanced features that they offer.

# 8 Broadband PPDR requirements and evolution

Broadband PPDR services can be realized through any type of network (commercial, hybrid or dedicated), which will be deployed in frequency bands identified for IMT. The possibility to use available commercial equipment, or equipment based on commercial radio modules or chipsets may significantly reduce the costs for network infrastructure (e.g. base stations) and user devices (e.g. terminals).

## 8.1 Broadband PPDR requirements

### 8.1.1 Considerations on further developments of B-PPDR services and applications

In addition to the generic requirements collected in Part-1 of this Report, the ITU-R considers the following demands and requirements as a basis for the further evolution and development of broadband PPDR services and applications. These assumptions are commonly based on the following:

– Mission critical PPDR voice communications technologies are currently applied in all ITU Regions.

– Broadband PPDR applications for PPDR such as transmission of high resolution images and multi-media capabilities require much higher bit-rates than narrowband PPDR technology can deliver.

– Broadband systems may have inherent noise and interference trade-offs with data rates and associated coverage. Depending on the technology and the deployed configuration, a single broadband network base station may have different coverage areas in the range of a few hundred metres up to hundred kilometres, offering a wide range in spectrum reuse capability.

## 8.2 Current broadband PPDR radiocommunication standards

Recommendation ITU-R M.2009 identifies radio interface standards applicable for public protection and disaster relief (PPDR) operations in some parts of the UHF band in accordance with Resolution **646** **(Rev.WRC-12).** The broadband standards identified in this Recommendation are capable of supporting users at broadband data rates, taking into account the ITU-R definitions of “wireless access” and “broadband wireless access” found in Recommendation ITU-R F.1399.These standards are based on common specifications developed by standards development organizations (SDOs). Using this Recommendation, regulators, manufacturers and PPDR operators and users should be able to determine the most suitable standards for their needs.

Report ITU-R [M.2291](http://www.itu.int/md/R12-SG05-C-0064/en) 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; this Report has assessed the LTE system capabilities to support these applications. Report ITU-R M.2291 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.

Standards development organizations (SDOs) such as 3GPP, ATIS and CCSA are working on standards to support broadband PPDR applications. Information from these SDOs is provided in Annex 9.

## 8.3 Harmonisation of spectrum and the establishment of harmonized conditions for PPDR

In Res. 646 (Geneva, 2003), the ITU recognized the benefits of spectrum harmonization, such as a greater potential for interoperability, the development of compatible networks and more effective services, a broader industrial base and a larger volume of material resulting from economies of scale and greater availability of equipment. Other benefits may include improved spectrum management and planning as well as greater cross-border coordination and circulation of equipment. Some Administrations across all the ITU Regions are considering implementation of PPDR broadband applications based on IMT system technologies, either in dedicated spectrum or shared spectrum with commercial networks.

Harmonisation of spectrum for broadband PPDR applications is in a transition phase, during which related studies and identification of possible tuning-ranges and sub-bands have been started.   
Such efforts aim to accommodate future operational needs of broadband applications, while significant amounts of spectrum bands are already in use in various countries for narrowband PPDR applications.

Specifically, some potential benefits of harmonization are as follows:

– economies of scale in the manufacturing of equipment;

– development of a more competitive market for equipment procurement;

– increased spectrum efficiency, and easy cross-border coordination;

– increased effective response to disaster relief.

Harmonized conditions can be established for PPDR if:

1. a tuning-range can be identified;
2. a technology standard can be harmonized, such as IMT (LTE).

Harmonized conditions should be broad and flexible enough for nations/regulators to choose their national, dedicated PPDR spectrum from within the tuning ranges, in accordance with local demands. The LTE technology will then provide full roaming and interoperability even if a particular PPDR spectrum band is not strictly harmonized across borders.

## 8.4 Advantages of globally harmonized IMT technology for BB PPDR

Should harmonized IMT technologies for BB PPDR be implemented, it would increase availability and drastically reduce the cost of equipment, increase the potential for interoperability, provide for a wider range of end-to-end solutions, and reduce network infrastructure rollout time.

Some countries are in the process of developing their technical requirements and analyses using example technologies (e.g. IMT standard LTE).

Furthermore, introduction of these technologies may enable PPDR agencies and organizations to keep up with increasing demands by enabling them to implement advanced voice, text, video and other intensive data applications and services designed to enhance service delivery

In this regard, it should be noted that any development or planning for the use of future IMT technologies would require that consideration be given to spectrum aspects for broadband PPDR applications.

### 8.4.1 Advantages of PPDR using frequency bands harmonized for IMT

Broadband PPDR based on open standards, such as 3GPP LTE or LTE-Advanced, could be realised through dedicated PPDR networks, the use of commercial networks, or with a hybrid network (combination of dedicated and commercial networks). When comparing the different alternatives, each solution has both advantages and disadvantages. Eventually the choice is a national matter. However, future regulation and harmonisation efforts should support all these three solutions.

The identification of dedicated spectrum for broadband PPDR in bands identified for IMT or in near adjacent bands in the Radio Regulations will most likely result in the majority of the commercial products (e.g. terminals and chipsets) being made available for PPDR.

The identification of frequency range(s) for dedicated broadband PPDR that include IMT bands or near adjacent bands is flexible enough to consider different needs such as the amount of available spectrum and the possible use of commercial networks. Furthermore it facilitates roaming arrangements between the broadband PPDR network and commercial networks. Using dedicated spectrum for PPDR in bands identified for IMT or adjoining bands provides this flexibility.

With the identification of harmonized IMT spectrum suitable for dedicated broadband PPDR and the adoption of a common standard (such as LTE) roaming between commercial and dedicated/hybrid solution is easily achieved. PPDR terminals using such bands will be able to roam into a country with a similar PPDR solution which is using harmonized frequencies supported by that common standard.

### 8.4.2 Gradual introduction of broadband PPDR

The PPDR user community clearly state that the need for PPDR broadband services exist already today. The regulation process for a harmonisation of PPDR broadband is a lengthy process.   
Given this, it is inevitable that the introduction of PPDR broadband services will go through commercial networks, no matter the final national choice of solution (dedicated, commercial or hybrid network). Dedicated frequencies for PPDR may make this migration problematic since the commercial user devices used in the temporary commercial solution cannot be used in the dedicated or hybrid network that replaces the commercial solution to ensure harmonization, PPDR UE’s may support all the frequency ranges of IMT.

### 8.4.3 Economies of scale

Economic considerations will be a key factor for the decisions to be made on a national level regarding, for example, the choice of PPDR solution, network design or/and realisation time frame. The broadband PPDR market is large, but it still will be a niche market compared to the commercial LTE-market. For this reason any dedicated PPDR spectrum should be from a range that is harmonised for IMT.

Assuming that a major part of the commercial equipment will not support a frequency band which is not harmonized for IMT, the user equipment used in dedicated PPDR networks (or hybrid solutions) operating in a band that is not identified for IMT may be considerably more expensive than equipment for PPDR networks deployed in the harmonized spectrum that has been identified suitable for broadband PPDR.

With a dedicated PPDR-spectrum not supported by commercial equipment, PPDR equipment may use different radio modules or chipsets. The lower production volumes (compared to the commercial market) for these products may result in longer product cycles where the availability and introduction of the latest commercial technology may be delayed for the PPDR market.

Part 4 – Needs of developing countries

# 9 The needs of developing countries

The ITU has made significant commitments to developing countries in a series of instruments:

– Article 17 of the ITU Constitution that the functions of ITU-T are to be performed “bearing in mind the particular concerns of the developing countries”;

– Resolution **123 (Rev. Antalya, 2006)** on bridging the standardization gap; and

– Resolution 34 (Rev. Dubai, 2014) of the World Telecom Development Conference (WTDC-14) on “The role of telecommunications/information and communication technology in disaster preparedness, early warning, rescue, mitigation, relief and response”

Most developing countries have areas which suffer due to their small size, limited resources, remoteness and susceptibility to natural disasters. The growth and development of these areas has been disadvantaged by high transportation and communication costs, disproportionately expensive public administration and PPDR infrastructure and the absence of opportunities to create economies of scale. The issue of harmonized spectrum and interoperability has become more important as these countries increasingly deploy PPDR systems to meet the challenge of worsening law and order situation as well as the threat of terror incidents and disasters. In order to provide high-quality services to citizens it is important that PPDR services can be accessed from the widest possible range of equipment at the lowest possible cost. Despite the enormous progress made in bridging the digital divide and, in particular, the standardization gap, there remain significant problems in terms of conformance and interoperability due to lack of commonly harmonized spectrum for PPDR.

In recognition of the rapidly increasing trend of urbanization and associated challenges in developing country contexts, Public safety organizations such as Police and fire safety agencies have been intensifying efforts at getting requisite PPDR communications infrastructures. For many countries, especially in developing country contexts, the lack of comprehensive and reliable indicators and indices of safety and peace makes it difficult to develop evidence-led and context-appropriate interventions with consequent investment decisions, and to allow for evaluation of progress and effectiveness. High levels of injury and criminal events together with the historical context in many such countries provide a particularly relevant test bed for deployment of advanced narrow band and broadband digital PPDR systems.

## 9.1 PPDR requirements for developing countries

### 9.1.1 Radio spectrum

Harmonized radio spectrum in which PPDR radio systems can be deployed is critical for developing countries requirements. The propagation characteristics of frequencies   
below 1 GHz are attractive for wide area, nationwide deployment of PPDR mobile broadband systems in developing countries.

### 9.1.2 Common standards and technologies

Communications supporting PPDR operations in developing countries cover a range of radiocommunication services such as fixed, mobile, amateur, and satellite services. Typically, narrowband systems are used for PPDR voice communications within the terrestrial mobile service. In order to provide narrowband voice and low speed data applications, the trend is to implement wide area digital trunked radio networks based on PPDR standard technologies such as TETRA, APCO P25 or DMR.

These networks provide voice and low speed data applications including predefined status messages, data transmissions of forms and messages, access to databases, etc. Mobile network worldwide are carrying increasing quantities of data traffic reflecting the needs for new services. This creates challenges for many Public Protection and Disaster Relief (PPDR) entities in order to meet this demand economically and at the same time support both population density and geographical coverage, particularly in developing countries. The larger the country’s land mass the greater the challenge.

IMT-Advanced technology such as LTE or LTE-Advanced is expected to be used for the next generation PPDR networks in most countries. These PPDR broadband networks based on LTE or LTE-Advanced will need to provide better coverage and availability/throughput performance than provided by typical commercial LTE systems which generally tend to focus on population density coverage at the expense of rural areas particularly in the early deployment phase.

### 9.1.3 Interoperability

PPDR interoperability is the ability of PPDR personnel from one agency to communicate seamlessly by radio with personnel from another agency in real time. The components that facilitate interoperability include the use of common frequencies, technology, standards and planning.

The adoption of open standards will, in addition to facilitating interoperability, will also contribute towards market transparency, increase completion and economies of scale.

### 9.1.4 Direct mode operation

Considering that critical power shortages, difficult terrain, and frequent disaster situations can occur anywhere and that the lack of infrastructure in developing countries may increase the impact of such events, it is likely that the base PPDR network may not be available at all times. Therefore the use of direct mode operations (DMO) or device to device (D2D) communications between the user terminals in a given area is a key PPDR requirement, particularly in developing countries. While the narrow band technologies such as TETRA, DMR and P25 provide sufficient capacity for the direct mode operation, the same is not necessarily true for LTE. Since DMO is also required as a PPDR feature in broadband LTE systems used for PPDR, sufficient resources need to be allowed for its operation.

Use of DMO or D2D operation may place constraints when smaller LTE channel bandwidths are used as the number of supported user talks groups would be limited in order to address co-existence with other co-located D2D user groups and cellular services deployed in the adjacent channel. These issues should be suitable addressed in the planning stage. In contrast, in certain circumstances narrowband DMO operation may provide a larger coverage range.

### 9.1.5 Wide area coverage

Coverage is generally poor in the uplink in a handset form factor due to the limit on transmit power caused by thermal considerations and associated battery life when transmitting a complex broadband modulation signal. One solution which has been adopted by 3GPP is to define a new power class for vehicular mobile applications which can be supported in a larger form factor to improve the coverage particularly for PPDR services. This new LTE Power class / form factor will allow “first responders” to send and receive video and data, thus providing the ability to co-ordinate response and protect lives in these wider geographical coverage scenarios. The key benefit would be to enhance the ability of both commercial and dedicated LTE systems to support wider coverage scenarios for PPDR services with no significant increase in network costs. The coverage and UL throughput gain obtained for the new Power Class 1 (31dBm) are significant, results in no particular performance impact and will co-exist with existing commercial Power class 3 (23dBm) devices in the network as well as co-exist with adjacent channel/band services.

### 9.1.6 Rural coverage

Providing wireless coverage in rural areas has always proved difficult. Rural areas also tend to be challenging in terms of terrain and size of the area that needs to be covered. However, the main reason is not the size of the area but the cost of building and deploying of Base Station sites, combined with lower Average Revenue per User (ARPU) due to reduced number of subscribers. This increase in deployment costs and reduction in revenue means that any rural deployment becomes unviable on a pure commercial basis.

In many developed countries, studies show that only 30-40% of the main roads are served by all the major 3G network operators and that critically nearly 10% of major roads have no cellular coverage whatsoever from any network operator. In terms of a traffic incident this lack of basic road coverage will be a major factor in the ability to support emergency services using LTE in areas of likely road incidents. Again, with the introduction of these high power vehicular mobiles it should now be possible to reduce these areas of limited coverage.

### 9.1.7 Higher LTE cell throughput to meet PPDR broadband requirements

In the Public Safety environment, the most demanding load expected is at the scene of a multi-response incident with multiple users at one location each vying for part of the sector bandwidth. These sorts of incidents can occur in any part of the PSBB coverage area particularly so at edge of cell coverage locations. In 2012, 3GPP introduced a LTE work item to study the benefits and impact of a new (Higher Power UE or HPUE Power Class based on the following objectives;

– The work item should take into account the co-existence and compatibility of LTE systems deployed in the 700 MHz band;

– Maintain the same co-existence impact as a standard UE in terms of throughput/OOB emissions from the HPUE to the adjacent band (through tighter implementation requirements for the HPUE).

Based on the outcome of this work which is documented in the 3GPP Technical report   
3GPP TR36.837 a new power Class (Power Class 1 (31dBm) for vehicular mobile applications was standardized in 3GPP for Band 14 for ITU Region 2 in addition to the normal Power Class 3 (+23 dBm), further information are available in Annex XX (technical considerations).

The needs of developing countries are particular salient in the following aspects.

## 9.2 Deployment

Developing countries may not have the resources to deploy a nationwide broadband PPDR network to support broadband PPDR applications. Considering the cost, technology gap and the existing deployment status of developing countries, the long-term coexistence of narrowband, wideband and broadband has to be highlighted. Developing countries may choose to install more broadband, wideband or narrowband network sites and equipment, based on their available budget. An integrated narrowband/wideband/broadband network system using the same core network might be suggested. So for developing countries there may be a need for a more flexible deployment scheme.

Annex 8 gives a practical example of a more flexible deployment scheme in China for reference.

## 9.3 Summary

Editor’s Note: This summary needs to be revised to align with the text above in sections 9.1 to 9.3

Most developing countries have areas that suffer due to their sometimes small size, limited resources, remoteness and susceptibility to natural disasters.

The issue of harmonized spectrum and interoperability has become more important as these countries increasingly deploy PPDR systems to meet the challenge of law and order situations as well as the threat of terror incidents and disasters.

Due to budget constraints, PPDR agencies in both developed and developing countries need harmonized radio spectrum below 1 GHz to deploy nationwide radio systems that cater for broadband, wideband and narrowband applications: below 1 GHz to minimize the cost of wide area (nationwide) coverage and; harmonized spectrum to benefit from the economies of scale created.

Larger LTE Bandwidths for broadband PPDR are required in developing countries to support DMO operations. Current 3GPP work to support DMO in 10+10 MHz LTE bandwidth could limit the DMO operations to a few simultaneous talk groups. DMO is not expected to be viable in bandwidths less than 10 + 10 MHz.

Radio coverage for PPDR services are driven by both population density and geographical considerations. Providing cellular wireless coverage in rural areas has always proved difficult due to high deployment costs and low budget. One solution which has been adopted by 3GPP is to define a new power class for vehicular mobile applications. The new LTE Power class for vehicular deployment will allow “first responders” to send and receive video and data, thus providing the ability to co-ordinate response and protect lives in these wider geographical coverage scenarios. The key benefit would be to enhance the ability of both commercial and dedicated LTE systems to support wider coverage scenarios for PPDR services while limiting increases in network costs.

ANNEX 1

References

ITU-R Recommendations and Reports

Editor's note: Most of the References below were taken from current Report ITU-R M.2033 and need to be reviewed.

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Resolution ITU-R [55](http://www.itu.int/pub/R-RES-R.55) – ITU studies of disaster prediction, detection, mitigation and relief.

Resolution ITU-R **646 (Rev.WRC-12)** – Public protection and disaster relief.

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Resolution ITU-R **647 (Rev.WRC-12)** – Spectrum management guidelines for emergency and disaster relief operations.

Report ITU-R [M.2085](http://www.itu.int/pub/R-REP-M.2085/en) – Role of the amateur and amateur-satellite services in support of disaster mitigation and relief.

Report ITU-R [M.2014](http://www.itu.int/pub/R-REP-M.2014) – Digital land mobile systems for dispatch traffic.

Report ITU-R [M.2291](http://www.itu.int/md/R12-SG05-C-0064/en) – The use of International Mobile Telecommunications (IMT) for broadband public protection and disaster relief (PPDR) applications.

Recommendation ITU-R [M.1042](http://www.itu.int/rec/R-REC-M/recommendation.asp?lang=en&parent=R-REC-M.1042) – Disaster communications in the amateur and amateur-satellite services.

Recommendation ITU-R [M.1637](http://www.itu.int/rec/R-REC-M.1637/en) – Global cross-border circulation of radiocommunication equipment in emergency and disaster relief situations.

Recommendation ITU-R [M.2015](http://www.itu.int/rec/R-REC-M.2015/en) – Frequency arrangements for public protection and disaster relief radiocommunication systems in UHF bands in accordance with Resolution **646 (Rev.WRC-12)**.

Recommendation ITU-R [M.2009](http://www.itu.int/rec/R-REC-M.2009/en) – Radio interface standards for use by public protection and disaster relief operations in some parts of the UHF band in accordance with Resolution **646 (WRC‑03)**.

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Recommendations and Reports of other organisations

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http://www.etsi.org/deliver/etsi\_tr/102000\_102099/10202201/01.01.01\_60/tr\_10202201v010101p.pdf

Editor’s Note: A relevant separate ECC Deliverable will at a later stage be provided to depict the decision of CEPT on possible frequency bands/ranges and spectrum needs and requirements.

Editor’s Note: CITEL Recommendation missing here.

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National Public Safety Telecommunications Council, “700 MHz Statement of Requirements for Public Safety (SoR)” <http://www.npstc.org/statementOfRequirements.jsp>.

U. S. Department of Homeland Security, “Technology Solutions and Standards Statement of Requirements” <http://www.safecomprogram.gov/library/lists/library/DispForm.aspx?ID=302>.

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National Public Safety Telecommunications Council, “Mission Critical Voice Communications Requirements for Public Safety”, NPSTC BBWG, 30 August 2011

National Public Safety Telecommunications Council, “Public Safety Broadband High‑Level Statement of Requirements for FirstNet Consideration”, NPSTC Report Rev B, 13 June 2012

Editor's note: The US to check the validity of the above references for Broadband use.

FCC "Third Report and Order and Fourth Further Notice of Proposed Rulemaking" pertaining to Docket Numbers: WT Docket No. 06-150, PS Docket No. 06-229 and WP Docket No. 07-100. The Report and Order was adopted on January 25, 2011 and released on 26 January 2011. <http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-11-6A1.pdf>.

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700 MHz Spectrum Requirements for Canadian Public Safety Interoperable Mobile Broadband Data Communications <http://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapi/smse-018-10-public-safety-sub2.pdf/$FILE/smse-018-10-public-safety-sub2.pdf>

ANNEX 2

Terminology and Abbreviations

Editor's Note: These definitions will need to be reviewed for their relevance and be cross-checked with similar or existing definitions already used within the ITU.

Editor’s Note: Definitions to be updated, consideration to given to deleting any mention of data rates.

Editor’s Note: Once reviewed we need to check and see if this can remain an annex or needs to be placed back into the main document and brought to the attention of CCV and checked that they do not conflict with existing definitions and abbreviations.

Terminology used for PPDR

Broadband (BB) PPDR Radiocommunications

Editor’s Note: to make sure the use of the term PPDR Radiocommunications is used throughout the document where appropriate.

Broadband applications enable an entirely new level of functionality, with additional capacity to support higher data speeds and higher image resolution. It should be noted that the demand for multimedia capabilities (several simultaneous wideband and/or broadband applications running in parallel) puts a huge demand for very-high bit rates on a wireless system.

Broadband applications provide voice, high-speed data, high-quality, digital, real-time video and multimedia (indicative data rates are in the range of 1-100 Mbit/s) with channel bandwidths dependent on the use of spectrally efficient technologies. Examples of possible applications include:

– high-resolution video communications from wireless clip-on cameras to a vehicle‑mounted computer, used during traffic stops or responses to other incidents, or for video surveillance of security entry points such as airports with automatic detection based on reference images, hazardous material or other relevant parameters;

– remote monitoring of patients and remote, real-time video views that demand high bit rates. The demand for capacity can easily be envisioned during rescue operations following a major disaster.

Editor's Note: The text above needs to be reviewed in line with the content of the report.

Commercial communication network

A commercial communication network is one that is built and operated by profit-oriented operators in order to offer public communication services.

Commercial technology standard

A technical standard e.g. GSM, LTE, that is initially or primarily developed as platform for the operation of commercial communication networks.

Cross-border

PPDR organisations have to assist each other in certain cases, meaning they have to be able to work in foreign countries with the local PPDR organisations and at the same time with their own organisation.

Day-to-day operation

Day-to-day operations encompass the routine tasks that PPDR agencies conduct within their jurisdiction. Typically these tasks are conducted inside national borders. Generally most PP spectrum and infrastructure requirements are determined using this scenario with the addition of extra capacity to cover unspecified and sudden emergency events.

Disaster

Disasters are situations caused by either natural or human activity. For example, natural disasters include an earthquake, major tropical storm, a major ice storm, floods, etc. Examples of disasters caused by human activity include large-scale criminal incidents or situations of armed conflict. Generally, both the existing PP communications systems and special on-scene communications equipment brought by DR organisations are deployed.

DMO

Direct Mode Operation: Two or more devices should be able to communicate with each other directly in case they are disconnected from the network

IMT

International Mobile Telecommunication Systems: IMT specifications and standards are defined in Recommendations ITU-R M.1457 and ITU-R M.2012.

Isolated Base Station (IBS)

Isolated Base Station (IBS) Communication mode: an isolated base station that is disconnected from its core can continue to serve devices connected to it. The case may be generalized to an isolated group of base stations which can connect directly with each other but are all disconnected from network core.

Large emergency/public events

Large emergencies and/or public events are those that PP and potentially DR agencies respond to in a particular area of their jurisdiction. However, they are still required to perform their routine operations elsewhere within their jurisdiction. The size and nature of the event may require additional PPDR resources from adjacent jurisdictions, cross-border agencies, or international organisations. In most cases there are either plans in place or there is some time to plan and coordinate the requirements.

LTE

LTE (Long Term Evolution), marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. The LTE specifications are developed by the 3GPP (3rd Generation Partnership Project, while the standards are written regionally such as in ETSI, ATIS, ARIB and other regional Standard Development Organizations.

Mission critical communications

Mission critical Communications are those communications that are used by PPDR organisations in situations where human life, property and other values for the society are at risk, especially when time is a vital factor. Mission critical communications are secure, reliable and readily available and as a consequence responders cannot afford the risk of having failures in their individual and group communications (e.g. voice and data or video transmissions).”

Narrowband (NB) PPDR radiocommunications

To provide PPDR narrowband applications, the trend is to implement wide area networks, including digital trunked radio networks that provide digital voice and low-speed data applications   
(e.g. pre-defined status messages, data transmissions of forms and messages, and access to databases). ITU Report ITU-R M.2014 lists a number of systems, with typical channel bandwidths up to 25 kHz, which currently are used to deliver narrowband PPDR applications. Some countries do not mandate specific technology standards, but rather promote the use of spectrum-efficient technologies.

Editor's Note: The text above needs to be reviewed in line with the content of the report.

Public protection and disaster relief (PPDR)

The term *Public Protection and Disaster Relief (PPDR)* is defined in ITU-R Resolution **646** **(WRC‑12)** as a combination of two key areas of emergency response activity:

*– Public protection (PP) radiocommunication: Radiocommunications used by agencies and organizations responsible for dealing with maintenance of law and order, protection of life and property, and emergency situations.*

*– Disaster relief (DR) radiocommunication: Radiocommunications used by agencies and organizations dealing with a serious disruption in the functioning of society, posing a significant, widespread threat to human life, health, property or the environment, whether caused by accident, nature or human activity, and whether ingsuddenly or as a result of complex, long-term processes.*

PPDR dedicated network

A network solely designed to fulfil the specific PPDR requirements: this can be a GoGo model (Government Owned, Government Operated), but also a service delivered by a third party (CoCo: Company Owned, Company Operated). Another model is GoCo (network owned by Government, but operated by a third party).

PPDR interoperability

PPDR interoperability is described in this Report as the ability of PPDR personnel from one agency/organisation to communicate by radio with personnel from another agency/organisation, on demand (planned and unplanned) and in real time. There are several elements/components which affect interoperability including, spectrum, technology, network, standards, planning, and available resources. Systems from different vendors, or procured for different countries, should be able to interoperate at a predetermined level without any modifications or special arrangements in other PPDR or commercial networks. Interoperability is also needed in a ‘multi-vendor’ situation where terminals from different suppliers are working on infrastructures from other suppliers.

PPDR specific standard

A radio communication standard that has been developed specifically for PPDR applications or that is a further development of an already existing (commercial) standard.

Relayed Device Mode Communications (RDM)

Relayed Device Mode Communications (RDM) – in RDM communications some of the devices do not have direct connectivity to the network core due to missing or obstructed coverage. In the RDM case some devices become also relays between the disconnected devices and the core, while continuing to perform their usual device tasks

Localised Communication Services

Localised Communication Services: general term for special communications modes prevalent in PPDR systems in cases where coverage is inadequate or network infrastructure is harmed by the disaster by failures or both.

Topologies included under Localised Communication Services are: Direct Mode Operation, Isolated Base Station (IBS) Communication and Relayed Device Mode (RDM) Communications.

Editor's Note: This section need to be moved to the correct position alphabetically and needs to be reviewed in line with what falls under localized communication services (e.g. D2D) see section 3.4.1.6.

Roaming

In wireless telecommunications, roaming is a general term referring to the extension of connectivity service in a network that is different from the home network where the service was registered. Roaming ensures that the wireless device is kept connected to a network, without losing the connection. Traditional (GSM)-Roaming is defined as the ability for a cellular customer to automatically make and receive voice calls, send and receive data, or access other services, including home data services, when travelling outside the geographical coverage area of the home network, by means of using a visited network. This can be done by using a communication terminal or simply just by using the subscriber identity in the visited network.

Wideband (WB) PPDR Radiocommunications

Wideband systems carry raw data rates of several hundred kilobits per second (e.g. in the range of 384-500 kbit/s). In the future, it is anticipated that networks may be required to support higher data rates to accommodate the introduction of a whole new class of applications, including wireless transmission of large blocks of data, video and Internet Protocol-based connections in mobile PPDR systems.

The use of relatively high data speeds in commercial activities has spurred the development of specialized mobile data applications. Short message and e-mail are seen as a fundamental part of any communications command and control system and may play an integral part of any PPDR capability.

A wideband wireless system may be able to reduce response times for accessing the Internet and other information databases directly from the scene of an incident or emergency. This has initiated the development of a range of secure applications for PPDR agencies.

Systems for wideband applications to support PPDR are under development in various standards organizations. Many of these developments are referenced in Report ITU-R M.2014 and in Recommendations ITU-R M.1073, ITU-R M.1457, ITU-R M.1801 and ITU-R M.2012.

Editor's Note: The text above needs to be reviewed in line with the content of the report.

Abbreviations and acronyms

Editor’s Note: Need to provide full spelling for EMC, CCSA and ECC (these acronyms appear in Report).

|  |  |
| --- | --- |
| A(V)LS | Automatic (Vehicle) Location System |
| AGA | Air-ground-air (communication) |
| ANPR | Automatic Number Plate Recognition |
| B-PPDR | Broadband PPDR |
| CCC | Command and control centre |
| D2D | Device to device (communications) |
| DMO | Direct mode operation |
| CHOGM | Commonwealth Heads of Government Meeting |
| GIS | Geo information system |
| GMPCS-MoU | Global Mobile Personal Communications by Satellite Memorandum of Understanding |
| GoS | Grade of Service |
| IMT | International Mobile Telecommunication |
| LTE | Long Term Evolution (3GPP 4G technology) |
| NB | Narrow band(widths) |
| OAM | Operation administration and maintenance |
| PDA | Personal Digital Assistant |
| PIM | Personal Information Manager |
| PPDR | Public Protection and Disaster Relief |
| PTT | Push to talk |
| RAN | Radio access network |
| SDR | Software defined radio |
| UE | User equipment |
| VPN | Virtual Private Network |
| WAN | Wide Area Network |
| WB | Wide band(widths) |
| BB | Broad band(widths) |

ANNEX 3

PPDR Operations

A3.1 Operating environments

Systems supporting PPDR efforts should be able to operate in a variety of radio operating environments explained in this section.

The purpose of further explaining distinct radio operating environments is to define scenarios that, from the radio perspective, may impose different requirements on the use of PPDR applications and their importance.

The identified PPDR scenarios could serve as the basis for identifying PPDR requirements and may complement the estimate for spectrum.

It is extremely beneficial to have PPDR systems and equipment capable of being deployed and set-up rapidly for large emergencies, public events and disasters (e.g. severe floods, large fires, the Olympics,) are extremely beneficial. It is also important to have the ability to reallocate both uplink and downlink (data) rates in order to manage radiocommunication resources more efficiently.

PPDR scenarios include day-to-day operations, large emergencies or public events and disasters. These can have distinct characteristics and may impose different requirements for PPDR communications, including a variety of cross-border operational activities (e.g. medical emergency, cross-border pursuit, Air-Ground-Air and Direct Mode Operations). The overall safety of PPDR personnel can be significantly improved via more functional, more reliable, and more extensive wireless communications systems.

It is preferable that PPDR radiocommunications equipment support all of these radio operating environments. For any of these environments, information may be required to flow to and from units in the field to the operational control centre and specialist knowledge centres.

Although the type of operator for systems supporting PPDR is usually a regulatory and national matter, systems supporting PPDR may be satisfied by public or private operators, or a combination of the two.

A3.2 Categories of operations

It is useful to identify categories of PDDR communications based on the situations in which they may be deployed. Public protection radiocommunications, for example, are used by responsible agencies and organisations dealing with maintenance of law and order, protection of life, property and emergency situations under the following types of scenarios:

– Day-to-day operations – planned (category “PP1”);

– Large emergency and/or public events – planned and/or unplanned (category “PP2”);

– Disasters – unplanned (category “DR”).

A3.2.1 Day-to-day operations

Day-to-day operations encompass the routine operations that PP agencies and organisations conduct within their jurisdictions. Typically, these operations are within national or, where appropriate, regional borders. Generally, most PP spectrum and infrastructure requirements are determined using this scenario, taking into account the need for extra capacity to cover unspecified emergency events. Day-to-day operations can be either mission-critical or non-mission-critical. For the most part, day‑to-day operations are minimal for DR.

A3.2.2 Large emergency and/or public events

Large emergencies and/or public events are those to which PP and potentially DR agencies respond in a particular area of their jurisdictions. Meanwhile, agencies must still perform standard PP operations elsewhere within their jurisdictions. The size and nature of the event may call for additional PPDR resources from adjacent jurisdictions, cross-border agencies, or international organizations. In most cases, there are either plans in place, or there is some time to plan and coordinate the requirements.

A large fire encompassing 3-4 blocks in a large city (e.g. New York, New Delhi) or a large forest fire are examples of large emergencies under this scenario. Likewise, a large public event (national or international) could include the Commonwealth Heads of Government Meeting (CHOGM), G8 Summit, the Olympic Games, etc.

Generally, additional radiocommunication equipment for large events is brought to the area as required. This equipment may, or may not, be linked to the existing PP network infrastructure. In Tables 6-1 and 6-2, large emergencies or public events are referred to as PP (2).

A3.2.3 Disaster relief

Disasters can be caused by either natural or human activity. For example, natural disasters may include earthquakes, major tropical storms, major ice storms, floods, etc. Examples of disasters caused by human activity include large-scale criminal or terrorist acts, or situations of armed conflict. Generally, both the existing PP communications systems and special on-scene communication equipment, brought by DR organizations, are employed.

In DR operations, public protection agencies will use a / entire variety of communications provided by PP networks to meet their operational requirements. Even in areas where suitable terrestrial services exist, satellite systems will play a significant role in disaster relief operations, because the existing terrestrial infrastructure may have been damaged or may be unable to cope with the increased traffic loads resulting from the disaster situation. In these situations, satellite services can offer a reliable solution.

The frequency bands used by Mobile Satellite Service (MSS) systems are generally harmonized at a global level. However, the cross border circulation of terminals in disaster situations is a critical issue, as recognised in the Tampere Convention. It is imperative that neighbouring countries that may possess satellite terminals as part of their contingency planning offer the initial essential communications needed, with minimum delay. To this end, advanced bilateral and multilateral agreements are desirable and may be accomplished through, for example the Global Mobile Personal Communications by Satellite Memorandum of Understanding (GMPCS-MoU).

Some PPDR agencies/organizations and amateur radio groups use High Frequency (HF) narrowband systems, allowing the use of data modes of operation as well as voice. Other capabilities, such as digital voice, high-speed data and video have been implemented using either terrestrial or satellite network services.

A3.3 Localized Communication Services

The degree of reliability required for PPDR communications is such that PPDR systems need to continue operating in cases where there is no coverage, where coverage is inadequate or network infrastructure is harmed by the disaster by failures or both and to have the ability to manage capacity.

In such an event localized communication services comprising Isolated Base Stations, Relayed Device Mode operation and Direct Mode Operation between PPDR users is required as an immediate solution for maintaining or re-establishing communications. The importance of the provisions of those services are summarized in Table A5-3 of Annex 5.

Methods of achieving a localized service between users are also needed either through deliberate user action or as a result of devices leaving the network coverage.

Editor's Note: This section needs to be reviewed in line with what falls under localized communication services (e.g. D2D) see section 3.4.1.6.

A3.4 Examples of PPDR network deployment scenarios and technical implementation

When considering these sections, it is important to note that public protection organisations currently use various arrangements of mobile systems or a combination thereof, as described below in Table A3-1.[[7]](#footnote-7)2

TABLE A3-1

Arrangements of mobile systems used by public protection agencies

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Item | Network ownership | Operator | User(s) | Spectrum assignment |
| a | PP organization | PP agency | PP exclusive | PP |
| b | PP organization | Commercial | PP exclusive | PP |
| c | Commercial | Commercial | PP exclusive | PP or commercial |
| d | Commercial | Commercial | Shared with PP priority | PP or commercial |
| e | Commercial and PP organization | Commercial and PP organization | Shared with PP  (e.g. Virtual Private Network (VPN) or PPDR as a preferential subscriber with suitable assigned priority) | Commercial |
| f) | Commercial | Commercial | Shared with PP treated as ordinary customer | Commercial |

A3.4.1 Dedicated PP systems owned and operated by Government/PP agencies

As shown in Table A6-1 (item a), PP agencies have traditionally relied on their own, purpose-built networks, using dedicated spectrum, to meet their unique operational requirements. Under such an approach, PP organizations have their own infrastructure and control their systems’ full capabilities during times of emergencies. PP organizations are able to dynamically change the performance of the service as the situation demands, so that PP decision-makers can make the appropriate decisions based on the best available information. With dynamic control of their systems, PP agencies can determine the level of security, reliability, robustness, and survivability of those systems.

A3.4.2 Dedicated PP systems owned by agencies’ but operated by commercial entities

A variation of the dedicated PP system approach (shown as item b in Table A6-1), involves use of PP agency-owned systems that are operated by commercial networks. In some countries, however, PP agencies have expressed concerns with the concept of operational reliance on commercial operators, and with the motivation or willingness of commercial entities to meet the functional and performance requirements specified by the PP sector.

These concerns are focused on:

– assurances with regard to communications security and priority access;

– the level of network “hardening” compared to their traditional networks, including susceptibility to failure, intrusion and sabotage;

– requirements for a range of more ruggedized user devices (e.g. for motorcycles, marine craft, aircraft and handheld applications) that contain chipsets that may differ in robustness from those provided to commercial consumers;

– commercial networks that do not extend into less-populated areas (while noting that investment constraints on PPDR networks often result in such coverage shortcomings); and

– reliance on commercial operators’ commitments to maintain mission-critical services, especially during major incidents.

However, where these concerns have been addressed, successful arrangements of mobile systems as described in item b) of Table A6-1 can result.

A3.4.3 Dedicated PPDR systems owned and operated by commercial

Under these service management arrangements, summarized as Item c, the PPDR network is owned and operated by a commercial entity. Reasons for this approach include flexibility for funding the build-out and maintenance of the network.

These networks enjoy the same benefits as the dedicated PP agencies’ networks and are used in some countries today. In some cases, such networks are not favoured due to privacy and security concerns.

A3.4.4 PPDR agencies using commercial networks as a special subscriber

As an alternative (or complementary) approach to deployment of a dedicated PPDR network, a further option (Item d) that might be considered by PPDR agencies is the use of commercial services as a special subscriber group. To satisfy PPDR operational needs, such an arrangement may involve negotiating special commercial terms for such features as:

– priority access privileges, especially relating to emergencies and disaster events;

– extended coverage arrangements that may go beyond areas ordinarily considered viable for commercial services;

– enhanced minimum Grade of Service (GoS), reliability and robustness, in the context of potential equipment failure, power failure and natural disaster scenarios;

– dynamically reconfigurable push-to-talk group-calling functions, in order to facilitate efficient and effective multi-agency co-ordination and response to events; and

– special encryption and authentication/security features, to ensure an appropriate level of network traffic integrity to protect PPDR operational communications.

At a domestic level, this option would provide a degree of natural harmonization of spectrum resources and technology compatibility among PPDR agencies. Depending on the agreements made between agencies and commercial operators, this option also could result in seamless interoperability across agencies and jurisdictions. This would not necessarily translate, however, into international interoperability. In this case, harmonisation among administrations would be subject to sovereign decisions by each country and associated agreements to adopt a common spectrum and technology approach.

In some cases, the cost to PPDR agencies of paying for such generic features as listed above may be less than the cost of deploying a dedicated PPDR network (since a large proportion of the underlying network and its functionality will be almost entirely subsidised by the larger ‘base-load’ of commercial users). However, this is dependent on a full cost analysis between the commercial and dedicated network options.

For example, many of the additional costs, such as for extended coverage, may provide indirect yet tangible benefits for the broader customer base.

Therefore, PPDR agencies may not bear the full amount of associated additional capital or operational costs. Consequently, this option may present a significantly lower capital and operational cost burden for national/local governments in comparison to deploying a dedicated network. Relevant savings could instead be directed toward further extending coverage and increasing functionality to a much greater degree than would otherwise be possible under a dedicated network approach. Furthermore, this option could negate the need for dedicated spectrum for PPDR, which could result in license cost savings for PPDR agencies. With regard to special PPDR requirements for user terminal devices, including issues of robustness, air and marine certification, and special mounting arrangements, sourcing arrangements may either be via the commercial network operator (who retains User Equipment (UE) authentication responsibility) or directly managed by the relevant PPDR agencies. In the latter case, there may also be a need for special arrangements to address UE authentication setup procedures.

On the assumption that the priority access, coverage, functionality and security concerns are met, there may yet be lingering concern over the degree of control that PPDR agencies can exert over their access usage, as well as the functional configuration of network resources.

This network sharing approach could provide the following benefits:

– access to new capabilities when required by both commercial and PPDR users;

– improved access to more radiocommunication resources for other uses;

– provision of better services and applications to consumers by the commercial operators; and

– access to a large ecosystem of terminals, integrated seamlessly in existing and future devices, providing hand-over among the various IMT systems as well as between different frequency bands, while also providing backward compatibility and international roaming.

A3.4.5 Sharing the public operator’s infrastructure (e.g. as a Shared RAN)

Under this model (Item e), PPDR organizations share the common radio access network (RAN) infrastructure with a commercial operator but own and be responsible for operation of their own switching nodes, authentication nodes, gateways, and user management facilities. Such arrangements are specifically aimed at reducing expenditures on duplication of the radio network portions of commercial systems – and for shared use of the scarce radio spectrum resource.

With this option, PPDR agencies have greater operational management control over their “networks” and users, because they share ownership of the system or, alternatively, enter into a contractual agreement that provides them the necessary level of control over the system in times of crisis. This requires that the system infrastructure be built to accommodate the required functions and features that PPDR organizations demand in order to execute their various missions.

It is expected that there will still be a need for negotiated commercial arrangements to cover additional requirements including: priority access in times of crisis, extended coverage, network reliability/robustness, and security. This option may provide improved coverage, capacity and the expanded functionality found in modern all-Internet Protocol (IP) public networks.

In this approach, coexistence of established, dedicated PPDR radiocommunication networks alongside commercial mobile broadband networks would need to continue into the foreseeable future. If a VPN-type model is to be adopted, detailed functional and coverage requirements need to be agreed between PPDR agencies and commercial network operators, and the contractual arrangements and tariff plans need to be negotiated to fit within financial budget constraints. Agreements with regard to response times to service outages, regular maintenance, technology upgrades, capacity expansions, and even arbitration, change of ownership or commercial circumstance terms need to be determined.

Such an integrated approach could reduce capital and operational costs, harness the power of   
the larger commercial ecosystem and provide seamless multimedia services to PPDR agencies and teams. There may also be cost savings for PPDR agencies if no licence fees are required for spectrum. It should be noted that systems described in Report ITU-R M.2014 may still be used.

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.” So, the network deployment scenarios described in Items d) and e) may enable PPDR networks to gain access to extra commercial channels or capacity during emergencies that cannot be made available on a permanent basis.

In some countries, network deployment scenarios described Annex 4 are currently used by PP organizations to supplement their own systems or in some cases to provide all their communications requirements, but not necessarily for all the features and requirements specified in Tables A4-1 and A5-1. It is likely that this trend will continue into the future, particularly with the introduction of advanced wireless technologies, such as IMT.

Some of the applications listed in Annex 4 may depend significantly on commercial systems, while other applications for the same PP organizations may be totally independent of commercial systems.

AnnEX 4

PPDR Applications and related examples

The tables in this annex consist of PPDR applications and related examples divided into its applicability for narrow-, wide- and broadband.

All applications in the “Narrowband” part are to be considered generic and should be covered by the systems providing for both, wideband and broadband as mentioned in Tables A4-2 and A4-3.

Table A4-1

Generic / Narrowband Part

| Application | Feature | PPDR Example | Importance(1) | | |
| --- | --- | --- | --- | --- | --- |
| PP (1) | PP (2) | DR |
| Voice | Person-to-person | Selective calling and addressing | H | H | H |
| One-to-many | Dispatch and group communication | H | H | H |
| Talk-around/direct mode operation | Groups of portable to portable / mobile-mobile in close proximity without infrastructure | H | H | H |
| Push-to-talk | Push-to-talk | H | H | H |
| Instantaneous access to voice path | Push-to-talk and selective priority access | H | H | H |
| Phone interconnect | Telephone call from/to radio subscriber | H | H | M |
| Dispatcher terminal | H | H | H |
| Multi select | H | H | H |
| CAD | Computer added dispatcher | H | H | H |
| Security | Voice encryption/scrambling | H | H | M |
| Facsimile | Person-to-person | Status, short message | L | L | H |
| Emergency alert | Pressing the emergency button causes alert at the TG or dispatcher | H | H | H |
| Security | Data encryption/scrambling | H | H | H |
| One-to-many (broadcasting) | Initial dispatch alert (e.g. address, incident status) | L | L | H |
| Messages | Person-to-person | Status, short message, short e-mail | H | H | H |
| One-to-many (broadcasting) | Initial dispatch alert (e.g. address, incident status) | H | H | H |
| Security | Priority/instantaneous access | Man down alarm button | H | H | H |
| Emergency alert | Pressing the emergency button causes alert at the TG or dispatcher | H | H | H |
| Emergency call | Priority voice call caused by pressing the emergency button | H | H | H |
| Location  Telemetry | Location status | GPS latitude and longitude information | H | M | H |
| Sensory data | Vehicle telemetry/status | H | H | M |
| EKG (electrocardiograph) in field | H | H | M |
| Environmental information including sensory data on air quality, temperature, contamination, radiation levels etc. | M | M | M |
| Database interaction (minimal record size) | Forms based records query | Accessing vehicle license records | H | H | M |
| Accessing criminal records/missing person | H | H | M |
| Computer aided dispatch directly to field resources | M | M | L |
| Forms based incident Report | Filing field Report | H | H | H |
| (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. | | | | | |

Systems providing for Wideband PPDR should support also the Narrowband applications as described in Tables A4-1.

Table A4-2

Additional Wideband Part

| Application | Feature | PPDR Example | Importance(1) | | |
| --- | --- | --- | --- | --- | --- |
| PP (1) | PP (2) | DR |
| Messages | E-mail possibly with attachments | Routine e-mail message | M | M | L |
| Privacy | Security | Data encryption/scrambling | H | H | H |
| 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 |
| Database interaction (medium record size) | Forms and records query | Accessing medical records | H | H | M |
| Lists of identified person/missing person | H | H | H |
| Computer aided dispatch directly to field resources | H | M | L |
| Computer aided dispatch directly to field resources | H | M | L |
| GIS (geographical information systems) | H | H | H |
| Text file transfer | Data transfer | Filing report from scene of incident | M | M | M |
| Records management system information on offenders | H | M | L |
| Downloading legislative information | M | M | L |
| Image transfer | Download/upload of compressed still images | Biometrics (finger prints, facial recognition) | H | H | M |
| ID picture (car number plate recognition) | H | H | M |
| Building layout maps | H | H | H |
| Telemetry | Location status and sensory data | Vehicle status | H | H | H |
| OTAP | Over the air programming | UE programming through the air | H | H | H |
| Security | Priority access | Critical care | H | H | H |
| Video | Download/upload compressed video | Video clips | M | L | L |
| Patient monitoring (may require dedicated link) | M | M | M |
| Video feed of in-progress incident | H | H | M |
| Interactive | Location determination | 2-way system | H | H | M |
| Interactive location data | H | H | H |
| (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. | | | | | |

Systems providing for Broadband PPDR should support also the Narrowband/Wideband applications as described in Tables A4-1 & A4-2.

Table A4-3

Additional Broadband Part

| Application | Feature | PPDR Example | Importance(1) | | |
| --- | --- | --- | --- | --- | --- |
| PP (1) | PP (2) | DR |
| Direct mode operation of video and data | Direct unit to unit video and data communication without infrastructure | Direct handset to handset, on-scene localized command and control | H | H | H |
| Privacy | Security | Data encryption/scrambling | H | H | H |
| Database access | Intranet/Internet access | Accessing architectural plans of buildings, location of hazardous materials | H | H | H |
| Web browsing | Browsing directory of PPDR organization for phone number | M | M | L |
| Robotics control | Remote control of robotic devices | Bomb retrieval robots, imaging/video robots | H | H | M |
| Video | Video streaming, live video feed, Download/upload of video clips, Video Conferencing | Video communications from wireless clip-on cameras used by in building fire rescue | H | H | H |
| Image or video to assist remote medical support | H | H | H |
| Surveillance of incident scene by fixed or remote controlled robotic devices | H | H | M |
| Assessment of fire/flood scenes from airborne platforms | M | H | M |
| Multi-scene video dispatch | L | H | H |
| Multicast of Multimedia from a BS to multiple users in a given area (e.g. Pt to MPt/Broadcast) | L | H | H |
| video conferencing 1 to 1, 1 to many, etc. | L | H | H |
| Encrypted video streaming | M | M | M |
| Real-time multimedia intelligence | Real time optimisation of video or other multimedia content | Optimise the use of allocated bandwidth to support multiple video streams | H | H | H |
| Imagery | Download/upload High resolution imagery | Downloading Earth exploration-satellite images | L | L | M |
| Real-time medical imaging | M | M | M |
| (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. | | | | | |

AnnEX 5

PPDR Requirements

This annex contains tables of requirements indicating the degree of importance attaching to particular requirements under the three radio operating environments: “Day-to-day operations”, “Large emergency and/or public events”, and “Disasters”. The degree of importance attributed to each requirement may be different between administrations. It is up to the administrations to make a choice regarding the relative importance of these requirements. This Annex may require future review and updating as mobile broadband technologies evolve.

Furthermore the tables divided into generic user requirements supported by NB/WB/BB communications (Table A5-1) and additional requirements supported by broadband communications only (Table A5-2).

Table A5-3 contains the capabilities to be provided in Localized Communication Services Mode

Table A5-1

Table of generic user requirement supported by PPDR narrow-, wide-, and broadband communications

| User Requirement | Specifics | Importance(1) | | |
| --- | --- | --- | --- | --- |
| PP (1) | PP (2) | DR |
| 1. *System* | | | | |
| Support and integration of multiple applications | Integration of multiple applications (e.g. voice and low/medium speed data) at high speed network to service localized areas with intensive in scene activity | H | H | M |
| Simultaneous use of multiple applications | Voice & data | H | H | M |
| Multicast and unicast services |  |  |  |
| Real time instant messaging |  |  |  |
|  |  |  |  |
| Mobile office functions |  |  |  |
| VPN services |  |  |  |
| Telemetry |  |  |  |
| Remote control |  |  |  |
| Location of terminals |  |  |  |
| Priority access | Manage high priority and low priority traffic load shedding during high traffic | H | H | H |
| 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 |
| Quality of Service | Quality of service | H | H | H |
| Reduced response times of accessing network and information directly at the scene of incidence, including fast subscriber/network authentication | H | H | H |
| Reliability | Stable and resilient working platform | H | H | H |
| Stable and easily operated management system | H | H | H |
| Resilient service delivery | H | H | H |
| High level of availability | H | H | H |
| Localised communication services (e.g. isolated base stations, relayed mode operation, direct mode operation (DMO), Device-to-Device (D2D). | H | H | H |
| Coverage | PPDR system should provide complete coverage within relevant jurisdiction and/or operation | H | H | M |
| Coverage of relevant jurisdiction and/or operation of PPDR organization whether at national, provincial/state or at local level | H | H | M |
| Systems designed for peak loads and wide fluctuations in use | H | H | M |
| 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 |
| Standalone transportable site in order to support local site operation | H | H | H |
| Mobile site in standalone mode or wide are mode in order to increase coverage/ to enhance capacity. | H | H | H |
| Air-to-ground communication | H | H | H |
| Vehicular repeaters (NB and WB) for coverage of localized areas/ transportable site | H | H | H |
| Reliable indoor/outdoor coverage including bi-directional amplifier (BDA) | H | H | H |
| Coverage of remote areas, underground and inaccessible areas including bi-directional amplifier (BDA) | H | H | H |
| Appropriate redundancy to continue operations, when equipment/infrastructure fails – standalone site services | H | H | H |
| 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 OAM offering status and dynamic reconfiguration | H | H | H |
| Internet Protocol compatibility (complete system or interface with) | M | M | M |
| Robust equipment (hardware, software, operational and maintenance aspects) | H | H | H |
| Portable equipment (equipment that can transmit while in motion) | H | H | H |
| 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 |
| Fast call set-up and instant push-to-talk (PTT) group call operation | H | H | H |
| Location services | H | H | H |
| Communications to aircraft and marine equipment, control of robotic devices | M | H | L |
| One touch broadcasting/group call/ATG – announcement to all or some of talk groups and session establishment | H | H | H |
| Terminal-to-terminal communications without infrastruc­ture (e.g. direct mode operations/talk-around), vehicular repeaters | H | H | H |
| Emergency alert - Pressing the emergency button causes alert at the TG or dispatcher | H | H | H |
|  | Emergency call - Priority voice call caused by pressing the emergency button | H | H | H |
| Recording and monitoring of audio and video transmissions for evidential purpose, for safety reasons and lessons learned. | H | H | H |
| Multi select TG’s - Ability to aggregate several TG’s and establish one call for all of them | H | H | H |
| Appropriate levels of interconnection to public telecommu­nication network(s). | H | H | H |
| Stable & easy to operate management system | H | H | H |
| 2. Security related requirements | End-to-end encrypted communications for mobile-mobile, dispatch and/or group calls communications (Voice & Data) | H | H | L |
| 3. *Cost related* | Open standards | H | H | H |
| Cost effective solution and applications | H | H | H |
| Competitive marketplace for supply of equipment and terminals | H | H | H |
| Reduction in deployment of permanent network infra­structure due to availability and commonality of equipment | H | H | L |
| 4. *EMC* | PPDR systems operation in accordance with national EMC regulations | H | H | H |
| 5. Operational | | | | |
| Scenario | Support operation of PPDR communications in any environment | H | H | H |
| Implementable by public and/or private operator for PPDR applications | H | H | M |
| Rapid deployment of systems and equipment for large emergencies, public events and disasters (e.g. large fires, Olympics, peacekeeping) | H | H | H |
| Information to flow to/from units in the field to the operational control center and specialist knowledge centers | H | H | H |
| Greater safety of personnel through improved commu­nications | H | H | H |
| Compatibility  Editor’s Note: the text in the table needs to be aligned with Section 3.4.5.2 | End-user to end-user connectivity | H | H | H |
| Compatible with existing networks used for PPDR communications (e.g. trunked radio) | H | H | M |
| Interoperability | Intra-system: Facilitate the use of common network channels and/or talk groups | H | H | H |
| Inter-system: Promote and facilitate the options common between systems | H | H | H |
| Coordinate tactical communications between on-scene or incident commanders of the multiple PPDR agencies | H | H | H |
| 6. *Spectrum usage and management* | Share with other terrestrial mobile users | L | L | M |
| Suitable spectrum availability (NB, WB, BB channels) | H | H | H |
| Minimize interference to PPDR systems | H | H | H |
| Increased efficiency in use of spectrum | M | M | M |
| Appropriate channel spacing between mobile and base station frequencies | M | M | M |
| 7. *Regulatory compliance* | Comply with relevant national regulations | H | H | H |
| Coordination of frequencies in border areas | H | H | M |
| Provide capability of PPDR system to support extended coverage into neighbouring country (subject to agreements) | M | M | M |
| 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 |
| 8. *Planning* | Reduce reliance on dependencies (e.g. power supply, batteries, fuel, antennas, etc.) | H | H | H |
| As required, have readily available equipment (inventoried or through facilitation of greater quantities of equipment) | H | H | H |
| Provision to have national, state/provincial and local (e.g. municipal) systems | H | H | M |
| 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 |
| 1. The importance of that particular requirement 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. | | | | |

Table A5-2 below consists of additional requirements of PPDR that are supported by broadband communications only.

Editor’s Note : There needs to be a check for duplication between this table and Table A5-1

Table A5-2

Table of additional requirements for PPDR broadband communications

| Technical Requirement | Specifics | Importance1 | | |
| --- | --- | --- | --- | --- |
| PP (1) | PP (2) | DR |
| Integration and Simultaneous use of multiple applications | Integration of multiple applications (e.g. Voice, data and video) on high speed network to service localized areas with intensive “at scene” activity | H | H | M |
| Scene video transmission | H | H | M |
| Quality of Service  (see Appendix 1 below) | support of a prioritized range of services | H | H | H |
| Guaranteed throughput | H | H | H |
| Rapid session set up |  |  |  |
| Coverage | RAN shall utilize maximum frequency reuse efficiency. | H | H | M |
|  | Vehicular repeaters (Broadband) for coverage of localized areas/transportable site | H | H | H |
| Capabilities | Network system level management capability | M | H | H |
| Network to perform basic self-recovery, expediting service restoration and a return to redundant operations. | H | H | H |
| Packet data capability | H | H | H |
| Rapid deployment capability - infrastructure & terminals | L | H | H |
| The Network shall provide seamless coverage (via handoff/handover mechanisms) and continuous connectivity within the 95th percentile coverage area at stationary and vehicular speeds up to 120 kph. | H | H | H |
| A single common air interface (CAI) shall be utilized for the mobile broadband network. | H | H | H |
| Mobile/portable station nominal transmit power shall be 0.25W ERP (24 dBm) and shall not exceed 3 W ERP (34.8 dBm) in rural areas for portable devices. | L | L | L |
| Support | 24-hour and 7 days-a-week (24/7) support for fixed and user equipment | H | H | H |
| The network operations centre to operate on a 24x7x365 basis | H | H | H |
| 24/7 operations including field based support as necessary to maintain the availability of the network. In all cases, 24/7 access to call centre support for issue resolution and assistance is also required | H | H | H |
| Reliability and adaptability  Editor’s Note : there needs to be a check for duplication between this part of the table and the reliability section in table A5-1 | Adaptable to extreme natural and electromagnetic environments. No functional network failure during climate events, operational vibration, earthquake, EMI/ESD, and supplied power events. | H | M | L |
| Fixed, mobile & terminal equipment adaptable to a wide range of natural environments, with any physical facilities supporting network equipment meeting contemporary standards for electric surge suppression, grounding and EMP Protection | H | H | H |
| Robust network and management system | H | H | H |
| Stable, resilient working platform | H | H | H |
| Self-managed network | H | H | H |
| Coordinated development of business continuity plans. | H | H | H |
| Resilient service delivery | H | H | H |
| High availability design e.g. Diversity, redundancy, automated failover protection, backup operational processes. | H | H | H |
| Network & operational testing to ensure data/call processing functionality is restored within  predetermined and guaranteed time period following an outage | H | H | H |
| The above should result in PPDR broadband networks at least matching the level of robustness displayed by the current public safety land mobile radio (i.e. P-25 or TETRA). | H | H | H |
| Availability | Service availability shall not be calculated to allow a prolonged outage even in one service area. | H | H | H |
| Power backup using battery backup and /or power generation. Redundant backhaul circuits from the RAN to the core and to the base stations. High wind loading for the cell towers (Availability 99.995% at year 10) | H | H | H |
| Highly reliable (99.999%) individual network elements. Ensuring adequate supply and easy access to spares to reduce Mean Time To Repair (MTTR). Operational readiness assured even in a maintenance window. | H | H | H |
| Redundant elements should automatically detect failure and activate to provide service upon failures of primary network components | H | H | H |
| Security | End to end encryption. The network shall provide cryptographic controls to ensure that transmissions can only be decoded by the intended recipient. This must include data encryption over all wireless links. | H | H | L |
| Support for domestic encryption arithmetic | H | H | L |
| The encryption should support both point-to-point traffic and point-to-multipoint traffic. | H | H | L |
| The network shall support periodic re-keying of devices such that traffic encryption keys may be changed without re-authentication of the device and without interruption of service. | H | H | H |
| The network shall provide cryptographic controls to ensure that received transmissions have not been modified in transit. | H | H | L |
| Access to public safety services and applications shall be provided only to those authenticated users and/or devices as specifically authorized by each PPDR organization. | H | H | M |
| The network shall require each device that attempts to connect to the network to prove its identity prior to granting access to network resources. Each device shall be assigned a unique identifier, and the authentication method must provide strong assurance (e.g. by public key cryptography) of the device's identity in a manner that requires no user interaction. | H | H | M |
| The device authentication service shall utilize an open standard protocol. | H | H | H |
| To protect against both malicious devices and malicious network stations, the authentication must be mutual, with the device proving its identity to the network and the network proving its identity to the device. | H | H | H |
| Each PPDR organization shall be granted the option to require user authentication in addition to device authentication for certain devices assigned to that organization. When user authentication has been selected as a requirement, the network shall require each of the organization's designated devices to prove its user's identity prior to granting access to network resources. | H | H | H |
| For organizations requiring user authentication, the network must facilitate sequential authentication of multiple users from a single device. | H | H | H |
| System authorization management. Each organization shall be granted control over authorization by means of an administrative interface. | H | H | H |
| For organizations requiring user authentication, the organization shall be granted via administrative interface (e.g. Web based) the ability to add, remove, and manage user accounts that are permitted to access the network. | H | H | H |
| For organizations requiring user authentication, the network must facilitate sequential authentication of multiple users from a single device | H | H | H |
| The network should have dedicated PPDR system core | H | H | H |
| 3rd party key management system | L | L | L |
|  | The network shall maintain a record of all device and user access attempts and all authentication and authorization transactions, including changes to authentication and authorization data stores. | H | H | H |
| Over the air key update | L | L | L |
| The network shall enforce a configurable time‐out, imposing a maximum time that each device may be connected to the network. | H | H | H |
| The network shall enforce an inactivity time‐out, imposing a maximum time that each device may be connected to the network without transmitting data. | H | H | H |
| Each PPDR organization shall be granted control of the network time out and inactivity setting for individual devices assigned to that organization. | H | H | H |
| Each organization shall also be granted via administrative interface the means to manually and forcibly terminate access, including active sessions, to the network for any of its assigned devices individually. | H | H | H |
| The network shall be capable of attack monitoring. | H | H | H |
| Terminal Requirements for preventing unauthorized use | Devices shall support the network's device authentication protocol. Each device shall be assigned a unique identifier, and the authentication method must provide strong assurance (e.g. by public key cryptography) of the device's identity in a manner that requires no user interaction. | H | H | H |
| To protect against both malicious devices and malicious network stations, the authentication must be mutual, with the device proving its identity to the network and the network proving its identity to the device. The device must not permit connectivity to the PPDR network unless the network is authenticated. | H | H | H |
| Each PPDR organization shall have the option to require user authentication for device access. When user authentication has been selected as a requirement, the device shall require each user to prove his or her identity prior to granting access to applications or network resources. | H | H | H |
| Devices may support a means of erasing (via best practice multiple pass overwriting of data storage media) all data stored on the device. | H | H | H |
| Devices may support a means of encrypting data stored on the device such that user authentication is required for decryption. | H | H | H |
| Cost | Scalable system | L | H | M |
| Open system architecture | H | H | H |
| Implementable by public and/or private operator for PPDR applications | H | H | M |
| Interoperability | Interoperable/Interconnection with narrowband trunked systems. Interconnection required with:  Inter RF subsystem Interface Voice service and Supplementary services  Console supplementary Interface Voice service and Supplementary services | M | H | H |
| Interoperable/ Interconnection with other broadband systems | H | H | H |
| Interoperable/ Interconnection with satellite systems | H | H | H |
| Interconnection with other information systems | H | H | H |
| Interfaces that interconnect to other communication systems | H | H | H |
| API compatible with standard interfaces | H | H | H |
| Appropriate levels of interconnection to public telecommunication network(s) – fixed and mobile | M | M | M |
| Spectrum usage & management | Dynamic spectrum allocation | H | H | H |
| Suitable spectrum availability (Broadband channels for uploads at maximum data rates) | H | H | H |
| Reallocation of upstream and downstream rates | H | H | H |

|  |
| --- |
| 1. The importance of that particular requirement 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. |

Table A5-3 summarizes capabilities to be provided under in Localized communication services modes:

Table A5-3

Capabilities provided under Localized Communication Services

Editor’s Note: This table needs to be reviewed to reflect whether D2D could be inserted as covering the same attributes as those for the DMO column or whether there needs to be a new column added for D2D.

| Localized Communication Services | | Attributes | DMO | Isolated Base Station | | Relayed Mode | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Topology | |  | Isolated | Connected  to Core | Isolated | Connected  to Core | Isolated |
| Voice  Editor’s note : there needs to gridlines entered to separate out the different sections | | Person-to-person | H | H | H | H | H |
| One-to-many | H | H | H | H | H |
| Push-to-talk | H | H | H | H | H |
| Priority | H | H | H | H | H |
| Encryption | H | H | H | H | H |
| Emergency PTT | H | H | H | H | H |
| Multimedia (V+V+D) | | Person-to-person | H | H | H | H | H |
| One-to-many | H | H | H | H | H |
| Push-to-MM | H | H | H | H | H |
| Priority | H | H | H | H | H |
| Encryption | H | H | H | H | H |
| Real time video | H | H | H | H | H |
| Text Message / Instant Message | | Person-to-person | H | H | H | H | H |
| Emergency alert | H | H | H | H | H |
| One-to-many | H | H | H | H | H |
| Multi Media Message / Instant Message | | Person-to-person | H | H | H | H | H |
| One-to-many | H | H | H | H | H |
| SD | H | H | H | H | H |
| HD | M | H | H | M | M |
| Presence | H | H | H | H | H |
| Data Base Interaction | |  | N | H | L | H | N |
| Location | | Interactive location data | H | H | H | H | H |
| File Transfer | |  | H | H | H | H | H |
| Client Server App. | |  | N | H | L | H | N |
| Peer to Peer App | |  | H | H | H | H | H |
| Miscellaneous | | Software /Firmware update online | N | M | N | M | N |
| GIS maps updates | N | M | N | M | N |
| Automatic telemetries | N | M | N | M | N |
| Hotspot on disaster or event area | H | H | H | H | H |
| Alarming / paging | H | H | H | H | H |
| H | Highly Desired | | | | | | |
| M | Medium Importance | | | | | | |
| L | Low Importance | | | | | | |
| N | Not Needed | | | | | | |
|  |  | | | | | | |

Appendix 1 of Annex 5

Definition of QoS

Table A5-4

|  |  |
| --- | --- |
| QoS Class of Service | Description/Definition |
| QoS Class of Service 0 | The network shall support a QoS class of service for real-time, jitter-sensitive, high interaction (cellular voice, push-to-talk voice, etc.). |
| QoS Class of Service 1 | The network shall support a QoS class of service for real-time, jitter-sensitive, interactive (cellular voice, push-to-talk voice, etc.). |
| QoS Class of Service 2 | The network shall support a QoS class of service for transaction data, highly interactive (signalling). |
| QoS Class of Service 3 | The network shall support a QoS class of service for transaction data, interactive. |
| QoS Class of Service 4 | The network shall support a QoS class of service for low-loss, real-time video. |
| QoS Class of Service 5 | The network shall support a QoS class of service for low-loss only (short transactions, bulk data). |
| QoS Class of Service 6 | The network shall support a QoS class of service for traditional applications of default IP networks. |

ANNEX 6

Spectrum requirements for narrow-band wide-band public  
protection and disaster relief

*Editor’s Note: Some of the studies this Annex were preserved from Annex 4 of Report ITU-R M.2033. Those studies need to be reviewed to determine their continuing appropriateness for inclusion.*

*Editor’s note: The source of the text included here in Annex 6A is Annex 4 of Report ITU-R M.2033 and will need to replace “Annex 4” by “Annex 6”.*

# 1 Introduction

This Annex addresses the estimation of the spectrum requirements for public protection and disaster relief (PPDR), particularly within the context of WRC-03 agenda Item 1.3. The Annex provides:

– a method of calculating amounts of spectrum;

– system scenarios and assumptions;

– validation of the method with respect to existing applications;

– examples of several administrations projections of their requirements by 2010;

– determining the amount of spectrum which should be harmonized in the context of future applications; and,

– conclusions.

The calculation method given in this Annex is provided for assisting in consolidating spectrum requirements.

A number of administrations have used the modified methodology in Appendix 1 to this Annex to estimate their national spectrum requirements for PPDR. That methodology, however, is not the only means by which administrations may calculate their national PPDR spectrum needs. Administrations have the discretion to use whatever method, including the modified methodology; they choose to determine their own spectrum requirements for PPDR.

Many PPDR entities around the world are currently evaluating the migration from analog wireless systems to digital for current telecommunication services. The migration to digital will also allow these entities to add some advanced services to these first generation PPDR digital systems. However, there are many more advanced services that PPDR users are likely to demand as they become available to commercial users. While spectrum demand has been estimated and allotted for 2nd and 3rd generation commercial wireless services, similar analysis has not been done for PPDR users.

The greatest demand for public protection and disaster relief telecommunication services is in large cities where different categories of traffic can be found, i.e. that generated by mobile stations (MS), vehicle mounted or portable stations, and personal stations (PS) (hand-held portable radios). The trend is toward designing the PPDR telecommunication network to provide services to personal stations both outdoor and indoor (building penetration).

Maximum demand will be created after a disaster, when many PPDR users converge on the emergency scene utilizing existing telecommunication networks, installing temporary networks, or utilizing vehicle mounted or portable stations. Additional spectrum may be required for interoperability between various PPDR users and/or additional spectrum may be required for installation of temporary disaster relief systems.

Considerations on spectrum demand should take into account the estimated traffic, the available and foreseeable techniques, the propagation characteristics and the time-scale to meet the users' needs to the greatest possible extent. Consideration on frequency matters should take into account that the traffic generated by mobile systems, as well as the number and diversity of services, will continue to grow. Any estimation of the traffic should take into consideration that in the future, non‑voice traffic will constitute an increasing portion of the total traffic and that traffic will be generated indoors as well as outdoors by personal and mobile stations.

# 2 Methods of projecting spectrum requirements

## 2.1 Description of the methodology

This public protection and disaster relief spectrum calculation methodology (Appendix 1 to this Annex) follows the format of the generic methodology that was used for the calculation of IMT‑2000 terrestrial spectrum requirements (Recommendation ITU‑R M.1390). The use of the methodology can be customized to specific applications by selecting values appropriate to the particular terrestrial mobile application. Another model based on a generic city approach was also used (see Appendix 2 to this Annex)

The values selected for the PPDR applications must take into account the fact that PPDR utilizes different technologies and applications (including dispatch and direct mode).

## 2.2 Required input data

The ITU-R M.1390 based model and the generic city model require a number of input values which can be categorized as environment, traffic or network systems. In applying the model to PPDR the main data elements required are:

– the identification of PPDR user categories, e.g. police, fire, ambulance;

– the number of users in each category;

– the estimated number of each user category in use in the busy hour;

– the type of information transmitted, e.g. voice, status message and telemetry;

– the typical area to be covered by the system under study;

– the average cell size of base stations in the area;

– the frequency reuse pattern;

– the grade of service;

* the technology used including RF channel bandwidth.
* the demographic population of the city.

## 2.3 Validity of the methodology

### 2.3.1 Discussion

Several aspects of the methodology, the assumptions inherent in the model as presented, timing, method of calculation, frequency reuse, possibility of separating the calculations for PPDR, urban as opposed to rural situations, and the nature of the operating environments were clarified in the ITU-R study period 2000-2003.

Specifically, the following issues were raised in connection with the methodology:

a) Applicability of IMT-2000 methodology to PPDR?

b) Substituting the geographic areas (e.g. urban, in-building, etc.) in the IMT-2000 methodology by service categories (NB, WB, BB)?

c) Use of assumptions of PSWAC Report[[8]](#footnote-8)4 with regard to assessment of traffic for PPDR?

d) Treatment of traffic for PP and DR together?

e) Use of cellular configurations/hotspots in estimating spectrum requirements for PPDR?

f) Applicability of the methodologies for the simplex/direct mode operations?

In response, the following points should be noted:

1 While the document is based on the methodology used for IMT-2000, the method is capable of including all technologies from simplex to cellular and beyond. Further work will be required to establish appropriate classifications of service environment categories (e.g. for fire, police, emergency medical services) and model systems for those environ­ments, in order to make the calculations needed for each type of use and technology.

2 Terms of the calculation of spectrum requirements public protection activities could be separated from disaster relief activities, with separate and appropriate parameter values and assumptions being applied for each case. However, it was noted that there are instances where public protection equipment, which is used for routine operations on a day-by-day basis, may also be employed in times of disaster. In these cases, there would need to be some means established to avoid double counting when undertaking calculations of spectrum requirements.

3 In considering the service environments (i.e. narrowband, wideband and broadband), it was noted that those used for IMT-2000 may also have some applicability to PPDR communications.

### 2.3.2 Validity study

One administration undertook the performance of a study of the validity of the results predicted by this methodology. This was done by inputting the parameters of a working narrowband PPDR system into a calculator spreadsheet and checking that the amount of spectrum it predicted was the same as that actually used by the system. It was concluded that this methodology is valid, provided it is used carefully and correctly. It was also concluded that although not validated by actual measurement, one might extrapolate that model works as well for wideband and broadband as long as the input parameters are carefully considered and applied. Another administration reported on a similar study undertaken in which examples were developed for typical cities, obtaining spectrum estimates that are consistent with other examples previously reported. Using two examples of the application of the methodology – one referred to a middle-sized city and the other to an industrial district – it was concluded that the methodology is appropriate for the evaluation of spectrum needed for PPDR radiocommunication.

## 2.4 Critical parameters

In assessing the validity of the methodology several critical parameters were identified which must be selected with care. Studies in estimating spectrum requirements for terrestrial land mobile systems were conducted by some administrations showed that the most influential input parameters are:

− cell radius/frequency reuse;

− number of users.

The results of the studies were shown to be heavily dependent upon cellular architecture parameters. The studies show that changes in cell radius will change the spectrum estimate significantly. While it is true that reducing the size of the cell radius will increase the reuse of the spectrum and thereby reduce the spectrum requirement, the cost of the infrastructure will also significantly increase. Similar considerations apply to other parameters, e.g. using sectored cells decreases the necessary spectrum by a factor of three. For these reasons it is advisable that careful studies of cellular structures are undertaken prior to the final specification of the spectrum to be reserved to PPDR.

In preparing the estimate of spectrum amounts, it will be necessary to get consensus on the input data to put into the generic methodology. Noting the sensitivity of the results to such critical parameters, the input data will need to be selected carefully and will need to reflect a balance between the amount of spectrum sought and the infrastructure cost. Countries that need less spectrum than the full amount identified will have greater freedom in network design, the degree of frequency reuse and infrastructure cost.

## 2.5 Extrapolated upper limit

Korea undertook a parametric analysis of the result of spectrum calculations made for Bhopal, Mexico City, and Seoul. The analysis also used data for other cites taken from other contributions to the work of the ITU-R. The parametric analysis provided insight into PPDR spectrum requirements and it showed that considering the worst case/dense user situation a maximum of 200 MHz (Narrowband: 40 MHz, Wideband: 90 MHz, Broadband: 70 MHz) is needed for the PPDR spectrum requirement for WRC-03 Agenda item 1.3.

# 3 Results

## 3.1 Results of estimates of amount of spectrum required by the year 2010 for PPDR

A summary of results of spectrum estimates for PPDR scenarios presented by some administrations using the proposed spectrum calculator methodology is given below. However the data in the last row was made using various other methods.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Location | Narrowband (MHz) | Wideband  (MHz) | Broadband  (MHz) | Total  (MHz) |
| Delhi | 51.8 | 3.4 | 47.6 | 102.8 |
| Bhopal | 24 | 5.2 | 32.2 | 61.4 |
| Seoul | 15.1 | 90.5 | 69.2 | 174.8 |
| Mexico City | 46.2 | 39.2 | 50.2 | 135.6 |
| Paris | 16.6 | 32.6 | – | – |
| Medium city (Italy high penetration) | 21.1 | 21.6 | 39.2 | 81.9 |
| Medium city (Italy medium penetration) | 11.6 | 11.4 | 39.2 | 62.2 |
| Industrial district (Italy) | 3.0 | 3.0 | 39.2 | 45.2 |
| USA | 35.2 | 12 | 50.0 | 97.2 |

The United States of America provided its current spectrum designations for PPDR and did not use the proposed methodology. It reported that it has designated a total of 35.2 MHz of spectrum for local and state PPDR agencies to use for narrowband applications. In addition, 12 MHz of spectrum has been designated for wideband PPDR applications. It has designated 50 MHz spectrum for broadband PPDR applications. The United States of America is continually reviewing its spectrum decisions to determine if spectrum has been designated appropriately for state and local PPDR applications.

## 3.2 Discussion of results

The totals listed in the above chart cover all the PPDR applications and both uplink and downlink requirements. The results range between 45 MHz and 175 MHz. Such results have to be compared with the national current and forecasted situations taking into account the whole spectrum needed by PPDR users.

There are several reasons for the wide range of spectrum estimates. First, the studies done in obtaining these results showed that the spectrum estimates are very dependent on density and the penetration rate. Second, administrations based their spectrum calculations on whatever scenarios they deemed most appropriate. For example, Korea based its spectrum calculations on the worst case/most dense user requirement. Italy chose to examine the PPDR spectrum needs of a typical medium-size city in Italy. Other administrations used other scenarios.

Many countries do not envisage having physically separate PP and DR networks in their countries and therefore see global/regional harmonization as applying to both PP and DR requirements. Other countries may decide to calculate separate PP and DR spectrum requirements.

Appendix 1 to Annex 6  
  
Methodology for the calculation of public protection and disaster  
relief terrestrial spectrum requirements

# 1 Introduction

The function of this attachment is to present an initial forecast for spectrum needed by public protection and disaster relief (PPDR) by the year 2010. A spectrum calculator methodology, following the format of ITU methodology for the calculation of IMT-2000 spectrum requirements, is developed. Because of the differences between commercial wireless users and PPDR wireless users, alternate methodologies are proposed to calculate PPDR user penetration rates and define the PPDR operational environments. Methodologies are also proposed to define PPDR net system capacity and PPDR quality of service.

The analysis is based upon current PPDR wireless technologies and expected trends in demand for advanced applications. From that, an initial forecast can be made for the amount of spectrum needed for specific advanced telecommunication services through the year 2010.

# 2 Advanced services

The advanced services likely to be available to PPDR community by year 2010 are:

− voice dispatch;

− telephone interconnect;

− simple messages;

− transaction processing;

− simple images (facsimile, snapshot);

− remote file access for decision processing;

− Internet/intranet access;

− slow video;

− full motion video;

− multimedia services, like videoconference.

# A Spectrum prediction model

This spectrum prediction model follows the methodology for the prediction of IMT-2000 Spectrum Requirements (Recommendation ITU-R M.1390).

The steps to be used are:

*Step 1*: Identify the geographical area over which the model will be applied.

*Step 2*: Identify the population of PPDR personnel.

*Step 3*: Identify the advanced services used by the PPDR community through year 2010.

*Step 4*: Quantify technical parameters that apply to each of the advanced services.

*Step 5*: Forecast the spectral need for each advanced service.

*Step 6*: Forecast total spectral need for PPDR through year 2010.

See Attachment A for a comparison of the proposed PPDR methodology versus the Recommendation ITU‑R M.1390 methodology. See Attachment B for a flowchart of the proposed PPDR methodology.

# B Geographical area

Determine the PPDR user populations within the area of the study.

For this model, we do not need to investigate spectrum demand over an entire country. The area(s) of interest will be one or more of the major metropolitan regions within each country. The population density is highest in these areas. The proportion of PPDR personnel relative to the general population is expected to be highest here, also. Therefore, the demand for spectrum resources should also be highest in the major metropolitan area(s). This is similar to the IMT‑2000 methodology where the geography and environments of only the most significant contributors to spectrum requirements are considered.

We need to clearly define the geographic and/or political boundaries of the metropolitan area of study. This may be the political boundary of the city or of the city and surrounding suburban cities and/or counties in the metropolitan area. We need general population data for the metropolitan area. This should be readily available from census data.

Instead of using general population density (population/km2), the PPDR population and penetration rates must be determined. Within the geopolitical boundaries of the study area, PPDR population must be defined and divided by the area to determine the PPDR user density (PPDR/km2).

Representative cell area (radius, geometry) needs to be determined for each operational environ­ment within the geographic study area. This is dependent upon the population density, network design, and network technology. PPDR networks tend to utilize higher power devices and larger radius cells than commercial systems.

*Follow IMT-2000 methodology A:*

Define geographic boundaries and area (km2) of each environment.

# C Operational environments versus service environments

In the methodology for the calculation of IMT-2000 spectrum requirements, the analysis is conducted on physical operational environments. These environments vary significantly in cell geometry and/or population density. PPDR population density is much lower than the general population density. PPDR networks generally provide wireless services into all physical environ­ments from one, or more, wide-area network(s). This model defines “service environments” which group services by the type of PPDR wireless telecommunication network: narrowband, wideband and broadband. Many services are currently, and will continue to be, delivered by networks using narrowband channels (25 kHz or less). These include dispatch voice, transaction processing, and simple images. More advanced services like internet/intranet access and slow video will require a wideband channel (50 to 250 kHz) to deliver these higher content services. Full motion video and multi-media services will require very wide channels (1 to 10 MHz) to deliver real-time images. These three “service environments” are likely to be deployed as separate overlapping networks utilizing different cell geometries and different network and subscriber technologies.

Also, the services offered within each “service environment” will need to be defined.

Modified version of IMT-2000 methodology A1, A2, A3, A4, B1:

Define “service environment”, i.e. narrowband, wideband, broadband.

Determine direction of calculations for each environment: uplink, downlink, combined.

Determine average/typical cell geometry within each “service” environment.

Calculate representative cell area within each “service” environment.

Define services offered in each “service environment” and net user bit rate for each.

# D PPDR population

Who are PPDR users? These are personnel who respond to day-to-day emergencies and to disasters. They would typically be public protection personnel grouped into mission oriented categories, such as police, fire brigades, emergency medical response. For disasters the scope of responders may increase to include other government personnel or civilians. All these PPDR personnel would be using PPDR telecommunication services during an emergency or disaster. PPDR users may be combined together into categories that have similar wireless communication usage patterns, i.e. the assumption is that all users grouped into “police” category personnel would have similar demands for telecommunication services.

For this model, the categories will only be used to group PPDR users with similar wireless service usage rates. That is, for police, each officer may have a radio, so the wireless penetration rate is 100% for police. For ambulance crews, there may be two people assigned to an ambulance, but only one radio, so the penetration rate is only 50% for ambulance crews. The current penetration rate can easily be determined if the number of mobile and portable stations deployed is known. It is simply the ratio of the number of radios deployed to the number of PPDR users in that category.

We need to determine the PPDR user populations. This can be collected for each PPDR user category; police, law enforcement, fire brigade, emergency medical response, etc. This data may be collected from the specific metropolitan governments or PPDR agencies. This data may be available from several public sources, including annual budgets, census data, and reports published by national or local law enforcements agencies.

The data may be presented in several formats, which must be converted into the total counts from each source for each PPDR category within the area of study.

− Some data may be presented as specific PPDR user counts within a political sub‑division; e.g. city A with a population of nnnnn has AA police officers, BB fire fighters, CC ambulance drivers, DD transit police, EE traffic wardens, and FF civilian support personnel.

− Some data may be presented as a percentage relative to the total population; e.g. there are XXX police officers per 100 000 population. This needs to be multiplied by the population within the area of study to calculate the total count for each PPDR category.

− There may be multiple levels of government within the area of study. The PPDR totals for each category need to be combined. Local police, county police, state police, and federal police could be combined into a single “police” category. The assumption is that all these “police” category personnel would have similar demands for telecommunication services.

*Example of PPDR categories*:

Regular Police Fire Brigades Emergency Medical Services  
Special Police Functions Part-time Fire EMS Civilian Support  
Police Civilian Support Fire Civilian Support  
General Government Personnel Other PPDR Users

Growth projections for population and planned increases in PPDR personnel may be used to estimate the future number of PPDR personnel within the area of study in 2010. Analysis over the study area may show that some towns/cities within the area of study do not provide advanced PPDR services today, but plan to deliver those services within the next 10 years. Growth projection may simply be the application of the higher PPDR user population density figures from cities/towns using advanced wireless services today within the area of study to all parts of the study area.

*Modified version of IMT-2000 methodology B2*:

Determine PPDR population density within study area.

− Calculate for each mission-oriented category of PPDR user or for groups of PPDR users with similar service usage patterns.

# E Penetration rates

Instead of using penetration rates from commercial wireless market analyses, the PPDR penetration rates for current and future wireless telecommunication services must be determined. It is expected that the ITU-R survey on PPDR communications will supply some of this data. One method would be to determine the penetration rate of each telecommunication service within each of the PPDR categories defined above, then convert this to the composite PPDR penetration rate for each telecommunication service within each environment.

*Modified version of IMT-2000 methodology B3, B4:*

Calculate PPDR population density.

− Calculate for each category of PPDR user.

Determine penetration rate for each service within each environment.

Determine users/cell for each service within each environment.

# F Traffic parameters

The proposed model follows the IMT-2000 methodology. Traffic parameters used in examples below represent average for all PPDR users. However, these traffic parameters could also be calculated for individual PPDR categories and combined to calculate composite traffic/user. Much of this data was determined by PSWAC and that busy hour traffic data will be used in the examples presented below. The “busy hour call attempts” are defined as the ratio between the total number of connected calls/sessions during the busy hour and the total number of PPDR users in the study area during the busy hour. Much of this data was determined by PSWAC and that busy hour traffic data will be used in the examples presented below. The activity factor is assumed to be 1 for all services, including PPDR speech. Current PPDR systems do not use vocoders with discontinuous voice transmission, so PPDR speech continuously occupies the channel and the PPDR speech activity factor is 1.

*Follow IMT-2000 methodology B5, B6, B7*:

Determine busy hour call attempts per PPDR user for each service in each environment.

Determine effective call/session duration.

Determine activity factor.

Calculate busy hour traffic per PPDR user.

Calculate offered traffic/cell (E) for each service in each environment.

*Example of traffic profiles from PSWAC Report*:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| PSWAC traffic profile summary | | Inbound (E) | Outbound (E) | Total (E) | (s) | Ratio of busy hour to average hour | Continuous  bit rate (at 4 800 (bit/s) |
| Voice | Current busy hour | 0.0073484 | 0.0462886 | 0.0536370 | 193.1 | 4.00 | 85.8 |
| Current average hour | 0.0018371 | 0.0115722 | 0.0134093 | 48.3 |  | 21.5 |
|  |  |  |  |  |  |  |
| Future busy hour | 0.0077384 | 0.0463105 | 0.0540489 | 194.6 | 4.03 | 86.5 |
| Future average hour | 0.0018321 | 0.0115776 | 0.0134097 | 48.3 |  | 21.5 |
|  | | | | | | | |
| Data | Current busy hour | 0.0004856 | 0.0013018 | 0.0017874 | 6.4 | 4.00 | 2.9 |
| Current average hour | 0.0001214 | 0.0003254 | 0.0004468 | 1.6 |  | 0.7 |
|  |  |  |  |  |  |  |
| Future busy hour | 0.0030201 | 0.0057000 | 0.0087201 | 31.4 | 4.00 | 14.0 |
| Future average hour | 0.0007550 | 0.0014250 | 0.0021800 | 7.8 |  | 3.5 |
|  | | | | | | | |
| Status | Current busy hour | 0.0000357 | 0.0000232 | 0.0000589 | 0.2 | 4.01 | 0.1 |
| Current average hour | 0.0000089 | 0.0000058 | 0.0000147 | 0.1 |  | 0.0 |
|  |  |  |  |  |  |  |
| Future busy hour | 0.0001540 | 0.0002223 | 0.0003763 | 1.4 | 3.96 | 0.6 |
| Future average hour | 0.00 | 0.00 | 0.00 | 0.34 |  | 0.15 |
|  | | | | | | | |
| Image | Current busy hour | 0.0268314 | 0.0266667 | 0.0534981 | 192.6 | 4.00 | 85.6 |
| Current average hour | 0.0067078 | 0.0066670 | 0.0133748 | 48.1 |  | 21.4 |

# G PPDR quality of service functions

The IMT-2000 methodology takes the offered traffic/cell data, converts it to the number of traffic channels required to carry that load in a typical cell reuse grouping, and then applies grade of service formulas to determine the number of service channels needed in a typical cell. The same methodology is proposed here, but the factors used for PPDR networks are significantly different.

For PPDR systems the reuse pattern is typically much higher than commercial wireless services. Commercial wireless services are normally designed to use low power devices with power control in an interference limited environment. PPDR systems are typically designed to be “coverage” or “noise” limited. Many PPDR systems use a mixture of high power vehicular devices and low power handheld devices, without power control. Therefore, the separation or reuse distance is much greater for PPDR systems, in the range of 12 to 21.

The technology modularity of PPDR systems is often different than commercial systems. There may be two or more networks covering the same geographic area, in different frequency bands, supporting the PPDR personnel from different levels of government or in different PPDR categories (federal networks may be independent of local networks; police networks may be independent of fire networks). The result is networks with fewer channel resources per cell.PPDR networks are normally designed for higher coverage reliabilities, 95 to 97%, because they are trying to cover all operational environments from a fixed network. Commercial networks, with a revenue stream, can continuously adapt their networks to changing user needs. PPDR networks, funded with public monies, normally undergo minimal change in cell locations or service channels per cell over their lifetime of 10-20 years.

For PPDR services, availability of the channel must be very high, even during busy hours, because of the immediate need to transmit critical, sometimes life-saving, information. PPDR networks are designed for lower call blocking levels, 1%, as PPDR personnel need immediate access to the network during emergency situations. While many routine conversations and data transactions can wait several seconds for a response, many PPDR situations are highly tense and require immediate channel availability and response.

Loading varies greatly for different PPDR network topologies and for different PPDR situations. Many police or fire situations may require individual channels to be set aside for on-scene interoperability with very low loading, 10%. Conventional, single channel, mobile relay systems in use today typically operate at 20-25% loading, because unacceptable blockage occurs at higher loading. Large 20 channel trunked systems, which spread the load across all available channels, with a mix of critical and non-critical users, may be able to operate at acceptable levels for critical PPDR operations with busy hour loading of 70-80%.

The net impact causes the Erlang B factor for the average PPDR network to be higher, about 1.5, instead of the 1.1 to 1.2 factors seen with commercial services at 90% coverage and 1% blocking.

*Follow IMT-2000 methodology B8:*

Unique PPDR requirements:

Blocking  1%

Modularity  ~ 20 channels per cell per network, results in a high Erlang B factor of about 1.5.

Frequency reuse cell format

 12 for like power mobile or personal stations

 21 for mixture of high/low power mobile and personal stations.

Determine number of service channels needed for each service in each “service” environment (NB, WB, BB)

# H Calculate total traffic

The proposed model follows the IMT-2000 methodology. The PPDR net user bit rate should include the raw data rate, the overhead factor and the coding factor. This is dependent upon the technology chosen for each service.

Information is coded to reduce or compress the content which minimizes the amount of data to be transmitted over an RF channel. Voice, which may be coded at a rate of 64 kbit/s or 32 kbit/s for wireline applications, is coded at rates of less than 4 800 bit/s for PPDR dispatch speech applications. The more the information is compressed, the more important each bit becomes, and the more important the error correction function becomes. Error coding rates from 50% to 100% of information content are typical. Higher transmission rates over the harsh multi-path propagation environment of an RF channel require additional synchronization and equalization functions, which use additional capacity. Also, other network access and control functions need to be carried along with the information payload (unit identity, network access functions, encryption).

PPDR systems in operation today use 50-55% of the transmitted bit rate for error correction and overhead.

For example: a technology for speech on narrowband channels may have a speech vocoder output rate of 4.8 kbit/s with a forward error correction (FEC) rate of 2.4 kbit/s and the protocol may be provisioned for another 2.4 kbit/s of overhead signalling and information bits, for a net user bit rate of 9.6 kbit/s.

*Follow IMT-2000 methodology C1, C2, C3:*

Define net user bit rate, overhead factors, coding factors for each service in each “service” environment.

Convert service channels from B8 back to per cell basis.

Calculate total traffic (Mbit/s) for each service in each “service” environment

# I Net system capacity

The net system capacity is an important measure of the spectrum efficiency of a wireless telecommunications system. The net system capacity calculation produces the maximum system capacity possible within the spectrum band being studied.

The proposed model follows the IMT-2000 methodology. However, the calculation of PPDR net system capacity should be based upon typical PPDR technologies, PPDR frequency bands, and PPDR reuse patterns, rather than the GSM model used in the IMT-2000 methodology.

Attachment C provides an analysis for several PPDR technologies currently in use against some existing PPDR spectrum allocations. These examples show maximum possible system capacity for the purpose of estimating future spectrum requirements. There are numerous other user require­ments and spectrum allocation factors, not included here, that affect the functional and operational deployment of a network, the choice of technology, and the resulting network’s spectrum efficiency.

Follow IMT-2000 methodology C4, C5:

Pick several PPDR network technologies.

Pick several representative frequency bands.

Follow same calculations format as GSM model.

Calculate typical net system capacities for PPDR land mobile radio technology.

# J Spectrum calculations

The proposed model follows the IMT-2000 methodology.

PPDR networks are very likely to have coincident busy hours. Therefore the alpha factor will be 1.0.

The number of PPDR personnel is likely to grow with general population growth. The demand for PPDR services is likely to increase following trends similar to the demand for commercial wireless telecommunication services.

The beta factor can be set to a number greater than 1.0 here, or the growth factor can be included in the net system capacity calculations.

Follow IMT-2000 methodology D1, D2, D3, D4, D5, D6:

Define alpha factor  1.

Define beta factor  1 (include growth under net system capacity, ignore other outside effects for example calculations).

Calculate spectrum need for each service in each “service” environment.

Sum up spectrum needs for each “service” environment (NB, WB, BB).

Sum up total spectrum need.

Examples

See Attachment E for a detailed narrowband voice example using London data from Attachment D. Attachment F shows example calculation summaries for narrowband voice, message, and image for London and New York City and for wideband data and slow video for New York City.

Conclusion

It has been demonstrated that the IMT-2000 methodology (Recommendation ITU-R M.1390) may be adapted to calculate the system requirements for public protection and disaster relief communications (or applications). Methods have been provided to determine the PPDR user population and service penetration rates. “Service” environments have been defined over which PPDR spectrum requirements can be calculated. The factors necessary to adapt the IMT‑2000 methodology to a PPDR methodology have been identified, including the development of a methodology to define PPDR net system capacity.

Attachment A  
of Appendix 1 to Annex 6

Comparison of proposed methodology for the calculation of PPDR   
spectrum requirements to IMT-2000 methodology

|  |  |  |
| --- | --- | --- |
| IMT-2000 methodology  (Recommendation ITU-R M.1390) | IMT-2000 methodology | Proposed PPDR methodology |
| **A** Geography |  |  |
| **A1** Operational Environment  Combination of user mobility and user mobility. Usually only analyse most significant contributors. | **A1** Look at three physical environments with different user densities: urban area and in-building, pedestrian, vehicular users | **A1** PPDR user density is much lower and more uniform. PPDR users roam from one environment to another as they respond to emergencies. PPDR systems are usually designed to cover all environments (i.e., wide‑area network provides in-build­ing coverage). Instead of analyzing by physical environment, assume that there will likely be multiple overlapping systems each providing different services (narrowband, wideband, and broadband). Each service environment will probably operate in a different frequency band with different network architectures. Analyse three overlapping urban “service environments”: narrowband, wideband, broadband. |
| **A2** Direction of calculation | **A2** Usually separate calculations for uplink and downlink due to asymmetry in some services | **A2** Same |
| **A3** Representative cell area and geometry for each environment type | **A3** Average cell radius of radius to vertex for hexagonal cells | **A3** Same |
| **A4** Calculate area of typical cell | **A4** Omni cells  i *R*2  Hexagonal cells  2.6 · *R*2  3-sector hex  2.6/3 · *R*2 | **A4** Same |

|  |  |  |
| --- | --- | --- |
| IMT-2000 methodology  (Rec. ITU-R M.1390) | IMT-2000 methodology | Proposed PPDR methodology |
| **B** Market & traffic |  |  |
| **B1** Services offered | **B1** Net user bit rate (kbit/s)  For each service: speech, circuit data, simple messages, medium multi­media, high multimedia, highly inter­active multimedia | **B1** Net user bit rate (kbit/s) for each of the three PPDR service environments: narrowband, wideband, broadband |
| **B2** Population density  Persons per unit of area within each environment. Population density varies with mobility | **B2** Potential users per km2  Relative to general population | **B2** Total PPDR user population within the total area under consideration. Divide PPDR population by total area to get PPDR population density.  PPDR users are usually separated into well-defined categories by mission. Example:  *Category Population*  Regular Police 25 498  Special Police Functions 6 010  Police Civilian Support 13 987  Fire Suppression 7  081  Part-time Fire 2 127  Fire Civilian Support 0  Emergency Medical Services 0  EMS Civilian Support 0  General Government Services 0  Other PPDR Users 0  **Total PPDR population 54 703**  Area under consideration. Area within well-defined geographic or political boundaries.  Example: City of London  1 620 km2  PPDR population density  PPDR population/area  Example: London  33.8 PPDR/km2 |

|  |  |  |
| --- | --- | --- |
| IMT-2000 methodology (Rec. ITU-R M.1390) | IMT-2000 methodology | Proposed PPDR methodology |
| **B3** Penetration rate  Percentage of persons subscribing to a service within an environment. Person may subscribe to more than one service | **B3** Usually shown as table,  Rows are services defined in B1, such as speech, circuit data, simple messages, medium multi-media, high multimedia, highly interactive multi­media.  Columns are environments, such as in-building, pedestrian, vehicular | **B3** Similar table.  Rows are services, such as voice, data, video  Columns are “service environments”, such as narrowband, wideband, broadband.  May collect penetration rate into each “service environment” separately for each PPDR category and then calculate composite PPDR penetration rate.  Example:  *Category Population* *Penetration*  (NB Voice)  Regular Police 25 498 100%  Special Police Functions 6 010 10%  Police Civilian Support 13 987 10%  Fire Suppression 7 081 70%  Part-time Fire 2 127 10%  Fire Civilian Support 0 0  Emergency Medical Services 0 0  EMS Civilian Support 0 0  General Government Services 0 0  **Other PPDR Users**   **0 0**  **TOTAL PPDR Population 54 703**  **Narrowband Voice  PPDR Population 32 667**  PPDR penetration rate for narrowband “service environment” and voice “service”:   Sum(Pop  Pen)/sum(Pop)  59.7% |

|  |  |  |
| --- | --- | --- |
| IMT-2000 methodology (Rec. ITU-R M.1390) | IMT-2000 methodology | Proposed PPDR methodology |
| **B4** Users/cell  Number of people subscribing to service within cell in environment | **B4** Users/cell   Pop density  Pen Rate  Cell area | **B4** Same |
| **B5** Traffic parameters  Busy hour call attempts: average number of calls/sessions attempted to/from average user during a busy hour  Effective call duration  Average call/session duration during busy hour  Activity factor  Percentage of time that resource is actually used during a call/session.  *Example*: bursty packet data may not use channel during entire session. If voice vocoder does not transmit data during voice pauses | **B5** Calls/busy hour    s/call  0-100% | **B5** Same  Sources: PSWAC Report or data collected from existing PPDR systems  Same  Same  More likely that activity factor is 100% for most PPDR services. |
| **B6** Traffic/user  Average traffic generated by each user during busy hour | **B6** Call-seconds/user   Busy hour attempts  Call duration  Activity factor | **B6** Same |
| **B7** Offered traffic/cell  Average traffic generated by all users within a cell during the busy hour (3 600 s) | **B7** Erlangs   Traffic/user  User/cell/3 600 | **B7** Same |

|  |  |  |
| --- | --- | --- |
| IMT-2000 methodology (Rec. ITU-R M.1390) | IMT-2000 methodology | Proposed PPDR methodology |
| **B8** Quality of service function  Offered traffic/cell is multiplied by typical frequency reuse cell grouping size and quality of Service factors (blocking function) to estimate offered traffic/cell at a given quality level  Group size  Traffic per group | Typical cellular reuse  7   Traffic/cell (E)  Group Size | Use 12 for portable only or mobile only systems.  Use 21 for mixed portable and mobile systems.  In mixed systems, assume that system is designed for portable coverage. Higher power mobiles in distant cells are likely to, so group size is increased from 12 to 21 to provide more separation.  Same |
| Service channels per group | Apply grade of service formulas  Circuit  Erlang B with 1% or 2% blocking  Packet  Erlang C with 1% or 2% delayed and delay/holding time ratio  0.5 | Similar  Use 1% blocking. Erlang B factor probably close to 1.5.  Need to consider extra reliability for PPDR systems, excess capacity for peak emergencies, and number of channels likely to be deployed at each PPDR antenna site.  Technology modularity may affect number of channels that can be deployed at a site |

|  |  |  |
| --- | --- | --- |
| IMT-2000 methodology (Rec. ITU-R M.1390) | IMT-2000 methodology | Proposed PPDR methodology |
| **C** Technical and system considerations |  |  |
| **C1** Service channels per cell to carry offered load | **C1** Service channels per cell Service channels per group/Group size | **C1** Same |
| **C2** Service channel bit rate (kbit/s)  Equals net user bit rate plus additional increase in loading due to coding and/or overhead signalling, if not already included | **C2** Service channel bit rate  Net user bit rate  Overhead factor  Coding factor  If coding and overhead already included in Net user bit rate, then Coding factor  1 and Overhead factor  1 | **C2** Same  Can also sum effects of coding and overhead.  If vocoder output  4.8 kbit/s, FEC  2.4 kbit/s, and Overhead  2.4 kbit/s, then Channel bit rate  9.6 kbit/s |
| **C3** Calculate traffic (Mbit/s)  Total traffic transmitted within area under study, including all factors | **C3** Total traffic   Service channels per cell x service channel bit rate | **C3** Same |
| **C4** Net system capability  Measure of system capacity for a specific technology. Related to spectral efficiency | **C4** Calculate for GSM system | **C4** Calculate for typical narrowband, wideband and broadband land mobile systems |
| **C5** Calculate for GSM model  200 kHz channel bandwidth, 9 cell reuse, 8 traffic slots per carrier, frequency division duplex (FDD) with 2  5.8 MHz, 2 guard channels, 13 kbit/s in each traffic slot, 1.75 overhead/coding factor | **C5** Net system capacity for GSM model   0.1 Mbit/s/MHz/cell | **C5** See Attachment A for several land mobile examples |

|  |  |  |
| --- | --- | --- |
| IMT-2000 methodology (Rec. ITU-R M.1390) | IMT-2000 methodology | Proposed PPDR methodology |
| **D** Spectrum Results |  |  |
| **D1-D4** Calculate individual components (each cell in service vs environment matrix) | **D1-D4**  Freq  Traffic net system capacity for each service in each environment | **D1-D4**  Similar, calculate for each cell in service vs. “service environment” matrix |
| **D5** Weighting factor (alpha) for busy hour of each environment relative to busy hour of other environments, may vary from 0 to 1 | **D5** if all environments have coincident busy hours, then alpha  1  Freqes  Freq  alpha requirements in D1‑D4 | **D5** Same  Same |
| **D6** Adjustment factor (beta) for outside effects – multiple operators/networks, guard bands, band sharing, technology modularity | **D6**  Freq(total)  beta  sum(alpha  Freqes) | **D6** Same |

Attachment B  
of Appendix 1 to Annex 6

PPDR Spectrum Requirements Flowchart











Attachment C to Appendix 1 to Annex 6

System capacity calculation examples

# 1 IMT-2000 net system capacity calculation methodology

The spectrum efficiency factor is an important measure of the capacity of a wireless telecommunications system. In order compare spectrum efficiency factors it is necessary to use a common basis to calculate the system capacity (kbit/s/MHz/cell), available to carry traffic. Analysis should take into consideration factors which reduce capacity over the air interface (guard bands,   
co-channel and adjacent channel interference, channels assigned to other purposes within the band). This calculation should produce the maximum system capacity possible within the spectrum band being studied. Actual systems will be sized for lower traffic levels to achieve the desired grade of service.

Annex 3 of the SAG Report on UMTS/IMT-2000 Spectrum[[9]](#footnote-9)5 calculates the capacity of a generalized GSM network as:

C4 and C5 Net system capability calculation

|  |  |  |  |
| --- | --- | --- | --- |
| GSM and IMT-2000 | | | |
| Width of band (MHz) | 5.8 | 11.6 | MHz total |
| Width of channel | 0.2 |  | MHz |
|  |  | 29.0 | FDD channels within band |
| Reuse group factor | 9 |  |  |
|  |  | 3.2 | Channels per cell |
| Guard channels | 2 |  | (At band edge) |
| I/O channels | 0 |  |  |
|  |  | **27.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 8 |  | 8 TDMA slots per channel |
| Data/channel | 13 |  | kbit/s/slot |
| Overhead and signalling | 1.75 |  | (182 kbit/s per channel total) |
|  |  | **546.0** | **kbit/s/cell** |
|  |  | 5.8 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | 94.1 | kbit/s/cell/MHz on outbound or inbound channel |
| Speech improvement | 1.05 | **98.8** | **kbit/s/cell/MHz on inbound or outbound channel with speech improvement** |
| All improvements | 1.1 | 103.6 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |

|  |
| --- |
| TDMA: time division multiple access |

The GSM net system capacity is usually rounded to 0.10 Mbit/s/MHz/cell for use in IMT-2000 calculations.

The same methodology is applied below to several example narrowband technologies and several sample spectrum bands. The examples show that the spectrum band structure and frequency reuse factor have a significant effect on the capacity calculation.

These are not meant to be a direct comparison between the selected technologies. There are numerous other user needs and spectrum allocation factors that effect the functional and operational deployment of a network, the choice of technology, and overall network efficiency. Some of the spectrum factors are considered in the alpha and beta factors (Recommendation ITU-R M.1390, D5 and D6).

|  |  |  |  |
| --- | --- | --- | --- |
| Net system capability summary | | | |
| **Spectrum band** | **Technology** | **Channels** | **Total capacity available** |
| **Reuse group factor = 12** | | | |
| **United States of America 821-824/866-869 MHz band** | **P25 phase I FDMA** | **1 × 12.5 kHz** | **60.0 kbit/s/MHz/cell** |
| **United States of America 700 MHz public safety band** | **P25 phase I FDMA** | **1 × 12.5 kHz** | **53.9 kbit/s/MHz/cell** |
| **United States of America 700 MHz public safety band** | **P25 phase II FDMA** | **1 × 6.25 kHz** | **107.7 kbit/s/MHz/cell** |
| **European 400 MHz public safety band** | **TETRA TDMA** | **4 slots/25 kHz** | **98.0 kbit/s/MHz/cell** |
| **Reuse group factor = 21** | | | |
| **United States of America 821-824/866-869 MHz band** | **P25 Phase I FDMA** | **1 × 12.5 kHz** | **34.3 kbit/s/MHz/cell** |
| **United States of America 700 MHz public safety band** | **P25 Phase I FDMA** | **1 × 12.5 kHz** | **30.8 kbit/s/MHz/cell** |
| **United States of America 700 MHz public safety band** | **P25 Phase II FDMA** | **1 × 6.25 kHz** | **61.6 kbit/s/MHz/cell** |
| **European 400 MHz public safety band** | **TETRA TDMA** | **4 slots/25 kHz** | **56.0 kbit/s/MHz/cell** |
| FDMA: frequency division multiple access.  NOTE – 1 Reuse group factor of 12 is used for systems implementing only low power, handheld, portable devices. Reuse factor of 21 is used for systems implementing both handheld portables and higher power, vehicular mounted, mobile devices. Greater reuse factor is required because of potential for interference from distant mobiles into cells designed for portable coverage. | | | |



*Example 1*: Narrowband technologies for dispatch voice and low rate data.

Project 25 phase I, FDMA applied to United States of America 800 MHz public safety band.

C4 and C5 Net system capability calculation

|  |  |  |  |
| --- | --- | --- | --- |
| NPSPAC using P25 phase I FDMA | | | **United States of America 821-824/866-869 MHz band** |
| Width of band (MHz) | 3 | 6.0 | MHz total |
| Width of channel | 0.0125 |  |  |
|  |  | 240.0 | FDD channels within band |
| Reuse group factor | 12 |  | (Portables only) |
|  |  | 20.0 | Channels per cell |
| Guard channels | 0 |  | (At band edge) |
| I/O channels | 15 |  | (5 × 12.5 plus 12.5 kHz guard on each side of I/O channel) |
|  |  | **225.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 1 |  |  |
| Data/channel | 4.8 |  | kbit/s |
| Overhead and signalling | 2 |  | (9.6 kbit/s per channel total) |
|  |  | **180.0** | **kbit/s/cell** |
|  |  | 3.0 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | **60.0** | **kbit/s/cell/MHz on outbound or inbound channel** |
| Speech improvement | 1.05 | 63.0 | kbit/s/cell/MHz on outbound or inbound channel with speech improvement |
| All improvements | 1.1 | 66.0 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |
|  | | | |
| NPSPAC using P25 phase I FDMA | | | **United States of America 821-824/866-869 MHz band** |
| Width of band (MHz) | 3 | 6.0 | MHz total |
| Width of channel | 0.0125 |  |  |
|  |  | 240.0 | FDD channels within band |
| Reuse group factor | 21 |  | (Portables and mobiles) |
|  |  | 11.4 | Channels per cell |
| Guard channels | 0 |  | (At band edge) |
| I/O channels | 15 |  | (5 × 12.5 plus 12.5 kHz guard on each side of I/O channel) |
|  |  | **225.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 1 |  |  |
| Data/channel | 4.8 |  | kbit/s |
| Overhead and signalling | 2 |  | (9.6 kbit/s per channel total) |
|  |  | **102.9** | **kbit/s/cell** |
|  |  | 3.0 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | **34.3** | **kbit/s/cell/MHz on outbound or inbound channel** |
| Speech improvement | 1.05 | 36.0 | kbit/s/cell/MHz on outbound or inbound channel with speech improvement |
| All improvements | 1.1 | 37.0 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |

*Example 2:* Narrowband technologies for dispatch voice and low rate data.

Project 25 Phase I, FDMA applied to United States of America 700 MHz public safety band.

C4 and C5 Net system capability calculation

|  |  |  |  |
| --- | --- | --- | --- |
| P25, Phase I FDMA | | | **United States of America 700 MHz public safety band** |
| Width of band (MHz) | 6 | 12.0 | MHz total (4 × 3 MHz blocks) |
| Width of channel | 0.0125 |  |  |
|  |  | 480.0 | FDD channels within band |
| Reuse group factor | 12 |  | (Portables only) |
|  |  | 40.0 | Channels per cell |
| Guard channels | 12 |  | (Low power channels at band edge) |
| I/O channels | 64 |  | (32 × 12.5 kHz I/O plus 32 × 12.5 kHz reserve) |
|  |  | **404.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 1 |  |  |
| Data/channel | 4.8 |  | kbit/s |
| Overhead and signalling | 2 |  | (9.6 kbit/s per channel total) |
|  |  | **323.2** | **kbit/s/cell** |
|  |  | 6.0 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | **53.9** | **kbit/s/cell/MHz on outbound or inbound channel** |
| Speech improvement | 1.05 | 56.6 | kbit/s/cell/MHz on outbound or inbound channel with speech improvement |
| All improvements | 1.1 | 59.3 | kbit/s/cell/MHz on outbound or inbound channel with all improvement |
|  | | | |
| P25, Phase I FDMA | | | **United States of America 700 MHz public safety band** |
| Width of band (MHz) | 6 | 12.0 | MHz total (4 × 3 MHz blocks) |
| Width of channel | 0.0125 |  |  |
|  |  | 480.0 | FDD channels within band |
| Reuse group factor | 21 |  | (Portables and mobiles) |
|  |  | 22.9 | Channels per cell |
| Guard channels | 12 |  | (Low power channels at band edge) |
| I/O channels | 64 |  | (32 × 12.5 kHz I/O plus 32 × 12.5 kHz reserve) |
|  |  | **404.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 1 |  |  |
| Data/channel | 4.8 |  | kbit/s |
| Overhead and signalling | 2 |  | (9.6 kbit/s per channel total) |
|  |  | **184.7** | **kbit/s/cell** |
|  |  | 6.0 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | **30.8** | **kbit/s/cell/MHz on outbound or inbound channel** |
| Speech improvement | 1.05 | 32.3 | kbit/s/cell/MHz on outbound or inbound channel with speech improvement |
| All improvements | 1.1 | 33.9 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |

*Example 3*: Narrowband technologies for dispatch voice and low rate data.

Project 25 phase II, FDMA applied to United States of America 700 MHz public safety band.

C4 and C5 Net system capability calculation

|  |  |  |  |
| --- | --- | --- | --- |
| P25, Phase II FDMA | | | **United States of America 700 MHz public safety band** |
| Width of band (MHz) | 6 | 12.0 | MHz total |
| Width of channel | 0.00625 |  |  |
|  |  | 960.0 | FDD channels within band |
| Reuse group factor | 12 |  | (Portables only) |
|  |  | 80.0 | Channels per cell |
| Guard channels | 24 |  | (Low power channels at band edge) |
| I/O channels | 128 |  | (64 × 6.25 kHz I/O plus 64 × 6.25 kHz reserve) |
|  |  | **808.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 1 |  |  |
| Data/channel | 4.8 |  | kbit/s |
| Overhead and signalling | 2 |  | (9.6 kbit/s per channel total) |
|  |  | **646.4** | **kbit/s/cell** |
|  |  | 6.0 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | **107.7** | **kbit/s/cell/MHz on outbound or inbound channel** |
| Speech improvement | 1.05 | 113.1 | kbit/s/cell/MHz on outbound or inbound channel with speech improvement |
| All improvements | 1.1 | 118.5 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |
|  | | | |
| P25, Phase II FDMA | | | **United States of America 700 MHz public safety band** |
| Width of band (MHz) | 6 | 12.0 | MHz total |
| Width of channel | 0.00625 |  |  |
|  |  | 960.0 | FDD channels within band |
| Reuse group factor | 21 |  | (Portables only) |
|  |  | 45.7 | Channels per cell |
| Guard channels | 24 |  | (Low power channels at band edge) |
| I/O channels | 128 |  | (64 × 6.25 kHz I/O plus 64 × 6.25 kHz reserve) |
|  |  | **808.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 1 |  |  |
| Data/channel | 4.8 |  | kbit/s |
| Overhead and signalling | 2 |  | (9.6 kbit/s per channel total) |
|  |  | **369.4** | **kbit/s/cell** |
|  |  | 6.0 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | **61.6** | **kbit/s/cell/MHz on outbound or inbound channel** |
| Speech improvement | 1.05 | 64.6 | kbit/s/cell/MHz on outbound or inbound channel with speech improvement |
| All improvements | 1.1 | 67.7 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |

*Example 4*: Narrowband technologies for dispatch voice and low rate data.

TETRA TDMA applied to European 400 MHz public safety band.

C4 and C5 Net system capability calculation

|  |  |  |  |
| --- | --- | --- | --- |
| TETRA TDMA | | | **European 400 MHz public safety band** |
| Width of band (MHz) | 3 | 6.0 | MHz total |
| Width of channel | 0.025 |  |  |
|  |  | 120.0 | FDD channels within band |
| Reuse group factor | 12 |  | (Hand-held portables only) |
|  |  | 10.0 | Channels per cell |
| Guard channels | 2 |  | (At band edge) |
| Interoperability channels | 20 |  | (Reserve for direct mode operations) |
|  |  | **98.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 4 |  | Slots/channel |
| Data/channel | 7.2 |  | kbit/s/slot |
| Overhead and signalling | 1.25 |  | (36 kbit/s per channel total) |
|  |  | **294.0** | **kbit/s/cell** |
|  |  | 3.0 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | **98.0** | **kbit/s/cell/MHz on outbound or inbound channel** |
| Speech improvement | 1.05 | 102.9 | kbit/s/cell/MHz on outbound or inbound channel with speech improvement |
| All improvements | 1.1 | 107.8 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |
|  | | | |
| TETRA TDMA | | | **European 400 MHz public safety band** |
| Width of band (MHz) | 3 | 6.0 | MHz total |
| Width of channel | 0.025 |  |  |
|  |  | 120.0 | FDD channels within band |
| Reuse group factor | 21 |  | (Mixture of portables and mobiles) |
|  |  | 5.7 | Channels per cell |
| Guard channels | 2 |  | (At band edge) |
| Interoperability channels | 20 |  | (Reserve for direct mode operations) |
|  |  | **98.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 4 |  | Slots/channel |
| Data/channel | 7.2 |  | kbit/s/slot |
| Overhead and signalling | 1.25 |  | (36 kbit/s per channel total) |
|  |  | **168.0** | **kbit/s/cell** |
|  |  | 3.0 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | **56.0** | **kbit/s/cell/MHz on outbound or inbound channel** |
| Speech improvement | 1.05 | 58.8 | kbit/s/cell/MHz on outbound or inbound channel with speech improvement |
| All improvements | 1.1 | 61.6 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |

*Example 5*: Wideband technologies for data and low rate video.

Technology capable of meeting requirement of United States of America 700 MHz public safety band for 384 kbit/s within 150 kHz channel bandwidth.

C4 and C5 Net system capability calculation

|  |  |  |  |
| --- | --- | --- | --- |
| 384 kbit/s / 150 kHz estimate | | | |
| Width of band (MHz) | 4.8 | 9.6 | MHz total |
| Width of channel | 0.15 |  | MHz |
|  |  | 32.0 | FDD channels within band |
| Reuse group factor | 12 |  |  |
|  |  | 2.7 | Channels per cell |
| Guard channels | 4 |  | (At band edge) |
| I/O channels | 12 |  |  |
|  |  | **16.0** | **Traffic channels** |
|  |  |  |  |
| Traffic/channel | 1 |  | Slots per channel |
| Data/channel | 192 |  | kbit/s/slot |
| Overhead and signalling | 2 |  | (192 kbit/s per channel total) |
|  |  | **512.0** | **kbit/s/cell** |
|  |  | 4.8 | MHz bandwidth on outbound or inbound channel |
|  |  |  |  |
|  |  | **Total capacity available** | |
|  |  | 106.7 | kbit/s/cell/MHz on outbound or inbound channel |
| Speech improvement | 1.05 | **112.0** | **kbit/s/cell/MHz on outbound or inbound channel with speech improve­ment** |
| All improvements | 1.1 | 117.3 | kbit/s/cell/MHz on outbound or inbound channel with all improvements |
| Data: assume 3/4 coding or 144 kbit/s source data, 48 kbit/s FEC, 192 kbit/s overhead.  Video: assume 1/2 coding or for medium quality full motion video at 10 frames/s  ~50 kbit/s for video and 4.8 kbit/s for voice channel, 55 kbit/s FEC, 110 kbit/s overhead | | | |

Attachment D  
of Appendix 1 to Annex 6

Example: Public safety and disaster relief population density data

## England and Wales

Population  ~ 52.2 million England  ~ 49.23 million

Wales  ~ 2.95 million

Land Area  ~151 000 km2 England  ~ 130 360 km2

Wales  ~ 20 760 km2

England population density  346 pop/km2  100 000 pop/289 km2

London population  7 285 000 people

London area  1 620 km2

London population density  4 496 pop/ km2  100 000 pop/ 22.24 km2

## Police officer strength[[10]](#footnote-10)6

Total Density /100 000

Police officers (ordinary duty) 123 841 237.2

Police officers (secondary assignments) 2 255 4.3

Police officers (outside assignments) 702 1.3

\_\_\_\_\_\_\_ \_\_\_\_\_\_\_

Total 126 798 242.9

**Full time civilian staff[[11]](#footnote-11)7**

Full time 48 759 93.4

Part time equivalent (7 897 staff) 4 272 8.2

\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_

Total 53 031 101.6

## Average densities (ordinary officers)

Average  237.2 officers per 100 000 population

Urban  299.7

Non-urban  201.2

8 largest metro  352.4

Lowest rural  176.4

Officer/civilian  126 798/53 031  2.4 officers/civilian staff

## Police officer distribution by rank

Chief Constable 49 0.04%

Assistant Chief Constable 151 0.12%

Superintendent 1 213 0.98%

Chief Inspector 1 604 1.30%

Inspector 5 936 4.80%

Sergeant 18 738 15.1%

Constable 96 150 77.6%

Other[[12]](#footnote-12)8

Special Constables 16 484

Traffic Wardens 3 342 full time equivalents

(3 206 full-time and 242 part-time)

Fire Brigade

Staffing in England and Wales (43 brigades)

Paid 35 417

Retained (part-time or volunteer) 14 600

50 082

London: assume 126 798/35 417  3.58 police/fire

or about 98 fires/100 000 population in London

Fire radio inventory ~24 500 radios

50% penetration of radios into total

70% penetration of full-time fire fighters

London PPDR estimates

PPDR PPDR PPDR penetration rate

category population for narrowband voice

Police 25 498 100%

Other Police Functions 6 010 10%

Police Civilian Support 13 987 10%   
                        (dispatchers, technicians, etc.)

Fire Brigade 7 081 70%

Part-time Fire 2 127 10%

Fire Civilian Support –    0%

Emergency Medical –    0%

EMS Civilian Support –    0%

Services généraux du gouvernement –    0%

General Government –    0%

Other PPDR Users –    0%

Attachment E  
of Appendix 1 to Annex 6

Example calculation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | IMT-2000 methodology (Rec. UIT-R M.1390) | | London TETRA Narrowband voice service | | |
| **A** | Geographic considerations |  |  |  |  |
| **A1** | Select operational environment type  Each environment type basically forms a column in calculation spreadsheet. Do not have to consider all environments, only the most significant contributors to spectrum requirements. Environments may geographically overlap.  No user should occupy any two operational environments at one time | Environment  “e”  Combination of user density and user mobility: Density: dense urban, urban, suburban, rural; Mobility: in-building, pedestrian, vehicular. Determine which of the possible density/mobility environments co-exist AND create greatest spectrum demand |  | **Urban pedestrian and mobile** | **Urban pedestrian and mobile** |
| **A2** | Select direction of calculation, uplink vs downlink or combined | usually separate calculations for uplink and downlink due to asymmetry in some services |  | **Uplink** | **Downlink** |
| **A3** | Representative cell area and geometry for each operational environment type | Average/typical cell geometry (m): radius for omnidirectional cells; radius of vertex for sectored hexagonal cells |  | **5** |  |
| **A4** | Calculate representative cell area | Omni cells: circular = π · *R*2; hexagonal = 2.6 · *R*2; Hex 3‑sector = 2.6 · *R*2/3 km2 |  | **65** |  |
| **B** | Market and traffic considerations |  |  |  |  |
| **B1** | Telecommunication services offered | Corresponding net user bit rate (kbit/s) |  | **7.2 kbit/s = 4.8 kbit/s vocoded voice  2.4 kbit/s FEC** |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | IMT-2000 methodology (Rec. UIT-R M.1390) | | London TETRA Narrowband voice service | | |
| **B2** | Population density | Total population  sum (POP by category) |  | **54 703** | **Total PPDR population within area under consideration** |
|  |  | = SUM (POP  PEN) |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |
|  |  | Police  Other Police  Police Civilian Support  Fire  Part-time Fire  Fire Civilian Support  EMS  EMS Civilian Support  General Government  Other PPDR Users | 25 498  6 010  13 987  7 081  2 127  0  0  0  0  0 | (Narrowband voice)  1.00  0.10  0.10  0.70  0.10  0.10  0.50  0.10  0.10  0.10 |
|  | **32 667,1** | **PPDR population using NB voice service** |
|  |  | **Area under consideration** | 308.9 square miles | **1 620** | **km2** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | IMT-2000 methodology (Rec. UIT-R M.1390) | | London TETRA Narrowband voice service | | |
|  | Number of persons per unit of area within the environment under consideration. Population density may vary with mobility | Potential user per km2 |  | **33.8** | **Total POP/km2** |
| **B3** | Penetration rate  Percentage of persons subscribing to a service within an environment. Person may subscribe to more than one service, therefore, total penetration rate of all services within environment can exceed 100% | = % of total PPDR POP | = PEN into PPDR category  PPDR category POP/total PPDR POP | By category (Police = Police PEN  Police POP) | By Category (Police = Police PEN  Police POP)/Total PPDR POP |
| Police  Other Police  Police Civilian Support  Fire  Part-time Fire  Fire Civilian Support  EMS  EMS Civilian Support  General Government Other PPDR Users | 25 498.00  601.00  1 398.70  4 956.70  212.70  0.00  0.00  0.00  0.00  0.00 | 0.466  0.011  0.026  0.091  0.004  0.000  0.000  0.000  0.000  0.000 |
| **Total PPDR penetration** | **59.717** | **% using NB voice** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | IMT-2000 methodology (Rec. UIT-R M.1390) | | London TETRA Narrowband voice service | | |
| **B4** | Users/cell  Represents the number of people actually subscribing to the service “s” within a cell in environment “e” | Users/cell = POP density  PEN rate  Cell area  Dependent upon population density, cell area, and service penetration rate in each environment |  | **1 311** | **PPDR NB voice users per cell** |
| **B5** | Traffic parameters |  |  | **Uplink** | **downlink** |
|  | Busy hour call attempts (BCHA) | Calls/busy hour | From PSWAC | 0.0073284 E/busy hour | 0.0463105 E/busy hour |
|  | Average number of calls/sessions attempted to/from average user during busy hour |  | **Per PPDR NB voice user** | **3.535** | **6.283** |
|  | Effective call duration Average call/session duration during busy hours | Seconds/call | **Per PPDR NB voice user** | **7.88069024** | **26.53474455** |
|  | Activity factor  Percentage of time that resource is actually used during a conversation/session. Packet data may be bursty and resource is only used a small percentage of time that session is active. If voice is only transmitted when user speaks it does not tie up resource during pauses in speech or when listening | Dispatch voice – each conversation ties up both sides of duplex channel | **Per PPDR NB voice user** | **1** | **1** |
| **B6** | Traffic/user  Average traffic in call-seconds generated by each user during busy hour | Call-seconds per user    Busy hour attempts  Call duration  Activity | **PPDR NB voice traffic/user** | **27.9** | **166.7** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | IMT-2000 methodology (Rec. UIT-R M.1390) | | London TETRA Narrowband voice service | | |
| **B7** | Offered traffic/cell  Average traffic generated by all users within a cell during the busy hour (3 600 s) | Erlangs  = Traffic/user  User/cell/3 600 | **PPDR NB voice traffic cell** | **10.14** | **60.70** |
| **B8** | Establish quality of service (QOS) function parameters |  |  | **Uplink** | **Downlink** |
|  | Group size  Number of cells in a group. Because cellular system deployment and technologies provide some measure of traffic “sharing” between adjacent cells, traffic versus QoS is considered within a grouping of cells | 12 (portable only) or 21 (portable  mobile)  Typical cellular grouping is 1 cell surrounded by 6 adjacent cells for a group size of 7. Traffic/cell is multiplied by group size and quality of service (or blocking function) is applied to grouping. Answer is divided by group size to restore to valuation per cell |  | **21** | **21** |
|  | Traffic per group | = Traffic/cell (E)  Group size | **PPDR NB voice traffic group** | **213.00** | **1 274.70** |
|  | Service channels per group  Determine number of channels required to support traffic from each service, round to next higher whole number | = apply grade of service formulas across group  Circuit = Erlang B with 1% blocking. Used Erlang = 1.5, assuming that dispatch voice in broken into multiple systems with no more than 20 channels per site |  | **1.50** | **1.50** |
|  |  |  | **PPDR NB voice service channels per group** | **319.50** | **1 912.05** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | IMT-2000 methodology (Rec. UIT-R M.1390) | | London TETRA Narrowband voice service | | |
| **C** | Technical and system considerations |  |  | **Uplink** | **Downlink** |
| **C1** | Service channels per cell needed to carry offered load  Actual number of “channels” that must be provisioned within each cell to carry intended traffic | = Service channels per group/Group size | **PPDR NB voice service channels per cell** | **15.21** | **91.05** |
| **C2** | Service channel bit rate (kbit/s)  Service channel bit rate equals net user bit rate, plus any additional increases in bit rate due to coding factors and/or overhead signalling | = Net user bit rate  Overhead factor  Coding factor  This is where coding and overhead factors are included. For coding factor = 1, and overhead factor = 1,  = B1  1  1 = Net user bit rate | 9.6 kbit/s includes coding and overhead  **PPDR NB voice service channel bit rate** | **9** | **9** |
| **C3** | Calculate traffic (Mbit/s)  Total traffic to be transmitted within the area of study – includes all factors; user traffic (call duration, busy hour call attempts, activity factor, net channel bit rate) environment, service type, direction of transmission (up/down link), cell geometry, quality of service, traffic efficiency (calculated across a group of cells), and service channel bit rate (including coding and overhead factors) | = Service channels/Cell  Service channel bit rate | **PPDR NB voice traffic (Mbit/s)** | **0.137** | **0.819** |
| **C4** | Net system capability  Measure of system capacity for a specific technology. Related to spectral efficiency. Requires complex calculation or simulation to determine net system capability for a specific technology deployed in a specific network configuration | Trade-offs between net system capability and QoS. May include the following factors; spectral efficiency of technology, *Eb*/*N*0 requirements, *C*/*I* requirements, frequency re‑use plan, coding/signalling factors of radio transmission technology, enviroment, deployment model |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | IMT-2000 methodology (Rec. UIT-R M.1390) | | London TETRA Narrowband voice service | | |
| **C5** | Calculate for GSM model | Calculation for TETRA TDMA using 25 kHz bandwidth channels, 21 cell re-use (mobile + portable), 4 traffic slots per carrier, ignoring signalling channels, 400 MHz bandplan, FDD with 2  3 MHz (120 RF channels ‑ 20 DMO channels –2 guard channels at edge of band), data rate of 7.2 kbits/s on each traffic slot, a factor of 1.25 for overhead and coding.  Net system capacity for  TETRA TDMA = 56.0 kbit/s/MHz/cell | **TETRA** | **0.056** | **0.056** |
| **D** | Spectrum results |  |  | **Uplink** | **Downlink** |
| **D1-D4** | Calculate individual components | Freq = Traffic/Net system capability | **PPDR NB voice (MHz)** | **2.445** | **14.633** |
| **D5** | Weighting factor for each environment (alpha)  Weighting of each environment relative to other environments ‑ alpha may vary from 0 to 1, correct for non‑simultaneous busy hours, correct for geographic offsets | = Freq  alpha  If all environments have coincident busy hours and all three environments are co‑located,, then alpha = 1 | **Alpha = 1** | **1** | **1** |
|  |  |  | **PPDR NB voice (MHz)** | **2.445** | **14.633** |
| **D6** | Adjustment factor (beta) | Freq(total) = beta  sum (alpha  Freq) |  |  |  |
|  | Adjustment of all environments to outside effects - multiple operators/users (decreased trunking or spectral efficiency), guardbands, sharing with other services within band, technology modularity, etc. | For dispatch voice model, assuming one system and fact that guardbands were included in C5, then beta = 1.  Multiple systems, such as one for Police and one for Fire/EMS may decrease efficiency and beta would be > 1 | **Beta = 1** | **1** |  |
| **D7** | Calculate total spectrum |  | **PPDR NB voice TOTAL (MHz)** | **17.078 MHz** | |

Attachment F  
of Appendix 1 to Annex 6

Example narrowband and wideband calculation summaries

**London narrowband voice, message, and image**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Narrowband PPDR category | London users |  | Penetration rates | | |
| NB voice | NB message | NB image |
| Police | 25 498 |  | 1.00 | 0.5 | 0.25 |
| Other Police | 6 010 |  | 0.10 | 0.05 | 0.025 |
| Police Civilian Support | 13 987 |  | 0.10 | 0.05 | 0.025 |
| Fire | 7 081 |  | 0.70 | 0.35 | 0.175 |
| Part-time Fire | 2 127 |  | 0.10 | 0.05 | 0.025 |
| Fire Civilian Support | 0 |  | 0.10 | 0.05 | 0.025 |
| EMS | 0 |  | 0.50 | 0.25 | 0.125 |
| EMS Civilian Support | 0 |  | 0.10 | 0.05 | 0.025 |
| General Government | 0 |  | 0.10 | 0.05 | 0.025 |
| Other PPDR Users | 0 |  | 0.10 | 0.05 | 0.025 |
| **Total – PPDR Users** | **54 703** |  | 32 667 | 16 334 | 8 167 |
|  |  |  |  |  |  |
| Spectrum by 'service environment' (MHz) | |  | 17.1 | 1.4 | 4.2 |
|  |  |  |  |  |  |
| **Narrowband spectrum 22.7 MHz** |  |  |  |  |  |
|  |  |  |  |  |  |
| **Other parameters:** |  |  |  |  |  |
| Environment | Urban pedestrian and mobile | | |  |  |
|  |  |  |  |  |  |
| Cell radius (km) | 5 |  |  |  |  |
| Study area (km2) | 1 620 |  |  |  |  |
| Cell area (km2) | 65 |  | (calculated) |  |  |
| Cells per study area | 25 |  | (calculated) |  |  |
|  |  |  |  |  |  |
| Net user bit rate | 9 kbit/s (7.2 kbit/s per slot + 1.8 kbit/s channel overhead) | | | | |
|  | = 4.8 kbit/s speech, data, or image per slot | | | | |
|  | + 2.4 kbit/s FEC per slot | | | | |
|  | + 1.8 kbit/s channel overhead and signalling | | | | |
|  |  |  |  |  |  |
|  |  |  | NB voice | NB data | NB image |
|  |  |  | Uplink | Uplink | Uplink |
| Erlangs per busy hour | (From PSWAC) | | 0.0077384 | 0.0030201 | 0.0268314 |
| Busy hour call attempts |  |  | 3.54 | 5.18 | 3.00 |
| Effective call duration |  |  | 7.88 | 2.10 | 32.20 |
| Activity factor |  |  | 1 | 1 | 1 |
|  |  |  |  |  |  |
|  |  |  | Downlink | Downlink | Downlink |
| Erlangs per busy hour | (From PSWAC) | | 0.0463105 | 0.0057000 | 0.0266667 |
| Busy hour call attempts |  |  | 6.28 | 5.18 | 3.00 |
| Effective call duration |  |  | 26.53 | 3.96 | 32.00 |
| Activity factor |  |  | 1 | 1 | 1 |
|  |  |  |  |  |  |
| Group size | 21 |  |  |  |  |
| Grade of service factor | 1.50 |  |  |  |  |
| Net system capacity | 0.0560 | kbit/s/MHz/cellule | |  |  |
| Alpha factor | 1 |  |  |  |  |
| Beta factor | 1 |  |  |  |  |

**New York City narrowband voice, message, and image**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Narrowband PPDR category | New York users |  | Penetration rates | | |
| NB voice | NB message | NB image |
| Police | 39 286 |  | 0.70 | 0.35 | 0.175 |
| Other Police | 0 |  | 0.10 | 0.05 | 0.025 |
| Police Civilian Support | 8 408 |  | 0.10 | 0.05 | 0.025 |
| Fire | 11 653 |  | 0.70 | 0.35 | 0.175 |
| Part-time Fire | 0 |  | 0.10 | 0.05 | 0.025 |
| Fire Civilian Support | 4 404 |  | 0.10 | 0.05 | 0.025 |
| EMS | 0 |  | 0.50 | 0.25 | 0.125 |
| EMS Civilian Support | 0 |  | 0.10 | 0.05 | 0.025 |
| General Government | 21 217 |  | 0.10 | 0.05 | 0.025 |
| Other PPDR Users | 3 409 |  | 0.10 | 0.05 | 0.025 |
| **Total – PPDR Users** | **8 8377** |  | 39 401 | 19 701 | 9 850 |
|  |  |  |  |  |  |
| Spectrum by “service environment” (MHz) | |  | 51.8 | 4.2 | 20.0 |
|  |  |  |  |  |  |
| **Narrowband spectrum 76.0 MHz** |  |  |  |  |  |
|  |  |  |  |  |  |
| **Other parameters:** |  |  |  |  |  |
| Environment | Urban pedestrian and mobile | | |  |  |
|  |  |  |  |  |  |
| Cell radius (km) | 4 |  |  |  |  |
| Study area (km2) | 800 |  |  |  |  |
| Cell area (km2) | 41.6 |  | (calculated) |  |  |
| Cells per study area | 19 |  | (calculated) |  |  |
|  |  |  |  |  |  |
| Net user bit rate | 9.6 kbit/s | | | | |
|  | = 4.8 kbit/s speech, data, or image | | | | |
|  | + 2.4 kbit/s FEC | | | | |
|  | + 2.4 kbit/s overhead and signalling | | | | |
|  |  |  |  |  |  |
|  |  |  | NB voice | NB data | NB image |
|  |  |  | Uplink | Uplink | Uplink |
| Erlangs per busy hour | (From PSWAC) | | 0.0077384 | 0.0030201 | 0.0268314 |
| Busy hour call attempts |  |  | 3.54 | 5.18 | 3.00 |
| Effective call duration |  |  | 7.88 | 2.10 | 32.20 |
| Activity factor |  |  | 1 | 1 | 1 |
|  |  |  |  |  |  |
|  |  |  | Downlink | Downlink | Downlink |
| Erlangs per busy hour | (From PSWAC) | | 0.0463105 | 0.0057000 | 0.0266667 |
| Busy hour call attempts |  |  | 6.28 | 5.18 | 3.00 |
| Effective call duration |  |  | 26.53 | 3.96 | 32.00 |
| Activity factor |  |  | 1 | 1 | 1 |
|  |  |  |  |  |  |
| Group size | 21 |  |  |  |  |
| Grade of service factor | 1.50 |  |  |  |  |
| Net system capacity | 0.0308 | kbit/s/MHz/cell | |  |  |
| Alpha factor | 1 |  |  |  |  |
| Beta factor | 1 |  |  |  |  |

New York City wideband data and video

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Narrowband PPDR category | New York users |  | Penetration rates | |  |
| WB data | WB video |  |
| Police | 39 286 |  | 0.23 | 0.14 |  |
| Other Police | 0 |  | 0.01 | 0.01 |  |
| Police Civilian Support | 8 408 |  | 0.01 | 0.01 |  |
| Fire | 11 653 |  | 0.28 | 0.20 |  |
| Part-time Fire | 0 |  | 0.01 | 0.01 |  |
| Fire Civilian Support | 4 404 |  | 0.01 | 0.01 |  |
| EMS | 0 |  | 0.31 | 0.17 |  |
| EMS Civilian Support | 0 |  | 0.01 | 0.01 |  |
| General Government | 21 217 |  | 0.01 | 0.03 |  |
| Other PPDR Users | 3 409 |  | 0.01 | 0.01 |  |
| **Total – PPDR Users** | **88 377** |  | 12 673 | 8 629 |  |
|  |  |  |  |  |  |
| Spectrum by 'service environment' (MHz) | |  | 18.3 | 19.5 |  |
|  |  |  |  |  |  |
| **Narrowband spectrum 37.9 MHz** |  |  |  |  |  |
|  |  |  |  |  |  |
| **Other parameters:** |  |  |  |  |  |
| Environment | Urban pedestrian and mobile | | |  |  |
|  |  |  |  |  |  |
| Cell radius (km) | 3.0 |  |  |  |  |
| Study area (km2) | 800 |  |  |  |  |
| Cell area (km2) | 23.4 |  | (calculated) |  |  |
| Cells per study area | 34 |  | (calculated) |  |  |
|  |  |  |  |  |  |
| Net user bit rate | Wideband video | |  | Wideband data | |
|  | (10 frames/s) | |  | 384 kbit/s |  |
|  | 220 kbit/s |  |  | =144 kbit/s data | |
|  | =55 kbit/s video and voice | |  | +48 kbit/s FEC |  |
|  | +55 kbit/s FEC |  |  | +192 kbit/s overhead | |
|  | +110 kbit/s overhead | |  |  |  |
|  |  |  |  |  |  |
| Erlangs per busy hour | Uplink |  |  | Uplink | Uplink |
| Busy hour call attempts | 0.0250 |  | (calculated) | 0.0008 | 0.0083 |
| Effective call duration | 3 |  |  | 3 | 3 |
| Activity factor | 30 s |  |  | 1 | 10 |
|  | 1 |  |  | 1 | 1 |
|  |  |  |  |  |  |
| Group size | 12 |  |  |  |  |
| Grade of service factor | 1.50 |  |  |  |  |
| Net system capacity | 0.1067 | kbit/s/MHz/cell | |  |  |
| Alpha factor | 1 |  |  |  |  |
| Beta factor | 1 |  |  |  |  |

Appendix 2 to Annex 6

PPDR spectrum calculation based on generic city   
analysis (demographic population)

# 1 Generic City Approach

Instead of looking at specific cities, the following analysis examines several medium sized cities in several countries. This analysis is based upon the average density of police officers relative to the general demographic population and the ratio of police to other public protection providers. From this analysis, a generic example of the relationship between the different PPDR user categories and demographic population density has been developed. This approach shows the optimum PPDR spectrum requirement based on the size of demographic population, that is, the amount of PPDR spectrum requirement based on the idealistic amount of PPDR users in a city based on demographic population size.

The police and PPDR densities were examined from national statistics and city budgets for the United States, Canada, Australia, and England. Statistics for police show a national average density in the 180 police per 100 000 population to 250 police per 100 000 population. The density in urban areas varies from about 25% above the national average for medium density cities to >100% above the national average for dense urban cities. The density in suburban areas varies from about 25% above the national average for suburbs of medium density cities to 50% above the national average for suburbs of dense urban cities.

Fire and EMS/Rescue levels were harder to determine because they are often combined together. Information was used for cities where they were separate, and ratios of the various PP and DR categories were determined relative to the police population density. For example, ratios for fire fighters were in the range of 3.5 to 4 police officers per fire fighter (25 to 30%). Where Rescue/Emergency Medical/Ambulance could be separated out, ratios for Rescue/EMS were in the range of 3.5 to 4 fire fighters per Rescue/EMS (25 to 30%).

In the generic examples below, and for simplicity, only two densities are used, 180 and 250 police per 100 000 population. Also for simplicity, only two types of cities were analysed: a medium size city (2.5 million population) and a large city (8 million population). This probably underestimates the PPDR density in large urban areas where there are many examples of police densities in the range of 400-500 police per 100 000 population.

The “doughnut” effect was also examined, where frequencies used in the urban center can not be reused in the suburbs immediately adjacent to the urban area. In ITU-R contributions from the 2000-2003 study period, many of the cities included both the urban and suburban areas together in a single spectrum requirement calculation. Cell size had to be averaged and PPDR user density was lowered. In retrospect, each area should have been treated separately, and the spectrum requirements added together.

Numerous urban areas were examined. Most had a central urban core with a dense population. There was also a suburban ring around the urban core that contained about the same amount of population, but was about 5 to 20 times the area of the urban core. The examples below use a ratio of 10:1 for suburban to urban area. Assuming 4 to 5 km radius cell sizes for the urban core, typical cell sizes in the suburbs should be about 10 times larger in area or ~3 times larger in radius.



# 2 PPDR categories

Three classes of users were defined, which is basically re-grouping the PPDR categories by penetration rates:

Primary users (usage with 30% penetration rate)  PP users normally operating within the geographic area on a day-to-day basis  local police, fire fighters, and emergency medical/rescue

Secondary users (usage with 10% penetration rate)  other police (state, district, province, federal, national, special operations, investigators), part-time or volunteer police/fire, general government workers, civil protection agencies, military/army, utility workers, disaster relief workers

Support users (usage with 10% penetration rate)  civilian support

Penetration rate and PPDR category data used to calculate spectrum requirements

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Narrowband and wideband CATEGORY name and number of USER's | | Services summary | NB voice | NB message | NB status | WB data | WB video |
| User category | Users |  | Penetration rate summary | | | | |
| Primary – Local Police | 5 625 |  | 0.300 | 0.300 | 0.300 | 0.250 | 0.125 |
| Secondary – Law Enforcement/ Investigators | 563 |  | 0.100 | 0.100 | 0.100 | 0.010 | 0.010 |
| Secondary – Police Functions | 0 |  | 0.100 | 0.100 | 0.100 | 0.010 | 0.010 |
| Police Civilian Support | 1 125 |  | 0.100 | 0.000 | 0.000 | 0.010 | 0.010 |
| Primary – Fire Fighters | 1 631 |  | 0.300 | 0.300 | 0.300 | 0.250 | 0.125 |
| Fire Civilian Support | 326 |  | 0.100 | 0.000 | 0.000 | 0.010 | 0.010 |
| Primary – Rescue/Emergency Medical | 489 |  | 0.300 | 0.300 | 0.300 | 0.250 | 0.125 |
| Rescue/EMS Civilian Support | 98 |  | 0.100 | 0.000 | 0.000 | 0.010 | 0.010 |
| Secondary – General Government and Civil Agencies | 563 |  | 0.100 | 0.100 | 0.100 | 0.010 | 0.010 |
| Secondary – Volunteers and other PPDR Users | 281 |  | 0.100 | 0.100 | 0.100 | 0.010 | 0.010 |
| Total Users | 10 701 |  |  |  |  |  |  |

Primary users are the users that local public protection system would be designed to handle. A local system would be designed to handle “average busy hour” traffic plus a loading factor to be able to handle peak loads with a reasonable grade of service.

Part of the assumption is that many secondary users may have their own communications system and loading added to local public protection system is for coordination between the secondary users and the primary users.

Disaster scenario

Disaster occurs and personnel from surrounding areas, national government, and international agencies come to support the local agencies. There is immediate need for emergency workers to handle fires and to rescue injured people. Later arrivals are investigators and personnel to clean up the damage.

For disaster response – the following assumptions were made:

– *Civilian support* (10% penetration rate): No increase in the number of civilian support workers for police/fire/EMS/rescue. The usage remains within the original system design parameters (30% penetration rate, 1.5 GoS peaking factor).

– *Police*: No increase in the number of local police. The usage remains within the original system design parameters (30% penetration rate, 1.5 GoS peaking factor).

– *Other Police*: Increase in personnel providing police functions equal to 30% of local police population, but at a lower secondary level (10% penetration rate). These are personnel who come from outside the area to supplement local police.

– *Investigators and Law Enforcement*: The population doubles as additional investigators move into the disaster area.

– *Fire and EMS/Rescue*: A 30% increase in the number of users. Users from surrounding areas immediately move into the disaster area and operate on the local system or set up additional communication systems. The need for communications is very great. Operate at primary level (30% penetration rate).

– *Secondary level users* (10% penetration rate): Double the number of general government users, volunteers, civil agency users, utility users, etc. who need to communicate with primary users or need to use the local network for communications.

Where is the disaster?

Look at three disaster scenarios:

1 No disaster  normal day-to-day operations

2 Disaster only in urban area

3 Disaster only in suburban area

# 3 Spectrum requirements

Calculate spectrum requirements for:

– Urban day-to-day

– Urban disaster

– Suburban day-to-day

– Suburban disaster

– Spectrum requirements for the three disaster scenarios:

(Instead of worst case analysis)

Urban and suburban systems designed to handle “average busy hour” traffic loading plus a 1.5 GoS factor to handle emergency loading by the normal PPDR users. Disaster operations assumes that additional, outside PPDR personnel are added to the system.

a) *Normal day-to-day operations*:

The amount of spectrum required for NB equals the sum of the urban and suburban spectrum calculations. The assumption is that spectrum used in the urban area can not be reused in the adjacent suburban area, due to large cell size and large reuse factor.

The amount of spectrum required for WB equals the sum of the urban and half of the suburban spectrum calculation. The assumption is that spectrum used in the urban area can be reused in the adjacent suburban area, due to the smaller cell size and smaller reuse factor. Also, because the urban area sits in middle of the suburban area, there is some additional separation, which would allow additional frequency reuse between suburban sites.

b) *Urban disaster operations*:

The amount of spectrum required for NB equals the sum of the urban disaster and the suburban non-disaster spectrum calculation.

The amount of spectrum required for WB equals the sum of the urban disaster and half of the suburban non-disaster spectrum calculation.

c) *Suburban disaster operations*:

The amount of spectrum required for NB equals the sum of the urban non-disaster and the suburban disaster spectrum calculation.

The amount of spectrum required for WB equals the sum of the urban non-disaster and half of the suburban disaster spectrum calculation.

Medium metropolitan area

Calculated spectrum requirements using a PPDR calculator spreadsheet.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Medium metropolitan area** (Urban population ≅ 2.5 million and area ≅ 600 km2) (Suburban population ≅ 2.5 million and area ≅ 6 000 km2) | | | | | | |
| **Medium PPDR density** (180 Police per 100 000 population) | | |  | **High PPDR density** (250 police per 100 000 population) | | |
| **Urban** |  |  |  | **Urban** |  |  |
| NB day-to-day WB day-to-day | 15.5 16.2 | MHz MHz |  | NB day-to-day WB day-to-day | 21.5 22.6 | MHz MHz |
|  |  |  |  |  |  |  |
| Disaster NB Disaster WB | 18.4 17.8 | MHz MHz |  | Disaster NB Disaster WB | 25.6 24.7 | MHz MHz |
| **Suburban** |  |  |  | **Suburban** |  |  |
| NB day-to-day WB day-to-day | 12.9 13.5 | MHz MHz |  | NB day-to-day WB day-to-day | 17.9 18.8 | MHz MHz |
|  |  |  |  |  |  |  |
| Disaster NB Disaster WB | 15.4 14.8 | MHz MHz |  | Disaster NB Disaster WB | 21.4 20.6 | MHz MHz |
| **Normal day-to-day** |  |  |  | **Normal day-to-day** |  |  |
| NB (urban  suburban) WB (urban  1/2 suburban) | 28.40 22.95 | MHz MHz |  | NB WB | 39.40 32.00 | MHz MHz |
|  | 51.35 | MHz |  |  | 71.40 | MHz |
| **Suburban disaster** |  |  |  | **Suburban disaster** |  |  |
| NB WB | 30.90 23.60 | MHz MHz |  | NB WB | 42.90 32.90 | MHz MHz |
|  | 54.50 | MHz |  |  | 75.80 | MHz |
| **Urban disaster** |  |  |  | **Urban disaster** |  |  |
| NB WB | 31.30 24.55 | MHz MHz |  | NB WB | 43.50 34.10 | MHz MHz |
|  | 55.85 | MHz |  |  | 77.60 | MHz |

The left-hand column shows the spectrum calculated for a medium PPDR user density and the right-hand column shows the spectrum calculated for a higher PPDR user density.

The top-half of the chart shows individual NB and WB spectrum calculations for normal “day‑to‑day” operations and for a disaster within the local area.

The total spectrum requirement is the sum of the urban and suburban calculations. For narrowband the assumption is that frequencies are not reused between the two areas, so the total is the sum of the NB urban and the NB suburban requirements. For wideband, the assumption is that some frequencies can be reused, therefore, the total is the sum of the wideband urban requirement and half of the wideband suburban requirement.

The bottom half of the chart shows the spectrum calculated for a disaster in either the urban area or the suburban area, where there is a significant increase in the number of users (up to 30% for primary users).

Normal day-to-day operations for this generic medium size city require from 51 MHz to 71 MHz depending on whether it is located in a country with a medium PPDR density or a high PPDR density.

If a disaster scenario described above occurs in the suburban area, then the NB/WB spectrum requirement increases by about 6%. If a disaster occurs in the urban area, then NB/WB spectrum requirement increases by about 9%.

Disaster operations for this generic medium size city require from 55 MHz to 78 MHz depending on where the disaster occurs and whether it is located in a country with a medium PPDR density or a high PPDR density.

The broadband spectrum requirement needs to be added. Since broadband will cover very small radius “hot spots”, the broadband frequencies can be reused throughout the urban and suburban area. ITU-R contributions from the 2000-2003 study period have shown broadband spectrum requirements to be in the 50-75 MHz range.

Therefore, for a generic medium size city, the total spectrum requirement is in the range of 105 to 153 MHz to handle the type of disaster scenario described above.

The following two tables show the breakout of PPDR users and narrowband and wideband services in a medium-sized metropolitan area.

Medium metropolitan area calculated for 180 police officers  
per 100 000 population

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Spectrum Requirements – Generic City Calculator** | | | | | | | | | | | | | | | Re-Formatted | | | | | July 2002 | | | |
|  | |  | | | | | | | | | | | | | | |  | | |  | | |  |
| Metropolitan Study Area | | Medium Metropolitan Area | | | | | | | | | | | | | | |  | | | Input Data | | |  |
|  | |  | | | | | | | | | | | | | | |  | | |  | | |  |
| Population of Urban Area | | 2 500 000 | | | | | People | | | **1.0** | | | | Ratio Suburban/Urban Population | | | | | | | | | |
| Population of Surrounding Suburban Area | | 2 500 000 | | | | | People | | | Ratio should be near 1.0 (Range of 0.5  to 1.5  of Urban Population) | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| Area of Urban Center | | 600 | | | | | km2 | | | **10.0** | | | | Ratio Suburban/Urban Area | | | | | | | | | |
| Area of Surrounding Suburbs | | 6 000 | | | | | km2 | | | Ratio should be near 10.0 (Range of 5  to 15  of Urban Area) | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| Urban Population Density | | 4 167 | | | | | People/km2 | |  | | | | | | | | | | | | | | |
| Suburban Population Density | | 417 | | | | | People/km2 | |
|  | |  | |  | | | | | | | |  | | | | | | | | | | | |
| “Large” or “Medium” City | | MED | | | | | If Urban Population Density > 5 000 people/km2, then this is a large city, OR if Urban population > 3 000 000 people, then this is a large city, otherwise this is a medium city | | | | | | | | | | | | | | | | |
|  | |  | | | | |
| Police User Density (national average) | | 180.0 | | | | | Police per 100 000 population | | | | | | | | | | | | | | | | |
|  | |  |  | | | | | | | | |  | | | | | | | | | | | |
| CATEGORY name and number of USERS User Category | Urban Day-to-Day | | | | | | | Urban Disaster | | | | | | | | Suburban Day-to-Day | | | | | Suburban Disaster | | |
| Population | | | | | | | Population | | | | | | | | Population | | | | | Population | | |
| Primary – Local Police | 6 750 | | | | | | | 6 750 | | | | | | | | 5 625 | | | | | 5 625 | | |
| Secondary – Law Enforcement/Investigators | 675 | | | | | | | 1 350 | | | | | | | | 563 | | | | | 1 125 | | |
| Secondary – Police Functions | 0 | | | | | | | 2 025 | | | | | | | | 0 | | | | | 1 688 | | |
| Police Civilian Support | 1 350 | | | | | | | 1 350 | | | | | | | | 1 125 | | | | | 1 125 | | |
| Primary – Fire Fighters | 1 958 | | | | | | | 2 545 | | | | | | | | 1 631 | | | | | 2 121 | | |
| Fire Civilian Support | 392 | | | | | | | 392 | | | | | | | | 326 | | | | | 326 | | |
| Primary – Rescue/ Emergency Medical | 587 | | | | | | | 763 | | | | | | | | 489 | | | | | 636 | | |
| Rescue/EMS Civilian Support | 117 | | | | | | | 117 | | | | | | | | 98 | | | | | 98 | | |
| Secondary – General Govern­ment and Civil Agencies | 675 | | | | | | | 1 350 | | | | | | | | 563 | | | | | 1 125 | | |
| Secondary – Volunteers and Other PPDR Users | 338 | | | | | | | 675 | | | | | | | | 281 | | | | | 563 | | |
| Total | 12 841 | | | | | | | 17 317 | | | | | | | | 10 701 | | | | | 14 431 | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Narrowband** | Urban Day-to-Day | | | | | | | Urban Disaster | | | | | | | | Suburban Day-to-Day | | | | | Suburban Disaster | | |
| Busy Hour Users | | | | | Spectrum Required (MHz) | | Busy Hour Users | | | Spectrum Required (MHz) | | | | | Busy Hour Users | | Spectrum Required (MHz) | | | Busy Hour Users | Spectrum Required (MHz) | |
| NB Voice Service | 3 143 | | | | | 13.8 | | 3 743 | | | 16.4 | | | | | 2 619 | | 11.5 | | | 3 119 | 13.7 | |
| NB Message Service | 2 957 | | | | | 1.6 | | 3 557 | | | 1.9 | | | | | 2 464 | | 1.3 | | | 2 965 | 1.6 | |
| NB Status Service | 2 957 | | | | | 0.1 | | 3 557 | | | 0.1 | | | | | 2 464 | | 0.1 | | | 2 965 | 0.1 | |
| Total Narrowband Spectrum Required (MHz) |  | | | | | **15.5** | |  | | | **18.4** | | | | |  | | **12.9** | | |  | **15.4** | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| Normal NB Day-to-Day 28.4 MHz | | | | | 15.5 | | | < | | | | | < | | | < | | | 12.9 | |  | |  |
| NB Urban Disaster Scenario 31.3 MHz | | | | | < | | | < | | | | | 18.4 | | | < | | | 12.9 | |  | |  |
| NB Suburban Disaster Scenario 30.9 MHz | | | | | 15.5 | | | < | | | | | < | | | < | | | < | | < | | 15.4 |
| Larger of the two NB Disaster Scenarios 31.3 MHz | | | | |  | | |  | | | | |  | | |  | | |  | |  | |  |

Medium metropolitan area calculated for 180 police officers  
per 100 000 population (*end*)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Wideband** | Urban Day-to-Day | | | | Urban Disaster | | | | | Suburban Day-to-Day | | | | | Suburban Disaster | | | |
| Busy Hour Users | | Spectrum Required (MHz) | | Busy Hour Users | | | Spectrum Required (MHz) | | Busy Hour Users | | | Spectrum Required (MHz) | | Busy Hour Users | | Spectrum Required (MHz) | |
| WB Data Service | 2 359 | | 15.7 | | 2 587 | | | 17.2 | | 1 966 | | | 13.1 | | 2 156 | | 14.3 | |
| WB Video Service | 1 197 | | 0.5 | | 1 330 | | | 0.6 | | 998 | | | 0.4 | | 1 108 | | 0.5 | |
| Total Wideband Spectrum Required (MHz) |  | | **16.2** | |  | | | **17.8** | |  | | | **13.5** | |  | | **14.8** | |
|  |  | |  | |  | | |  | |  | | | **× 1/2** | |  | | **× 1/2** | |
| Normal WB Day-to-Day 23.0 MHz | | | | 16.2 | | | < | | < | | < | | | 6.8 |  | |  | |
| Urban WB Disaster Scenario 24.6 MHz | | | | < | | | < | | 17.8 | | < | | | 6.8 |  | |  | |
| Suburban WB Disaster Scenario 23.6 MHz | | | | 16.2 | | | < | | < | | < | | | < | < | | 7.4 | |
| Larger of the two WB Disaster  Scenarios 24.6 MHz | | | |  | | |  | |  | |  | | |  |  | |  | |
|  | | | | | | | | | | | | | | | | | | |
| **Spectrum Requirement Totals** | | NB | |  | | WB | | |  | | | Sum |  | | |  | |  |
| Normal Day-to-Day | | 28.4 | | + | | 23.0 | | | = | | | 51.4 | MHz | | |  | |  |
| Suburban Disaster Scenario | | 30.9 | | + | | 23.6 | | | = | | | 54.5 | MHz | | |  | |  |
| Urban Disaster Scenario | | 31.3 | | + | | 24.6 | | | = | | | 55.9 | MHz | | |  | |  |

Medium metropolitan area calculated for 250 police officers  
per 100 000 population

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Spectrum Requirements – Generic City Calculator** | | | | | | | | | | | | | | | | | | | | | | | | | Re-Formatted | | | | | | July 2002 | | | | | |
|  | | | | | | | |  | | | | | | | | | | | | | | | | | | | | |  | |  | | |  | | |
| Metropolitan Study Area | | | | | | | Medium Metropolitan Area | | | | | | | | | | | | | | | | | | | | | |  | | Input Data | | |  | | |
|  | | | | | | | | |  | | | | | | | | | | | | | | | | | | |  | | |  | | |  | | |
| Population of Urban Area | | | | | | 2 500 000 | | | | | | | | | | People | | | **1.0** | | | | Ratio Suburban/Urban Population | | | | | | | | | | | | | |
| Population of Surrounding Suburban Area | | | | | | 2 500 000 | | | | | | | | | | People | | | Ratio should be near 1.0 (Range of 0.5  to 1.5  of Urban Population) | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Area of Urban Center | | | | | 600 | | | | | | | | | | | km2 | | **10.0** | | | | Ratio Suburban/Urban Area | | | | | | | | | | | | | | |
| Area of Surrounding Suburbs | | | | | 6 000 | | | | | | | | | | | km2 | | Ratio should be near 10.0 (Range of 5  to 15  of Urban Area) | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Urban Population Density | | | | | 4 167 | | | | | | | | | | People/km2 | | | | | |  | | | | | | | | | | | | | | | |
| Suburban Population Density | | | | | 417 | | | | | | | | | | People/km2 | | | | | |
|  | |  | | | | | | | | | | |  | | | | | | |  | | | | | | | | | | | | | | | | |
| “Large” or “Medium” City | | | | MED | | | | | | | | | | If Urban Population Density > 5 000 people/km2, then this is a large city, OR if Urban population > 3 000 000 people, then this is a large city, otherwise this is a medium city | | | | | | | | | | | | | | | | | | | | | | |
|  | |  | | | | | | | | | | | |
| Police User Density (national average) | | | 250.0 | | | | | | | | | | | Police per 100 000 population | | | | | | | | | | | | | | | | | | | | | | |
|  | |  | | | | | | | | | |  | | | | | | | |  | | | | | | | | | | | | | | | | |
| CATEGORY name and number of USERS User Category | Urban Day-to-Day | | | | | | | | | | | | | | | | Urban Disaster | | | | | | | | | Suburban Day-to-Day | | | | | | Suburban Disaster | | | | |
| Population | | | | | | | | | | | | | | | | Population | | | | | | | | | Population | | | | | | Population | | | | |
| Primary – Local Police | 9 375 | | | | | | | | | | | | | | | | 9 375 | | | | | | | | | 7 813 | | | | | | 7 813 | | | | |
| Secondary – Law Enforcement/Investigators | 938 | | | | | | | | | | | | | | | | 1 875 | | | | | | | | | 781 | | | | | | 1 563 | | | | |
| Secondary – Police Functions | 0 | | | | | | | | | | | | | | | | 2 813 | | | | | | | | | 0 | | | | | | 2 344 | | | | |
| Police Civilian Support | 1 875 | | | | | | | | | | | | | | | | 1 875 | | | | | | | | | 1 563 | | | | | | 1 563 | | | | |
| Primary – Fire Fighters | 2 719 | | | | | | | | | | | | | | | | 3 534 | | | | | | | | | 2 266 | | | | | | 2 945 | | | | |
| Fire Civilian Support | 544 | | | | | | | | | | | | | | | | 544 | | | | | | | | | 453 | | | | | | 453 | | | | |
| Primary – Rescue/ Emergency Medical | 816 | | | | | | | | | | | | | | | | 1 060 | | | | | | | | | 680 | | | | | | 884 | | | | |
| Rescue/EMS Civilian Support | 163 | | | | | | | | | | | | | | | | 163 | | | | | | | | | 136 | | | | | | 136 | | | | |
| Secondary – General Govern­ment and Civil Agencies | 938 | | | | | | | | | | | | | | | | 1 875 | | | | | | | | | 781 | | | | | | 1 563 | | | | |
| Secondary – Volunteers and Other PPDR Users | 469 | | | | | | | | | | | | | | | | 938 | | | | | | | | | 391 | | | | | | 781 | | | | |
| Total | 17 835 | | | | | | | | | | | | | | | | 24 052 | | | | | | | | | 14 863 | | | | | | 20 043 | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Narrowband** | Urban Day-to-Day | | | | | | | | | | | | | | | | Urban Disaster | | | | | | | | | Suburban Day-to-Day | | | | | | Suburban Disaster | | | | |
| Busy Hour Users | | | | | | | | | | Spectrum Required (MHz) | | | | | | Busy Hour Users | | | | | | | Spectrum Required (MHz) | | Busy Hour Users | | | | Spectrum Required (MHz) | | Busy Hour Users | | | Spectrum Required (MHz) | |
| NB Voice Service | 4 365 | | | | | | | | | | 19.2 | | | | | | 5 199 | | | | | | | 22.8 | | 3 638 | | | | 16.0 | | 4 333 | | | 19.1 | |
| NB Message Service | 4 107 | | | | | | | | | | 2.2 | | | | | | 4 941 | | | | | | | 2.7 | | 3 423 | | | | 1.9 | | 4 117 | | | 2.2 | |
| NB Status Service | 4 107 | | | | | | | | | | 0.1 | | | | | | 4 941 | | | | | | | 0.1 | | 3 423 | | | | 0.1 | | 4 117 | | | 0.1 | |
| Total Narrowband Spectrum Required (MHz) |  | | | | | | | | | | **21.5** | | | | | |  | | | | | | | **25.6** | |  | | | | **17.9** | |  | | | **21.4** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Normal NB Day-to-Day 39.4 MHz | | | | | | | | | | 21.5 | | | | | | | < | | | | | | | < | | | < | | | 17.9 | | |  | | |  |
| NB Urban Disaster Scenario 43.5 MHz | | | | | | | | | | < | | | | | | | < | | | | | | | 25.6 | | | < | | | 17.9 | | |  | | |  |
| NB Suburban Disaster Scenario 42.8 MHz | | | | | | | | | | 21.5 | | | | | | | < | | | | | | | < | | | < | | | < | | | < | | | 21.4 |
| Larger of the two NB disaster Scenarios 43.5 MHz | | | | | | | | | |  | | | | | | |  | | | | | | |  | | |  | | |  | | |  | | |  |

Medium metropolitan area calculated for 250 police officers  
per 100 000 population (*end*)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Wideband** | Urban Day-to-Day | | | | Urban Disaster | | | Suburban Day-to-Day | | | | Suburban Disaster | | | |
| Busy Hour Users | | | Spectrum Required (MHz) | Busy Hour Users | | Spectrum Required (MHz) | Busy Hour Users | | Spectrum Required (MHz) | | Busy Hour Users | | Spectrum Required (MHz) | |
| WB Data Service | 3 277 | | | 21.8 | 3 593 | | 23.9 | 2 731 | | 18.2 | | 2 994 | | 19.9 | |
| WB Video Service | 1 663 | | | 0.7 | 1 847 | | 0.8 | 1 386 | | 0.6 | | 1 539 | | 0.7 | |
| Total Wideband Spectrum Required (MHz) |  | | | **22.5** |  | | **24.7** |  | | **18.8** | |  | | **20.6** | |
|  |  | | |  |  | |  |  | | **× 1/2** | |  | | **× 1/2** | |
| Normal WB Day-to-Day 31.9 MHz | | | 22.5 | | < | | < | | < | 9.4 | | |  | |  |
| Urban WB Disaster Scenario 34.1 MHz | | | < | | < | | 24.7 | | < | 9.4 | | |  | |  |
| Suburban WB Disaster Scenario 32.8 MHz | | | 22.5 | | < | | < | | < | < | | | < | | 10.3 |
| Larger of the two WB Disaster Scenarios 34.1 MHz | | |  | |  | |  | |  |  | | |  | |  |
|  | | | | | | | | | | | | | | | |
| **Spectrum Requirement Totals** | | NB |  | | | WB |  | Sum | | |  |  | |  | |
| Normal Day-to-Day | | 39.4 | + | | | 31.9 | = | 71.3 | | | MHz |  | |  | |
| Suburban Disaster Scenario | | 42.8 | + | | | 32.8 | = | 75.7 | | | MHz |  | |  | |
| Urban Disaster Scenario | | 43.5 | + | | | 34.1 | = | 77.6 | | | MHz |  | |  | |

Large metropolitan area

Calculated spectrum requirements using a PPDR calculator spreadsheet.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Large metropolitan area** (Urban population ≅ 8.0 million and area ≅ 800 km2) (Suburban population ≅ 8.0 million and area ≅ 8 000 km2) | | | | | | |
| **Medium PPDR density** (180 Police per 100 000 population) | | |  | **High PPDR density** (250 police per 100 000 population) | | |
| **Urban** |  |  |  | **Urban** |  |  |
| NB day-to-day WB day-to-day | 23.7 24.9 | MHz MHz |  | NB day-to-day WB day-to-day | 33.0 34.6 | MHz MHz |
|  |  |  |  |  |  |  |
| Disaster NB Disaster WB | 28.3 27.4 | MHz MHz |  | Disaster NB Disaster WB | 39.3 38.0 | MHz MHz |
| **Suburban** |  |  |  | **Suburban** |  |  |
| NB day-to-day WB day-to-day | 19.8 20.7 | MHz MHz |  | NB day-to-day WB day-to-day | 27.4 28.7 | MHz MHz |
|  |  |  |  |  |  |  |
| Disaster NB Disaster WB | 23.6 22.7 | MHz MHz |  | Disaster NB Disaster WB | 32.7 31.5 | MHz MHz |
| **Normal day-to-day** |  |  |  | **Normal day-to-day** |  |  |
| NB (urban  suburban) WB (urban  1/2 suburban) | 43.50 35.25 | MHz MHz |  | NB WB | 60.40 48.95 | MHz MHz |
|  | 78.75 | MHz |  |  | 109.35 | MHz |
| **Suburban disaster** |  |  |  | **Suburban disaster** |  |  |
| NB WB | 47.30 36.25 | MHz MHz |  | NB WB | 65.70 50.35 | MHz MHz |
|  | 83.55 | MHz |  |  | 116.05 | MHz |
| **Urban disaster** |  |  |  | **Urban disaster** |  |  |
| NB WB | 48.10 37.75 | MHz MHz |  | NB WB | 66.70 52.35 | MHz MHz |
|  | 85.85 | MHz |  |  | 119.05 | MHz |

The left-hand column shows the spectrum calculated for a medium PPDR user density and the right-hand column shows the spectrum calculated for higher PPDR user density.

The top-half of the chart shows individual NB and WB spectrum calculations for normal “day‑to‑day” operations and for a disaster within the local area.

The total spectrum requirement is the sum of the urban and suburban calculations. For narrowband the assumption is that frequencies are not reused between the two areas, so the total is the sum of the NB urban and the NB suburban requirements. For wideband, the assumption is that some frequencies can be reused, therefore, the total is the sum of the wideband urban requirement and half of the wideband suburban requirement.

The bottom half of the chart shows the spectrum calculated for a disaster in either the urban area or the suburban area, where there is a significant increase in the number of users (up to 30% for primary users).

Normal day-to-day operations for this generic large city requires from 79 MHz to 109 MHz depending on whether it is located in a country with a medium PPDR density or a high PPDR density.

If a disaster scenario described above occurs in the suburban area, then the NB/WB spectrum requirement increases by about 6%. If disaster occurs in the urban area, then the NB/WB spectrum requirement increases by about 9%.

Disaster operations for this generic large city require from 84 MHz to 119 MHz depending on where the disaster occurs and whether it is located in a country with a medium PPDR density or a high PPDR density.

The broadband spectrum requirement needs to be added. Since broadband will cover very small radius “hot spots”, the broadband frequencies can be reused throughout the urban and suburban area. ITU-R contributions from the 2000-2003 study period have shown broadband spectrum requirements to be in the 50-75 MHz range.

Therefore, for a generic large city, the total spectrum requirement is in the range of 134 to 194 MHz to handle the type of disaster scenario described above.

The following two tables show the breakout of PPDR users and narrowband and wideband service in a large-sized metropolitan area.

Large metropolitan area calculated for 180 police officers  
per 100 000 population

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Spectrum Requirements – Generic City Calculator** | | | | | | | | | | | | | | | | | | | | | | | | Re-Formatted | | | | | July 2002 | | | | | |
|  | | | | | | | |  | | | | | | | | | | | | | | | | | | |  | |  | | |  | | |
| Metropolitan Study Area | | | | | | | Large Metropolitan Area | | | | | | | | | | | | | | | | | | | |  | | Input Data | | |  | | |
|  | | | | | | | | |  | | | | | | | | | | | | | | | | |  | | |  | | |  | | |
| Population of Urban Area | | | | | | 8 000 000 | | | | | | | | | People | | | **1.0** | | | | Ratio Suburban/Urban Population | | | | | | | | | | | | |
| Population of Surrounding Suburban Area | | | | | | 8 000 000 | | | | | | | | | People | | | Ratio should be near 1.0 (Range of 0.5  to 1.5  of Urban Population) | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Area of Urban Center | | | | | 800 | | | | | | | | | | km2 | | **10.0** | | | | Ratio Suburban/Urban Area | | | | | | | | | | | | | |
| Area of Surrounding Suburbs | | | | | 8 000 | | | | | | | | | | km2 | | Ratio should be near 10.0 (Range of 5  to 15  of Urban Area) | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Urban Population Density | | | | | 10 000 | | | | | | | | | People/km2 | | | | | |  | | | | | | | | | | | | | | |
| Suburban Population Density | | | | | 1 000 | | | | | | | | | People/km2 | | | | | |
|  | |  | | | | | | | | | |  | | | | | | |  | | | | | | | | | | | | | | | |
| “Large” or “Medium” City | | | | LAR | | | | | | | | | If Urban Population Density > 5 000 people/km2, then this is a large city, OR if Urban population > 3 000 000 people, then this is a large city, otherwise this is a medium city | | | | | | | | | | | | | | | | | | | | | |
|  | |  | | | | | | | | | | |
| Police User Density (national average) | | | 180.0 | | | | | | | | | | Police per 100 000 population | | | | | | | | | | | | | | | | | | | | | |
|  | |  | | | | | | | | |  | | | | | | | |  | | | | | | | | | | | | | | | |
| CATEGORY name and number of USERS User Category | Urban Day-to-Day | | | | | | | | | | | | | | | Urban Disaster | | | | | | | | | Suburban Day-to-Day | | | | | Suburban Disaster | | | | |
| Population | | | | | | | | | | | | | | | Population | | | | | | | | | Population | | | | | Population | | | | |
| Primary – Local Police | 21 600 | | | | | | | | | | | | | | | 21 600 | | | | | | | | | 18 000 | | | | | 18 000 | | | | |
| Secondary – Law Enforcement/Investigators | 2 160 | | | | | | | | | | | | | | | 4 320 | | | | | | | | | 1 800 | | | | | 3 600 | | | | |
| Secondary – Police Functions | 0 | | | | | | | | | | | | | | | 6 480 | | | | | | | | | 0 | | | | | 5 400 | | | | |
| Police Civilian Support | 4 320 | | | | | | | | | | | | | | | 4 320 | | | | | | | | | 3 600 | | | | | 3 600 | | | | |
| Primary – Fire Fighters | 6 264 | | | | | | | | | | | | | | | 8 143 | | | | | | | | | 5 220 | | | | | 6 786 | | | | |
| Fire Civilian Support | 1 253 | | | | | | | | | | | | | | | 1 253 | | | | | | | | | 1 044 | | | | | 1 044 | | | | |
| Primary – Rescue/ Emergency Medical | 1 879 | | | | | | | | | | | | | | | 2 443 | | | | | | | | | 1 566 | | | | | 2 036 | | | | |
| Rescue/EMS Civilian Support | 376 | | | | | | | | | | | | | | | 376 | | | | | | | | | 313 | | | | | 313 | | | | |
| Secondary – General Govern­ment and Civil Agencies | 2 160 | | | | | | | | | | | | | | | 4 320 | | | | | | | | | 1 800 | | | | | 3 600 | | | | |
| Secondary – Volunteers and Other PPDR Users | 1 080 | | | | | | | | | | | | | | | 2 160 | | | | | | | | | 900 | | | | | 1 800 | | | | |
| Total | 41 092 | | | | | | | | | | | | | | | 55 415 | | | | | | | | | 34 243 | | | | | 46 179 | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Narrowband** | Urban Day-to-Day | | | | | | | | | | | | | | | Urban Disaster | | | | | | | | | Suburban Day-to-Day | | | | | Suburban Disaster | | | | |
| Busy Hour Users | | | | | | | | | Spectrum Required (MHz) | | | | | | Busy Hour Users | | | | | | | Spectrum Required (MHz) | | Busy Hour Users | | | Spectrum Required (MHz) | | Busy Hour Users | | | Spectrum Required (MHz) | |
| NB Voice Service | 10 058 | | | | | | | | | 21.2 | | | | | | 11 979 | | | | | | | 25.2 | | 8 382 | | | 17.6 | | 9 982 | | | 21.0 | |
| NB Message Service | 9 463 | | | | | | | | | 2.5 | | | | | | 11 384 | | | | | | | 3.0 | | 7 886 | | | 2.0 | | 9 487 | | | 2.5 | |
| NB Status Service | 9 463 | | | | | | | | | 0.1 | | | | | | 11 384 | | | | | | | 0.1 | | 7 886 | | | 0.1 | | 9 487 | | | 0.1 | |
| Total Narrowband Spectrum Required (MHz) |  | | | | | | | | | **23.7** | | | | | |  | | | | | | | **28.3** | |  | | | **19.8** | |  | | | **23.6** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Normal NB Day-to-Day 43.5 MHz | | | | | | | | | | 23.7 | | | | | | < | | | | | | | < | | < | | | 19.8 | | |  | | |  |
| NB Urban Disaster Scenario 48.1 MHz | | | | | | | | | | < | | | | | | < | | | | | | | 28.3 | | < | | | 19.8 | | |  | | |  |
| NB Suburban Disaster Scenario 47.3 MHz | | | | | | | | | | 23.7 | | | | | | < | | | | | | | < | | < | | | < | | | < | | | 23.6 |
| Larger of the two NB disaster  scenarios 48.1 MHz | | | | | | | | | |  | | | | | |  | | | | | | |  | |  | | |  | | |  | | |  |

Large metropolitan area calculated for 180 police officers  
per 100 000 population (*end*)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Wideband** | Urban Day-to-Day | | Urban Disaster | | Suburban Day-to-Day | | | Suburban Disaster | | | |
| Busy Hour Users | Spectrum Required (MHz) | Busy Hour Users | Spectrum Required (MHz) | Busy Hour Users | Spectrum Required (MHz) | | Busy Hour Users | | Spectrum Required (MHz) | |
| WB Data Service | 7 549 | 24.1 | 8 279 | 26.4 | 6 291 | 20.0 | | 6 899 | | 22.0 | |
| WB Video Service | 3 831 | 0.8 | 4 256 | 0.9 | 3 193 | 0.7 | | 3 546 | | 0.8 | |
| Total Wideband Spectrum Required (MHz) |  | **24.9** |  | **27.4** |  | **20.7** | |  | | **22.7** | |
|  |  |  |  |  |  | **× 1/2** | |  | | **× 1/2** | |
| Normal WB Day-to-Day 35.3 MHz | | 24.9 | < | < | < | | 10.3 | |  | |  |
| Urban WB Disaster Scenario 37.7 MHz | | < | < | 27.4 | < | | 10.3 | |  | |  |
| Suburban WB Disaster Scenario 36.3 MHz | | 24.9 | < | < | < | | < | | < | | 11.4 |
| Larger of the two WB disaster Scenarios 37.7 MHz | |  |  |  |  | |  | |  | |  |
|  | | | | | | | | | | | |
| **Spectrum Requirement Totals** | NB |  | WB |  | Sum |  | |  | |  | |
| Normal Day-to-Day | 43.5 | + | 35.3 | = | 78.8 | MHz | |  | |  | |
| Suburban Disaster Scenario | 47.3 | + | 36.3 | = | 83.6 | MHz | |  | |  | |
| Urban Disaster Scenario | 48.1 | + | 37.7 | = | 85.8 | MHz | |  | |  | |

Large metropolitan area calculated for 250 police officers  
 per 100 000 population

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Spectrum Requirements – Generic City Calculator** | | | | | | | | | | | | | | | | | | | | | | | | | Re-Formatted | | | | | | July 2002 | | | | | |
|  | | | | | | | |  | | | | | | | | | | | | | | | | | | | |  | | |  | | |  | | |
| Metropolitan Study Area | | | | | | | Large Metropolitan Area | | | | | | | | | | | | | | | | | | | | |  | | | Input Data | | |  | | |
|  | | | | | | | | |  | | | | | | | | | | | | | | | | | |  | | | |  | | |  | | |
| Population of Urban Area | | | | | | 8 000 000 | | | | | | | | | | People | | | | | **1.0** | | | Ratio Suburban/Urban Population | | | | | | | | | | | | |
| Population of Surrounding Suburban Area | | | | | | 8 000 000 | | | | | | | | | | People | | | | | Ratio should be near 1.0 (Range of 0.5  to 1.5  of Urban Population | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Area of Urban Center | | | | | 800 | | | | | | | | | | | km2 | | | | **10.0** | | | | Ratio Suburban/Urban Area | | | | | | | | | | | | |
| Area of Surrounding Suburbs | | | | | 8 000 | | | | | | | | | | | km2 | | | | Ratio should be near 10.0 (Range of 5  to 15  of Urban Area) | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Urban Population Density | | | | | 10 000 | | | | | | | | | | People/km2 | | | | | | | |  | | | | | | | | | | | | | |
| Suburban Population Density | | | | | 1 000 | | | | | | | | | | People/km2 | | | | | | | |
|  | |  | | | | | | | | | | |  | | | | | | | | |  | | | | | | | | | | | | | | |
| “Large” or “Medium” City | | | | LAR | | | | | | | | | | If Urban Population Density > 5 000 people/km2, then this is a large city, OR if Urban population > 3 000 000 people, then this is a large city, otherwise this is a medium city | | | | | | | | | | | | | | | | | | | | | | |
|  | |  | | | | | | | | | | | |
| Police User Density (national average) | | | 250.0 | | | | | | | | | | | police per 100 000 population | | | | | | | | | | | | | | | | | | | | | | |
|  | |  | | | | | | | | | |  | | | | | | | | | |  | | | | | | | | | | | | | | |
| CATEGORY name and number of USERS User Category | Urban Day-to-Day | | | | | | | | | | | | | | | | | | Urban Disaster | | | | | | | Suburban Day-to-Day | | | | | | Suburban Disaster | | | | |
| Population | | | | | | | | | | | | | | | | | | Population | | | | | | | Population | | | | | | Population | | | | |
| Primary – Local Police | 30 000 | | | | | | | | | | | | | | | | | | 30 000 | | | | | | | 25 000 | | | | | | 25 000 | | | | |
| Secondary – Law Enforcement/Investigators | 3 000 | | | | | | | | | | | | | | | | | | 6 000 | | | | | | | 2 500 | | | | | | 5 000 | | | | |
| Secondary – Police Functions | 0 | | | | | | | | | | | | | | | | | | 9 000 | | | | | | | 0 | | | | | | 7 500 | | | | |
| Police Civilian Support | 6 000 | | | | | | | | | | | | | | | | | | 6 000 | | | | | | | 5 000 | | | | | | 5 000 | | | | |
| Primary – Fire Fighters | 8 700 | | | | | | | | | | | | | | | | | | 11 310 | | | | | | | 7 250 | | | | | | 9 425 | | | | |
| Fire Civilian Support | 1 740 | | | | | | | | | | | | | | | | | | 1 740 | | | | | | | 1 450 | | | | | | 1 450 | | | | |
| Primary – Rescue/ Emergency Medical | 2 610 | | | | | | | | | | | | | | | | | | 3 393 | | | | | | | 2 175 | | | | | | 2 828 | | | | |
| Rescue/EMS Civilian Support | 522 | | | | | | | | | | | | | | | | | | 522 | | | | | | | 435 | | | | | | 435 | | | | |
| Secondary – General Govern­ment and Civil Agencies | 3 000 | | | | | | | | | | | | | | | | | | 6 000 | | | | | | | 2 500 | | | | | | 5 000 | | | | |
| Secondary – Volunteers and Other PPDR Users | 1 500 | | | | | | | | | | | | | | | | | | 3 000 | | | | | | | 1 250 | | | | | | 2 500 | | | | |
| Total | 57 072 | | | | | | | | | | | | | | | | | | 76 965 | | | | | | | 47 560 | | | | | | 64 138 | | | | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Narrowband** | Urban Day-to-Day | | | | | | | | | | | | | | | | | Urban Disaster | | | | | | | | Suburban Day-to-Day | | | | | | Suburban Disaster | | | | |
| Busy Hour Users | | | | | | | | | | Spectrum Required (MHz) | | | | | | | | Busy Hour Users | | | | | Spectrum Required (MHz) | | Busy Hour Users | | | Spectrum Required (MHz) | | | Busy Hour Users | | | Spectrum Required (MHz) | |
| NB Voice Service | 13 969 | | | | | | | | | | 29.4 | | | | | | | | 16 637 | | | | | 35.1 | | 11 641 | | | 24.5 | | | 13 864 | | | 29.2 | |
| NB Message Service | 13 143 | | | | | | | | | | 3.4 | | | | | | | | 15 811 | | | | | 4.1 | | 10 953 | | | 2.8 | | | 13 176 | | | 3.4 | |
| NB Status Service | 13 143 | | | | | | | | | | 0.1 | | | | | | | | 15 811 | | | | | 0.2 | | 10 953 | | | 0.1 | | | 13 176 | | | 0.1 | |
| Total Narrowband Spectrum Required (MHz) |  | | | | | | | | | | **33.0** | | | | | | | |  | | | | | **39.3** | |  | | | **27.4** | | |  | | | **32.7** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Normal NB Day-to-Day 60.4 MHz | | | | | | | | | | 33.0 | | | | | | | < | | | | | | | < | | < | | | | 27.4 | | |  | | |  |
| NB Urban Disaster Scenario 66.8 MHz | | | | | | | | | | < | | | | | | | < | | | | | | | 39.3 | | < | | | | 27.4 | | |  | | |  |
| NB Suburban Disaster Scenario 65.7 MHz | | | | | | | | | | 33.0 | | | | | | | < | | | | | | | < | | < | | | | < | | | < | | | 32.7 |
| Larger of the two NB Disaster Scenarios 66.8 MHz | | | | | | | | | |  | | | | | | |  | | | | | | |  | |  | | | |  | | |  | | |  |

Large metropolitan area calculated for 250 police officers  
per 100 000 population (*end*)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Wideband** | Urban Day-to-Day | | | | Urban Disaster | | | | | | | Suburban Day-to-Day | | | Suburban Disaster | | | |
| Busy Hour Users | | Spectrum Required (MHz) | | Busy Hour Users | | | Spectrum Required (MHz) | | | | Busy Hour Users | Spectrum Required (MHz) | | Busy Hour Users | | Spectrum Required (MHz) | |
| WB Data Service | 10 485 | | 33.5 | | 11 498 | | | 36.7 | | | | 8 738 | 27.8 | | 9 582 | | 30.5 | |
| WB Video Service | 5 321 | | 1.1 | | 5 910 | | | 1.3 | | | | 4 434 | 0.9 | | 4 925 | | 1.0 | |
| Total Wideband Spectrum Required (MHz) |  | | **34.6** | |  | | | **38.0** | | | |  | **28.7** | |  | | **31.5** | |
|  |  | |  | |  | | |  | | | |  | **× 1/2** | |  | | **× 1/2** | |
| Normal WB Day-to-Day 49.0 MHz | | | | 34.6 | | < | | | < | | | < | | 14.4 | |  | |  |
| Urban WB Disaster Scenario 52.4 MHz | | | | < | | < | | | 38.0 | | | < | | 14.4 | |  | |  |
| Suburban WB Disaster Scenario 50.4 MHz | | | | 34.6 | | < | | | < | | | < | | < | | < | | 15.8 |
| Larger of the two WB Disaster Scenarios 52.4 MHz | | | |  | |  | | |  | | |  | |  | |  | |  |
|  | | | | | | | | | | | | | | | | | | |
| **Spectrum Requirement Totals** | | NB |  | | | | WB | | |  | Sum | | |  |  | | |  |
| Normal Day-to-Day | | 60.4 | + | | | | 49.0 | | | = | 109.4 | | | MHz |  | | |  |
| Suburban Disaster Scenario | | 65.7 | + | | | | 50.4 | | | = | 116.1 | | | MHz |  | | |  |
| Urban Disaster Scenario | | 66.8 | + | | | | 52.4 | | | = | 119.1 | | | MHz |  | | |  |

PPDR population density analysis

– National average for police officers in the range180 or 250 police/100 000 population.

– Suburban PPDR populations based upon police density of 1.25 times the national average.

– Urban PPDR populations based upon police density of 1.5 times the national average.

– Day-to-day PPDR population estimates:

– Local police – population based on national average

– Law enforcement/investigators – 10% of police density

– Secondary police (coming from outside) – none

– Police civilian support – 20% of police density

– Fire fighters – 29% of police density (~3.5 police per fire)

– Fire civilian support – 20% of fire fighter density

– Rescue/EMS – 30% of fire fighter density (~11.7 police per EMS)

– EMS civilian support – 20% of rescue/EMS density

– General Government – 10% of police density

– Other PPDR users and volunteers – 5% of police density

– Changes in PPDR populations during a disaster:

– Local police – population remains the same

– Law enforcement/investigators – population doubles

– Secondary police (coming from outside)

– Additional population about 30% of local police

– Police civilian support – population remains the same

– Fire fighters (coming from outside) – 30% increase in fire population

– Fire civilian support – population remains the same

– Rescue/EMS (coming from outside) – 30% increase in fire population

– EMS civilian support – population remains the same

– General government – population doubles

– Other PPDR users and volunteers – population doubles

Summary of formulas used to calculate population density

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PPDR user category | PPDR density | Suburban normal | Changes for disaster | Suburban disaster |
| Primary – Local Police | For suburban areas use 1.25 times national average police density | D(sub) = Police density × 1.25  population/ 100 000 | Remains the same | D(sub) |
| Secondary – Law Enforcement/Investigators | 10% of police density | 0.10 × D(sub) | Doubles | 2.0 × (0.10 × D(sub)) |
| Secondary – Police Functions | 0 | 0.0 × D(sub) | 30% of police density | 0.3 × D(sub) |
| Police Civilian Support | 20% of police density | 0.2 × D(sub) | Remains the same | 0.2 × D(sub) |
| Primary – Fire Fighters | 29% of police density | 0.29 × D(sub) | 29% increase | 1.3 × 0.29 × D(sub) |
| Fire Civilian Support | 20% of fire density | 0.2 × (0.29  D(sub)) | Remains the same | 0.2 × 0.29 × D(sub) |
| Primary – Rescue/Emergency Medical | 30% of fire density | 0.3 × (0.29  D(sub)) | 30% increase | 1.3 × 0.29 × 0.5 × D(sub) |
| Rescue/EMS Civilian Support | 20% of EMS density | 0.2 × (0.3 × (0.29 × D(sub) | Remains the same | 0.2 × 0.3 × 0.29 × D(sub) |
| Secondary – General Government and Civil Agencies | 10% of police density | 0.10 × D(sub) | Doubles | 2.0 × 0.10 × D(sub) |
| Secondary – Volunteers and Other PPDR | 5% of police density | 0.05 × D(sub) | Doubles | 2.0 × 0.05 × D(sub) |

Summary of formulas used to calculate population density (*end*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PPDR user category | PPDR density | Urban normal | Changes for disaster | Urban disaster |
| Primary – Local Police | For urban areas use 1.5 times national average police density | D(urb) = Police density × 1.50  population/ 100 000 | Remains the same | D(urb) |
| Secondary – Law Enforcement/Investigators | 10% of police density | 0.10 D(urb) | Doubles | 2.0 × (0.10 × D(urb)) |
| Secondary – Police Functions | 0 | 0.0 × D(urb) | 30% of police density | 0.3 × D(urb) |
| Police Civilian Support | 20% of police density | 0.2 × D(urb) | Remains the same | 0.2 × D(urb) |
| Primary – Fire Fighters | 29% of police density | 0.29 × D(urb) | 29% increase | 1.3 × 0.29 × D(urb) |
| Fire Civilian Support | 20% of fire density | 0.2 × (0.29 × D(urb)) | Remains the same | 0.2 × 0.29 × D(urb) |
| Primary – Rescue/Emergency Medical | 30% of fire density | 0.3 × (0.29 × D(urb)) | 30% increase | 1.3 × 0.29 × 0.5 × D(urb) |
| Rescue/EMS Civilian Support | 20% of EMS density | 0.2 × (0.3 × (0.29 × D(urb) | Remains the same | 0.2 × 0.3 × 0.29 × D(urb) |
| Secondary – General Government and Civil Agencies | 10% of police density | 0.10 × D(urb) | Doubles | 2.0 × 0.10 × D(urb) |
| Secondary – Volunteers and Other PPDR | 5% of police density | 0.05 × D(urb) | Doubles | 2.0 × 0.05 × D(urb) |

Example parameters

Narrowband – medium city – suburban – medium PPDR density

Population  2 500 000 people

Area  6 000 km2

Police Density Suburban  U(sub)  1.25  180 x 2 500 000/100 000  5 625 police

Cell radius  14.4 km

Cell antenna pattern  Omni

Reuse factor  21

GoS factor  1.5

Width of frequency band  24 MHz

Channel bandwidth  12.5 kHz

% of band not used for traffic  10%

Narrowband – medium city – urban – medium PPDR density

Population  2 500 000 people

Area  600 km2

Police density suburban  U(urb)  1.5  180  2 500 000/100 000  6 750 police

Cell radius  5.0 km

Cell antenna pattern  Hex

Reuse factor  21

GoS factor  1.5

Width of frequency band  24 MHz

Channel bandwidth  12.5 kHz

% of band not used for traffic  10%

Wideband – medium city – suburban – medium PPDR density

Population  2 500 000 people

Area  6 000 km2

Police density suburban  U(sub)  1.25  180  2 500 000/100 000  5 625 police

Cell radius  9.2 km

Cell antenna pattern  Omni

Reuse factor  12

GoS factor  1.5

Width of frequency band  24 MHz

Channel bandwidth  150 kHz

% of band not used for traffic  10%

Wideband – medium city – urban – medium PPDR density

Population  2 500 000 people

Area  600 km2

Police density suburban  U(urb)  1.5  180  2 500 000/100 000  6 750 police

Cell radius  3.2 km

Cell antenna pattern  Hex

Reuse factor  12

GoS factor  1.5

Width of frequency band  24 MHz

Channel bandwidth  150 kHz

% of band not used for traffic  10%

Narrowband – large city – suburban – medium PPDR density

Population  8 000 000 people

Area 8 000 km2

Police density suburban  U(sub)  1.25  180  8 000 000/100 000  18 000 Police

Cell radius  11.5 km

Cell antenna pattern  Omni

Reuse factor  21

GoS factor  1.5

Width of frequency band  24 MHz

Channel bandwidth  12.5 kHz

% of band not used for traffic  10%

Narrowband – large city – urban – medium PPDR density

Population  8 000 000 people

Area  800 km2

Police density suburban  U(urb)  1.5  180  8 000 000/100 000  21 600 Police

Cell radius  4.0 km

Cell antenna pattern  Hex

Reuse factor  21

GoS factor  1.5

Width of frequency band  24 MHz

Channel bandwidth  12.5 kHz

% of band not used for traffic  10%

Wideband – large city – suburban – medium PPDR density

Population  8 000 000 people

Area  8 000 km2

Police density suburban  U(sub)  1.25  180  8 000 000/100 000  18 000 Police

Cell radius  7.35 km

Cell antenna pattern  Omni

Reuse factor  12

GoS factor  1.5

Width of frequency band  24 MHz

Channel bandwidth  150 kHz

% of band not used for traffic  10%

Wideband – large city – urban – medium PPDR density

Population  8 000 000 people

Area  800 km2

Police density suburban  U(urb)  1.5  180  2 500 000/100 000  21 600 Police

Cell radius  2.56 km

Cell antenna pattern  Hex

Reuse factor  12

GoS factor  1.5

Width of frequency band  24 MHz

Channel bandwidth  150 kHz

% of band not used for traffic  10%

ANNEX 7

Annexes on Broadband Spectrum Calculations and Scenarios

Annex 7A

Methodology for the calculation of broadband PPDR   
spectrum requirements within CEPT[[13]](#footnote-13)

The frequency ranges used for estimating the necessary spectrum bandwidth are the 400 MHz and 700 MHz ranges. It is assumed that a wide area network would be deployed below 1 GHz in order to reduce the number of necessary cell sites.

A brief description of the methodology used for calculation of spectrum requirements is presented below.

This methodology can be considered as an incident based approach where traffic is summed over several separate incidents and background traffic is then added in order to define the total spectrum requirements.

Methodology for PP1

The methodology used for PP1 scenarios consists of the following 5 steps:

Step 1: Definition of the incidents (scenarios).

Step 2: Estimate the total traffic requirement per incident including background traffic.

Step 3: Calculate the link budgets and cell size.

Step 4: Estimate the number of incidents that should be taken into account simultaneously per cell.

Step 5: Estimate the total spectrum requirement based on assumptions on number of incidents per cell, location of incidents within a cell and spectrum efficiency per incident.

Methodology for PP2

The methodology used for PP2 scenarios consists of the following 3 steps:

Step 1: Definition of the PP2 scenarios.

Step 2: Estimate of the PP2 scenarios traffic.

Step 3: Estimate the total spectrum requirement based on assumptions on location of users within the cell and spectral efficiency.

Annex 7B

Spectrum requirements for BB PPDR Based on LTE in  
the United Arab Emirates

Background

After the WRC-12 Resolution 648, the UAE TRA initiated and hosted a national dialog through the creation of a National PPDR Committee with representatives from all public safety and disaster relief agencies.

The Committee held regular meetings to create a better understanding of the evolution of technologies, technical and spectrum requirements for broadband services and applications.

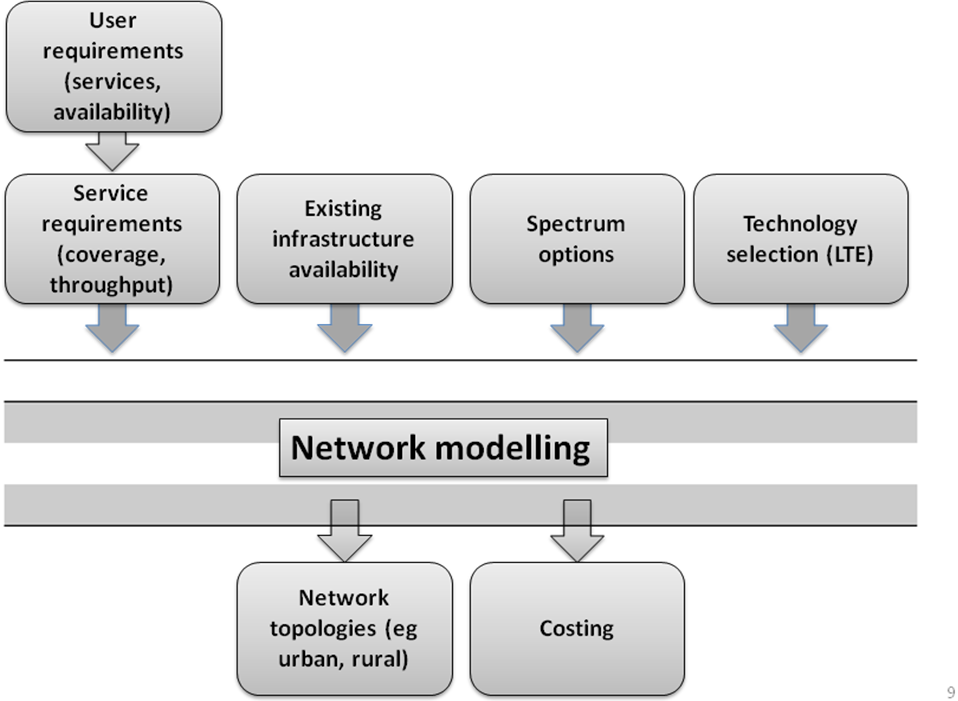
The UAE TRA has met with PPDR industry on several occasions to better understand industry trends and to ensure that what is being proposed for the UAE and the region is consistent with our national interest.

In addition, the TRA has commissioned a specialized consulting company to study, model and calculate the spectrum requirements for BB PPDR in the UAE.

**Methodology**

The study is addressing the methodology used to assess and calculate minimum spectrum requirements were derived from the works that were done by CEPT under FM49 particularly Report 199 and FM49 LEWP Matrix. The flowchart below explains the basic methodology that was followed. Input was sought from all members of the National PPDR Committee. Number of PPDR users, user requirements for services, applications, coverage, and availability were inputted. Additional data based on technology adopted (LTE/LTE-A), number of existing towers and sites used for the TETRA LMR, and spectrum options from UHF sub 1GHz to 3.6 GHz.

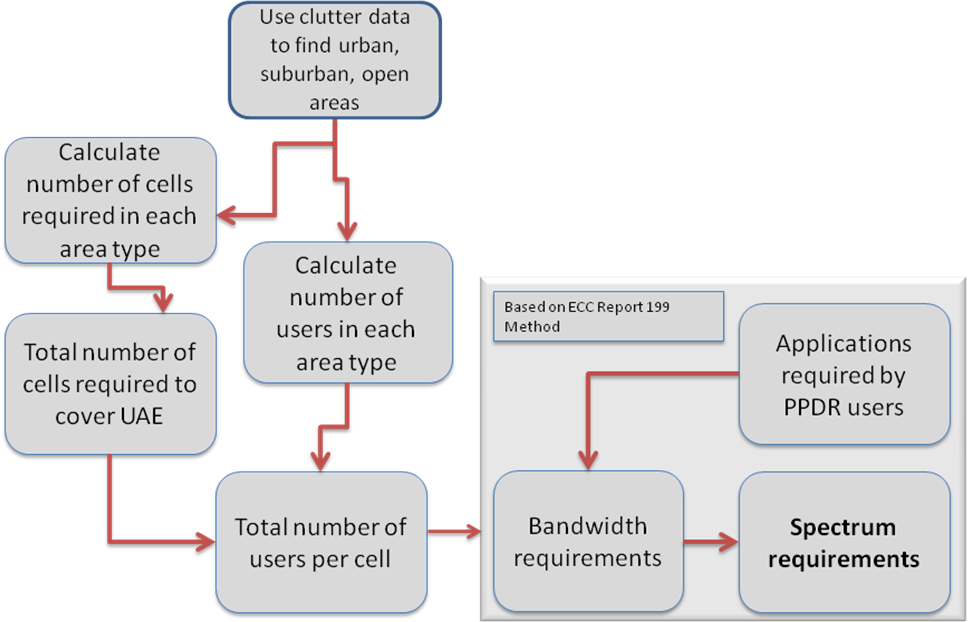
Figure 1



In order to model the number of PPDR users per cell site, a study was based on propagation model assumptions for LTE, a list of frequency bands to be considered, clutter data for UAE, and link budget parameters and certain distribution factor for PPDR users.

The total number of users was calculated based on input collected from PDDR representatives to the Committee with additional growth margin. The number used in the model for UAE was based on 98192 PPDR users.

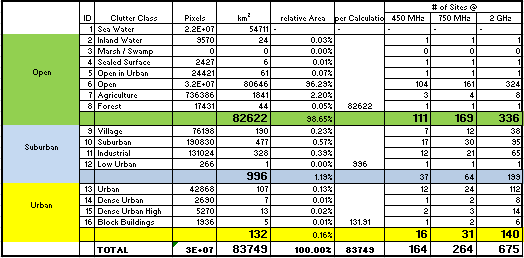
Figure 2



Highlights of PPDR spectrum requirements results for UAE

Table 1

Clutter Data and Minimum number of Sites required against Frequency Band calculation sheet



Assumption on antenna height and other parameters were reasonability assumed based on the following data:

Table 2

|  |
| --- |
| User Equipment |
| **Parameters** | **Value** | **Unit** |
| Height | 1.5 | m |
| Frequency | 420/750/2000 | MHz |
| Output Power EIRP | 30 | dBm |
| Antenna Gain | 0 | dBi |
| Cable Loss | 0 | dB |
| Body Loss | 3 | dB |
| Sensitivity | -106.5 | dBm |

Table 3

|  |
| --- |
| Base Station |
| **Parameters** | **Value** | **Unit** |
| Height | 40 | m |
| Frequency | 420/750/2000 | MHz |
| Output Power EIRP | 43 | dBm |
| Antenna Gain | 4.3 | dBi |
| Duplexer Loss | 1 | dB |
| Cable Loss | 2 | dB |
| Sensitivity | -123.7 | dBm |

Table 4

Coverage probability used was based on 95% availability location and time.

A minimum of 264 sites is expected to be required to achieve the coverage requirements for UAE in the 750 MHz band which is close to what the PPDR number of available sites is (< 300 site).

|  |  |  |
| --- | --- | --- |
|  | Users per sq. km | Total Users |
| Open | 0.9 | 74360 |
| Suburban | 15 | 11952 |
| Urban | 90 | 11880 |
| **Total** |  | 98192 |

Table 5

The average number of users per cell in peak time was calculated based on assumed distribution by geographic zone and based on number of sites required per clutter zone as follows:

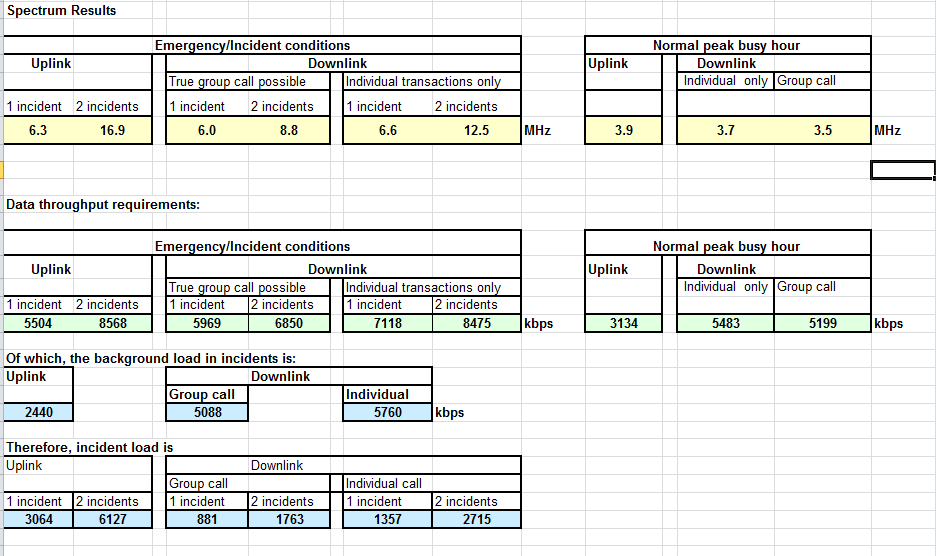
|  |  |  |  |
| --- | --- | --- | --- |
| Users per cell | |  |  |
|  | 450 MHz | **750 MHz** | 2 GHz |  |
| Open | 670 | 440 | 221 |  |
| Suburban | 323 | 187 | 60 |  |
| Urban | 743 | 383 | 85 |  |
| Avg. | **599** | **372** | **145** |  |

The number of 372 Users per cell in peak time was used to calculate spectrum requirements for different scenarios of BB-PPDR use.

**Summary of the spectrum requirements calculation – Results**

* Normal peak busy hours (day-to-day operations) requires 3.9 MHz
* 1 incident requires 6.3 MHz
* 2 incident requires 16.9 MHz

Table 6



Annex 7C

Throughput requirements of broadband PPDR scenarios

Mobile Broad Band technology aiming at wide area coverage constitute an evolution from Narrow Band technology currently applied for mission critical PPDR voice communications in all ITU-R Regions.

A Mobile Broad Band application for the PPDR such as transmission of high resolution images and video requires much higher basic bit-rates than current PPDR technology can deliver.

It should be noted that the new demands for several simultaneous multimedia capabilities (several simultaneous applications running in parallel) over a mobile system presents a huge demand on throughput and high speed data capabilities while the system at the same time shall provide very high peak data rates.

Such demand is particularly challenging when deployed in a localized areas with intensive scene-of-incident requirements where PPDR responders are operating under often very difficult conditions.

For example a 700 MHz LTE PPDR base station deployed to support Broad Band applications in urban environments could typically be tailored to servicing a localized area in the order of 1 km2 or even less offering access to voice, high-speed data, high quality digital real time video and multimedia services, at indicative continuous data rates in the downlink direction in the range of 1 ‑ 10 - 100 - 150 Mbit/s per sector, with a total capacity of 300-450 Mbit/s over the area of 1 km2, with channel bandwidths determined by the particular deployment of the system. Examples of possible applications include:

– high-resolution video communications from portable terminals such as during traffic stops;

– video surveillance of security entry points such as airports with automatic detection based on reference images, hazardous material or other relevant parameters;

– remote monitoring of patients and remote real time video view of the single patient demanding the order of up to 1 Mbit/s. The demand for capacity can easily be envisioned during the rescue operation following a major disaster. This may equate to a net hot spot capacity of over 100 Mbit/s close to a broadband PPDR base station.

Mobile Broad Band systems may have inherent noise and interference trade-offs with data rates and associated coverage. Depending on the technology and the deployed configuration, a single broadband network base station may have different coverage areas in the range of a few hundred metres up to hundred kilometres, offering a wide range in spectrum reuse capability.

Collectively, the high peak data rates, extended coverage and data speeds plus localized coverage area open up numerous new possibilities for BB PPDR applications including tailored area networks as described.

A spectrum throughput and bandwidth calculator has been developed based on the requirements of some Public Safety agencies. This calculator is based on a set of PPDR applications which is based on their current operational experience and their vision of future working practices. The Calculator allows the user to model up to two incident scenes of small, medium, large or very large emergencies. The first incident scene is assumed to take place near the cell edge, and the second incident scene is assumed to be uniformly distributed somewhere in the cell (at a median location/area). The calculator utilizes a blended spectral efficiency model (with a total of 9 spectral efficiency values dependent on the deployment scenario), where background data traffic is modelled with average spectral efficiencies, and the incident scenes are modelled with different spectral efficiencies depending on their location (based on simulations, which are ongoing).

In this calculator, the user may change any boxes highlighted in blue to study different effects (e.g., incident scene size, placement, system deployment topology, bldg. coverage, actual application usage for each incident size/type). While the calculator allows the study of various effects through simulations of various scenarios, it may be noted that there is significant increase in spectral requirements at a cell edge and for large incidents; this requirement becomes overwhelming, likely resulting in the need to offload PS traffic to commercial networks, or deploy an incident scene microcell (CoW). One can also see from the spreadsheet that a medium sized incident near the cell edge and a large incident at a median location require approximately 10+10 MHz of spectrum which is in-line with some other published studies.



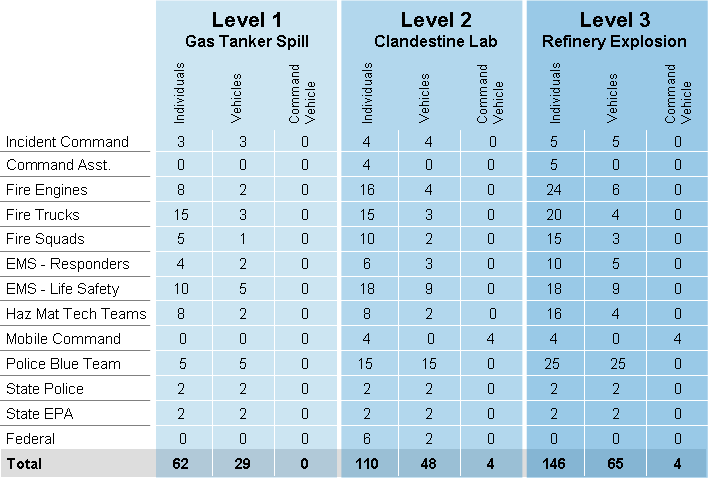
Appendix 1 of this Annex provides some of the PPDR scenarios using this calculator to show the throughput and the bandwidth requirements of these Broadband PPDR scenarios. These scenarios include level 1 being a Tanker Spill, Level 2, a Clandestine (Drug) Lab, and Level 3, a Petrochemical Refinery incident. Figure 1 below summarizes the expected public safety equipment and personnel response needed to manage such an incident in a local Chicago (Illinois, USA) suburb.

Appendix 1 of Annex 7C

Given the unique mission critical requirements of public safety, it is essential that first responders have unilateral control over sufficient broadband capacity to serve current and future needs. To this end, Motorola Solutions developed a model to evaluate public safety’s broadband wireless requirements by drawing upon existing policies and recent incident feedback. For purposes of this research, Level 1 through Level 3 Hazardous Materials Incidents were considered: Level 1 being a Tanker Spill, Level 2, a Clandestine (Drug) Lab, and Level 3, a Petrochemical Refinery incident. Figure 1 below summarizes the expected public safety equipment and personnel response needed to manage such an incident in a local Chicago (Illinois, USA) suburb.[[14]](#footnote-14)

Figure 7C-1

Typical Response Scope for Level 1-3 Hazardous Materials Incidents



As is clearly evident in Figure 7C-1, even the lowest level incident, Level 1, will elicit considerable response from a variety of public safety agencies that will all arrive on the scene needing broadband services.

The incident scene broadband demands are classified as follows based on usage:

**1 Individual (Person/Vehicle) CAD overhead functions**: The classification includes incident data, GPS information, biosensors and other status, messaging, and queries. Each station individually consumes relatively low down/uplink bandwidth but in aggregate usage can be significant across many users.

**2 Incident scene database lookups/downloads and information searches**: The classification includes the download of manuals, incident scene images, maps and topography information, building plans, etc. This use case has the unique requirement that, in general, the information is needed quickly as incident commanders initially assess the scene and develop a strategy. The model assumes that all expected initial data is downloaded and available with the first 10 minutes of the incident. The demands are scaled with the incident size and complexity.

**3 Video**: This classification of usage is comprised of personal video cameras for workers operating in the hot-zone, incident scene (car) video positioned around the perimeter, and cameras deployed within the scene. The video is uplinked via the network and a subset of the streams (switchable on command) is down-linked to the on-scene command centre. Rates of 400kbps (QVGA 320x240 @ 30fps) and 1.2 Mbps (1280x960 @ 30fps) are used and the number of each type of video stream is scaled with the size and complexity of the incident.

Figure 2 below summarizes the results of the analysis where the bandwidth demands for both uplink and downlink are compared with the expected *average* capacity of a single LTE serving sector (*cell edge* performance, especially on the uplink, would be considerably less and obviously under optimistic conditions peak data rates can be much higher). A “background” load of 20% is added to the total demand assuming this would be a minimum “base load” for other non-incident related, nominal activities across the sector coverage area.

Figure 7C-2

Broadband Wireless Capacity Implications



LTE spectrum requirement observations

The results shown in Figure 7C-2 clearly show that for the environment applying in the United States of America, 10 MHz (5+5) of capacity is insufficient to service the uplink demands for even a Level 1 incident. On the other hand, although 10+10 is still deficient for the ideal Level 3 workload, it services the Level 1 and Level 2 incident demands and comes much closer to providing reasonable capability for the Level 3 case.

It is estimated that in the U.S., a Level 2 incident occurs once a week in a large metropolitan city with a population in the millions, such as Chicago, once a month in a large suburb with a population upwards of 100,000, and two times a year in a small suburb with a population in the tens of thousands.

Application of the methodology to the calculation of spectrum requirements for Wuhan city in China

According to above modified method, the frequency band based on TD-LTE system is predicted, considering voice (including point-to-point downlink and uplink and point-to-multipoint downlink and uplink), narrow band data, image and video. Packet data is carried in TD-LTE system, the quality of the voice service focus on time delay, corresponding spectrum efficiency is a litter bit low, shown in Table 1. The spectrum efficiency of Point-to-point uplink and downlink is 0.2 Mbit/s/cell/MHz; In order to guarantee the quality of cell edge, corresponding spectrum efficiency of point-to-multipoint downlink is a little bit lower, that is 0.1 Mbit/s/cell/MHz.

To narrow band data and image, it needs to be differentiated the average spectrum efficiency and edge spectrum efficiency. According to simulation results, average spectrum efficiency uplink is 1.2 Mbit/s/cell/MHz, however, the edge of spectrum efficiency uplink is only 0.1 Mbit/s/cell/MHz; Average spectrum efficiency downlink is 1.6 Mbit/s/cell/MHz, however, the edge of spectrum efficiency uplink is only 0.1 Mbit/s/cell/MHz. Average spectrum efficiency is applied to uplink and downlink in this report.

To wide band video service, spectrum efficiency is calculated by factoring average spectrum efficiency and edge spectrum efficiency, shown in Table A3-3.

Table 7C-1

Spectrum efficiency of TD-LTE voice

|  |  |  |
| --- | --- | --- |
| Parameters of voice | Value | Unit |
| Band（MHz) | 20 |  |
| Frequency Reuse factor | 1 |  |
| Point-to-point uplink spectrum efficiency | 0.2 | Mbit/s/cell/MHz |
| Point-to-point downlink spectrum efficiency | 0.2 | Mbit/s/cell/MHz |
| Point-to-multipoint downlink spectrum efficiency | 0.1 | Mbit/s/cell/MHz |

Table 7C-2

Spectrum efficiency of TD-LTE narrow band data and image

|  |  |  |
| --- | --- | --- |
| Parameters of voice | Value | Unit |
| Band（MHz) | 20 |  |
| Frequency Reuse factor | 1 |  |
| Uplink average spectrum efficiency | 1.2 | Mbit/s/cell/MHz |
| Uplink edge spectrum efficiency | 0.1 | Mbit/s/cell/MHz |
| Downlink average spectrum efficiency | 1.6 | Mbit/s/cell/MHz |
| Downlink edge spectrum efficiency | 0.1 | Mbit/s/cell/MHz |

Table 7C-3

Spectrum efficiency of TD-LTE video

|  |  |  |
| --- | --- | --- |
| Parameters of voice | Value | Unit |
| Band（MHz) | 20 |  |
| Frequency Reuse factor | 1 |  |
| Spectrum efficiency adjustment factor/ Edge proportion | 0.7 |  |
| Uplink spectrum efficiency | 0.437 | Mbit/s/cell/MHz |
| Downlink spectrum efficiency | 0.536 | Mbit/s/cell/MHz |

Wuhan city is capital of Hubei province and centre of politics, economy and culture, which located in the centre of China. It’s urban and main suburb cover 1550 km2. It is predicted that population of 2020 will be about 20 million.

The PPDR is categorized as 4 classes that are police, other police, police civilian support, and fire. The respective probable number is shown as following .

Table 7C-4

PPDR population of Wuhan city in 2020

|  |  |
| --- | --- |
| PPDR category | PPDR population |
| Police | 25848 |
| Special police function | 5169 |
| Police civilian support | 12924 |
| Fire | 7755 |
| Emergency medical service | 1292 |
| General government service | 130 |
| Other PPDR users | 5039 |

Service model of voice and data are from Report ITU-R M.2033.

Table 7C-5

Spectrum requirement of TD-LTE Voice

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| A | Geographic considerations |  |  |  |  |
| A1 | Select operational environment type Each environment type basically forms a column in calculation spread sheet. Do not have to consider all environments, only the most significant contributors to spectrum requirements. Environments may geographically overlap. No user should occupy any two operational environments at one time |  | Urban pedestrian and mobile | Urban pedestrian and mobile |  |
| A2 | Select direction of calculation, uplink vs. downlink or combined |  | Uplink | Downlink |  |
| A3 | Representative cell area and geometry for each operational environment type，(radius of vertex for sectored hexagonal cells km） |  | 1.5 | |  |
| A4 | Calculate representative cell area hexagonal = 2.6 • r\*r |  | 5.85 | |  |
|  |  |  |  |  |  |
| B | Market and traffic considerations |  |  |  |  |
| B1 | Telecommunication services offered(kbit/s) |  |  |  |  |
| B2 | Total population |  | 58157 |  |  |
|  |  |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |  |
|  |  | Police | 25848 | 1 |  |
|  |  | Special police function | 5169 | 0.2 |  |
|  |  | Police civilian support | 12924 | 0.1 |  |
|  |  | Fire | 7755 | 0.7 |  |
|  |  | Emergency Medical service | 1292 | 0.5 |  |
|  |  | General Government Service | 130 | 0.4 |  |
|  |  | Other PPDR users | 5039 | 0.4 |  |
|  |  |  | 36807.9 |  |  |
|  | Area under consideration |  | 1550 | km2 |  |
|  | Number of persons per unit of area within the environment under consideration. Population density may vary with mobility Potential user per km2 |  | 37.5 | POP/km2 |  |
|  |  |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |  |
| B3 | Penetration rate | Police | 25848 | 0.481 |  |
|  |  | Special police function | 5169 | 0.024 |  |
|  |  | Police civilian support | 12924 | 0.025 |  |
|  |  | Fire | 7755 | 0.106 |  |
|  |  | Emergency medical service | 1292 | 0.011 |  |
|  |  | General government service | 130 | 0.001 |  |
|  |  | Other PPDR users | 5039 | 0.034 |  |
|  |  |  | 0.34 | using voice |  |
| B4 | The number of cell |  | 265 |  |  |
| Users/cell |  | 139.58 |  |  |
| B5 | Traffic parameters |  | Uplink | Downlink | |
|  |  |  |  | Point-to-Point | Point-to-Multipoint |
|  | Busy hour call attempts (BCHA) (Calls/busy hour) | From PSWAC | 0.0073284E/ busy hour | 0.0463105E/ busy hour |  |
|  |  |  |  | 0.007718417 | 0.038592083 |
|  | Average number of calls/sessions attempted to/from average user during busy hour |  | 3.54 | 1.05 | 5.24 |
|  | Average call/session duration during busy hours Seconds/call |  | 7.88 | 26.53 | 26.53 |
|  | Activity factor |  | 1.00 | 1.00 | 1.00 |
| B6 | Average traffic in call-seconds generated by each user during busy hour |  | 27.86 | 27.79 | 138.93 |
| B7 | Average traffic generated by all users within a cell during the busy hour  (3 600 s) Erlangs |  | 1.08 | 1.08 | 5.39 |
| B8 | Establish quality of service (QOS) function parameters |  | 1.5 | 1.5 | 1.5 |
|  | frequency reuse factor |  | 1 | 1 | 1 |
|  | Traffic per cell |  | 1.08 | 1.08 | 5.39 |
|  | Total Traffic per cell |  | 1.62 | 1.62 | 8.08 |
|  |  |  |  |  |  |
| C | Technical and system considerations |  |  |  |  |
| C1 | Total Traffic per cell |  | 1.62 | 1.62 | 8.08 |
| C2 | Bitrate（kbit/s)(12.2k AMR，about 16k) |  | 16.00 | 16.00 | 16.00 |
| C3 | Calculate traffic（Mbit/s) |  | 0.026 | 0.026 | 0.129 |
| C4 | Frequency Efficiency |  | 0.200 | 0.200 | 0.1 |
|  |  |  |  |  |  |
| D | Spectrum results |  |  |  |  |
| D1 |  |  | 0.13 | 0.13 | 1.29 |
| D2 | Weighting factor for each environment （α） |  | 1.00 | 1.00 | 1 |
| D3 | Adjustment factor（β） |  | 1.00 | 1.00 | 1 |
| D4 | Calculate total spectrum(MHz) |  | 1.55 | | |

Table 7C-6

Spectrum requirement of TD-LTE narrow band data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| A | Geographic considerations |  |  |  |  |
| A1 | Select operational environment type Each environment type basically forms a column in calculation spreadsheet. Do not have to consider all environments, only the most significant contributors to spectrum requirements. Environments may geographically overlap. No user should occupy any two operational environments at one time |  | Urban pedestrian and mobile | Urban pedestrian and mobile |  |
| A2 | Select direction of calculation, uplink vs downlink or combined |  | Uplink | Downlink |  |
| A3 | Representative cell area and geometry for each operational environment type，(radius of vertex for sectored hexagonal cells km） |  | 1.5 | |  |
| A4 | Calculate representative cell area hexagonal = 2.6 • r\*r |  | 5.85 | |  |
|  |  |  |  |  |  |
| B | Market and traffic considerations |  |  |  |  |
| B1 | Telecommunication services offered(kbit/s) |  |  |  |  |
| B2 | Total population |  | 58157 |  |  |
|  |  |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |  |
|  |  | Police | 25848 | 0.5 |  |
|  |  | Special police function | 5169 | 0.05 |  |
|  |  | Police civilian support | 12924 | 0.05 |  |
|  |  | Fire | 7755 | 0.35 |  |
|  |  | Emergency medical service | 1292 | 0.2 |  |
|  |  | General government service | 130 | 0.2 |  |
|  |  | Other PPDR users | 5039 | 0.21 |  |
|  |  |  | 18162.8 |  |  |
|  | Area under consideration |  | 1550 | km2 |  |
|  | Number of persons per unit of area within the environment under consideration. Population density may vary with mobility Potential user per km2 |  | 37.5 |  |  |
|  |  |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |  |
| B3 | Penetration rate | Police | 25848 | 0.240 |  |
|  |  | Special police function | 5169 | 0.006 |  |
|  |  | Police civilian support | 12924 | 0.012 |  |
|  |  | Fire | 7755 | 0.053 |  |
|  |  | Emergency medical service | 1292 | 0.05 |  |
|  |  | General government service | 130 | 0 |  |
|  |  | Other PPDR users | 5039 | 0.02 |  |
|  |  |  | 0.39 |  |  |
| B4 | The number of cell |  | 265 |  |  |
| Users/cell |  | 68.46 |  |  |
| B5 | Traffic parameters |  | Uplink | Downlink |  |
|  | Busy hour call attempts (BCHA) (Calls/busy hour) |  | 30.00 | 30.00 |  |
|  | kbit/date |  | 80.00 | 80.00 |  |
|  | Activity factor |  | 1.00 | 1.00 |  |
| B6 | Average traffic in call-seconds generated by each user during busy hour |  | 2400.00 | 2400.00 |  |
| B7 | Average traffic generated by all users within a cell during the busy hour  (3 600 s) Erlangs Throughput(kbps) |  | 0.67 | 0.67 |  |
| B8 | Establish quality of service (QOS) function parameters |  | 1.5 | 1.5 |  |
|  | Frequency reuse factor |  | 1 | 1 |  |
|  | Traffic/user in a cell Throughput/ kbps |  | 1.00 | 1.00 |  |
|  |  |  |  |  |  |
| C | Technical and system considerations |  |  |  |  |
| C1 | Total Throughput / Mbps |  | 0.07 | 0.07 |  |
| C2 | Frequency Efficiency |  | 1.200 | 1.600 |  |
|  |  |  |  |  |  |
| D | Spectrum results |  |  |  |  |
| D1 |  |  | 0.06 | 0.04 |  |
| D2 | Weighting factor for each environment （α） |  | 1.00 | 1.00 |  |
| D3 | Adjustment factor（β ） |  | 1.00 | 1.00 |  |
| D4 | Total Spectrum(MHz) |  | 0.10 | | |

Table 7C-7

Spectrum requirement of TD-LTE image

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| A | Geographic considerations |  |  |  |  |
| A1 | Select operational environment type Each environment type basically forms a column in calculation spreadsheet. Do not have to consider all environments, only the most significant contributors to spectrum requirements. Environments may geographically overlap. No user should occupy any two operational environments at one time |  | Urban pedestrian and mobile | Urban pedestrian and mobile |  |
| A2 | Select direction of calculation, uplink vs downlink or combined |  | Uplink | Downlink |  |
| A3 | Representative cell area and geometry for each operational environment type，(radius of vertex for sectored hexagonal cells km） |  | 1.3 | |  |
| A4 | Calculate representative cell area hexagonal = 2.6 • r\*r |  | 5.85 | |  |
|  |  |  |  |  |  |
| B | Market and traffic considerations |  |  |  |  |
| B1 | Telecommunication services offered(kbit/s) |  |  |  |  |
| B2 | Total population |  | 58157 |  |  |
|  |  |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |  |
|  |  | Police | 25848 | 0.6 |  |
|  |  | Special police function | 5169 | 0.05 |  |
|  |  | Police civilian support | 12924 | 0.01 |  |
|  |  | Fire | 7755 | 0.3 |  |
|  |  | Emergency medical service | 1292 | 0.2 |  |
|  |  | General government service | 130 | 0.2 |  |
|  |  | Other PPDR users | 5039 | 0.24 |  |
|  |  |  | 19908.4 |  |  |
|  | Area under consideration |  | 1550 | km2 |  |
|  | Number of persons per unit of area within the environment under consideration. Population density may vary with mobility Potential user per km2 |  | 37.5 |  |  |
|  |  |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |  |
| B3 | Penetration rate | Police | 25848 | 0.289 |  |
|  |  | Special police function | 5169 | 0.006 |  |
|  |  | Police civilian support | 12924 | 0.002 |  |
|  |  | Fire | 7755 | 0.046 |  |
|  |  | Emergency medical service | 1292 | 0.005 |  |
|  |  | General government service | 130 | 0 |  |
|  |  | Other PPDR users | 5039 | 0.023 |  |
|  |  |  | 0.40 |  |  |
| B4 | The number of cell |  | 265 |  |  |
| Users/cell |  | 75.19 |  |  |
| B5 | Traffic parameters |  | Uplink | Downlink |  |
|  | Busy hour call attempts (BCHA) (Calls/busy hour) |  | 6.00 | 6.00 |  |
|  | kbit /Image |  | 8000.00 | 8000.00 |  |
|  | Activity factor |  | 1.00 | 1.00 |  |
| B6 | Average traffic in call-seconds generated by each user during busy hour |  | 48000.00 | 48000.00 |  |
| B7 | Average traffic generated by all users within a cell during the busy hour  (3 600 s) Erlangs Throughput(kbps) |  | 13.33 | 13.33 |  |
| B8 | Establish quality of service (QOS) function parameters |  | 1.5 | 1.5 |  |
|  | Frequency Reuse factor |  | 1 | 1 |  |
|  | Traffic/user in a cell Throughput/ kbps |  | 20.00 | 20.00 |  |
|  |  |  |  |  |  |
| C | Technical and system considerations |  |  |  |  |
| C1 | Total Throughput / Mbps |  | 1.50 | 1.50 |  |
| C2 | Frequency Efficiency |  | 1.200 | 1.600 |  |
|  |  |  |  |  |  |
| D | Spectrum results |  |  |  |  |
| D1 |  |  | 1.25 | 0.94 |  |
| D2 | Weighting factor for each environment (α) |  | 1.00 | 1.00 |  |
| D3 | Adjustment factor（β） |  | 1.00 | 1.00 |  |
| D4 | Total Spectrum(MHz) |  | 2.19 | | |

Table 7C-8

Spectrum requirement of TD-LTE video

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| A | Geographic considerations |  |  |  |  |
| A1 | Select operational environment type Each environment type basically forms a column in calculation spreadsheet. Do not have to consider all environments, only the most significant contributors to spectrum requirements. Environments may geographically overlap. No user should occupy any two operational environments at one time |  | Urban pedestrian and mobile | Urban pedestrian and mobile |  |
| A2 | Select direction of calculation, uplink vs downlink or combined |  | Uplink | Downlink |  |
| A3 | Representative cell area and geometry for each operational environment type，(radius of vertex for sectored hexagonal cells km） |  | 1.5 | |  |
| A4 | Calculate representative cell area hexagonal = 2.6 • r\*r |  | 5.85 | |  |
|  |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| B | Market and traffic considerations |  |  |  |  |
| B1 | Telecommunication services offered(kbit/s) |  |  |  |  |
| B2 | Total population |  | 58157 |  |  |
|  |  |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |  |
|  |  | Police | 25848 | 0.2 |  |
|  |  | Special police function | 5169 | 0.04 |  |
|  |  | Police civilian support | 12924 | 0.02 |  |
|  |  | Fire | 7755 | 0.4 |  |
|  |  | Emergency medical service | 1292 | 0.1 |  |
|  |  | General government service | 130 | 0.3 |  |
|  |  | Other PPDR users | 5039 | 0.1 |  |
|  |  |  | 9694.4 |  |  |
|  | Area under consideration |  | 1550 | km2 |  |
|  | Number of persons per unit of area within the environment under consideration. Population density may vary with mobility Potential user per km2 |  | 37.5 |  |  |
|  |  |  | Population (POP) by PPDR category | Penetration (PEN) rate within PPDR category |  |
| B3 | Penetration rate | Police | 25848 | 0.096 |  |
|  |  | Special police function | 5169 | 0.005 |  |
|  |  | Police civilian support | 12924 | 0.005 |  |
|  |  | Fire | 7755 | 0.061 |  |
|  |  | Emergency medical service | 1292 | 0.002 |  |
|  |  | General government service | 130 | 0.001 |  |
|  |  | Other PPDR users | 5039 | 0.009 |  |
|  |  |  | 0.33 |  |  |
| B4 | The number of cell |  | 265 |  |  |
| Users/cell |  | 36.58 |  |  |
| B5 | Traffic parameters |  | Uplink | Downlink |  |
|  | Busy hour call attempts (BCHA) (Calls/busy hour) |  | 6.00 | 3.00 |  |
|  | Average traffic in call-seconds generated by each user during busy hour |  | 60.00 | 60.00 |  |
|  | Activity factor |  | 1.00 | 1.00 |  |
| B6 | Average traffic generated by all users within a cell during the busy hour (3 600 s) Erlangs Throughput(kbps) |  | 360.00 | 180.00 |  |
| B7 | Average traffic generated by all users within a cell during the busy hour (3 600 s) Erlangs Throughput(kbps) |  | 3.66 | 1.83 |  |
| B8 | Establish quality of service (QOS) function parameters |  | 1.5 | 1.5 |  |
|  | Frequency Reuse factor |  | 1 | 1 |  |
|  | Traffic of all users in a cell Throughput/ kbps |  | 3.66 | 1.83 |  |
|  | Total traffic in a cell Throughput/ kbps |  | 5.49 | 2.74 |  |
|  |  |  |  |  |  |
| C | Technical and system considerations |  |  |  |  |
| C1 | Total Traffic per cell |  | 5.49 | 2.74 |  |
| C2 | Bitrate（kbit/s)(2MHz) |  | 2000.00 | 2000.00 |  |
| C3 | Total Throughput / Mbps |  | 10.975 | 5.487 |  |
| C4 | Frequency Efficiency |  | 0.430 | 0.550 |  |
|  |  |  |  |  |  |
| D | Spectrum results |  |  |  |  |
| D1 |  |  | 25.52 | 9.98 |  |
| D2 | Weighting factor for each environment ( α ) |  | 1.00 | 1.00 |  |
| D3 | Adjustment factor（β） |  | 1.00 | 1.00 |  |
| D4 | Total Spectrum(MHz) |  | 35.50 | | |

Frequency prediction is summarised in Table 7C-9.

Table 7C-9

Example narrowband and wideband calculation summaries

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PPDR category** | **Wuhan population** | | **Penetration rates** | | | | | | |
| **Narrowband voice** | **Narrowband data** | | | **Wideband image** | | **broadband video** |
| Police | 25848 | | 1 | 0.5 | | | 0.6 | | 0.2 |
| Special police function | 5169 | | 0.2 | 0.05 | | | 0.05 | | 0.04 |
| Police civilian support | 12924 | | 0.1 | 0.05 | | | 0.01 | | 0.02 |
| Fire | 7755 | | 0.7 | 0.35 | | | 0.3 | | 0.4 |
| Emergency medical service | 1292 | | 0.5 | 0.2 | | | 0.2 | | 0.1 |
| General government service | 130 | | 0.4 | 0.2 | | | 0.2 | | 0.3 |
| Other PPDR users | 5039 | | 0.4 | 0.21 | | | 0.24 | | 0.1 |
| Total – PPDR users | 58157 | | 36870 | 18162 | | | 19908 | | 9673 |
| Spectrum (MHz) |  | | 1.55 | 0.1 | | | 2.19 | | 35.50 |
| Spectrum in total (MHz) | 39.34 | |  |  | | |  | |  |
| Other parameters: |  |  | | |  |  | |  | |
| Environment | Urban pedestrian and mobile |  | | |  |  | |  | |
| Cell radius (km) | 1.5 |  | | |  |  | |  | |
| Study area (km2) | 1550 | (Calculated) | | | |  | |  | |
| Cell area (km2) | 5.85 | (Calculated) | | | |  | |  | |
|  |  | NB Voice | | | NB data | WB image | | BB Video | |
|  |  | Uplink | | | Uplink | Uplink | | Uplink | |
| Erlangs per busy hour |  | 0.007328 | | |  |  | | 0.1 | |
| Busy hour call attempts |  | 3.54 | | | 30 | 6 | | 6 | |
| Effective call duration |  | 7.88s | | | 80kbit | 8000kbit | | 60s | |
| Activity factor |  | 1 | | | 1 | 1 | | 1 | |
|  | NB Voice | | | | NB data | WB image | | BB Video | |
|  | DL PTP | DL PTM | | | Downlink | Downlink | | Downlink | |
| Erlangs per busy hour | 0.00771 | 0.03859 | | |  |  | | 0.05 | |
| Busy hour call attempts | 1.05 | 5.24 | | | 30 | 6 | | 3 | |
| Effective call duration | 26.53s | 26.53s | | | 80kbit | 8000kbit | | 60s | |
| Activity factor | 1 | 1 | | | 1 | 1 | | 1 | |
| Group size | 1 |  | | |  |  | |  | |
| Grade of service factor | 1.5 |  | | |  |  | |  | |
| α factor | 1 |  | | |  |  | |  | |
| β factor | 1 |  | | |  |  | |  | |

Considering narrow band voice, narrow band data, wide band image and broad band video, total 39.34 MHz is maybe minimum PPDR spectrum according to requirement development of Wuhan city in 2020.

Table 7c-10

Total spectrum requirement of TD-LTE

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Voice/MHz | Narrow data/MHz | Image/MHz | Video/MHz | Total spectrum /MHz |
| 1.55 | 0.1 | 2.19 | 35.5 | 39.34 |

Appendix 1 to Annex 7C

Methodology to calculate broadband spectrum requirements

Table 7CA-1

Methodology

|  |  |
| --- | --- |
| **IMT-2000 methodology  (Recommendation ITU-R M.1390)** | **Methodology** |
| **A Geography** |  |
| **A1** Operational Environment  Combination of user mobility and user mobility. Usually only analyse most significant contributors. | **A1** PPDR user density is much lower and more uniform. PPDR users roam from one environment to another as they respond to emergencies. PPDR systems are usually designed to cover all environments (i.e., wide area network provides in-building coverage). Instead of analyzing by physical environment, assume that there will likely be multiple overlapping systems each providing different services (narrowband, wideband, and broadband). Each service environment will probably operate in a different frequency band with different network architectures. Analyse three overlapping urban “service environments”: narrowband, wideband, broadband. |
|  |
|  |
| **A2** Direction of calculation | **A2** Usually separate calculations for uplink and downlink due to asymmetry in some services |
| **A3** Representative cell area and geometry for each environment type | **A3**Average cell radius of radius to vertex for hexagonal cells |
| **A4** Calculate area of typical cell | **A4** Omni cells  i *R*2  Hexagonal cells  2.6 · *R*2  3-sector hex  2.6/3 · *R*2 |
|
|
| **B** Market & traffic |  |
| **B1** Services offered | **B1** Net user bit rate (kbit/s) for each of the four PPDR service environments: narrowband voice, narrowband data, wideband image, broadband video. |
| **B2** Population density  Persons per unit of area within each environment. Population density varies with mobility | **B2** Total PPDR user population within the total area under consideration. Divide PPDR population by total area to get PPDR population density.  PPDR users are usually separated into well-defined categories by mission. Example:  *Category Population*  Regular Police 25848  Special Police Functions 5169  Police Civilian Support 12924  Fire Suppression 7755  General Government Service 130  Other PPDR users 5039  **Total PPDR population 58157**  Area under consideration. Area within well-defined geographic or political boundaries.  Example: City of Wuhan 1550 km2  PPDR population density  PPDR population/area  Example: Wuhan 37.5 PPDR/km2 |

|  |  |
| --- | --- |
| **B3** Penetration rate  Percentage of persons subscribing to a service within an environment. Person may subscribe to more than one service | **B3** Similar table.  Rows are services, such as voice, data, video Columns are “service environments”, such as narrowband, wideband, and broadband.  May collect penetration rate into each “service environment” separately for each PPDR category and then calculate composite PPDR penetration rate.  Example:  *Category Population* *Penetration*  (NB Voice)  Regular Police 25848 100%  Special Police Function 5169 20%  Police Civilian Support 12924 10%  Fire Suppression 77557 0%  Emergency Medical service 1292 50%  General Government Service 130 40%  Other PPDR users 5039 40%  **Total PPDR Population 58157**  **Narrowband Voice  PPDR Population 36807.9**  PPDR penetration rate for narrowband “service environment” and voice “service”:   Sum(Pop  Pen)/sum(Pop)  63.2% |
| **B4** Users/cell  Number of people subscribing to service within cell in environment | **B4** Users/cell   Pop density  Pen Rate  Cell area |
| **B5** Traffic parameters  Busy hour call attempts: average number of calls/sessions attempted to/from average user during a busy hour  Effective call duration  Average call/session duration during busy hour  Activity factor  Percentage of time that resource is actually used during a call/session.  Example: bursty packet data may not use channel during entire session. If voice vocoder does not transmit data during voice pauses | **B5** Calls/busy hour  Sources: current PPDR data and prediction data  s/call  0-100% |
| **B6** Traffic/user  Average traffic generated by each user during busy hour | **B6** Call-seconds/user  Busy hour attempts  Call duration  Activity factor |
| **B7** Offered traffic/cell  Average traffic generated by all users within a cell during the busy hour (3 600 s) | **B7** Erlangs   Traffic/user  User/cell/3 600 |
| **B8** Quality of service function  Offered traffic/cell is multiplied by typical frequency reuse cell grouping size and quality of Service factors (blocking function) to estimate offered traffic/cell at a given quality level | One carrier is applied in TD-LTE system. Group size is 1. |

|  |  |
| --- | --- |
| Group size |  |
| Traffic per group | =Traffic/cell (E) |
| Service channels per group | Use 1% blocking. Erlang B factor probably close to 1.5.  Need to consider extra reliability for PPDR systems, excess capacity for peak emergencies, and number of channels likely to be deployed at each PPDR antenna site.  Technology modularity may affect number of channels that can be deployed at a site |
| **C** Technical and system considerations |  |
| **C1** Service channels per cell to carry offered load | **C1** Service channels per cell  Service channels per group/Group size |
| **C2** Service channel bit rate (kbit/s) | **C2** Service channel bit rate  Net userbit rate   Overhead factor  Coding factor |
| Equals net user bit rate plus additional increase in loading due to coding and/or overhead signalling, if not already included | If vocoder output  4.8 kbit/s, FEC  2.4 kbit/s, and Overhead  2.4 kbit/s, then Channel bit rate  9.6 kbit/s |
| **C3** Calculate traffic (Mbit/s)  Total traffic transmitted within area under study, including all factors | **C3** Total traffic   Service channels per cell x service channel bit rate |
| **C4** Net system capability  Measure of system capacity for a specific technology. Related to spectral efficiency | **C4** Calculate for typical narrowband voice, narrowband data, wideband image and broadband video, spectrum efficiency based on simulation results. |
| **D** Spectrum results |  |
| **D1-D4** Calculate individual components (each cell in service vs environment matrix | **D1-D4** Calculate for each cell in service vs. “service environment” matrix |
| **D5** Weighting factor (alpha) for busy hour of each environment relative to busy hour of other environments, may vary from  0 to 1 | **D5** If all environments have coincident busy hours, then alpha  1  Freqes Freq  alpha requirements in D1‑D4 |
| **D6** Adjustment factor (beta) for outside effects – multiple operators/networks, guard bands, band sharing, technology modularity | **D6**  Freq(total)  beta  sum(alpha  Freqes) |

ANNEX 7D

Representative scenario- deploying LTE for PPDR

Use of IMT-LTE for Broadband PPDR system refers to 15 time line events and a typical response sequence based on the number of responders, as well as the broadband resources throughout the incident. The data traffic supporting this response is assumed to be served by a wide area, mobile broadband network. The PPDR agencies also use Project-25 system for voice only. Project-25 system had not been analysed during this event.

Incident scenario

The scenario includes an accident in which a chemical material truck crashes in the city; the truck hits several cars and the truck tank is damaged. The chemical material starts to leak, and the PPDR agencies start to evacuate the area. Two cars are on fire, the fire is spreading fast, people are injured and some are trapped inside the cars, a nearby building must be evacuated as soon as possible.

The following table shows the time line scenario step by step.

The table includes:

1. Event description.
2. Time line from 0 to 6 hours.
3. Link type: Project 25 system for Voice and LTE for data.
4. Required actions uplink.
5. Required actions downlink.
6. Total number of users that arrive each time line.

The following PPDR agencies take part during the event:

1. Police.
2. Ambulances.
3. Fire brigade.
4. Hazardous materials response team.
5. City control forces.

Event description

Call received at police operation centre, and the operation centre dispatch immediately broadcasts to all forces to go there as soon as possible. 12 police cars confirm that they on the way to scene. The operation centre dispatch sends location information to vehicles’ computers and the police cars also request more information about the area and more GIS information. The dispatch sends them the GIS information and high resolution video of the event from a security camera close to the truck. After 7 minutes, the police cars arrive at the scene and send real time low resolution video from the area. The policemen are getting real time high resolution video from a high resolution security camera via the LTE system on a nearby building in which people are trapped because of the fire. They are also getting GIS information and building information. After 12 minutes, additional police vehicles with 2 chief officers arrive at the scene. They also send real time low resolution video from the area and they receive real time high resolution video from a police helicopter via the LTE system. After 13 minutes, a city control vehicle with 2 officers arrives at the scene. They send real time low resolution video from the area to the city control room and they receive real time high resolution video from a city traffic control camera via the LTE system. After 14 minutes, four ambulances arrive. They request GIS information and send real time high resolution video to their Command Centre. They are receiving real time high resolution video from a security camera via the LTE system about the injuries and getting medical information and GIS information. After 15 minutes the fire-brigade arrives, requests GIS information, sends real time medium resolution video from the vehicle’s camera, receives real time medium resolution video from the scene and gets GIS information and building scheme. After 16 minutes, hazardous materials response team arrive and request GIS information, send high resolution pictures in order to verify the chemical liquid with the help of their experts, receive real time medium resolution video from the scene and get GIS information. After 20 minutes, Front Command and Control deployed in the scene area are connecting to the police database. They operate voice conference calls and video conferences; receive real time low resolution video from the helicopter and real time high resolution video from forces inside the building. At this point the Front Command and Control are fully connected to the police database and can use any police information such as cars and people information, real time video, and pictures that can be shared with anyone that needs the information. The information is now fully displayed in the main command and control room of the police and other forces. Commanders can share the information and get full control of the event.

Table 7D-1

Incident scenario time line

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Scenario time line | | | | | | |
| No of users | Used systems | Required action Downlink | Required action Uplink | Link type | Time+ | Part number and event description |
|  |  |  |  |  | 0 | 1. Accident occurs |
|  |  |  |  |  | 1 minute | 1. Call received at police Operation Centre |
| 12 | Project 25 | Call to the closest police vehicles and send location information to vehicles' computer |  | Voice | 2 minutes | 1. Operation Centre dispatch sent |
| 12 | Project 25 & LTE | Getting GIS information and each policeman (total of 12 ) getting real time high resolution video of the event from security camera close to the truck | Request for information from Vehicle’s computer+GIS information | Voice+Data | 3 minutes | 1. Police vehicles on the way to scene |
| 12 | Project 25 & LTE | Getting real time high resolution video from security camera close to the truck and getting GIS information | Sending real time low resolution video from the area | Voice+Data | 7 minutes | 1. Policemen arrive at scene |
| 2 | Project 25 & LTE | Getting real time high resolution video from police helicopter | Sending real time low resolution video from the area | Voice+Data | 12 minutes | 1. Additional police vehicle with 2 chief officers arrives |
| 2 | Project 25 & LTE | Getting real time high resolution video from traffic control camera | Sending real time low resolution video from the area | Voice+Data | 13 minutes | 1. City control vehicle with 2 officers arrives at scene |
| 12 | Project 25 & LTE | Getting real time high resolution video from security camera about the injuries and getting GIS information | Request for GIS information and sending real time high resolution video to command centre | Voice+Data | 14 minutes | 1. Four ambulances arrival |
| 3 | Project 25 & LTE | Getting real time medium resolution video from scene and get GIS information | Request for GIS information and sending real time medium resolution video from vehicle camera | Voice+Data | 15 minutes | 1. Fire forces arrival |
| 1 | Project 25 & LTE | Getting real time medium resolution video from scene and getting GIS information | Request for GIS information and sending high resolution pictures | Voice+Data | 16 minutes | 1. Hazardous materials response team arrival |
| 4 | Project 25 & LTE | Video conference , getting real time low resolution video from helicopter and real time high resolution video from scene | Connecting to police database and video conference | Voice+Data | 20 minutes | 1. Front Command and Control deployment |
|  | Project 25 & LTE | Total of 36 users who operate 72 applications simultaneously | Total of 36 users who operate 36 applications simultaneously | Voice+Data | 20 minutes | 1. All forces arrived and operational |
|  | Project 25 & LTE |  |  | Voice+ Data | 40 minutes | 1. The ambulances leave the area on the way to hospital |
|  | Project 25 & LTE |  |  | Voice+ Data | 100 minutes | 1. The forces succeeded to isolate the truck and to close the leak |
|  |  |  |  | Voice+ Data | 125 minutes | 1. Chemical material removing to replacement tanks |
|  |  |  |  | Voice+ Data | 200 minutes | 1. Replacements tanks are removed from area |
|  |  |  |  | Voice+ Data | 250 minutes | 1. The area is clean and checked |
|  |  |  |  | Voice+ Data | 360 minutes | 1. End of the event |

The following table summarizes the data rate (kbps) for each application during the event:

Table 7D-2

Application data rate

|  |  |  |  |
| --- | --- | --- | --- |
| UL (kbps) | Downlink (kbps) | Description | Application |
| N/A (Project 25) | N/A (Project 25) | Voice call | Voice |
| N/A (Project 25) | N/A | Information from the command centre | Request for Information from Vehicle computer |
| 100 | 2000 | Map of the area of the event | GIS Information |
| 2000 | 2000 | Real time video | High resolution video |
| 1000 | 1000 | Real time video | Medium resolution video |
| 500 | 500 | Real time video | Low resolution video |
| 384 | 384 | Video conference application | Video conference |
| 300 | 300 | Image | High resolution picture |

The event occurs within 1.6 km radius area. The area has been closed by the police, and one 45 m antenna mast LTE site gives service to this area.

Analysis

In order to analyse the required spectrum 'Monte Carlo' simulation has been used. The urban clutter loss has been defined to 10 dB. The LTE data (see Report ITU-R M.2241 Table 2.2.1-1 for most of the site and equipment parameters):

1. 3 sector site.
2. Dual-transmitter and dual-receiver configuration per sector (MIMO).
3. 40 W on each diversity antenna[[15]](#footnote-15).
4. 45 m antenna height above ground level.
5. Antenna parameters:
   1. 17 dBi antenna gain.
6. 65 deg Horizontal pattern (aperture in the horizontal plane at 3 dB (in deg.).
7. 15 deg Vertical pattern (aperture in the vertical plane at 3 dB (in deg.).
8. 3 dB losses (cable losses + connector losses feeder losses).
9. 60 dBm eirp, including cable losses.
10. 2 degree down tilt.
11. Modulation parameters: QPSK, 16-QAM and 64 QAM.
12. Duplex mode – FDD.
13. Duty cycle(downlink applications activity factor): 0.5.

The LTE UE data (see Report ITU-R M.2241 Table 2.2.1-1 for most of the parameters):

1. 1.5 m antenna height above ground level.
2. Omni antenna.
3. 0 dBi antenna gain.
4. Maximum Transmitter e.i.r.p. (dBm): 21 to 23.
5. Average Transmitter e.i.r.p. (dBm): -9.
6. Modulation parameters: QPSK , 16-QAM and 64 QAM.
7. Duplex mode – FDD.
8. Duty cycle (uplink applications activity factor): 0.5.

The analysis has been run to analyse part 12 (all the forces arrived to the area). A total of 36 users get information from a few LTE applications (Table 2). Six bandwidths have been checked to get the required spectrum for event part 12 (the maximum required spectrum):

1. 10 MHz.
2. 15 MHz.
3. 18 MHz (Not a LTE BW based on spec. Has been used just for calculation).
4. 18.8 MHz (Not a LTE BW based on spec. Has been used just for calculation).
5. 20 MHz.

The results from each simulation are:

Reliability. The reliability in % that the system will be able to give the required data rate and for the required spectrum for all users during the event. The goal is to achieve 95% reliability for the whole area and 90% reliability for a particular application. The reliability results are for each application and composite reliability.

Results

The reliability tables results for each bandwidth are shown below:

Table 7D-3

10 MHz reliability results (%)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| High resolution image | Video conference | Low resolution video | Medium resolution video | High resolution video | GIS Information | Whole area | Time line |
| N/A | 81.9 | 76.19 | 58.1 | 35.8 | 36.6 | 47.7 | Downlink |
| 98.9 | 98.8 | 98.6 | 97.9 | 78.9 | N/A | 97.5 | Uplink |

Table 7D-4

15 MHz reliability results (%)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| High resolution image | Video conference | Low resolution video | Medium resolution video | High resolution video | GIS Information | Whole area | Time line |
| N/A | 98.3 | 94 | 79.1 | 65.8 | 66.4 | 72.9 | Downlink |
| 98.9 | 98.9 | 98.8 | 98.2 | 96.2 | N/A | 98.5 | Uplink |

Table 7D-5

18 MHz reliability results (%)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| High resolution image | Video conference | Low resolution video | Medium resolution video | High resolution video | GIS Information | Whole area | Time line |
| N/A | 99 | 98.9 | 93.7 | 86.8 | 88.5 | 94.3 | Downlink |
| 98.9 | 98.9 | 98.8 | 98.2 | 96.5 | N/A | 98.6 | Uplink |

Table 7D-6

18.8 MHz reliability results (%)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| High resolution image | Video conference | Low resolution video | Medium resolution video | High resolution video | GIS Information | Whole area | Time line |
| N/A | 99 | 99 | 96.2 | 93.6 | 94.3 | 97 | Downlink |
| 98.9 | 98.9 | 98.8 | 98.3 | 96.6 | N/A | 98.7 | Uplink |

Table 7D-7

20 MHz reliability results (%)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| High resolution image | Video conference | Low resolution video | Medium resolution video | High resolution video | GIS Information | Whole area | Time line |
| N/A | 99 | 99 | 98.4 | 97.7 | 98 | 98.7 | Downlink |
| 98.9 | 98.9 | 98.9 | 98.3 | 96.8 | N/A | 98.6 | Uplink |

Conclusions of the representative scenario

The reliability results show that the required spectrum for this event is 18.8 MHz for the downlink and 15 MHz for the uplink. The heavy loaded application is the high resolution video at the downlink and uplink paths. The limitation path is the Downlink, since more capacity is required; but if additional users would be using additional high resolution video than the uplink path could be the limitation of the spectrum. The growing demand for broadband mobile LTE PPDR requires a dedicated RF spectrum. Since the present IMT FDD channel arrangements provide equal RF for downlink and uplink, and 18.8 MHz is not part of the LTE specification, 20MHz X 2 is the required spectrum for this example.

Appendix 1 of Annex 7D

Example for wireless applications needed for broadband PPDR system

|  |
| --- |
| Wireless Applications |
| Video |
| real time video from helicopter |
| real time video from UAS |
| real time video from other cameras |
| video transmission from scene |
| Data |
| First responders information database connectivity |
| First responders tactical systems connectivity |
| First responders cars computers connectivity |
| First responders citizens information database connectivity |
| First responders GIS information database connectivity |
| First responders LPR information database connectivity |
| First responders vehicle information database connectivity |
| First responders technical information database connectivity |
| First responders internal mail connectivity |
| First responders internal application connectivity |
| TMS/SMS and MMS capability |
| Location and GIS |
| Sending location information |
| Maps and GIS information |
| First responders tactical GIS system connectivity |
| Communications |
| VOICE call |
| Conference call |
| PTT call to P25 |
| PTT group call |
| Emergency call |
| Talk around between to handsets capability |
| video call |
| Broadband communications |
| Voice over IP connectivity |
| Mobile base station connectivity |
| front command and control connectivity |

Annex 7E

Scenario of LTE based technology for PPDR broadband

This is a study of a typical PPDR incident, a bank robbery, which happened in China. Wireless bandwidth requirements of PPDR agencies in this mission critical scenario are analyzed.

Process to handle the incident:

1. 110 command centre receives emergency call and dispatches nearby police officers to the scene.
2. The dispatched police officers contact the command centre and ask for the aid of SWAT Police officers in accordance with the situation and set up a command centre on the scene.
3. Firefighters and medical team arrive on the scene.
4. Police helicopter arrives on the scene. The helicopter transmits panoramic high definition images to the on-scene command centre and the on-scene command centre transmits the images through wireless network to remote command centre. The remote command centre transmits large amount of data concerning the incident and the scene to the on-scene command centre, which in turn broadcasts the data to each emergency team.
5. The SWAT Police officers arrive on the scene. They deploy surveillance equipment to conduct covert surveillance and collect information. Critical information is transmitted to the on-scene command centre in a manner of high definition images while general information is transmitted through two channels standard definition images. The on‑scene command centre broadcasts the video images to whichever emergency team that needs the video.
6. The SWAT Police officers deploy remote-controlled reconnaissance robots and transmit indoor video in two manners, high definition and standard definition.
7. Negotiation experts arrive on the scene. To make sure the experts can see and hear every detail of the scene; assistants for the negotiation monitor the negotiation by making full use of videos collected through all equipment.
8. SWAT Police officers make the strategy for strike and ten of them prepare to start the strike. Two head-mounted cameras of standard definition are carried with them.
9. The operation is finished.

Throughout the whole process, the peak spectrum demand happens when the SWAT Police team strike. Only when bandwidth requirement during this period is met, the emergency can be properly handled.

Tests have proved that for video of standard definition, at a distance of about 15 meters, CIF 352×288p, 25fps, only gender, figure, and motions can be identified, whereas D1 704×576p, 25 fps, face, details of figure, and license plate numbers can be identified; for videos of high definition, at a distance of over 30 meters, 720P 1280×720p, only gender, figure, and motions can be identified, whereas 1080P, face, details of figure, and plate numbers can be identified.

Table 1 lists the bandwidth requirements of different personnel and equipment during the strike. Compared to the bandwidth for video transmission, the bandwidth for uploading and downloading voice and data can be ignored. Thus, table 1 only lists the statistics for downlink and uplink bandwidth required by video.

Table 1

Analysis of bandwidth requirements during the strike

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Emergency Team | Personnel and Equipment | Service(s) | Source Coding Rate | Uplink  Bandwidth | Downlink Bandwidth |
| Command Centre | 15 | compressed video broadcast |  |  | 7 MHz |
| Ordinary Police Officers | 20 | identity authentication and query |  |  |  |
| Medical Team | 5 | 1 channel D1 video upload and download | 1 Mbps | 2 MHz | 2 MHz |
| Fire Fighters | 5 | 1 channel D1 video upload and download | 1 Mbps | 2 MHz | 2 MHz |
| Negotiation Experts | 3 | high definition video download |  |  | 4 MHz |
| Strike Team | 10 | 2 channels CIF video upload and download | 0.5 Mbps | 2 MHz | 4 MHz |
| Police Helicopter | 1 | 1 channel 1080P video upload and download | 3 Mbps | 5 MHz | 1 MHz |
| Reconnaissance Robot | 10 | 1 channel 720P, 1 channel CIF video upload | 3.5 Mbps | 6 MHz |  |

The above analysis shows that to fulfill the task, uplink needs at least 17 MHz bandwidth and broadcast downlink at least 7 MHz (frequency spectrum utilization about 50%). Consider the routine work; extra 10% background spectrum width is needed. The total spectrum width is about 27 MHz. It is asserted that the more complex the incident case, the more spectrum is needed.

The bandwidth needed by broadband PPDR would be tremendously different in different scenarios. However, the typical case above shows that allocating about 30 MHz bandwidth for PPDR agencies may fulfill the requirements of PPDR general scenarios, except in disaster relief situations that require more spectrum.

ANNEX 7F

Broadband PPDR spectrum requirements in Korea

# 1 Introduction

The Government of Korea recently decided to use Public Safety LTE technologies to build nationwide Public Protection and Disaster Relief (PPDR) Broadband network for sharing among Korean PPDR agencies. According to this decision, the Ministry of Security and Public Affairs of Korea (MOSPA; <http://www.mospa.go.kr/eng/a01/engMain.do>) will lead the related project to build PPDR Broadband network from 2014. And the Ministry of Science ICT and Future Planning of Korea (MSIP; <http://english.msip.go.kr/index.do>) proposed to use 2 x 10 MHz bandwidth among the frequency spectrum of 698-806 MHz for the nationwide PPDR broadband system. This broadband network is considered to be not only used for PPDR agencies (police, fire brigade, etc.) but also carry out public broadband services for express railway[[16]](#footnote-16) and inshore vessel[[17]](#footnote-17). The PPDR network is supposed to be built as a nationwide dedicated network basically but the use of commercial network to cover area where PPDR network coverage does not reach is also being considered.

The spectrum requirements have been studied and they are based on traffic scenarios of PPDR agencies (e.g. police, fire brigade, coast guard) in PP1 (day-to-day operation), PP2 (large emergency and public event), DR (disaster) scenarios respectively. Spectrum requirements when multiple PPDR agencies jointly carry out operation are considered. Korea government is considering integrated public broadband services for PPDR, railway, and inshore vessels in a single nationwide LTE network. Thus, spectrum requirements for the integrated public broadband service are also analyzed.

In section 2, spectrum requirement calculation methodology is explained and traffic parameters of each scenario are presented. section 4 shows spectrum requirement calculation results and conclusions are drawn in section 5.

# 2 Spectrum Requirements Calculation Methodology

The spectrum requirement calculation methodology adopted in this study is based on Recommendation ITU-R M.1390 which is used for the calculation of IMT-2000 terrestrial spectrum requirements and its use to calculate spectrum requirements for PPDR is shown in PPDR in Report ITU-R M.2033. The spectrum requirement calculation procedure consists of 4 stages as in Figure 1

Figure 1

Spectrum requirements calculation procedure in Rec. ITU-R M.1390

A. Geographic Consideration

B. Market and Traffic

Consideration

C. Technical and System

Consideration

D. Spectrum Results

Consideration

In this study, the Recommendation ITU-R M.1390 methodology is considered but modified to reflect PPDR service characteristics as explained below.

**A) Geographic Considerations**

In this stage, environment type, cell area and geometry etc. are considered. Environment types are usually selected most significant contributors. In this study, dense urban and urban are considered as density and in-building and pedestrian are considered as mobility. Circular cell geometry and at least 1 km cell diameter is assumed. In general, cell diameter is used to calculate the number of user in a cell, but in this study cell diameter is irrelevant to the number of user since it is assumed that most of users are concentrated on one cell. When operation being carried out over wide area (e.g. police PP2 scenario in section 3.1), we assume cell diameter is 1 km.

**B) Market and Traffic Considerations**

In this stage, the number of user per cell is calculated from service type, population density and penetration rate. Traffic parameters (busy hour call attempt, average call duration, activity factor) for each service (e.g. voice, data, and video) are also considered and traffic per cell in Erlang unit is calculated from the traffic parameters. To calculate required channels from traffic per cell, QoS parameters (e.g. call blocking probability for circuit switched network, packet delay for packet switched network) is also considered. In this study, traffic parameters are collected from major PPDR agencies (police, fire brigade, coast guard) as given in section 3. Stages B and C to calculate traffic in kbps unit are integrated as explained in stage C.

**C) Technical and System Considerations**

The number of channel required for each application is obtained from traffic per cell and QoS parameters through Erlang B or C formula. The obtained number of channel for each application is multiplied by required bit rate of the corresponding applications. Finally, spectral efficiency parameter is considered to transform traffic into spectrum requirements.

In above stages B and C, traffic in Erlang unit are calculated into the required number of channel and transformed into traffic in kbps. In this study, for simplicity of calculation, traffic in kbps is calculated directly as follows referring to ECC Report 199.

For real time application, traffic [kbps] = number of user x call (transaction) attempt per hour x required bit rate [kbps] x call (transaction) duration per hour [min] / 60. For non-real time application [kbps] = 8 x number of user x call (transaction) attempt per hour x data [Byte] / (3 600 x 1 000).

The result of traffic in kbps obtained from this calculation method may be smaller than the result from M.1390 which takes into account QoS parameters. However, it is anticipated that the difference would not be significant because HD quality video transmission services which account for the most of spectrum is assumed to be ensued for their channel.

As a radio interface technology, LTE Release 8 is assumed and its spectral efficiency is given as follows.

Table 1

Spectral Efficiencies Assumption

|  |  |  |
| --- | --- | --- |
| Spectral Efficiency [bps/Hz] | Uplink (1x2 MIMO) | Downlink (2x2 MIMO) |
| Average | 0.735 | 1.69 |
| Cell edge | 0.024 | 0.05 |

The values of spectral efficiency differ depending on location of mobile station in a cell or transmission modes (e.g. Multicast-broadcast single frequency network (MBSFN)) for a specific application (e.g. group call)[[18]](#footnote-18). In this study, average spectral efficiency is assumed for simplicity. We also assume a cell is spitted into 3 sectors and due to the cell split total cell capacity is increased by 2.5 times considering inter-sector interference.

**D) Spectrum Results Considerations**

Traffic in kbps for each application is divided by spectral efficiency to obtain spectrum requirements. Weighting factor and adjustment factor are assumes as 1 in this study.

# 3 Traffic Parameters

Traffic parameters for broadband PPDR network in PP1 (day-to-day operation), PP2 (large emergency and public event), DR (disaster) scenarios are considered. Applications are categorized into voice, data, and video though there are some differences for each agency.

## 3.1 Individual PPDR Agency Operation

Traffic parameters for major individual PPDR agencies of police, fire brigade and coast guard are considered. Each parameter of each scenario is assumed as an average value. Traffic parameter values for PP2 and DR scenarios are presented as below to save pages.

**A) Police**

In PP1 scenario, commitment of 500 police officers in a cell for daily works such as traffic enforcement, 112 call incident responses, and special facility security are assumed.

In PP2 scenario, it is assumed that a special event occurs over diameter 4-5 km in Seoul metropolitan area and 20-30 thousand police officers are committed to the guard operation. In general, base stations are built densely in metropolitan area to avoid traffic overload in a cell. Thus, it can be assumed that cell diameter is reduced to 1 km and about 2,500 police officers are crowded within a cell[[19]](#footnote-19).

Table 2

Traffic parameters of police in PP2 scenario

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Traffic** | **Application** | **Call attempt per hour** | **Uplink** | | | | **Downlink** | | | |
| **Number of user (or group)** | **Bit Rate**  **[kbps]** | **Call duration per hour [min]** | **Activity factor** | **Number of user (or group)** | **Bit Rate [kbps]** | **Call duration per hour [min]** | **Activity factor** |
| Voice | Individual Call | 0.5 | 2500 | 45.3 | 0.5 | 0.5 | 2500 | 45.3 | 0.5 | 0.5 |
| Group Call | 1 | 250 | 45.3 | 60 | 0.05 | 250 | 45.3 | 60 | 0.05 |
| Data | Message | 10 | 250 | 1 | 0.02 | 1 | 250 | 1 | 0.02 | 1 |
| Mobile inquiry | 20 | 250 | 64 | 0.02 | 1 | 250 | 64 | 0.02 | 1 |
| 112 mobile | 5 | 25 | 64 | 0.02 | 1 | 25 | 64 | 0.02 | 1 |
| Navigation | 10 | 25 | 64 | 0.02 | 1 | 25 | 64 | 0.02 | 1 |
| GPS | 30 | 25 | 64 | 0.02 | 1 | 25 | 64 | 0.02 | 0.1 |
| ANPR | 500 | 5 | 1 | 0.02 | 1 | 5 | 1 | 0.02 | 1 |
| Video | Video Transmission | 1 | 3 | 2,000 | 60 | 1 | 3 | 2,000 | 60 | 1 |
| Video Call | 1 | 3 | 512 | 2 | 0.5 | 3 | 512 | 2 | 0.5 |
| Image Transmission | 4 | 150 | 512 | 0.02 | 1 | 150 | 512 | 0.02 | 1 |

In DR scenario, a special event in Seoul metropolitan area as PP2 scenario along with a disaster is assumed.

Table 3

Traffic parameters of police in DR scenario

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Traffic** | **Application** | **Call attempt per hour** | **Uplink** | | | | **Downlink** | | | |
| **Number of user (or group)** | **Bit Rate**  **[kbps]** | **Call duration per hour [min]** | **Activity factor** | **Number of user (or group)** | **Bit Rate [kbps]** | **Call duration per hour [min]** | **Activity factor** |
| Voice | Individual Call | 0.05 | 3,000 | 45.3 | 0.5 | 0.5 | 3,000 | 45.3 | 0.5 | 0.5 |
| Group Call | 1 | 300 | 45.3 | 60 | 0.05 | 300 | 45.3 | 60 | 0.05 |
| Data | Message | 10 | 300 | 1 | 0.02 | 1 | 300 | 1 | 0.02 | 1 |
| Mobile inquiry | 30 | 300 | 64 | 0.02 | 1 | 300 | 64 | 0.02 | 1 |
| 112 mobile | 10 | 30 | 64 | 0.02 | 1 | 20 | 64 | 0.02 | 1 |
| Navigation | 10 | 30 | 64 | 0.02 | 1 | 30 | 64 | 0.02 | 1 |
| GPS | 30 | 30 | 64 | 0.02 | 1 | 30 | 64 | 0.02 | 0.1 |
| ANPR | 500 | 5 | 1 | 0.02 | 1 | 5 | 1 | 0.02 | 1 |
| Video | Video Transmission | 1 | 3 | 2,000 | 60 | 1 | 3 | 2,000 | 60 | 1 |
| Video Call | 2 | 30 | 512 | 3 | 0.5 | 30 | 512 | 3 | 0.5 |
| Image Transmission | 5 | 30 | 512 | 0.02 | 1 | 30 | 512 | 0.02 | 1 |

**B) Fire Brigade**

In PP1 scenario, commitment of 1 fire station of average 86 fire fighters is assumed.

In PP2 scenario, it is assumed that regional fire department of 171 fire fighters carry out emergency operation in a cell.

Table 4

Traffic parameters of fire brigade in PP2 scenario

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Traffic** | **Application** | **Call attempt per hour** | **Uplink** | | | | **Downlink** | | | |
| **Number of user (or group)** | **Bit Rate**  **[kbps]** | **Call duration per hour [min]** | **Activity factor** | **Number of user (or group)** | **Bit Rate [kbps]** | **Call duration per hour [min]** | **Activity factor** |
| Voice | Individual Call | 0.2 | 171 | 45.3 | 0.39 | 0.5 | 171 | 45.3 | 0.39 | 0.5 |
| Group Call | 1 | 19 | 45.3 | 60.00 | 0.075 | 19 | 45.3 | 60.00 | 0.075 |
| Data | SMS | 1.5 | 19 | 1 | 0.02 | 1 | 19 | 1 | 0.02 | 1 |
| MMS | 1.5 | 19 | 520 | 0.02 | 1 | 19 | 520 | 0.02 | 1 |
| Internet Access | 2 | 22 | 384 | 0.21 | 1 | 22 | 384 | 1.05 | 1 |
| Sensor | 360 | 18 | 76 | 0.02 | 1 | 22 | 76 | 0.02 | 1 |
| GPS | 360 | 34 | 76 | 0.02 | 1 | 22 | 76 | 0.02 | 1 |
| Video | Image(SD) | 0.2 | 171 | 512 | 0.03 | 1 | 171 | 512 | 0.03 | 1 |
| Video(HD) | 1 | 1 | 2,000 | 60 | 1 | 1 | 2,000 | 60 | 1 |
| Individual Call | 0.2 | 171 | 512 | 0.39 | 0.5 | 171 | 512 | 0.39 | 0.5 |
| Group Call | 1 | 9.5 | 512 | 60 | 0.075 | 9.5 | 512 | 60 | 0.075 |

In DR scenario, multiple regional fire departments of 685 fire fighters come together to carry out emergency operation in a cell.

Table 5

Traffic parameters of fire brigade in DR scenario

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Traffic** | **Application** | **Call attempt per hour** | **Uplink** | | | | **Downlink** | | | |
| **Number of user (or group)** | **Bit Rate**  **[kbps]** | **Call duration per hour [min]** | **Activity factor** | **Number of user (or group)** | **Bit Rate [kbps]** | **Call duration per hour [min]** | **Activity factor** |
| Voice | Individual Call | 0.2 | 685 | 45.3 | 0.39 | 0.5 | 685 | 45.3 | 0.39 | 0.5 |
| Group Call | 1 | 76 | 45.3 | 60.00 | 0.075 | 76 | 45.3 | 60.00 | 0.075 |
| Data | SMS | 3 | 76 | 1 | 0.02 | 1 | 76 | 1 | 0.02 | 1 |
| MMS | 3 | 76 | 520 | 0.02 | 1 | 76 | 520 | 0.02 | 1 |
| Internet Access | 2 | 30 | 512 | 0.39 | 1 | 30 | 512 | 1.95 | 1 |
| Sensor | 360 | 70 | 76 | 0.02 | 1 | 30 | 76 | 0.02 | 1 |
| GPS | 360 | 137 | 76 | 0.02 | 1 | 30 | 76 | 0.02 | 1 |
| Video | Image(SD) | 0.2 | 685 | 512 | 0.03 | 1 | 685 | 512 | 0.03 | 1 |
| Video(HD) | 1 | 2 | 2,000 | 60 | 1 | 2 | 2,000 | 60 | 1 |
| Individual Call | 0.2 | 685 | 512 | 0.39 | 0.5 | 685 | 512 | 0.39 | 0.5 |
| Group Call | 1 | 38 | 512 | 60.00 | 0.075 | 38 | 512 | 60.00 | 0.075 |

**C) Coast Guard**

In PP1 scenario, 1 coast guard vessels are committed to respond vessel failure or to transport emergency patient of island area.

In PP2 scenario, 10 coast guard vessels are committed to carry out searching operation, to respond to marine oil spill, ship fire and flood.

Table 6

Traffic parameters of coast guard in PP2 scenario

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Traffic** | **Application** | **Call attempt per hour** | **Uplink** | | | | **Downlink** | | | |
| **Number of user (or group)** | **Bit Rate**  **[kbps]** | **Call duration per hour [min]** | **Activity factor** | **Number of user (or group)** | **Bit Rate [kbps]** | **Call duration per hour [min]** | **Activity factor** |
| Voice | Individual Call | 0.5 | 300 | 45.3 | 0.5 | 0.5 | 300 | 45.3 | 0.5 | 0.5 |
| Group Call | 1 | 10 | 45.3 | 60 | 0.05 | 10 | 45.3 | 60 | 0.05 |
| Data | Message | 2 | 10 | 520 | 0.02 | 1 | 10 | 520 | 0.02 | 1 |
| Paging | 1 | 300 | 1 | 0.02 | 1 | 300 | 1 | 0.02 | 1 |
| Location data | 120 | 300 | 56 | 0.01 | 1 |  |  |  |  |
| Video | Video(HD) | 2 | 10 | 512 | 0.2 | 0.5 | 10 | 512 | 0.2 | 0.5 |
| Group Call | 1 | 2 | 2,000 | 60 | 1 |  |  |  |  |

In DR scenario, 50 coast guard vessels are committed to carry out searching operation or to respond to large scale marine oil spill, ship fire and sinking accident.

Table 7

Traffic parameters of coast guard in DR scenario

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Traffic** | **Application** | **Call attempt per hour** | **Uplink** | | | | **Downlink** | | | |
| **Number of user (or group)** | **Bit Rate**  **[kbps]** | **Call duration per hour [min]** | **Activity factor** | **Number of user (or group)** | **Bit Rate [kbps]** | **Call duration per hour [min]** | **Activity factor** |
| Voice | Individual Call | 0.5 | 1,500 | 45.3 | 0.5 | 0.5 | 1,500 | 45.3 | 0.5 | 0.5 |
| Group Call | 1 | 50 | 45.3 | 60 | 0.05 | 50 | 45.3 | 60 | 0.05 |
| Data | Message | 3 | 50 | 520 | 0.02 | 1 | 50 | 520 | 0.02 | 1 |
| Paging | 1 | 1,500 | 1 | 0.02 | 1 | 1,500 | 1 | 0.02 | 1 |
| Location data | 120 | 1,500 | 56 | 0.01 | 1 | 1,500 | 56 |  |  |
| Video | Video(HD) | 2 | 50 | 512 | 0.3 | 0.5 | 50 | 512 | 0.3 | 0.5 |
| Group Call | 1 | 3 | 2,000 | 60 | 1 |  |  |  |  |

## 3.2 Multiple PPDR Agencies Operation

In case of large emergency, there would be a case that multiple PPDR agencies carry out joint operation to respond emergency. In this study, a gym collapse incident occurred at Gyeongju, Korea in Feb. 2014 is considered. Total number of committed responder is 1,448 which consist of 788 fire fighters, 500 police officers, 80 local government officials and 80 soldiers.

Table 8

Traffic parameters of multiple agencies operation scenario

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Traffic** | **Application** | **Call attempt per hour** | **Uplink** | | | | **Downlink** | | | |
| **Number of user (or group)** | **Bit Rate**  **[kbps]** | **Call duration per hour [min]** | **Activity factor** | **Number of user (or group)** | **Bit Rate [kbps]** | **Call duration per hour [min]** | **Activity factor** |
| Voice | Individual Call | 0.1 | 1,448 | 45.3 | 0.39 | 0.5 | 1,448 | 45.3 | 0.39 | 0.5 |
| Group Call | 1 | 145 | 45.3 | 60 | 0.075 | 145 | 45.3 | 60 | 0.075 |
| Data | SMS | 3 | 145 | 1 | 0.02 | 1 | 145 | 1 | 0.02 | 1 |
| MMS | 3 | 145 | 520 | 0.02 | 1 | 145 | 520 | 0.02 | 1 |
| Internet Access | 2 | 30 | 512 | 1 | 1 | 30 | 512 | 20 | 1 |
| Sensor | 360 | 70 | 76 | 0.02 | 1 | 70 | 76 | 0.02 | 0.1 |
| GPS | 360 | 145 | 76 | 0.02 | 1 | 145 | 76 | 0.02 | 0.1 |
| Video | Image(SD) | 1 | 64 | 512 | 0.02 | 1 | 64 | 512 | 0.02 | 1 |
| Video(HD) | 1 | 3 | 2,000 | 60 | 1 | 3 | 2,000 | 60 | 1 |
| Video(SD) | 1 | 3 | 1,000 | 60 | 1 | 3 | 1,000 | 60 | 1 |
| Individual Call | 0.2 | 788 | 512 | 0.39 | 0.5 | 788 | 512 | 0.39 | 0.5 |
| Group Call | 1 | 39 | 512 | 60 | 0.075 | 39 | 512 | 60 | 0.075 |

## 3.3 PPDR operation with other public broadband services

Traffic scenario of integrated public broadband service where not only PPDR but also other public broadband services (e.g. for railway or inshore vessels) is provided. To calculate spectrum requirement of integrated service, traffic scenarios can be considered separated by geographical service area of land and sea. For land area, PPDR and railway broadband services, for sea area, PPDR and inshore vessel broadband services are used simultaneously. Spectrum requirement are determined so as to meet spectrum requirements of all service areas.

In this study, an incident near Seoul station is assumed for land area scenario and traffic parameters of multiple PPDR agencies as given in section 3.2 is adopted. For sea area scenario, ship sinking near Busan harbor is considered. In this scenario, PPDR agency officers in harbor area and coast guard vessels in sea are assumed and broadband service for in shore vessel is also provided simultaneously.

# 4 Spectrum Requirements

Tables 9 and 10 show that for individual PPDR agency operation 2x5 MHz would be sufficient for PP1, PP2, DR scenarios.

Table 9

Uplink spectrum requirements for individual PPDR agency operation [MHz]

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Agency | Police | | | Fire Brigade | | | Coast Guard | | |
| Scenario | PP1 | PP2 | DR | PP1 | PP2 | DR | PP1 | PP2 | DR |
| Voice | 0.087 | 0.437 | 0.524 | 0.038 | 0.211 | 0.152 | 0.003 | 0.028 | 0.139 |
| Data | 0.036 | 0.060 | 0.102 | 0.250 | 0.322 | 0.983 | 0.035 | 0.165 | 0.843 |
| Video | 0.007 | 3.326 | 3.695 | 1.323 | 1.460 | 4.206 | 1.089 | 2.186 | 3.335 |
| Total | 0.131 | 3.822 | 4.321 | 1.611 | 1.992 | 5.340 | 1.127 | 2.379 | 4.316 |

Table 10

Downlink spectrum requirements for individual PPDR agency operation [MHz]

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Agency | Police | | | Fire Brigade | | | Coast Guard | | |
| Scenario | PP1 | PP2 | DR | PP1 | PP2 | DR | PP1 | PP2 | DR |
| Voice | 0.038 | 0.190 | 0.228 | 0.016 | 0.092 | 0.066 | 0.001 | 0.012 | 0.060 |
| Data | 0.015 | 0.023 | 0.003 | 0.150 | 0.548 | 0.352 | 0.000 | 0.001 | 0.011 |
| Video | 0.008 | 1.446 | 1.607 | 0.575 | 0.635 | 1.829 | 0.000 | 0.004 | 0.030 |
| Total | 0.061 | 1.660 | 1.838 | 0.742 | 1.274 | 2.247 | 0.001 | 0.017 | 0.102 |

In case of multiple PPDR agencies operation, 7.4 MHz and 5.2 MHz are required for uplink and downlink respectively thus 2x10 MHz should be provided for this case.

Table 11

Spectrum requirements for multiple PPDR agencies operation [MHz]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Services | Voice | Data | Video | Total |
| Uplink | 0.28 | 1.202 | 5.869 | 7.351 |
| Downlink | 0.122 | 2.477 | 2.552 | 5.151 |

When PPDR service is integrated with other public broadband service, spectrum should be provided to cover all areas (both land and sea). From Table 12, it is shown that broadband services in each service area can be supported by using 2x10 MHz spectrum.

Table 12

Spectrum requirements for PPDR operation with other public broadband services [MHz]

|  |  |  |  |
| --- | --- | --- | --- |
| Service Area | Service | Uplink | Downlink |
| Land Area | PPDR | 7.35 | 5.15 |
| Railway Broadband\* | 2.05 | 1.85 |
| Sub Total | 9.4 | 7 |
| Sea Area | Coast Guard | 4.32 | 0.1 |
| Inshore Vessel Broadband\* | 4.89 | 4.21 |
| PPDR | 0.35 | 0.62 |
| Sub Total | 9.56 | 4.93 |

\* Analysis of spectrum requirements for railway and inshore vessel broadband service is presented in separate report, which will be published in the near future.

# 5 Conclusion

For individual PPDR agency operation, it is shown that 2x5 MHz spectrum would be sufficient for all scenarios. In case of multiple PPDR agencies operation, 2x10 MHz should be provided. Furthermore, in case of integrated public broadband service, services in each service area can be supported within the range of 2x10 MHz spectrum. Thus, when comparing with individual spectrum use for each public broadband service where total required spectrum would be 2x20 MHz, it can be shown that spectrum can be saved by 2x10 MHz. Furthermore, considering that PPDR spectrum would be under utilized in day-to-day situation, integration with other public broadband services would be beneficial in terms of efficient spectrum use.

Spectrum requirement in above are analyzed based on specific traffic scenarios and average spectral efficiency thus spectrum deficiency may occur in severe disaster situations. Specifically, HD quality video transmission identified in demand among Korean PPDR agencies requires considerable spectrum and it is anticipated that the demand will increase due to the trend of price reduction of high quality video transmission equipments. Also, spectrum needs may be increased when an incident scene is located near cell edge where spectral efficiency is significantly low. In this case, spectrum usage can be limited to a certain level referred to as spectrum cap in ECC Report 199 but users may be subject to service quality degradation.

To respond to spectrum deficiency, PPDR agencies should take countermeasures to secure additional communication capacity. For example, a mobile cell site can be installed near cell edge to secure additional cell capacity and ad-hoc point-to-point or point-to-multi point networks using frequency such as 5 GHz band recommended as broadband PPDR frequency band in APT/AWF/REC-01(Rev.1) also can be built to offload heavy traffic due to a hot spot area. Roaming to a commercial network also can be considered when there is service provision agreement between PPDR agencies and commercial wireless broadband service provider.

Annex 8

Study on deployment of broadband and narrowband integrated  
PPDR network in China

# 1 Background

The existing narrowband PPDR network has been deployed in many countries, which can supply mission critical voice and short message services for PPDR agency. It might be uneconomical to abandon the existing narrowband PPDR network completely. Meanwhile, it will be a huge investment to build a new nationwide broadband PPDR network based on LTE technology. Therefore, the broadband and narrowband integrated network deployment solution which is a cost-efficient, operable and quickly applied deployment mode need to be studied.

For example, in China, 12,000 narrowband base stations have been built and well-covered the whole nationwide to provide the PPDR applications for police and fire department. Dedicated broadband PPDR network might require several times or even more of base stations than narrow band network, with the approximate spectrum and technology as IMT. In the short-term, it would be a tremendous load for Chinese administration and PPDR agency to afford the huge investment to achieve the full coverage of broadband PPDR network at once.

The advantages of broadband and narrowband integrated network deployment solution areas following:

*Make full use of existing backbone network and mature technology, protecting the original investment.* The existing narrowband system can still meet the needs of PPDR requirements in voice and short message. Its equipment and operational mode are quite mature, which could be transplanted to the emerging broadband system. It can still be used rather than being replaced as a whole. If the integration with broadband system is achieved in the core network, the existing narrowband system resources can be reused to protect the original investment.

*Have more flexible and practical investment options.* With the hot spots and the key parts of the city being deployed firstly, the administration’s budget might be well met by a step-to-step investment, avoiding the large one-off cost.

*Obtain by natural robust invulnerability ability*. In the case of disaster recovery, the two radio access networks in parallel may back up each other and it may improve the invulnerability of one single system.

# 2 Deployment Schemes

The unified trunking core network is adopted in the broadband and narrowband integrated network with unified service procedures, interfaces, numbering of user and multi-mode terminals, which supports the broadband and narrowband trunking services (voice, data, image, multimedia services etc.). The overall architecture is shown below as Figure 1.

Figure 1

The architecture of broadband and narrowband integrated network



The network architecture includes four layers: Terminal, base station, Switch control platform, Dispatching & network management platform.

Terminal layer includes various terminals, e.g. Multi-mode terminal, Single-mode terminal, Data terminal, Vehicle-carried terminal, which support the functions of video and voice codec, channel coding, modulation-demodulation, service applications, and human-machine interface.

Base station layer includes broadband and narrowband base stations to process signalling and data of PPDR functions (radio resource management, scheduling, user access control, user authentication, etc.). It allows the access of terminals with different modes and connects to the same trunking core network.

Switch control platform includes the unified trunking core network elements to provide the PPDR service control (service registration, service establishment and management, data routing and transmission, management of user information, etc.) and PPDR service traffic transfer including voice, video, and data. It supports the access of various base stations (e.g. narrowband base station, broadband base station), and interface with other communication systems (e.g. public network, satellite).

Dispatch & network management platform includes dispatch console and network management server. The major functions include dispatching and command, user service record, network management, etc. which provide the interfaces for manual operations.

# 3 Operational procedure

On the circumstance that narrowband PPDR network had been build and fulfilled PPDR services, the integrated network operational procedure is as following.

Phase 1: some broadband PPDR sites are built and cover the hot spots separately; these distributed sites only offer broadband data services.

Phase 2: the broadband PPDR sites are deployed contiguously and cover all hot spots and large cities, working together with narrowband PPDR sites to offer all kinds of voice, video and data services, which play an important role in PPDR communication. But some rural, mountain and undeveloped areas may only be covered by narrowband.

Phase 3: the broadband sites cover the whole area of the country to offer all kinds of services. However, considering the backup and disaster recovery invulnerability, the narrow communication sites would support the narrow voice and low rate service for a period of time.

ANNEX 9

Information from international standardisation organisation on activities  
with regards to public protection and disaster relief (PPDR)

**ATIS** would like to draw attention to two ATIS WTSC Issues (i.e., work items) concerning PPDR:

– Issue P0032, Support of Public Safety Requirements in LTE Networks.

– Issue P0039, Public Safety Mission Critical Push to Talk (PTT) Voice Interoperation between Land Mobile Radio (LMR) and Long Term Evolution (LTE) Systems.

Furthermore, ATIS is working on activities related to PPDR as shown below:

| **Issue #** | **Title** | **Output** |
| --- | --- | --- |
| P0018 | Proposed Joint ATIS/TIA Standards on Commercial Mobile Alerts Service (CMAS) | J-STD-100 J-STD-101 |
| [P0019](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0019.doc) | ATIS Standard on Commercial Mobile Alerts Service (CMAS) Specification for GSM/UMTS Using Cell Broadcast Service | ATIS-0700006 |
| [P0021](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0021.doc) | Canadian LAES Location Reporting | ATIS-0700009 |
| [P0024](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0024.doc) | ATIS Implementation Guidelines and Best Practices for GSM/UMTS Cell Broadcast Service | ATIS-0700007 |
| [P0026](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0026.doc) | CMAS via Evolved Packet System (EPS) Public Warning System (PWS) | ATIS-0700010 |
| [P0027](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0027.doc) | Cell Broadcast Entity (CBE) to Cell Broadcast Centre (CBC) Interface Protocol | ATIS-0700008 |
| [P0028](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0028.doc) | Certification and Testing of the CMAS C-Interface | J-STD-102 |
| [P0030](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0030.doc) | Implementation of 3GPP Common IMS Emergency Procedures for IMS Origination and ESInet/Legacy Selective Router Termination | ATIS-0700015 |
| [P0031](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0031.docx) | CMAS C1 Interface between PBS and CMSP Gateway | J-STD-101.a |
| [P0033](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0033.docx) | Support for Delivery of Spanish Language Commercial Mobile Alerts System (CMAS) Alerts | ATIS-0700012 ATIS-0700013  ATIS-0700014 |
| [P0034](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0034.docx) | Automating Location Acquisition for Non-Operator-Managed Over-the-Top VoIP Emergency Services Calls | *Under development* |
| [P0037](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0037.docx) | SMS-to-9-1-1 | J-STD-110 |
| [P0038](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0038.docx) | Errata for ATIS and Joint ATIS/TIA Standards on Commercial Mobile Alerts Service (CMAS) | ATIS-0700006.a ATIS-0700010.a J-STD-100.a J-STD-101.a J-STD-101.b J-STD-102.a |
| [P0040](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0040.docx) | Canadian Commercial Mobile Alerts Service (CMAS) | *Under development* |
| [P0041](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0041.docx) | Commercial Mobile Alerts Service (CMAS) International Roaming | *Under development* |
| [P0042](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0042.docx) | CMRS and TCC Provider Implementation Guidelines for the Joint ATIS/TIA SMS to 911 Standard (J-STD-110) | J-STD-110.01 |
| [P0043](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0043.docx) | Implementability Fixes for J-STD-110 | J-STD-110.a |
| [P0044](http://www.atis.org/0160/_Com/Docs/IssueStatements/P0044.doc) | Extending ATIS-0700015 to address Multimedia Emergency Services (MMES) | *Under development* |

CCSA has approved 4 Technical Specifications for B-TrunC System, which can support PPDR communications. The Technical Requirement for B-TrunC and Technical Specification for Radio interface have been published by Ministry of Industry and Information Technology of the People’s Republic of China.

1. YD/T 2689-2014, Technical Requirement for B-TrunC System (Phase 1). The scope of the technical specification is the services, scenario, functions, performance, architecture and interfaces for B-TrunC System. The technical specification is already approved by CCSA and published by Ministry of Industry and Information Technology of the People’s Republic of China.
2. YD/T 2741-2014, Technical Specification for Uu-T Interface of B-TrunC System (Phase 1). The scope of the technical specification is the physical layer protocol, Medium Access Control protocol, Radio Link Control protocol, Packet Data Convergence Protocol and Radio Resource Control protocol of radio interface for B-TrunC System. The technical specification is already approved by CCSA and published by Ministry of Industry and Information Technology of the People’s Republic of China.
3. Technical Specification for Interface between UE and Trunking Core Network of B-TrunC System (Phase 1). The scope of the technical specification is the high layer protocol of the interface between UE and Trunking Core Network. The technical specification is already approved by CCSA.
4. Technical Specification for Interface between Trunking Core Network and Dispatcher of B-TrunC System (Phase 1). The scope of the technical specification is the application layer protocol of the interface between Trunking Core Network and Dispatcher. The technical specification is already approved by CCSA.

For the detailed specifications, please refer to the link below:

<http://www.ccsa.org.cn/english/show_article.php?categories_id=737fa209-91aa-9568-4f4a-46b7e24c3a99&article_id=cyzx_f8ee005b-8736-e347-4737-5365989a05f6>

ANNEX 10

Using higher power terminals to increase cell coverage in rural areas

High power user equipment (HPUE) can be deployed in rural areas for coverage extension purposes. The studies conducted for 3GPP Release 11 resulted in the development of specifications for a new power class of device (Power Class 1 UE 31 dBm) for ITU-R Region 2 in the 700 MHz Band. Coexistence studies were performed to make sure that when two systems are deployed in the same geographical area and in adjacent spectrum there would be no interference. The results of this analysis can be extended to any other bands where HPUE can be potentially deployed. Intuitively, as long as the absolute OOBE of the HPUE is kept the same as the power class 3 UE 23 dBm, the victim receiver does not see any difference in terms of the interference between a HPUE and a power class 3 UE.

In a PPDR network, it is possible that in urban areas, the system is designed for power class 3 UE and in rural areas; the system is designed for HPUE. In this case, the cost can be reduced significantly while still providing necessary area/population coverage. It is calculated that the coverage of an LTE eNodeB could be increased by 300% through the use of HPUE.

This deployment scenario creates a system that has mixed power class UEs. However, this will not cause any problems and is well under the scope of 3GPP EUTRAN specification due to power control. Power control implies for a given service or throughput the network will set the maximum transmit power. So for a similar that service/throughput the network will define the same transmit power irrespective if the device is a higher power (31 dBm) or standard power (23 dBm).

A10.1 Link budget calculations for higher power LTE UE to meet PPDR broadband requirements of developing countries

The estimated increase in coverage using a higher transmit power is shown below assuming the maximum LTE cell radius to support a required 256 kbps UL throughput. The required SINR from this service is chosen from 3GPP TS36.104 specification. The RF environmental assumptions are for a rural forested environment which is mapped to a Hata suburban propagation model used for the cell radius calculation.

Note that we have assumed the vehicular antenna gain to be –1 dBd as indicated in TIA TSB‑88.1‑C. Typical mobile cable loss is 2 dB and therefore the aggregate gain is   
(–1 dBd + 2.1-2) = –0.9 dBi.

So using a HPUE will provide 300% increase in coverage area and will also reduce the number of sites required by roughly 66%. Additionally this would provide the ability to re-use existing high tower rural antenna sites. This analysis on link budget is similar to the other contributions in 3GPP that shows the benefit of a higher UE power class in terms of increase cell radius and higher cell throughput.

Table A10-1

Example link budget to show impact of higher UE transmit power (23 dBm vs. 31 dBm)



A10.2 Coexistence issues for high power LTE systems

A10.2.1 Co-existence of HPUE with adjacent system

When two systems are deployed in the same geographical area and in adjacent spectrum, coexistence issues needs to be studied to make sure both systems are not causing harmful interference to each other. Typical interference mechanisms considered are Transmitter Out‑Of‑Band emission (OOBE), Receiver Blocking.

– Interfering Transmitter OOBE: The OOBE sums with the thermal noise floor of the victim receiver. The increase in noise power in the receiver requires an equal increase in desired signal power to maintain equivalent signal-to-noise ratio (SNR) and thus causes a reduction in the sensitivity of the victim receiver. The interference is due to noise that is on-channel to the victim receiver and there is nothing that can be done at the victim receiver to mitigate interference due to OOBE.

– Victim Receiver Blocking: The interfering in-band Tx power itself can block reception of the desired signal or degrade sensitivity of the victim handsets or base stations.

Figure A10-1

Coexistence of HPUE with adjacent system

**Energy the Receiver captures**

**from channels other than its**

**own can cause overload**

**effects such as**

**Blocking**

**Transmitter emissions into**

**other channels are out of Band Emissions (OOBE)**

Out of Band

Emission

Receiver

Overload

Out of Band

Emission

**Interfering**

**Transmitter**

**(System A)**

**Victim**

**Receiver**

**(System B)**

Receiver

Overload

Out of Band

Emission

Receiver

Overload

Out of Band

Emission

Receiver

Overload

To analyze the system impact of the victim system due to adjacent system interference, complex simulations are usually employed. In 3GPP, extensive studies have been conducted for various system coexistence issues, the results were used to derive RF requirements. The simulation methodology is described in 3GPP TR 36.942(Radio Frequency (RF) system scenarios).

During the B14 LTE HPUE WI study phase, comprehensive simulations have been conducted by the industry to study the interference issue between B14 HPUE and adjacent LTE system’s eNBs, both due to OOBE and due to Rx blocking. Four companies have run the Monte-Carlo simulations to analyze the interference impact from HPUE to adjacent LTE systems and the results are shown in Figure below (based on the results reported in 3GPP TR36.837).

Both the average throughput degradation and cell edge user (5-percentile) throughput degradation were simulated, and results are compared with the impact from a baseline system with 23 dBm UEs. Table below shows the delta ACLR needed for HPUE in order to achieve the similar impact to B13 700 MHz systems from power class 3 (23 dBm) UEs.

It can be seen that due to the deployment difference (HPUE are mainly deployed in rural area with bigger cell radius), an ACLR value increase of up to 6 dB is enough for HPUE to co-exist with adjacent LTE system for different type of network power control algorithms. However, it was eventually decided that the ACLR of HPUE should be 7 dB higher (37 dB) than the power class 3 UE (30 dB). In the meantime, HPUE shall have the same absolute output RF spectrum emission requirement as a power class 3 UE (see 3GPP TS 36.101 sub clause 6.6).

Figure A10-2

Impact of HPUE to adjacent systems (based on results reported in TR36.837)

|  |  |
| --- | --- |
|  |  |

Table A10-2

B14 HPUE (+31dBm) ACLR offset value (dB) to achieve similar interference as the baseline

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Power control Parameters | Company | Power control set 1A | | Power control set 2A | |
| Average throughput | 5% CDF | Average throughput | 5% CDF |
| **1A/2A** | Ericsson/ST-Ericsson | <5 | <5 | <5 | <5 |
| **1A/2A** | EADS | 5 | 3.6 | 2 | 4 |
| **1A/2A** | General Dynamics Broadband | 4.6 | 5.4 | 2.9 | 3.3 |
| **1A/2A** | Motorola Solutions | 4.5 | 3.5 | 3 | 3 |

(Table 5.4.2.6-2 from 3GPP TR 36.837)

The results of this analysis can be extended to any other bands where HPUE can be potentially deployed. Intuitively, as long as the absolute OOBE of the HPUE is kept the same as the power class 3 UE, the victim receiver does not see any difference in terms of the interference between a HPUE and a power class 3 UE. The blocking level at the victim receiver is higher for HPUE; however, it is still well under the tolerance of LTE eNBs.

A10.2.2 Co-existence of HPUE in the same system

HPUE is usually deployed in rural areas for coverage extension purpose. In a PPDR network, it is possible that in urban areas, the system is designed for power class 3 UE and in rural areas; the system is designed for HPUE. In this case, the cost can be reduced significantly while still providing necessary area/population coverage.

This deployment scenario creates a system that has mixed power class UEs. However, this will not cause any problems and is well under the scope of 3GPP EUTRAN specification due to power control. Power control implies for a given service or throughput the network will set the maximum transmit power. So for a similar that service/throughput the network will define the same transmit power irrespective if the device is a higher power (31 dBm) or standard power (23 dBm).

In this case higher power > 23 dBm would only be used at the edge of the cell to provide an increase in coverage/throughput.

Additionally, the maximum transmit power of a UE is always under the control of the network in a per cell basis, i.e., the network can signal different maximum allowed transmit power of the UE for each cell irrespective of the Power Class of the device. When a HPUE move from rural into urban area, it will obey the max power rule set by the urban cell. Similarly, if a power class 3 UE move to rural areas, it can switch to power class 1 mode if the network allows. So in this case the network can limit the maximum power of any device in its network on a per cell bases.

ANNEX 11

37 functional requirements for the nationwide mission critical PPDR  
wireless communication System

Table A11-1

**Table of functional requirements for the nationwide mission critical PPDR broadband  
wireless communication System:**

**\*\* Note: 37 functional requirements are generated from 5 Generic Requirements: Survivability and Resilience (7), Capability to Respond Disaster (10), Security (5), Interoperability (3) and Operational Efficiency (12)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Functional Requirements)** | **Specifics** | **Importance1** | | |
| **PP** | **PP** | **DR** |
| **-1** | **-2** |
| *1. Survivability and Resilience* | | | | |
| Direct mode Operation | Function for Direct mode operation between mobile terminals/ Repeater and gateway Functions in order to achieve survivability of mobile terminal in any unexpected circumstances | H | H | H |
|
|
| Mobility Support | Function that enables mobile terminal to sustain established bearer path in order to sustain service continuity thus to maintain stable service status in any system coverage area | H | H | H |
|
| Capability to respond to burst call attempt | Function that provides capability to respond to burst call attempt in order to support stable system operation thus ultimately to prepare the unexpected highest demand of call situation, i.e., disaster | H | H | H |
|
| Standalone mode operation of base station | Function that provides base station with stand-alone operation mode in which base station provides communication bearer path in case of any possible failure in mobile backhaul and switching centre in order to support group communication function in corresponding area | M | M | M |
|
|
| Duplication/transport media management | Function that provides automatic switch-over of transport network media (Microwave, satellite and other IP networks) for switching centre, base station and access network in case of any failure and stable provision of seamless communication service | M | ,M | M |
|
|
| Communication service quality | Function that satisfies voice, video and data service provided by domestic professional technical group under the stable provision of seamless communication service | M | M | M |
|
|
| Backup Restoration | Function that provides automatic back-ups and restoration of important data in management system (Group management information, call attempt history and failure logs ) in order to support remote situation recognition around mobile terminal e.g., hijacking by system management node (Dispatcher) | M | M | M |
|
|
| *2. Capability to respond disaster* | | | | |
| Individual Call | Function that provides one-to-one communication by using of callee ID in order to give a call to a specific person | H | H | H |
|
|

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Group call | Function that provides one-to-many communication. This function provides effective communication capability that enable group based communication in order to provide effective communication service in specific circumstances e.g. mutual cooperation or assessing situation | H | H | H |
|
| Area selection | Function that all mobile terminals registered in specific area (single or multiple base stations) shall be selected and called by use of system management interface in order to respond fast in specific regional catastrophe | H | H | H |
|
| Dynamic Group Number Assignment | Function that creates new communication group, delete communication group and re-program existing communication group remotely according to situational change | H | H | H |
|
| Call Interruption | Function that suspend on-going group call to join the conversation in order to enable high priority intervention call by dispatcher | H | H | H |
|
| Emergency call | Function that provides prioritized network access by use of special UI on mobile terminal e.g. pushing emergency button in order to provide immediate communication service without waiting time | H | H | H |
|
| Identification of mobile terminal location | Function that provides location of mobile terminal by use of satellite or base station location measurement technology in order to identify the location of mobile terminal in any situation | H | H | H |
|
| Video call | Function that provides one-to-one or one-to-many video call for the rapid situation recognition and response | M | M | M |
|
| Ambient Listening | Function that provides remote listening of mobile terminals whose transmitter was turned on by remote system manager (or dispatcher) in order to support remote situation recognition around mobile terminal e.g. hijacking by system management node (or dispatcher) | M | M | M |
|  |
| Multiple group communication reception by single mobile terminal | Function that provides single mobile terminal with reception of multiple group communication in order to support situation monitoring function for multiple group communications | M | M | M |
|
| *3. Security* | | | | |
| Validation or barring the use of mobile terminal | Function that authenticates or invalidates the use of mobile terminal in order to sustain security in case of stolen/missing terminals) | H | H | H |
|
| Encryption | Function that eavesdrops or wiretaps by encrypting the bearer path in order to achieve communication security in case of specific events and talks between major commanders | H | H | H |
|
|
| Authentication | Function that provides valid communication service to authenticated users with registration of mobile terminal/users | H | H | H |
|
|
| Provision of security enforcement interface | Function that provides standardized interface to inter-work with external security equipment in order to conform the security standard of law and institution | H | H | H |
|
|
| Integrated Security Control | Function that provides integrated security control e.g. intrusion detection, prevention against security attack in order to protect from possible hacking attack in order to provide integrated security monitoring system to respond to any security issues | H | H | H |
|
| *4. Interoperability* | | | | |
| Openness/conformity of standards | Function that provides inter-working interface specification and conform domestic/international standards to achieve interoperability between different vendor’s system | M | M | M |
|
| Call establishment | Function that provides minimal call establishment and delay time to support interoperability between different vendor’s systems | M | M | M |
|
| Network | Function that provides interoperability with legacy PPDR network (UHF/VHF/TRS …) and public network (PSTN, PSDN and Internet) in order to support information sharing | M | M | M |
| interconnectivity |
|  |
| *5. Operational efficiency* | | | | |
| Rapid propagation of situation messages | Function that provides message ( included data) broadcasting by system management (dispatcher) or mobile terminal for rapid propagation of situation status | H | H | H |
|
| Security of communication capacity | Function that provides security of subscriber capacity required for stable PPDR operation of telecommunication network in various situations | H | H | H |
|
| Full duplex multi group communication | Function that provides simultaneous calls with different multiple mobile terminals in order to support conference call in any situation | M | M | M |
|
| Data service | Function that supports data communication service while in single/multiple calls in order to support seamless communication capability | M | M | M |
| Recording of voice/video call | Function that provides recording of specific voice/video call in order to secure the evidence in any cases of incident/accident | M | M | M |
| Caller ID representation | Function that provides caller identification by use of ID appearing on any display unit in order to identify any communication-protocol-related offense case by use of caller ID | M | M | M |
|
| Remote network management | Function that provides remote management function to authenticate/register mobile terminal as well as network O&M in order to provide efficient network management function e.g. remote programming of mobile terminal | M | M | M |
| Network Management system | Function that provides centralized network management systems which give the overall information of network operation in order to provide the management functions e.g. system control, securing of account and security, resolve of obstacle and performance | M | M | M |
|
| Reporting function | Function that provides automatic report generation function about subscriber information, traffic statistics and alarm history in order to provide systematic response to any cases | M | M | M |
|
| Call capacity enhancement | Function that provides the enhancement communication capacity in the system and base stations when insufficient communication capacity issue arises in specific area in disaster situation | M | M | M |
|
| Broadband/Network coverage | Function that provides enhanced throughput speed and nationwide network coverage in order to establish mobile broadband and secure nationwide network coverage | M | M | M |
|
|
| Frequency Multiplexing | Function that provides high communication capacity in a single frequency band in order to support efficient management of limited radio frequency resource | M | M | M |
|

(1) The importance of that particular requirement 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

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1. Low Latency – very short call set up times (< 200 ms) and very limited end to end voice/data transmission delay (< 1 s). Source: ETSI TR 102 022-1. [↑](#footnote-ref-1)
2. Low Latency – very short call set up times (< 200 ms) and very limited end to end voice/data transmission delay (< 1 s). Source: ETSI TR 102 022-1. [↑](#footnote-ref-2)
3. Availability – in time (often) specified as three or four nines of availability (e.g., 99.98% or better at all times). Source: ETSI TR 102 022-1 V1.1.1 (2012-08). [↑](#footnote-ref-3)
4. Coverage (national) – defined by geography rather than population, e.g., 99% of landmass. Also see 99.5% (outdoor mobile), 65% or better (indoor mobile), 99.9% (air to ground). Source: ETSI TR 102 022-1 V1.1.1 (2012-08). [↑](#footnote-ref-4)
5. <http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP199.PDF>. [↑](#footnote-ref-5)
6. Narrowband PPDR portable radios with broadband (LTE) module are now available. [↑](#footnote-ref-6)
7. 2 Examples of the types of mobile systems can be found in Recommendations ITU-R M.1073, ITU‑R M.1457, ITU‑R M.1801, ITU‑R M.2012, and in Report ITU-R M.2014. [↑](#footnote-ref-7)
8. 4 United States Public Safety Wireless Advisory Committee, Attachment D, Spectrum Requirements Subcommittee Report, September 1996. [↑](#footnote-ref-8)
9. 5 UMTS Auction Consultative Group, A note on spectrum efficiency factors – UACG(98) 23. (<http://www.spectrumauctions.gov.uk/documents/uacg23.html>) Reference 1  SAG Report, Spectrum calculations for terrestrial UMTS, release 1.2, 12 March 1998. [↑](#footnote-ref-9)
10. 6 Source: Police Service Personnel, England and Wales, as of 31 March 1999, by Julian Prime and Rohith Sen-gupta @ Home Office, Research Development & Statistics Directorate. [↑](#footnote-ref-10)
11. 7 Includes National Crime Squad (NCS) & National criminal Intelligence Service (NCIS) civilian staffing. [↑](#footnote-ref-11)
12. 8 Not included in totals above. [↑](#footnote-ref-12)
13. See ECC Report 199 for more details on methodology used in CEPT. [↑](#footnote-ref-13)
14. Specifically Posen, Illinois was used and their MABAS (Multi-Agency Box Alarm System) “Box Card” was evaluated with interpretation from Posen PS employees. [↑](#footnote-ref-14)
15. 3GPP TS 36.104 version 11.4.0 Release 11 – Table 6.2.1. [↑](#footnote-ref-15)
16. Ministry of Land, Infrastructure and Transport of Korea has been planning a railway broadband service known as Intelligent Railway Integrated System (IRIS) which provides train safety applications including train control and monitoring. [↑](#footnote-ref-16)
17. Ministry of Oceans and Fisheries of Korea has been planning to provide ship safety broadband services primarily to inshore small vessels which are not equipped with Global Maritime Distress and Safety System (GMDSS). [↑](#footnote-ref-17)
18. The effect on spectrum requirement due to communication at cell edge area and the use of different transmission mode is discussed in other literatures such as ECC Report 199. [↑](#footnote-ref-18)
19. In LTE system, cell diameter for 700 MHz band is in the range of 2-3 km. [↑](#footnote-ref-19)