International Telecommunication Union

Emergency and Disaster relief

ITU-R Special Supplement

Radiocommunication Bureau

International Telecommunication Union

THE RADIOCOMMUNICATION SECTOR OF ITU

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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Foreword

Telecommunication is critical at all phases of disaster management. Aspects of radiocommunication services associated with disasters include, *inter alia*, disaster prediction, detection, alerting and disaster relief. In certain cases, when the "wired" telecommunication infrastructure is significantly or completely destroyed by a disaster, only radiocommunication services can be employed for disaster relief operation.

Two major tasks of the ITU-R – ensuring the effective use of the radio-frequency spectrum and studies concerning development of radiocommunication systems - concern all radiocommunication services. Moreover, the Radiocommunication Study Groups carry out studies related to the continuing development of radiocommunication systems used in disaster mitigation/relief operations and these can be found within the work programmes of the Radiocommunication Study Groups.

Disaster phases	Major radiocommunication services involved	Major tasks of radiocommunication services	Studies carried out by Radio-communication
Prediction and Detection	- Meteorological services (meteorological aids and meteorological- satellite service) - Earth exploration-satellite service	Weather and climate prediction. Detection and tracking of earthquakes, tsunamis hurricanes, typhoons, forest fires, oil leaks etc. Providing warning information	Study Group 7
Alerting	- Amateur services	Receiving and distributing alert messages	Study Group 8
	- Broadcasting services terrestrial and satellite (radio, television, etc.)	Disseminating alert messages and advice to large sections of the public	Study Group 6
	- Fixed services terrestrial and satellite	Delivering alert messages and instructions to telecommunication centres for further dissemination to public	Study Group 9 Study Group 4
	- Mobile services (land, satellite, maritime services, etc.)	Distributing alert messages and advice to individuals	Study Group 8
Relief	- Amateur services	Assisting in organizing relief operations in areas (especially when other services are still not operational)	Study Group 8
	- Broadcasting services terrestrial and satellite (radio, television, etc.)	Coordination of relief activities by disseminating information from relief planning teams to population	Study Group 6
	- Earth exploration-satellite service	Assessment of damage and providing information for planning relief activities	Study Group 7
	- Fixed services terrestrial and satellite	Exchange of information between different teams/groups for planning and coordination relief activities	StudyGroup 9 Study Group 4
	- Mobile services (land, satellite, maritime services, etc.)	Exchange of information between individuals and/or groups of people involved in relief activities	Study Group 8

ITU-R is also invited to pursue studies on the further identification of suitable frequency bands that could be used on a global/regional basis for public protection and disaster relief (PPDR), as well as on facilitating cross-border circulation of equipment intended for use in emergency and disaster relief situations - the second of these tasks being reinforced by the Tampere Convention on the provision of telecommunication resources for disaster mitigation and relief operations. Impetus for the work also comes from several Resolutions of World Radiocommunication Conferences (**Resolution 644 (WRC-2000)**, **Resolution 646 (WRC-03)**) requesting ITU-R to study aspects of radiocommunications relevant to disaster mitigation and relief operations.

The Tampere Convention

The Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations came into force 8 January 2005. The Tampere Convention calls on States to facilitate the provision of prompt telecommunication assistance to mitigate the impact of a disaster, and covers both the installation and operation of reliable, flexible telecommunication services. Regulatory barriers that impede the use of telecommunication resources for disasters are waived. These barriers include the licensing requirements to use allocated frequencies, restrictions on the import of telecommunication equipment, as well as limitations on the movement of humanitarian teams. The treaty, signed on 18 June 1998, simplifies the use of life-saving telecommunication equipment. The ITU assists in fulfilling the objectives of this Convention (see also http://www.reliefweb.int/telecoms/tampere/icet98-e.htm).

Introduction

Activities in ITU-R concerning radiocommunications for emergency and disaster relief

1. Background

Studies on radiocommunications for emergency situations and for ensuring safety of life represent a major responsibility of the ITU Radiocommunication Sector. The Radio Regulations (RR) contains numerous provisions for those services associated with distress and safety communications, such as the maritime, aeronautical and radiodetermination services. In addition, there exist many texts (ITU-R Recommendations, Reports, Handbooks) developed by the Radiocommunication Study Groups that have a direct bearing on prediction, detection and radiocommunications relating to disasters and emergencies. These address aspects of spectrum management, such as the protection of safety services from unwanted emissions, as well as providing information on the technical characteristics, spectrum requirements, channelling plans and operational aspects of systems used by services that play a safety of life role.

Following the tsunami in south-east Asia in December 2004, steps have been taken to promote the importance of studies within the Radiocommunication Study Groups which have a bearing on radiocommunications needed in the event of natural disasters. To this end, a letter from the Director, BR, was sent to Study Group Chairmen in February 2005 inviting them to review and stimulate activities in their Study Groups pertaining to the topic with a view to contributing to the global effort focused on mitigating the effects of such events in the future.

A summary of the main activities is given below.

2. Radiocommunication Study Group activities

2.1 Study Group 4 (Fixed-satellite service)

In a letter, the Study Group Chairman informed the Director, BR, of a revision to Recommendation ITU-R S.1001 - *Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations*. This Recommendation provides guidelines on the use of satellite networks in the event of natural disasters and similar emergencies, providing information about the overall system and terminal design that is suitable for disaster relief telecommunications. The revision contains a new section on the use of small earth stations for relief operation and there is an Appendix containing examples of small transportable earth stations and of satellite networks used for emergencies in Japan and Italy. Study Group 4 is seeking further examples from administrations on the use of satellite networks for emergency operations.

2.2 Study Group 6 (Broadcasting services)

The Study Group's initial response was a note to the Director summarizing the means by which the broadcasting-satellite service (BSS) can assist in warning the public of impending disasters and in disseminating information relating to relief operations. This was followed by the approval of Question ITU-R 118/6 - *Broadcasting means for public warning and disaster relief*. In response, the Study Group is developing a new Recommendation on the use of satellite and terrestrial broadcast infrastructures for public warning and disaster relief, the aim of which is to help permit the rapid deployment of equipment and networks currently available in the terrestrial and satellite-broadcasting services. These services can provide means for alerting the public, for informing them of preventive measures and for disseminating information on the coordination of rescue procedures. The Recommendation will give technical guidance on the improved usage of terrestrial and satellite broadcast services in cases of natural disasters.

2.3 Study Group 7 (Science services)

This Study Group addresses those services associated with scientific aspects of the subject. The meteorological aids, meteorological-satellite and Earth exploration-satellite services play a major role in the prediction and detection of disasters and in retrieving and relaying data from monitoring equipment (e.g. tsunami detection and prediction system uses buoys – see Fig. 1) to land-based siren systems. More advanced systems involve remote sensing of the ocean temperature whose variations can be linked with seismic activity.

The systems linked with Study Group 7 are used in activities such as:

– weather forecasting and climate change prediction (using the Global Climate Observing System (GCOS) – see Fig. 2);

– detection and tracking of earthquakes, tsunamis, hurricanes, forest fires, oil leaks, etc;

– providing alerting/warning information;

– damage assessment;

– providing information for planning relief operations.

It is essential that the frequencies allocated to these passive services remain free of interference. In this respect, the last World Radiocommunication Conference (WRC-03) secured several relevant frequency allocations. Likewise, the next WRC, in 2007, will look for extended frequency allocations for several science services that will result in improvements such as increased resolution of satellite imaging of the Earth's surface, at the same time ensuring that adequate protection is given to passive services from harmful interference from other services.

FIGURE 1

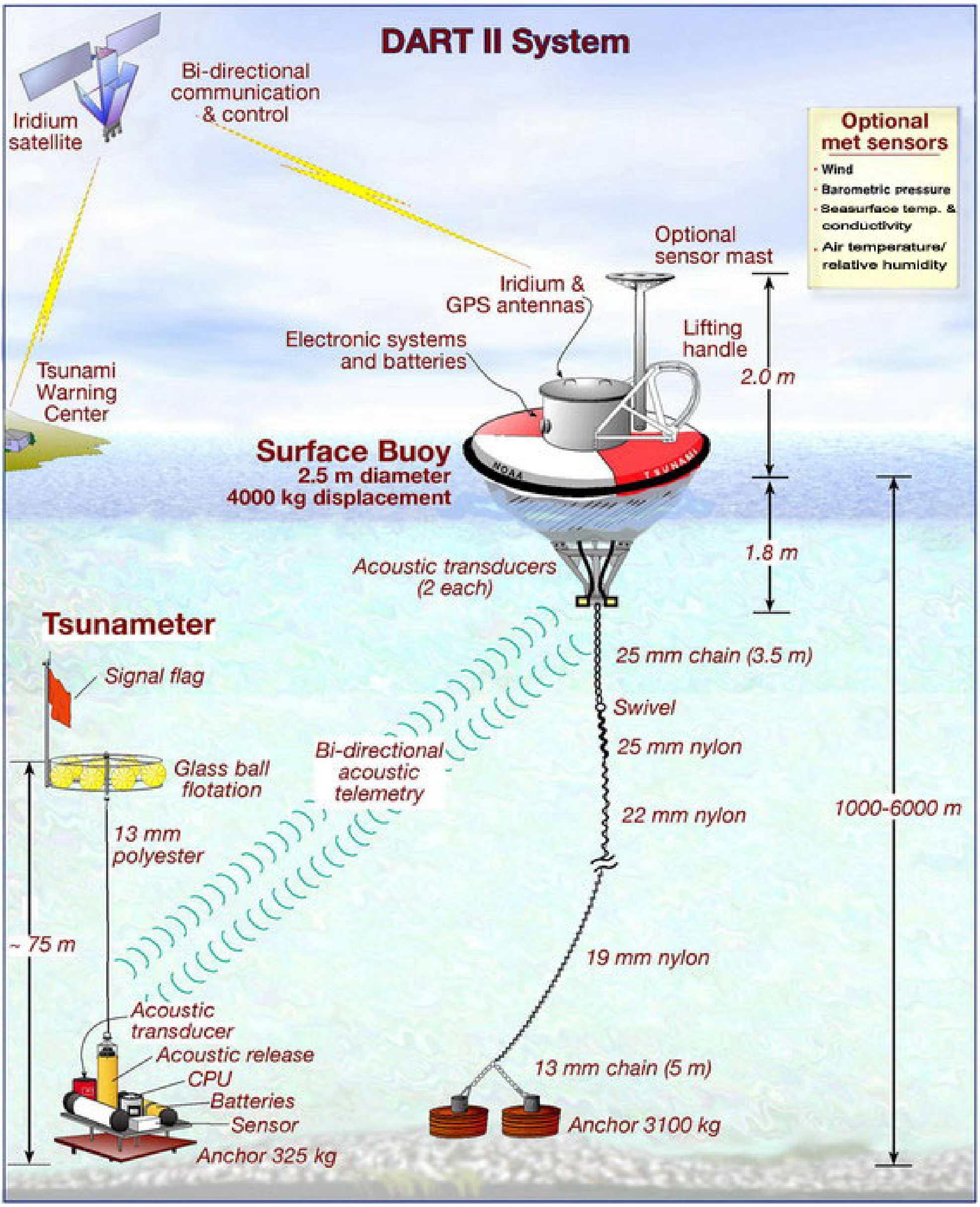
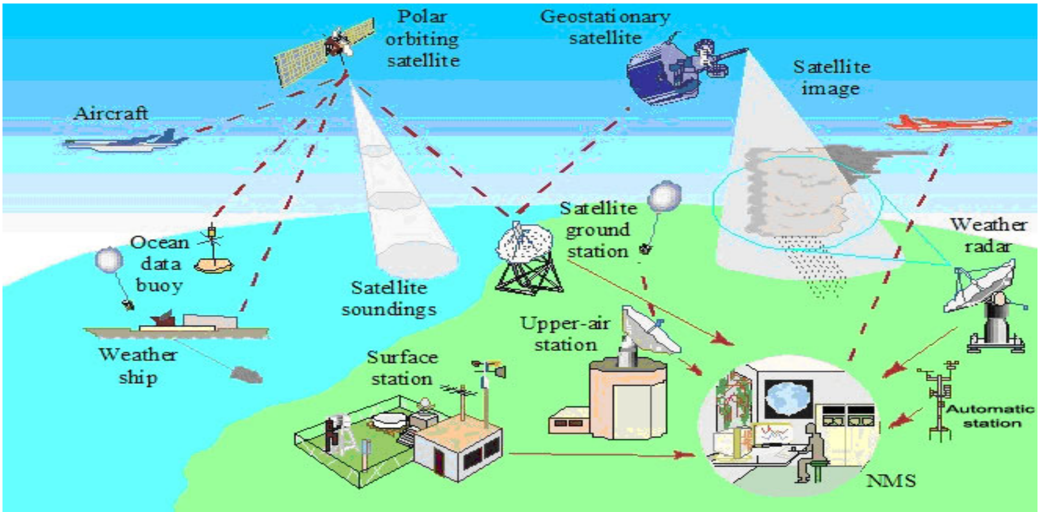

DART II System
Bi-directional communication & control
Iridium satellite
Optional met sensors
Wind
Barometric pressure
Seasurface temp. & conductivity
Air temperature/ relative humidity
Optional sensor mast
Iridium & GPS antennas
Lifting handle
Electronic systems and batteries
2.0 m
Tsunami Warning Center
Surface Buoy
2.5 m diameter
4000 kg displacement
1.8 m
Acoustic transducers (2 each)
Tsunameter
25 mm chain (3.5 m)
Signal flag
Swivel
25 mm nylon
Bi-directional acoustic telemetry
Glass ball flotation
22 mm nylon
1000-6000 m
13 mm polyester
~ 75 m
19 mm nylon
Acoustic transducer
Acoustic release
CPU
Batteries
Sensor
Anchor 325 kg
13 mm chain (5 m)
Anchor 3100 kg

FIGURE 2



In support of the further development of the services relevant to the prediction and detection of disasters, as well as supporting the regulatory decisions made at WRC's, Study Group 7 has developed many texts, e.g. ITU-R Recommendations and Reports, that address the technical characteristics of the services concerned, as well as related spectrum issues. Amongst new texts currently in preparation are Recommendations on ground-based meteorological aids systems using optical frequencies, spectrum aspects of active and passive sensors (for example used for meteorological observations, vegetation cover assessment, detection of fires and oil leaks, etc.), data collection and dissemination, and interference mitigation techniques applicable in certain bands used by the Earth exploration-satellite service (see http://www.itu.int/ITU-R/study-groups/rsg7 for further details). In addition, a Handbook is in preparation on the Earth exploration-satellite service which will complement the already existing Handbook on the use of radio spectrum for meteorology, written in conjunction with IMO, that also describes modern meteorological systems, tools and methods; (http://www.itu.int/publications/productslist.aspx?lang=e&CategoryID=R-HDB&product=R-HDB-45).

2.4 Study Group 8 (Mobile, radiodetermination, amateur and related satellite services)

The Study Group is responsible for many Recommendations that have a bearing on emergency and disaster relief communications. Typically these provide the technical characteristics of equipment associated with the GMDSS (Global Maritime Distress and Safety System) which include such examples as the transmission characteristics of emergency position-indicating radio beacons (EPIRB) and of a universal shipborne automatic identification system. The Study Group has also been instrumental in studies on PPDR (public protection and disaster relief) and in this respect organized a Workshop on the topic in 2002 (see http://www.itu.int/ITU-R/study groups/rsg8/rwp8a/seminars/protection/index.html). The amateur service has a long history in assisting with radiocommunications during emergencies and disaster events and there are Recommendations developed by Study Group 8 which address the contribution made by amateurs, coupled with that of the land mobile service (see Question ITU-R 209/8).

Much of the work undertaken within the Study Group has been in support of Radio Regulatory texts and procedures addressing distress and safety communications and many relevant provisions exist in Articles of the RR. The subject of frequency bands for PPDR communications was an important item on the agenda of WRC-03. The previous Conference, WRC-2000, had adopted two Resolutions (**644 (Rev. WRC-2000)** and **645 (WRC-2000)**) addressing the subject, requesting ITU-R (Study Group 8) to study aspects of radiocommunications relevant to disaster mitigation and relief operations and also to study the question of identifying frequency bands that could be used on a global/regional basis. Report ITU-R M.2033 was prepared in response to those Resolutions.

The result from WRC-03 is reflected in Resolution **646 (WRC-03)** which strongly recommends use of regionally harmonized bands and encourages consideration of the use of certain bands in the three ITU Regions. Studies in this domain continue within Study Group 8 and include, amongst others, the further identification of other frequency ranges suitable for such purposes and the use of mobile-satellite systems for disaster relief.

2.5 Study Group 9 (Fixed service)

Two new Questions have been adopted addressing the need for technical and operational characteristics of systems in the fixed service for disaster mitigation and relief, one of the Questions placing particular emphasis on systems operating in the MF/HF bands. At the same time, the Study Group has prepared a significant revision to Recommendation ITU-R F.1105 - *Transportable fixed radiocommunications equipment for relief operations*. This Recommendation updates the characteristics of such fixed wireless systems that are specified according to channel capacity, operating frequencies, transmission distance and propagation path characteristics. The features of a regional digital simultaneous communication system (RDSCS) are described. Such a system can provide simultaneous individual or group communications between a central station and a number of terminals in a region. The central station collects data and information relevant to the prevention phase of a disaster and can then transmit such information to residents for alerting purposes; interactive capabilities are also available.

3. Other activities in BR

3.1 ITU-R website on the role of radiocommunications in disaster mitigation and relief operations

A dedicated website has been developed which describes the role that ITU-R plays in disaster mitigation and relief operations. In distinguishing the different phases of a disaster - *prediction, detection, alerting, relief* - the website identifies the radio services involved, their tasks and the relevant Radiocommunication Study Groups involved in studies for providing information and recommendations.

3.2 Additional information of the Radiocommunication Sector

3.2.1 Maritime mobile Access and Retrieval System (MARS)

The system has been developed by the International Telecommunication Union (see http://www.itu.int/ITU-R/terrestrial/mars/) with the purpose of providing the Maritime Community, in particular those entities that are involved in search and rescue activities, with the most up-to-date data registered in the ITU master Ship station database.

Updated weekly and available on a 24-hour per day/7-day per week basis, this system contains characteristics of over 400 000 ship stations as well as the addresses and contact information of Accounting Authorities (AAICs) and Notifying Administrations.

3.2.2 Regionally harmonized bands

Based on Resolution **646 (WRC-03)** – *Public protection and disaster relief* (see http:// www.itu.int/ITU-R/information/emergency/bands/index.html).

4. Other activities in ITU

4.1 General Secretariat ITU

See http://www.itu.int/emergencytelecoms/index.html

4.2 ITU-T

See http://www.itu.int/ITU-T/emergencytelecoms/index.html

4.3 ITU-D

See http://www.itu.int/ITU-D/emergencytelecoms/index.html

ITU-D published in 2005 the Handbook on Emergency Telecommunication. Owing to the fast evolving nature of both the technologies and the regulatory framework related to disaster mitigation and relief coupled with the high frequency with which disasters are occurring, we found it necessary to release this particular edition to address most of the topical issues related to this subject.

The Handbook includes three Parts:

Part I: It discusses disaster prevention, response, and the available means of telecommunications.

Part II: Focuses on the operational aspects of emergency telecommunications:

a) telecommunications as tools for the providers of emergency response

b) public telecommunication networks and their role in disaster relief

c) the use of the Internet, private telecommunication services and networks, the amateur radio service, broadcasting, and emerging technologies respectively.

Part III: Discusses the technical elements of emergency telecommunications. This segment is critical especially for field practitioners who are often confronted by technical challenges while installing and using telecommuni cations equipment in the field.

Annex 1

ITU-R texts concerning radiocommunications for emergency and disaster relief

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Section I – Radio Regulations texts

ARTICLE 30

General provisions

Section I – Introduction

30.1 § 1 This Chapter contains the provisions for the operational use of the global maritime distress and safety system (GMDSS), which is fully defined in the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended. Distress, urgency and safety transmissions may also be made, using Morse telegraphy or radiotelephony techniques, in accordance with the provisions of Appendix **13** and relevant ITU-R Recommendations. Stations of the maritime mobile service, when using frequencies and techniques in conformity with Appendix **13**, shall comply with the appropriate provisions of that Appendix.

30.2 § 2 No provision of these Regulations prevents the use by a mobile station or a mobile earth station in distress of any means at its disposal to attract attention, make known its position, and obtain help (see also No. **4.9**).

30.3 § 3 No provision of these Regulations prevents the use by stations on board aircraft, ships engaged in search and rescue operations, land stations, or coast earth stations, in exceptional circumstances, of any means at their disposal to assist a mobile station or a mobile earth station in distress (see also Nos. **4.9** and **4.16**).

Section II – Maritime provisions

30.4 § 4 The provisions specified in this Chapter are obligatory (see Resolution **331 (Rev.WRC-97)***) in the maritime mobile service and the maritime mobile-satellite service for all stations using the frequencies and techniques prescribed for the functions set out herein (see also No. **30.5**). However, stations of the maritime mobile service, when fitted with equipment used by stations operating in conformity with Appendix **13**, shall comply with the appropriate provisions of that Appendix.

30.5 § 5 The International Convention for the Safety of Life at Sea (SOLAS), 1974 as amended, prescribes which ships and which of their survival craft shall be provided with radio equipment, and which ships shall carry portable radio equipment for use in survival craft. It also prescribes the requirements which shall be met by such equipment.

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* *Note by the Secretariat:* This Resolution was revised by WRC-03.

30.6 § 6 Ship earth stations located at rescue coordination centres[1] may be authorized by an administration to communicate for distress and safety purposes with any other station using bands allocated to the maritime mobile-satellite service, when special circumstances make it essential, notwithstanding the methods of working provided for in these Regulations.

30.7 § 7 Mobile stations[2] of the maritime mobile service may communicate, for safety purposes, with stations of the aeronautical mobile service. Such communications shall normally be made on the frequencies authorized, and under the conditions specified in Section I of Article **31** (see also No. **4.9**).

Section III – Aeronautical provisions

30.8 § 8 The procedure specified in this Chapter is obligatory for communications between stations on board aircraft and stations of the maritime mobile-satellite service, wherever this service or stations of this service are specifically mentioned.

30.9 § 9 Certain provisions of this Chapter are applicable to the aeronautical mobile service, except in the case of special arrangements between the governments concerned.

30.10 § 10 Mobile stations of the aeronautical mobile service may communicate, for distress and safety purposes, with stations of the maritime mobile service in conformity with the provisions of this Chapter.

30.11 § 11 Any station on board an aircraft required by national or international regulations to communicate for distress, urgency or safety purposes with stations of the maritime mobile service that comply with the provisions of this Chapter, shall be capable of transmitting and receiving class J3E emissions when using the carrier frequency 2 182 kHz, or class J3E emissions when using the carrier frequency 4 125 kHz, or class G3E emissions when using the frequency 156.8 MHz and, optionally, the frequency 156.3 MHz.

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[1] **30.6.1** The term "rescue coordination centre", as defined in the International Convention on Maritime Search and Rescue (1979) refers to a unit responsible for promoting the efficient organization of search and rescue services and for coordinating the conduct of search and rescue operations within a search and rescue region.

[2] **30.7.1** Mobile stations communicating with the stations of the aeronautical mobile (R) service in bands allocated to the aeronautical mobile (R) service shall conform to the provisions of the Regulations which relate to that service and, as appropriate, to any special arrangements between the governments concerned by which the aeronautical mobile (R) service is regulated.

Section IV – Land mobile provisions

30.12 § 12 Stations of the land mobile service in uninhabited, sparsely populated or remote areas may, for distress and safety purposes, use the frequencies provided for in this Chapter.

30.13 § 13 The procedure specified in this Chapter is obligatory for stations of the land mobile service when using frequencies provided in these Regulations for distress and safety communications.

ARTICLE 31

Frequencies for the global maritime distress and safety system (GMDSS)

Section I – General

31.1 § 1 The frequencies to be used for the transmission of distress and safety information under the GMDSS are contained in Appendix **15**. In addition to the frequencies listed in Appendix **15**, coast stations should use other appropriate frequencies for the transmission of safety messages.

31.2 § 2 Any emission causing harmful interference to distress and safety communications on any of the discrete frequencies identified in Appendices **13** and **15** is prohibited.

31.3 § 3 The number and duration of test transmissions shall be kept to a minimum on the frequencies identified in Appendix **15**; they should be coordinated with a competent authority, as necessary, and, wherever practicable, be carried out on artificial antennas or with reduced power. However, testing on the distress and safety calling frequencies should be avoided, but where this is unavoidable, it should be indicated that these are test transmissions.

31.4 § 4 Before transmitting for other than distress purposes on any of the frequencies identified in Appendix **15** for distress and safety, a station shall, where practicable, listen on the frequency concerned to make sure that no distress transmission is being sent.

31.5 Not used.

Section II – Survival craft stations

31.6 § 5 1) Equipment for radiotelephony use in survival craft stations shall, if capable of operating on any frequency in the bands between 156 MHz and 174 MHz, be able to transmit and receive on 156.8 MHz and at least one other frequency in these bands.

31.7 2) Equipment for transmitting locating signals from survival craft stations shall be capable of operating in the 9 200-9 500 MHz band.

31.8 3) Equipment with digital selective calling facilities for use in survival craft shall, if capable of operating:

31.9 *a)* in the bands between 1 606.5 kHz and 2 850 kHz, be able to transmit on 2 187.5 kHz; (WRC-03)

31.10 *b)* in the bands between 4 000 kHz and 27 500 kHz, be able to transmit on 8 414.5 kHz;

31.11 *c)* in the bands between 156 MHz and 174 MHz, be able to transmit on 156.525 MHz.

Section III – Watchkeeping

31.12 *A – Coast stations*

31.13 § 6 Those coast stations assuming a watch-keeping responsibility in the GMDSS shall maintain an automatic digital selective calling watch on frequencies and for periods of time as indicated in the information published in the List of Coast Stations.

31.14 *B – Coast earth stations*

31.15 § 7 Those coast earth stations assuming a watch-keeping responsibility in the GMDSS shall maintain a continuous automatic watch for appropriate distress alerts relayed by space stations.

31.16 *C – Ship stations*

31.17 § 8 1) Ship stations, where so equipped, shall, while at sea, maintain an automatic digital selective calling watch on the appropriate distress and safety calling frequencies in the frequency bands in which they are operating. Ship stations, where so equipped, shall also maintain watch on the appropriate frequencies for the automatic reception of transmissions of meteorological and navigational warnings and other urgent information to ships. However, ship stations shall also continue to apply the appropriate watch-keeping provisions of Appendix **13** (see Resolution **331 (Rev.WRC-97)***).

31.18 2) Ship stations complying with the provisions of this Chapter should, where practicable, maintain a watch on the frequency 156.650 MHz for communications related to the safety of navigation.

31.19 *D – Ship earth stations*

31.20 § 9 Ship earth stations complying with the provisions of this Chapter shall, while at sea, maintain watch except when communicating on a working channel.

* *Note by the Secretariat:* This Resolution was revised by WRC-03.

ARTICLE 32

Operational procedures for distress and safety communications in the global maritime distress and safety system (GMDSS)

Section I – General

32.1 § 1 Distress and safety communications rely on the use of terrestrial MF, HF and VHF radiocommunications and communications using satellite techniques.

32.2 § 2 1) The distress alert (see No. **32.9**) shall be sent through a satellite either with absolute priority in general communication channels or on exclusive distress and safety frequencies or, alternatively, on the distress and safety frequencies in the MF, HF and VHF bands using digital selective calling.

32.3 2) The distress alert (see No. **32.9**) shall be sent only on the authority of the person responsible for the ship, aircraft or other vehicle carrying the mobile station or the mobile earth station.

32.4 § 3 All stations which receive a distress alert transmitted by digital selective calling shall immediately cease any transmission capable of interfering with distress traffic and shall continue watch until the call has been acknowledged.

32.5 § 4 Digital selective calling shall be in accordance with the relevant ITU-R Recommendations.

32.5A § 4A Each administration shall ensure that suitable arrangements are made for assigning and registering identities used by ships participating in the GMDSS, and shall make registration information available to rescue coordination centres on a 24-hour day, 7-day week basis. Where appropriate, administrations shall notify responsible organizations immediately of additions, deletions and other changes in these assignments (see Nos. **19.39**, **19.96** and **19.99**). Registration information shall be in accordance with Resolution **340 (WRC-97)**.

32.5B § 4B Any GMDSS shipboard equipment which is capable of transmitting position coordinates as part of a distress alert message and which does not have an integral electronic position-fixing system receiver shall be interconnected to a separate navigation receiver, if one is installed, to provide that information automatically.

32.6 § 5 Transmissions by radiotelephony shall be made slowly and distinctly, each word being clearly pronounced to facilitate transcription.

32.7 § 6 The phonetic alphabet and figure code in Appendix **14** and the abbreviations and signals in accordance with the most recent version of Recommendation ITU-R M.1172 should be used where applicable[1]. (WRC-03)

Section II – Distress alerting

32.8 *A – General*

32.9 § 7 1) The transmission of a distress alert indicates that a mobile unit[2] or person[3] is threatened by grave and imminent danger and requests immediate assistance. The distress alert is a digital selective call using a distress call format[4] in the bands used for terrestrial radiocommunication or a distress message format, in which case it is relayed through space stations.

32.10 2) The distress alert shall provide[5] the identification of the station in distress and its position.

32.10A § 7A A distress alert is false if it was transmitted without any indication that a mobile unit or person was in distress and required immediate assistance (see No. **32.9**). Administrations receiving a false distress alert shall report this infringement in accordance with Section V of Article **15**, if that alert:

a) was transmitted intentionally;

b) was not cancelled in accordance with Resolution **349 (WRC-97)**;

c) could not be verified as a result of either the ship's failure to keep watch on appropriate frequencies in accordance with Nos. **31.16** to **31.20**, or its failure to respond to calls from an authorized rescue authority;

d) was repeated; or

e) was transmitted using a false identity.

Administrations receiving such a report shall take appropriate steps to ensure that the infringement does not recur. No action should normally be taken against any ship or mariner for reporting and cancelling a false distress alert.

---

1 **32.7.1** The use of the Standard Marine Communication Phrases and, where language difficulties exists, the International Code of Signals, both published by the International Maritime Organization (IMO), is also recommended.

2 **32.9.1** Mobile unit: a ship, aircraft or other vehicle.

3 **32.9.2** In this Article, where the case is of a person in distress, the application of the procedures may require adaptation to meet the needs of the particular circumstances.

4 **32.9.3** The format of distress calls and distress messages shall be in accordance with the relevant ITU-R Recommendations (see Resolution **27 (Rev.WRC-03)**.

5 **32.10.1** The distress alert may also contain information regarding the nature of the distress, the type of assistance required, the course and speed of the mobile unit, the time that this information was recorded and any other information which might facilitate rescue.

32.11 *B – Transmission of a distress alert*

B1 – Transmission of a distress alert by a ship station or a ship earth station

32.12 § 8 Ship-to-shore distress alerts are used to alert rescue coordination centres via coast stations or coast earth stations that a ship is in distress. These alerts are based on the use of transmissions via satellites (from a ship earth station or a satellite EPIRB) and terrestrial services (from ship stations and EPIRBs).

32.13 § 9 Ship-to-ship distress alerts are used to alert other ships in the vicinity of the ship in distress and are based on the use of digital selective calling in the VHF and MF bands. Additionally, the HF band may be used.

B2 – Transmission of a shore-to-ship distress alert relay

32.14 § 10 1) A station or a rescue coordination centre which receives a distress alert shall initiate the transmission of a shore-to-ship distress alert relay addressed, as appropriate, to all ships, to a selected group of ships or to a specific ship by satellite and/or terrestrial means.

32.15 2) The distress alert relay shall contain the identification of the mobile unit in distress, its position and all other information which might facilitate rescue.

B3 – Transmission of a distress alert by a station not itself in distress

32.16 § 11 A station in the mobile or mobile-satellite service which learns that a mobile unit is in distress shall initiate and transmit a distress alert in any of the following cases:

32.17 *a)* when the mobile unit in distress is not itself in a position to transmit the distress alert;

32.18 *b)* when the master or person responsible for the mobile unit not in distress or the person responsible for the land station considers that further help is necessary.

32.19 § 12 A station transmitting a distress alert relay in accordance with Nos. **32.16**, **32.17**, **32.18** and **32.31** shall indicate that it is not itself in distress.

32.20 *C – Receipt and acknowledgement of distress alerts*

C1 – Procedure for acknowledgement of receipt of distress alerts

32.21 § 13 Acknowledgement by digital selective calling of receipt of a distress alert in the terrestrial services shall be in accordance with relevant ITU-R Recommendations (see Resolution **27 (Rev.WRC-03)**).

32.22 § 14 Acknowledgement through a satellite of receipt of a distress alert from a ship earth station shall be sent immediately (see No. **32.26**).

32.23 § 15 1) Acknowledgement by radiotelephony of receipt of a distress alert from a ship station or a ship earth station shall be given in the following form:

- the distress signal MAYDAY;
- the call sign or other identification of the station sending the distress message, spoken three times;

– the words THIS IS (or DE spoken as DELTA ECHO in case of language difficulties);

– the call sign or other identification of the station acknowledging receipt, spoken three times;

– the word RECEIVED (or RRR spoken as ROMEO ROMEO ROMEO in case of language difficulties);

– the distress signal MAYDAY.

32.24 2) The acknowledgement by direct-printing telegraphy of receipt of a distress alert from a ship station shall be given in the following form:

– the distress signal MAYDAY;

– the call sign or other identification of the station sending the distress alert;

– the word DE;

– the call sign or other identification of the station acknowledging receipt of the distress alert;

– the signal RRR;

– the distress signal MAYDAY.

32.25 § 16 The acknowledgement by direct-printing telegraphy of receipt of a distress alert from a ship earth station shall be given by the coast earth station receiving the distress alert, by retransmitting the ship station identity of the ship transmitting the distress alert.

C2 – Receipt and acknowledgement of receipt by a coast station, a coast earth station or a rescue coordination centre

32.26 § 17 Coast stations and appropriate coast earth stations in receipt of distress alerts shall ensure that they are routed as soon as possible to a rescue coordination centre. Receipt of a distress alert is to be acknowledged as soon as possible by a coast station, or by a rescue coordination centre via a coast station or an appropriate coast earth station.

32.27 § 18 A coast station using digital selective calling to acknowledge a distress call shall transmit the acknowledgement on the distress calling frequency on which the call was received and should address it to all ships. The acknowledgement shall include the identification of the ship whose distress call is being acknowledged.

C3 – Receipt and acknowledgement of receipt by a ship station or ship earth station

32.28 § 19 1) Ship or ship earth stations in receipt of a distress alert shall, as soon as possible, inform the master or person responsible for the ship of the contents of the distress alert.

32.29 2) In areas where reliable communications with one or more coast stations are practicable, ship stations in receipt of a distress alert should defer acknowledgement for a short interval so that receipt may be acknowledged by a coast station.

32.30 § 20 1) Ship stations operating in areas where reliable communications with a coast station are not practicable which receive a distress alert from a ship station which is, beyond doubt, in their vicinity, shall, as soon as possible and if appropriately equipped, acknowledge receipt and inform a rescue coordination centre through a coast station or coast earth station (see No. **32.18**).

32.31 2) However, a ship station receiving an HF distress alert shall not acknowledge it but shall observe the provisions of Nos. **32.36** to **32.38**, and shall, if the alert is not acknowledged by a coast station within 3 minutes, relay the distress alert.

32.32 § 21 A ship station acknowledging receipt of a distress alert in accordance with No. **32.29** or No. **32.30** should:

32.33 *a)* in the first instance, acknowledge receipt of the alert by using radiotelephony on the distress and safety traffic frequency in the band used for the alert;

32.34 *b)* if acknowledgement by radiotelephony of the distress alert received on the MF or VHF distress alerting frequency is unsuccessful, acknowledge receipt of the distress alert by responding with a digital selective call on the appropriate frequency.

32.35 § 22 A ship station in receipt of a shore-to-ship distress alert (see No. **32.14**) should establish communication as directed and render such assistance as required and appropriate.

32.36 *D – Preparations for handling of distress traffic*

32.37 § 23 On receipt of a distress alert transmitted by use of digital selective calling techniques, ship stations and coast stations shall set watch on the radiotelephone distress and safety traffic frequency associated with the distress and safety calling frequency on which the distress alert was received.

32.38 § 24 Coast stations and ship stations with narrow-band direct-printing equipment shall set watch on the narrow-band direct-printing frequency associated with the distress alert signal if it indicates that narrow-band direct-printing is to be used for subsequent distress communications. If practicable, they should additionally set watch on the radiotelephone frequency associated with the distress alert frequency.

Section III – Distress traffic

32.39 *A – General and search and rescue coordinating communications*

32.40 § 25 Distress traffic consists of all messages relating to the immediate assistance required by the ship in distress, including search and rescue communications and on-scene communications. The distress traffic shall as far as possible be on the frequencies contained in Article **31**.

32.41 § 26 1) The distress signal consists of the word MAYDAY, pronounced in radiotelephony as the French expression "m'aider".

32.42 2) For distress traffic by radiotelephony, when establishing communications, calls shall be prefixed by the distress signal MAYDAY.

32.43 § 27 1) Error correction techniques in accordance with relevant ITU-R Recommendations shall be used for distress traffic by direct-printing telegraphy. All messages shall be preceded by at least one carriage return, a line feed signal, a letter shift signal and the distress signal MAYDAY.

32.44 2) Distress communications by direct-printing telegraphy should normally be established by the ship in distress and should be in the broadcast (forward error correction) mode. The ARQ mode may subsequently be used when it is advantageous to do so.

32.45 § 28 1) The Rescue Coordination Centre responsible for controlling a search and rescue operation shall also coordinate the distress traffic relating to the incident or may appoint another station to do so.

32.46 2) The rescue coordination centre coordinating distress traffic, the unit coordinating search and rescue operations[6] or the coast station involved may impose silence on stations which interfere with that traffic. This instruction shall be addressed to all stations or to one station only, according to circumstances. In either case, the following shall be used:

32.47 *a)* in radiotelephony, the signal SEELONCE MAYDAY, pronounced as the French expression "silence, m'aider";

32.48 *b)* in narrow-band direct-printing telegraphy normally using forward-error correcting mode, the signal SILENCE MAYDAY. However, the ARQ mode may be used when it is advantageous to do so.

32.49 § 29 Until they receive the message indicating that normal working may be resumed (see No. **32.51**), all stations which are aware of the distress traffic, and which are not taking part in it, and which are not in distress, are forbidden to transmit on the frequencies in which the distress traffic is taking place.

32.50 § 30 A station of the mobile service which, while following distress traffic, is able to continue its normal service, may do so when the distress traffic is well established and on condition that it observes the provisions of No. **32.49** and that it does not interfere with distress traffic.

32.51 § 31 When distress traffic has ceased on frequencies which have been used for distress traffic, the rescue coordination centre controlling a search and rescue operation shall initiate a message for transmission on these frequencies indicating that distress traffic has finished.

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[6] **32.46.1** In accordance with the International Convention on Maritime Search and Rescue (1979) this is the on-scene commander (OSC) or the coordinator surface search (CSS).

32.52 § 32 1) In radiotelephony, the message referred to in No. **32.51** consists of:

- the distress signal MAYDAY;
- the call "Hello all stations" or CQ (spoken as CHARLIE QUEBEC) spoken three times;
- the words THIS IS (or DE spoken as DELTA ECHO in the case of language difficulties);
- the call sign or other identification of the station sending the message;
- the time of handing in of the message;
- the name and call sign of the mobile station which was in distress;
- the words SEELONCE FEENEE pronounced as the French words "silence fini".

32.53 2) In direct-printing telegraphy, the message referred to in No. **32.51** consists of:

- the distress signal MAYDAY;
- the call CQ;
- the word DE;
- the call sign or other identification of the station sending the message;
- the time of handing in of the message;
- the name and call sign of the mobile station which was in distress; and
- the words SILENCE FINI.

32.54 *B – On-scene communications*

32.55 § 33 1) On-scene communications are those between the mobile unit in distress and assisting mobile units, and between the mobile units and the unit coordinating search and rescue operations[6].

32.56 2) Control of on-scene communications is the responsibility of the unit coordinating search and rescue operations[6]. Simplex communications shall be used so that all on-scene mobile stations may share relevant information concerning the distress incident. If direct-printing telegraphy is used, it shall be in the forward error-correcting mode.

32.57 § 34 1) The preferred frequencies in radiotelephony for on-scene communications are 156.8 MHz and 2 182 kHz. The frequency 2 174.5 kHz may also be used for ship-to-ship on-scene communications using narrow-band direct-printing telegraphy in the forward error correcting mode.

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[6] **32.55.1**, **32.56.1** and **32.59.1** In accordance with the International Convention on Maritime Search and Rescue (1979) this is the on-scene commander (OSC) or the coordinator surface search (CSS).

32.58 2) In addition to 156.8 MHz and 2 182 kHz, the frequencies 3 023 kHz, 4 125 kHz, 5 680 kHz, 123.1 MHz and 156.3 MHz may be used for ship-to-aircraft on-scene communications.

32.59 § 35 The selection or designation of on-scene frequencies is the responsibility of the unit coordinating search and rescue operations[66]. Normally, once an on-scene frequency is established, a continuous aural or teleprinter watch is maintained by all participating on-scene mobile units on the selected frequency.

32.60 *C – Locating and homing signals*

32.61 § 36 1) Locating signals are radio transmissions intended to facilitate the finding of a mobile unit in distress or the location of survivors. These signals include those transmitted by searching units, and those transmitted by the mobile unit in distress, by survival craft, by float-free EPIRBs, by satellite EPIRBs and by search and rescue radar transponders to assist the searching units.

32.62 2) Homing signals are those locating signals which are transmitted by mobile units in distress, or by survival craft, for the purpose of providing searching units with a signal that can be used to determine the bearing to the transmitting stations.

32.63 3) Locating signals may be transmitted in the following frequency bands:

117.975-136 MHz;

156-174 MHz;

406-406.1 MHz;

1 645.5-1 646.5 MHz; and

9 200-9 500 MHz.

32.64 4) Locating signals shall be in accordance with the relevant ITU-R Recommendations (see Resolution **27 (Rev.WRC-03)**).

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[6] **32.55.1**, **32.56.1** and **32.59.1** In accordance with the International Convention on Maritime Search and Rescue (1979) this is the on-scene commander (OSC) or the coordinator surface search (CSS).

ARTICLE 33

Operational procedures for urgency and safety communications in the global maritime distress and safety system (GMDSS)

Section I – General

33.1 § 1 Urgency and safety communications include:

33.2 *a)* navigational and meteorological warnings and urgent information;

33.3 *b)* ship-to-ship safety of navigation communications;

33.4 *c)* ship reporting communications;

33.5 *d)* support communications for search and rescue operations;

33.6 *e)* other urgency and safety messages; and

33.7 *f)* communications relating to the navigation, movements and needs of ships and weather observation messages destined for an official meteorological service.

Section II – Urgency communications

33.8 § 2 In a terrestrial system the announcement of the urgency message shall be made on one or more of the distress and safety calling frequencies specified in Section I of Article **31** using digital selective calling and the urgency call format. A separate announcement need not be made if the urgency message is to be transmitted through the maritime mobile-satellite service.

33.9 § 3 The urgency signal and message shall be transmitted on one or more of the distress and safety traffic frequencies specified in Section I of Article **31**, or via the maritime mobile-satellite service or on other frequencies used for this purpose.

33.10 § 4 The urgency signal consists of the words PAN PAN. In radiotelephony each word of the group shall be pronounced as the French word "panne".

33.11 § 5 The urgency call format and the urgency signal indicate that the calling station has a very urgent message to transmit concerning the safety of a mobile unit or a person.

33.12 § 6 1) In radiotelephony, the urgency message shall be preceded by the urgency signal (see No. **33.10**), repeated three times, and the identification of the transmitting station.

33.13 2) In narrow-band direct-printing, the urgency message shall be preceded by the urgency signal (see No. **33.10**) and the identification of the transmitting station.

33.14 § 7 1) The urgency call format or urgency signal shall be sent only on the authority of the master or the person responsible for the mobile unit carrying the mobile station or mobile earth station.

33.15 2) The urgency call format or the urgency signal may be transmitted by a land station or a coast earth station with the approval of the responsible authority.

33.16 § 8 When an urgency message which calls for action by the stations receiving the message has been transmitted, the station responsible for its transmission shall cancel it as soon as it knows that action is no longer necessary.

33.17 § 9 1) Error correction techniques in accordance with relevant ITU-R Recommendations shall be used for urgency messages by direct-printing telegraphy. All messages shall be preceded by at least one carriage return, a line feed signal, a letter shift signal and the urgency signal PAN PAN.

33.18 2) Urgency communications by direct-printing telegraphy should normally be established in the broadcast (forward error correction) mode. The ARQ mode may subsequently be used when it is advantageous to do so.

Section III – Medical transports

33.19 § 10 The term "medical transports", as defined in the 1949 Geneva Conventions and Additional Protocols, refers to any means of transportation by land, water or air, whether military or civilian, permanent or temporary, assigned exclusively to medical transportation and under the control of a competent authority of a party to a conflict or of neutral States and of other States not parties to an armed conflict, when these ships, craft and aircraft assist the wounded, the sick and the shipwrecked.

33.20 § 11 For the purpose of announcing and identifying medical transports which are protected under the above-mentioned Conventions, the procedure of Section II of this Article is used. The urgency signal shall be followed by the addition of the single word MEDICAL in narrow-band direct-printing and by the addition of the single word MAY-DEE-CAL pronounced as in French "médical", in radiotelephony.

33.21 § 12 The use of the signals described in No. **33.20** indicates that the message which follows concerns a protected medical transport. The message shall convey the following data:

33.22 *a)* call sign or other recognized means of identification of the medical transport;

33.23 *b)* position of the medical transport;

33.24 *c)* number and type of vehicles in the medical transport;

33.25 *d)* intended route;

33.26 *e)* estimated time en route and of departure and arrival, as appropriate;

33.27 *f)* any other information, such as flight altitude, radio frequencies guarded, languages used and secondary surveillance radar modes and codes.

33.28 § 13 1) The identification and location of medical transports at sea may be conveyed by means of appropriate standard maritime radar transponders (see Recommendation **14 (Mob-87)**).

33.29 2) The identification and location of aircraft medical transports may be conveyed by the use of the secondary surveillance radar (SSR) system specified in Annex 10 to the Convention on International Civil Aviation.

33.30 § 14 The use of radiocommunications for announcing and identifying medical transports is optional; however, if they are used, the provisions of these Regulations and particularly of this Section and of Articles **30** and **31** shall apply.

Section IV – Safety communications

33.31 § 15 In a terrestrial system the announcement of the safety message shall be made on one or more of the distress and safety calling frequencies specified in Section I of Article **31** using digital selective calling techniques. A separate announcement need not be made if the message is to be transmitted through the maritime mobile-satellite service.

33.31A Safety messages transmitted by coast stations in accordance with a predefined timetable should not be announced by digital selective calling techniques. (WRC-03)

33.32 § 16 The safety signal and message shall normally be transmitted on one or more of the distress and safety traffic frequencies specified in Section I of Article **31**, or via the maritime mobile-satellite service or on other frequencies used for this purpose.

33.33 § 17 The safety signal consists of the word SECURITE. In radiotelephony, it shall be pronounced as in French.

33.34 § 18 The safety call format or the safety signal indicates that the calling station has an important navigational or meteorological warning to transmit.

33.35 § 19 1) In radiotelephony, the safety message shall be preceded by the safety signal (see No. **33.33**) repeated three times, and the identification of the transmitting station.

33.36 2) In narrow-band direct-printing, the safety message shall be preceded by the safety signal (see No. **33.33**), and the identification of the transmitting station.

33.37 § 20 1) Error correction techniques in accordance with relevant ITU-R Recommendations shall be used for safety messages by direct-printing telegraphy. All messages shall be preceded by at least one carriage return, a line feed signal, a letter shift signal and the safety signal SECURITE.

33.38 2) Safety communications by direct-printing telegraphy should normally be established in the broadcast (forward error correction) mode. The ARQ mode may subsequently be used when it is advantageous to do so.

Section V – Transmission of maritime safety information[1]

33.39 *A – General*

33.39A § 20A 1) Messages from ship stations containing information concerning the presence of cyclones shall be transmitted, with the least possible delay, to other mobile stations in the vicinity and to the appropriate authorities at the first point of the coast with which contact can be established. These transmissions shall be preceded by the safety signal.

33.39B 2) Messages from ship stations containing information on the presence of dangerous ice, dangerous wrecks, or any other imminent danger to marine navigation, shall be transmitted as soon as possible to other ships in the vicinity, and to the appropriate authorities at the first point of the coast with which contact can be established. These transmissions shall be preceded by the safety signal.

33.40 § 21 The operational details of the stations transmitting maritime safety information in accordance with Nos. **33.43**, **33.45**, **33.46**, **33.48** and **33.50** shall be indicated in the List of Radiodetermination and Special Service Stations (see also Appendix **13**).

33.41 § 22 The mode and format of the transmissions mentioned in Nos. **33.43**, **33.45**, **33.46** and **33.48** shall be in accordance with the relevant ITU-R Recommendations.

33.42 *B – International NAVTEX system*

33.43 § 23 Maritime safety information shall be transmitted by means of narrow-band direct-printing telegraphy with forward error correction using the frequency 518 kHz in accordance with the international NAVTEX system (see Appendix **15**).

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[1] **33.V.1** Maritime safety information includes navigation and meteorological warnings, meteorological forecasts and other urgent messages pertaining to safety normally transmitted to or from ships, between ships and between ship and coast stations or coast earth stations.

33.44 *C – 490 kHz and 4 209.5 kHz*

33.45 § 24 1) The frequency 490 kHz may be used for the transmission of maritime safety information by means of narrow-band direct-printing telegraphy with forward error correction (see Appendix **15**). (WRC-03)

33.46 2) The frequency 4 209.5 kHz is used exclusively for NAVTEX-type transmission by means of narrow-band direct-printing telegraphy with forward error correction.

33.47 *D – High seas maritime safety information*

33.48 § 25 Maritime safety information is transmitted by means of narrow-band direct-printing telegraphy with forward error correction using the frequencies 4 210 kHz, 6 314 kHz, 8 416.5 kHz, 12 579 kHz, 16 806.5 kHz, 19 680.5 kHz, 22 376 kHz and 26 100.5 kHz.

33.49 *E – Maritime safety information via satellite*

33.50 § 26 Maritime safety information may be transmitted via satellite in the maritime mobile-satellite service using the band 1 530-1 545 MHz (see Appendix **15**).

Section VI – Intership navigation safety communications

33.51 § 27 1) Intership navigation safety communications are those VHF radiotelephone communications conducted between ships for the purpose of contributing to the safe movement of ships.

33.52 2) The frequency 156.650 MHz is used for intership navigation safety communications (see also Appendix **15** and note *k)* in Appendix **18**).

Section VII – Use of other frequencies for distress and safety

33.53 § 28 Radiocommunications for distress and safety purposes may be conducted on any appropriate communications frequency, including those used for public correspondence. In the maritime mobile-satellite service, frequencies in the bands 1 530-1 544 MHz and 1 626.5-1 645.5 MHz are used for this function as well as for distress alerting purposes (see No. **32.2**).

Section VIII – Medical advice

33.54 § 29 1) Mobile stations requiring medical advice may obtain it through any of the land stations shown in the List of Radiodetermination and Special Service Stations.

33.55 2) Communications concerning medical advice may be preceded by the urgency signal.

ARTICLE 34

Alerting signals in the global maritime distress and safety system (GMDSS)

Section I – Emergency position-indicating radiobeacon (EPIRB) and satellite EPIRB signals

34.1 § 1 The emergency position-indicating radiobeacon signal transmitted on 156.525 MHz and satellite EPIRB signals in the band 406-406.1 MHz or 1 645.5-1 646.5 MHz shall be in accordance with relevant ITU-R Recommendations (see Resolution **27 (Rev.WRC-03)**).

Section II – Digital selective calling

34.2 § 2 The characteristics of the "distress call" (see No. **32.9**) in the digital selective calling system shall be in accordance with relevant ITU-R Recommendations (see Resolution **27 (Rev.WRC-03)**).

RESOLUTION 646 (WRC-03)

Public protection and disaster relief

The World Radiocommunication Conference (Geneva, 2003),

considering

a) that the term "public protection radiocommunication" refers to radiocommunications used by responsible agencies and organizations dealing with maintenance of law and order, protection of life and property and emergency situations;

b) that the term "disaster relief radiocommunication" refers to radiocommunications used by agencies and organizations dealing with a serious disruption of the functioning of society, posing a significant widespread threat to human life, health, property or the environment, whether caused by accident, natural phenomena or human activity, and whether developing suddenly or as a result of complex, long-term processes;

c) the growing telecommunication and radiocommunication needs of public protection agencies and organizations, including those dealing with emergency situations and disaster relief, that are vital to the maintenance of law and order, protection of life and property, disaster relief and emergency response;

d) that many administrations wish to promote interoperability and interworking between systems used for public protection and disaster relief, both nationally and for cross-border operations in emergency situations and for disaster relief;

e) that current public protection and disaster relief applications are mostly narrow-band supporting voice and low data-rate applications, typically in channel bandwidths of 25 kHz or less;

f) that, although there will continue to be narrow-band requirements, many future applications will be wideband (indicative data rates in the order of 384-500 kbit/s) and/or broadband (indicative data rates in the order of 1-100 Mbit/s) with channel bandwidths dependent on the use of spectrally efficient technologies;

g) that new technologies for wideband and broadband public protection and disaster relief applications are being developed in various standards organizations[1];

h) that continuing development of new technologies such as IMT-2000 and systems beyond IMT-2000 and Intelligent Transportation Systems (ITS) may be able to support or supplement advanced public protection and disaster relief applications;

i) that some commercial terrestrial and satellite systems are complementing the dedicated systems in support of public protection and disaster relief, that the use of commercial solutions will be in response to technology development and market demands and that this may affect the spectrum required for those applications and for commercial networks;

j) that Resolution 36 (Rev. Marrakesh, 2002) of the Plenipotentiary Conference urges Member States to facilitate use of telecommunications for the safety and security of the personnel of humanitarian organizations;

k) that Recommendation ITU-R M.1637 offers guidance to facilitate the global circulation of radiocommunication equipment in emergency and disaster relief situations;

l) that some administrations may have different operational needs and spectrum requirements for public protection and disaster relief applications depending on the circumstances;

m) that the Tampere Convention on the Provision of Telecommunications Resources for Disaster Mitigation and Relief Operations (Tampere, 1998), an international treaty deposited with the United Nations Secretary-General and related United Nations General Assembly Resolutions and Reports are also relevant in this regard,

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[1] For example, a joint standardization programme between the European Telecommunications Standards Institute (ETSI) and the Telecommunications Industry Association (TIA), known as Project MESA (Mobility for Emergency and Safety Applications) has commenced for broadband public protection and disaster relief. Also, the Working Group on Emergency Telecommunications (WGET), convened by the United Nations Office for Humanitarian Affairs (OCHA), is an open forum to facilitate the use of telecommunications in the service of humanitarian assistance comprising United Nations entities, major non-governmental organizations, the International Committee of the Red Cross (ICRC), ITU and experts from the private sector and academia. Another platform for coordination and to foster harmonized global Telecommunication for Disaster Relief (TDR) standards is the TDR Partnership Coordination Panel, which has just been established under the coordination of ITU with participation of international telecommunication service providers, related government departments, standards development organizations, and disaster relief organizations.

recognizing

a) the benefits of spectrum harmonization such as:

– increased potential for interoperability;

– a broader manufacturing base and increased volume of equipment resulting in economies of scale and expanded equipment availability;

– improved spectrum management and planning; and

– enhanced cross-border coordination and circulation of equipment;

b) that the organizational distinction between public protection activities and disaster relief activities are matters for administrations to determine at the national level;

c) that national spectrum planning for public protection and disaster relief needs to have regard to cooperation and bilateral consultation with other concerned administrations, which should be facilitated by greater levels of spectrum harmonization;

d) the benefits of cooperation between countries for the provision of effective and appropriate humanitarian assistance in case of disasters, particularly in view of the special operational requirements of such activities involving multinational response;

e) the needs of countries, particularly the developing countries[2], for low-cost communication equipment;

f) that the trend is to increase the use of technologies based on Internet Protocols;

g) that currently some bands or parts thereof have been designated for existing public protection and disaster relief operations, as documented in Report ITU-R M.2033[3];

h) that for solving future bandwidth requirements, there are several emerging technology developments such as software-defined radio, advanced compression and networking techniques that may reduce the amount of new spectrum required to support some public protection and disaster relief applications;

i) that in times of disasters, if most terrestrial-based networks are destroyed or impaired, amateur, satellite and other non-ground-based networks may be available to provide communication services to assist in public protection and disaster relief efforts;

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[2] Taking into account, for example, the ITU-D Handbook on disaster relief.

[3] 3-30, 68-88, 138-144, 148-174, 380-400 MHz (including CEPT designation of 380-385/390-395 MHz), 400-430, 440-470, 764-776, 794-806 and 806-869 MHz (including CITEL designation of 821-824/866-869 MHz).

j) that the amount of spectrum needed for public protection on a daily basis can differ significantly between countries, that certain amounts of spectrum are already in use in various countries for narrow-band applications, and that in response to a disaster, access to additional spectrum on a temporary basis may be required;

k) that in order to achieve spectrum harmonization, a solution based on regional frequency ranges[4] may enable administrations to benefit from harmonization while continuing to meet national planning requirements;

l) that not all frequencies within an identified common frequency range will be available within each country;

m) that the identification of a common frequency range within which equipment could operate may ease the interoperability and/or inter-working, with mutual cooperation and consultation, especially in national, regional and cross-border emergency situations and disaster relief activities;

n) that when a disaster occurs, the public protection and disaster relief agencies are usually the first on the scene using their day-to-day communication systems, but that in most cases other agencies and organizations may also be involved in disaster relief operations,

noting

a) that many administrations use frequency bands below 1 GHz for narrow-band public protection and disaster relief applications;

b) that applications requiring large coverage areas and providing good signal availability would generally be accommodated in lower frequency bands and that applications requiring wider bandwidths would generally be accommodated in progressively higher bands;

c) that public protection and disaster relief agencies and organizations have an initial set of requirements, including but not limited to interoperability, secure and reliable communications, sufficient capacity to respond to emergencies, priority access in the use of non-dedicated systems, fast response times, ability to handle multiple group calls and the ability to cover large areas as described in Report ITU-R M.2033;

d) that, while harmonization may be one method of realizing the desired benefits, in some countries, the use of multiple frequency bands can contribute to meeting the communication needs in disaster situations;

e) that many administrations have made significant investments in public protection and disaster relief systems;

[4] In the context of this Resolution, the term "frequency range" means a range of frequencies over which a radio equipment is envisaged to be capable of operating but limited to specific frequency band(s) according to national conditions and requirements.

f) that flexibility must be afforded to disaster relief agencies and organizations to use current and future radiocommunications, so as to facilitate their humanitarian operations,

emphasizing

a) that the frequency bands identified in this Resolution are allocated to a variety of services in accordance with the relevant provisions of the Radio Regulations and are currently used intensively by the fixed, mobile, mobile satellite and broadcasting services;

b) that flexibility must be afforded to administrations:

– to determine, at national level, how much spectrum to make available for public protection and disaster relief from the bands identified in this Resolution in order to meet their particular national requirements;

– to have the ability for bands identified in this Resolution to be used by all services having allocations within those bands according to the provisions of the Radio Regulations, taking into account the existing applications and their evolution;

– to determine the need and timing of availability as well as the conditions of usage of the bands identified in this Resolution for public protection and disaster relief in order to meet specific national situations,

resolves

1 to strongly recommend administrations to use regionally harmonized bands for public protection and disaster relief to the maximum extent possible, taking into account the national and regional requirements and also having regard to any needed consultation and cooperation with other concerned countries;

2 to encourage administrations, for the purposes of achieving regionally harmonized frequency bands/ranges for advanced public protection and disaster relief solutions, to consider the following identified frequency bands/ranges or parts thereof when undertaking their national planning:

– in Region 1: 380-470 MHz as the frequency range within which the band 380-385/ 390-395 MHz is a preferred core harmonized band for permanent public protection activities within certain countries of Region 1 which have given their agreement;

– in Region 2[5]: 746-806 MHz, 806-869 MHz, 4 940-4 990 MHz;

– in Region 3[6]: 406.1-430 MHz, 440-470 MHz, 806-824/851-869 MHz, 4 940-4 990 MHz and 5 850-5 925 MHz;

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5 Venezuela has identified the band 380-400 MHz for public protection and disaster relief applications.

6 Some countries in Region 3 have also identified the bands 380-400 MHz and 746-806 MHz for public protection and disaster relief applications.

3 that the identification of the above 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;

4 to encourage administrations, in emergency and disaster relief situations, to satisfy temporary needs for frequencies in addition to what may be normally provided for in agreements with the concerned administrations;

5 that administrations encourage public protection and disaster relief agencies and organizations to utilize both existing and new technologies and solutions (satellite and terrestrial), to the extent practicable, to satisfy interoperability requirements and to further the goals of public protection and disaster relief;

6 that administrations may encourage agencies and organizations to use advanced wireless solutions taking into account *considering h)* and *i)* for providing complementary support to public protection and disaster relief;

7 to encourage administrations to facilitate cross-border circulation of radiocommunication equipment intended for use in emergency and disaster relief situations through mutual cooperation and consultation without hindering national legislation;

8 that administrations encourage public protection and disaster relief agencies and organizations to utilize relevant ITU-R Recommendations in planning spectrum use and implementing technology and systems supporting public protection and disaster relief;

9 to encourage administrations to continue to work closely with their public protection and disaster relief community to further refine the operational requirements for public protection and disaster relief activities;

10 that manufacturers should be encouraged to take this Resolution into account in future equipment designs, including the need for administrations to operate within different parts of the identified bands,

invites ITU-R

1 to continue its technical studies and to make recommendations concerning technical and operational implementation, as necessary, for advanced solutions to meet the needs of public protection and disaster relief radiocommunication applications, taking into account the capabilities, evolution and any resulting transition requirements of the existing systems, particularly those of many developing countries, for national and international operations;

2 to conduct further appropriate technical studies in support of possible additional identification of other frequency ranges to meet the particular needs of certain countries in Region 1 which have given their agreement, especially in order to meet the radiocommunication needs of public protection and disaster relief agencies.

Section II – ITU-R Recommendations and Reports

RECOMMENDATION ITU-R M.693*,**

TECHNICAL CHARACTERISTICS OF VHF EMERGENCY POSITION-INDICATING RADIO BEACONS USING DIGITAL SELECTIVE CALLING (DSC VHF EPIRB)

(1990)

The ITU Radiocommunication Assembly,

considering

a) that the alerting and locating functions are parts of the basic requirements of the GMDSS;

b) that chapter IV of the 1988 Amendments to the International Convention for the Safety of Life at Sea (SOLAS), 1974, permits the carriage of a DSC VHF EPIRB in sea area A1*** in lieu of a satellite EPIRB;

c) that the characteristics of the digital selective calling system are given in Recommendation ITU-R M.493;

d) that the characteristics of a search and rescue radar transponder (SART) for locating purposes are given in Recommendation ITU-R M.628,

recommends

that the technical characteristics of DSC VHF EPIRBs should be in accordance with Annex I to this Recommendation and with Recommendation ITU-R M.493.

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* The Director of the ITU-R is requested to bring this Recommendation to the attention of the International Maritime Organization (IMO).

** *Note by the Secretariat* – This Recommendation was amended editorially in March 2006.

*** "Sea area A1" means an area within the radiotelephone coverage of at least one VHF coast station in which continuous DSC alerting is available, as may be defined by a contracting government to the 1974 SOLAS Convention.

Annex 1

Minimum technical characteristics of DSC VHF EPIRBs

1. General

– DSC VHF EPIRBs should be capable of transmitting distress alerts by digital selective calling and of providing a locating or homing facility. To meet the locating requirements of the GMDSS, Regulation IV/8.3.1 of the 1974 SOLAS Convention requires that a SART (see Recommendation ITU-R M.628) be used for this function.

– The EPIRB should be provided with a battery of sufficient capacity to enable it to operate for a period of at least 48 hours.

– The EPIRB should be designed to operate under the following environmental conditions:

  – ambient temperatures of −20 °C to +55 °C,
  – icing,
  – relative wind speeds up to 100 knots,
  – after stowage at temperatures between −30 °C and +65 °C.

2. Alerting transmissions

– The alerting signals should be transmitted on the frequency 156.525 MHz using G2B class of emission.

– The frequency tolerance should not exceed 10 parts per million.

– The necessary bandwidth should be less than 16 kHz.

– The emission should be vertically polarized. The antenna should be omnidirectional in the azimuthal plane and sufficiently high to ensure reception of the transmission at the maximum range of the A1 sea area.

– The output power should be at least 100 mW[****].

3. DSC message format and transmission sequence

– The technical characteristics for the DSC message should be in accordance with the sequence for the "distress call" specified in Recommendation ITU-R M.493.

– The "nature of distress" indication should be "EPIRB emission" (symbol No. 112).

[****] The output power required to carry a ship-to-shore alert at the maximum range of the A1 sea area should be at least 6 W with an appropriate antenna height above sea level.

– The "distress coordinates" and "time" information need not be included. In this case the digit 9 repeated 10 times and the digit 8 repeated four times should be included, respectively, as specified in Recommendation ITU-R M.493.

– The "type of subsequent communication" indication should be "no information" (symbol No. 126) which indicates that no subsequent communications will follow.

– The alerting signals should be transmitted in bursts. Each burst should consist of five successive DSC sequences with the (N + 1)th burst of transmission being made with an interval T_n after the (N)th burst as given in Fig. 1, where:

$$T_n = (240 + 10\,N) \text{ s } (\pm 5\%) \text{ and}$$

$$N = 0, 1, 2, 3, \ldots, \text{etc.}$$

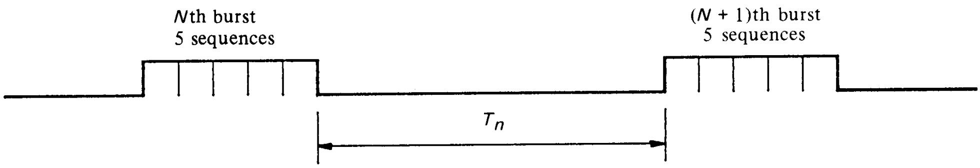

FIGURE 1

RECOMMENDATION ITU-R M.830-1*

Operational procedures for mobile-satellite networks or systems in the bands 1 530-1 544 MHz and 1 626.5-1 645.5 MHz which are used for distress and safety purposes as specified for the GMDSS

(Question ITU-R 90/8)

(1992-2005)

Scope

This Recommendation provides operational procedures for mobile-satellite networks or systems in the bands 1 530-1 544 MHz and 1 626.5-1 645.5 MHz which are used for distress and safety purposes as specified for the GMDSS. The means to ensure the necessary priority access for maritime mobile-satellite distress and safety communications are given in the Recommendation.

The ITU Radiocommunication Assembly,

considering

a) that multiple mobile-satellite networks or systems are operating or being developed to operate in the 1 530-1 544 MHz and 1 626.5-1 645.5 MHz bands;

b) that the bands 1 530-1 544 MHz and 1 626.5-1 645.5 MHz (Radio Regulations (RR) Appendix 15, Table 15-2) available for GMDSS distress and safety communications are also available for other radio services;

c) that with the introduction of mobile-satellite networks or systems within these frequency bands, some of which may not be participants in the GMDSS, the integrity, effectiveness and protection of distress and safety communications must be continuously maintained;

d) that maritime mobile-satellite distress and safety communications must be protected from harmful interference (see RR No. 5.353A);

e) that maritime distress and safety communications require priority access with real time preemptive capability or dedicated channels in the mobile-satellite service;

f) that account must be taken of the priority of safety-related communications (Article 53 of the RR);

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* This Recommendation should be brought to the attention of the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO) and ITU-T.

g) that maritime mobile-satellite distress and safety communications must be relayed to the appropriate Rescue Coordination Centres (RCCs) in the most rapid and expedient manner;

h) that priority relay of distress alerts from ships in distress to the appropriate RCCs must be preserved and be in accordance with Article 53 of the RR;

j) that internetwork or intersystem linking of mobile-satellite systems may be provided via means other than the mobile-satellite service links operating in the 1.5-1.6 GHz frequency bands,

recommends

1 that mobile-satellite networks or systems participating in the GMDSS should be equipped with the means for intersystem linking between coast earth stations;

2 that mobile-satellite networks or systems operating in the frequency bands 1 530-1 544 MHz and 1 626.5-1 645.5 MHz participating in the GMDSS should be equipped with the means to ensure that maritime mobile-satellite distress and safety communications are given the necessary priority access with real time preemptive capability or dedicated channels to ensure the most expeditious handling and relay of the messages to the appropriate RCCs;

NOTE 1 – Section 2 does not apply to MSS systems providing distress and safety services, for which the technical and operational characteristics have already been established in accordance with the relevant provisions of the RR or of the IMO, as applicable.

3 that communications of mobile-satellite system stations operating in the frequency bands 1 530-1 544 MHz and 1 626.5-1 645.5 MHz not participating in the GMDSS shall operate on a secondary basis to distress and safety communications of stations operating in the GMDSS. Account shall be taken of the priority of safety-related communications in the other mobile-satellite services.

RECOMMENDATION ITU-R S.1001*

Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations

(1993)

The ITU Radiocommunication Assembly,

considering

a) that reliable and rapid deployment of telecommunication equipment is essential for relief operations in the event of natural disasters and similar emergencies;

b) that inherent to natural disaster events is the unpredictability of the site location thus implying the need for prompt on-site transportation of the telecommunication equipment;

c) that satellite transmission using transportable earth stations is invaluable and at times is the only viable solution to provide emergency telecommunication services for warning and relief operations;

d) that the World Radio Conference (Geneva, 1979) has adopted Recommendation No. 1;

e) that the telecommunication equipment might perform a variety of functions including, but not limited to, voice communication, field reporting, data collection and in some instances video transmission primarily for aerial site survey,

recommends

1 that when planning the use of systems in the fixed-satellite service for warning and relief operations in the event of natural disasters and similar emergencies, the material in Annex 1 should be taken into consideration;

2 that the following Notes should be regarded as part of this Recommendation:

NOTE 1 – The logistics of the transportation, installation and operation of the telecommunication equipment requires careful consideration in order to maximize the system performance in terms of reliability and deployment rapidity.

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* Radiocommunication Study Group 4 made editorial amendments to this Recommendation in 2001 in accordance with Resolution ITU-R 44 (RA-2000).

NOTE 2 – Although the use of transportable earth stations for disaster management makes it impractical to undertake detailed prior coordination and interference assessment, attention should be paid to these aspects when using shared frequency bands.

ANNEX 1

The use of small earth stations for relief operation in the event of natural disasters and similar emergencies

1 Introduction

In the event of natural disasters, epidemics and famines, etc., the most urgent need is for a reliable communication link for use in relief operations. To set up these communications using the fixed-satellite service (FSS), it is desirable that a transportable earth station, with access to an existing satellite system, should be available for transportation to, and installation at, the disaster area.

To establish such a communication service, any satellite system compatible with the technical characteristics of the transportable earth station can be used.

2 Basic considerations

2.1 Required services and associated channel capability

The communication link for the relief operation connects the disaster area with designated relief centres, and its basic transmission capability would be composed of telephony circuits (including teletype and facsimile) and an engineering service channel.

In addition, because a real time aerial site survey of the disrupted area is also considered to be highly desirable in order to better coordinate relief operations (priority evaluation), in some instances a one-way 2.048 Mbit/s, video-compressed channel could also be needed. Furthermore, a network of unattended platforms for continuous monitoring of main environmental data (1.2 kbit/s average throughput) on specific risk parameters could be usefully integrated in the emergency communications network covering the whole concerned territory, in order to help in the timely location of the disaster area.

2.2 Circuit quality

The quality of circuits for emergency relief operations need not necessarily be of the high quality recommended by the ITU for the FSS. An equivalent weighted signal-to-noise ratio of about 30 dB for a voice channel would appear to provide acceptable voice intelligibility for this purpose.

2.3 Selection of frequency band

For relief operation the use of the 6/4 GHz band is desirable. Where suitable satellites are available, it is preferable that relief operations should be conducted in bands which are not generally shared with terrestrial facilities. Bands such as 14/12 GHz and 30/20 GHz may be suitable in some circumstances.

2.4 Associated earth station

The transportable earth terminal could operate with any suitable existing earth station provided it is suitably equipped. Suitable earth stations would need to be identified so that they may be provided, in advance, with the additional equipment.

3 Preferred modulation methods

The choice of the form of modulation best suited to a system using a transportable earth station must take account of the power-limited condition of the downlink together with the need for flexibility of access to the satellite system.

A station of this type might employ frequency division multiplex FM, or single-channel-per-carrier (SCPC), CFM, PCM/PSK, delta-modulated PSK and low rate encoding LRE/PSK.

The single-channel-per-carrier PCM/PSK is in operation already, and is provided on a global basis. Companded single-channel FM, delta modulation (DM/PSK) and LRE/PSK systems are more effective in a power-limited environment. System efficiency may be further improved by use of forward error-correction coding techniques.

Examples of the required satellite e.i.r.p., the earth station e.i.r.p. and the bandwidth required for most of these modulation methods in the 6/4 GHz band are shown in Table 1. However it should be emphasized that this Table does not reflect all the advanced techniques available at the moment.

TABLE 1

Examples of transmission system parameters in 6/4 GHz band

***G/T* ratio dB(K^{-1}) (diameter)**	**Type of modulation**	**Bandwidth per carrier (kHz)**	**Satellite e.i.r.p. per carrier (dBW)**	**Earth station e.i.r.p. per carrier (dBW)**	**Earth station transmit power per carrier (W)**	**Circuit quality (clear-sky condition)**
17.5 (2.5 m)	FDM-FM (for 6 ch)	250	14	57.5	45	*S/N* 30 dB
	SCPC 64 kbit/s PCM-QPSK	45	11	54.5	22	Bit error ratio: 10^{-4}
	SCPC 32 kbit/s ΔM-BPSK	45	5	48.5	5.6	Bit error ratio: 10^{-3}
	SCPC companded FM	30	1	44.5	2.2	*S/N* 22 dB (without compander)
23.5 (5 m)	FDM-FM (for 6 ch)	250	8	57.5	11	*S/N* 30 dB
	SCPC 64 kbit/s PCM-QPSK	45	5	54.5	5.6	Bit error ratio: 10^{-4}
	SCPC 32 kbit/s ΔM-BPSK	45	–1	48.5	1.4	Bit error ratio: 10^{-3}
	SCPC companded FM	30	–5	44.5	0.6	*S/N* 22 dB (without compander)

NOTE 1 – In the FDM-FM and SCPC companded FM systems, the use of a threshold extension demodulator is assumed.

NOTE 2 – Values of satellite e.i.r.p. and earth station e.i.r.p. are for a small earth station with antenna elevation of 10^{o} excluding any margin. Earth stations with which the small earth station is communicating have a *G*/*T* of 40.7 dB(K^{-1}).

NOTE 3 – Satellite transponder characteristics are similar to those of the Intelsat-V global beam transponder and the transponder gain is assumed such that the difference between earth station e.i.r.p. and the corresponding satellite e.i.r.p. is 65 dB.

NOTE 4 – In addition to FDM-FM, time division multiplexing techniques should also be considered for multichannel applications.

NOTE 5 – Other SCPC encoding techniques such as LRE/PSK at 16 kbit/s should also be considered for use in these applications.

4 Characteristics of the transportable earth station

4.1 System *G/T* ratio

In the 4 GHz band, it will be reasonable to consider a system *G*/*T* in the range of 17.5 to 23.5 dB(K^{-1}) as an objective. Assuming a low noise amplifier with a noise temperature of about 50 K (uncooled FET) and an antenna elevation angle of 10^{o}, these values correspond to antenna diameters in the range 2.5 m to 5 m approximately.

In the 11 to 13 GHz bands, typical receiver noise temperatures range from 100 K to 150 K (FET amplifier). With antennas having diameters around 3 m, *G*/*T* in the order of 23 dB(K^{-1}) could be achieved.

In the 20 GHz band, it will be reasonable to consider a system *G*/*T* in the range of 14.5 to 24.5 dB(K^{-1}) as an objective. Assuming an FET amplifier of noise temperature of about 750 K, these values correspond to antenna diameters in the range of 1 m to 3 m approximately.

4.2 Earth station e.i.r.p.

The earth-station e.i.r.p. depends on the type of modulation, the transmitting channel capacity, and the satellite characteristics.

However, in case of multi-carrier operation, such as the SCPC transmission, the maximum output power of the transmitter must take account of a back-off level to reduce intermodulation noise to an acceptable level. Table 1 shows typical e.i.r.p. required for the transportable earth station.

5 Configuration of the transportable earth station

The earth station may be divided into the following major subsystems:

- antenna,
- power amplifier,
- low noise receiver,
- ground communication equipment,
- control and monitoring equipment,
- terminal equipment, including teleprinters, facsimile and telephones,
- support facilities.

5.1 Weight and size

All the equipment, including shelters, should be capable of being packaged into units of weight which can be handled by a few persons. Furthermore, the total volume and weight should not be in excess of that which could be accommodated in the luggage compartment of a passenger jet aircraft such as a Boeing B707 (allowable weight 7 000 kg) or a Douglas DC8-62 (allowable weight 10 000 kg). This is readily attainable with present-day technology.

5.2 Antenna

One of the major requirements for the antenna is ease of erection and transportation. For this purpose, the antenna reflector could consist of several panels made of light material such as fibre reinforced plastic or aluminium alloy. The use of an antenna of a diameter from 2.5 to 5 m is foreseen for use in the 6/4 GHz band. However, for other frequency bands, antenna construction requirements are eased because smaller antenna sizes can be used.

The main antenna reflector may be illuminated by a front-fed horn or a feed which includes a sub-reflector. The latter type may have a slight advantage in *G*/*T* performance, since the curvature of both the sub-reflector and main reflector can be optimized, but ease of erection and alignment may take precedence over *G*/*T* considerations.

A manual or automatic pointing system may be provided commensurate with weight and power consumption, by monitoring a carrier signal from the satellite, having a steerable range of approximately ±5°.

5.3 Power amplifier

Air-cooled klystron and TWT (helix-type) amplifiers are both suitable for this application, but from the point of view of efficiency and ease of maintenance, the former is preferred.

Although the instantaneous transmission bandwidth is small, the output amplifier may need to have the capability of being tunable over a wider bandwidth, e.g. 500 MHz, since the available satellite channel may be anywhere within this bandwidth.

For power requirements less than 15 W, a solid state power amplifier (FET) would also be suitable.

In the 30 GHz band, IMPATT, TWT and klystron amplifiers are suitable for this application.

5.4 Low-noise receiver

Because the low-noise receiver must be small, light and be capable of easy handling with little maintenance, an uncooled low noise amplifier is the most desirable.

A temperature of 50 K has been realized and even lower temperatures are expected in the future in the 4 GHz band. An FET amplifier is more suitable from the point of view of size, weight and power consumption than a parametric amplifier. A noise temperature of 50 K in the 4 GHz band and 150 K in the 12 GHz band has been realized by FET amplifiers. In the 20 GHz band, an FET amplifier with a noise temperature of 300 K or less at room temperature has been realized.

6 Examples of transportable earth station realizations and system implementation

6.1 Small transportable earth stations

In the 6/4 GHz band, a number of transportable earth stations are operating now with various antenna diameters. In the 14/12 GHz band, most of the transportable stations have antennas with around 3 m diameters.

6.1.1 An example of a small transportable earth station for operation at 6/4 GHz

An air-transportable earth station, which may also be carried by an 8-ton truck, has been manufactured using the principles outlined in § 5 and satisfactory performance has been achieved.

The station has a 3 m diameter antenna, a peak e.i.r.p. of about 67 dBW and a *G*/*T* of about 18 dB(K^{-1}). The total weight is 7.0 tons and the power requirement, including air conditioning, is 12.5 kVA. The reflector is in one piece and the total setting up time for the system is about 1 hour using three persons. The station uses FDM-FM and provides 132 two-way channels using a shaped beam transponder similar to the Japanese CS-3 (Communication Satellite-3) transponder with a channel signal-to-noise ratio of about 43 dB*.

6.1.2 Examples of air transportable and vehicle equipped small earth stations in the 14/12 GHz band

Various types of small earth station equipment have been developed for the use of new satellite communication systems in the 14/12 GHz band in Japan. For implementing small earth stations, efforts have been made to decrease the size and to improve transportability so as to ease their use for general applications. This allows the occasional or temporary use of these earth stations for relief operation elsewhere in the country or even worldwide. Such temporary earth stations are installed either in a vehicle or use portable containers with a small antenna. It is thus possible to use them in an emergency.

The vehicle equipped earth station in which all the necessary equipment is installed in the vehicle, e.g. a four-wheel drive van, permits operation within 10 min of arrival including all necessary actions such as antenna direction adjustments.

A portable earth station is disassembled prior to transportation and reassembled at the site within approximately 15 to 30 min. The size and weight of the equipment generally allow it to be carried by hand by one or two persons, and the containers are within the limit of the IATA checked luggage regulations. Total weight of this type of earth station including power generator and antenna assembly is reported to be as low as 150 kg, but 200 kg is more usual. It is also possible to carry the equipment by helicopters.

Examples of small transportable earth stations for use with Japanese communication satellites in the 14/12 GHz band are shown in Table 2.

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* *Note from the Director, Radiocommunication Bureau* – The information contained in the second paragraph of § 6.1.1 of this Recommendation has been updated based on the proposal from the Japanese Administration which was received after the approval under former ex-CCIR Resolution 97 (Düsseldorf, 1990).

TABLE 2

Example of small transportable earth stations for the 14/12 GHz band

Example No.	1	2	3	4	5	6
Type of transportation	Vehicle equipped			Air transportable		
Antenna diameter (m)	2.6 × 2.4	1.8	1.2	1.8	1.4	1.2
e.i.r.p. (dBW)	72	70	62.5	70	64.9	62.5
RF bandwidth (MHz)	24-27	20-30	30	20-30	30	30
Total weight	6.4 tons	6.0 tons	2.5 tons	275 kg	250 kg	200 kg
Package: – Total dimensions (m) – Total number – Max. weight (kg)	 – – –	 – – –	 – – –	 <2 10 45	 <2 13 34	 <2 8 20
Capacity of engine generator (kVA)	7.5	10	5	3	0.9-1.3	1.0
Required number of persons	1-2	1-2	1-2	2-3	2-3	1-2

6.1.3 Examples of small transportable earth stations for operation at 30/20 GHz

Two types of 30/20 GHz small transportable earth stations, which can be transported by a truck or a helicopter, have been manufactured and operated satisfactorily in Japan.

Examples of small transportable earth stations for operation at 30/20 GHz are shown in Table 3.

6.2 Example of an emergency network and associated earth stations in the 14/12.5 GHz band

An emergency satellite network has been designed and implemented in Italy for operation in the 14/12.5 GHz frequency band via a EUTELSAT transponder. This dedicated network, which is based on the use of wholly digital techniques, provides emergency voice and data circuits and a time shared compressed video channel for relief operations and environmental data collection. The network architecture is based on a dual sub-networking star configuration, for the two services and makes use of a TDM-BPSK and an FDMA-TDMA-BPSK dynamic transmission scheme, respectively for the outbound and inbound channels. The ground segment is composed of: a master common hub station for the two star networks, which is a fixed-earth station having a 9 m antenna and a 80 W transmitter; a small number of transportable earth stations, having antennas of 2.2 m and 110 W transmitters; a number of fixed data transmission platforms with 1.8 m dishes and 2 W solid state power amplifier transmitters. These platforms have a receive capability (G/T of 19 dB/K), in order to be remotely controlled by the master station, and their average transmit throughput is 1.2 kbit/s.

The transportable earth stations are mounted on a lorry, but if necessary, can also be loaded in a cargo helicopter for fast transportation. They have a *G*/*T* of 22.5 dB(K^{-1}) and are equipped with two sets of equipment each containing one 16 kbit/s (vocoder) voice channel and one facsimile channel at 2.5 kbit/s. These earth stations which are also able to transmit a compressed video channel at 2.048 Mbit/s in SCPC-BPSK, are remotely controlled by the master station. The major features of this *ad hoc* emergency network are summarized in Table 4.

TABLE 3

Examples of small transportable earth stations

Operating frequency (GHz)	Total weight (tons)	Power requirement (kVA)	Antenna		Maximum e.i.r.p. (dBW)	*G*/*T* dB(K^{-1}))	Type of modulation	Total setting-up time (h)	Normal location of earth station
			Diameter (m)	Type					
30/20	5.8	12	2.7	Cassegrain	76	27	FM (colour TV 1 channel) (1) or FDM-FM (132 telephone channels)	1	On a truck
	2	9	3	Cassegrain (2)	79.8	27.9	FM (colour TV 1 channel) (1) and ADPCM-BPSK-SCPC (3 telephone channels)	1	On the ground
	1	1(3)	2	Cassegrain	56.3	20.4	ADM-QPSK-SCPC (1 telephone channel)	1.5	On the ground
	0.7	3	1	Cassegrain	59.9	15.2	FM-SCPC (1 telephone channel) or DM-QPSK-SCPC (1 telephone channel)	1	On a truck

(1) One-way.
(2) The reflector is divided into three sections.
(3) Excluding power for air conditioning.

TABLE 4

Example of an emergency satellite communication network operating at 14/12.5 GHz

Station designa-tion	**Antenna diameter (m)**	***G/T*** **(dB(K^{-1}))**	**Trans-mitter power (W)**	**Primary power requi-rement (kVA)**	**Transmission scheme**		**Service capability**
Master	9.0	34.0	80	15.0	Tx	512 kbit/s-TDM/BPSK (+ FEC 1/2)	12 × 16 kbit/s (vocoder) voice channels 12 × 2.4 kbit/s facsimile channels 1 × 2.048 Mbit/s video channel
					Rx	“*n*” × 64 kbit/s- FDMA/TDMA/BPSK (+ FEC 1/2) and 2.048 Mbit/s- SCPC/QPSK (+ FEC 1/2)	
Peripherals (transpor-table)	2.2	22.5	110	2.0	Tx	64 kbit/s-TDMA/BPSK (+ FEC 1/2) and 2.048 Mbit/s- SCPC/QPSK (+ FEC 1/2)	2 × 16 kbit/s (vocoder) voice channels 2 × 2.4 kbit/s facsimile channels 1 × 2.048 Mbit/s video channel
					Rx	512 kbit/s-TDM/BPSK (FEC 1/2)	
Unattended platforms	1.8	19.0	2	0.15	Tx	64 kbit/s-TDMA/BPSK (+ FEC 1/2)	1 × 1.2 kbit/s data transmission channel
					Rx	512 kbit/s-TDM/BPSK (+ FEC 1/2)	

RECOMMENDATION ITU-R M.1042-2

Disaster communications in the amateur and amateur-satellite services

(Question ITU-R 48/8)

(1994-1998-2003)

The ITU Radiocommunication Assembly,

considering

a) Resolution 36 of the Plenipotentiary Conference (Kyoto, 1994);

b) Resolution 644 (Rev.WRC-2000) concerning telecommunications resources for disaster mitigation and relief operations;

c) the adoption of the Tampere Convention on the provision of telecommunications resources for disaster mitigation and relief operations by the Intergovernmental Conference on Emergency Telecommunications from 16-18 June 1998;

d) ITU-D Resolution 34 (Istanbul, 2002) (WTDC-02) on telecommunication resources in the service of humanitarian assistance;

e) ITU-D Recommendation 12 (Istanbul, 2002) (WTDC-02) regarding consider-ation of disaster telecommunication needs in telecommunication development activities,

recommends

1 that administrations encourage the development of amateur service and amateur-satellite service networks capable of providing communications in the event of natural disasters;

2 that such networks be robust, flexible and independent of other telecommunications services and capable of operating from emergency power;

3 that amateur organizations be encouraged to promote the design of robust systems capable of providing communication during disasters and relief operations;

4 that amateur organizations be allowed to exercise their networks periodically during normal non-disaster periods.

RECOMMENDATION ITU-R F.1105-1*

Transportable fixed radiocommunications equipment for relief operations

(Question ITU-R 121/9)

(1994-2002)

The ITU Radiocommunication Assembly,

considering

a) that rapid and reliable telecommunications are essential for relief operations in the event of natural disasters, epidemics, famines and similar emergencies;

b) that transportable fixed wireless equipment may be used for relief operation of either radio or cable links and may involve multi-hop applications with digital and analogue equipment;

c) that fixed wireless equipment for relief operations may be operated in locations with differing terrain and in differing climatic zones;

d) that fixed wireless equipment for relief operations may be used in areas with an unfavourable interference environment;

e) that interoperability and internetworking between transportable fixed wireless equipment and other networks would be beneficial in emergency situations as stated in *considering* a);

f) that the World Radiocommunication Conference (Istanbul, 2000) (WRC-2000) resolved to invite ITU-R to conduct studies on the technical and operational basis for global cross-border circulation of radiocommunication equipment in emergency and disaster relief situations (see Resolution 645 (WRC-2000)),

recommends

1 that for relief operations in devastated areas or restoration of a break in transmission links several types of transportable fixed wireless equipment as given in Table 1 are required;

* This Recommendation should be brought to the attention of Radiocommunication Study Group 8 (Working Party 8A) and Telecommunication Development Study Group 2.

TABLE 1

Types of transportable fixed wireless equipment for relief operations

Type	Feature	Application
A	A simple communication link which can be established rapidly for telephone communication with a governmental or international headquarters	(1) (2)
B	One or more local networks which connect a communications centre and up to about 10 or 20 end-user stations with telephone links	(1)
C	A telephone link for between about 6 and 24 channels or a data link up to the primary rate over a line-of-sight or near line-of-sight path	(1) (2)
D	A link over an obstructed or trans-horizon path	(2)
E	A high-capacity telephone link (more than 24 channels) or digital fixed wireless link (above the primary rate)	(2)

Application (1): for devastated areas

Application (2): for breaks in transmission links

2 that frequency bands used for operation of transportable fixed wireless equipment should be in accordance with the Radio Regulations for the fixed service, as well as with national and regional frequency allocations (see Table 2);

3 that radio-frequency arrangements for transportable fixed wireless equipment in the chosen bands should be in accordance with ITU-R Recommendations (see Recommendation ITU-R F.746) and national standards;

4 that interconnection with working analogue and digital fixed wireless systems and cable systems at the terminal and nodal stations should be made at baseband in accordance with Recommendations ITU-R F.380, ITU-R F.270 and ITU-R F.596 (see Notes 1, 2 and 3);

5 that interconnection with working analogue radio-relay systems and digital radio-relay systems without regeneration at repeater stations should be made at the intermediate frequency in accordance with Recommendation ITU-R F.403;

6 that interconnection with analogue and digital cable systems at repeater stations should be made at baseband;

7 that interconnection with fibre-optic systems at repeater stations may be made at points with a significant level of optical power;

8 that for equipment characteristics, the information contained in § 1 of Annex 1 can be referred to as a guide for administrations and system planners;

9 that performance objectives of links which use transportable fixed wireless equipment as well as separate links formed by the transportable fixed wireless equipment during restoration should have performance values sufficient for normal service (see § 3 of Annex 1);

10 that transportable fixed wireless equipment given in Table 1 can be used for the access link to a base station in mobile communications that are operating in disaster relief and emergency situations.

NOTE 1 – For Types A and B, which usually terminate in a telephone, few interface problems will arise.

NOTE 2 – Analogue equipment can also be used for small capacity digital signal transmission provided that suitable interface equipments are available.

NOTE 3 – Digital equipment can contain multiplexing/demultiplexing functions for more effective operation.

ANNEX 1

1 Equipment characteristics

For each type of equipment in Table 1, the channel capacities, frequency bands and path distances specified in Table 2 are suitable.

TABLE 2

Basic characteristics

Equipment type	Capacity	Suitable frequency bands	Transmission path distance
A	1-2 channels	HF (2-10 MHz)	Up to 250 km
B	Local network with 10-20 outstations (several channels)	VHF (50-88 MHz) (150-174 MHz) UHF (335-470 MHz)	Up to a few km
C	6-24 or 30 channels up to the primary rate	UHF (335-470 MHz) (1.4-1.6 GHz) SHF (7-8 GHz) (10.5-10.68 GHz)	Up to 100 km
D	12-120 channels	UHF (800-1 000 MHz) (1.7-2.7 GHz) SHF (4.2-5 GHz)	Line-of-sight or obstructed paths
E	960-2 700 FDM channels STM-0 (52 Mbit/s) or STM-1 (155 Mbit/s)	SHF (4.4-5 GHz)(1) (7.1-8.5 GHz)(1) (10.5-10.68 GHz) (11.7-13.2 GHz)(1) (23 GHz)	Up to several tens of km

FDM: frequency division multiplexing

STM: synchronous transfer mode

(1) These bands are shared with satellite services.

In the case of links to an earth station operating in a satellite service, the following additional restrictions should be considered:

– space-to-Earth frequency bands should be avoided;

– problems could arise if Earth-to-space frequency bands are used;

– trans-horizon systems (Type D) should be avoided.

It would be preferable to avoid bands likely to be in use or planned for trunk communications. However, these bands may be used for Type E with careful consideration of interference problems by the administration.

2 Engineering principles

2.1 Low-capacity links (equipment Type A)

HF transportable equipment for 1 or 2 channels should employ only solid-state components and should be designed to switch off the transmitters when not in use, in order to conserve battery power, and to reduce the potential of interference.

As an example, a solid-state 100 W single-sideband terminal in a band between, say, 2 and 8 MHz operated with a whip antenna, could have a range of up to 250 km. Simplex operation (transmitter and receiver employing the same frequency) with a frequency synthesizer to ensure a wide and rapid choice of frequency when interference occurs and to facilitate setting-up in an emergency, can give up to 24 h operation from a relatively small battery (assuming that use of the transmitter is not excessive). The battery can be charged from a vehicle generator and all units can be hand-carried over rough country.

2.2 Local radio networks (equipment Type B)

Radio networks of Type B are envisaged as local centres with single-channel radiocommunication with 10 to 20 out-stations, operating on VHF or UHF up to about 470 MHz. Single-channel and multi-channel equipments similar to types used in the land mobile service could be used.

2.3 Links up to 30 channels (equipment Type C)

d.c. operated solid-state equipment is preferred. It can be associated with light-weight, high gain Yagi (or similar) antennas, giving a range of up to 100 km line-of-sight, but capable of accepting some obstruction from trees on shorter paths. Simply erected guyed poles which can be rotated from ground level are to be preferred. If separate antennas are used for transmitting and receiving with cross-polarization, it is convenient for the transmitters to be connected to antennas which are polarized at 45^o (from top right to bottom left looking along the path from behind the antenna); if transmit and receive antennas are mounted on the same sub-assembly, with male and female connectors, there can then be no confusion over the plane of polarization to be selected, since the received signal will always be cross-polarized with respect to the transmitted one.

Single frequency, or selectable pre-set frequencies are to be preferred to eliminate as many variables as possible during the initial setting-up of the equipment. Foam-filled or solid dielectric flexible cable is to be preferred as this is less liable to mechanical damage and the effects of moisture.

2.4 Trans-horizon (equipment Type D)

Equipment which is suitable for transportation by road or railway or by helicopter is available. Such equipment, together with power supply equipment, can be easily and quickly installed and put into service. The equipment capacity is from about 12 to 120 telephone channels, depending on the requirements, the topography and other factors. The use of receivers with low noise factors and with special demodulators and of diversity reception, enables the size of the antennas, the transmitter power and the size of the power supply equipment, to be smaller than those often used for conventional trans-horizon installations.

2.5 High capacity links (equipment Type E)

For capacities of 300 telephone channels and above, it is recommended that the radio-frequency equipment is integrated directly to the antennas. For transportable equipment, preference should be given to equipment in which reflectors of diameter less than about 2 m are available. Because IF interconnection at repeaters is a desirable feature, an IF interconnection should be possible between the radio-frequency heads.

However, since the equipment which is to be bypassed in an emergency or for temporary use will most likely be at ground level, the control cable should bring the IF to the control unit at ground level. The antennas of equipments used for relief operations are likely to be smaller than those of fixed microwave links and it is therefore important that the output power of the transmitters should be as high as possible and the noise factor of receivers should be as low as possible. Battery operated equipment is preferable: 12 V and/or 24 V supplies are appropriate if the batteries are to be rechargeable from the dynamos or alternators of any vehicles which are available.

An alternative arrangement would be to house the equipment in a number of containers. These would not only facilitate the transport of the equipment but each container could provide facilities for rapidly installing a number of transmitters and receivers. The maximum number of transceivers to be housed in any one container would depend on the dimensions and maximum weight adopted, allowing for transport by helicopter, aeroplane or any other means of transport. Furthermore, it is preferable to take into consideration equipment operating with ordinary commercial power supplies. Fixed wireless systems generally require line-of-sight operation. For digital fixed wireless systems, the interface should be based on the primary rate (2 Mbit/s (E1) or 1.5 Mbit/s (T1)).

3 Transmission quality

Equipment of Type A will have a noise performance which is critically dependent upon the antennas and path length in a particular case.

Equipments of Types B and C are likely to provide similar transmission quality, when in use for relief work, as in normal use.

Equipment of Type D would, as with Type A, be very dependent upon the siting of the terminals and the size of antennas.

Transportable microwave equipment of Type E, because of the need to use smaller antennas and lower transmitter powers than for fixed links, would be likely to have a transmission quality below that normally required for trunk connections. Nonetheless this performance should be such that the network can still carry out all normal functions. Guidance for the performance in such emergency conditions is given as follows:

– $<$ 1 000 pW for up to 50 km for 960 channels (4-12 GHz);

– $<$ 5 000 pW for up to 50 km for more than 1 800 channels (4-6 GHz);

– $<$ 5 000 pW for up to 25 km for 2 700 channels (11 GHz);

– $< 1 \times 10^{-8}$ BER for digital systems.

RECOMMENDATION ITU-R M.1467*

PREDICTION OF A2 AND NAVTEX RANGES AND PROTECTION OF A2 GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM DISTRESS WATCH CHANNEL

(Question ITU-R 92/8)

(2000)

The ITU Radiocommunication Assembly,

considering

a) that the International Convention for Safety of Life at Sea (SOLAS) 1974, as amended, prescribes that all ships subject to this Convention shall be fitted for the global martime distress and safety system (GMDSS) by 1 February 1999;

b) that some administrations have yet to establish A2 services for the GMDSS;

c) that Question ITU-R 92/8 identifies the need for promulgation of minimum performance criteria for the protection of the service, and guidance to accelerate the upgrade of shore-based facilities for GMDSS operation in the A2 sea area,

recommends

1 that administrations currently upgrading, or planning to upgrade, their shore-based facilities for GMDSS operation in the A2 sea area should use the information contained in Annex 1.

NOTE 1 – Administrations are invited to develop appropriate software to enable the calculations, described in Annex 1, to be performed.

* This Recommendation should be brought to the attention of the International Maritime Organization (IMO).

ANNEX 1

Prediction of A2 and NAVTEX ranges

1 Overview

In order to establish a new A2 sea area it is necessary to account for variations in the propagation conditions. A2 coverage is by groundwave, which is largely stable, enabling the extent of the service area to be confirmed by measurement, as is recommended by the IMO, before committing capital expenditure.

The design criteria to be used for establishing A2 and NAVTEX sea areas are defined by the IMO in Annex 3 to their Resolution A.801(19).

2 Prediction of A2 and NAVTEX ranges

2.1 IMO performance criteria

The criteria developed by the IMO for determination of A2 and NAVTEX ranges are reproduced in Table 1 and should be used in the determination of ranges for A2 and NAVTEX services.

TABLE 1

Performance criteria for A2 and NAVTEX transmissions

Distress channel	**Radio-telephony**	**DSC**	**ARQ NBDP**	**NAVTEX**
Frequency (kHz)	2 182	2 187.5	2 174.50	490 and 518
Bandwidth (Hz)	3 000	300	300	500
Propagation	Groundwave	Groundwave	Groundwave	Groundwave
Ships power (W)	60	60	60	
Ships antenna efficiency (%)	25	25	25	25
RF full bandwidth signal/ noise ratio (*S*/*N*) (dB)	9	12	18 min[(1)]	8
Mean Tx power below peak (dB)	8	0	0	0
Fading margin (dB)	3	Not stated		3
IMO reference for above	Res. A.801(19)	Res. A.804(19)	Rec. ITU-R F.339	Res. A.801(19)
Availability required (%)	95	Not stated	Not stated	90

DSC: digital selective calling
NBDP: narrow band direct printing
(1) Stated as 43 dB(Hz) under stable and 52 dB(Hz) under fading conditions with 90% traffic efficiency.

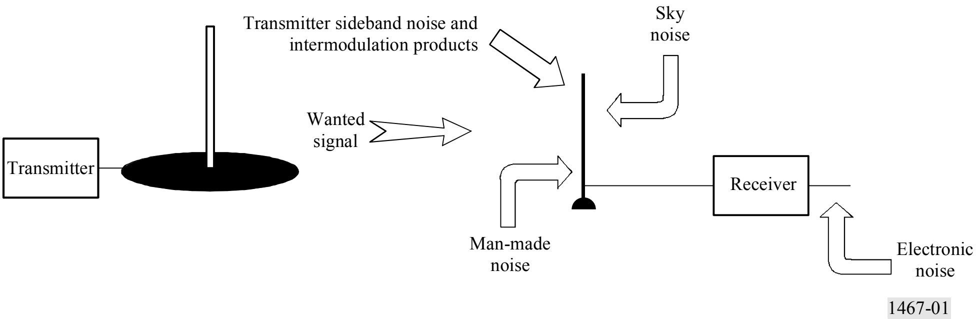
2.2 Achieving the required quality of signal

2.2.1 The effect of received noise

On a very quiet site, man-made noise dominates below 4 MHz and galactic noise above. These combine, at the receive antenna with seasonal levels of atmospheric noise, and also transmitter sideband noise, as shown in Fig. 1 below. Recommendation ITU-R P.372 should be used to account for atmospheric and normal man-made noise levels.

FIGURE 1

Determination of required carrier-to-noise ratio (*C*/*N*)



Paragraph 3.5 should be used to ensure that the levels of transmitter sideband noise and intermodulation products reaching the receive antenna by groundwave do not exceed the tolerable limit for protection of the A2 DSC watch frequency.

2.2.2 *C/N* required for single sideband (SSB) radiotelephony

In order to maintain the intelligibility of a received SSB radiotelephony signal it is necessary to provide the operator with a minimum AF signal/noise plus distortion ratio (SINAD), which in turn defines the RF *C/N* required at the receive antenna.

The capture range for an A2 receive system should be calculated assuming an RF *C/N* density figure of 52 dB(Hz) at the shore-based receive antenna. This will ensure that a ship's transmitter operating with a peak-to-mean ratio of 8 dB provides the shore-based operator with a 9 dB *S/N* in a 3 000 Hz bandwidth, as stipulated by the IMO.

The receive antenna and multicoupler should be designed to offer good linearity to minimize the risk of intermodulation products being generated on the watch frequencies. With good electronic design the noise generated within the receive system itself can be ignored below 3 MHz.

2.2.3 *C/N* required for NAVTEX broadcasts

The transmit range for NAVTEX broadcasts should be calculated assuming an RF *C*/*N* density figure of 35 dB(Hz) at the ship's antenna. This will ensure that the NAVTEX receiver is provided with an RF *S*/*N* of 8 dB in a 500 Hz bandwidth, as stipulated by the IMO.

2.3 Accounting for ships topside noise

Topside noise refers to the environmental noise generated by ship-borne machinery, and other sources, and a figure is required for entry into NOISEDAT and other programs. Table 2 shows a number of published figures, and for reference purposes includes galactic and quasi-minimum noise levels, which is accepted as representing the best achievable noise floor.

TABLE 2

Naval environmental categories for topside noise

Environmental category	dB below 1 W ref. 3 MHz
DOD Cat 1 mobile platform	–137.0
IPS ship (ASAPS and GWPS)	–142.0
AGARD ship	–148.0
Quasi-minimum noise	–156.7
Noise galactic (Rec. ITU-R P.372)	–163.6

ASAPS: advanced stand alone prediction system
GWPS: groundwave prediction system

The Australian Department of Defence (DOD) and Advisory Group for Aeronautical Research and Development (AGARD) have both published relevant figures. The AGARD figure represents a naval vessel under normal cruise conditions, whilst the DOD figure represents the maximum level under battle conditions with all machinery in operation.

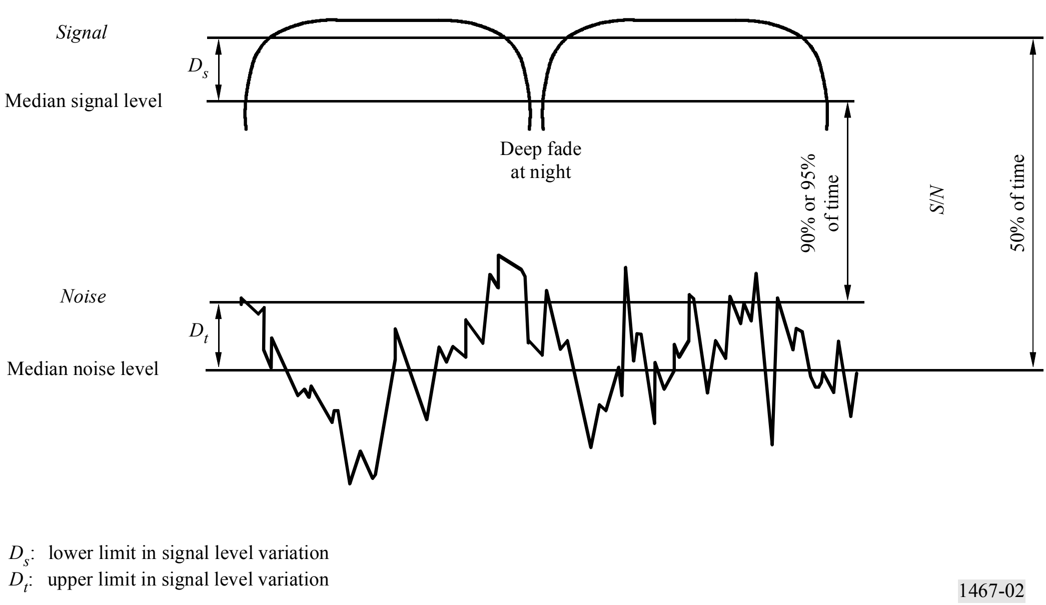
The levels of noise to be expected on commercial vessels can be expected to range between these figures. The IPS Radio and Space Services (IPS) of the Australian Department of Industry have adopted an intermediate figure in their GWPS, which is well accepted as representing the noise level encountered on container vessels, pleasure cruisers, and utility ships. This figure, –142 dBW, should be used in prediction of coverage area of shore-based GMDSS transmitters.

2.4 Determination of external noise factor, F_a, for the required availability

An A2 area in the GMDSS is defined as the area within which ship stations can alert shore stations by using DSC on MF and communicate with the shore stations using MF radiotelephony, (class of emission J3E). The communications ranges for voice signals are shorter than for DSC and the IMO criteria for determination of A2 areas should therefore be based on the communication of voice signals.

The range achieved by a transmitter or a receiver depends upon the radiated power, the propagation loss, and the ability of the receiver to discriminate between the wanted signal and the unwanted noise or interference. The level of each component in the received signal will drift as the propagation conditions change with time, and therefore arrive at the receive antenna in varying proportions. The final system design should therefore ensure that the level of the signal will exceed the level of the noise by an adequate amount for an adequate proportion of the time. This proportion is called the availability, and is determined by quantifying the behaviour of the signal and the noise with time as shown in Fig. 2.

FIGURE 2



Equation (1) should be used to calculate an upper value F_a for the external noise factor which corresponds to the required availability:

$$F_a = F_{am} + \sqrt{D_t^2 + D_s^2} \quad \text{dB above } k\, T_0\, B \qquad (1)$$

where:

F_{am}: median external noise factor

D_s: variation in signal level expected for the required time percentage, to which is ascribed the figure of 3 dB specified by the IMO as fading margin

D_t: variation in noise level expected for the required percentage of time.

90% availability is required for NAVTEX broadcasts, and so the upper decile value D_u should be substituted for D_t in equation (1).

95% availability is required for A2 coverage. To achieve this, substitute $D_t = D_u + 3$ dB in equation (1).

First F_{am} and D_u should be determined by running the Noise1 program, which comes with the ITU NOISEDAT package. The program requests seasons required, site location, frequency, level or category of man-made noise, and type of data output required (select F_a), local mean time, and statistical parameters required (select overall median). For prediction of external noise factor on ship stations, the reference figure of –142 dBW should be used to account for topside noise, if no better data is available.

The data is presented in seasonal blocks as shown in Table 3, the data fields being explained in Table 4.

TABLE 3

Sample NOISEDAT output

LAT = –51.45,		LONG = –57.56,		DUMMY SITE					
WINTER	FMHZ = 2.182,			QUIET RURAL NOISE					
				OVERALL NOISE					
TIME BLOCK	ATMO	GAL	MAN-MADE	OVER-ALL	DL	DU	SL	SM	SU
0000-0400	59.3	44.2	43.9	59.6	7.2	9.2	2.3	3.5	2.6
0400-0800	54.0	44.2	43.9	54.5	4.1	1.9	3.2	3.4	2.7
0800-1200	28.2	44.2	43.9	45.9	4.3	9.0	2.2	3.4	1.3
1200-1600	31.0	44.2	43.9	46.0	4.2	8.9	2.2	3.3	1.3
1600-2000	53.5	44.2	43.9	53.9	10.4	12.2	3.6	3.9	2.9
2000-2400	54.3	44.2	43.9	55.2	7.2	9.2	2.3	3.7	2.6

TABLE 4

Fields presented for use in the NOISEDAT output

Field	Symbol	Description
TIME BLOCK		Time block during which original measurements were made
ATMO		Level of atmospheric component
GAL		Level of galactic component
MANMADE		Level of man-made component
OVERALL	F_{am}	Median level of F_a
DL	D_l	Lower decile of deviation from median
DU	D_u	Upper decile of deviation from median
SL	σD_l	Standard deviation of D_l
SM	σF_{am}	Standard deviation of F_{am}
SU	σD_u	Standard deviation of D_u

The median and upper values for F_a should be organized as shown in Table 5, and the seasonal spread in the value of F_a for the required availability should be plotted as a bargraph in Fig. 3. This presentation enables the process to be reviewed if any anomalies occur.

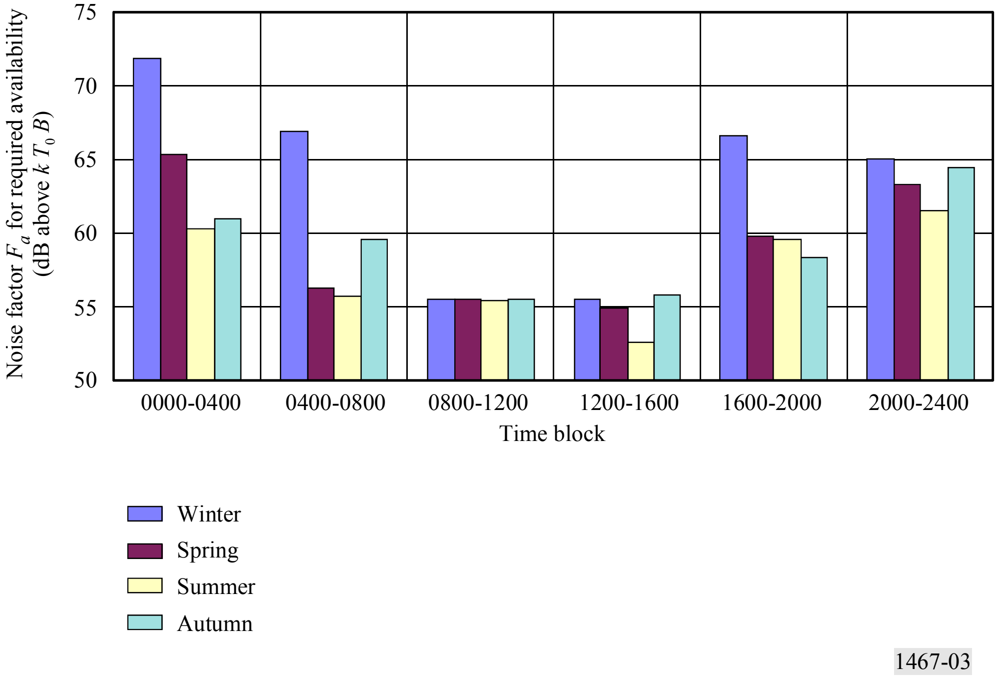
TABLE 5

External noise factor, F_a

	Median value, F_{am}				**F_a for required availability** $F_{am} + \sqrt{D_t^2 + D_s^2}$			
Time block	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn
0000-0400	59.6	55.9	52	52.2	71.7	65.2	60.2	60.9
0400-0800	54.5	43.7	45.9	46	66.8	56.2	55.6	59.5
0800-1200	45.9	45.9	45.8	45.9	55.4	55.4	55.3	55.4
1200-1600	46	41.9	37.7	45.8	55.4	54.8	52.5	55.7
1600-2000	53.9	43.2	43.6	43.9	66.5	59.7	59.5	58.2
2000-2400	55.2	55	54.4	55.8	64.9	63.2	61.4	64.3

FIGURE 3

Seasonal spread in external noise, F_a, calculated for required availability



In the example shown, a figure of 72 dB should be taken for calculation of A2 range.

2.5 Accounting for propagation by groundwave

2.5.1 Introduction

Horizontally polarized waves will not propagate along the surface of normal ground, as the electric vector runs tangential to the surface causing a current to flow, which results in absorption and heavy transmission losses. For this reason groundwaves have to be vertically polarized, and can only be generated by a vertical antenna, or to a limited extent by an antenna which is not perfectly horizontal, either because one end is higher than the other, or because the elements droop.

The prime mover for groundwave propagation is the cymomotive force (c.m.f.) exerted by the transmit antenna. In free space, power flux-density (W/m2) decreases inversely with the square of distance, and so the field strength decreases inversely with distance and has a value equal to the product of c.m.f. and distance. The c.m.f. is synonymous with the effective monopole radiated power (e.m.r.p.), which is the power (kW) which would have to be fed into a short lossless monopole to achieve the same c.m.f., and in dB terms the two have the same value. A short lossless monopole on a perfect ground fed with 1 kW has a c.m.f. of 300 V, which is the reference used in the groundwave curves given in Recommendation ITU-R P.368.

Subsequent calculation of the transmitter power required should take account of the following losses associated with the antenna:

– the transmitter output power may be de-rated by an antenna offering a poor match;

– power will be absorbed by the ground and the feeder;

– whereas an ideal monopole will produce maximum radiation along the ground, the radiation from a real antenna will peak a few degrees above the ground and tuck in to a lower value along the ground.

2.5.2 Proof of performance tests

IMO Resolution A.801(19) stipulates that the range of the A2 sea area should be verified by field strength measurement. The c.m.f. of any shore-based transmitter and antenna should therefore be determined by operating the transmitter continuously at peak power, and measuring the resulting field strength using a portable field strength meter. This should be done on an arc around the station with an approximate radius of 1 km in the required directions of propagation. The precise location of the antenna and each measurement point should be fixed using a GPS navigator. The c.m.f. on each bearing is then the product of field strength (mV/m) and range (km) for each measurement point. The antenna drive point current should also be recorded before and after the measurement.

The procedures in this Recommendation should be used by administrations to determine the c.m.f. required to establish coverage, which should then be demonstrated by the equipment supplier, effectively eliminating uncertainties in performance due to local ground conditions, and the antenna and station earthing system.

2.5.3 Determination of extent of A2 service area

The extent of the A2 service area is determined by the range over which SSB communication is effective at 2 182 kHz between ship and shore. The ship is considered to be fitted with a 60 W transmitter, feeding a short monopole antenna with an efficiency of 25%, as given in Table 1. The range is fixed by the maximum distance at which the ship can be from the shore station to produce a S/N of 9 dB in a 3 kHz bandwidth out of the receive antenna at the shore station. The shore transmit station must transmit sufficient power to return the same S/N at the output of the ship's receive antenna.

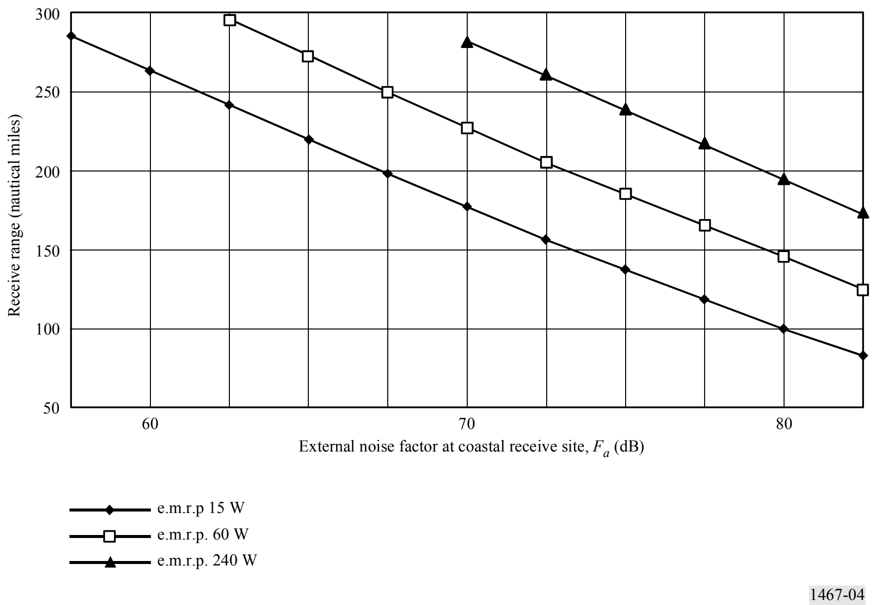
The range in both directions depends upon the sensitivity of the receive antenna, which depends upon the levels of natural and man-made noise present, and the ability of the antenna to discriminate between the wanted signal and the unwanted radiated noise. Although some improvement can be achieved by using a directional receive antenna, this often proves to be uneconomic and impractical, and is outside the scope of this Recommendation. It will be assumed that a short whip antenna is used for reception, that it has been installed on clear ground on an earth mat, and that it is regularly maintained to avoid the effects of corrosion. The noise factor of the receive system connected to the antenna can be ignored at 2 182 kHz.

2.5.3.1 Determination of shore-based receive range

The IMO minimum range thus achieved should be determined for all seasonal values of F_a using the 15 W curve in Fig. 4. Additional curves have been included to demonstrate the benefit of vessels using higher transmit powers.

FIGURE 4

Distress receive range versus F_a for various transmitted ships powers



2.5.3.2 Determination of shore-based transmit power required

Effective two-way SSB radiotelephony requires matched conditions in both directions. Since the transmission loss is the same in both directions the power required to return a call depends primarily upon the difference in noise levels at each end, and also the difference in transmit antenna efficiency. However the following additional factors have a direct impact on the power to be transmitted by the shore station:

– peaks and troughs in the radiation pattern of the receive antenna on the ship, due to interaction with the ship's hull;

– losses due to the condition of the ship's receive antenna on the ship.

Tests on scale models of a number of vessels indicate that variability in gain of receive antennas is typically ±5 dB. Furthermore, allowance should be made for ships whose antennas are in poorly maintained condition. A figure of 10 dB has been included in the calculation of shore-ship power budget to take account of these factors.

To determine the radiated power required from the shore-based transmitter the external noise factors for the receive stations on shore, F_{ac}, and ship, F_{as}, should first be established as described in § 2.4. The minimum e.m.r.p. required to return a GMDSS call at the same S/N to a ship on the limit of the service area should then be calculated using equation (2):

$$P_{e.m.r.p.} = (F_{as} - F_{ac}) - 16 + R_{pm} \qquad \text{dB(kW)} \qquad (2)$$

where:

R_{pm}: peak-to-mean ratio of the transmitter used on the shore station (dB).

The transmitter power required, P_{Tx}, should then be determined from equation (3), in which L_a should account for all the losses associated with the antenna described in § 2.5.1:

$$P_{Tx} = P_{e.m.r.p.} + L_a \qquad (3)$$

Substituting typical figures $(F_{as} - F_{ac})$ = 10 dB, R_{pm} = 3 dB, and L_a = 3 dB yields a typical value of 1 000 W for the minimum required transmitter power at the coast station.

If the antenna efficiency Eff_{ant} is required it should then be determined from equation (4):

$$Eff_{ant} = P_{e.m.r.p.} / P_{Tx} \qquad (4)$$

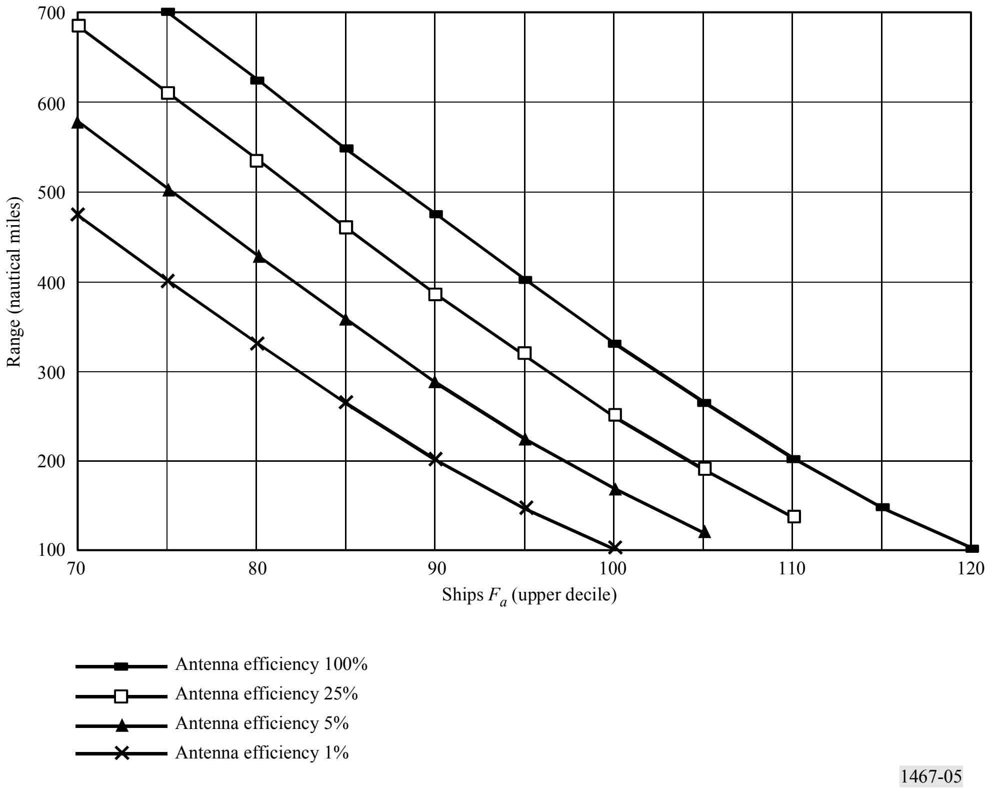
2.5.4 Determination of the range achieved using NAVTEX operation

The range achieved by a given NAVTEX transmitter depends upon the efficiency of the transmit antenna, and the external noise factor on board the ship, as shown in Fig. 5. The antenna efficiency depends upon the quality of the earth system provided, and once the required c.m.f. has been determined, it should be measured as described in § 2.5.2, and the efficiency determined.

FIGURE 5

NAVTEX range for a 1 kW transmitter, versus ships F_a

(For 5 kW transmitter, reduce F_a by 7 dB)



IMO Resolution A.801(19) specifies 90% availability and so the upper decile value for F_a should be calculated using the statistical data produced by NOISEDAT.

3 Protection of A2 watch frequency

The IMO specify that the distress channels should be watched 24 h per day. The system should be designed so that the watch function is not desensitized by noise or interference. It is essential therefore that all transmit channels assigned for use on the transmitting station are selected so that no intermodulation products are allowed to fall within the frequency bands of the watch channels.

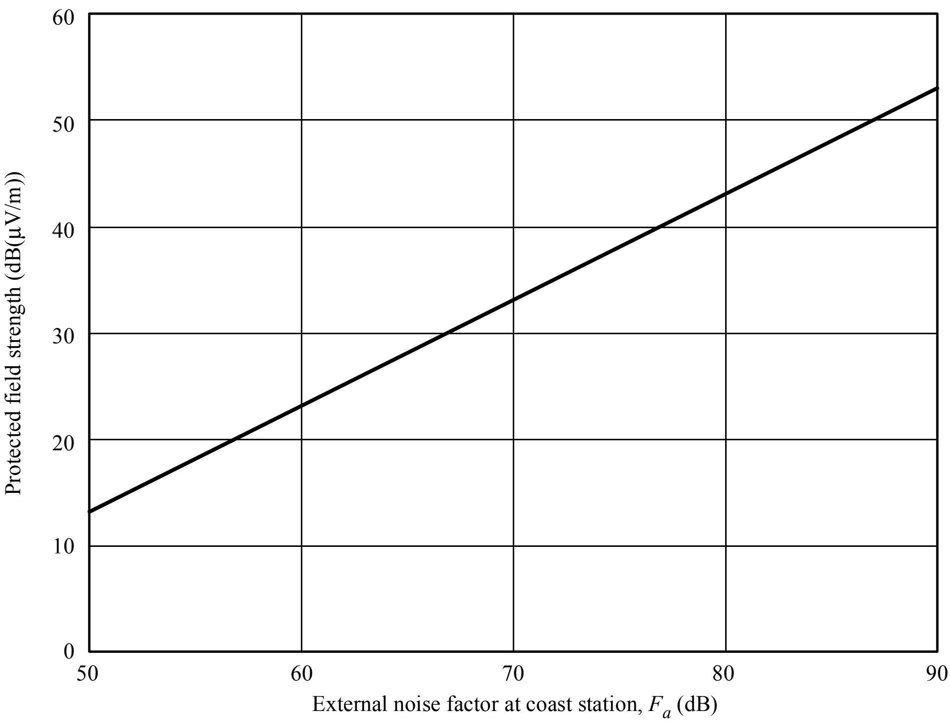
For very close channel separations the watch process can be threatened by energy in upper sideband of the adjacent SSB transmission falling within the receiver passband, where the wanted signal could be swamped by blocking or reciprocal mixing. Where channel separation is large enough to remove the threat of reciprocal mixing, a further, but lesser threat to the watch process may be sideband noise from the transmitter falling in the receiver passband.

The resulting DSC signal level reaching the shore station will depend upon the declared A2 range for the shore station, and in turn depend upon the sensitivity, F_a.

The level to be protected would be the level reaching the shore station after suffering a 3 dB fading loss, and is shown in Fig. 6.

FIGURE 6

Protected DSC field strength at receive site



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3.1 Impact of site separation on system performance

3.2 Estimating the level of the interference field

The tolerable amount of sideband noise leaving the transmit antenna, and the level of adjacent channel isolation required by the watch receiver both depend upon the separation between the transmit and receive antenna, and Fig. 7 provides a reference power P_{ref} (mW), which corresponds to the radiated power which would produce a field strength at the receive antenna equal to the DSC field strength to be protected and Fig. 8 provides a rule of thumb to relate this to transmitter and receiver characteristics.

FIGURE 7

A2 Tx power yielding field strength equal to protected DSC field strength at receive site

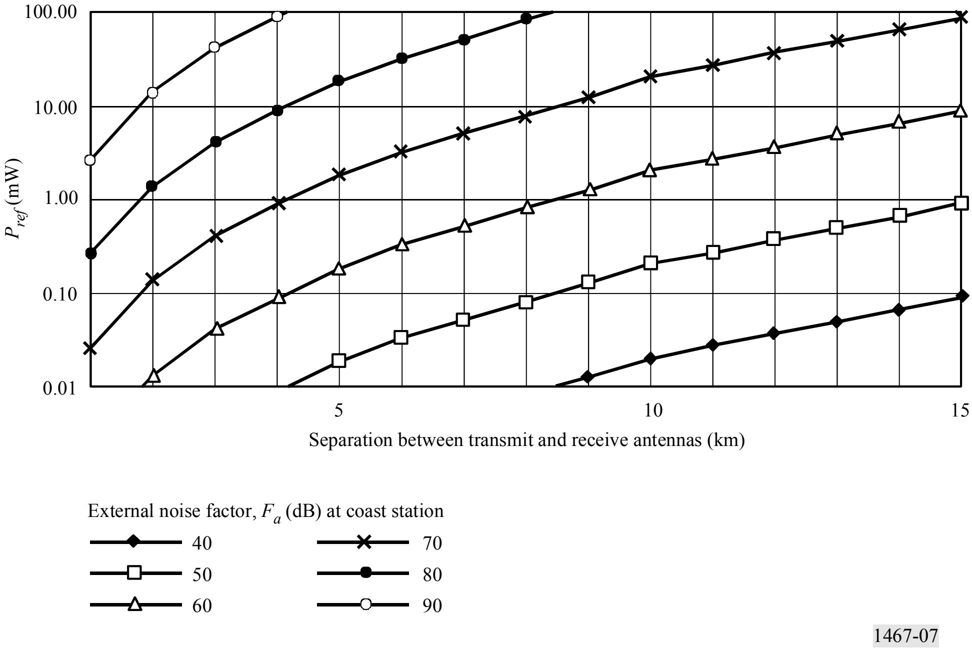
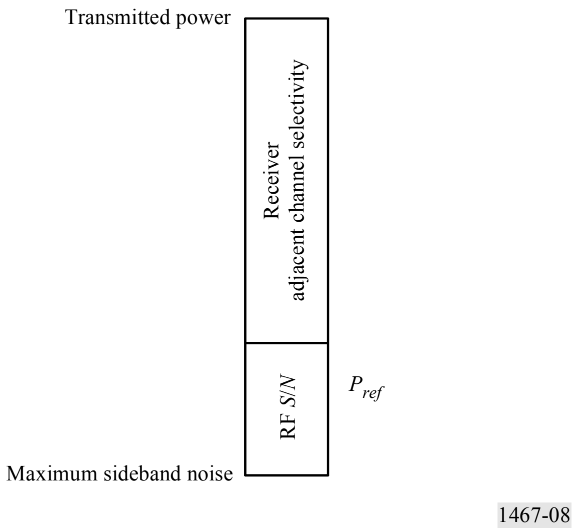


FIGURE 8

Relationship between transmitter and receiver characteristics



3.3 Required adjacent channel selectivity

The level of adjacent channel isolation required by the watch receiver depends upon the separation between transmit and receive antennas. Figure 7 provides a reference power, P_{ref}, which corresponds to the radiated power which would produce a field strength at the receive antenna equal to the DSC field strength to be protected. If the receiver has an adjacent channel isolation figure of I_{adj} (dB), then the maximum power radiated by the station should be limited to:

$$P_{rad} = P_{ref} + I_{adj} \qquad (5)$$

Three grades of receiver may be considered for providing the DSC watch: commercial communications receivers, ships DSC watch receivers, or high performance crystallized DSC watch receivers, conforming with Table 6:

TABLE 6

Selectivity (dB)	**Offset (Hz)**
6	Between 150 and 220
30	Less than 270
60	Below 400
80	Less than 550

3.4 Protection from adjacent channel interference

The maximum permitted transmitter power should be determined using equation (6):

$$P_{Tx} = 30 + 10 \log(P_{ref}) + I_{adj} - 10 \log(Eff_{ant}) \qquad (6)$$

where:

P_{Tx}: transmitter power (dBW)

I_{adj}: adjacent channel isolation figure for the receiver

Eff_{ant}: antenna efficiency.

For example, consider a receiver of the grade used on board ship having a typical adjacent channel isolation figure of 60 dB, on a site offering an F_a of 65 dB located 2.5 km from a transmit antenna with an efficiency of 75%. Fig. 7 gives a P_{ref} of 0.1 mW and so the maximum level of radiated power would be 60 dB above 0.1 mW, which is 100 W. Allowing for antenna efficiency the maximum transmitter power would be 133 W. In order to benefit from a 500 W transmitter a pre-filter offering an additional 4 dB adjacent channel isolation would be required.

3.5 Protection from transmitter sideband noise

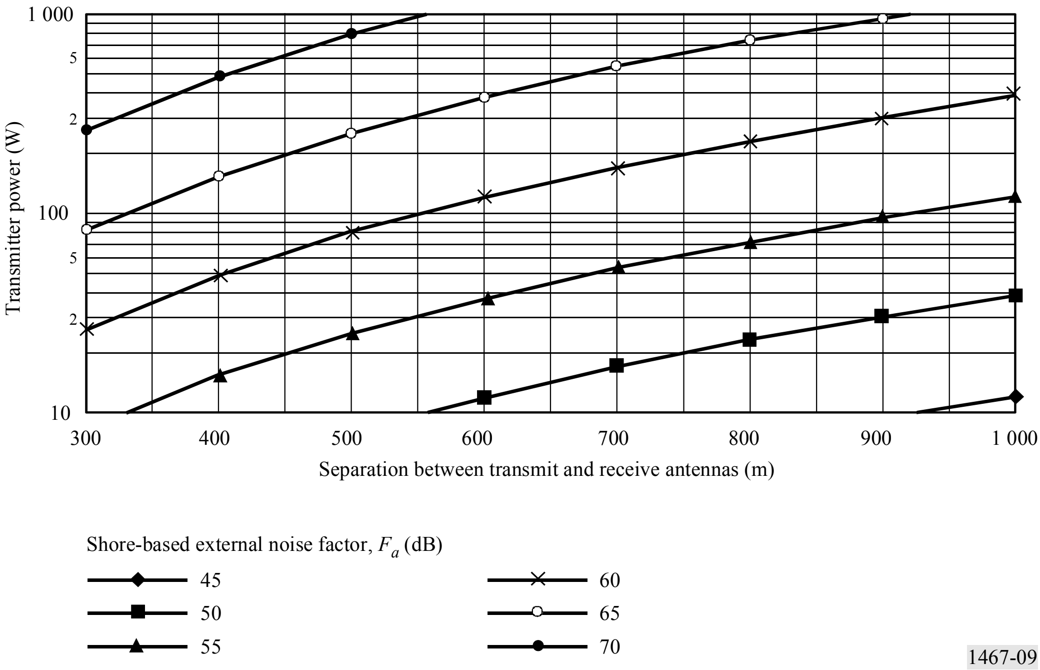
The maximum tolerable level of sideband noise is determined by the required *C/N* at the receive antenna. In the above example, for a *S/N* of 10 dB, the maximum tolerable level of sideband power would be 10 mW, which is quite low, and may call for use of a post-selector to reduce the noise leaving the transmitter modulator unit.

3.6 Co-site operation

Figure 9 shows the effect of reducing the separation between the transmit and receive antenna below 1 km to 300 m, the minimum value computed using GRWAVE. By way of example, if a station close to the shoreline had a maximum annual median external noise factor F_a of 65 dB then from Fig. 4 the range achieved would be just over 200 nautical miles. If the adjacent channel isolation were 80 dB, then for an e.m.r.p. of 200 W the antenna separation should be not less than 450 m.

FIGURE 9

Transmitter power versus antenna separation for 80 dB adjacent channel isolation



Under such circumstances a long feeder would be required to attain the separation required. As the frequency increases there is a considerable reduction in external noise and increase in feeder loss. At 2 MHz the external noise factor is very much greater than the system noise factor, and for a system noise factor of 15 dB up to 10 dB of feeder loss would be tolerable on a well designed and maintained system. A cost-effective way to avoid the cost of a very long low loss coaxial cable would be to use a separate antenna for A2.

4 Software requirements

4.1 Noise calculation

To simplify the determination of range for A2 and NAVTEX transmissions a modified form of NOISEDAT is ideally required including calculation of F_{am} in accordance with the procedures of this Recommendation.

4.2 Intermodulation

In order to protect the DSC watch channels from the harmful effects of interference caused by intermodulation products, a new program is ideally required to enable the frequencies assigned for use on a shore-based transmitting station to be checked to ensure that no intermodulation products are produced within the passbands of the DSC watch receivers, down to at least the 9th order. Such software should account for the offset spectrum occupied by SSB transmissions to be used.

RECOMMENDATION ITU-R M.1637

Global cross-border circulation of radiocommunication equipment in emergency and disaster relief situations

(2003)

The ITU Radiocommunication Assembly,

considering

a) that public protection radiocommunication is radiocommunication used by responsible agencies and organizations dealing with maintenance of law and order, protection of life and property, and emergency situations;

b) that disaster relief radiocommunication is radiocommunication used by agencies and organizations dealing with a serious disruption of the functioning of society, posing a significant, widespread threat to human life, health, property or the environment, whether caused by accident, nature or human activity, and whether developing suddenly or as the result of complex, long-term processes;

c) that disaster relief operations have evolved over the years to make use of radiocommunication systems as a reliable and effective means of communication for the crucial success of the disaster relief operation;

d) that many international disaster relief organizations utilize telecommunication networks for coordinating their efforts and for linking to authorities and affected persons when providing emergency care;

e) that providers of international humanitarian assistance employ and depend on non-dedicated radiocommunication equipment which is widely in use and available, including amateur radio and mobile portable satellite facilities for their telecommunications during international disaster relief operations;

f) that disaster relief users have operational requirements that may differ from other wireless users;

g) that the importation and circulation of radiocommunication equipment is usually required when the local telecommunication infrastructure is damaged, overloaded or non-existent in the area of the disaster;

h) that when an emergency or disaster occurs, the speed of the response is critical;

j) that the efforts of emergency and disaster relief workers are often delayed by a number of factors which may include actions by some administrations that:

– restrict or prohibit the import and use of radiocommunication equipment;
– have lengthy and/or costly immigration and customs procedures;

– lack an expedient process for the authorization to operate radiocommunication equipment or for the permission to use radiocommunication equipment in border areas;

– insist on the use of certain types of fixed frequency radios making it technically difficult to operate in changing situations,

noting

a) that national and regional authorities should, when possible, and in conformity with their national laws, cooperate in order to reduce and remove any obstacles hindering global cross-border circulation of radiocommunication equipment intended for use in emergency and disaster relief situations, particularly to:

– develop agreements and regulations intended for use in emergency and disaster relief situations from all import, export and transit duties,

recognizing

a) that Resolution 645 (WRC-2000) invites ITU-R to conduct studies for development of a Resolution concerning the technical and operational bases for global cross-border circulation of radiocommunication equipment in emergency and disaster relief situations;

b) that the World Customs Organization (WCO) has developed two international agreements which are applicable to radiocommunication equipment intended for disaster relief operations:

– the *Istanbul Convention*, which binds countries to eliminating customs duties on personal effects and professional equipment carried by visitors;

– the *Professional Equipment Convention*, which has so far been adopted by about 40 countries, which exempts from customs duties equipment used by professionals, e.g. journalists, doctors, relief workers, businessmen, etc.;

c) that the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA) which has the mandate to coordinate international humanitarian assistance, disaster relief and disaster mitigation convenes the Working Group on Emergency Telecommunications (WGET), an inter-agency forum of entities concerned with humanitarian assistance;

d) that WGET is following up on potential applications of Resolution 645 (WRC-2000) to deal with regulatory issues, specifically regarding the trans-border use of telecommunication equipment during acute emergencies;

e) that the Istanbul Declaration of WTDC-02 included among a number of pressing issues, the importance of emergency telecommunications;

f) that the 1998 Intergovernmental Conference on Emergency Telecommunications (ICET-98), with the participation of 76 countries and various intergovernmental and non-governmental organizations, adopted the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations. In 1998, 33 States signed this comprehensive Convention which also contains an article dealing with the removal of regulatory barriers. Thirty ratifications or definitive signatures are needed by June 2003 for entry in force;

g) that the World Radiocommunication Conference (Istanbul, 2000), has revisited Resolution 644 (Rev.WRC-2000) which:

– urges administrations to take all practical steps to facilitate the rapid deployment and effective use of telecommunication resources for disaster mitigation and disaster relief operations by reducing and where possible removing regulatory barriers and strengthening trans-border cooperation between States;

– invites the ITU-R to continue to study, as a matter of urgency, those aspects of radiocommunications that are relevant to disaster mitigation and relief operations;

h) that the Information Technology Agreement (ITA) of the World Trade Organization (WTO) aims at eliminating import duties on all information technology equipment including wireless terminals and equipment;

j) that administrative arrangements for circulation should be aimed at simplifying existing regulation;

k) that inter-administration measures facilitating cross-border use of radio equipment exist in some cases,

recommends

1 that, when discussing circulation of any radiocommunication equipment for emergency and disaster relief situations, present needs as well as future and advanced solutions should be taken into account;

2 that, in order to facilitate a speedy authorization process for the operation of radiocommunication equipment in emergency and disaster relief situations, the regulatory authorities are encouraged to develop plans and rules in place before a possible disaster that:

– facilitate the operation of radiocommunication equipment by visiting personnel in the territory of the disaster/emergency;

– facilitate the use of radiocommunication equipment that such organizations employ;

– take into account, as appropriate, the frequencies of the radiocommunication equipment that will be used by such organizations;

3 that, in order to establish the technical basis for global circulation of radiocommunication equipment in emergency and disaster relief situations, such equipment needs to fulfill the requirement for avoiding harmful interference in any country where they circulate:

– by conforming to ITU-R Recommendations, particularly with regard to emission limits.

REPORT ITU-R M.2033

Radiocommunication objectives and requirements for public protection and disaster relief

(2003)

1 Scope

The purpose of the Report is to define the public protection and disaster relief (PPDR) objectives and requirements for the implementation of future advanced solutions to satisfy the operational needs of PPDR organizations around the year 2010. Specifically, it identifies objectives, applications, requirements, a methodology for spectrum calculations, spectrum requirements and solutions for interoperability.

This Report has been developed in preparation for WRC-03 agenda item 1.3:

> "to consider identification of globally/regionally harmonized bands, to the extent practicable, for the implementation of future advanced solutions to meet the needs of public protection agencies, including those dealing with emergency situations and disaster relief, and to make regulatory provisions, as necessary, taking into account Resolution **645 (WRC-2000)**."

Resolution 645 (WRC-2000) invited the ITU-R to "study, as a matter of urgency, identification of frequency bands that could be used on a global/regional basis by administrations intending to implement future solutions for public protection agencies and organizations, including those dealing with emergency situations and disaster relief;" and "to study, as a matter of urgency, regulatory provisions necessary for identifying globally/regionally harmonized frequency bands for such purposes;". Resolution 645 (WRC-2000) also invited the ITU-R to "... conduct studies for the development of a resolution identifying the technical and operational basis for global cross-border circulation of radiocommunication equipment in emergency and disaster relief situations,". Recommendation ITU-R M.1637 provides additional guidance on this element.

2 Background

Radiocommunications have become extremely important to public protection and disaster relief (PPDR) organizations to the extent that PPDR communications are highly dependent upon it. At times, radiocommunication is the only form of communications available.

In order to provide effective communications, PPDR agencies and organizations have a set of objectives and requirements that include interoperability, reliability, functionality, security in operation and fast call set-up[1] in each area of operation. Considering that the radiocommunication needs of PPDR agencies and organizations are growing, future advanced solutions used by PPDR will require higher data rates, along with video and multimedia capability.

This Report forms part of the process of specifying these objectives and the requirements of PPDR organizations to meet their future needs. PPDR organizations will operate their communications in a complex environment, which requires the recognition of the following factors:

a) the involvement of a number of interests (such as governments, service providers, manufacturers);

b) the changing regulatory framework for those involved in supplying systems supporting PPDR;

c) that PPDR applications may be narrowband, wideband or broadband, or a mixture of these;

d) the need for interoperability and interworking between networks;

e) the need for high levels of security;

f) the needs of developing countries;

g) the ITU-D Handbook on Disaster Communications;

h) the needs of countries, particularly for developing countries, for low-cost communications equipment for public protection and disaster relief agencies and organizations;

i) that the 1998 Intergovernmental Conference on Emergency Telecommunications (ICET-98), with the participation of 76 countries and various intergovernmental and non-governmental organizations, adopted the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations. In 1998, thirty-three States signed this comprehensive Convention that also contains an article dealing with the removal of regulatory barriers;

j) that the *Working Group on Emergency Telecommunications* (WGET), which is also the *Reference Group on Telecommunications (RGT)* of the *Inter-Agency Standing Committee (IASC)* on humanitarian affairs has adopted frequencies in the VHF and UHF bands allocated to the land mobile service for inter-agency coordination of relief operations and safety and security communications in international humanitarian assistance as listed in Annex 3 to this Report;

k) that many disaster relief organizations require independence to fulfill their humanitarian mandate by maintaining their operational autonomy while fully respecting the laws of the countries in which they operate;

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[1] Fast call set-up indicates reducing the response time to access the particular network.

l) that in times of disasters, when most terrestrial based networks may be destroyed or impaired, amateurs, satellite and other non-ground based networks may be able to provide communications services to assist in public protection and disaster relief efforts;

m) that systems operating within various radiocommunication services, including mobile, fixed, mobile satellite, fixed satellite and/or amateur, could support both current and future advanced PPDR applications;

n) that in some countries, national regulations and/or legislation may affect the ability of PPDR organizations to use commercial wireless systems or networks;

o) that in some countries, commercial wireless systems currently offer and will probably continue to support PPDR applications;

p) that there is potential for new technologies such as IMT-2000 systems and beyond, and intelligent transportation systems (ITS), which may support or supplement advanced PPDR applications and that such complementary use would be in response to market demands.

3 Harmonization of 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. Experience has shown that spectrum that is harmonized has benefits that 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. Specifically, some potential benefits are as follows:

– economies of scale in the manufacturing of equipment;
– competitive market for equipment procurement;
– increased spectrum efficiency;
– 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 PPDR, 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.

The more bands that may be identified with different propagation characteristics the more difficult it becomes to benefit from economies of scale. Therefore, a balance needs to be struck between the number and location of the bands identified.

4 Aspects of frequency bands for PPDR

Based upon an ITU-R survey of PPDR communications conducted in the 2000-2003 study period from over 40 ITU members and international organizations and consequent considerations, the following comments should be noted:

a) There is little uniformity in regard to frequency bands that are used for PPDR in different countries.

b) 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.

c) Many administrations have designated one or more frequency bands for narrowband PPDR operations. It should be noted that only particular sub-bands of the frequency ranges or parts thereof listed below are utilized in an exclusive manner for PPDR radiocommunications: 3-30 MHz, 68-88 MHz, 138-144 MHz, 148-174 MHz, 380-400 MHz (including CEPT designation of 380-385/390-395 MHz), 400-430 MHz, 440-470 MHz, 764-776 MHz, 794-806 MHz, and 806-869 MHz (including CITEL designation of 821-824/866-869 MHz). One administration has designated PPDR spectrum for wideband and broadband applications.

d) Some administrations in Region 3 are using or plan to use or have identified parts of the frequency bands 68-88 MHz, 138-144 MHz, 148-174 MHz, 380-399.9 MHz, 406.1-430 MHz and 440-502 MHz, 746-806 MHz, 806-824 MHz and 851-869 MHz for PPDR applications. Some administrations in Region 3 are also using the bands 380-399.9 MHz, 746-806 MHz and 806-824 MHz paired with 851-869 MHz for Government communications.

The bands which are listed in § c) and d) above and other potential candidate bands are discussed in detail in the CPM-02 Report (§ 2.1.2.6) together with their advantages and disadvantages and are listed in Annex 2.1-1 of the CPM-02 Report.

5 Summary

Based on the studies undertaken in ITU-R on PPDR, this Report focuses on the numerous radiocommunication objectives and requirements that may be required to support future advanced solutions for PPDR applications. The following areas of interest were generated during the process of developing this report:

Annex 1 Radiocommunication objectives for public protection and disaster relief

Annex 2 Radiocommunication requirements for public protection and disaster relief

Annex 3 Narrowband frequencies for inter-agency coordination and safety and security communications in international humanitarian assistance presently in use

Annex 4 Spectrum requirements for public protection and disaster relief

Annex 5 Existing and emerging solutions to support interoperability for public protection and disaster relief

Annex 1

Radiocommunication objectives for public protection and disaster relief

1 General objectives

Public protection and disaster relief (PPDR) radiocommunication systems aim to achieve 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;

c) to aid the provision of future advanced solutions requiring high data rates, video and multimedia used by PPDR agencies and organizations;

d) to support interoperability and interworking between networks, both nationally and for cross-border operation, in emergency and disaster relief situations;

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

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

g) to accommodate a variety of mobile terminals from those which are small enough to be carried on one's person to those which are mounted on vehicles;

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

i) to make available PPDR radiocommunications at reasonable costs in all markets;

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

2 Technical objectives

Systems for PPDR aim to achieve the following technical objectives:

a) to support the integration of voice, data, and image communication;

b) to provide additional level(s) of security associated with the type of information carried over the communication channels associated with the various PPDR applications and operations;

c) to support equipment that operates in extreme and diverse operational conditions (rough road, dust, extreme temperature, etc.);

d) 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;

e) to provide fast call set-up, one touch broadcasting and group call features.

3 Operational objectives

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

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

b) to enable communications management to be controlled by PPDR agencies and organizations such as instant/dynamic reconfiguration change, set-up talk groups, guaranteed access including priority and pre-emption calls, groups or general calls, spectrum resource availability for multiple PPDR agencies and organizations, coordination and rerouting;

c) to provide communications through the system/network and/or independent of the network such as direct mode operation (DMO), simplex radio and push-to-talk;

d) to provide customized and reliable coverage especially for indoor areas such as underground and inaccessible areas. To also allow for the extension of cell size or capacity in rural and remote areas or under severe conditions during emergency and disaster situations;

e) to provide full service continuity through measures such as redundancy for emergency operations, prompt capacity increase to survive partial loss of infrastructure crucial to effective mission compliance and the safety and security of PPDR personnel;

f) to provide high quality of service including instant call set-up and instant push-to-talk, resilience under extreme load, very high call set-up success rate, etc.

g) to take account of various PPDR applications.

Annex 2

Radiocommunication requirements for public protection and disaster relief

1 Terminology

1.1 Public protection and disaster relief (PPDR)

There are terminology differences between administrations and regions in the scope and specific meaning of PPDR. The following terms are appropriate for the purpose of discussing this issue:

– *Public protection (PP) radiocommunication*: Radiocommunications used by responsible agencies and organizations 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 of 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 developing suddenly or as a result of complex, long-term processes.

1.2 Applicability of voice, data, graphics and video to global/regional PPDR

As PPDR operations become more reliant on electronic databases and data processing, access to accurate and detailed information by staff in the field such as police, firefighters and medical emergency personnel is critical to improving the effectiveness of the staff 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 control robotic devices. 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 current PPDR applications. The availability of future advanced solutions is expected to be of benefit to PPDR operations.

1.3 Consideration of advantages with future technologies

While voice communications will remain a critical component of PPDR operations, new data and video services will play a key role. For instance, PPDR agencies today use applications such as video for surveillance of crime scenes and of highways, to monitor and conduct damage assessment of wild land fire scenes from airborne platforms to provide real-time video back to emergency command centres. Also, there is a growing need for full motion video for other uses such as robotic devices in emergency situations. These types of future advanced solutions will be capable of providing local voice, video and data networks, thereby serving the needs of emergency personnel responding to an incident.

If these future technologies were implemented globally, it could reduce the cost of equipment, increase availability of equipment, increase potential for interoperability, may provide for a wider range of capabilities and reduce network infrastructure rollout time.

Introduction of these technologies may enable PPDR agencies and organizations to keep up with increasing demands but also may enable 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 technologies may require that consideration be given to spectrum aspects for PPDR applications.

If PPDR applications used IMT-2000 technology, it may be possible to use commercial IMT-2000 networks in regions where it was not cost-effective to deploy a dedicated network. IMT-2000 is intended for deployment in a wide range of environments, from rural to the densest urban areas. Commercial systems that are being deployed using IMT-2000 technologies may not meet all of the identified needs for PPDR. However, the use of these technologies and systems should be considered, particularly in terms of the potential associated cost savings and advanced features that they offer.

1.4 Narrowband, wideband, broadband

Communications supporting PPDR operations cover a range of radiocommunication services such as fixed, mobile, amateur and satellite. Typically, narrowband technologies are used for PPDR communications within the terrestrial mobile service, while wideband and broadband technologies are finding PPDR applications within all radiocommunication services.

There are some differences between administrations and regions in the scope and specific meaning of narrowband, wideband and broadband. However, the ITU-R considers the terms described in § 1.4.1, 1.4.2 and 1.4.3 appropriate for the purpose of discussing this issue:

1.4.1 Narrowband (NB)

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

1.4.2 Wideband (WB)

It is expected that the wideband technologies will carry data rates of several hundred kilobits per second (e.g. in the range of 384-500 kbit/s). Since it is expected that networks and future technologies may require higher data rates, a whole new class of applications including: wireless transmission of large blocks of data, video and Internet protocol-based connections in mobile PPDR may be introduced.

The use of relatively high-speed data in commercial activities gives a wide base of technology availability and will therefore spur the development of specialist mobile data applications. Short message and e-mail are now being seen as a fundamental part of any communications control and command system and therefore could most likely be an integral part of any future PPDR capability.

A wideband wireless system may be able to reduce response times of accessing the Internet and other information databases directly from the scene of an incident or emergency. It is expected that this will initiate the development of a range of new and secure applications for PPDR organizations.

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.1221 and ITU-R M.1457 and with channel bandwidths dependent on the use of spectrally efficient technologies.

1.4.3 Broadband (BB)

Broadband technology could be seen as a natural evolutionary trend from wideband. Broadband applications enable an entirely new level of functionality with additional capacity to support higher speed data and higher resolution images. It should be noted that the demand for multimedia capabilities (several simultaneous wideband and/or broadband applications running in parallel) puts a huge demand with very high bit rates on a wireless system deployed in a localized area with intensive on-scene requirements (often referred to as “hot spot” areas) where PPDR personnel are operating.

Broadband applications could typically be tailored to service localized areas (e.g. 1 km^2 or less) providing voice, high-speed data, high quality digital real time video and multimedia (indicative data rates in 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 laptop computer, used during traffic stops or responses to other incidents and 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 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.

Broadband systems may have inherent noise and interference tradeoffs with data rates and associated coverage. Depending on the technology deployed, a single broadband network may have different coverage areas in the range of a few metres up to hundreds of metres, providing a wide range in spectrum reuse capability. Collectively, the high data speeds and localized coverage area open up numerous new possibilities for PPDR applications (tailored area networks, hot spot deployment and ad-hoc networks).

Finally, it should be noted that various standards organizations are beginning work on systems for broadband applications including Project MESA.

2 Radio operating environments for PPDR

Various radio operating environments are applicable to PPDR and are 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 estimates for spectrum.

The scenarios include average day-to-day operations, large emergencies or public events and disasters. These have been identified since they are distinct in terms of the characteristics and may impose different requirements for PPDR communications.

2.1 Day-to-day operations

Day-to-day operations encompass the routine operations that PPDR agencies conduct within their jurisdiction. Typically, these operations are within national borders. Generally, most PP spectrum and infrastructure requirements are determined using this scenario with extra capacity to cover unspecified emergency events. For the most part day-to-day operations are minimal for DR. In Tables 2 and 3, day-to-day operations are referred to as PP (1).

2.2 Large emergency and/or 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 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 a large emergency under this scenario. Likewise, a large public event (national or international) could include the Commonwealth Heads of Government Meeting (CHOGM), G8 Summit, the Olympics, etc.

Generally, additional radiocommunications equipment for large events is brought to the area as required. This equipment may or may not be linked into the existing PP network infrastructure.

In Tables 2 and 3, large emergencies or public events are referred to as PP (2).

2.3 Disasters

Disasters can be those 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 incidences or situations of armed conflict. Generally, both the existing PP communications systems and special on-scene communications equipment brought by DR organizations are employed.

Even in areas where suitable terrestrial services exist, MSS systems will play a significant role in disaster situation. The terrestrial services which do exist may have been damaged by the disaster itself, or may be unable to cope with the increased traffic demands resulting from a disaster situation. In these situations, satellite solutions can offer a reliable solution. The frequency bands used by MSS systems are generally harmonised 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 hold MSS terminals as part of their contingency planning are able to offer the initial essential communications required with minimum delay. To this end, advanced bilateral and multilateral agreements are desirable and may be accomplished through, for example the GMPCS-MoU.

Some PPDR agencies/organizations and amateur radio groups use HF narrowband systems including the use of data modes of operation as well as voice. Other technologies such as digital voice, high-speed data and video are in early implementations either using terrestrial or satellite network services.

In Tables 2 and 3, disasters are referred to as DR.

3 Requirements

Tables 2 and 3 summarize § 3.1 and 3.2, which describe PPDR application and user requirements.

When considering these sections, it is important to note that public protection organizations currently use various arrangements of mobile systems or a combination thereof, as described below in Table 1.[2]

Items b), c), d) and e) of Table 1 in some countries are currently used by PP organizations to supplement their own systems or in some cases to provide all their communications requirements, but not necessarily all the items specified in Tables 2 and 3. It is likely that this trend will continue into the future, particularly with the introduction of advanced wireless solutions, such as IMT-2000.

Some of the applications listed in § 3.1.3 and Table 2 may depend significantly on commercial systems, while other applications for the same PP organizations may be totally independent of commercial systems.

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[2] Examples of the types of mobile systems can be found in Recommendations ITU-R M.1073, ITU-R M.1457 and in Report ITU-R M.2014.

TABLE 1

Arrangements of mobile systems used by public protection

Item	Network ownership	Operator	User(s)	Spectrum assignment
a	PP organization	PP organization	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	Commercial	Shared with PP treated as ordinary customer	Commercial

3.1 Applications

3.1.1 General

a) Applications associated with the routine day-to-day and emergency operations for public protection applications as outlined in Table 2 could be offered.

b) Applications associated with disaster relief operations as outlined in Table 2 could be offered.

c) Regional and/or international harmonization of spectrum for the provision of PPDR applications could be allowed if a requirement is determined for this need.

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

e) The description of environments for PPDR is provided in § 2 of this Annex.

3.1.2 Application accessibility requirements

The eventual accessibility of applications for PPDR may depend on various issues. These include the cost, the regulatory and the national legislative climate, the nature of mandates PPDR, and the need 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.

3.1.3 Envisioned applications

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

TABLE 2

PPDR Applications and Examples

Application	Feature	PPDR Example	Importance(1)		
			PP (1)	PP (2)	DR
1. *Narrowband*					
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
	Security	Voice encryption/ scrambling	H	H	M
Facsimile	Person-to-person	Status, short message	L	L	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
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
Database interaction (minimal record size)	Forms based records query	Accessing vehicle license records	H	H	M
		Accessing criminal records/missing person	H	H	M
	Forms based incident report	Filing field report	H	H	H
2. *Wideband*					
Messages	E-mail possibly with attachments	Routine e-mail message	M	M	L
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

TABLE 2 (*cont.*)

Application	**Feature**	**PPDR Example**	**Importance**[1]		
			PP (1)	**PP (2)**	**DR**
Database interaction (medium record size)	Forms and records query	Accessing medical records	H	H	M
		Lists of identified person/missing person	H	H	H
		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)	H	H	M
		ID picture	H	H	M
		Building layout maps	H	H	H
Telemetry	Location status and sensory data	Vehicle status	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
3. *Broadband*					
Database access	Intranet/Internet access	Accessing architectural plans of buildings, location of hazardous materials	H	H	H
Database access (*cont.*)	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

TABLE 2 (*end*)

Application	**Feature**	**PPDR Example**	**Importance(1)**		
			PP (1)	**PP (2)**	**DR**
Video	Video streaming, live video feed	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
		Assessment of fire/flood scenes from airborne platforms	M	H	M
Imagery	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.

3.2 User requirements

This section includes the requirements from the perspective of the PPDR end users. General technology, functional and operational requirements are described. Although some of the requirements do not relate specifically to the radiocommunication network or system used by PPDR, they do affect the design, implementation and use of radiocommunications.

Table 3, at the end of this section, is a general summary of the user requirements. The requirements are grouped under the same headings as § 3.2.1 through 3.2.8 and any key attributes related to the requirement are listed in the second column. 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 § 2.1 "Day-to-day operations", § 2.2 "Large emergency and/or public events", and § 2.3 "Disasters", represented by PP (1), PP (2) and DR, respectively.

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 following requirements.

3.2.1 System requirements

3.2.1.1 Support of multiple applications

As desired by PPDR organizations, systems serving PPDR should be able to support a broad range of applications, as identified in § 3.2.

3.2.1.2 Simultaneous use of multiple applications

As desired by the PPDR organization, systems serving PPDR should be able to support the simultaneous use of several different applications with a range of bit rates.

Some PPDR users may require the integration of multiples applications (e.g. voice and low/medium speed data) over the complete network or on a high speed network to service localized areas with intensive on-scene activity.

3.2.1.3 Priority access

As desired by the PPDR organizations, 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 may require the exclusive use of frequencies or equivalent high priority access to other systems.

3.2.1.4 Grade of service (GoS) requirements

Suitable grade of service should be provided for PPDR applications.

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

3.2.1.5 Coverage

The PPDR system is usually required to provide complete coverage (for "normal" traffic within the relevant jurisdiction and/or operation (national, provincial/state or at the local level). This coverage is required 24 h/day, 365 days/year.

Usually, systems supporting PPDR organizations are designed for peak loads and wide fluctuations in use. Additional resources, enhancing system capacity may be added during a PP emergency or DR event by techniques such as reconfiguration of networks with intensive use of DMO and vehicular repeaters (NB, WB, BB), which may be required for coverage of localized areas.

Systems supporting PPDR are also usually required to provide reliable indoor and outdoor coverage, coverage of remote areas, and coverage of underground or inaccessible areas (e.g. tunnels, building basements). Appropriate redundancy to continue operations when the equipment/infrastructure fails is extremely beneficial.

PPDR systems are not generally installed inside numerous buildings. PPDR entities do not have a continuous revenue stream to support installation and maintenance of an intensive variable density infrastructure. Urban PPDR systems are designed for highly reliable coverage of personal stations outdoors with limited access indoors by direct propagation through the building walls. Sub-systems may be installed in specific building or structures, like tunnels, if penetration through the walls is insufficient. PPDR systems tend to use larger radius cells and higher power mobile and personal stations than commercial service providers.

3.2.1.6 Capabilities

PPDR users require control (full or in part) of their communications, including centralized dispatch (command and control center), access control, dispatch group (talk group) configuration, priority levels, and pre-emption (override other users).

Rapid dynamic reconfiguration of the system serving PPDR may be required. This includes robust operation administration and maintenance (OAM) offering status and dynamic reconfiguration. System capability of over-the-air programmability of field units is extremely beneficial.

Robust equipment (e.g. hardware, software, operational and maintenance aspects) are required for systems serving PPDR. Equipment that functions while the user is in motion are also required. Equipment may also require high audio output (high noise environment), unique accessories, such as special microphones, operation while wearing gloves, operation in hostile environments (heat, cold, dust, rain, water, shock, vibration, explosive environments, etc.) and long battery life.

PPDR users may require the system to have capability for fast call set-up, instant push-to-talk operations or one touch broadcasting/group call. Talk-around (direct mode, simplex), communications to aircraft and marine equipment, control of robotic devices, vehicular repeater (on-scene repeater, extend network to remote locations) may also be required.

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.

Appropriate levels of interconnection to the public telecommunications network may also be required[3]. The decision regarding the level of interconnection (i.e. all mobile terminals vs. a percentage of terminals) may be based on the particular PPDR operational requirements. Furthermore, the specific access to the public telecommunications network (i.e. directly from mobile or through the PPDR dispatch) may also be based on the particular PPDR operational requirements.

There may be additional requirements for simulcast (quasi-synchronous broadcast), receiver operating (in-bound path diversity) that have not been covered in Table 3.

3.2.2 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 organisations, 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.

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[3] A description of an international emergency preference scheme (IEPS) is described in ITU-T Recommendation E.106.

3.2.3 Cost related requirements

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 permanent network infrastructure.

3.2.4 Electromagnetic compatibility (EMC) requirements

Systems supporting PPDR should be in accordance with appropriate EMC regulations. Adherence to national EMC regulations may be required between networks, radiocommunications standards and co-located radio equipment.

3.2.5 Operational requirements

This section defines the operational and functional requirements for PPDR users and lists key attributes in Table 3.

3.2.5.1 Scenario

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 § 2. PPDR radiocommunication equipment should be able to support at least one of these operating environments, however, it is preferable that PPDR radiocommunication 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.

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, peacekeeping) is extremely beneficial.

3.2.5.2 Interoperability

Interoperability is the seamless, coordinated, and integrated PPDR communications for the safe, effective, and efficient protection of life and property. Communications interoperability can be achieved at many levels of a PPDR operation. From the most basic level, i.e., a fire fighter of one organization communicating with a fire fighter of another, up to the highest levels of command and control.

Various options are available to facilitate communications interoperability between multiple agencies. These include, but are not limited to:

a) the use of common frequencies and equipment,

b) utilizing local, on-scene command vehicles/equipment/procedures,

c) via dispatch centres/patches, or

d) utilizing technologies such as audio switches or software defined radios. Typically multiple agencies use a combination of options.

Annex 5 provides a more detailed explanation of interoperability and possible solutions.

How these options are used to obtain interoperability depends how the PPDR organizations want to talk to 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.

Notwithstanding, while the importance of interoperability is recognised, 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 interoperable equipment since this requirement should not be so expensive as to preclude implementation within an operational context.

3.2.6 Spectrum usage and management

Depending on national frequency allocations, PPDR users must share 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 geographical area. Therefore, interference to systems supporting PPDR from non-PPDR users should be minimized as much as possible.

Depending on the national regulations, systems supporting PPDR may be required to use specific channel spacing between mobile and base station transmit frequencies.

Each administration has the discretion to determine suitable spectrum for PPDR. Annexes 3 and 4 provide additional information on spectrum usage and requirements.

3.2.7 Regulatory compliance

Systems supporting PPDR should comply with the relevant national regulations. In border areas (near the boundary between countries), suitable coordination of frequencies should be arranged, as appropriate.

The capability of systems supporting PPDR to support extended coverage into the neighbouring country(ies) should also comply with regulatory agreements between the neighbours.

For disaster relief communications, administrations are encouraged to adhere to the principles of the Tampere Convention.

Flexibility should be afforded to PPDR users to employ various types of systems (e.g. HF, satellite, terrestrial, amateur, Global Maritime Distress and Safety System (GMDSS) at the scene of the incident in times of large emergencies and disasters.

3.2.8 Planning

Planning and pre-coordination activities can greatly support PPDR communications. Planning should take into account readily available equipment that could be provided for unpredictable events and disasters through existing inventory thereby reducing the reliance on supplies. It would be beneficial to maintain accurate and detailed information so that PPDR users can access this information at the scene.

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

TABLE 3

User requirements

Requirement	Specifics	Importance(1)		
		PP (1)	**PP (2)**	**DR**
1. *System*				
Support of multiple applications		H	H	M
Simultaneous use of multiple applications	Integration of multiple applications (e.g. voice and low/medium speed data)	H	H	M
	Integration of local voice, high speed data and video on high speed network to service localized areas with intensive on-scene activity	H	H	M
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	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
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
	Vehicular repeaters (NB, WB, BB) for coverage of localized areas	H	H	H
	Reliable indoor/outdoor coverage	H	H	H
	Coverage of remote areas, underground and inaccessible areas	H	H	H
	Appropriate redundancy to continue operations, when equipment/infrastructure fails	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

TABLE 3 (*cont.*)

Requirement	**Specifics**	**Importance**[1]		
		PP (1)	**PP (2)**	**DR**
Capabilities (*cont.*)	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 operation	H	H	H
	Communications to aircraft and marine equipment, control of robotic devices	M	H	L
	One touch broadcasting/group call	H	H	H
	Terminal-to-terminal communications without infrastructure (e.g. direct mode operations/talk-around), vehicular repeaters	H	H	H
	Appropriate levels of interconnection to public telecommunication network(s)	M	M	M
2. Security	End-to-end encrypted communications for mobile-mobile, dispatch and/or group calls communications	H	H	L
3. *Cost related*	Open standards	H	H	H
	Cost effective solution and applications	H	H	H
	Competitive marketplace	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
	Robust OAM offering status and dynamic reconfiguration	H	H	H
	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

TABLE 3 (*end*)

Requirement	Specifics	Importance[1]		
		PP (1)	PP (2)	DR
Interoperability	Intra-system: Facilitate the use of common network channels and/or talkgroups	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
	Efficient 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.

Annex 3

Narrowband frequencies for inter-agency coordination and safety and security communications in international humanitarian assistance presently in use

The Working Group on Emergency Telecommunications (WGET), which is also the Reference Group on Telecommunications (RGT) of the Inter-Agency Standing Committee (IASC) on humanitarian affairs for the United Nations, has adopted and uses the following frequencies whenever the situation permits.

Within the spectrum allocated to land-mobile service in the VHF range:

Primary channel (A):

Simplex: 163.100 MHz

Duplex: Repeater transmits on 163.100 MHz
Repeater receives on 158.100 MHz

Alternative channel (B):

Simplex: 163.025 MHz

Duplex: Repeater transmits on 163.025 MHz
Repeater receives on 158.025 MHz

Alternative channel (C):

Simplex: 163.175 MHz

Duplex: Repeater transmits on 163.175 MHz
Repeater receives on 158.175 MHz

Within the spectrum allocated to land-mobile service in the UHF range:

Primary channel (UA):

Simplex: 463.100 MHz

Duplex: Repeater transmits on 463.100 MHz
Repeater receives on 458.100 MHz

Alternative channel (UB):

Simplex: 463.025 MHz

Duplex: Repeater transmits on 463.025 MHz
Repeater receives on 458.025 MHz

Alternative channel (UC):

Simplex: 463.175 MHz

Duplex: Repeater transmits on 463.175 MHz
Repeater receives on 458.175 MHz

Annex 4

Spectrum requirements for public protection and disaster relief

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[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

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[4] United States Public Safety Wireless Advisory Committee, Attachment D, Spectrum Requirements Subcommittee Report, September 1996.

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 4

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/km^2), 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/km^2).

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 (km^2) 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.ẹ. 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	Conti-nuous 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 4

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 = πi R^2 Hexagonal cells = $2.6 \cdot R^2$ 3-sector hex = $2.6/3 \cdot R^2$	**A4** Same

IMT-2000 methodology (Recommendation 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 km^2 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 km^2 PPDR population density = PPDR population/area Example: London = 33.8 PPDR/km^2

<table>
<tr><th>IMT-2000 methodology
(Recommendation ITU-R M.1390)</th><th>IMT-2000 methodology</th><th>Proposed PPDR methodology</th></tr>
<tr>
<td>B3 Penetration rate

Percentage of persons subscribing to a service within an environment. Person may subscribe to more than one service</td>
<td>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</td>
<td>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:
<table>
<tr><th>Category</th><th>Population
(NB Voice)</th><th>Penetration</th></tr>
<tr><td>Regular Police</td><td>25 498</td><td>100%</td></tr>
<tr><td>Special Police Functions</td><td>6 010</td><td>10%</td></tr>
<tr><td>Police Civilian Support</td><td>13 987</td><td>10%</td></tr>
<tr><td>Fire Suppression</td><td>7 081</td><td>70%</td></tr>
<tr><td>Part-time Fire</td><td>2 127</td><td>10%</td></tr>
<tr><td>Fire Civilian Support</td><td>0</td><td>0</td></tr>
<tr><td>Emergency Medical Services</td><td>0</td><td>0</td></tr>
<tr><td>EMS Civilian Support</td><td>0</td><td>0</td></tr>
<tr><td>General Government Services</td><td>0</td><td>0</td></tr>
<tr><td>Other PPDR Users</td><td>0</td><td>0</td></tr>
<tr><td>TOTAL PPDR Population</td><td>54 703</td><td></td></tr>
<tr><td>Narrowband Voice PPDR Population</td><td>32 667</td><td></td></tr>
</table>
PPDR penetration rate for narrowband “service environment” and voice “service”:
= Sum(Pop × Pen)/sum(Pop) = 59.7%</td>
</tr>
</table>

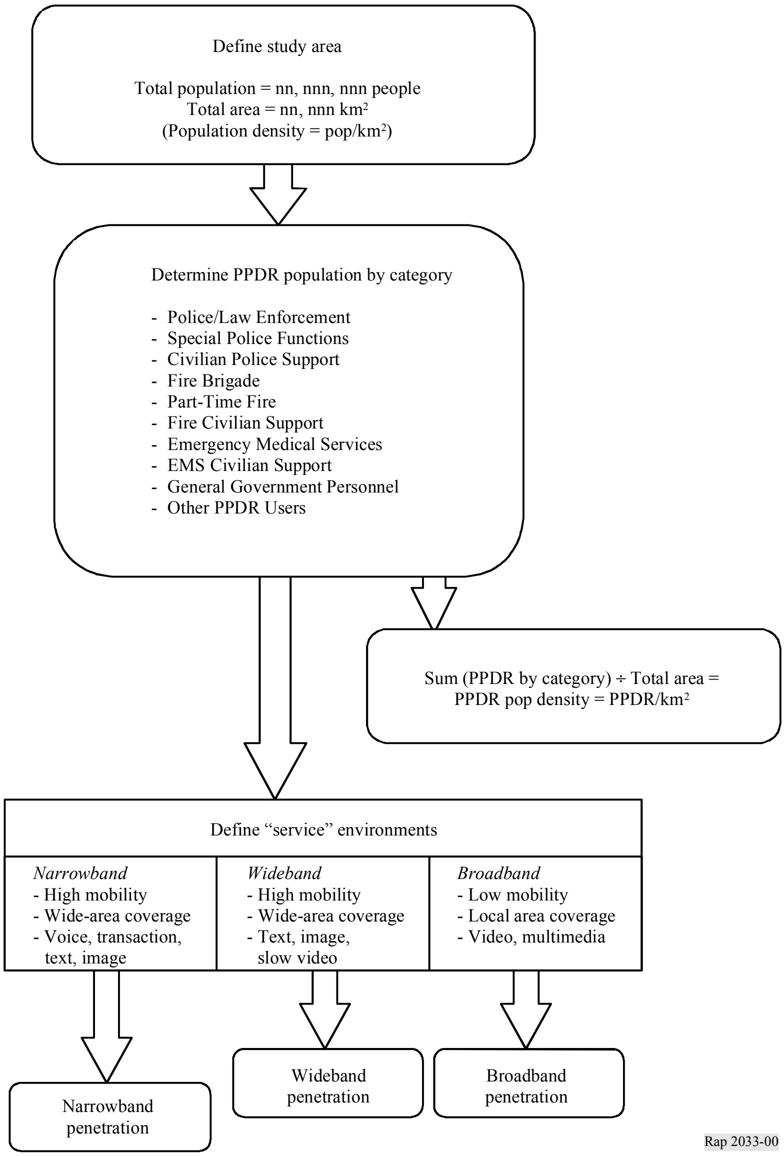
IMT-2000 methodology (Recommendation ITU-R M.1390)	IMT-2000 methodology	Proposed PPDR methodology
B4 Users/cell Number of people subscribing to service within cell in environment	**B4** Users/cell = Pop density × Pen Rate × Cell area	**B4** Same
B5 Traffic parameters Busy hour call attempts: average 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

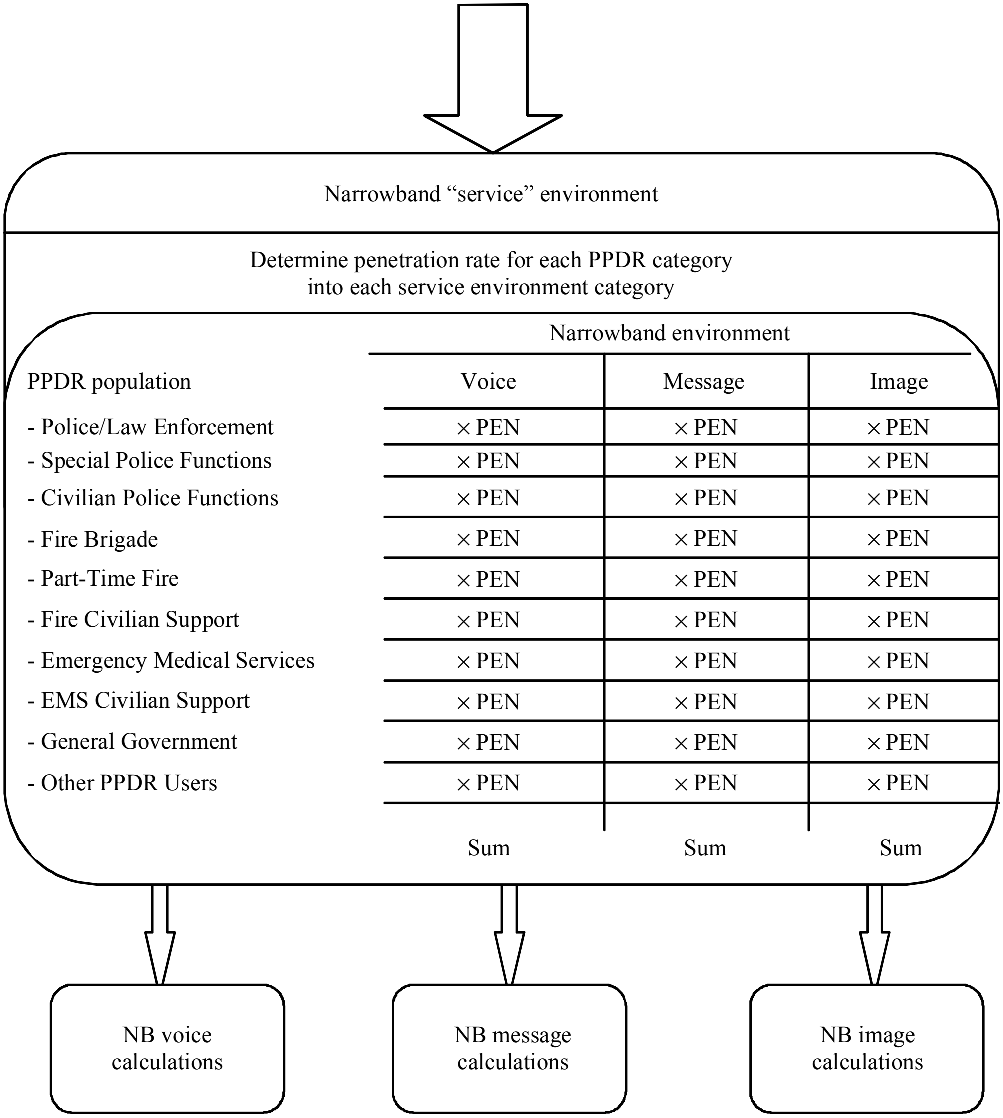
IMT-2000 methodology (Recommendation ITU-R M.1390)	IMT-2000 methodology	Proposed PPDR methodology
B8 Quality of service function Offered traffic/cell is multiplied by typical frequency reuse cell grouping size and quality of Service factors (blocking function) to estimate offered traffic/cell at a given 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
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

IMT-2000 methodology (Recommendation ITU-R M.1390)	IMT-2000 methodology	Proposed PPDR methodology
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
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 $Freq_{es}$ = 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 × $Freq_{es}$)	**D6** Same

Attachment B
of Appendix 1 to Annex 4

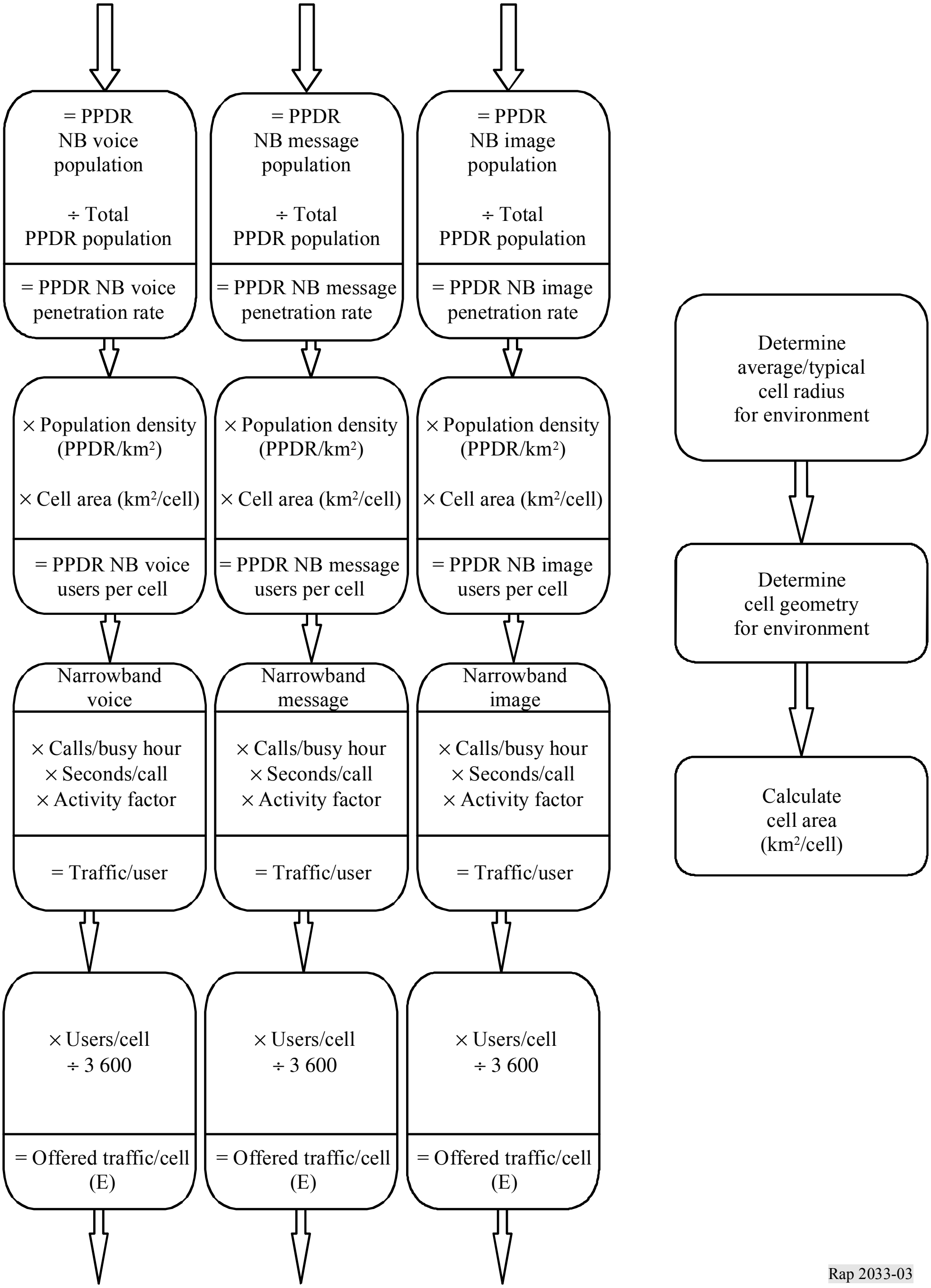
PPDR Spectrum Requirements Flowchart

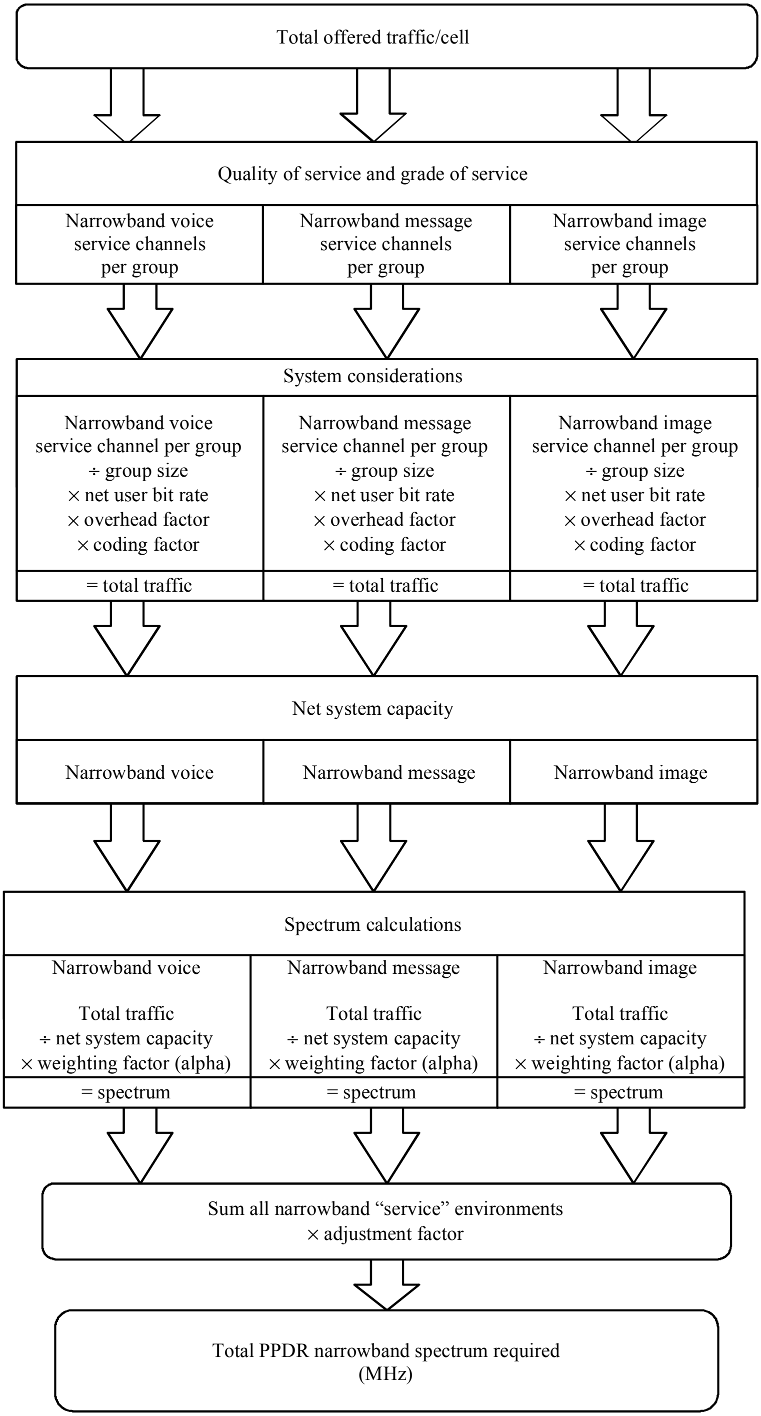




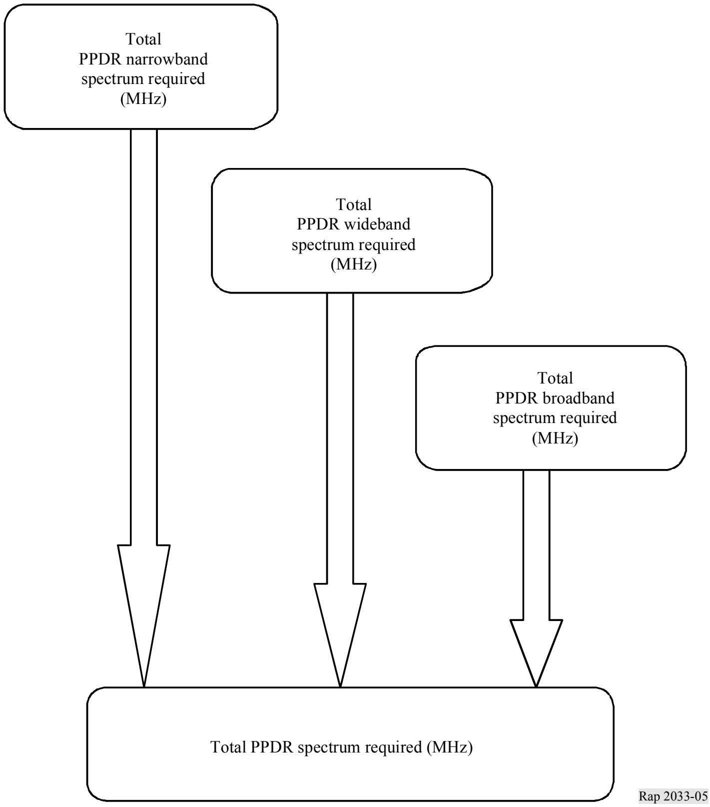
PEN: penetration

Rap 2033-02


= PPDR
NB voice
population
÷ Total
PPDR population
= PPDR NB voice
penetration rate
= PPDR
NB message
population
÷ Total
PPDR population
= PPDR NB message
penetration rate
= PPDR
NB image
population
÷ Total
PPDR population
= PPDR NB image
penetration rate
× Population density
(PPDR/km²)
× Cell area (km²/cell)
= PPDR NB voice
users per cell
= PPDR NB message
users per cell
= PPDR NB image
users per cell
Narrowband
voice
Narrowband
message
Narrowband
image
× Calls/busy hour
× Seconds/call
× Activity factor
= Traffic/user
× Users/cell
÷ 3 600
= Offered traffic/cell
(E)
Determine
average/typical
cell radius
for environment
Determine
cell geometry
for environment
Calculate
cell area
(km²/cell)
Rap 2033-03


Total offered traffic/cell
Quality of service and grade of service
Narrowband voice service channels per group
Narrowband message service channels per group
Narrowband image service channels per group
System considerations
Narrowband voice service channel per group ÷ group size × net user bit rate × overhead factor × coding factor
Narrowband message service channel per group ÷ group size × net user bit rate × overhead factor × coding factor
Narrowband image service channel per group ÷ group size × net user bit rate × overhead factor × coding factor
= total traffic
= total traffic
= total traffic
Net system capacity
Narrowband voice
Narrowband message
Narrowband image
Spectrum calculations
Narrowband voice Total traffic ÷ net system capacity × weighting factor (alpha)
Narrowband message Total traffic ÷ net system capacity × weighting factor (alpha)
Narrowband image Total traffic ÷ net system capacity × weighting factor (alpha)
= spectrum
= spectrum
= spectrum
Sum all narrowband “service” environments × adjustment factor
Total PPDR narrowband spectrum required (MHz)

Rap 2033-04



Attachment C
to Appendix 1 to Annex 4

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[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.

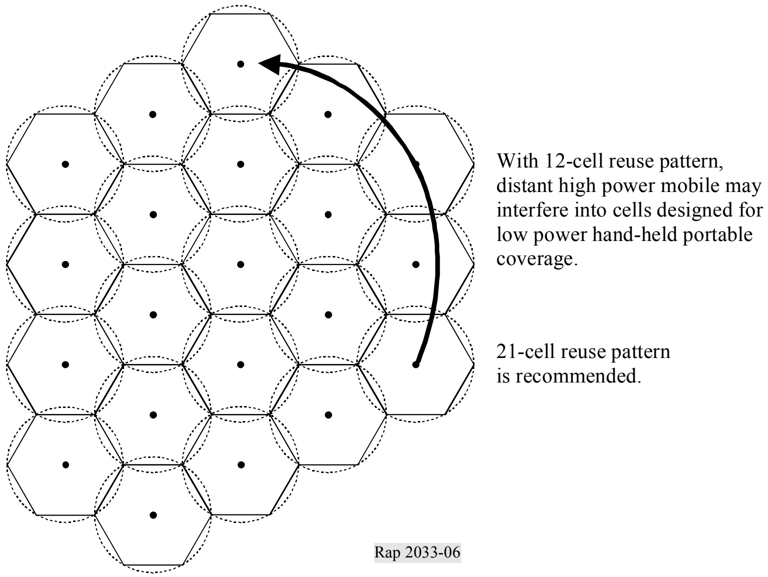
These are not meant to be a direct comparison between the selected technologies. There are numerous other user needs and spectrum allocation factors that effect the functional and operational deployment of a network, the choice of technology, and overall network efficiency. Some of the spectrum factors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

[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.

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.



Rap 2033-06

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 4

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 km^2 England = ~ 130 360 km^2

Wales = ~ 20 760 km^2

England population density = 346 pop/km^2 = 100 000 pop/289 km^2

London population = 7 285 000 people

London area = 1 620 km^2

London population density = 4 496 pop/ km^2 = 100 000 pop/ 22.24 km^2

Police officer strength[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[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%

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.

7 Includes National Crime Squad (NCS) & National criminal Intelligence Service (NCIS) civilian staffing.

Other[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 category	PPDR population	PPDR penetration rate 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%

8 Not included in totals above.

Attachment E
of Appendix 1 to Annex 4

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 omni-directional cells; radius of vertex for sectored hexagonal cells		**5**	
A4	Calculate representative cell area	Omni cells: circular = $\pi \cdot R^2$; hexagonal = $2.6 \cdot R^2$; Hex 3-sector = $2.6 \cdot R^2/3$ km^2		**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**
				Population (POP) by PPDR category	Penetration (PEN) rate within PPDR category
					(Narrowband voice)
			Police	25 498	1.00
			Other Police	6 010	0.10
			Police Civilian Support	13 987	0.10
			Fire	7 081	0.70
			Part-time Fire	2 127	0.10
			Fire Civilian Support	0	0.10
			EMS	0	0.50
			EMS Civilian Support	0	0.10
			General Government	0	0.10
			Other PPDR Users	0	0.10
		= SUM (POP ☐ PEN)		**32 667,1**	**PPDR population using NB voice service**
		Area under consideration	308.9 square miles	**1 620**	**km^2**

	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 km^2		**33.8**	**Total POP/km^2**
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%		= 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	25 498.00	0.466
			Other Police	601.00	0.011
			Police Civilian Support	1 398.70	0.026
			Fire	4 956.70	0.091
			Part-time Fire	212.70	0.004
			Fire Civilian Support	0.00	0.000
			EMS	0.00	0.000
			EMS Civilian Support	0.00	0.000
			General Government	0.00	0.000
			Other PPDR Users	0.00	0.000
		= % of total PPDR POP	**Total PPDR penetration**	**59.717**	**% using NB voice**
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**

	IMT-2000 methodology (Rec. UIT-R M.1390)		London TETRA Narrowband voice service		
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**
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**

	IMT-2000 methodology (Rec. UIT-R M.1390)		London TETRA Narrowband voice service		
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**
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**

	IMT-2000 methodology (Rec. UIT-R M.1390)		London TETRA Narrowband voice service		
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, E_b/N_0 requirements, C/I requirements, frequency re-use plan, coding/signalling factors of radio transmission technology, enviroment, deployment model			
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**

	IMT-2000 methodology (Rec. UIT-R M.1390)		London TETRA Narrowband voice service		
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 4

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 (km^2)	1 620			
Cell area (km^2)	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 narrrowband 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 (km^2)	800			
Cell area (km^2)	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 4

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%).

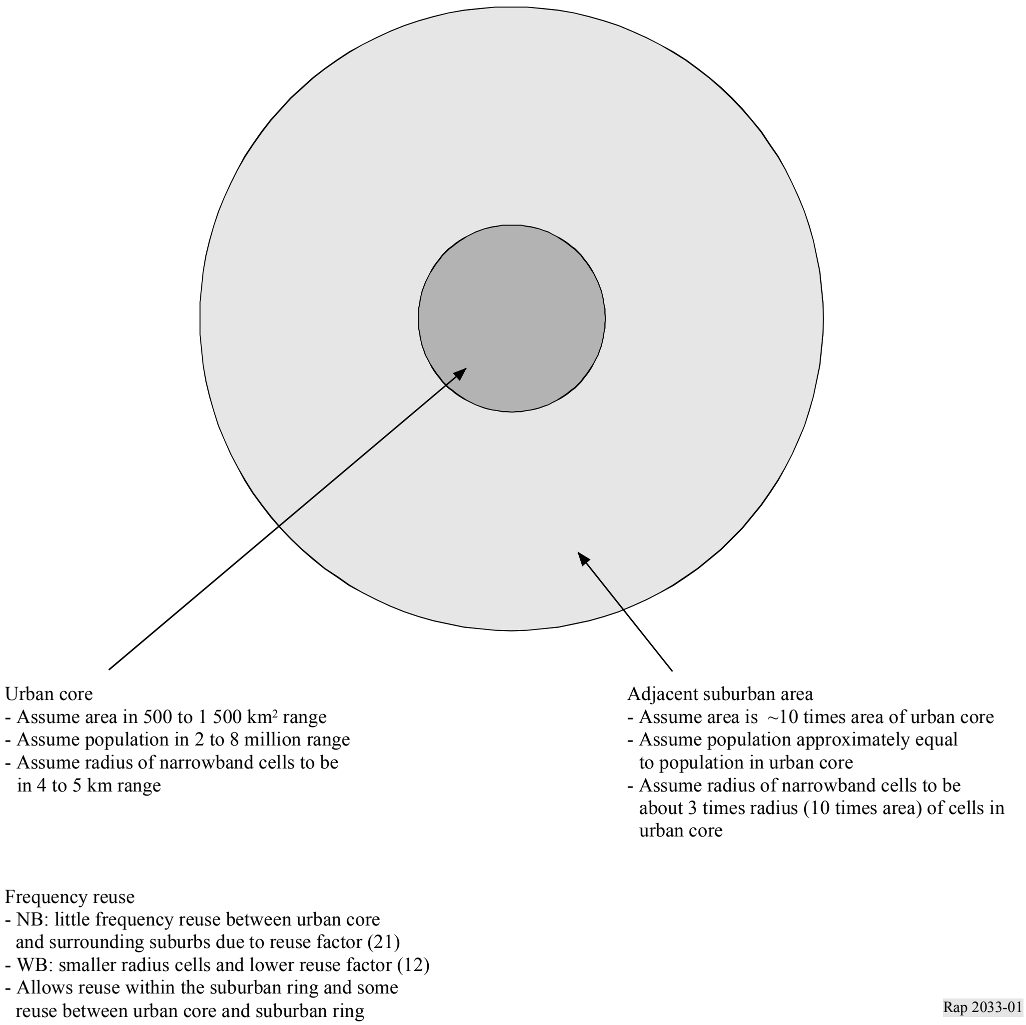
In the generic examples below, and for simplicity, only two densities are used, 180 and 250 police per 100 000 population. Also for simplicity, only two types of cities were analysed: a medium size city (2.5 million population) and a large city (8 million population). This probably underestimates the 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.

FIGURE 1

Metropolitan Area
(Urban core and adjacent suburbs)



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	15.5	MHz	NB day-to-day	21.5	MHz
WB day-to-day	16.2	MHz	WB day-to-day	22.6	MHz
Disaster NB	18.4	MHz	Disaster NB	25.6	MHz
Disaster WB	17.8	MHz	Disaster WB	24.7	MHz
Suburban			**Suburban**		
NB day-to-day	12.9	MHz	NB day-to-day	17.9	MHz
WB day-to-day	13.5	MHz	WB day-to-day	18.8	MHz
Disaster NB	15.4	MHz	Disaster NB	21.4	MHz
Disaster WB	14.8	MHz	Disaster WB	20.6	MHz
Normal day-to-day			**Normal day-to-day**		
NB (urban + suburban)	28.40	MHz	NB	39.40	MHz
WB (urban + 1/2 suburban)	22.95	MHz	WB	32.00	MHz
	51.35	MHz		71.40	MHz
Suburban disaster			**Suburban disaster**		
NB	30.90	MHz	NB	42.90	MHz
WB	23.60	MHz	WB	32.90	MHz
	54.50	MHz		75.80	MHz
Urban disaster			**Urban disaster**		
NB	31.30	MHz	NB	43.50	MHz
WB	24.55	MHz	WB	34.10	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	km^2	**10.0**	Ratio Suburban/Urban Area
Area of Surrounding Suburbs	6 000	km^2		Ratio should be near 10.0 (Range of 5 × to 15 × of Urban Area)
Urban Population Density	4 167	People/km^2		
Suburban Population Density	417	People/km^2		
"Large" or "Medium" City	MED	If Urban Population Density > 5 000 people/km^2, 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

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

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							
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 NB 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	km^2	**10.0**	Ratio Suburban/Urban Area
Area of Surrounding Suburbs	6 000	km^2		Ratio should be near 10.0 (Range of 5 × to 15 × of Urban Area)
Urban Population Density	4 167	People/km^2		
Suburban Population Density	417	People/km^2		
"Large" or "Medium" City	MED	If Urban Population Density > 5 000 people/km^2, 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

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

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							
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 NB 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 km^2) (Suburban population ≅ 8.0 million and area ≅ 8 000 km^2)					
Medium PPDR density (180 Police per 100 000 population)			**High PPDR density** (250 police per 100 000 population)		
Urban			**Urban**		
NB day-to-day	23.7	MHz	NB day-to-day	33.0	MHz
WB day-to-day	24.9	MHz	WB day-to-day	34.6	MHz
Disaster NB	28.3	MHz	Disaster NB	39.3	MHz
Disaster WB	27.4	MHz	Disaster WB	38.0	MHz
Suburban			**Suburban**		
NB day-to-day	19.8	MHz	NB day-to-day	27.4	MHz
WB day-to-day	20.7	MHz	WB day-to-day	28.7	MHz
Disaster NB	23.6	MHz	Disaster NB	32.7	MHz
Disaster WB	22.7	MHz	Disaster WB	31.5	MHz
Normal day-to-day			**Normal day-to-day**		
NB (urban + suburban)	43.50	MHz	NB	60.40	MHz
WB (urban + 1/2 suburban)	35.25	MHz	WB	48.95	MHz
	78.75	MHz		109.35	MHz
Suburban disaster			**Suburban disaster**		
NB	47.30	MHz	NB	65.70	MHz
WB	36.25	MHz	WB	50.35	MHz
	83.55	MHz		116.05	MHz
Urban disaster			**Urban disaster**		
NB	48.10	MHz	NB	66.70	MHz
WB	37.75	MHz	WB	52.35	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	Medium 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	km^2	**10.0**	Ratio Suburban/Urban Area
Area of Surrounding Suburbs	8 000	km^2		Ratio should be near 10.0 (Range of 5 × to 15 × of Urban Area)
Urban Population Density	10 000	People/km^2		
Suburban Population Density	1 000	People/km^2		
"Large" or "Medium" City	LAR	If Urban Population Density > 5 000 people/km^2, 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

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

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							

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 NB 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	Medium Metropolitan Area			Input Data
Population of Urban Area	8 000 000	People	**1.0**	Ratio Suburban/Urban Population
Population of Surrounding Suburban Area	2 000 000	People		Ratio should be near 1.0 (Range of 0.5 × to 1.5 × of Urban Population)
Area of Urban Center	800	km^2	**10.0**	Ratio Suburban/Urban Area
Area of Surrounding Suburbs	8 000	km^2		Ratio should be near 10.0 (Range of 5 × to 15 × of Urban Area)
Urban Population Density	10 000	People/km^2		
Suburban Population Density	1 000	People/km^2		
"Large" or "Medium" City	LAR	If Urban Population Density > 5 000 people/km^2, 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

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

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							

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 NB 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 range 180 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 km^2

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 km^2
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 km^2
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 km^2
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 km^2
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 km^2
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 km^2
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 km^2
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 5

Existing and emerging solutions to support interoperability for public protection and disaster relief

1 Introduction

Interoperability is becoming increasingly important for PPDR operations. PPDR interoperability 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 technologies, which could support and facilitate interoperability.

A variety of these new technologies with future enhancements including developments in digital processing techniques, could be applied to increase the data throughput of systems supporting PPDR. These technologies could also support and may 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. This Annex provides a general description of some of the existing and emerging solutions which PPDR agencies and organizations could employ in combination with the other key elements (spectrum, standards, etc.) required to facilitate interoperability.

2 Existing solutions

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

2.1 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 analog 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.

2.2 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.

2.3 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.

2.4 Multi-band, multi-mode radios

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.

2.5 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.

2.6 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 allow the users of different equipment in different bands the ability to utilize the type of equipment that best meets their requirements.

3 Emerging technology solutions for PPDR

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

3.1 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.

3.2 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.

3.3 SDR

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.

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