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Foreword

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

Introduction

The purpose of producing the present document is to lay a foundation for industry to quickly bring innovative and useful products to the market while avoiding any harmful interference with other services and equipment.

These applications provide incident communication, data and location information exchange. The applications will be used temporarily by emergency services in all aspects of disaster situations, including disaster prevention and post event scenarios. Disaster prevention means that these systems may be temporary deployed (not necessarily used) during very exceptional and high-risk events. Infrequent usage during large extraordinary local incidents may also use broadband disaster communications. The equipment used for this is often the same as in disaster relief operations (PP(2)) usage as described in ITU-R Recommendation M.2033 [1]).

1 Scope

The present document describes the requirements for radio frequency usage for broadband disaster relief applications around 5 GHz.

PP(2) BB-DR systems might be combined with a location functionality. Such additional functionality will have to make use of a much wider frequency range to achieve sufficient accuracy/resolution and, as such, is outside of the scope of the present document.

The present document includes necessary information to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT).

Additional information is given in the following annexes:

- detailed market information (annex A);
- technical information (annex B);
- expected compatibility issues (annex C).

2 References

For the purposes of the present document the following references apply:

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

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

[3] ETSI EN 301 893: "Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[4] ETSI EN 302 502: "Broadband Radio Access Networks (BRAN); 5,8 GHz fixed broadband data transmitting systems; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[5] ITU-R Radio Regulations.

[6] 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".

[7] Draft IEEE 802.11s: "Draft Amendment to STANDARD [FOR] Information Technology-Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: IEEE 802.11 ESS Mesh".

[8] ITU-R Recommendation M.1390: "Methodology for the calculation of IMT-2000 Terrestrial spectrum requirements".

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

[10] CEPT/ERC/REC 74-01 Spurious emissions: "Unwanted Emissions in the Spurious Domain".

[11] ITU-R Recommendation SM.328: "Spectra and bandwidth of emissions".

[12] ETSI TS 170 001: "Project MESA; Service Specification Group - Services and Applications; Statement of Requirements (SoR)".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

ad-hoc network: mesh network or classical network with a manual or automatic reconfiguration of radio planning and of routing tables

NOTE: All these configurations are corresponding to ad-hoc networks. Ad-hoc networks are sometimes also designated as "Hastily Formed Networks", abbreviated in "HFN". The ad-hoc network would normally be torn down at the end of the emergency operation.

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

NOTE: Source: annex 2, clause 1.1 of ITU-R Recommendation M.2033 [1] as well as Resolution 646 [2].

disaster prevention: temporary deployment (not necessarily usage) of ad-hoc networks at very exceptional events in areas without fixed installations

NOTE: The system is not intended for use in areas permanently equipped for high-risk events, such as sports stadium.

emergency service: service, recognized 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

NOTE: As defined in European Commission Recommendation C(2003)2657.

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

3.2 Symbols

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

dB	deciBel
dBm	deciBel relative to one milliwatt

3.3 Abbreviations

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

BW	BandWidth
BB-DR	BroadBand Disaster Relief
CEPT	European Conference of Postal and Telecommunications administrations
BPSK	Binary Phase Shift Keyed
DFS	Dynamic Frequency Selection
DR	Disaster Relief
ECC	Electronic Communications Committee
EESS	Earth Exploration Satellite Services
e.i.r.p	equivalent isotropically radiated power
EMTEL	EMergency TELecommunications
FHSS	Frequency Hopping Spread Spectrum
FP6	Framework Programme 6
FS	Fixed Service
FSS	Fixed Satellite Service

FWA	Fixed Wireless Access
GNSS	Global Navigation Satellite Services
GSC	Global Standardization Collaboration
IDC	International Data Corporation
IST	Information Society Technologies
ITS	Intelligent Transport Systems
ITU-R	International Telecommunication Union - Radiocommunication sector
MAC	Media Access Control
MESA	Mobility for Emergency and Safety Application
MoU	Memory of Understanding
NATO	North Atlantic Treaty Organisation
OFDM	Orthogonal Frequency Division Multiplex
PHY	PHYsical layer
PP	Public Protection
PP(1)	Public Protection type 1
PP(2)	Public Protection type 2
PPDR	Public Protection and Disaster Relief
QPSK	Quadrature Phase Shift Keying
Rec	Recommendation
RF	Radio Frequency
RLAN	Radio Local Area Networks
RR	Radio Regulations
RTTT	Road Transport & Traffic Telematics
TETRA	TErrestrial Trunked RAdio
UWB	UltraWideBand
VoIP	Voice over Internet Protocol
WAS	Wireless Access Systems
WLAN	Wireless Local Area Network
WIDENS	WIreless DEployable Network System

4 Executive summary

The present document describes the spectrum requirements of broadband disaster relief communications equipment.

Disaster Relief (DR) emergency services require efficient rapid deployment of incident ad-hoc networks. Applications are used temporarily by emergency services in all aspects of disaster situations, including disaster prevention and post event scenarios. For instance, they provide incident communications, video or robotic data applications, telecommand and telemetry parameters, critical data base queries, field reporting, data and location information exchange.

The same equipment may also be used during extraordinary infrequent local incidents (PP(2)) applications as described in ITU-R recommendation 2033 [1]).

Users of such systems (e.g. fire-fighters) belong to a group of people having a very high risk associated with their work. Statistics show that it is comparable only to the coal extraction industry. There is evidence that such systems will significantly enhance the security and sustainability of life of persons involved in rescue measures and therefore will provide a socio-economic benefit.

4.1 Status of the present document

The present document was ETSI approved for publication in March 2006.

4.1.1 Statement from MINEFI - France

MINEFI-France does not support the inclusion of the 4 940 MHz to 4 990 MHz and 5,70 MHz to 5 850 MHz frequency bands due to expected incompatibility with existing primary radio services.

4.2 Related EC and other initiatives

A reference project supported by the European Commission under the IST Sixth Framework Programme (FP6) is WIDENS. This co-operative project involves European industries and universities. The overall objectives are to design, prototype and validate a high data-rate, rapidly deployable and scalable wireless ad-hoc communication system for future public safety, emergency and disaster applications.

In addition, the European Council recently issued a framework to improve security and efficiency of intervention for Civil Protection called the "Mechanism" (investigate the possibility of developing an EU rapid response capability to deal with disasters.

NOTE: See http://europa.eu.int/comm/environment/civil/pdfdocs/com_2005_137_en.pdf.

Inside ETSI, Special Committee EMTEL has the responsibility to capture user requirements for emergency communications (see TS 102 181 [9]). Technical committees developing standards for relevant technology include BRAN, ERM, MESA and TETRA.

Furthermore, through the joint partnership project MESA, ETSI is involved in defining and identifying systems that - inter alia - are designed for broadband DR (see TS 170 001 [12] from MESA).

The Global Standardization Collaboration (GSC) agreed on a common resolution on PPDR in support of future global standards for PPDR systems, including BB-DR. Identifying spectrum for BB-DR in Europe would be a step forward to achieve this objective.

NOTE: See http://www.itu.int/itu-t/gsc/index.html for GSC documents.

4.3 Technical system description

For detailed technical information, see annex B.

4.4 Market information

For detailed market information, see annex A.

5 Current regulations

There are no current regulations, i.e. no identification of frequency ranges, permitting the operation of broadband disaster relief applications in Europe. However, Resolution ITU 646 [2] encourages administrations to consider the designation of spectrum for BB-DR.

6 Proposed regulations

A tuning range from 4 940 MHz to 5 925 MHz is proposed within which one or more continuous frequency slots of 50 MHz out of the proposed candidate frequency bands in table 6.1 needs to be implemented for BB-DR applications by the National Regulatory Authorities. The important aspect of this proposal to be noted is that the designated frequency slot always be 50 MHz wide.

BB-DR applications may not claim protection like a radio service. However, the following elements of the proposal may result in a certain effective protection:

- the proposed power levels for BB-DR in table 6.2;
- the designation of more than one 50 MHz frequency slot (e.g. have a different frequency slot in areas with military usage).

The current DFS regulations are not considered to be appropriate for BB-DR because:

- the assumptions for developing DFS for WLANs were based on the high projected usage density which is not the case for BB-DR equipment. Consequently, the necessity of DFS for BB-DR to ensure coexistence with radars needs to be studied;

- the use of DFS may be incompatible with the inherent operational requirements for BB-DR (see also TS 170 001 [12]) certainly in countries where only the bands 5 470 MHz to 5 725 MHz and/or 5 725 MHz to 5 850 MHz will be available.

In consequence, the proposed candidate bands in table 6.1 without existing DFS requirements are considered as preferred frequency bands for BB-DR.

The following frequency ranges are proposed to be considered by the ECC for broadband disaster relief applications:

Table 6.1: Proposed candidate frequency bands to be considered

Candidate band	Remarks
From 4 940 MHz to 4 990 MHz.	In Europe, this frequency band is a NATO harmonized band type 1 for fixed and mobile usage. It is important to note that the band 4 940 MHz to 4 990 MHz has been selected in ITU-R Region 2 and Region 3 for BB-DR. There is no military usage of this band in the US, but only in the adjacent band below. Exceptional and very localized usage of this NATO band for BB-DR might be considered, in particular noting that military forces may be involved as well in disaster situations (joint civil/military disaster relief actions).
From 5 150 MHz to 5 250 MHz.	No coexistence issues with radars. WLAN indoor and power restrictions imposed for the protection of satellite feeder links may not apply to BB-DR because of the absence of any aggregation effects.
From 5 470 MHz to 5 725 MHz (see note 1).	E.g. used for outdoor WAS/RLANs, military systems, EESS (active), meteorological radars. It is expected that this band will be used heavily by WAS/RLAN in the future which may hinder the deployment of reliable BB-DR network in this specific band. Coexistence with radars may require the use of DFS as interference mitigation.
From 5 725 MHz to 5 875 MHz.	E.g. used for FWA, SRDs, ISM (see note 2), RTTT, military systems, fixed satellite applications. It is expected that this band will be used heavily by FWA in future which may hinder the deployment of reliable BB-DR network in this specific band. Coexistence with radars within 5 725 MHz to 5 850 MHz may require the use of DFS as interference mitigation.
From 5 875 MHz to 5 925 MHz.	In use for FS in some European countries, and FSS uplink. This band has already been proposed by ETSI to become harmonized in Europe for ITS vehicle-to-vehicle communications for applications in relation to road safety. Co-existence of ITS and BB-DR should be investigated taking into account the exceptional and very localized usage of BB-DR.
NOTE 1: Protection of ground based radars used for meteorological purposes (RR, Article 5, Footnote 5.452 [5]). NOTE 2: RR, Article 5, Footnote 5.150 [5].	

Technologies covered by EN 301 893 [3] for WAS/RLANs and EN 302 502 [4] for FWA may be used for Broadband Disaster Relief (BB-DR) Applications on channels within the proposed candidate bands as mentioned in table 6.1

The minimum total spectrum requirement in table 6.2 below is derived from the results from ITU-R Recommendation M.2033 [1] and in addition, from the fact, that some countries in ITU-R Region 2 and Region 3 have already been designated 50 MHz.

The following limits are proposed as input values for the discussions and considerations in ECC:

Table 6.2: Proposed regulations

Frequency band	Maximum mean power and mean power density (e.i.r.p.)	Duty cycle	Channel spacing	Remarks
As identified by ECC, a minimum spectrum requirement of 50 MHz is requested.	39 dBm 26 dBm/MHz (see note 2)	No restriction	No restriction	Temporary usage limited to emergency services in disaster relief situations.

NOTE 1: A licensing scheme which includes restrictions with regards to the potential users, i.e. emergency services, is proposed to the National Regulatory Authorities. Users may not claim protection from interference from other users within the same spectrum for this kind of application.

NOTE 2: Taking into account that the equipment will operate within a tuning range, the power level may depend on the frequency band implemented on the national level.

It should be noted that the FCC regulation allows power levels ranging from 29 dBm e.i.r.p. for a 1 MHz channel up to 42 dBm e.i.r.p. for a 20 MHz channel. APT (Asia-Pacific Telecommunity) recommends maximum conducted output power levels of 33 dBm (20 dBm/MHz) in combination with a maximum antenna gain of 26 dBi.

7 Main conclusions

There is a need for a frequency designation to enable broadband wireless applications to be used by emergency services (e.g. fire workers, police, civil protection authorities) in disaster situations and disaster prevention.

Especially, the socio-economic aspect regarding the enhancement of the security and sustainability of life of persons involved in rescue measures has to be considered. Operations performed in disaster situations may require a license issued to the emergency services. International collaboration may require a license regime as simple as possible (e.g. no coordination needed).

Harmonization of spectrum usage has two key advantages in this area. Firstly, cross border circulation of terminals in disaster situations is a critical issue and secondly, economy-of-scale in production line will decrease equipment manufacturing costs. In addition, these aspects are covered in the considerings of Resolution ITU 646 (WRC 03) [2] and are also of special importance for developing countries. The concept of the proposed tuning range defined in the present document is considered to be in support of the above findings.

8 Expected ECC and ETSI actions

ETSI requests ECC to consider the present document, which includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT).

It is proposed that ECC considers the proposed regulation in clause 6 and identifies the tuning range and the frequency bands to be included in the tuning range for BB-DR.

It is proposed that the ECC will create a new ECC Decision designating radio spectrum for the broadband disaster relief applications described in the present document in order to facilitate cross-border issues and also international collaboration in disaster situations. It is understood that BB-DR will have to share the radio spectrum with other services or applications already existing. A license regime as simple as possible is needed to support:

- rapid deployments;
- international/ cross-border collaboration;
- avoiding cross-border interference issues and unauthorized use.

NOTE: ETSI would appreciate if the ECC would be able to finalize the new deliverable(s) by the end of 2006 or early 2007.

Annex A: Detailed market information

A.1 Applications

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

Broadband technology and its related applications could be seen as a natural evolutionary trend from wideband applications for Public Protection (PP) and Disaster Relief (DR) technology and applications. The broadband technology is especially important for disaster relief applications.

The infrequent nature and localized areas of disasters means that RF spectrum for Disaster Relief (DR) applications could utilize a frequency band used by other users, on the basis that these users accept loss of service in the affected area during disasters. This is different from narrowband and wideband PPDR communications requiring larger coverage, e.g. for normal daily public protection usage (described as PP(1) in ITU-R Recommendation M.2033 [1]).

A research on applications and potential users was carried out by IDC in 2005.

Potential users were identified as the police, fire service, emergency medical services, local authority, civil protection forces, etc.

Disaster Relief applications and examples are also depicted in annex 2 (tables 2 and 3) of ITU-R Recommendation M.2033 [1].

The technologies for BB-DR are basically IP-based broadband networks that support voice, data and other supplementary services and facilities.

Mobile ad-hoc self-forming / self-healing networks provide high speed connectivity among the users and/or vehicles enabling voice, video, and data applications over one network.

The primary application will still be voice communications (e.g. VoIP). Focusing on the broadband applications will enable these user groups 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 DR 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 Mbit/s to 100 Mbit/s) with channel bandwidths dependent on the use of spectrally efficient technologies.

Examples of possible applications include:

- the ability to transfer video data back to incident commanders to make faster and more informed decisions;
- high-resolution video communications from wireless clip-on cameras to a vehicle-mounted laptop computer with automatic detection based on reference images, hazardous material or other relevant parameters;
- point-to-point data communications, e.g. accessing architectural plans of buildings, location of hazardous materials;
- 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;
- an indoor location application with high accuracy;

- simultaneous use of several different applications like interactive location data, critical care, vehicle status, layout maps, list of identified/missing persons, security, telemetry, etc.

The main benefits for emergency services are:

Fire / Rescue

- Location:
  - Staff safety monitored indoor or outdoor. Staff can be quickly identified, located and extracted from dangerous situations.
  - Users can instantly determine their own location.
  - Improved management of resource tracking and staff positioning.
- Physical /RF resilience:
  - Self healing / Self forming, reliability around obstacles, failed devices and RF interference. Immunity achieved through multiple data channels and intelligent re-routing for continuous communications.
  - Lowering the need for redundant / duplicate equipment.
- Always connected:
  - Continuous link to control staff and management commands.
- Rapid deployment:
  - Instant networks formed by just turning on the device.
  - Improves efficiency, instantly deployable self-forming broadband communications.
- Broadband capacity:
  - Faster solutions:
    - Real time video surveillance feeds (to and from moving vehicles or staff).
    - Send and receive body sensors (biometrics).
    - Interdepartmental communications, e.g. real time mobile access to building plans.
  - Improved resilience and reduced costs:
    - Instant incident communications, with mobile data, video and voice services.

Initial time-to-market in Europe for the equipment is planned for the end of 2006. It should be noted that such equipment is already placed on other markets outside of Europe in countries having an existing regulation in place.

NOTE: Asia Pacific made the decision in September 2005 to implement the use of the band from 4 940 MHz to 4 990 MHz for PPDR application. In the US while the 700 MHz band was reallocated for additional Public Safety spectrum (2x12 MHz) in 1998, the actual implementation stated in 2004. Further the US allocated the 4 940 MHz - 4 990 MHz in 2004 according to the Resolution ITU 646 [2].

In conclusion, TS 102 181 [9] from ETSI EMTEL, TS 170 001 [12] from Project MESA and ITU-R Recommendation M.2033 [1] all cover various aspects of user requirements including security aspects, safety aspects, requirements on digital air interface protocols, and spectrum usage. However, it is to be noted that most of these requirements are neutral to the frequency usage. They impose requirements on the communications protocol rather than mandate a specific frequency usage.

A.2 Market size

The volume for the European target market for ad-hoc wireless broadband systems is estimated by the proponents to be in the range of 300 000 users (only emergency services users). It is assumed that a typical ad-hoc wireless communication and location system would consist of around 25 user devices and 25 wireless routers, coupled with incident command location software, and 10 mobile cameras. Other ad-hoc systems designed for instant response would be similar in design, but with greater emphasis on back office connection to data bases and data type devices.

A.2.1 Markets covered

The primary markets initially targeted are in Europe, North America and in the developed Asian region. Trial networks are already in operation in the US and in Asia.

Fire and Rescue market segments have been chosen in order to clarify the numerous application possibilities. The market for the system can be arbitrarily expanded in different directions, for example:

Fire and Rescue

- Personnel protection and surveillance with panic alarm.
- Surveillance personnel.
- Respirator wearers (fire departments and civil protection).
- Thermal image video capture and transmission.
- Asset tracking.

Police rapid response / SWAT

- Asset tracking.
- Personnel protection and surveillance.
- Video surveillance.
- Perimeter Zone Control: a "circle of steel" that will track all cars coming in and going out of a fixed location. Smaller deployment of the system targeted at a specific street. This allows for highly targeted deployment in areas of high social, political or economic concern.
- Data Capture and Control Devices: a broad portfolio of edge devices to capture or deliver data to the point of decision.
- Back office Applications: a suite of software products and services that enable the business functions in each area.

A.2.2 Market forecast

The initial market penetration within the first 4 years is estimated to not exceed 20 % of the target market in any case. This would assume 60 000 users in 2 400 ad-hoc systems.

Research carried out by IDC in 2005 categorized user applications and user groups into the following groups: fire services, police and emergency medical services.

The research shows market sizing on the emergency services within a number of European markets. It is forecast that a sub sect of these groups would be users for ad-hoc wireless broadband networks. Fire services would represent about 50 % of the total demand.

A.3 Traffic evaluation

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

The minimum bandwidth requirement for BB-DR in the following example is based on results from ITU-R Recommendation M.2033 [1]:

A scenario of a large fire in a high rise building:

- Hot-spot area: 1 km2.
- No. of Fire-fighters: 20.
- No. of robots: 5.

Corresponding spectrum calculation:

The basic equations using the Rec. ITU-R Recommendation M.1390 [8] methodology. Anticipating a single BB-DR hot spot, the results show a spectrum need of 50 MHz.

Annex B: Technical information

B.1 Detailed technical description

Broadband Disaster relief networks consist of small local ad-hocly installed instant networking and self-forming networks.

Communication links normally provide physical layer link speeds of 2 Mbit/s up to 8 Mbit/s under harsh (hostile) and mobility conditions. For security, there is a multiple layer security approach implied. The networks are typically end-to-end fully IP-addressed. All clients in the network are fully meshed and provide multi-hopping with nets working with up to 500 clients (depending on the disaster size).

Current developed chipsets work with the frequency range from 4,8 GHz to 6 GHz.

An adaptive transmit protocol optimizes data throughput and radio link reliability by using:

- Predicts Power and Data Rate on per Packet Basis.
- Deals with Asymmetric Wireless Links.
- Maximizes Link Performance while managing Battery/RF Power.
- Manages links to neighbouring network elements.

Technologies such as those covered by EN 301 893 [3] for WAS/RLANs and draft EN 302 502 [4] for FWA may be used for Broadband Disaster Relief (BB DR) applications.

In addition, a new air interface protocol standard IEEE 802.11s [7] is currently under development in IEEE for meshing.

The new standard will address issues not present in traditional IEEE 802.11 [6] networks, such as multi-hop topology and link quality determination over multiple hops. RF radio conformance standardization in ETSI will make use of this new air interface protocol for BB-DR equipment.

Table B.1.1: System parameters

Parameter	Value	Comments
Frequency stability	10 ppm	This figure takes account of the frequency tolerance, together with the expected doppler variation from mobile operations.
Maximum radiated mean power	39 dBm eirp	Operating distance up to 1 000 m (i.e. hot spot radius).
Antenna beam shape/gain	N/A	No beam shape is specified. The user will specify a beam shape in accordance with the coverage required by the set of applications to be supported, or the manufacturer will offer a number of antenna options.
Examples of typical Modulation schemes	BPSK, QPSK, 16-QAM, 64-QAM, OFDM	Modulation schemes currently used by broadband wireless air interfaces.
Typical data rates	2 Mbit/s up to 8 Mbit/s physical layer	Depending on the channel bandwidth.
Typical Channel Bandwidth (examples, other channel bandwidths may also be of use)	1,75 MHz, 5 MHz, 10MHz or 20MHz	Possible channel plans (avoiding band edges): 1) 8 x 5 MHz channels; 2) 4 x 10 MHz channels; 3) 6 x 5 MHz and 1 x 10 MHz channel; 4) 4 x 5 MHz and 2 x 10 MHz channel; 5) etc.
Communication mode	Half Duplex, Full Duplex, broadcast	Duplex and broadcast are believed to be adequate for the applications considered to date.
Typical minimum sensitivity , BER, noise figure etc.	-80 dBm (8 Mbit/s)	Depending on channel width (-80 dBm @ 20 MHz channel, -86 dBm @ 5 MHz channel).

Finally, the outgoing communication links are managed e.g. by TETRA, satellite communications or other solutions, i.e. the used equipment may consist of multiple radio interface devices.

B.2 Limits for RF parameters

The requested maximum mean power limit (e.i.r.p.) and the mean power density (e.i.r.p.) are shown in table B.2.1.

Table B.2.1: Maximum e.i.r.p. values

Maximum e.i.r.p. values	
Maximum mean power	39 dBm
Mean power density	26 dBm/MHz

B.3 Technical justification

The result of a simple link budget calculation is shown in figure B.3.1 to justify the required in-band level.

For the e.i.r.p as proposed in table B.2.1 communication ranges up to 1 000 m can be supported. The actual communication range depends on the data rate and the environmental conditions. Severe impacts are expected from the physical properties of the communication channel, e.g., line-of-sight or non-line-of-sight conditions. However, at the proposed carrier frequency the path loss is unduly influenced by weather conditions such as rain, snow, and dust.

To justify the requested e.i.r.p a detailed link budget has been evaluated which is presented in the following summary. From this analysis it follows that an e.i.r.p of 39 dBm is required to achieve a transmission range of up to 1 000 m for typical environments with sufficient link quality.

For the link budget calculation we assume omni-directional roof antennas with an antenna gain of 3 dBi. This assumption is proper for all kind of situations.

For the calculations a carrier frequency of 5,9 GHz or, equally, a wave length of 5,08 cm is assumed.

Table B.3.1: Minimum receiver sensitivity for a BW of 10 MHz

Data Rate (Mbits/s)	Minimum Sensitivity (dBm)
3	-85
4,5	-84
6	-72
9	-80
12	-77
18	-70
24	-69
27	-67

The proposed PHY and MAC is akin to IEEE 802.11a using a BW of 10 MHz. The link budget calculated here assumes data rates and minimum receiver sensitivities shown in Table B.2. The data rates are gross values for all possible combinations of symbol alphabets (i.e. BPSK, QPSK, 16QAM, 64QAM and OFDM symbol constellation) and code rates (i.e. ½-rate and ¾-rate code). The minimum receive sensitivity specifies the required receive input power (i.e. at the antenna connection) including an implementation margin of 5 dB for a receiver noise figure of 10 dB and a BER of 10^{-5}. Error correction techniques are used.

Link Budget

The link budget is calculated in dBm as:

$$P_e = P_s + G_s + G_e + L;$$

where P_e is the received power in dBm, P_s is the transmit power in dBm, G_s is the transmit antenna gain in dBi, G_e is the receive antenna gain in dBi, and L is the path loss in dB. Note that e.i.r.p = $P_s + G_s$. To account for the increased path loss coefficient, the total path loss is split up into two contributions:

$$L = L_0 + L_1;$$

Where:

$$L_0 = 20 \log \left(\frac{\lambda}{4\pi d_0} \right);$$

is the path loss in dB up to the breakpoint d_0 = 15 m where free space transmission is given and:

$$L_1 = 10 \log \left(\frac{d}{d_0} \right)^n;$$

is the path loss in dB from distance d_0 to d assuming a path loss coefficient n = 2,7.

For an e.i.r.p = 39 dBm, $G_s = G_e$ = 3 dBi, and d = 1 000 m we obtain a received power of P_e = - 76 dBm. Comparing P_e with the minimum receive sensitivities in table B.3.1, we obtain that for the requested e.i.r.p data rates of 3 Mbit/s and possibly 4,5 Mbit/s can be supported over a range of about 1 000 m. Note that for an e.i.r.p = 30 dBm as specified for 5 GHz WLAN this communication range cannot be achieved.

Finally, note that for BB-DR typical non-line-of-sight conditions it is well documented for mobile communications that the path loss coefficient is in the range $n \approx 3$ to 5. E.g. assuming n = 4, e.i.r.p = 39 dBm, and a data rate of 3 Mbit/s a maximum communication range of 480 m is obtained. Note that some margin must be assumed to reflect operations at very harsh conditions etc.

BB-DR systems might be combined with a location functionality. Such additional functionality will have to make use of a much wider frequency range to achieve sufficient accuracy/resolution and, as such, is outside of the scope of the present document.

Possible examples may use FHSS or impulsive modulated UWB technologies. Other solutions, achieving a somewhat lower accuracy may rely on data conveyed from/to other systems, such as GNSS.

Annex C: Expected compatibility issues

C.1 Coexistence issues

It must be stressed that the application is only to be used by emergency services on a temporary basis at a given disaster situation/location.

When necessary, the antenna of the reference stations may not be omnidirectonal and could be directly aligned towards the building / hot spot centre in which the rescue or disaster relief measure is carried out. This will facilitate sharing with other existing radio services or applications.

In addition, automatic dynamic power control may be used in wireless devices to enhance battery-life and consequently, risk of interference might be lowered.

C.1.1 Current allocations in the proposed frequency bands

The following radio services are allocated in the frequency band proposed for studying for operation of the BB-DR application equipment:

Table C.1.1.1: European Common Allocations and Applications in the proposed frequency bands for study

From 4 940 MHz to 4 990 MHz	HARMONISED MILITARY SERVICES FOR FIXED AND MOBILE SYSTEMS SAP and SAP SERVICES	
From 5 150 MHz to 5 250 MHz	Fixed Satellite (Earth-to-space) Mobile	Feederlinks Hiperlans (from 5 150 MHz to 5 350 MHz)
From 5 470 MHz to 5 570 MHz	MARITIME RADIONAVIGATION MOBILE except aeronautical mobile EARTH EXPLORATION-SATELLITE (active) SPACE RESEARCH (active) RADIOLOCATION	Maritime radar (from 5 250 MHz to- 5 725 MHz) Radiolocation (civil) (from 5 250 MHz to 5 725 MHz) Radiolocation (military) (from 5 250 MHz to 5 725 MHz) Tactical radar (from 5 250 MHz to 5 725 MHz) Weather radar (from 5 250 MHz to 5 850 MHz) WLANs (from 5 470 MHz to 5 725 MHz)
From 5 570 MHz to 5 650 MHz	MARITIME RADIONAVIGATION MOBILE except aeronautical mobile RADIOLOCATION	Maritime radar (from 5 250 MHz to 5 725 MHz) Radiolocation (civil) (5 250 MHz to 5 725 MHz) Radiolocation (military) (from 5 250 MHz to 5 725 MHz) Tactical radar (from 5 250 MHz to 5 725 MHz) Weather radar (from 5 250 MHz to 5 850 MHz) WLANs (from 5 470 MHz to 5 725 MHz)
From 5 650 MHz to 5 725 MHz	MOBILE except aeronautical mobile RADIOLOCATION AMATEUR SPACE RESEARCH (deep space)	Maritime radar (from 5 250 MHz to 5 725 MHz) Radiolocation (civil) (from 5 250 MHz to 5 725 MHz) Radiolocation (military) (from 5 250 MHz to 5 725 MHz) Tactical radar (from 5 250 MHz to 5 725 MHz) Weather radar (from 5 250 MHz to 5 850 MHz) HIPERLANs (from 5 470 MHz to 5 725 MHz) Amateur (from 5 660 MHz to 5 670 MHz) Amateur-satellite (from 5 660 MHz to 5 670 MHz) WLANs (from 5 470 MHz to 5 725 MHz)
From 5 725 MHz to 5 830 MHz	ISM FIXED-SATELLITE (Earth-to-space) RADIOLOCATION	Weather radar (from 5 250 MHz to 5 850 MHz) Amateur Radiolocation (military) (from 5 725 MHz to

	AMATEUR MOBILE	5 850 MHz) ISM (from 5 725 MHz to 5 875 MHz) Non-specific SRDs (from 5 725 MHz to 5 875 MHz) RTTT (from 5 795 MHz to 5 805 MHz)
From 5 830 MHz to 5 850 MHz	ISM FIXED-SATELLITE (Earth-to-space) RADIOLOCATION AMATEUR MOBILE AMATEUR SATELLITE (space-to-Earth)	Weather radar (from 5 250 MHz to 5 850 MHz) Radiolocation (military) (from 5 725 MHz to 5 850 MHz) ISM (from 5 725 MHz to 5 875 MHz) Non-specific SRDs (from 5 725 to 5 875 MHz) Amateur-satellite
From 5 850 MHz to 5 925 MHz	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	ISM (from 5 725 MHz to 5 875 MHz) Non-specific SRDs (from 5 725 MHz to 5 875 MHz) FSS Earth stations (from 5 850 MHz to 6 700 MHz)

C.1.2 Implication on radio services outside the proposed frequency band

Out-of-band emissions as defined in ITU-R Recommendation SM. 328 [11] at the band edges (i.e. the total frequency band identified for BB-DR) will not exceed -20 dBc. The BB-DR equipment will also fulfil spurious emission limits according to ERC Recommendation 74-01 [10].

C.1.3 Duty cycle

No duty cycle restriction is proposed since typical usage includes applications that run continuous transmissions, e.g. video applications.

C.2 Current ITU-R allocations

BB-DR communications are considered as an land mobile application.

C.3 Sharing issues

Sharing is required with all radio services allocated within the proposed frequencies of which some may be identified by the ECC.

The following technical aspects need to be taken into account as these will decrease the probability of interference with the existing radio services:

- the usage of BB-DR applications by emergency services is exceptional. It is only deployed at a specific location to relieve a disaster or to prevent one occurring. Its deployment is therefore limited both in time and location.

History

Document history		
V1.1.1	July 2006	Publication