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Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); System reference document; Land Mobile Service; Additional spectrum requirements for future Public Safety and Security (PSS) wireless communication systems in the UHF frequency range

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Introduction

Status of pre-approval draft

The present document has been created by TC-TETRA and received also support from ETSI SC EMTEL. It has undergone an ETSI internal consultation. The present document is submitted to ERM#41 for final approval for publication as ETSI Technical Report.

Earlier versions had already been submitted to the ECC and its working groups where it was subsequently discussed. The present draft version is an update from TC TETRA. Comments from the ETSI-ECC officials meeting and also from ECC WGFM and ECC WGFM PT38 have been considered and led to changes. In addition, results from the WGFM PPDR workshop in March 2010 as well as National studies have been considered. The approved document is requested to be sent to WGFM, WGSE (cc to ECC) and the EC for their information and consideration at their future meetings (for ECC fora see under "Expected ECC actions"). It should be noted that no further comments were received during a second ETSI internal enquiry on the document.

Target version	Pre-approval date version (see note)				
V1.1.1	**A**	**s**	**m**	**Date**	**Description**
V1.1.1	0.0.4			26th March 2008	TETRA WG4#81 output
V1.1.1	0.0.5			28th April 2008	Incorporation of comments received
V1.1.1	0.0.6			22nd May 2008	TETRA WG4#82 output
V1.1.1	0.0.7			31st May 2008	Incorporation of comments received
V1.1.1	0.0.8			18th June 2008	Incorporation of comments from ERM TG17 and radio microphone manufacturers
V1.1.1	0.0.9			26th June 2008	Mini ETSI internal enquiry version
V1.1.1	0.0.10			14th August 2008	Incorporation of TETRA WG 4 comments received
V1.1.1	0.0.11			20th August 2008	Incorporation of comments received during ETSI internal consultation
V1.1.1	0.0.12			29th August 2008	Comments resolution by WG4#84
V1.1.1	0.0.13			4th March 2009	Output from WG4#89
V1.1.1	0.0.14			13th March 2009	Output from TETRA#33
V1.1.1	0.0.15			10th June 2009	Output from WG4#91
V1.1.1	0.0.16			3rd October 2009	Input for TETRA#34
V1.1.1	0.0.17			27th November 2009	Input for TETRA WG4#95
V1.1.1	0.0.18			3rd December 2009	Output from TETRA WG4#95
V1.1.1	0.0.19			14th December 2009	Update taking into account comments and considerations from TETRA WG 4 etc.
V1.1.1	0.0.20			14th January 2010	Update taking into account further comments inside TC TETRA
V1.1.1	0.0.21			18th January 2010	Further updating, inclusion of CPC in B.2.6.
V1.1.1	0.0.22			2nd March 2010	Inclusion feedback from TETRA WG 4
V1.1.1	0.0.23			10th March 2010	Update at TETRA#35 from rapporteur
V.1.1.1	0.0.24			15th March 2010	Update after PPDR workshop taking into account the workshop results, comments from TETRA WG 4 and TC TETRA chairman and TETRA LO Regulatory Affairs
V1.1.1	0.0.25			22nd March 2010	Changes based on late comment from regulators on expected schedule. V1.1.1_0.0.25 went to a second ETSI internal enquiry for comments.
V1.1.1	0.0.26			23rd May 2010	Final draft for approval at ERM#41 after no comments had been received during 2nd internal enquiry.
NOTE: See clause A.2 of EG 201 788 [i.8].					

1 Scope

The present document is aimed at establishing a dedicated, harmonized European spectrum designation for PPDR mission-critical Public Safety and Emergency Communications. This proposed resource would be a harmonized spectrum across Europe allowing interoperable and permanent PPDR networks to be established in the 300 MHz to 790 MHz band (including "Digital Dividend" band), preferably in the lower parts of the band. It is proposed that such a network would cater for all narrowband, wideband and broadband PPDR applications requiring wide area coverage. The applications will be used for voice, voice and data or data only. For local and temporary broadband PPDR usage, so-called 5 GHz Broadband Disaster Relief (BBDR) applications, the current regulation may also be reviewed.

Additional information is given in the following annexes:

- Annex A: Detailed market information.
- Annex B: Detailed technical information.
- Annex C: Expected sharing and compatibility issues.
- Annex D: Public Safety frequency statement from 18 countries that was provided to the WG FM Workshop on Spectrum Harmonisation for Public Protection and Disaster Relief (PPDR) 11-12 March 2010 - Mainz (Germany).
- Annex E: The Swedish Presidency of the EU informed the ETSI that the Council in June 2009 approved Council Recommendations on improving radio communication between operational units in border areas and invites to start producing a European standard satisfying law-enforcement and public-safety services' operational requirements regarding high-speed data communication and roaming functionality in the medium term.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area**.**

[i.1] ETSI EN 302 561 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land Mobile Service; Radio equipment using constant or non-constant envelope modulation operating in a channel bandwidth of 25 kHz, 50 kHz, 100 kHz or 150 kHz; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[i.2] ECC Decision (08)05: "Harmonisation of frequency bands for the implementation of digital Public Protection and Disaster Relief (PPDR) radio applications in bands within the 380-470 MHz range".

[i.3] ECC Recommendation (08)04 on the identification of frequency bands for the implementation of Broad Band Disaster Relief (BBDR) radio applications in the 5 GHz frequency range.

[i.4] ECC Report 102 (January 2007): "Public protection and disaster relief spectrum requirements".

[i.5] Report ITU-R M.2033: "Radiocommunication objectives and requirements for public protection and disaster relief".

[i.6] Commission Recommendation C(2003)2657 (25 July 2003) on the processing of caller location information in electronic communication networks for the purpose of location-enhanced emergency call services.

[i.7] CEPT/ERC Report 25: "The European table of frequency allocations and utilisations in the frequency range 9 kHz to 3000 GHz".

[i.8] ETSI EG 201 788 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Guidance for drafting an ETSI System Reference Document".

[i.9] ETSI TR 102 485: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics for Broadband Disaster Relief applications (BB-DR) for emergency services in disaster situations; System Reference Document".

[i.10] ETSI EN 300 392-2 (V3.2.1): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

[i.11] ETSI TR 102 580: "Terrestrial Trunk Radio (TETRA); Release 2; Designer's Guide; TETRA High-Speed Data (HSD); TETRA Enhanced Data Service (TEDS)".

[i.12] ETSI TR 102 491 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); TETRA Enhanced Data Service (TEDS); System reference document".

[i.13] ECC Report 99 (2007): "TETRA Enhanced Data Service (TEDS): Compatibility studies with existing PMR/PAMR and Air Ground Air (AGA) systems in the 400 MHz band".

[i.14] Wireless World Research Forum, Working Group 6 White Paper (2005): "Cognitive radio and management of spectrum and radio resources".

[i.15] Delaere, D. and Ballon, P. (April 2007): "Flexible spectrum management and the need for controlling entities for reconfigurable wireless systems", IEEE DySPAN 2007 Conference, Dublin, Ireland.

[i.16] ITU-R Recommendation P.1546: "Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz".

[i.17] ETSI TR 102 621: "Terrestrial Trunked Radio (TETRA); TWC2007 Future of TETRA workshop report".

[i.18] wik-Consult, study white paper (May 2008): "Safety first: Reinvesting the digital dividend in safeguarding citizens".

[i.19] ETSI TS 102 181 (clause 5): "Emergency Communications (EMTEL); Requirements for communication between authorities/organizations during emergencies".

[i.20] ETSI TR 102 021-2 (V1.2.1): "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 2: High Speed Data".

[i.21] ETSI TR 102 445: "Emergency Communications (EMTEL); Overview of Emergency Communications Network Resilience and Preparedness".

[i.22] ETSI EN 302 625: "Electromagnetic compatibility and Radio spectrum Matters (ERM); 5 GHz BroadBand Disaster Relief applications (BBDR); Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.23] Communication from the European Commission to the European Parliament on Reaping the full benefits of the digital dividend in Europe (November 2007).

[i.24] ITU Resolution 646 (WRC-03): "Public protection and disaster relief".

[i.25] ITU Resolution 647 (WRC-07): " Spectrum management guidelines for emergency and disaster relief radiocommunication".

[i.26] ITU Radio Regulations footnote 5.286AA.

[i.27] CEPT Reports 019, 022 to 025.

NOTE: Available at www.erodocdb.dk.

[i.28] Council of the European Union (December 2008): "Progress report from the PCWG Ad hoc Working Party on Radiocommunications", Brussels.

[i.29] PSCE presentation to the Radio Spectrum Policy Group on Spectrum requirements regarding public protection and disaster relief (November 2008).

[i.30] Motorola: "Reuse methodology": (25th January 2008) ETSI TETRA WG4 document 407076r1.

[i.31] WiMAX Forum (June 2006): "Mobile WiMAX- Part 1: A Technical Overview and Performance Evaluation".

[i.32] Analysis Mason (November 27, 2008): "Wireless network traffic to increase tenfold".

[i.33] The Council of the European Union: Council Recommendation 10141/09 on improving radio communication between operational units in border areas.

[i.34] Use Cases for Cognitive Applications in Public Safety Communications Systems - Volume 1: Review of the 7 July Bombing of the London Underground.

NOTE: Available at http://www.sdrforum.org/pages/documentLibrary/documents/SDRF-07-P-0019-V1_0_0.pdf.

[i.35] ETSI TS 102 734: "Reconfigurable Radio Systems (RRS): User Requirements for Public Safety".

[i.36] ETSI TR 102 733: "Reconfigurable Radio Systems (RRS); System Aspects for Public Safety".

[i.37] MESA TS 70.001 (Version 3.2.1) project MESA: "Service specification group - services and applications; Statement of Requirements (SoR)".

[i.38] ETSI TR 102 496: "Electromagnetic compatibility and Radio spectrum Matters (ERM);System Reference Document; Short Range Devices (SRD);Technical characteristics for Location tracking Applications for Emergency Services (LAES) in disaster situations operating within the frequency range from 3,4 GHz to 4,8 GHz".

[i.39] ITU-R Recommendation P.370-7: "Dependence of field strength on horizon angle theta in ITU-R Recommendation P.370-7".

[i.40] ETSI TR 102 513: "Terrestrial Trunked Radio (TETRA); Feasibility Study into the Implications of Operating Public Safety Sector (PSS) TEDS using the proposed "Tuning Range" concept in the 410 MHz to 430 MHz and 450 MHz to 470 MHz frequency bands".

[i.41] PCWG letter from Swedish presidency to CEPT-ERO with request for a harmonised frequency band for mobile data.

[i.42] PCWG letter from Swedish presidency to ETSI with request for a technology solution for mobile data.

[i.43] PCWG interim report December 2009.

[i.44] ETSI TR 102 682: "Reconfigurable Radio Systems (RRS); Functional Architecture (FA) for the Management and Control of Reconfigurable Radio Systems".

[i.45] ETSI TR 102 683: "Reconfigurable Radio Systems (RRS); Cognitive Pilot Channel (CPC)".

[i.46] ETSI Reconfigurable Radio Systems - Status and Future Directions on Software Defined Radio and Cognitive Radio Standards; by Markus Mueck, Antti Piipponen, George Dimitrakopoulos, Kostas Tsagkaris, Fernando Casadevall, Panagiotis Demestichas, Jordi Pérez-Romero, Oriol Sallent, Gianmarco Baldini, Stanislav Filin, Hiroshi Harada, Merouane Debbah, Thomas Haustein, Jens Gebert, Benoist Deschamps, Paul Bender, Michael Street, Kari Kalliojärvi, Sithamparanathan Kandeepan, Jaswinder Lota, Aawatif Hayar. Manuscript dated 15th January 2010.

[i.47] IST-E2R II Whitepaper: "The E2RII Flexible Spectrum Management (FSM) Framework and Cognitive Pilot Channel (CPC) Concept - Technical and Business Analysis and Recommendations" by Pérez-Romero, O. Sallent, R. Agustí, L. Giupponi, "A Novel On-Demand Cognitive Pilot Channel enabling Dynamic Spectrum Allocation", DySPAN 07, 17-20 April, 2007.

[i.48] Report ITU-R M.2014: "Digital land mobile systems for dispatch traffic".

[i.49] ITU-R Recommendation M.1073: "Digital cellular land mobile telecommunication systems".

[i.50] ITU-R Recommendation M.1221:"Technical and operational requirements for cellular multimode mobile radio stations".

[i.51] ITU-R Recommendation M.1457: "Draft revision of Recommendation ITU-R M.1457-8 - Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications 2000 (IMT-2000)".

[i.52] Decision No 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community (Radio Spectrum Decision).

[i.53] IEEE Std 802.16e-2005: "Amendment to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed Broadband Wireless Access Systems - Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands".

[i.54] IEEE Std 802.16m: "Amendment to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Broadband Wireless Access Systems - Advanced Air Interface".

[i.55] IEEE 802.11: "IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks-Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

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[i.65] Council Decision 2008/616/JHA of 23 June 2008 on the implementation of Decision 2008/615/JHA on the stepping up of cross-border cooperation, particularly in combating terrorism and cross-border crime.

NOTE: Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:210:0012:0072:EN:PDF.

[i.66] Draft Council Recommendation 13796/08 of 3 October 2008 on improving communication between operational units in border areas.

NOTE: Available at http://register.consilium.europa.eu/pdf/en/08/st13/st13796.en08.pdf.

[i.67] Communication from the Commission to the European Parliament and the Council on Reinforcing the Union's Disaster Response Capacity.

NOTE: Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0130:FIN:EN:PDF.

[i.68] ERC Report 52 (December 1997): "Methodology for the assessment of PMR systems in terms of spectrum efficiency, operation and implementation", Bucharest.

[i.69] ECC Report 42 (February 2004): "Spectrum efficiency of CDMA-PAMR and other wideband systems for PMR/PAMR", Granada.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

air-interface: wireless interface between a base station and a mobile station (trunked mode) or between two mobile stations (direct mode)

broadband: communication service providing data rates higher than wideband (typically above 1 Mbit/s)

NOTE: ITU-R Definition [i.5]: 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).

common control channels: control channels transmitted by the infrastructure to control the MS population

NOTE: The common control channels comprise the main control channel and common secondary control channels.

Cognitive Pilot Channel (CPC) for PPDR: channel which conveys the elements of necessary information facilitating the operations of Cognitive Radio Systems involving the PPDR network

day-to-day operations (PP1): routine PPDR operations

NOTE: "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." (Quotation from Report ITU-R M.2033 [i.5]).

PP1 networks are for general public protection and require reliable, available, secure systems provided by dedicated systems permanently available and covering all necessary wide areas (regional, country, continent) on a permanent basis. These operations insure primarily voice and messaging communications which can be fulfilled by narrowband and wideband communications.

dedicated PPDR spectrum: spectrum assigned to PPDR networks

NOTE: This does not imply an exclusive use but sharing part of the spectrum with other networks under strict pre-emptive regime to ensure the expected performance of the PPDR network for disaster relief.

disaster relief operations: special operations to minimize the effects of a disaster

NOTE: "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." (Quotation from Report ITU-R M.2033 [i.5]).

These require efficient rapid deployment incident networks. Applications are used temporarily by emergency services in all aspects of disaster situations, including disaster prevention. For instance, they provide simultaneous hot spot type of robust communications, video or robotic data information, telemetry parameters, critical data base queries, location information exchange and other heavy data communications.

Furthermore interoperability of equipment to ensure joint operations is a mandatory requirement.

disaster relief radiocommunications: radiocommunications used to facilitate disaster relief operations

NOTE: "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." (Quotation from Report ITU-R M.2033 [i.5]).

emergency service or public safety agency: organisation providing immediate assistance and relief in emergency situations

NOTE: A service or agency, recognized as such by the Member State, that provides immediate and rapid assistance in situations where there is a direct risk to life or limb, individual or public health or safety, to private or public property, or the environment but not necessarily limited to these situations (Source: Commission Recommendation C(2003)2657 [i.6]).

IP packet data: packetized data according to the Internet Protocol

large emergency and/or public events (PP2): events outside routine operations (i.e. not PP1 operations)

NOTE: "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." (Quotation from Report ITU-R M.2033 [i.5]).

A large fire encompassing 3-4 blocks in a large city (e.g. London, Paris) or a large forest fire are examples of a large emergency under this scenario (also the plane crash at Schiphol 2009). 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.

It is to be noted that the equipment used for large extraordinary local incidents will request reinforced communications means including BB equipment.

mission critical situations: situations where human life, rescue operations and law enforcement are at stake

NOTE: In a mission critical situation public safety organizations cannot afford the risk of having transmission failures in their voice and data communications or for police in particular to be "eaves-dropped".

narrowband: communication service providing data rates up to about 100 kbit/s

NOTE: ITU-R Definition [i.5]: "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). Report ITU-R M.2014 [i.48] 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." (Quotation from Report ITU-R M.2033 [i.5]).

non-mission critical situations: situations where human life and properties are not at stake

NOTE: In non-mission critical situations communication needs are non critical: human life and properties are not at stake, administrative tasks for which the time and security elements are not critical.

QAM channel: channel on which signalling and data messages are sent using QAM bursts

real-time class data: data that cannot tolerate delay but can tolerate some packet loss

public protection radiocommunications: specific radiocommunication for agencies and public safety organizations

NOTE: "Public protection radiocommunications used by responsible agencies and organizations dealing with maintenance of law and order, protection of life and property, and emergency situations." (Quotation from Report ITU-R M.2033 [i.5]).

public safety operations: any kind of operation performed by a public safety organisation

NOTE: Public Safety organizations addresses three (PP1, PP2, DR) types of operations. (Source: Report ITU-R M.2033 [i.5]). Furthermore it should be noted that training exercises will also take place and consequently have to be taken into account when considering frequency planning and harmonisation. In order to avoid unnecessary use of spectrum, a training mode may be required for BB.

wideband: communication service providing higher data rates than narrowband (typically hundreds of kbit/s)

NOTE: ITU-R Definition from section 1.4.3 of Report ITU-R M. 2033 [i.5]: 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 [i.48] and in ITU-R Recommendations M.1073 [i.49], M.1221 [i.50] and M.1457 [i.51] and with channel bandwidths dependent on the use of spectrally efficient technologies.

π/4-DQPSK channel: channel on which signalling and data messages are sent using π/4-DQPSK bursts

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3G	3rd Generation
π/4-DQPSK	π/4-shifted Differential Quaternary Phase Shift Keying
π/8-D8PSK	π/8-shifted Differential 8 Phase Shift Keying
ACP	Adjacent Channel Power
ACR	Adjacent Channel Rejection
ADC	Analogue-to-Digital Converter
APCO	Association of Public-Safety Communications Officials
ASM	Adaptive Spectrum Management
BER	Bit Error Rate
BS	Base Station
BB	BroadBand
BBDR	BroadBand Disaster Relief
CEPT	Conference Européenne des administrations des Postes et des Telecommunications
CPC	Cognitive Pilot Channel
DAC	Digital-to-Analogue Converter
DR	Disaster Relief
ECC	Electronic Communications Committee
ECO	European Communications Office (of CEPT)
ECS	Electronic Communications Services
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplex
GPRS	General Packet Radio Service
HEN	Harmonised European Norm
HSD	High Speed Data
IP	Internet Protocol
ITU	International Telecommunication Union
LAES	Location Application for Emergency Services
LLC	Logical Link Control
LW	Long Wave
MAC	Medium Access Control
MC	Multi Carrier
MEX	Multimedia EXchange Layer
MIMO	Multiple-Input Multiple-Output
MISO	Multiple-Input Single-Output
MLE	Mobile Link Entity
MS	Mobile Station
MW	Medium Wave
NB	NarrowBand
NPSPAC	National Public Safety Planning Advisory Committee
OTAR	Over The Air Re-keying
PAMR	Public Access Mobile Radio

PCWG	Police Cooperation Working Group
PMR	Private Mobile Radio
PNC	Police National Computer
PP	Public Protection

NOTE: See clause 3.1 definitions and terminology for PP1 and PP2.

PPDR	Public Protection and Disaster Relief
PSCE	Public Safety Communications Europe
PSK	Phase Shift Keying
PSS	Public Safety and Security
PWMS	Professional Wireless Microphone System
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RAT	Radio Access Technology
RF	Radio Frequency
RRS	Re-configurable Radio Systems
RSC	Radio Spectrum Committee (of the European Commission)
RSPG	Radio Spectrum Policy Group (of the European Commission)
RSSI	Receive Signal Strength Indication
RX	Receiver
SEAMCAT	Spectrum Engineering Advanced Monte Carlo Analysis Tool
SRDoc	System Reference Document
SwMI	Switching and Management Infrastructure
TC-TETRA	Technical Committee TETRA
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TEDS	TETRA Enhanced Data Service
TETRA	TErrestrial Trunked RAdio
TX	Transmitter
UHF	Ultra High Frequency
UMB	Universal Mobile Broadband
V+D	Voice plus Data
VHF	Very High Frequency
WAPECS	Wireless Access Policy for Electronic Communications Services
WB	WideBand
WGFM	Working Group on Frequency Management (of ECC)
WGSE	Working Group Spectrum Engineering (of ECC)

4 Comments on the System Reference Document

Comments from ERM TG17 (standards for broadcast and ancillary communications equipment) and EMTEL have been received and incorporated in the present document. Further comments received during the ETSI internal consultation or within ECC fora have also been incorporated.

4.1 Statement from NATO (supported by Hungary and France at WGFM meeting in May 2009)

"The NATO UHF Band is the most essential common resource for the operation of military forces in all NATO nations and in a large number of non-NATO nations in Europe and worldwide. In recent years it became evident that more and more military systems must be fitted into this band because of the loss of other bands to the profit of civil systems. In addition, traditional Tactical Radio Relay has been or will be replaced in the near future with new technology (meshed networks) with higher deployment density and mobility, and larger bandwidths, increasing the demand on the UHF band. Satellite communication in this band is also expanding. The enlargement of NATO to 28 nations over the years has also induced more A/G/A usage in the UHF while the new Nations transition from their old systems to the standard UHF A/G/A radios of NATO. Finally, the UHF reorganisation which came into force in January 2006 showed increasing difficulties to provide A/G/A assignments of the required quality to all the users. Therefore the NATO UHF band constitutes a vital pre-requisite for the interoperability and deployability required amongst NATO forces and national forces of NATO nations. Military access to the full range of the band is crucial to NATO and national defence and the operations of military forces".

4.2 Statement from ETSI ATTM-AT3 members UPC Broadband Holding Services BV, Cable Europe, Cable Labs, A.S.P. (Working Group on Integrated broadband cable and television networks, dated 24th February 2010)

ATTM-AT3 wishes to bring to the attention of those preparing spectrum requests and standards in the 25 - 862MHz band that current incumbent users of these frequencies such as Terrestrial broadcasting, Fixed Broadband Networks and distributed (or communal) aerial systems (used in multiple dwellings and campus), use these frequencies to distribute TV broadcasts, video, high speed data, interactive and voice services over their networks. In 2009 with terrestrial and broadband cable networks alone there were some 152 million subscribers and 198 million homes passed in Europe plus an unknown number of communal aerial viewers.

Recent work within CEPT and Administrations has shown that transmitters co-channel with receivers from either off-air terrestrial or fixed broadband networks (e.g. cable networks) will cause interference to current viewers' services by interfering with the customer premise equipment (CPE).

In those instances where your proposed new service for the 25-862MHz spectrum is likely to result in the equipment being used in proximity to CPE we request that you keep ATTM-AT3 and other relevant ETSI bodies informed of your work and consider the technical requirements for such new services to ensure protection of existing users of these frequencies to minimise interference to viewers of these services.

5 Executive summary

5.1 Background information

5.1.1 The current situation

A number of major man-made and natural disasters in recent years have changed the way governments are responding to these events. Europe is embracing the concept of Homeland Security resulting in an increasing co-operation between Police, Fire, Rescue, Health and Military organizations. This has called for interoperable, secure and wide-area coverage communications between these agencies often across national boundaries.

In addition to the PSS services, other organisations such as transportation, utilities, etc. are expected to share to some extent the same communications network infrastructure to enable reliable and interoperable communications in disaster situations.

A new ECC Decision [i.2] on the harmonisation of frequency bands for the implementation of digital Public Protection and Disaster Relief (PPDR) radio applications in bands within the 380 MHz to 470 MHz range covering narrowband and wideband PPDR applications has been approved in 2008. However, the reality is that numerous applications and technologies are already in use in the 410 MHz to 430 MHz and 450 MHz to 470 MHz bands making the possibility for HSD PSS applications to a large extent impractical.

Narrowband and wideband PPDR applications in Europe are covered to a great extent by TETRA Release 1 and TETRA Release 2 (that includes TEDS) systems. The new ECC Decision (08)05 [i.2] is based on ECC Report 102 [i.4] which is an outcome of the ECC work programme on PPDR applications, developing spectrum requirements for PPDR communications for wide-band and broadband applications.

The demand for wider coverage as stipulated in the present document in terms of cell size, number of cells needed for wider-area coverage for use by daily and more permanent PP1 applications as defined in Report ITU-R M.2033 [i.5] differs very much from the BBDR as covered in TR 102 485 [i.9] (see clause 3.1 for the definition and terminology of PP1, PP2 and DR) and the LAES application as covered in TR 102 496 [i.38]. Both, BBDR and LAES are complementary applications to wider coverage PPDR networks described in the present document. They provide only local coverage and are focusing on in-building usage scenarios. On the other side, such wider coverage emergency communications do not require the same high capacity offered in ad-hoc local high user density networks. The present document therefore complements the existing ECC deliverables on PPDR and proposes to close this gap on broadband PP1 and DR applications that need spectrum more permanently (i.e. "daily", more frequently used BB usage) and with wider coverage. Clauses A.4 and A.5 provide some results on the mixture of the broadband demand, in terms of local & temporary demand, need for minimum of permanent demand as well demand requiring a larger coverage area.

Currently, wide consultation is taking place in Europe about the potential use of the "Digital Dividend" band, which is becoming available from 2012 for new innovative services. In November 2007 a communication from the Commission to the European Parliament on "Reaping the full benefits of the digital dividend in Europe" contained a list of new services [i.23]. The first service on the list was "Wireless broadband communications". Furthermore, it stated that "Wireless broadband communication also has the potential to support EU-wide interoperability of essential **public safety** applications such as PPDR services".

There is an overwhelming list of reasons why the public mobile networks are unsuitable for providing the above type of service. The main shortcomings of such networks are in the areas of availability, lack of ultimate controllability/ operational control over the network, coverage, resilience, security, interoperability and a host of other specific Public Safety/PPDR functional requirements. A more detailed discussion of these differentiating features is given in clause 6.3.

5.1.2 The new proposal

In the present document the emphasis is on a spectrum within the tuning range of the technology, to be used for wide-band and broadband applications. It is of critical importance that:

1) The high-speed data emergency communication services assume a very high priority in European spectrum designation.

2) The requested band is considered as a European-wide asset for PPDR communication and is not subject to criteria used in spectrum designation for commercial consumer networks and services such as auctions.

3) This band is to be designated on a dedicated (and protected) basis.

4) This band is for harmonised use (interoperable) across Europe.

Although TC-TETRA is the originating body of the SRDoc, this initiative is being made on behalf of the PSS community at large and as such the future broadband communications needs may be developed in accordance to options given in clause B.2.3. If a single frequency band cannot be designated, a tuning range of ±12,5 % of the centre frequency is also acceptable.

With the support of the European Commission, "Forum for Public Safety Communication Europe" (PSC-E) has been established in order to facilitate consensus building in the area of public safety communication and information management systems. PSC-E have made representation on this subject to ECC plenary in June 2008 and to RSPG in November 2008. PSC-E coordinates amongst user organisations and across industry.

5.1.3 The socio-economic benefits

Public Protection and Disaster Relief is a priority subject for citizens, National Governments and the European Union and effective communication is an essential element for Public Safety operations. Public safety services bring value to society by creating a stable and secure environment and this can only be done by building robust, secure and reliable, modern Public Safety mobile communications networks which also allow for interoperability across international borders. To fulfil this requirement, it is essential for Public Safety services to have access to appropriate and protected spectrum in all parts of the territory, sufficient to meet their evolving operational needs. Building these modern essential services requires a long project lead time, for example, today's national digital radio system for emergency services, often part of Critical National Infrastructure, typically takes 10 years in planning before they are operational.

The Socio-economic benefits of this single harmonised spectrum for PPDR communication are immense:

1) Saving lives of citizens and public safety officers and minimising injury.
2) Minimising damage to private properties and public places.
3) Faster response and more efficient communication at times of disaster.
4) Enhancement of a single emergency communication network with high reliability (QoS), availability (free from congestion at times of disaster) and a high level of security.
5) Better co-ordination between different agencies nationally and over international borders for routine and emergency communications.
6) Developing countries will benefit from availability of such a low cost and globally interoperable emergency communication network.
7) Prolonged investments in European national public safety infrastructures maintained by an evolutionary enhancement.
8) A single wide-area coverage network results in major cost savings in the network infrastructure.
9) Creation of a European (and possibly global) harmonised set of equipment resulting in a higher economy of scale and lower costs.
10) European technology lead in this globally significant area.

5.2 Market information

Considering the special nature of PPDR, traditional market mechanisms are not appropriate to consider in determining the correct amount of spectrum needed. The PPDR community is a specialist market, driven by different market forces to those that drive the public mobile mass markets. The ERC decision [i.24] in 1996 for 380 MHz to 385 MHz / 390 MHz to 395 MHz has proven to be highly successful. Most European countries have deployed or are in the process of deploying nationwide PPDR (more exactly PP1 and PP2) networks based on that decision, shared by police, fire brigades, emergency services and other PPDR users. As a result the PPDR community has never before had so much competition, innovation, specialized products and improved cost/benefit ratio.

User communities have determined that mobile data is equally as "mission critical" as voice and therefore cannot be safely transported over commercial networks. This is because officers will become more and more reliant and dependent on mobile data communications in support of their day to day operations and thus losing and or interrupting these services in an emergency would seriously impact their ability to meet their public safety commitments. Consequently, additional spectrum is required to meet the future needs of PPDR.

It is expected that some PSS TETRA networks will start being replaced at least in part, commencing within the 2012 to 2015 timeframe, with new technology that will need to support voice, NB, WB and BB data services and be backward compatible and interoperable with TETRA. For voice it is expected that TETRA will still be the solution because for "mission critical group voice communication" there are no real alternatives in the coming period.
Furthermore, the users' expectation is that the new enhancements will not require addition of new base stations to the network.

With the support of the European Commission, "Forum for Public Safety Communication Europe" (PSC-E) has been established in order to facilitate consensus building in the area of public safety communication and information management systems. PSC-E have made representation on this subject to ECC plenary in June 2008 and to RSPG in November 2008. PSC-E coordinates amongst user organisations and across industry.

The Mason study also supports the above findings [i.32].

Detailed market information is provided in annex A.

6 Requirements and justification

6.1 Future spectrum requirements and justification

Future spectrum requirements are summarised below:

- The following future spectrum pairs (FDD operation, for uplink and downlink as a basis, however also to study possible asymmetry of the demand in up- and downlink, see clause A.5).
- preferably, 2 separate contiguous blocks of 10 MHz plus 2 separate non-contiguous blocks of 2 × 3 MHz for new NB and 2 × 3 MHz for new WB as indicated in table 1), minimum, dedicated to PSS and harmonised across Europe; the total of **additional** 16 MHz for each direction (uplink and downlink). The tuning range concept of ±12,5 % of the centre frequency applies to NB and WB, however not to BB. The BB spectrum designation may be located in separate spectrum range.

  This requirement is based on the following assumptions in a disaster relief scenario:

1) A mixture of NB, WB and BB channels.
2) Multiple WB channels (each up to 150 kHz) per site.
3) Use of 1 BB channel per site (up to 10 MHz wide depending on the choice of broadband technology).
4) Extensive field data from a number of operating TETRA networks has shown that the frequency re-use factor for 25 kHz TETRA NB channels is 20 to 30. A detailed consideration on how the frequency reuse was derived is in clause B.3.3.
5) A simulation study [i.30] carried out by TC TETRA WG4 showed that the re-use factor for WB (TEDS) channels is at minimum a factor of 2 lower than the TETRA NB (25 kHz) channels (i.e. 10 to 15).
6) The additional NB demand is caused by increased multi-slot packet data usage in existing networks and caused by the additional demand for spectrum used for the avoidance of congestions of the control channel due to dynamic/intelligent location data usage. This was reported by several European countries within ETSI TC TETRA. Clause B.3.3 also provides some information on why additional NB demand (high usage density situations, cross-border additional channel needs, to support higher mobility requirements, etc.) is necessary.
7) The frequency re-use factor of 1 to 3 has been reported by some of the BB technologies listed in [i.31], clause B.2.3.

   Using the above assumptions table 1 shows that additional 2 × 16 MHz is about the minimum to serve the above scenario.

Table 1: Derivation of Typical Future Spectrum Requirement

Channel Type	Number of Channels	Total Spectrum MHz (paired bands)
NB	120 (network wide) 10 (per site)	2 x 5 (existing allocation)
New NB	120 (network wide) 6 (per site)	2 x 3
New WB	20 (network wide) 2 (per site)	2 x 3
New BB	1 (network wide and per site)	2 x 10
Cognitive Pilot Channel (CPC)	1 or more	n x 0,1 (100 kHz) within tuning range
Total new requirement (excl. CPC)		2 x 16

- ETSI noted the decision of WGFM that the main focus will be on the broadband requirements (2 × 10 MHz), as the narrowband and wideband requirements should be covered within the tuning range 380 MHz to 470 MHz, as identified in the ECC Decision (08)05 [i.2]. The new broadband requirement needs to be realized at either end of the existing allocation.

- The further separated that the new NB and WB allocations are from existing NB allocations, the greater the performance degradation is likely to be due to the increased bandwidth needed for equipment and antennas, and the higher the costs are likely to be for these.

- If the BB spectrum is located with a high frequency separation from the NB and WB spectrum, equipment that provides all services will need to cover multiple frequency bands, as will the associated antennas. This is liable to increase cost and size of terminal devices, and may cause reduced battery life. It may also degrade network performance as the propagation characteristics and antenna gains will be different in different bands.

As many factors affect the performance of radio terminal equipment (mobile nature of use) and if communications are lost and/or degraded only one user is affected, reduced performance may be acceptable, however, field trials will be needed to quantify actual degradation.

A detailed discussion about the consequences of larger tuning ranger can be found in [i.40].

Duplex spacing

It is assumed that NB/WB channels would have to work with the same duplex spacing as existing TETRA networks. Keeping the 10 MHz duplex spacing as in existing networks would be easiest to deploy new network and subscriber equipment.

For BB spectrum, presumably the need is for enough spacing, which would need to be at least 20 MHz for a 10 MHz channel bandwidth, preferably higher to ease the requirements for base station duplex filtering. On the other hand, if the identified granted BB spectrum were at lower frequency, then too great a spacing starts to cause antenna performance fall off between Tx and Rx bands. In this case, adequate spacing needs to be discussed further on in the process.

It is to be noted that the use of TDD in the spectrum proposed to be assigned should not be ruled out. German studies presented during the ECC WGFM PPDR workshop outlined a possible asymmetry of the demand (see clause A.5).

Furthermore, the above spectrum requirement is in addition to any existing PSS spectrum to allow interoperability, full wide-area coverage for routine PSS operations and equipment cost and size considerations.

PPDR services have the primary duty of ensuring law and order as well as protecting the life, health and property of citizens. Spectrum requirements for PSS have to prevail over requests for non-PSS spectrum.

The current 2 × 5 MHz PPDR spectrum is extensively used in Europe for NB data and voice services and is in need of expansion to cater for emerging PPDR WB data services.

As indicated above any spectrum designation (as a result of the present document) requires at least one contiguous component as wide as one required broadband channel (10 MHz). A solution based on split or fragmented spectrum for the required channel is not viable because of:

- RF front end design complexities:

  A fragmented band for a BB channel requires using either multiple transmitters and receivers for the different parts of the channel or employing very wide bandwidth DAC and ADC devices with a very high dynamic range to allow protection against high interference within the fragmented band. In both examples the technology is complex, expensive or does not exist. Furthermore, guard bands and adjacent band compatibility would be a big challenge for fragmented BB spectrum.

As for the non-contiguous 2 × 6 MHz band, there are the following problems compared to:

- Protection requirements:

  A wider total guard band would be necessary because of the need for a guardband at each fragmentation edge to meet the PSS compatibility requirements. This reduces the overall efficiency in utilisation of the spectrum compared to the non-fragmented scenario. Otherwise extremely strict, perhaps technically even not feasible ACR and ACP specifications would be needed.

- Wastage of spectrum due to additional guard bands:

  As seen from the above second bullet point, more and wider guard bands are needed, which results in more wastage of the spectrum.

- Difficulties with interoperability:

  With a fragmented spectrum there will be more likelihood of Administrations using different sub-bands for their public safety TETRA network hence making the task of a cross border or pan European interoperability much more difficult.

In any case, the fragmented scenario requires a more complex and time consuming compatibility analysis. The scarcity of additional spectrum resources within the 400 MHz range (e.g. between 406,1 MHz to 430 MHz and 440 MHz to 470 MHz) will make it difficult to fulfil requests in future for wideband and broadband PPDR networks. These frequencies are also heavily used by non-PPDR, PMR/PAMR networks. Furthermore, WRC 07 has identified the band 450 MHz to 470 MHz for use by administrations wishing to implement International Mobile Telecommunications (IMT) [i.26]. This will make it even more difficult to find additional spectrum resources. Clearly, a lack of further availability of spectrum will put the fulfilment of the duties of PPDR services at risk by (among others):

- Inability to support new services requiring more data (e.g. identity cards, photographs, fingerprints).

- Lagging behind criminals who increasingly adopt advanced data applications.

- Inability to manage efficiently major disaster scenarios.

Even though the European PSS community welcomes and appreciates the spectrum already assigned for dedicated PSS use, this allocation is clearly insufficient for supporting the data applications as listed in annex A, detailed market information. Back in early 1990, when the estimation of future spectrum needs for PSS determined that 2 × 5 MHz was needed, features like GPS (or AVLS/APLS - Automatic Vehicle/ Automatic Personal Location Services) were not known. Today most terminals - mobiles and handsets - have a GPS receiver built-in and the users have a need to inform their control rooms of their location at any given time. This additional data traffic has not been calculated and is just one reason on why additional spectrum is required. One other example, PPDR in Europe has access to 2 × 5 MHz of dedicated spectrum whereas the Public Safety community in North America has access to more than 97 MHz spectrum - a significant difference. See table 2 reproduced from [i.18].

Table 2: European Harmonized Dedicated PSS Spectrum Allocation

	United States		Europe		
Frequency Band	**Tuning Range (MHz)**	**Available Bandwidth (MHz)**	**Frequency Band**	**Tuning Range (MHz)**	**Available Bandwidth (MHz)**
VHF Low band (see note 1)	25 - 50	6,3			
VHF High band (see note 1)	150 - 174	3,6	68 MHz to 87,5 MHz, 146 MHz to174 MHz VHF band		(see note 4)
220 MHz band (see note 1)	220 - 222	0,1			
UHF band (see note 1)				380 - 385	5
	450 - 470	3,7		390 - 395	5
700 MHz band	764 - 776	12		*410 - 430*	20 (see note 2)
	794 - 806	12	UHF band	*450 470*	20 (see note 2)
800 MHz band (see note 1)	806 - 821	1,75			
	851 - 866	1,75			
NPSPAC band	821 - 824	3			
	866 - 869	3			
5 GHz band	4 940 - 4 990	50	5 GHz band	*5 150 5 250* alternatively: 4 940 - 4 990	50 (see note 3)
Total available bandwidth		**97,2**			**10**

NOTE 1: Denotes approximate available bandwidth.
NOTE 2: Shows non-dedicated bands in Europe, hence not included in the total available bandwidth.
NOTE 3: For local and temporary usage (PP2 and DR) only, hence not included in the total available bandwidth.
NOTE 4: Many European countries have national frequency designations for PPDR in the VHF frequency range which are not harmonized throughout Europe, hence not included in the total available bandwidth.

Furthermore, the spectrum available to PPDR in Europe is fully used by voice traffic and some data usage. Examples of such PPDR networks are Airwave (UK), ASTRID (Belgium), C2000 (Netherland) and VIRVE network in Finland, all using the spectrum shown in table 1. The wideband ECC Decision [i.2] for 380 MHz to 470 MHz does give the PPDR community some extra data capability, but high utilization of the current does not permit the establishment of channels suitable for the use of high speed data as required for future enhancements of public investments.

The mission-critical PPDR communications requirement is exhibiting an urgent and growing need for inter-operable high-speed data services (see annex A). A number of PSS organisations in Europe have been conducting trials on PSS high-speed data in recent years ([i.19]). These organisations clearly see a need for a nation-wide network in the near future to allow the HSD services and applications (often mission critical) listed in clause A.1. The ETSI Special Committee EMTEL and project MESA have identified user requirements for future broadband mission critical PP1, PP2 and DR applications. The EMTEL document TS 102 181 [i.19] on requirements for communication between authorities and organisations during emergencies also lists situations and services for effective communication (as listed in clause A.1).

These services could be supported e.g. by TETRA Release 2 technology today and in the future by further enhancements to the TETRA standard. The implementation of these services however has been inhibited by a lack of suitable radio channels in range 380 MHz to 470 MHz. For example, although the new NB/WB ECC Decision [i.2] provides a tunable facility over this band, some European countries are not in a position to provide spectrum in this band within the foreseeable future. This is why the implementation of wideband PPDR networks is inhibited from taking off in Europe. A wideband PPDR network, when implemented, could also provide the complementary role of a core network for the BBDR deployments, interconnecting various "hot zones". However, the emphasis in the present proposal is on a wide-area coverage for WB and BB services using the same spectrum.

Considering the above points it is therefore natural to consider the next relevant spectrum opportunity, i.e. the "digital dividend" band as an ideal solution to this vital problem, allowing a spectrum designation for these important networks (if possible) close to their current operating frequencies. This view is based on the fact that the PSS/PPDR market segment is relatively small and that there is a limited economic case for the high degree of terminal integration (different spectrum bands and different standards) that we see e.g. in the GSM / UMTS market segments.

As a longer term consideration, the Adaptive Spectrum Management (ASM) based on the use of Cognitive Radio (CR) is believed by many regulators to be the solution for spectrum congestion. As part of the proposal of the present document, clause B.4 provides an outline of CR requirements, spectrum management aspects and the role of ASM for a potential sharing the PSS/PPDR spectrum. Based on these considerations, a spectrum identification for a PPDR-Cognitive Pilot Channel (CPC) is needed which is inside the tuning range of the PPDR network.

6.2 Considerations in selecting the PPDR spectrum

The current TETRA public safety networks operate in the 400 MHz band as the propagation properties are well suited to the network density and excellent coverage levels necessary for such applications while also maintaining appropriate infrastructure costs for tax-payer funded services. However the 400 MHz band has been used almost fully by the existing networks for NB user applications (mainly for mission critical voice communication).

PMR/PAMR frequencies have been available in the 870 MHz to 876 MHz / 915 MHz to 921 MHz band; however these have not been practical to use in PPDR for the following reasons:

- Interference from Cellular Systems: The existing 870 MHz to 876 MHz / 915 MHz to 921 MHz designation for PMR/PAMR was adjacent to public mobile cellular spectrum and technically it was difficult to achieve rejection of the adjacent congested spectrum.
- Different propagation characteristics at 400 MHz to 800 MHz: This causes a problem at 800 MHz in that the infrastructure density would need to be higher than for 400 MHz making a data services overlay network more expensive and difficult to plan based on existing cell sites. This problem is more related to rural and suburban areas where the network is range limited. On the other hand in urban and dense urban areas where the network is capacity limited this issue is not significant. This is a good reason to request as low a frequency as possible out of the 300 MHz to 790 MHz frequency range, but does not preclude the use of higher frequencies if that would be considered by the frequency authorities the only spectrum available.
- The bands are already licensed/used in some European countries for other wideband PMR/PAMR (see ECC Decision (04)06) or for military radio applications.

The above issues present important barriers to PPDR operation of integrated TETRA voice / data services in different frequency bands.

6.3 Use of Public Networks to fulfil PSS requirements

NOTE: The present clause 6.3 has been introduced on request from ECC Working Group FM on *"the use of public networks to fulfil the PSS requirements should be considered"* in relation to providing justification to the PSS spectrum request covered by the present document.

6.3.1 What can Public Network offer to PS organizations

In recent years the Public Safety Agencies have been involved in pilot schemes and implementation of data services via public mobile networks. However these applications have been in "routine" operations primarily to increase the efficiency of the personnel by eliminating repeated travel from the field to the headquarters. For example the UK Police have improved their performance considerably using PDAs and smart-phones such as "Blackberry" for access to:

- Police National Computer (PNC)
- National Voter's Register
- Vehicle Licence Agencies

This has helped the officers to obtain vital data and photographic records on e.g. missing persons, crime alerts, web view of duty schedules etc. British Transport Police have been also able to locally print out forms and penalty notices using such devices.

6.3.2 Service Shortcomings of Public Networks as a total solution

Apart from the above being limited to routine operations, mainly in urban environments, the permitted level of "security" over-the-air to blackberry or smart phone devices has been limited to the "restricted" level. Hence the mandatory services and facilities required by public safety organizations can only partially be provided on networks designed for commercial use since these organizations cannot base all their mission critical communication on commercial networks.

In many commercial networks data is sent at lower priority than voice traffic, where a common infrastructure is used for voice and data (as in public cellular networks). This could be a significant problem for the public safety users who often find themselves in areas where voice services are being used intensively (i.e. at an "incident") - thus data services could be degraded when most needed.

Even if a commercial network was designed to meet the needs (see clause 6.3.3) - operational, resilience, QoS, etc. of PPDR users - many governments would still need to ensure that ownership of the operator would be under control (selling the shares to unwanted parties is not considered acceptable in many countries). Alternatively they may require continued guaranteed financial viability of the operator; options to take management control of the operator when needed. All existing specialized operators of that type (UK, Portugal, Austria, and Denmark) have this type of legal constraints. These constraints would not be possible to impose on a traditional telecom operator, who, in theory, can be sold to investors who have no interest in the requirements of public safety. Many Governments feel they need to retain control over the spectrum to achieve that level of control.

Excessive reliance on commercial services has also security implications (i.e. risk of eavesdropping, impersonation, and lack of resilience in the event of disasters or attacks on base sites, etc.).

6.3.3 Public Safety specific Requirements

The most important factor is to understand and differentiate the needs of public safety networks from public mobile networks [i.21]. The relevant items include:

- Control over security implementation and other operational aspects of the network.
- Redundancy of components on cell sites (e.g. transceivers, site controllers, antennas etc.), redundancy of UPS power supply capability, including battery and generator powered supplies, and a high degree of network resilience based on overlapping coverage from multiple cell sites in the same area.
- Fallback strategies to allow stand alone operation of sites disconnected from the rest of the network. In addition, most PSS networks have a number of fully transportable base stations that can be set up quickly in required locations to provide communication in case of a BS site loss or for additional coverage.
- To balance the economic impact of meeting the high level of RF Coverage, System Availability/Reliability and GoS, the PSS community requires the provision of Direct Mode Operation (DMO) in all radio terminals. The use of DMO plus the associated repeaters and gateways provides RF coverage in difficult areas, communications in areas where base station RF coverage has been lost and additional capacity at major incidents.
- Use of multiple transmission links to sites using various topologies including redundant stars and rings.
- Operational requirements lead to a different distribution of switching centers together with a redundancy provision in the case of the PSS/PPDR networks compared to public mobile networks.
- Various other special functional requirements, specific to PPDR users. For example use of comprehensive group calls with dynamic group number assignment and use of many simultaneous group calls with each reaching group members in any cell within the network.
- A need for a fast communication set-up in combination with a much higher call set-up success rate, typically 99 % or even higher for PPDR compared to what is offered by public networks.
- A comprehensive suite of security functions and level of encryption algorithms far superior to any offered in public cellular networks including immunity against jamming.
- Use of dispatchers and centralized or distributed network management centers with access rights for network capacity control.

PPDR networks, in contrast to public mobile networks, constitute a private network that should provide command and control of safe data transfer and thus require highly reliable radio communications. It is not sufficient for a PPDR network to describe the call success by Monte Carlo models or other statistical simulations as in public mobile radio systems. Safety-relevant data transmissions require immediate real time access and cannot be transferred some time later as soon as the interference may have disappeared.

In spite of public mobile networks being a unique world-wide success story, it should be stated that public mobile radio networks basically cannot guarantee 99 % call success. The International Standardisation bodies are very conscious of this fact and define the system availability within the traffic area by statistical Monte Carlo-simulations based on a call success probability of e.g. 95 %. This definition is sufficient for public mobile radio systems because standardisation and operators are not in a position to guarantee a 99 % call success. However, based on permanent user movement and permanently changing traffic situations, the residual 5 % of users are a short time later in a position to launch their calls. In this way operators can basically offer the wanted service to 100 % of the customers.

It is a fact that for PPDR systems, statistical probabilities for call success are totally unsuited since each break by interference constitutes an inadmissible interruption of radio links. It should be stated that the operational conditions of PPDR networks and the efforts of their network planners, are very different from public mobile networks since the reliability of PPDR networks is important for the safety of the PPDR users. Furthermore, the transferred information and the technical investments of Administrations also vary significantly from that of typical public systems.

The security aspects for these PPDR systems are multi-facetted as they form part of the essential communication structures for government agencies:

- The operators security processes and procedures need to be such that they can be approved by the national security audit organisation; i.e. all staff needs to be security cleared.
- The operators financial viability needs to be proven regularly potentially leading to governments taking control of the operator.
- All physical locations are typically declared confidential and the base stations not listed in the national database of transmitter sites.

In conclusion, it is not the functions and facilities as such that is the primary challenge for public safety HSD, but the way they are made available from a commercial operator. Commercial operators make their service available driven by their business cases, whereas PPDR organisations have needs for service at places where there typically are no business case to support deployment. One could argue that the PPDR organisations could buy that extra service (coverage, availability, resilience, uptime etc,) from an operator. That however, leads to a problem with choosing the "right" operator and placing a contract without being challenged to spend government funding to distort the normal competitive situation. Even if a way could be found to use a commercial operator - that one operator would be the de-facto sole supplier to PPDR for 10+ years and that situation would have an impact on the operator ability to be remain agile and competitive in its normal market space. Commercial operators who have looked at today's PPDR requirements have been reluctant to commit to the legal conditions imposed by the PPDR organisations.

It is for the above reasons that PPDR networks in Europe rely dominantly on the TETRA technology today, and are operated independently from public mobile networks.

6.3.4 Example of PPDR network Design Goals

The typical design goals for a PPDR network, based on information provided by ASTRID (National PSS network in Belgium) and the National Policing Improvement Agency (NPIA) in the UK, are consolidated as follows.

RF Coverage:

- Population: 99 %
- Land Mass Area: 95 %
- Handportable: Urban Areas
- Mobile: Urban and Rural Areas
- In Building: Specified Establishments
- Underground: Selected tunnels and underground areas

- Cross Border: 25 km minimum beyond national border
- Special: Air-Ground-Air communications

System Availability and Reliability:

- Base Station Sites:
    - Main/Standby Base Stations and Controllers
    - Standby Power Supplies
    - Automatic Trunked Operation if bearer circuit fails
- Bearer Circuits:
    - Route diversity to/from major base station sites and control/switching centres
- Control/Switching Centres:
    - Fully redundant control and switching centre equipment
    - Separate physical locations for main and standby control and switching centre equipment and databases

Grade of Service (GOS):

Besides provisioning base station sites with sufficient channel capacity during the busy hour (Erlang C traffic theory) to support the anticipated traffic and radio users the network also needs to provided a number of Services and Facilities to optimise the GoS, such as the following examples:

- FIFO/Priority Level Call Queuing with Automatic Call Back when System Busy.
- Preferred Site Operation.
- Different User Priority Levels including multi-level precedence and pre-emption. This also includes voice call priorities without using too long waiting queues leading to pre-emption of other existing call requests.
- Dynamic Call Duration Timers.
- Recent User Priority (entries on SIM-cards would need changes via air interface).
- Dynamic Group Call Membership (entries on SIM- cards would need changes via air interface).
- Handover for all situations (not possible for listeners when using a downlink channel only in a public network for attending a group call).
- Dynamic call group sizes.
- Authentication during registration (not during call setup) for listeners-only.

6.3.5 System Cost

Some of PPDR data applications may not require a high quality of service. In these cases using commercial infrastructure is an option. For those applications, the issues to consider are mainly the costs of using commercial infrastructure for the intermittently heavy data traffic envisaged.

For other, mission- critical applications, the design goals described in clause 6.3.4 apply.

Considering these and related issues is thus the overall cost of a service to achieve a given level of functionality, which is deemed necessary for an individual State's public safety applications, which should be evaluated. Cost should be considered closely for, as previously noted, these are tax payer funded services even if the networks are managed by commercial organisations.

As explained it is not necessarily the case that using a commercial system is the best option if that system cannot provide the complete and integrated solution.

Using a public mobile network for PPDR purposes would require many changes in the public network. So far, such technical changes have only been demonstrated in limited local projects but no country-wide implementation has occurred. This places a public safety organisation considering the usage of mobile networks always in a difficult situation since it has to deal with subjects such as:

- What are the real investment costs for additional infrastructure and specific terminal equipment (new terminal equipment to be developed)?
- What will be the additional operating costs over the lifetime of the network?
- Lack of any references or proven network operations in other countries.
- Availability and reliability of the network for PSS use can hardly be determined due to public usage.
- There is likely to be only one provider for the technical solution (no multiple vendorship/operatorship).
- The operator will always put all assumed connections costs for PSS usage in upfront subscription fee per PSS device.
- Specific security for the network and its operations incur additional cost to the operator.

6.4 Views from European PSS User Groups

In December 2008 the new radio expert-group Police Communications Group (PCWG) of the EU Police Co-operation Council issued an Interim Report [i.28] containing:

- Lack of a sufficient level of interoperability between different law enforcement authorities.
- Growing operational needs for data exchange between the authorities on the ground and their representatives in control rooms.
- Need for development of a single standard for high-speed data transmission.
- Need for a dedicated, harmonised and interoperable means of radio-communication to answer the mission critical and security requirements.
- A proposal to be prepared for a Council Recommendation to task the European bodies responsible for managing frequencies with allocating additional frequencies to the security and emergency services.

Meanwhile there is an official Council recommendation [i.33] and also the expert group has made progress [i.43]. The Swedish presidency has sent a letter December 2009 to CEPT-ERO with the request to find a harmonised frequency band for mobile data applications [i.41] and a letter to ETSI to ask for a mobile data technology solution [i.42].

PSCE (Public Safety Communications Europe) Forum has been established in recent years with the support of European Commission to facilitate consensus building in the area of PS communication and information management systems. The following are extracts from a presentation by this Forum to the EU Radio Spectrum Policy Group in November 2008 [i.29].

- Need for a public safety and security sector for national and regional radio-communications interoperability and harmonised spectrum.
- Need for dedicated networks on dedicated spectrum for mission critical operations.

Public networks do not meet PS user requirements such as coverage, availability, security, resilience and interoperability.

Operational needs for broadband applications (including video and web-based) are a reality today (not a future speculation). These needs cannot be met by current PMR technologies, hence, there is a growing need for developing a dedicated broadband inter-operable network for PS and mission critical services.

7 Current Regulations

ECC Decision (08)05 [i.2] addresses the harmonisation of bands within the frequency range 380 MHz to 470 MHz for the implementation of digital Public Protection and Disaster Relief (PPDR) narrow band and wide band radio applications in the mobile service (land mobile service).

Report ITU-R M.2033 [i.5] was developed in preparation for WRC-03 and defines the Public Protection and Disaster Relief (PPDR) objectives and requirements for the implementation of future advanced solutions.

ITU Resolution 646 (WRC-03, Geneva) [i.24] strongly recommends to use regionally harmonised bands for PPDR radio applications to the maximum extent possible.

ITU Resolution 647 (WRC-07, Geneva) [i.25] encourages administrations to consider global and/or regional frequency bands/ranges for emergency and disaster relief when undertaking their national planning and to communicate this information to the Radiocommunication Bureau of the ITU. A database system has been established and is maintained by the Radiocommunication Bureau.

In addition, the ECC Report 102 [i.4] identified Broadband Disaster Relief applications that are non-permanent, local hot-spot type services operating in limited time periods. BBDR applications have been described in TR 102 485 [i.9].

ECC Recommendation on Broadband Disaster Relief (ECC REC (08)04) was also developed in ECC in early 2008 [i.3] to cover local and temporary BBDR applications for so-called PP2 and DR applications as defined in Report ITU-R M.2033 [i.5].

The spectrum usage for these BBDR applications is going to be around 5 GHz [i.7], [i.9]. It is complementary to the proposal covered in the present document.

8 Foreseen limits in the Harmonised Standard

It is envisaged that the applicable Harmonised Standard will be EN 302 561 [i.1]. However this document may not be applicable to the TETRA broadband evolution yet to be defined, for which an additional HEN may be required.

9 Expected ETSI Actions

The following actions are expected from ETSI bodies:

- Creation of a new Harmonized Standard and further enhancement of TETRA standards.
- Cognitive Radio aspects as depicted in clause B.4 will be further studied. In ETSI, TC TETRA and ETSI TC RRS (Re-configurable Radio Systems) will collaborate in this work. Work will be based on the following objectives:
  - Only if the PPDR is the "primary" user of the spectrum of which a portion is shared with other networks.
  - It is under a strict pre-emptive arrangement that guarantees the recovery of that part of spectrum for mission critical applications.
  - The need for a fully field-tested RRS system before willingness to embark on sharing the spectrum (or network).

This requires a great deal of work, among others, in the areas of:

- Interoperability at MS and BS levels with standardization of the necessary SW architecture applicable to Public Safety environment, which do not require unreasonable cost level at implementation stage.
- Standardization of a fully reliable and secure cognitive pilot channel, perhaps in-band for "network sharing" and out-of-band for "spectrum sharing".

- Development and standardization of ASM procedures that allow PPDR networks to enjoy strict preemption (of the portion of the spectrum let to commercial and other entities) without fear of interference from these sharers.
- Full security of the whole system from rogue users and hackers.
- Backward compatibility to TETRA (the most widely used PPDR capable standard) and others.
- The first work item should focus on a top-level definition of the architecture of a RRS system for a PPDR network that meets the objectives set in this liaison statement.
- The next stage should deal with breaking down the top-level block diagram into several work items dealing with different aspects of the RRS system. These aspects include areas such as; software architecture, cognitive pilot channel, SDR aspects of the MS and BS, security aspects, ASM procedures, each requiring a separate WI and funding approach.

It is necessary that the above actions on re-configurable / cognitive radio will also be considered by ECC and its responsible working group WGSE/ WGSE project team SE43.

As part of the mandate of ETSI TC-TETRA to continuously enhance the TETRA standard, further enhancements to TETRA are expected enabling this technology to provide broadband as well as wide-band and narrow-band applications within a single technical solution.

The Swedish Presidency of the EU informed the ETSI that the Council in June 2009 approved Council Recommendations on improving radio communication between operational units in border areas and invites to start producing a European standard satisfying law-enforcement and public-safety services' operational requirements regarding high-speed data communication and roaming functionality in the medium term (see annex E).

10 Requested ECC Actions

The ECC is requested to consider harmonized availability and use of the radio spectrum for PSS (PPDR) as detailed in the present document. This may include necessary spectrum engineering and spectrum management work.

A first action taken was to send out a questionnaire on the radio spectrum demand for PSS by the ECO, which had been developed by WGFM.

Based on the responses received, WGFM (FM PT 38) identified some main conclusions based on these responses to the questionnaire and on the discussions the project team had during the evaluation of these responses:

- **The use of existing and new data applications (high speed data) by PPDR users will increase rapidly.**
- **Increased data usage, especially for mission critical communications, will have a significant effect on the frequency need and justifies requirements for additional spectrum.**
- **There are many requirements and conditions for the use of PPDR, which lead to the need to use dedicated PPDR networks. However, in addition to the dedicated networks, commercial / public networks are and will also be used for non-mission critical data applications.**

In order to progress with the PPDR issues an ECC WGFM workshop was organised on PPDR on 11th -12th March 2010 in Mainz (Germany). It has to be assumed that follow-up activities within ECC will consequently be triggered by this workshop and appropriate action points for the relevant entities of the ECC will be identified. It is assumed by ECC that ETSI will take into account the information provided during the workshop and also the resulting follow-up activities as far as possible when producing the final version of the present document. WG FM also agreed that the frequency bands to be discussed will be kept open for the time being.

The subject was also on the agenda of the WG FM civil/military meeting on 30th - 31st March 2010.

It is recommended that an appropriate decision will be made by ECC by end 2011 to allow manufacturers sufficient time to have equipment in the market before end of 2013.

WG FM met after the workshop and after the civ/mil meeting in May 2010. The action points being developed by FM PT 38 were discussed. The ECC plenary could then decide in the future on a work item in WGFM for a new ECC Decision, at the time when the frequency issues will have been solved.

- **Consequently and based on the decisions during the WGFM meeting in October 2009, there is a need to study the possibilities for a wider implementation and a promotion of ECC/DEC/(08)05 [**i.2**] on PPDR in order to improve the availability of frequencies for narrowband and wideband PPDR in the tuning range 380 MHz to 470 MHz.**
- **There is a need that WGFM / FM PT 38 will continue their work on the future broadband PPDR frequency issues after the analysis of the PPDR workshop results.**
- **It may be necessary to inform WGSE about the present document and to request to commence studying cognitive radio aspects also for broadband PPDR. However, this request should not prejudice any decision on other possible candidate bands.**

Finally, there is a need to identify the spectrum for one or more PPDR Cognitive Radio Channel(s) to enable in a longer term consideration that Adaptive Spectrum Management (ASM) based on the use of Cognitive Radio (CR) is available as a solution for PPDR and for the foreseen spectrum congestion in the UHF band (for more information, see annex B). The proposal is intended to be further developed in ETSI, also by means of an ETSI Special Task Force and in collaboration of two ETSI Technical Committees RRS and TETRA. The provided information on ASM in the present document can therefore only be illustrative.

It should be noted that the proposal expressed in the present document is supported by the *Public Safety frequency statement from 18 countries that was provided t*o the WG FM Workshop on Spectrum Harmonisation for Public Protection and Disaster Relief (PPDR) 11-12 March 2010 - Mainz (Germany) (see annex D).

With regard to the broadband component of the future demand, there are 2 aspects that need further investigation in the ECC:

- The symmetry / asymmetry of the spectrum demand for the broadband component also needs further investigations (see also clause A.5).
- The mixture between local, temporary demand on one side as well as the need for PPDR spectrum for more permanent or requiring larger coverage for broadband PPDR (see clauses A.4 and A.5).

With regard to the wideband demand, an investigation for solutions that foster a better implementation of the available decision ECC Decision (08)05 [i.2] is also requested.

11 Requested EC Actions

The recently approved (Justice and Home Affairs) Council Recommendation (10141/09) [i.33] on improving radio communication between operational units in border areas concludes that law enforcement and public safety radio communication systems will need to support and to be able to exchange high speed mobile data information beyond the capabilities of current networks, and a common standard operating in a harmonised frequency band will make this possible. Consequently the Recommendation suggests that the ECC should be tasked to study the possibility of obtaining sufficient additional frequency allocation below 1 GHz for the development of future law enforcement and public safety networks. An official letter has been send to CEPT-ERO by the Swedish presidency in December 2009 [i.41].

The ongoing dialogue on Digital Dividend is an ideal opportunity to further consider and evaluate the needs of mission critical users and consequently take the required actions to a political level to move the issue forward towards practical decisions at administrations level.

It is suggested that the European Commission should keep the needs of the public safety/public protection and disaster relief communities on the agenda when proceeding with the Digital Dividend and further initiates measures to have a harmonised spectrum identified for future PPDR services within the range 300 MHz to 1 GHz.

It is further proposed that the Commission should encourage the Member States to recognise that the spectrum requirements for public safety/public protection and disaster relief constitutes a special case and adopt policies and processes that will enable public safety/public protection and disaster relief agencies to have access to new spectrum at a cost that is within the limits of their budgetary resources as these are continually under pressure because of ever rising demands for service and the need to implement enhanced technological systems to provide effective response services in the future.

Pursuant to Article 4(2) of the Radio Spectrum Decision (Decision No 676/2002/EC [i.52] of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community (OJ L 108, 24.4.2002, p. 1)), the European Commission may issue mandates to the CEPT (European Conference of Postal and Telecommunications Administrations) for the development of technical implementing measures (harmonisation of radio spectrum). For the development and adoption of technical implementing measures (Commission Decisions) the European Commission is assisted by the Radio Spectrum Committee (RSC), composed of representatives of the Member States. The RSC has already planned a new work item on spectrum requirements for emergency communications in its Draft Work Programme for the year 2010. This could be the basis for RSC to discuss this issue further by taking into account studies on PPDR spectrum requirements undertaken by Member States.

In addition, future spectrum usage by PPDR in the Digital Dividend spectrum may require cognitive radio techniques. It is assumed that the development of these techniques can be performed under the existing mandate of ETSI TC TETRA on further enhancements on TETRA in collaboration with ETSI TC RRS.

The EC has already expressed this need for standardization by writing to ETSI (see annex E), inviting ETSI to liaise intensively with regulatory bodies and their experts and take into account the work to be performed by the CEPT ECC.

The Swedish Presidency of the EU informed the ETSI that the Council in June 2009 approved Council Recommendations on improving radio communication between operational units in border areas and invites to start producing a European standard satisfying law-enforcement and public-safety services' operational requirements regarding high-speed data communication and roaming functionality in the medium term.

Annex A: Detailed market information

A.1 Range of applications

At present, the operational PSS networks are only capable of supporting voice and NB data services. Hence the following important services that are of WB and BB nature cannot be supported by these networks [i.18].

- video conferencing;
- video streaming (CCTV on scene);
- full Satellite Navigation (AVLS works well on narrowband but not as comprehensive);
- passport and bio-metric checks (secure information) undertaken remotely as this requires data rates just above those available on narrowband;
- fire services on-line access to Gazetteer (provides information on what might be kept at premises that could be a problem e.g. propane gas bottles as well as other data that might be required) requires around 100 kbit/s;
- improved on-line access to contacts data base that can be shared to know all those organisations / people that should be contacted depending on, for example, the incident;
- full e-mail;
- intranet browsing;
- improved transfer of files (maps and pictures);
- improved transfer of medical information;
- ability to move the back office into the field; and
- increased over the air key programming downloads of new software updates. Allows the staff to be kept operational which could be a significant cost and operational benefit.

In recent years PSS organisations in the UK, France, Netherlands and others have been conducting trials on PSS high-speed data. There is clearly a need amongst these organisations to have in 2 to 3 years a nationwide network to allow the services listed above and to support mission critical applications such as:

- Sending detailed photographic images of children lost, people wanted to speak to officers in the field so they can act on the requests immediately. Currently with narrowband can only send small pictures and they are often not enough for identification.
- Relaying ad-hoc video camera and surveillance camera real time information to patrol cars responding to incidents so they are fully prepared when they arrive at the scene.
- Sending detailed maps and plans that can be used at an incident, e.g. a fire.
- Sending biometric data such as finger prints from an incident so it can be acted on at that time, rather than having to return to the office.

The ETSI Special Committee EMTEL and project MESA have identified user requirements for future broadband mission critical PP1, PP2 and DR applications [i.37]. The EMTEL document TS 102 181 [i.19] on requirements for communication between authorities and organisations during emergencies lists the following situations for effective communication:

- mobilization of the teams and people;
- updates on the emergency - situational reports;

- updates on requirements to other organisations so they can prepare e.g. informing hospitals on likely number of;
- casualties and individual patients and their needs;
- sending of command and control information to the incident area;
- requesting of information from the incident area e.g. building plans, chemical information; and
- sending of still and video images from the incident area.

The services required to support the above include:

- voice services (one to one and group calling);
- high level security encryption with multiple keys and Over The Air Re-keying (OTAR);
- video teleconferencing to assist in coordination between the services and also to provide information from the incident area back to the control rooms;
- data services (see table A.1 for the attributes of these services); and
- status monitoring and location services, including, for example, measuring exposure to environmental conditions, reporting PSS responders' vital signs and determining their physical proximity, all in real time.

Table A.1: Data services attributes from TS 102 181 [i.19]

Service	Throughput	Timeliness	Robustness
E-mail	Medium	Low	Low
Imaging	High	Low	Variable
Digital mapping / Geographical information services	High	Variable	Variable
Location services	Low	High	High
Video (real time)	High	High	Low
Video (slow scan)	Medium	Low	Low
Data base access (remote)	Variable	Variable	High
Data base replication	High	Low	High
Personnel monitoring	Low	High	High

A.2 Expected market size and value

The most appropriate methodology to determine market size and value is to use indicators based on factual information and data provided under the following sections:

1) Existing and planned deployment of Narrowband PSS networks in Europe
2) Planned Deployment of Wideband PSS networks in Europe
3) Number of Independent Manufacturers of Infrastructure and Terminals
4) Application Providers
5) Number of PSS Contracts for Narrowband and Wideband PSS Products let in Europe
6) Expected use of the range of applications described in clause A.1
7) Attractiveness of the PSS Market
8) Export Potential outside Europe

1) Existing and planned deployment of Narrowband PSS networks in Europe

Figure A.1 shows the existing and planned deployment of TETRA and Tetrapol narrowband PSS networks in Europe.

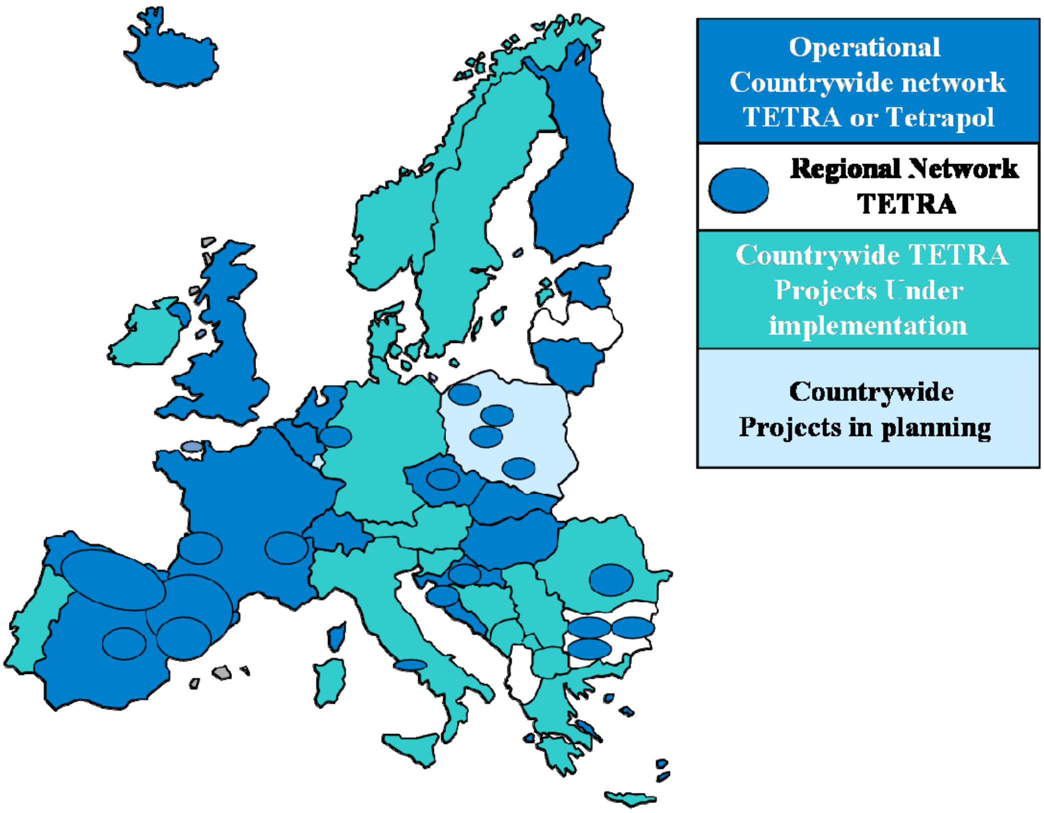


Figure A.1: Planned deployment of TETRA and Tetrapol narrowband PSS networks in Europe

The vast majority of Europe, with the exception of Poland who are in the planning stages for a countrywide network, have already deployed, or in the stages of deploying, narrowband TETRA or Tetrapol networks.

2) Planned Deployment of Wideband PSS networks in Europe

Because of limited spectrum availability and/or upgrade difficulties with existing networks, TEDS wideband data is currently planned for Norway only.

3) Number of Independent Manufacturers of Infrastructure and Terminals

A positive indicator to the size and attractiveness of the PSS TETRA market is the number of independent TETRA manufacturers of narrowband infrastructure and terminals, of which some are listed in table A.2.

Table A.2: Manufacturers of Infrastructure and Terminals

Manufacturer	Infrastructure	Terminals
Cleartone		√
Damm	√	
EADS	√	√
ETELM	√	
Frequentis	√	
HYT		√
Motorola	√	√
PMRS		√
R&S Bick Mobilfunk	√	
Rohill	√	
Selex	√	√
Sepura		√
Teltronic	√	√
Thales	√	√
Tyco Electronics	√	
Unimo Technology		√
Team Simoco	√	
Artevea	√	

In total there are thirteen (13) manufacturers of infrastructure and ten (10) manufacturers of terminals. As the chosen broadband technology solution is not yet known, it is likely that the manufacturing and supplier base addressing the market will change. Even so, the market size for broadband solutions will be significantly large enough to attract several independent manufacturers thus maintaining the important PSS user benefits of competition and second source security.

4) Application Providers

The architecture of a TETRA network, combined with its core narrowband voice and data services, has attracted a large number of independent Application Providers to provide additional voice and data applications. A list of Application Providers that are currently members of the TETRA Association, are provided below.

- Aerial facilities Ltd
- APD communications Ltd
- Beaconsim Oy
- Cybertech International
- Etherstack Ltd
- Hormann Funkwerk Kolleda GmbH
- Instasec Oy
- Mentura Group Oy
- Net Technologies Ltd
- Portalify Ltd
- Radio IP Software Inc
- Rheinmetall Defence Electronics GmbH
- Roscom Ltd
- Swissphone Telecom AG
- T-Systems Enterprise Services GmbH
- T.E.S.S. FZCO

- Team Simoco Ltd
- Telvent
- TetraNed vof
- Tetraprom LLC
- Zenitel NV
- Zetron Inc

In total there are twenty two (22) independent Application Providers. As the chosen broadband technology solution is not yet known, it is likely that the Application Provider base addressing the market will change. Even so, the market size for broadband applications will be significantly large to attract several independent Application Providers thus maintaining the important PSS user benefits of competition and second source security.

5) Number of PSS TETRA Contracts for Narrowband and Wideband PSS Products

In May 2008 there were a total of 1 964 reported TETRA contracts across the world spanning 97 countries. The PSS sector in Europe represents the largest market for TETRA, representing 51 % of all European Contracts. Although 51 % is a high percentage the value related to these contracts is far higher simply because PSS infrastructures are mainly nationwide and the number of PSS terminals in operation far exceeds the number of terminals used in other PMR markets. For example, it can be reasonably assumed that the value of the PSS market is between 75 % and 85 % of the total market value.

NOTE 1: Because the TETRA market is highly competitive, suppliers of infrastructure and terminals do not disclose the actual value of contracts won and as a consequence it is difficult to put an exact value on the market in monetary terms.

6) Expected use of the range of applications described in clause A.1

From a recent survey conducted by Motorola and APCO (The Association of Public-Safety Communications Officials) of more than 200 public safety administrators and officers in the top 100 U.S. markets made several significant findings about current and future use of communications technology. According to the survey results:

- 72 % report using systems that enable cross-departmental communications;
- 72 % report using computer mapping technology to enhance response time;
- 68 % report using personal digital assistants to perform "back office" work in the field;
- 44 % report using traffic light sensors for approaching emergency vehicles; and
- 42 % report using mobile video systems and video surveillance devices in public places.

On the "wish lists" for future applications:

- 47 % of PSS officials believe tracking solutions such as satellite tracking of vehicles are necessary;
- 37 % of PSS officials want "recognition/identification" technologies including facial recognition;
- 41 % of PSS officials want automatic license plate recognition;
- 26 % of PSS officials want rugged notebooks;
- 30 % of PSS officials mobile video systems;
- 31 % of PSS officials want traffic light sensors;
- 35 % of fire departments would like more mapping technologies;
- 63 % of police officials want mobile video systems; and

- 51 % of police officials and 20 % of fire departments want improvements in interoperability of communications.

Taking all these requirements into consideration it can be reasonably assumed that around 50 % of all PSS mobile terminal users will require a broadband capable terminal.

NOTE 2: Although this survey was carried out in the USA, these requirements are considered sufficiently representative of the PSS user requirements in Europe.

7) Attractiveness of the PSS Market

Another positive indicator of the size and value of the PSS market in Europe is the offer by a number of commercial GSM/GPRS/EDGE operators to provide total nationwide solutions for PSS organisations. Similarly, the manufacturers of GSM-R solutions for the railroad market are promoting GSM-R as a technology suitable for "blue light" applications. Although these offers have had no significant success they are both clear indicators of the attractiveness of the PSS market as well as the difficulty in adapting commercial technologies to match the exacting needs of the PSS community.

8) Export Potential outside Europe

Currently PSS TETRA contracts in Europe represent approximately 69 % of the total PSS market, which means that approximately 31 % of PSS TETRA contracts are outside Europe. Although Europe is still experiencing some market growth, the Asia-Pacific region has had a growth of 98 % compared with the previous year and is now the second largest market representing approximately 30 % of the total market in terms of contracts of which 41 % are PSS contracts. It is therefore logical that the broadband technology solution chosen in Europe should experience the same growth potential as TETRA outside Europe, assuming sufficient frequency spectrum is available.

Summary

From the above data it is reasonable to assume that the expected value of the PSS market in Europe for broadband infrastructure, terminals and applications is very large, albeit not as large as the commercial operator market using GSM, GPRS, EDGE, UMTS/3G technologies. However, this market will be significantly reduced and fragmented if the harmonised spectrum as requested in this SRDoc is not made available for the PSS community.

NOTE 3 (IMPORTANT):

The expected market size and value information provided in the annex only considers the PSS market. For reasons of efficiency it is assumed that any PSS spectrum allocated will likely be on a protected basis using pre-emptive cognitive radio technology to allow non-PSS users to utilise the same spectrum when it is not being used for mission critical PSS communications. Because PSS traffic patterns and geographic usage varies greatly the amount of spectrum available to non-PSS users will be significant and as such the market size and value for technologies serving these non-PSS users will also be significant.

A.3 Deployment

The deployment of PSS broadband networks is expected to follow the same deployment as experienced by the uptake of narrowband TETRA and Tetrapol in Europe as shown in figure A.1. The timescale for deployment of first generation broadband technology solutions is dependent on two main factors these being spectrum availability and the broadband technology choice made by the PSS user community.

Once spectrum is made available and the technology choice has been made, first generation broadband networks and terminals should be available between 18 and 24 months later for early adopters. Assuming a decision on spectrum is made by 2010, closely followed by a technology choice decision by the PSS community, first generation broadband networks and terminals could be deployed as early as 2012, which roughly follows what is indicated in the White Paper titled: "Safety First: Reinvesting the Digital Dividend in Safeguarding Citizens" [i.18].

A.4 High Speed Data requirements

The TETRA Future Vision Workshop staged on 25th February 2009 in Brussels dealt with the objective of understanding future high speed data requirements in a better way.

The workshop objectives were outlined as follows:

- To demonstrate that the Manufacturing Industry is united in its vision to evolve TETRA towards a fully integrated and seamless ICT solution providing NB/WB/BB wireless communications.
- To reassure members of the TETRA Association and the industry in general about the planned evolution of TETRA towards BB.
- To agree a list of applications and their data rate/bandwidth/QoS requirements so that they can be used within TC TETRA to help select the optimum technology solution to support BB data.
- To confirm user requirements for BB data so that they can also be used within TC TETRA to help select the optimum technology solution to support BB data.
- To identify other areas that need to be considered in the selection and standardisation of a BB solution.

The fundamental high speed data requirements of the workshop were summarized as follows:

- Same RF coverage as voice (no need for additional base station sites).
- Instant access at all times (Perfect Grade of Service).
- Never goes wrong (100 % Reliability).
- Able to support all non-voice applications (real time and other).
- Air-Ground-Air (500 kph).
- Local Communications Independent of Network Infrastructure.

Even though these requirements can be provided trade-offs in the interest of economics could be made, such as:

- Use of ad-hoc HSD "Hot Spot" networks.
- RF coverage only in high density urban areas.
- Rapidly deployable HSD base stations.
- Commercial/Public Networks in rural areas (loss of "mission critical" communications accepted in major incidents).

A.5 Results from recent National studies

The German Ministry of the Interior commissioned a study that was presented during the ECC WGFM PPDR workshop on 11th to 12th March 2010. The conclusions of the study can be summarized as follows:

- Exclusive frequency usage by PPDR is seen as the preferred solution in the future.
- There is a need to study the symmetry (or asymmetry) of the demand. The results in Germany showed an asymmetric distribution (40 MHz in the uplink and 20 MHz in the downlink). These numbers are for the year 2025.
- Within the first 30 minutes of a disaster, mission critical communication means are needed to be available. A minimum communications capacity needs to be available on a permanent basis; Dutch studies also showed that public networks cannot provide this needed "immediate" capacity. A full short-term, temporary assignment of capacity is not considered to be realistic.

- More than 60 % of the mission scenarios (use cases) are considered as "mission critical" and more than 90 % of all scenarios require high usage requirements (extreme high availability and low latency).
- It is expected that more than 65 % of the future scenarios need a bandwidth of greater than 1 Mbps, more than 40 % even more than 10 Mbps in the future.
- More than 60 % of all scenarios require a coverage of larger than 10 km operating distance.
- The greatest bandwidth demand has been calculated in the categories "demonstration, special event, and natural disaster". These are temporary and mostly local events such as described under the BBDR regulations. For this case however, the probability of occurrence of the maximum bandwidth requirement is very low.
- Mission-tactical prioritisation of the bandwidth usage leads to better usage efficiency.
- The calculations included a reduction factor of 2,5 in the German studies in order to take into account technological advances.
- The recommendations include expansion of the BBDR regulation to an additional 50 MHz on top of the existing 50 MHz in 5 150 MHz to 5 250 MHz.

An interpolation of the Dutch demand presented during the workshop for the year 2025 shows an even greater demand compared with the German study.

In the US, 80 MHz in the 700 MHz frequency range ("D-block") are under discussion, although the PPDR user density in some regard is lower than in European metropolitan areas.

Annex B: Detailed technical information

B.1 Detailed technical description

At present the only European standard capable of HSD operation is TETRA 2 [i.10]. This standard includes:

- 25 kHz channels using π/4-DQPSK modulation for NB Voice plus Data (V+D) services.
- 25 kHz, 50 kHz, 100 kHz and 150 kHz channels using various QAM and phase modulation schemes to provide IP based WB (HSD) data services. The HSD capability has been provided by an in-house development of the TEDS technology.

Table B.1 gives an estimate of the maximum Internet Protocol (IP) packet data throughput for the various RF bandwidths and modulation types, where it is assumed that there are no message errors.

Table B.1: Estimated IP throughputs (kbit/s) on TETRA packet data channels

Modulation type and coding rate	RF channel bandwidth (kHz)							
	25		50		100		150	
	Uplink	Downlink	Uplink	Downlink	Uplink	Downlink	Uplink	Downlink
π/4-DQPSK, r = ⅔	15	15						
π/8-D8PSK, r = ⅔	24	24						
4-QAM, r = ½	10	10	24	26	49	55	77	86
16-QAM, r = ½	19	20	47	51	98	110	153	173
64-QAM, r = ½	29	30	71	77	146	164	230	259
64-QAM, r = ⅔	39	40	94	103	195	219	306	345
64-QAM, r = 1	58	60	141	154	293	329	459	518
NOTE: The estimated rates are given in kbit/s assuming that transmission occurs in all four TDMA slots in 17 out of 18 frames and assuming that there are no message errors.								

Note that the gross bit rates of TETRA channels are higher than the figures given in table B.1.

For details of TEDS technology refer to the TEDS Designer's Guide [i.11]. The details of the current TETRA standard which incorporates TEDS are given in EN 300 392-2 [i.10].

B.2 TETRA Evolution

B.2.1 General

As described above TETRA today supports two types of modulation, namely Phase Shift Keying (PSK) for narrowband 25 kHz channels and Multi Carrier (MC) Quadrature Amplitude Modulation (QAM) for wideband channels, scalable bandwidth between 25 kHz and 150 kHz. The PSK modulation forms the basis of the TETRA voice, data, and control services, while QAM modulation extends the bit rates for packet data services.

Both the PSK and QAM modulations use a root raised cosine pulse shaping function to provide a sharp roll off of the spectrum in the neighbouring channels while maintaining immunity to delay spread caused by multipath propagation. This adds some complexity to the implementation but is done in order to enable coexistence between TETRA and other narrow- or wide-band technologies existing in the same frequency band.

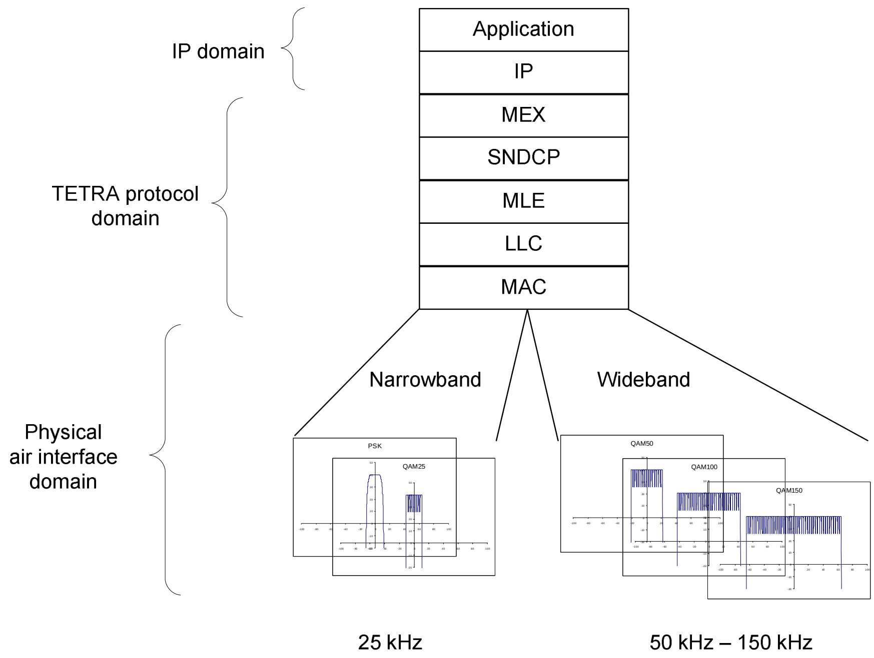


Figure B.1: Current TETRA access methods

The TETRA air interface thus allows for a wide variety of access methods, covering narrowband and wideband operation (figure B.1), all deployable in the spectrum currently designated for public safety. The TETRA standard has been designed to allow seamless selection of the best-suited technology when service is requested. That is, the different access methods appear transparent to the end user.

The TETRA air interface is, however, constantly evolving. The development of the TETRA standard in the near future will focus on:

- Optimisation of the existing narrowband air interface (voice and data), adding new services when market need arises, and improving performance and capacity of the air interface.
- Optimisation and extended scalability of the relatively new wideband air interface. The standard will be adapted and expanded as development and deployment of the wideband air interface progresses.
- Addition of a broadband air interface, which can be integrated with existing narrow and wideband services, maintaining end user transparency.

The integration between broadband and TETRA will be studied in ETSI TC TETRA, but may include migrating the TETRA air interface to an IP based protocol. This will allow the added broadcast interface to support new multimedia / IP based services, while maintaining the capability of using TETRA services. Moreover, this will enable TETRA voice calls to span multiple air interface technologies. This means that the broadband air interface should maintain the same high level of security as the current TETRA air interface.

B.2.2 Wideband Evolution

The QAM air interface can be optimised in several ways. The following enhancements have already been identified as candidates for addition to the QAM air interface part of TETRA:

- Adding control channel capability to the QAM air interface, allowing more flexible deployment of wideband services.
- Further optimisation of the channel coding and interleaving.
- MIMO and MISO.
- Frequency hopping.
- Further optimisation of the TETRA protocol (overhead, header compression, etc.).

- TETRA voice services on wideband carriers - including spectrum efficient point to multipoint calls.
- Efficient voice over IP on wideband carriers (TETRA over IP, SIP/IMS, etc.).

In addition to this, the TETRA air interface utilising the QAM modulation can be further scaled within the wideband regime if needed.

B.2.3 Broadband Evolution

The optimal outcome is a harmonized frequency band coupled with certainty about availability (time) and an indication of where (space) in the frequency band plans it will be allocated. Until those factors are going to be determined it will be unlikely that the technology choice for PSS Broadband communications will be made.

However, the majority of user requirements listed in the TETRA Release 2 HSD URS TR 102 021-2 [i.20] are still considered relevant for broadband evolution purposes and as such these user requirements will be updated as required by analysing the results of the Future TETRA Workshop held at the World Congress in Madrid in 2007 (TWC2007 Future TETRA Workshop Report TR 102 621 [i.17]), which clearly indicates that HSD capabilities similar to those offered by wideband and broadband commercial GPRS and 3G/UMTS operators and WiFi and WiMax access services are required by the PSS community. Further broadband user requirements are given in [i.18].

The technology choice for PSS broadband evolution will be based on evaluating a number of candidate technologies that best meet the user requirements balanced against any technology constraints that will be identified during the evaluation and selection process. To date, there are a number of possible wireless technologies offering broadband HSD rates, some of which are listed below:

- TEDS enhancement (broadband);
- 3GPP/HSPA/LTE;
- 3GPP2/ EV-DO (Rev 0, A, B, C (UMB));
- WiMax (IEEE 802.16e [i.53]);
- IEEE 802.16m [i.54] (enhancement to 802.16e currently in process).

As well as PSS user requirements, the evaluation of candidate technologies will also consider performance requirements such as:

- Performance at different propagation conditions and speeds.
- Spectrum efficiency.
- RF range performance.
- Encryption capability.
- Interference susceptibility.

B.3 Technical justification for spectrum

B.3.1 Current wideband justification

The technical justification for the only European wideband PMR technology is given in the TEDS SRDoc [i.12], which was used by the ECC for compatibility studies between TEDS and other technologies in the 400 MHz region of the spectrum [i.13]. Since those studies, there have been some minor updates in the wideband noise specifications of the TEDS standard which are unlikely to affect the results of those studies. The updated specifications are included in clause 6 of the TETRA 2 standard [i.10] in case new spectrum engineering work will be carried out in any new PPDR spectrum designation.

B.3.2 Proposed Broadband Spectrum Mask

As the technology selection for broadband evolution has yet to be made, the "notional" transmitter spectrum mask shown in figure B.2 is proposed here for Spectrum Engineering purposes.

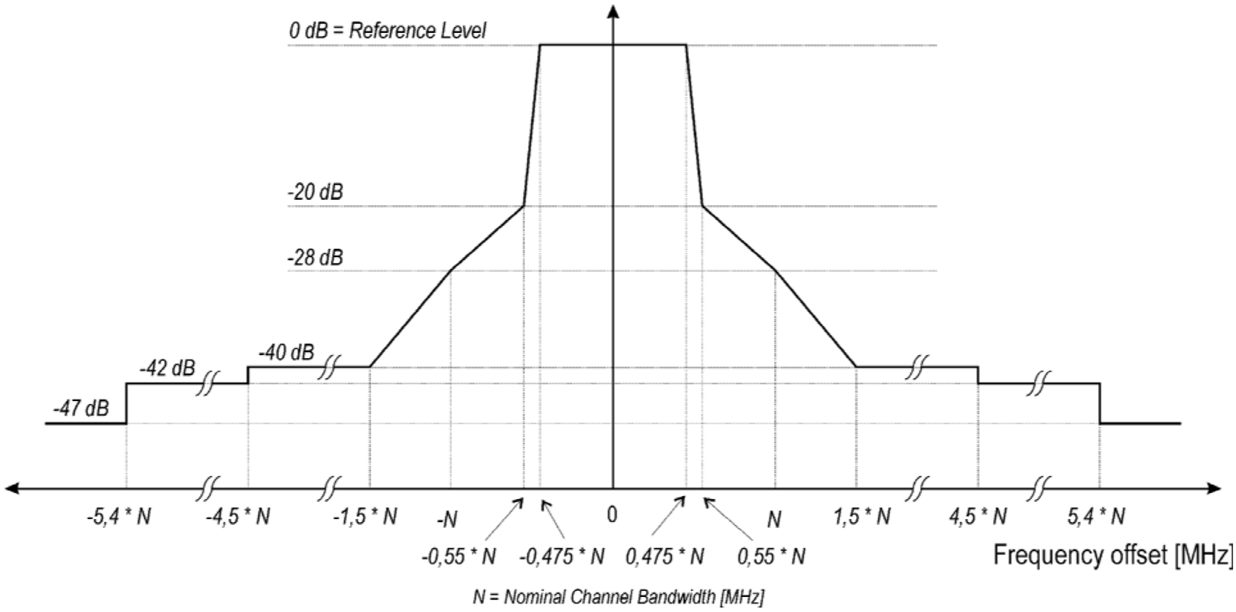


Figure B.2: Proposed spectrum mask for broadband service

This choice has been based on a number of preliminary considerations given below:

- Most BB technologies listed above, i.e. HSPA / LTE (3GPP), EV-DO Rev 0, A, B, C (UMB) (3GPP2), WiMAX and the IEEE 802.16m [i.54] are converging to OFDM carrier structure.
- TEDS carriers have multi sub-carrier structure and its evolution to wider carriers with more sub-carriers brings it more in line with the OFDM structure.
- The above mask is based on the IEEE 802.11 [i.55] standard with minor modifications to tighten the interference well away from the carrier.
- This modified mask is also proposed in the current ETSI draft Harmonised EN (HEN 302 625) for localised BB-DR service at 5 GHz [i.22].
- The mask is independent of carrier bandwidth, allowing e.g. to use more than one carrier bandwidth in the selected technology.

The Broadband Spectrum Mask is intended to accommodate known BB technologies.

B.3.3 Determination of the frequency demand, frequency reuse and fading

- The following illustrates the methodology and parameters to be taken into account for the determination of the spectrum demand.
- It is assumed that the PPDR is a cellular planar network requiring gapless coverage.

This can be seen in the equations (1) to (2):

$$\boxed{\text{ClusterSize} = \text{Frequency Reuse Factor}} \qquad (1)$$

Hence for a planar network (2):

$$\text{Required nb of channels per BS} = \frac{\text{Total nb of channels of the radio network}}{\text{Cluster Size}} \quad (2)$$

Assuming a frequency reuse factor of X, the cluster size becomes Y.

Margins are needed for high density usage scenarios, highly mobile usage (more handovers) and cross-border coordination.

The frequency reuse factor depends mainly on the percentage of receiving locations. This itself requires a specified coverage probability. This means that in each location interval with a specified diameter the measured coverage level has to be verified with a probability value of at least a determined percentage. For an example PPDR radio network planning a value of 97 % may be used.

For the evaluation of the values the ITU-Recommendation P.370-7 [i.39] is used, as shown in figure B.3.

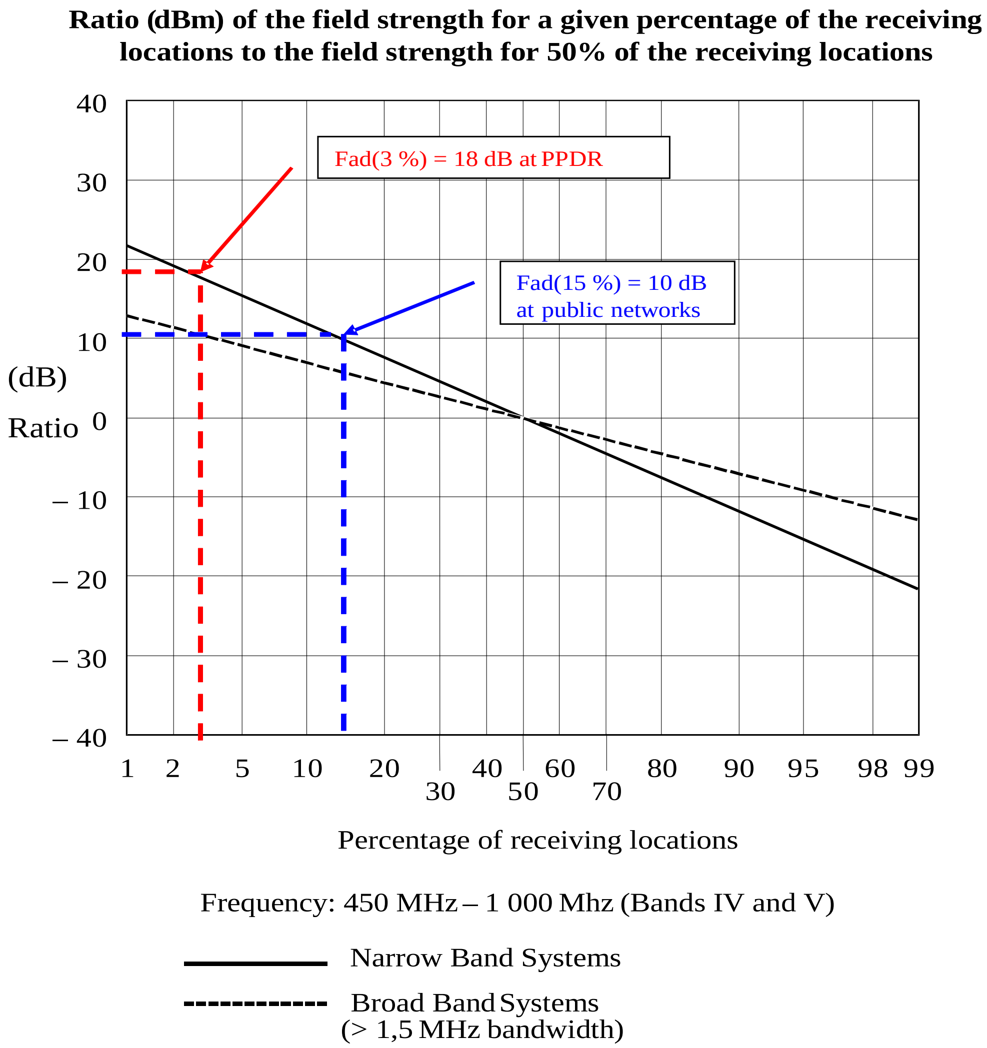


Figure B.3: Ratio (dB) of the field strength for a given percentage of the receiving locations to the field strength for 50 % of the receiving locations

A value of 97 % of probability is equal to a value of 3 % fading. The consequence of this is that an additional average margin of 18 dB is necessary. Taking into consideration this margin, the following equations are assumed:

Relation of fading, frequency reuse factor and data loss:

$$F = c - \gamma \cdot \log(d) \quad (3)$$

Calculation of the received signal strength depending on the distance and according to the attenuation per decade of the ITU diagram:

$$F_{car} - F_{Int} = c/i_{PPDR\text{-}System} + \sum Fad_{(x\%)} = \gamma \cdot \log\left(\frac{d_{Int}}{d_{car}}\right) = \gamma \cdot \log(\text{Frequency reuse factor}) \quad (4)$$

and the frequency reuse factor is given by:

$$\text{Frequency reuse factor} = 10^{\frac{c/i_{PPDR\text{-}System} + \sum Fad_{(x\%)}}{\gamma}} \quad (5)$$

$$\sum Fad_{(x\%)} = Fad_{(x\%)car} \text{ und } Fad_{(x\%)Int} = Fad_{(x\%)user/interferer} \cdot \sqrt{2} \quad (6)$$

Key to symbols used in the equations:

- F = field strength.
- F_{car} = field strength of wanted carrier.
- F_{Int} = field strength of interfering signal.
- c = constant, includes data of the BS such as transmit power and antenna characteristics.

γ = propagation coefficient (ref ITU curves for UHF, approximately 50 dB/decade of distance; up to values of 35 dB/decade of distance; the calculations below use 50 dB/decade).

d = distance.

$Fad_{(x\%)}$ = Fading (in dB); there is a relation to the probability of location and hence the data losses, expressed as a percentage.

ΣFad = Fading; single fading events of the wanted and unwanted signals.

$c/i_{PPDR\text{-}System}$ = protection criteria of NB/WB/BB = 9 dB (see example).

NOTE: The TETRA NB/WB protection criterion is normally much higher and equals 19 dB (on average).

For PPDR applications a specified coverage probability 98 %, which is equal to 5 % of fading.

According to the formulas above, a frequency reuse factor can be calculated:

EXAMPLE Case 1: C/I=9 dB; Fading 2 %, which is equal to 19 dB, γ=50 dB, the frequency reuse factor is calculated 5,24.

B.3.3.1 Determination in the case of TETRA TEDS

NOTE: This clause does not use all the assumptions as outlined in the more generic clause B.3.3.

Based on the generic case in clause B.3.3, this clause discusses the methodology to be used for TETRA TEDS reuse evaluation. The methodologies presented here use SEAMCAT and MCL to calculate probability of co-channel interference. A few results of TETRA reuse is given here for illustration and validation of the methodologies.

Figure B.4 illustrates a basic reuse pattern using 7 frequency pairs. Each of the cells in the centre (with hexagons) uses a different frequency. The same frequency is then reused in the neighbour "clusters", so that all cells marked with the same number use the same frequency.

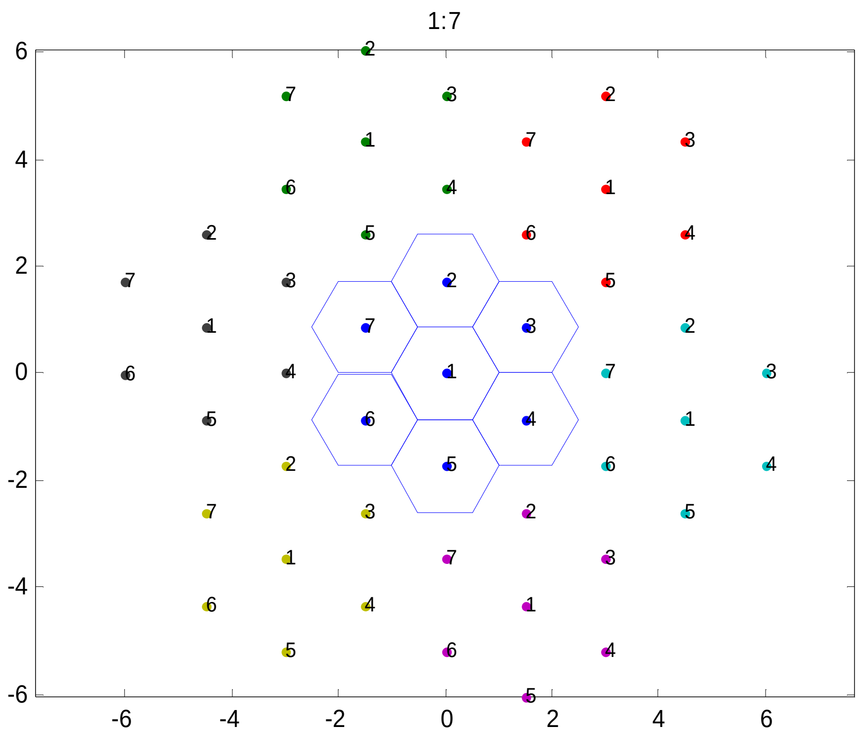


Figure B.4: Cluster

B.3.3.1.1 Methodology - SEAMCAT

The methodology presented here is that only the closest cells on the same frequency are considered for the reuse evaluation. That is, only cells marked with "1" in the above example. Therefore, any effects due to immediate neighbouring cells operation at different frequencies are ignored. This basically means that all TETRA / TEDS transmitter and receiver parameters relating to "off channel" behaviour can be ignored. Only transmit power, sensitivity, antenna configuration and C / I protection requirements are needed.

For the initial TETRA simulation, the following parameters are used as depicted in figure B.5.

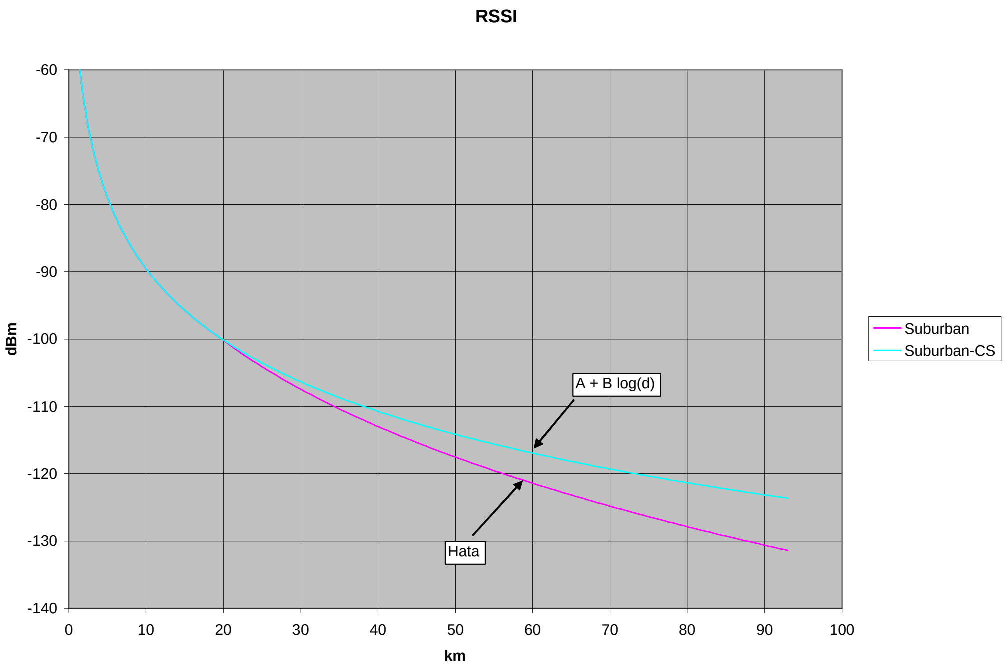
```
BS antenna height: 30 m

BS transmit power: 44 dBm

BS antenna gain:   11 dB, Omni (perhaps a little high)

BS sensitivity:    -109 dBm

BS diversity gain: 4.77 dB (3x diversity, conservative)

MS antenna height: 1.5 m

MS transmit power: 30 dBm

MS antenna gain:   0 dB, Omni

MS sensitivity:    -103 dBm

Propagation:       suburban

Fade margin:       11.53 dB (90% contour)

C/I protection:     19 dB

Frequency:         400 MHz
```

Figure B.5: Cluster

Note that the BS sensitivity has been set slightly better than required in the standard, whereas MS sensitivity is set to the standard value. This is done as the planner typically would know the exact sensitivity of the deployed bases stations, whereas a "worst case" would have to be assumed for the MS population (at least in some systems).

Before simulation can begin in SEAMCAT with these parameters, the cell coverage radius and location of the neighbouring cells at the same frequency need to be established. With the above parameters, the system is uplink limited with a link gain of 155 dB. Using a contour reliability of 90 %, this gives a range of 9,2 km (suburban) (see note). The neighbour cells will then be placed according to selected reuse factor.

NOTE: The range will impact the results somewhat due to the additional loss in the Hata model [i.59] for distances above 20 km. At 80 km this additional loss is approximately 6 dB. That is, the result will improve as cell range increases, which again means that urban is the worst case environment.



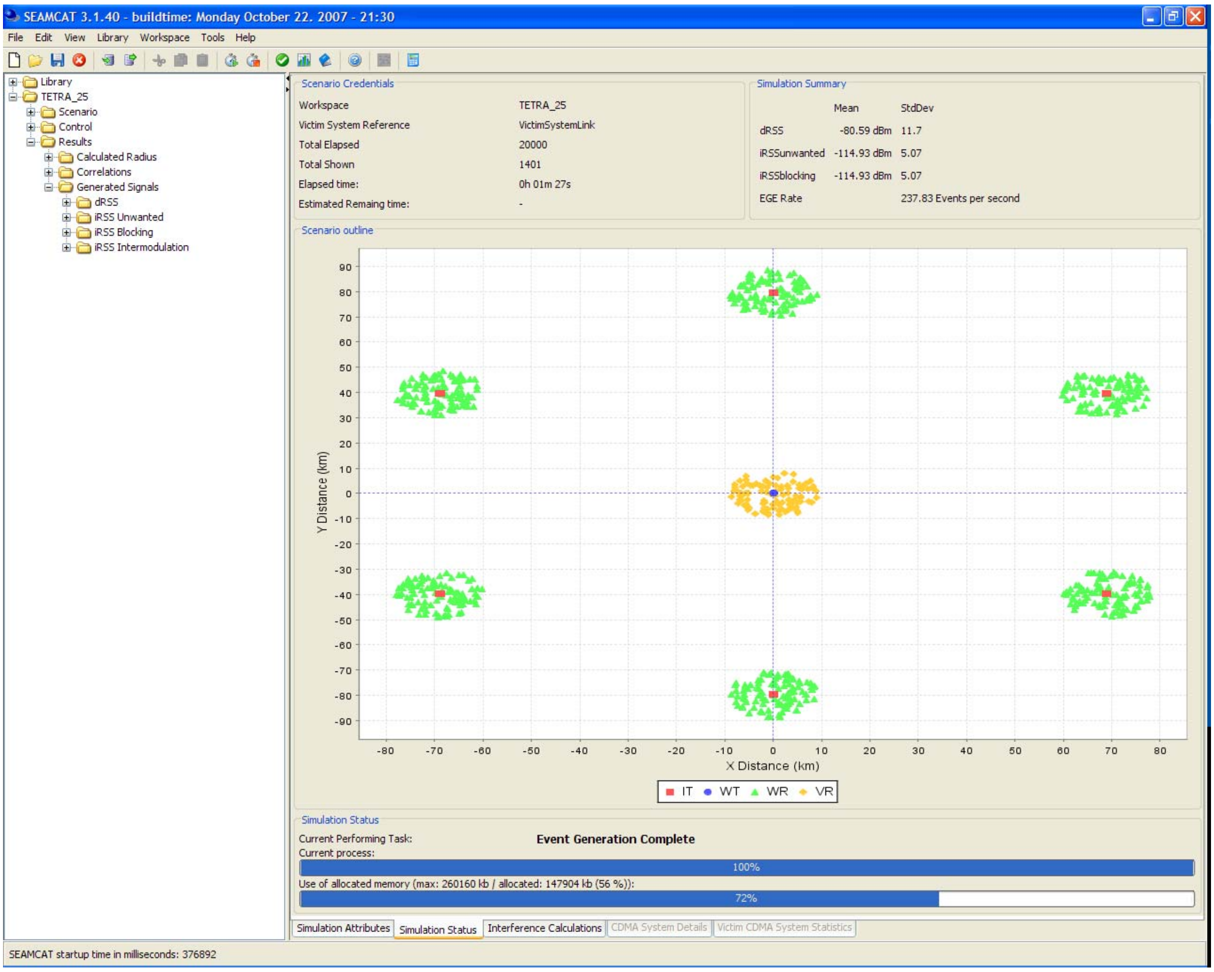
With this, all required parameters for SEAMCAT simulation has been established, and the scenario can be entered.

Results

For a reuse of 25, the co-channel BSs will be located at:

```
BS 1: x =   0.000 km y =  79.568 km
BS 2: x =  68.908 km y =  39.784 km
BS 3: x =  68.908 km y = -39.784 km
BS 4: x =   0.000 km y = -79.568 km
BS 5: x = -68.908 km y = -39.784 km
BS 6: x = -68.908 km y =  39.784 km
```

The example simulation is illustrated below.



The probability of interference in this scenario is ~9 %.

Figure B.6: Simulation results

Two other scenarios have also been tested in SEAMCAT: reuse 12 and reuse 36. Results are shown below:

Reuse	% interference
12	29 %
25	9 %
36	3,4 %

Figure B.7: Results

Note that these probabilities apply to the downlink direction only. However, unless the activity factor for the MS is somewhat below 100 %, this is not expected to be that different on the uplink (need validation).

Methodology Evaluation

SEAMCAT has been developed primarily to simulate inter-system interference scenarios. In such scenarios, the parameters for the simulation should be chosen conservatively so that if SEAMCAT results indicate that no interference problems exist, then really no interference problems exist.

However, SEAMCAT can also simulate intra-system interference scenarios (which is pointed out in the SEAMCAT help text). A major difference is here that the parameters now should be selected as "most likely" rather than "conservative". However, SEAMCAT does not allow the amount and nature of shadow fading to be controlled. One could therefore expect SEAMCAT results to be on the pessimistic side.

Another observation is the apparently self contradicting scenarios that are simulated in SEAMCAT: each "event" represents a draw from the possible MS positions in the simulated system. Each "event" is then taken as a static scenario - i.e. the MS does not move - however, at the same time C/I results for an MS moving at 50 km/h is used.

For voice calls, this is an acceptable "mix". However, for non-real time data transfers, packets are not lost but instead retransmitted later. If the correlation distance is 20 m and the MS speed is 50 km/h, the correlation time is ~1 sec. Using retransmissions to address "shadow fades" of this duration does not seem unreasonable. If on the other hand the MS is not moving, then interference really means loss of service. However, in this case it does not seem right to use the dynamic C/I protection level - static C/I protection level should be used instead (taking extra variation due to multipath into consideration). That is, either a higher interference probability (which is usually unacceptable for voice) should be used, or a lower value of the C/I protection should be used.

B.3.3.1.2 Methodology - Alternative MCL

The "MCL" approach to reuse calculation can be found in ERC Report 52 (from 1997) [i.68]. The method was later refined in ECC Report 42 (from 2004) [i.69]. Equation (9) in ERC Report 52 [i.68], refined to equation (4.3-1) in ECC Report 42 [i.69] gives the following formula for the reuse of any technology:

$$N_R = 1 / 3 \, [M \, K \, A \, (C/I)_T]^{2/\alpha} \qquad (7)$$

Where M is the slow fading margin (not present in ERC Report 52 [i.68] - 8 dB in ECC Report 42 [i.69]), K is the "geometry" factor (set to 6 in ERC Report 52 [i.68] - 7 in ECC Report 42 [i.69]), A is the system load or activity (set to 0,5 in ERC Report 52 [i.68] - 1,0 in ECC Report 42 [i.69]), α is the exponent from Hata and $(C/I)_T$ is the required dynamic co-channel interference ratio.

Results

Using the formula above, the following calculations can be made for TETRA.

C/I	M	K	A	alfa	NR	
19	0	6	0,5	3,5	7,61	ERC 52
19	8	7	1	3,5	35,37	ECC 42

The ECC Report 42 [i.69] results can be said to somewhat match the SEAMCAT results above, whereas ERC Report 52 [i.68] is in disagreement.

The results for TEDS using this methodology are:

C/I	M	K	A	alfa	NR	
14	8	7	1	3,5	18,32	4-QAM
19	8	7	1	3,5	35,37	16-QAM
23	8	7	1	3,5	59,87	64-QAM 1/2
27	8	7	1	3,5	101,34	64-QAM 2/3

Assuming these numbers are correct, this means that the efficiency of TEDS compared to TETRA is:

- 4-QAM: approximately same bit rate per Hz, half the number of frequencies used, i.e. ~2 ×
- 16-QAM: approximately twice bit rate per Hz, same number of frequencies used, i.e. also ~2 ×
- 64-QAM 1/2: approximately three times bit rate per Hz, twice the number of frequencies, i.e. ~1,5 ×
- 64-QAM 2/3: approximately four times bit rate per Hz, three times the number of frequencies, i.e. ~1,3 ×

However, if take adaptive modulation into account, one could say that we a) can use half the frequencies while b) still have four times bit rate in a large percentage of the cell area - approaching 8x efficiency, but in practice a bit lower.

Methodology Evaluation

The MCL method is fast, but seems very dependent on input parameters. Especially the margin M can be difficult to set. The two CEPT reports states the TETRA reuse to be 7 or 36, which illustrates this difficulty. The method can be used for quick evaluation though - but the parameter choice should be validated against "real world" experience.

B.3.3.1.3 Simulation results using proprietary tool

This clause will present results using a proprietary tool. The tool is basically a number of MATLAB scripts, implementing the scenario generation and Hata propagation model (the same as used in SEAMCAT). The advantage of the proprietary tool is that all aspects of the scenario generation can be controlled and that basic parameters of the propagation model can be tuned to appropriate values.

In addition to this, we have obtained the SEAMCAT propagation source code, which makes it possible to control the basic parameters of the propagation model used in SEAMCAT.

This clause will discuss some parameters and present initial results. All results for now assume same conditions as given in clause B.3.3.1.1.

Log Normal Fading

The sigma for log normal fading is one of the crucial parameters for reuse evaluation. The value in SEAMCAT depends on the distance between the transmitter and receiver - however, for distances above 600 m, the value remains fixed at 9 dB [i.57].

Actual measurements are sparse but can be found in the literature:

- Jakes [i.56]: Refers to measurements made by other authors at various frequencies - no real consistency in measurements, except that range is from 5 dB to 12 dB.
- Curves reproduced from Okumura et al [i.58] suggest that sigma is increasing with frequency and that @400MHz the values are 6 dB for TU and 7,5 dB for SU.

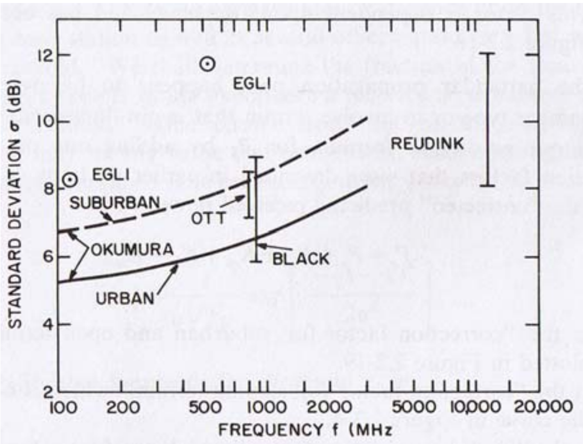


Figure B.8: Measurement results

- Algans et al [i.60]: Measurements @1.8GHz in Denmark (Århus, Gistrup) and Sweden (Stockholm) finds sigma of 6 dB for SU, between 7,3 dB and 8,5 dB for TU, and 10 dB for BU.
- Perahia et al [i.61]: Measurements @1.9GHz in the US (Mountain View, Scottsbluff) finds sigma of between 2 dB and 7,7 dB for "relatively flat" SU, and between 3,7 dB and 10 dB for "undulating hills" rural area. They find no correlation between shadow fading from multiple BS.
- Zayana et al [i.62]: Measurements @900MHz in France (Mulhouse) finds sigma of 5,5 dB. They find significant correlation between shadow fading from multiple BS.
- Elfadhil et al [i.63]: Measurements @900MHz in Oman finds sigma of 3,2 dB for open area.
- Weitzen et al [i.64]: Measurements @1.9GHz in the US (Boston, Cambridge). No results for sigma given, however, a histogram of the log normal fading suggests a value in the order of 2 dB to 3 dB. The main objective of the paper is to show that there is no correlation between shadow fading from multiple BS.

The results reported above are not entirely consistent - some results seem to point in opposite directions. The only thing that really can be concluded is that the results show that the actual sigma will vary as a result of local factors, and that it is difficult to settle on one specific value of sigma.

The proposed conclusion on sigma is to state results for four different values of sigma:

1) 4 dB, representing optimal local conditions

2) 6 dB, representing most likely local conditions

3) 8 dB, representing difficult local conditions

4) 10 dB, representing bad local conditions

A nationwide network may consist of areas with different local conditions.

Mobility / Macro Diversity

The references in the previous clause contained 3 references to results relating to the correlation of shadow fading from multiple BS [i.61], [i.62], and [i.64]. The results are unfortunately contradicting, but for now, the assumption is that there is no correlation.

Now, with this assumption of no correlation and with the sigmas given in the previous clause, this means that there will be a significant probability that the geographically closest BS will not be the BS with highest RSSI. With the parameters in clause B.3.3.1.1 (and 9 dB shadow fading), this probability will be above 40 %.

This is illustrated in figure B.9, where green dots indicate MS positions where the geographically closest BS is not the one with highest RSSI.

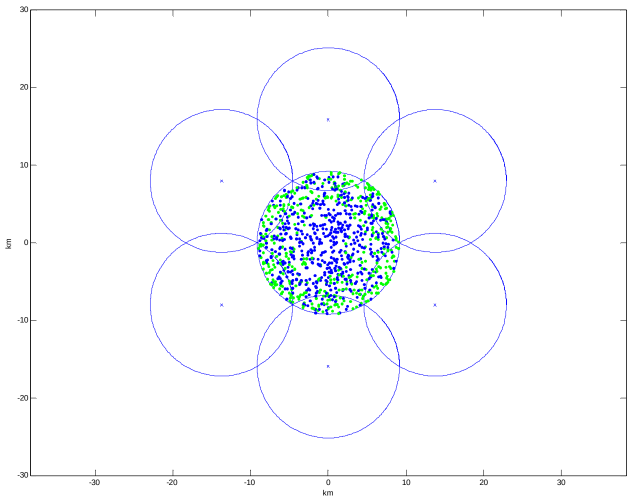


Figure B.9: MS positions (1)

To address this, the tool can use two mobility models:

- MS is using geographically closest BS. This is essentially the same method as used in SEAMCAT.
- MS is using neighbour BS with highest RSSI if this is above that of the geographically closest cell by more than X dB. This is not quite the algorithm used in the TETRA standard, but close. If a neighbour cell is chosen, the map is "shifted" so that the selected BS again becomes the BS located at (0, 0).

The second option is illustrated in figure B.10 for X = 6 dB, where red dots indicate MS positions where the initial BS was not selected, and green dots indicate MS positions where the geographically closest BS is not the one with the highest RSSI but the 6 dB difference is not met.

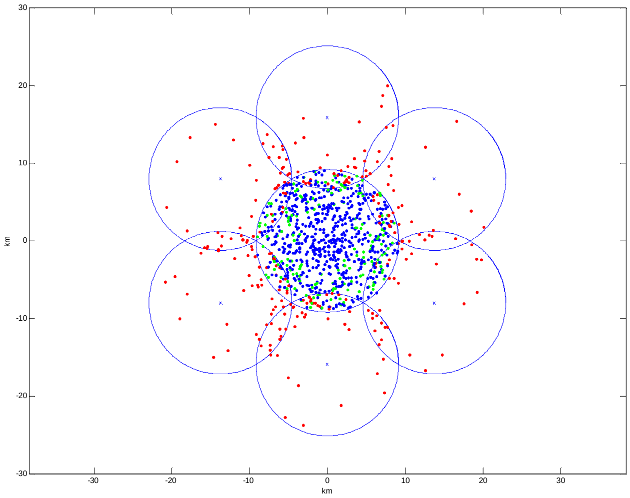


Figure B.10: MS positions (2)

The distribution is ~25 % red, ~15 % green and the rest blue.

C/I Numbers

EN 300 392-2 [i.10] gives the C/I protection ratio needed for 4PSK and QAM:

- 4PSK: 19 dB
- 4-QAM R1/2: 14 dB
- 16-QAM R1/2: 19 dB
- 64-QAM R1/2: 23 dB
- 64-QAM R2/3: 27 dB

However, all of these numbers include a fair amount of implementation margin. This implementation margin is, however, a bit different from the implementation margin assumed in the MS and BS noise figures, in the sense that meeting the C/I performance is largely unaffected by the RF parts of the receiver. Instead, the C/I performance is assured by the all-digital parts of the receiver, and therefore not sensitive to production variations. One could therefore argue that most receivers are unlikely to utilize this margin.

Without margin, the numbers are (derived from internal data and [i.11]):

- 4PSK: 17,5 dB
- 4-QAM R1/2: 11,5 dB
- 16-QAM R1/2: 16,5 dB [i.11]
- 64-QAM R1/2: 21,5 dB
- 64-QAM R2/3: 24,5 dB

Results

With the tool introduction done, we are now ready to look at some results.

Tool Comparison

The first curve with results show the probability of interference for TETRA with the same parameters and assumptions as used in SEAMCAT in clause B.3.3.1.1 as a function of the reuse factor (labelled "SEAMCAT T1" as the SEAMCAT method is used). As the tool is based on a scripting language it is fairly easy to vary parameters, so result here are given for all reuse factors from 3 to 63 (see note 1).

NOTE 1: 3, 4, 7, 9, 12, 13, 16, 19, 21, 25, 27, 28, 31, 36, 37, 39, 43, 48, 49, 49, 52, 57, 61, 63.

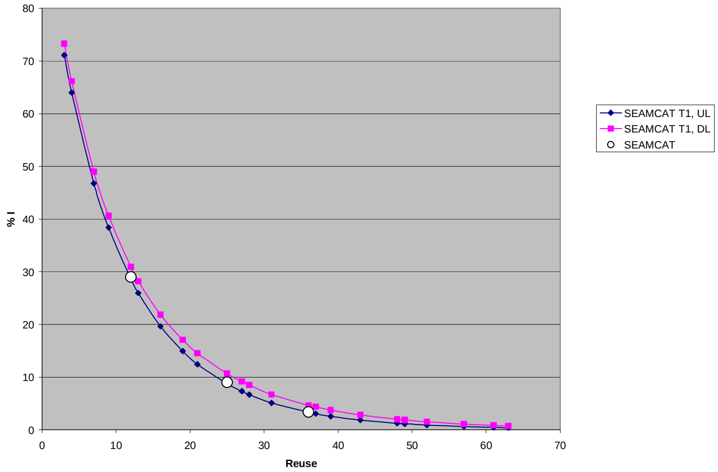


Figure B.11: comparison

The results obtained by use of SEAMCAT in clause B.3.3.1.1 have been added to the graph as well (labelled "SEAMCAT" indicated by white dots) - as can be seen, there is an excellent match of results, although SEAMCAT seem to be slightly more optimistic (DL was simulated in SEAMCAT).

Now, since the interesting part of the curve is the area with low probability of interference, the y-axis has been scaled on the following figure (and all following figures) to ease reading the graph.

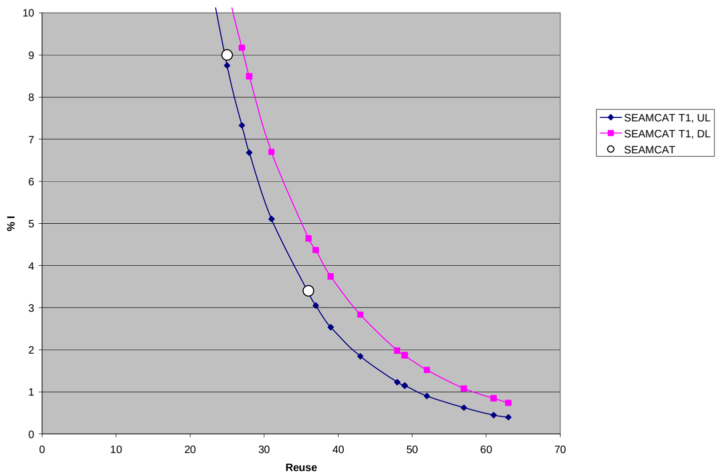


Figure B.12: Results

TETRA Results - Log Normal Sigma Sensitivity

The curves below show the effect of changing sigma. Some of the values have been calculated using SEAMCAT with modified propagation model parameter (white circles - corresponding to a sigma of 6 dB, 8 dB and 9 dB).

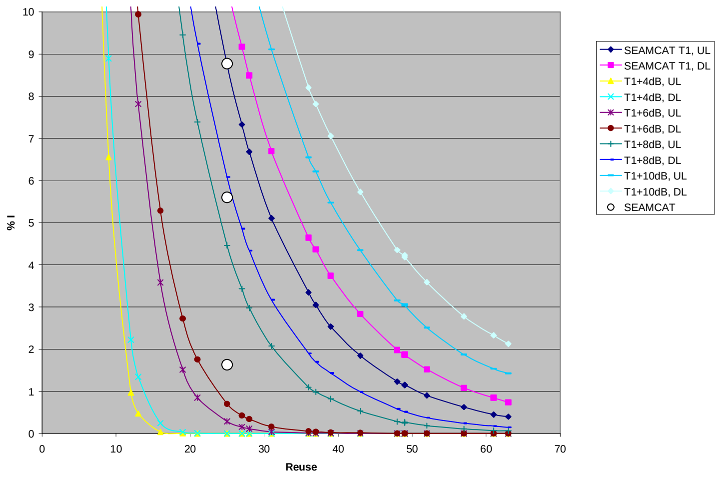


Figure B.13: Propagations

As can be seen, the value of sigma has a dramatic effect on the results.

TETRA Results - Mobility / Macro Diversity Sensitivity

The curves below show the effect of including mobility / macro diversity for some different values of X (0 dB, 2 dB, 4 dB, 6 dB and 8 dB).

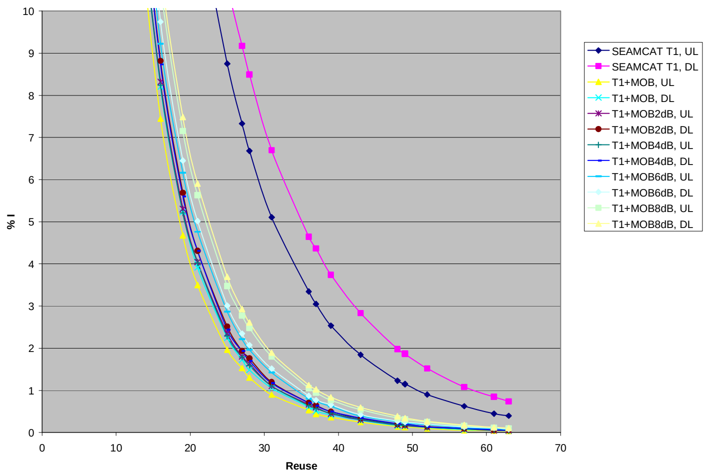


Figure B.14: Diversity

This shows that the mobility will contribute to increasing the received RSSI (and therefore indirectly increase C/I) and therefore improve the reuse. However, the impact is not as sensitive to values of X as one might initially think.

The use of the strongest BS also results in the area reliability increasing to close to 100 %. The cell size could therefore be increased beyond that of a single cell system; however, this has not been done here.

TETRA Results - Selected Curves

The curves below show the effect of some of the changes to the simulation proposed above.

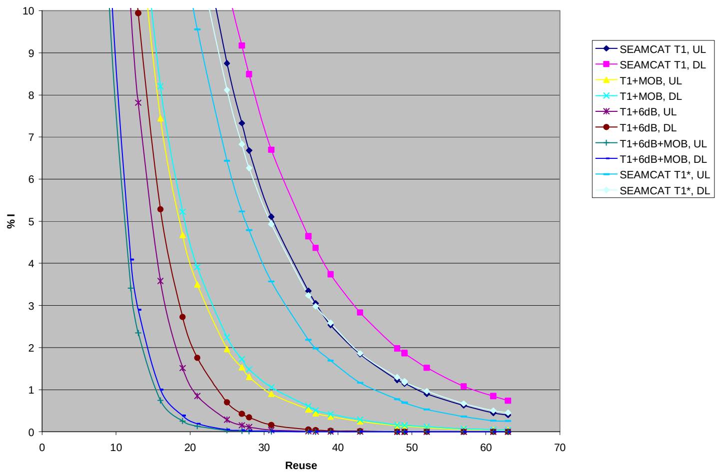


Figure B.15: Results

The curves are:

- "SEAMCAT T1" - basically the same curves as presented in Tool Comparison.
- "T1+MOB" - mobility as described in clause B.3.3.1.3 added (X = 0).
- "T1+6dB" - sigma in log normal changed from 9 dB to 6 dB.
- "T1+6dB+MOB" - sigma in log normal changed from 9 dB to 6 dB, and mobility as described in section Mobility / Macro Diversity section added
(X = 0).
- "SEAMCAT T1*" - C/I margin reduced from 19 dB to 17,5 dB.

The curves show that that the reuse factor is strongly affected by the assumptions on mobility and sigma. The reuse for TETRA can therefore only be given as a range of possible values.

NOTE 2: All curves assume 100 % UL activity and no UL power control.

B.4 Cognitive Radio & Spectrum Management

B.4.1 Cognitive radio requirement

Cognitive radio is a tool for use in adaptive spectrum management to enable an efficient use of spectrum in an intelligent way. The following list provides examples of features that may need to be incorporated in cognitive radios:

- Frequency agility;
- Dynamic frequency selection;
- Adaptive modulation;
- Adaptive bandwidth;
- Transmit power control;
- Location awareness (its own and that of other devices operating in the same spectrum);

- Interference cancellation.

Modern HSD digital mobile technologies such as TEDS networks and radios are already utilising a degree of reconfigurability in provision of link adaptation to changing propagation conditions. A dynamic reconfiguration of TEDS Physical/MAC layers parameters such as adaptive modulation, coding rate and channel bandwidth as well as transmit power are features already included in the present document in line with the technology of cognitive and software-controlled radios.

An idea being promoted currently in discussions of "Reconfigurable Radio Systems" is a cognitive control channel. This channel could be used to identify other wireless systems in operation. It would provide information about band occupation, power levels or Transmit-Power-Control settings of active radio systems. With this information, PPDR systems could adapt themselves to a radio environment which might otherwise be difficult to measure, for the purposes of band-sharing. Likewise, other spectrum sharers could be obliged to provide the same information on such a channel that is provided by the PPDR system if they like to use the spectrum (under the assumption that pre-emption would take place, if spectrum is needed by the PPDR network). Another interesting aspect is that such a channel would be part of the PPDR network and therefore, under control of the PPDR network operator. The concept of a "cognitive control channel" discussed above is already in use in TETRA albeit for internal network purposes. Nonetheless, this concept should be carefully investigated in sharing spectrum between the PPDR and other networks to ensure that more severe requirements in terms of fast communications set-up, availability and reliability exercised by the PPDR network are fulfilled.

Furthermore, from the perspective of a PPDR network sharing spectrum with other users, it is important to have a strict pre-emption capability as part of the sharing arrangement to ensure the required performance from the PPDR network is achieved at times of disaster (see further, clause B.4.2.3).

It is clear that a co-operation criterion has to be established between the technologies sharing the spectrum. Implementing these techniques does rely on contiguous blocks of spectrum under the control of a PPDR network infrastructure, which makes the opportunity of the digital dividend band ideal for implementing this advanced cognitive concept. However as explained below the nature of the pan-European emergency communication dictates a fully secure primary spectrum allocation. A cognitive radio deployment of future PPDR radio in an opportunistic spectrum usage could be envisaged in non mission-critical (routine) operations.

B.4.2 Emergency communication and adaptive spectrum management based on cognitive radio

B.4.2.1 General

It is generally understood that spectrum availability for emergency communications should be given a high priority by regulatory authorities. Furthermore, the national and regional security dictates a permanent harmonised band, which could be effectively utilised across national boundaries at times of calamity. Such a spectrum allocation should not be governed by costly auction procedures that are best suited for high-user-density commercial networks.

So far the only harmonised public safety band available to European users is 380-385/390-395 MHz in which (narrow-band) TETRA technology is the dominant user. However this band is now so highly congested in a number of European countries that it is not possible to add wide-band TETRA channels let alone broadband enhancements.

One of the main goals for any public safety and disaster relief communication network should be the provision of ***high-speed data*** with a ***wide-area coverage***. Emergency communications require effective levels of geographical coverage adapted to potential events including those at remote locations. Emergency situations could occur anywhere and at any time. The wider the coverage of the network the more responsive it is to such events. The lower UHF frequency bands and in particular the digital dividend band (preferably the lower parts) are ideal candidates for this purpose. However in the case of unavailability of a "preferred spectrum" any designation in the 300 MHz to 790 MHz band including an adoption of the "tuning range" approach would be considered.

B.4.2.2 Adaptive (cognitive) spectrum management

The shortcoming of the current spectrum allocation regime based on fixed blocks of spectrum is that portions of the allocated spectrum are used in certain geographical areas and there are some portions of the assigned spectrum that are used only for brief periods of time. Studies have shown that an order of magnitude increase in capacity could be achieved if this "wasted" spectrum is utilized [i.14].

In a quest for a more-efficient spectrum utilisation the Wireless Access Platform for Electronic Communications Services (WAPECS) concept is currently under serious consideration by European regulators. WAPECS is defined [i.15] as "a framework for the provision of electronic communications services (ECS) within a set of frequency bands to be identified and agreed between European Union Member States in which a range of ECS may be offered on a technology and service neutral basis, provided that certain technical requirements to avoid interference are met, to ensure the effective and efficient use of the spectrum, and the authorisation conditions do not distort competition". However, the EU Radio Spectrum Policy Group (RSPG) recognised that "The use of bands by services pursuing particular general interest objectives (e.g. Service of General Economic Interest, safety-of-life services etc.) ***require special consideration***. Member states may have to fulfil some obligations relating to such services, even when they fall under the WAPECS scope, and to safeguard some spectrum for them". CEPT Report 19 addressed such questions in the context of WAPECS [i.28].

In the long run, the use of cognitive radios with *Adaptive Spectrum Management (ASM)* is believed by many regulators to be the answer for the spectrum congestion problem. A flexible spectrum framework such as WAPECS is expected to pave the way for "policy-based" adaptive-radio regulatory framework required in ASM although, as described below, other challenges remain in achieving a cognitive-radio based ASM. This approach is particularly suited for unlicensed bands. In early implementations in licensed bands, a static allocation of spectrum (for primary usage) could be complemented by the opportunistic use of the unused spectrum in an instant-by-instant basis in a manner that limits interference to primary users. In this approach the cognitive radio monitors the spectrum in which it wants to transmit, looks for inactivity in time and frequency and transmits without interference to primary users.

There are real challenges to ASM in areas such as real-time wide-band spectrum sensing, identification of opportunities and co-ordination of such activities throughout a network. Some possible sensing options are listed below:

- Base station controlled operation where the base station chooses the spectrum based on either sensing done at the base station or on information made available via other means (databases of incumbent users, etc), and control MS operating parameters within a defined coverage area.
- Sensing of channel / adjacent channel use by primary user - that is, sensing of the "useful" signal from the incumbent user. Any such sensing will require some a priori knowledge of the nature of the "useful" signal.
- Transmitting and reception of "disabling/enabling beacons". This seems particularly interesting for public safety, as this mechanism can enable priority-based access to spectrum. This, however, requires that all technologies using the spectrum use a common disabling/enabling beacon signal or cognitive control channel (described earlier).
- Location based / database enabled devices with knowledge of primary use of spectrum. This offers a better protection of the incumbent users, with possibilities of dealing with unforeseeable operating and propagation conditions.

Identification and avoidance of the interference sources is another challenge. Furthermore, algorithms need to be developed enabling the sharing of spectrum according to policies and pre-arranged agreements between a licensee and a third party.

It is proposed that the PPDR network will be the "licensee" who will be in "control" of the sharing procedure. Hence some unified approach is needed for network sharing in case of emergency, between different governmental agencies, police, fire brigades, service and utilities companies. Depending on the priorities, the less critical or routine users like service and utilities users can be taken "off the air" and their band can be allocated to emergency users such as police and fire brigades. This approach will form the basis for "ruthless pre-emption" strategy. Overall, the information from public safety organisations does not need to be used outside of their network. To ensure that the above pre-emption works without delay or failure testing on regular basis during routine operation has to be carried out.

B.4.2.3 What approach for spectrum allocation for emergency communication

The present document advocates allocation of a dedicated spectrum for harmonised wide-area coverage communication across the EC countries capable of high-speed IP-based data applications. This spectrum should be sufficient to meet the requirements of steady PSS traffic (e.g. PP1 and PP2) and also cater for the peak DR usage during major incidents. Furthermore, for reasons of interoperability (national and trans-European) and economy of scale this spectrum should be a single Europe-wide frequency designation. This allocation needs to be treated as a special strategic resource to meet the general security interests of the European Community.

When cognitive radio deployment and adaptive spectrum management (ASM) have reached maturity, considering the full range of PPDR requirements (routine and mission-critical), it may be possible to consider a shared PSS and non-PSS scenario in the above PPDR designated spectrum.

In a shared scenario, it is important to take into account, particularly in urban/metropolitan areas, that the third party use of PPDR spectrum can cause no congestion or disruption of PPDR radio communication. Considering the risks involved, it is out of the question to accept restrictions on the availability and reliability of the PPDR radio communication due to third party use of spectrum.

Sharing users such as utilities, government and local authorities, transport police, coastguard service and other commercial networks may be allowed to:

a) share the PPDR network (for certain users). This is the preferred method of sharing as it allows more users to access the PPDR network in a controlled fashion, so that when needed priority services are guaranteed; or

b) share the PPDR dedicated spectrum using a cognitive radio approach.

However, the sharing of spectrum should be allowed only under a strict pre-emption regime with no risk of interference to the PPDR service and availability of sufficient spectrum for mission critical part of the PPDR service. Therefore, PPDR designated spectrum needs an exclusive "core" radio spectrum for PP1 and PP2 services plus sufficient shared spectrum (with a ruthless pre-emption arrangement) for occasional DR applications. The sharing arrangement is proposed to be facilitated by using a cognitive channel being provided by the PPDR system (see also clause B.4.1). Table B.2 shows the optimal and sub-optimal options under a shared scenario.

Table B.2: Network and spectrum sharing options

		Spectrum	
		Dedicated	**Shared**
Network	**Dedicated**	Optimal.	Possible for Mission Critical applications if provided on primary basis and using pre-emption. Possible for non-mission critical applications.
	Shared	Suboptimal: Possible with clearly defined rights and duties. Network should be robust, reliable, and available to accommodate PSS users.	Not possible for Mission Critical applications.

The allocation of preemptable spectrum for PPDR use would be in addition to core dedicated, exclusive spectrum, and would only be accessed in certain limited circumstances. Preemption can only work in one direction with sharer networks taking advantage of spectrum dedicated to PPDR communications, and with PPDR being able to "ruthlessly" invoke emergency use at the expense of other users. It is to be noted that DR services, have "average" or long-term spectrum requirements which are very different from the peak requirements that arise during major incidents. However, dedicated does not necessarily mean that the entire designated spectrum has to remain exclusive to PPDR all the time. Hence there is likely to be benefits in a combination of dedicated and shared use spectrum, where the shared spectrum is used to cater for the peaks as and when they arise. Furthermore, since the occasional peak spectrum requirement is highly localised, the locations outside the incident area do not have to invoke the pre-emption arrangement.

B.4.2.4 Formation of WG 4 of ETSI TC RRS to look on PSS (Public Safety System) needs

ETSI TC RRS had its second meeting at the beginning of June 2008, where the ETSI TC TETRA proposal outlined in the present clause B.4 regarding cognitive radio & spectrum management was discussed.

In response, TC RRS indicated to TC TETRA that the interests of Public Safety stakeholders need to be considered in the definition of the framework of Reconfigurable Radio Systems. In this regard the second RRS meeting has established a Public Safety working group.

In a liaison between TC TETRA and TC RRS a list of comments were received by TC TETRA from TC RRS (Public Safety Working Group) regarding the above clause B.4. The above text was revised to take the TC RRS comments into account.

NOTE: In ETSI TC RRS, the term Dynamic Spectrum Management is used to identify the concept of Adaptive Spectrum Management described in the present document.

ETSI TC RRS have published the following documents:

- TR 102 733 on RRS system aspects in public safety [i.36];
- TS 102 734 "User requirements" on public safety. [i.35];
- additional information can be found in [i.33] and [i.34].

The following paragraphs are mainly excerpt from these documents relevant for the purpose of the present document:

Spectrum sharing presents a number of challenges, which are not only at technical level, but they are mostly at procedural, organization and regulatory level:

- A clear definition of "normal" (routine) and "exceptional" (peak traffic) operational contexts to support the spectrum sharing arrangements and procedures.
- Definition of the operational procedures to be established for re-allocation of the spectrum.
- A technical method is required to enforce pre-emption.
- Definition of the technical and operational mechanism to ensure that commercial domain networks and devices will not transmit when the shared spectrum is made exclusive to PPDR. Otherwise, Public Safety communication systems will suffer from wireless interference by commercial providers.

Public Safety wireless communication usage is characterized by a moderate usage pattern during routine operations and extremely high usage patterns during major disasters or events. Because traffic capacity is directly related to RF spectrum occupation, the consequence is that Public Safety organizations require a flexible approach to spectrum management to support their operational needs.

An important advantage offered by RRS radio system is to provide the needed flexibility and reconfigurability. RRS radio system can implement cognitive radio capability to implement an adaptive spectrum management approach.

The RRS radio system should be able to share spectrum resources in the same area with other radio networks. Spectrum sharing policies and etiquettes ensure that heterogeneous systems share the available resources in a fair manner.

We can define the following requirements:

- RRS should be able to adapt the transmission parameters like frequency bandwidth, frequency carrier modulation, power.
- RRS should be able to support adaptive spectrum assignment to network elements.
- RRS should be able to detect spectrum usage in the area. In other words, RRS should have spectrum sensing capability.
- RRS should be RF spectrum "aware" of the existence of other wireless communication systems transmitting in the area of operation.
- RRS should be able to exchange information on the use of spectrum usage with other RRSs in the coverage area.
- RRS should be able to support various organizations with different levels of authority and operational priority in the use of the spectrum.

Allocation of spectrum bands for public safety is quite diversified across Europe. The same communication system may have different frequency bands assigned in different nations across Europe.

A strong benefit of RRS technology should be the capability to transmit in different frequency bands depending on the regulation context, where the RRS should operate. This capability is particularly important in public safety operations in geographical areas with spectrum regulation different from where the public safety organization usually operates.

The following detailed requirements can be defined:

- RRS should be able to support communication for different frequency bands.
- RRS should be able to dynamically change the operating frequency band depending on the context both operational and regional. For example, if a RRS system is moved, during an emergency crisis, from one regional area to another area, which uses a different allocation of RF spectrum bands, the RRS system should be able to reallocate its use of RF spectrum bands.

Adaptive spectrum management has a number of technical and organizational challenges to be resolved before it can be applied to Public Safety domain. For example, the use of Cognitive Radio and Adaptive Spectrum Management may increase the risk of wireless interference and harmful coexistence between RRS or non-RRS wireless communication systems. For more details, see TR 102 733 [i.36], System Aspects.

ETSI TC RRS and ETSI TC TETRA agreed in December 2009 on a first generic work item which focuses on a top-level definition of the architecture of a RRS system for a PPDR network that meets the objectives as described in the present document. set in this liaison statement. PPDR RRS would comply with the RRS system architecture (which itself is assumed to be specified in TC RRS and taking into account the already published TR 102 682 [i.44] and TR 102 683 [i.45]), i.e. The PPDR RRS technical solution should find the necessary "hooks" in the RRS system architecture.

Research has not proven yet that ASM can satisfy the public safety requirements listed above. Further investigation is needed in this field. To date, the applicability of Dynamic Spectrum Allocation to Public Safety communications with their specific requirements regarding availability, access time, reliability etc. has not yet been sufficiently verified. Some technical obstacles, like e.g. the hidden node problem, still have to be overcome.

Therefore, it is likely that, in an evolutionary approach, cognitive radio concepts will initially be used for other, less complex functions like for example Public Safety coverage enhancements.

A preliminary proposal for the application of CR and ASM to Public Safety could be based on two layers approach.

A static allocation of the spectrum is used for basic services like voice and low data rate communication and messaging.

A dynamic allocation of the spectrum is used instead to provide broadband connectivity. Adaptive spectrum allocation can be based on the concept of spectrum sharing with commercial providers in case of emergency.

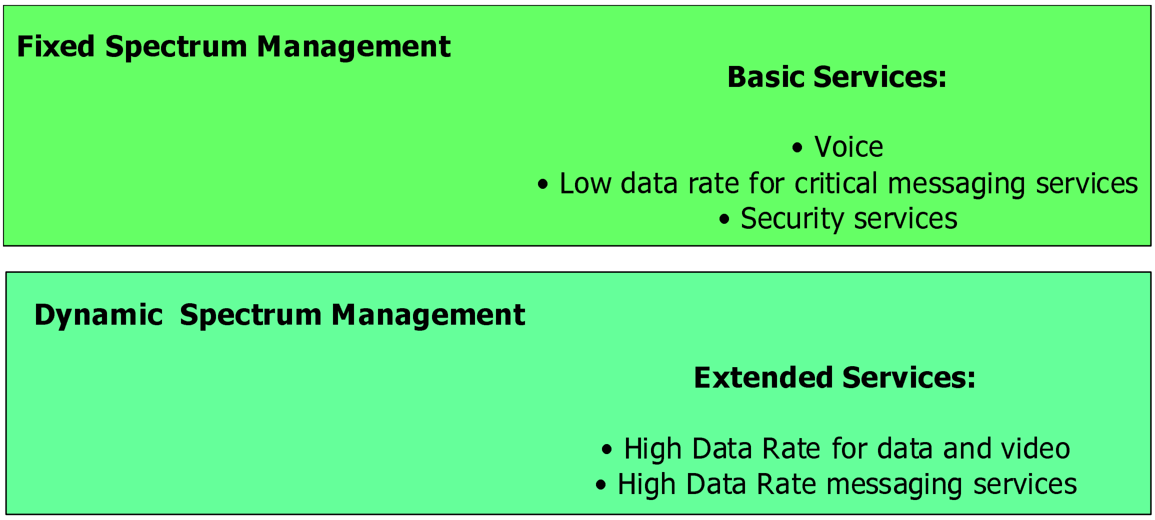


Figure B.16: Two layers approach for spectrum management in Public Safety

NOTE: There is a need for a lower capacity BB service in the day by day work. If something happens a higher demand for BB capacity may appear.

Dynamic (Adaptive) spectrum allocation can be based on the concept of spectrum sharing with commercial providers. In case of emergency, commercial providers will shut down their communication systems and free their spectrum bands. Public Safety RRS nodes will be able communicate and transmit in these spectrum bands for the duration of the emergency crisis.

There are a number of issues with this approach:

- Some public safety organizations may consider basic services event high data messaging services, as they would be essential for their activities.
- Who will guarantee that commercial providers will promptly shut down their networks in case of emergency? The risk is that some commercial providers will still transmit in the shared spectrum bands and they will create interference to RRS public safety communication systems.
- Emergency telecommunications as described in the TRs produced by ETSI EMTEL [i.19] and [i.21], show that commercial networks are still needed in case of emergency crisis to alert the population through broadcast communication and messages. Commercial networks like GSM/UMTS are also used by volunteer organizations.
- Ad-hoc Cognitive radio networks do still present a number of technical challenges, which should be resolved to validate the requirements of reliability and time described in TS 102 734 [i.35].

As seen from clause 6 of the present document, it is proposed to establish an eventual sharing scenario with commercial or other networks under an ASM regime subject to the following conditions:

- only if the PPDR is the "primary" user of the spectrum of which a portion is shared with the above entities;
- it is under a strict pre-emptive arrangement that guarantees the recovery of that part of spectrum for mission critical applications;
- the need for a fully field tested RRS system before willingness to embark on sharing the spectrum (or network).

To develop a robust RRS system for PPDR networks requires detailed specifications and testing in the areas of:

- Interoperability at MS and BS levels with standardisation of the necessary SW architecture (perhaps some adaptation of the software communications architecture) applicable to Public Safety environment which do not require unreasonable cost levels at implementation stage.
- Standardisation of a fully reliable and secure cognitive pilot channel(s), perhaps in-band for "network sharing" and out-of-band for "spectrum sharing" dedicated to provide the control messages regarding the spectrum environment [i.36].
- Development and standardisation of ASM procedures that allow PPDR networks to enjoy strict pre-emption (of the portion of the spectrum let to commercial and other entities) without fear of interference from these sharers.
- Full security of the whole system from rogue users and hackers.
- Backward compatibility to TETRA (the most widely used PPDR capable standard) and others.

The above list is not exhaustive. However, above all, this work should have the objective of leading to a pilot system that could be tested in conjunction with a TETRA network before going into implementation.

B.4.2.5 Multi-tiered frequency pre-emption

NOTE: The usage of the term <<pre-emption>> in this context does not mean a full pre-emption of frequencies (and consequently possible blocking situation) but rather a flexible, adaptive bandwidth management. The PPDR applications involved are data applications and their bandwidth/ capacity requirements are steadily changing within the subsecond timeframe. The concept may work in a military / PPDR sharing scenario. Even under stress in collision scenarios, the secondary, lower priority user may require a certain minimum capacity. To apply the concept together with a commercial service may include other, economical challenges. The attempt in the USA to auction pre-emptible spectrum in the UHF band has greatly failed.

B.4.2.5.1 Introduction

This clause outlines an idea that emerged in ETSAI TC TETRA concerning the management of spectrum use by public safety and other users.

B.4.2.5.2 Use of spectrum by the emergency services

In general, emphasis by the emergency services over the use of their spectrum is not (in reality) on making full and efficient use of all available spectrum on a daily basis. Instead, the emphasis is (and should be) on having instant access to sufficient spectrum when an emergency occurs. The traditional method of ensuring that sufficient spectrum is always available is to provide the emergency services with exclusive use of spectrum that may be underused for a large percentage of the time. Modern modulation and coding schemes seek to provide ever increasing spectrum efficiency (in terms of information bits per Hz per square meter of land surface area), and it is important to use this increasing efficiency to minimise the amount of spectrum that should be made available to public safety workers in a particular location or locations when an emergency occurs.

The present document proposes that some of this reserve capacity could be made available to other users for a significant percentage of the time, as long as it can be seized back into public safety use when special events (e.g. large sporting events, planned demonstrations etc.) or disasters and other emergencies occur. The present document talks about using "ruthless pre-emption".

The present document observes that the civilian public safety organisations are not the only groups that like to reserve spectrum in case of emergencies. The military organisations (e.g. the UK MoD, NATO, etc.) hold considerable quantities of spectrum that may be rarely used but would be required in case of serious national and international emergencies.

B.4.2.5.3 Assumptions

This proposal makes the following assumptions:

a) military organisations possess considerable regions of spectrum;

b) military spectrum can be divided into core spectrum in regular or frequent use and reserve spectrum that is used infrequently (e.g. during training exercises and national emergencies);

c) military users require instant access to their reserve spectrum;

d) spectrum owned by public safety organisations can be divided into core spectrum in regular use, and reserve spectrum that is used less frequently (e.g. during training exercises, special events, local disasters and emergencies);

e) public safety users occupy their reserve spectrum more frequently than military users occupy their reserve spectrum (daily public protection use - PP1);

f) on occasions when military users are not using their reserve spectrum, the military users will agree to make available that spectrum to public safety users, on the understanding that the reserve spectrum can be instantly returned to the military users when required;

g) on those occasions when military users need to use all their reserve spectrum, the public safety organisations can operate satisfactorily in co-ordination with the military users without using spectrum temporarily freed from the military users;

h) there exist commercial and other users who are prepared to use spectrum that may be removed instantly in the event of emergencies, disasters, and by pre-arrangement in the case of planned events (e.g. sporting fixtures).

B.4.2.5.4 Basic principles

In this proposal, reserve military spectrum is made available to public safety organisations (in this case clearly the "secondary" users) whenever it is not in active use by the military user (the "primary" user). This spectrum then becomes part of the reserve spectrum available to secondary users.

The secondary PSS users can again provide their available reserve spectrum to commercial and other non-public safety organisations ("tertiary" users) whenever that spectrum is not in active use by secondary users.

In both cases, the principle of rapid "ruthless" pre-emption would apply. The owner of the reserve spectrum would be able to take it back into its own use at very short notice (e.g. within a few seconds), and technical methods would be employed to prevent lower-tier users from causing interference to higher-tier users during that time.

Preferably, this should be combined with the use of adaptive frequency assignment methods as described in clause B.4.2.2 by secondary users, so that under-used channels can be merged and released frequencies instantly redistributed across a wide area by automated network planning methods, thereby recovering frequencies that can be provided temporarily to tertiary users.

When secondary users require more spectrum, spectrum is removed from the tertiary users by a process of rapid "ruthless" pre-emption.

When the primary users require the use of their reserve spectrum, the temporarily provided spectrum is removed from secondary users by a process of rapid "ruthless" pre-emption that may in turn cause secondary users to initiate pre-emption of spectrum leased to tertiary users.

The secondary users' core spectrum is protected from pre-emption by the primary user. The tertiary users may also have core spectrum that is exempt from pre-emption.

Note that tertiary users would not be aware when a pre-emption was caused by a military emergency. They would only know that the public safety user had need of the spectrum.

B.4.2.5.5 Technical methods

The pre-emption control between the primary user and secondary users would be based on an out-of-band channel that allows the primary user to communicate directly with the secondary users' radio systems (e.g. the TETRA SwMI). Emergency pre-emption signalling from the primary would force the secondary users' base stations to immediately evacuate the frequencies indicated by the pre-emption signalling (the secondary users' core spectrum would be exempt from this). More usually, pre-emption signalling would pre-book times when spectrum is returned to the primary user (e.g. for training exercises) so that secondary users could adjust their use of reserve spectrum in advance to avoid interruption of on-going calls and data transactions, etc. See TR 102 733 [i.36], clause 5.4.3.1, for a more detailed discussion of the use of the out-of-band channel for sending cognitive control messages to base stations.

The pre-emption channel between a secondary user and tertiary users would use an in-band channel. If a secondary user needs to remove spectrum from tertiary users, either instantly or at some time in the future, this would be signalled over the in-band channel. Tertiary radio equipment would be subject to tests to verify that they respond to in-band channel pre-emption messages by shutting off their transmitters on the indicated frequencies within a defined time period (e.g. one second).

When a secondary user has "sub-leased" the primary user's spectrum to tertiary users, emergency pre-emption of that spectrum by the primary user via the out-of-band channel will immediately and automatically cause the secondary user's radio system to remove the spectrum from tertiary users by sending appropriate signalling messages on the in-band channel.

The reliability of the in-band channel method requires further study. If instant pre-emption of tertiary users is really needed, the tertiary users' radio equipment should constantly monitor the in-band cognitive channel and should stop using the leased spectrum as soon as the in-band cognitive channel is lost. This may not be attractive to prospective tertiary users. It would be more useful to allow a time delay of several (e.g. thirty) seconds during which the tertiary radio equipment (TETRA DMO would be included in this) would be permitted to continue transmitting without receiving the in-band cognitive channel. However, it is hard to see how this could be acceptable to TETRA DMO users, for example, since the whole point of TETRA DMO is that it can be used when the radio equipment is out of range of a TETRA base station. Perhaps a supplementary wireless out-of-band channel could be used, shared with other users and carrying a very small amount of tertiary pre-emption information (e.g. "no change", "change imminent", "emergency pre-emption"); this supplementary out-of-band signal would require high coverage and penetration (e.g. by using a DAB channel or long-range MW or LW broadcast signal) and would carry just enough information to allow an emergency pre-emption to be conducted rapidly. In another method, the tertiary radio equipment would be required to relay emergency pre-emption signalling between each other, so that tertiary radio equipment in range of the in-band pre-emption control channel would forward pre-emption information to tertiary radio equipment outside the coverage area of the in-band pre-emption channel.

B.4.2.5.6 Discussion

In the multi-tiered approach, military users and public safety users would enjoy exclusive use of their core spectrum. However, the public safety users would lease some or all of their reserve spectrum from a portion of the military user's reserve spectrum. The public safety users would then make available some or all of their reserve spectrum (including that provided from military users) to commercial or other users when it was not required for public safety emergencies or planned events.

The proposal is based on the assumptions listed in clause B.4.2.5.3, and the expectation that we can devise technical mechanisms that will enforce controlled use of the reserve spectrum, and that the control mechanisms can operate at the desired speed.

Fast-acting spectrum control mechanisms combined with the ability to make rapid dynamic adjustments to spectrum use right across a cellular network offer the best hope of minimising spectrum waste (i.e. by avoiding times when spectrum cannot be used because of delays in reallocating it).

It is not proposed to discuss the validity of the assumptions or the viability of the technical mechanisms in the present document.

However, assumptions g) and h) seem to deserve special scrutiny. And military users may dispute assumption b).

Finally, it is worth mentioning that a much finer grained sharing of military spectrum would be possible if military users could be persuaded to make use of (i.e. share capacity on) PSS networks in use by public safety users. The military users might then wish to have the ability to take up extra capacity on the PSS system in times of emergency by appropriate agreements and by using the existing pre-emptive priority mechanisms available in PSS systems. The military users could allow the spectrum use of the PSS networks to expand or contract according to the current use of the frequency band for other military purposes.

B.4.2.6 Cognitive Pilot Channel for PPDR

The CPC is defined as a channel which conveys the elements of necessary information facilitating the operations of the PPDR cognitive radio system. The principles on cognitive pilot channels in cognitive radio systems can be found in [i.46] and [i.47].

The CPC provides information on which radio accesses can be expected in a certain geographical area. This information includes operator information, RAT type as well as used frequencies. Exemplary scenarios where the CPC is seen as useful are:

a) The CPC is used to support a terminal during the start-up phase in an environment where the terminal does not yet know the available RATs and corresponding used frequencies.

b) In the context of a secondary system, the CPC is used to exchange sensing information between terminals and base stations in order to perform collaborative/cooperative sensing facilitating the searching of white spaces to start communication.

c) The CPC is used for an efficient level of collaboration between a network and the terminals by supporting Radio Resource Management (RRM) optimisation procedures.

For PPDR systems, the **out-band CPC solution** seems more appropriate, where the CPC is conceived as a radio channel outside the component Radio Access Technologies (such as the future PPDR BB air interface), the CPC either uses a new radio interface, or alternatively uses an adaptation of legacy technology with appropriate characteristics.

A cognitive control message is estimated to be around 160 bytes in size, as it should contain the following information:

- Location of the cognitive radio node transmitting the message (12 bytes).
- Identifier of the cognitive radio node transmitting the message (4 bytes).
- Identified or the group, to which the cognitive radio nodes belongs (4 bytes). This is used to identify various groups of users.

- Allocation of the allowed spectrum bands. We can use a spectrum bitmask to identify blocks of 1 MHz or 5 MHz to be allocated in the spectrum range used by Public Safety. Each bit represents a spectrum block, which can be used (set to 1) or not used (set to 0). For example, with a spectrum range of 0 GHz to 1 GHz, we have a spectrum bitmask of 1 000 bits or 125 bytes.

- Power level of the received signal of the cognitive channel: 4 bytes.

- BER of the received signal: 4 bytes.

- Features of the cognitive radio node: 8 bytes. This is a placeholder to identify the capabilities of the cognitive radio nodes (TBC).

Assuming a rate of transmission of the message every 20 seconds and considering a population of maximum 500 cognitive radio nodes in the area, there would be an overall maximum throughput of 32 kbits:

$$((160 \times 8bits) \times 500nodes)/20 = 32Kbits/\text{sec}.$$

If one includes 10 % overhead for message integrity and security, the result is a maximum throughput of 35 Kbits/s. Based on these assumptions, a single spectrum of 100 kHz within the PPDR tuning range is proposed to be identified to enable cognitive PPDR radio systems.

The CPC bandwidth requirement - may be several times 0,1 MHz because of the probable need for nation-wide CPC coverage using some kind of cellular reuse pattern. Interesting questions arise:

- would the CPC carry the same information nation-wide? or

- would it carry information local to particular areas?

- The latter might allow lower bandwidth CPCs and finer-grained dynamic spectrum control, but would preclude the use of a nation-wide single frequency e.g. using quasi-sync technology.

There is a need to organize the information delivered over the CPC according to the geographical area where this information applies.

A difference can be made between two options differing on how they provide geographical related information:

- Mesh-based approach: The geographical area is divided in small zones, called meshes. In that case the CPC should provide network information for each one of these meshes, being possibly transmitted over a wide zone and therefore including a lot of meshes. Initial requirements evaluations seem to conclude that this solution could require a very high amount of bandwidth.

- Coverage area approach: In this approach, the concept of mesh is not needed in defining the CPC content, and the coverage area is provided via the BS of the PPDR technology.

Mesh-based approach

In this approach, the CPC operates in a certain geographical area subdivided into meshes. A mesh is defined as a region where certain radio electrical commonalities can be identified (e.g. a certain frequency that is detected with a power above a certain level in all the points of the mesh, etc.). The mesh is univocally defined by its geographic coordinates, and its adequate size would depend on the minimum spatial resolution where the above commonalities can be identified. The concept is illustrated in figure B.17, where, for simplicity, square meshes of identical dimension have been considered, although other approaches could exist based on e.g. dynamic definition of meshes with an adaptive size.

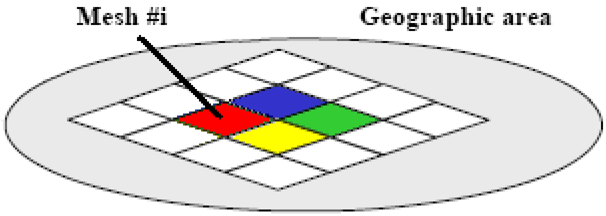


Figure B.17: CPC mesh-based approach

It can be logically inferred that there will be very likely little variations of the CPC information when moving from a given mesh to a neighbouring one. From this observation, a possible optimized implementation of the concept to reduce the required CPC bandwidth could be considered. The base station transmits all the information of a reference mesh and for the other meshes the network would send the identifier of the reference mesh together with the delta CPC information. The delta CPC information stands for the pieces of CPC information which differ from the information corresponding to the reference mesh. This includes the frequencies that appear or disappear in the present mesh with respect to the reference mesh. The network may determine the reference mesh as the one having the most commonalities in terms of CPC content. The mobile terminal infers the CPC information by decoding the information of the reference mesh and the delta CPC information corresponding to the mesh in which it is located.

Coverage area approach

In this approach the CPC content for a given geographical zone is organised taking into account the area, under-laying CPC umbrella, where such information has to be considered valid.

For instance, in case the CPC information is related to availability of a frequency, the CPC content will be organised e.g. per coverage area of each BS.

It is worth to be noted that knowing the position of the mobile terminal is not a strict requirement for the CPC operation using this approach, but a capability that enables higher efficiency in obtaining knowledge:

- in case positioning is not available, as long as the mobile terminal is able to receive the CPC information, the information about the different regions in that area are available;
- in case positioning is available, a subset of the information at the actual position could be identified. The mobile terminal could then use that information.

Annex C: Expected sharing and compatibility issues

C.1 Current ITU allocations

PPDR is considered as a radio application under the Land Mobile Service or under the Mobile Service.

Due to the broad range of frequencies covered, an excerpt of the European Common Allocation Table [i.7] is not reproduced here. Please see [i.7] for further details.

C.2 Coexistence issues

The following coexistence issues should be studied with the following systems in the band 300 MHz to 790 MHz:

- SAP/SAB (PWMS systems, including multichannel radiomicrophone receivers);
- TV Broadcasting (DVB-T);
- PMR/PAMR systems (narrowband and wideband);
- Military radio applications;
- radio astronomy service.

Special attention should be paid to the wideband noise characteristic of TETRA systems.

The first step towards harmonisation of a sub-band for fixed/mobile applications in the band 300 MHz to 862 MHz has been made in CEPT Report 22 [i.27] ("Report B" from CEPT to EC) for the range from 470 MHz to 862 MHz on the technical feasibility of harmonising a sub-band of Bands IV and V for mobile applications (including uplinks). In order to progress further with the non-mandatory harmonised introduction of fixed/mobile services in the band 300 MHz to 862 MHz, CEPT Report 23 (Complementary Report to "Report B") [i.27] listed a number of technical issues with regard to the range 470 MHz to 862 MHz requiring careful consideration. Any use of the harmonised sub-band for fixed/mobile services in the band 300 MHz to 790 MHz is subject to co-ordinated technical arrangements including the establishment of a common methodology for Administrations for cross-border co-ordination. In particular, band planning for Public Safety applications, including guard bands between the Public Safety broadband applications and broadcasting services as well as duplex gap and duplex spacing, need to be explored. The arrangements that are most suitable need to be identified.

ECC had started discussions in ECC TG 4 on CEPT Report 24 [i.27] ("Report C" from CEPT to EC) preparing a preliminary assessment of the feasibility of fitting new/future applications/services into non-harmonised spectrum of the digital dividend (namely the so-called "white spots" between allotments). The final CEPT Report 24 was adopted on 27 June 2008 by ECC and has been submitted to the EC.

Regarding interference to Public Safety broadband applications, as broadcast networks typically have high power/high tower transmitters, it is necessary to assess the interference from DVB-T to Public Safety broadband applications with all surrounding transmitters.

Where the information is available on link budget parameters and system compatibility the criteria for the tolerated interference to DVB-T remain to be defined. These criteria should be expressed in a way such that any degradation of the DVB-T service can be identified in terms of coverage loss. This could be in terms of coverage or in terms of field strength level, either evaluated over the whole coverage area or at the border only, and should define the type of assessment to be used (Minimum Coupling Loss, statistical methods, coverage percentages).

In several recent compatibility studies the HATA model and the ITU-R Recommendation P.1546 [i.16] model have been applied, but suitable propagation models, combining elements of both approaches, should be studied and agreed for the different interference scenarios.

Annex D: Public Safety Frequency Statement from 18 Countries

To the WG FM Workshop on Spectrum Harmonisation for Public Protection and Disaster Relief (PPDR) 11-12 March 2010 - Mainz (Germany)

The Police Corporation Working Group (PCWG) under The European Council started in 2008 the Radio Expertgroup as an initiative to assure future high-speed mobile data information. That coupled with the Council Decision 2008/615/JHA of 23 June 2008 to improve cross-border cooperation, particularly in combating terrorism and cross-border crime (the "Prüm" Decision) [i.65] means that common spectrum and a common standard will be required.

The PCWG initiative is supported by the Ministers of Justice and Interior of all 27 Member States who at the JHA Council meeting in Prague 4-5th June 2009 approved the Council Recommendation 10141/09 [i.33].

The Recommendation specifically RECOMMENDS that:

> "The Electronic Communication Committee (CEPT / ECC) be tasked to study the possibility of obtaining sufficient additional frequency allocation below 1 GHz for the development of future law-enforcement and public-safety voice and high-speed data networks.
>
> When needed and justified, and taking account of national arrangements for the distribution of spectrum, that Member States allocate additional frequencies at national level in a coordinated timeframe in cooperation with CEPT.
>
> That ministries responsible for police and justice be encouraged to contact their counterparts responsible for spectrum policy to ask for their assistance with the above proposal, given the important role of the national frequency administrations."

The Swedish Presidency established end 2009 two expert subgroups from the Radio Expertgroup as result of this Recommendation.

The "Forerunner Group" (for the long term solutions) met in March 2010 to expand on the user requirements.

This document is the first agreed output.

The Forerunner Group has following position:

1) The Group welcomed the initiative from CEPT/ECC to hold a workshop on Public Protection and Disaster Relief (PPDR) in Mainz 11-12 March 2010.

2) We recall that one of the objectives of the European Union is to strengthen operational cooperation between neighboring States in order to combat all forms of crime more effectively, thereby participating in the consolidation of the European Union.

3) We recall Council Decision 2008/615/JHA of 23 June 2008 on improving cross-border cooperation, particularly in combating terrorism and cross-border crime (the "Prüm" Decision) [i.65].

4) We recall Council Recommendation on improving communication between operational units in border areas, which was approved on 24 October 2008 (13796/08 ENFOPOL 181 COMIX 716) [i.66].

5) We recall that the Commission published on 5 March 2008, its Communication on "Reinforcing the Union's Disaster Response Capacity" [i.67]. The chapter on "Capacity building across Community policies and instruments" states that the enhancement of broadband and mobile communications for public protection and disaster relief services, as well as the opportunity to enable EU-wide interoperability, should be examined.

6) We note that the Spanish, Belgian and Hungarian Presidencies in their Justice and Home Affairs TRIO PRESIDENCY PROGRAMME from 4th January 2010 in section IX. Police and Customs cooperation states they will seek to enhance the interoperability between radio communication systems in the field of law enforcement. That demonstrates that the initiative taken by France and followed up by the Czech Republic and Sweden continues to receive good political support.

With that as a backdrop we note that:

1) Public Safety Service (PSS) organisations provide the community with indispensable police, fire and other emergency services. These services use spectrum for essential communication purposes. PSS organisations require reliable, high-availability and secure solutions provided by dedicated systems. Such systems should cover all necessary national geographic areas (local, regional, country) and allow PSS organisations to enable cross-border cooperation.

2) In order to fulfil their obligation to save lives and property, PSS organisations and their personnel require wireless access not only to voice and simple data services (narrowband) but also increasingly to wide-band and broadband data services. The ability to utilise these services requires more spectrum than the two 5 MHz-wide blocks currently harmonised across Europe.
Calculations in the present document show that approximately two additional 3 MHz-wide blocks are required for additional voice traffic, two 3 MHz-wide blocks are required for wide-band data traffic and two 10 MHz-wide blocks are required for future broadband data services.
These allocations should be Pan-European even though different parts of the same frequency bands might be utilised in each country.

3) PSS bring value to society by creating a stable and secure environment; this can only be done by building dedicated robust, secure and reliable modern Public Safety mobile communications networks.
Building these modern essential services requires a long project lead time, for example, today's national digital radio system for emergency services, often part of Critical National Infrastructure, typically have taken 10 years in planning before they became operational.

4) It is of utmost importance that CEPT/ECC decides that the PSS spectrum requirement - as a principle - will be met. A clear position to that question will establish the platform for the most cost effective solution.

5) Without trying to influence the work in CEPT/ECC, we want ideally to be able to re-use the antenna sites we have today for the existing narrow-band systems, also for future wideband and broadband systems. Spectrum in the lower end around 400 MHz will have a positive impact on cost of deployment.

Involved countries from the PCWG Radio Expertgroup gave permission to The Netherlands to bring the opinion described above to the attention of the PPDR workshop 11+12 March 2010 in Mainz.

This opinion is supported by Justice and Home affairs representatives from:
Belgium, UK, France, Spain, Finland, Italy, Poland, Portugal, Slovakia, Cyprus, Denmark, The Netherlands, Switzerland, Lithuania, Norway, Czech Republic, Austria, Germany (see note).

The Netherlands

8-3-2010

NOTE: In principle, Germany supports the initiative to increase the amount of spectrum available for PPDR services. The specific requirements on which the spectrum needs of the German PPDR are based have been identified in a study which will be presented at the workshop on 11-12 March 2010 in Mainz. Germany is in favor of identifying harmonized spectrum. Proposals will be elaborated in a second study.

Annex E: Information on recommendation on improving radio communication

Recommendations submitted by the Swedish Presidency:

"The Swedish Presidency of the EU would like to inform the ETSI that the Council in June 2009 approved Council Recommendations on improving radio communication between operational units in border areas.

In these recommendations, the European standardisation bodies are invited to start producing a European standard satisfying law-enforcement and public-safety services' operational requirements regarding high-speed data communication and roaming functionality in the medium term. In the long term, after the life cycle of the current TETRA and TETRAPOL systems has ended, a fully integrated solution could be envisaged."

Annex F: Bibliography

ECC Report 5: "Adjacent band compatibility between GSM and TETRA mobile services at 915 MHz".

Results from previous TA/TC-Tetra workshops on mobile data.

ETSI TC TETRA (11th to 13th March 2009): "Feedback from the TETRA future vision workshop"; document TETRA330914r2.

FP7 project on security EULER: "End-User requirements".

Directive 98/34/EC of the European Parliament and of the Council laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on information society services.

History

Document history		
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