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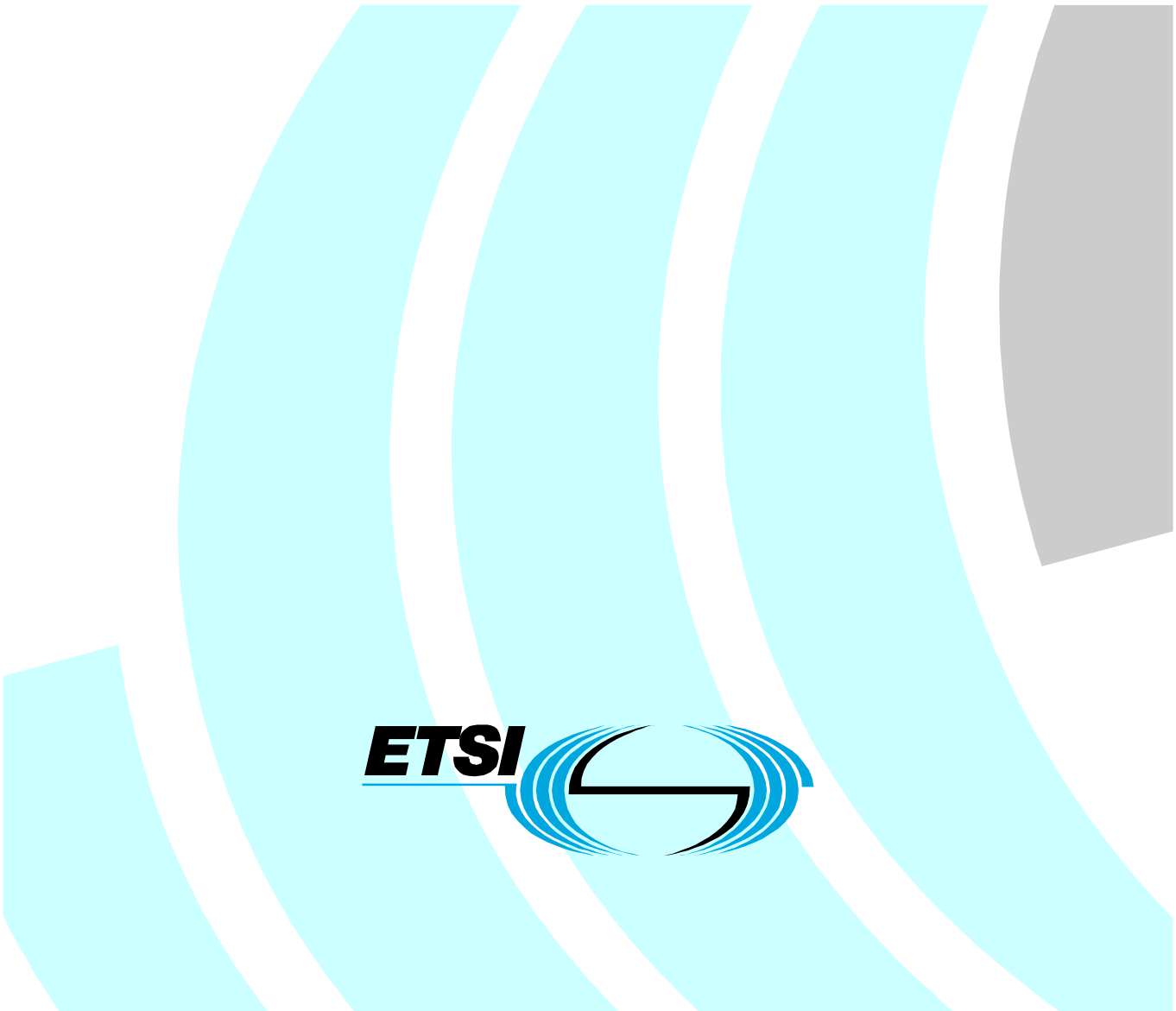
Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for indoor Location Application for Emergency Services (LAES) in disaster situations operating within the frequency range from 3 GHz to 5 GHz; System Reference Document



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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

The present document covers applications for a short range indoor location system using radio frequency within the range from 3 GHz to 5 GHz. The system will be used by emergency services in disaster situations.

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.

1 Scope

The present document defines the requirements for radio frequency usage for a short range indoor location application to be used by emergency services (e.g. fire workers, police, civil protection authorities) in disaster situations and operating within the frequency range from 3 GHz to 5 GHz.

It includes necessary information to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post 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] VDI, Ministries for Domestic Affairs/Security, TÜV.

[2] http://www.thw.de.

[3] Berlin Senat Administration for Domestic Affairs; http://www.berlin.de/SenInn/Abteilungen/OeS/a.html

[4] http://www.bka.de , Federal Bureau of Criminal Investigation Dept. LS2 Public Relation.

[5] CEPT/ERC Report 25: "The European Table of Frequency Allocations and Utilisations Covering the Frequency Range 9 kHz to 275 GHz", Lisboa January 2002 - Dublin 2003 - Turkey 2004 - Copenhagen 2004.

[6] EFIS, www.ero.dk.

3 Definitions, symbols and abbreviations

3.1 Definitions

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

commander: central unit of the system, which receives position related data from locators and references via a communication link

NOTE: The data will be processed and stored for documentation in the commander and displayed on its screen.

cycle time: period beginning with the transmission of the master reference signal and ending with the reception of the last locator's signal by the reference

duty cycle: proportion of time during which a component, device, or system is operated

NOTE: The duty cycle can be expressed as a ratio or as a percentage. In regulations, the duty cycle is normally defined as the ratio of the transmitter on-time to within one hour. In other terminologies, activity factor is also used which reflects the effective transmission time ratio. In the present document, duty cycle and activity factor are identical.

locator: transceiver connected to the moving target (e.g. fire fighter) which receives range signals from the master reference station

NOTE: It is connected to the commander by a communication link.

master reference station: transmitter at a fixed position during the time of operation, transmitting range signals and connected to the commander by a communication link

necessary bandwidth: width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions

slave reference station: reference station triggered by the master reference and located at the snap point

snap point: it defines the starting point of an operation

transmission time: time within one cycle where signals are transmitted

3.2 Symbols

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

C	Commander unit
dB	deciBel
dBm	deciBel relative to one milliwatt
DX	Distance of a locator from the reference station in x-direction (related to a arbitrary Cartesian co-ordinate system with the master reference as origin
DY	Distance of a locator from the reference station in y-direction (see above)
L	moving locators
M	master reference
R	repeater station
S	slave reference
t_{on}	starting time of a pulse group
t_{off}	ending time of a pulse group

3.3 Abbreviations

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

BKA	BundesKriminalAmt
CEPT	European Conference of Post and Telecommunications administrations
ECC	Electronic Communications Committee
e.i.r.p	equivalent isotropically radiated power
INS	Inertial Navigation Systems
ITU-R	International Telecommunications Union - Radio sector
LORAN	LOng RAnge Navigation
MoU	Memory of Understanding
PMR	Professional Mobile Radio
PSD	Power Spectral Density
REC	RECommendation
RF	Radio Frequency
SNR	Signal to Noise Ratio
SRD	Short Range Device
TDMA	Time Divison Multiple Access
TETRA	TErestrial Trunked RAdio
THW	Technisches HilfsWerk

4 Executive summary

The present document describes a new, indoor, short-range location application using short direct-pulsed modulation in disaster situation, i.e. at reference points which are not known in advance. Consequently, fixed installations of equipment are not needed.

The system is normally ad-hoc installed with two reference points outside of the building at the disaster location and provides accurate positioning information of objects or persons from the inside of the building affected by disaster.

There is evidence that such a system will significantly enhance the security and sustainability of life of persons involved in rescue measures and therefore will provide a socio-economic benefit.

The objective of designers and operators of the location equipment is to use direct signals preferably within buildings during operations in disaster situation. Significant radiation into the air is not intended so that perturbations of other radio services can be excluded as far as possible.

A high precision in range measurement is required. This means that the required signals necessarily demand short pulse length resulting in a high bandwidth to provide the required accuracy. In addition, a high signal power must be required in order to enable the penetration of obstacles (walls, etc.).

4.1 Status of the present document

An earlier version of the present document was created in ERM TG31-LAA in April 2005, following the adoption of the new ETSI work item at ERM#25 in March 2005. ERM RM#30 (3-6 May 2005) approved the present document for submission to ECC-TG3 for consideration and to ERM#26 for approval for publication.

4.1.1 Statement from France Telecom

At this stage, France Telecom expresses its reservations concerning the proposed emission powers levels (0 dBm/MHz) and proposed unwanted emissions (see table B.2.1, which shows values which France Telecom consider to be insufficient to protect other services).

France Telecom would also like to understand how individual licensing or general licensing should be applied for the three bullets reproduced below from the clause A.2.1 on market covered. France Telecom understands that licensing regime for respirator wearers applications is possible, but it seems difficult for the other applications.

- personnel protection;
- surveillance personnel;
- respirator wearers (fire departments and civil protection).

4.2 Technical system description

For detailed technical information, see annex B.

4.3 Market information

For detailed market information, see annex A.

5 Current regulations

There are no current regulations permitting the operation of this new, short range, location application in Europe.

6 Proposed regulations

The following limits are proposed as input values for the ongoing discussions and considerations in ECC-TG3:

Table 6.1: Proposed regulations

Frequency band	Maximum average power density	Duty cycle	Channel spacing	ECC Deliverable	Notes
3 GHz to 5 GHz	0 dBm/MHz	0,0001 %	No spacing	An ECC/REC is proposed in order to achieve harmonization. Operations performed in disaster situations under individual licenses issued to authorities are expected (see note).	1) Use limited to emergency services in disaster relief situations. 2) The antenna of the reference stations is not omnidirectonal and will be directly aligned towards the building in which the rescue or disaster relief measure is carried out. 3) Dynamic power control is used at the reference stations with a dynamic range of at least 60 dB.
NOTE: National Regulatory Authorities may decide whether an individual licensing scheme or a general licensing scheme (which includes e.g. a restriction with regards to the potential users, i.e. authorities, etc.) should be applied.					

7 Main conclusions

There are requirements for radio frequency usage for a short range, indoor, location application to be used by emergency services (e.g. fire workers, police, civil protection authorities) in disaster situations.

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 under individual licenses issued to emergency services are expected.

8 Expected ECC and ETSI actions

It is proposed that ECC considers the proposed regulation in clause 6.

Therefore, 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 Post and Telecommunications Administrations (CEPT).

A new ETSI Technical Specification that will include the air interface protocol, RF conformance requirements and location service specifications will be created by the end of 2005.

Annex A:
Detailed market information

A.1 Applications

The dominant application for the equipment described in the present document is an indoor location application to be used by emergency services (police, fire workers, civil protection authorities, etc.).

The main benefits for these authorities are:

- high indoor availability within buildings affected by disaster;
- very high positioning accuracy, presently unknown from other technologies (e.g. satellite-based, triangulation, beacons, LORAN C pulses);
- no fixed installations required (ad-hoc reference stations).

Altogether, based on figures from insurance agencies for several metropolitan areas in Europe, it can be forecasted that the application might save up to 100 lives per annum European-wide.

Initial time-to-market for the equipment is planned for the end of 2006.

A.2 Market size

The volume for the European target addressable market is estimated by the proponents to be in the range of 50 000 systems, each equipped with about 10 devices (i.e. a system consists of 2 reference stations and 8 locators).

A.2.1 Markets covered

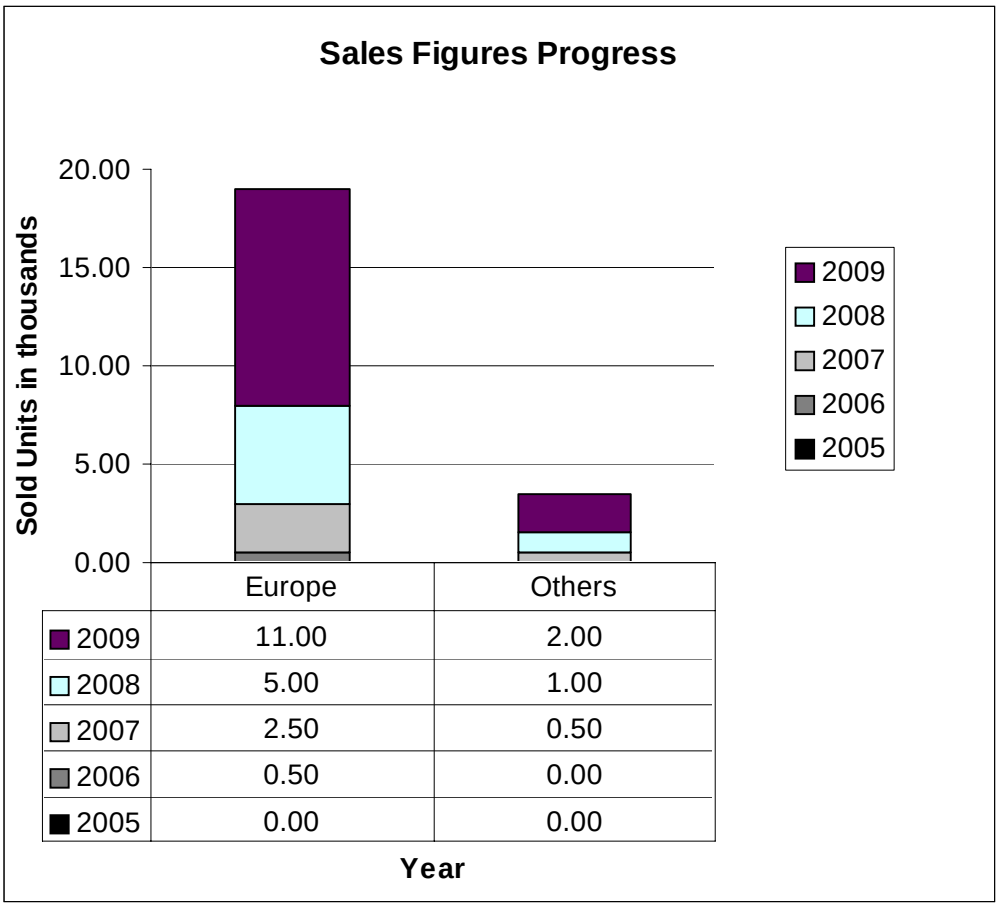
The primary market targeted is the EU market, however discussions have already shown that there is high interest for this technology in many other countries, and steps are being taken by the proponents to explore a number of markets and regulatory processes.

Exemplary 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:

- Personnel protection.
- Surveillance personnel.
- Respirator wearers (fire departments and civil protection).

A.2.2 Market forecast

The initial market penetration within the first 4 years is estimated to not exceed 20 % of the target addressable market in any case.



	Europe	Others
2009	11.00	2.00
2008	5.00	1.00
2007	2.50	0.50
2006	0.50	0.00
2005	0.00	0.00

Figure A.2.2.1: Sales Figures Progress (2005-2009)

A.2.2.1 Fire Brigade in Germany

In Germany, for example, the clients to be considered for the system are first of all fire departments which are financed by cities and communities. 330 000 of the approx. 1,5 million fire fighters are respirator wearers. Analyzed, it matches a total need of 82 500 systems.

Table A.2.2.1.1: Fire Departments in Germany

Specification	Quantity
Professional Fire Brigades	97
Plant Fire Departments	3 000
Voluntary Fire Brigades	14 300
Respirator Wearers	328 900
Fire Stations	39 000
Total of all Fire Fighters (voluntary/professional)	**1,5 Million**
NOTE: Sources: Federal Yearly Report, TÜV Publications, Ministry for Education, Research and Technology, VDI Center for Technology, Federal Office for Bundesanstalt für Labor Protection and Labor Medicine.	

A.2.2.2 German Technical Support Force (THW)

The Technical Support Force in Germany (Technisches Hilfswerk, THW [2]) maintains nationwide 810 technical "platoons" with 40 active helpers each. Each platoon can be expanded for short periods of time with 20 additional reserve helpers. Each platoon is built from a command troop, two salvage troops and eventually a professional locating troop. Nationwide exist approx. 2 500 relevant groups (810 command troops, 1 620 salvage troops, 66 professional locating troops).

Each of these units operates with an average of 5 persons. An optimal equipping of all the groups makes a need of approximately 2 500 units.

A.2.2.3 Police

The Berlin Police Department [3] alone employs approximately 28 000 employees in more then hundreds of stations and administrative units. The budget volume for personnel, resources, administration and technique stands currently at approximately € 1,15 Billions a year. Especially for special operations, which run under aggravated conditions, this application can be helpful.

It is assumed that 50 systems might be required e.g. in Berlin. Extrapolated to Germany a need of about 250 devices can be estimated. Assuming that European-wide there will be a need 20 times bigger than in Germany, the resulting total addressable market in Europe might be up to 5 000 systems.

A.2.2.4 Federal Bureau of Criminal Investigation in Germany

The Federal Bureau of Criminal Investigation (BundesKriminalAmt, BKA [4]) in Germany contributes actively to the maintenance of the domestic security, together with the federal and country police departments as well as by cooperating with the foreign law enforcement agencies. The Federal Bureau of Criminal Investigation has been assigned the job of protecting the members of the Federal Constitution Elements. The use of the most modern technical resources such as special protected vehicles, weapons technology or a special communication and telecommunication technology is indispensable.

The BKA controls a pool of several hundreds of special trained officers, who are assigned for special tasks in groups of 4 to 6 persons.

A.2.2.5 "Smoke Jumpers"

The "Smoke Jumpers" are an elite troop of the American fire brigades, who are assigned to embank forest fires. They are dropped off from a chopper with parachutes in the center of a fire region in order to open, with axes and chain saws, passages in the forest to avoid an additional spread of the fire. Contrary to the urban fire fighters, they try to embank the fire, rather then to extinguish it. Smoke Jumpers are assigned for tasks in outlying regions such as Alaska, which are hardly accessible from ground.

Although there is yet no such comparable special unit in many European Countries, we shall point to this special market segment. There are approximately 200 teams in the USA, which can be equipped with the system.

However, investigations from insurance agencies have proven the existence of a significant cost saving benefit of such a system. Therefore, it might be assumed that authorities will require the mandatory use of such a system in certain disaster relief situations.

A.3 Traffic evaluation

The equipment will be used only at disaster situations. It is assumed that one system normally consists of two reference stations and 8 mobile devices. The pulse length does not exceed a duration of 250 picoseconds, and the location information is updated three times per second.

Based on the above assumptions, it can be assumed that the maximum duty cycle at the disaster situation during the rescue measure does not exceed under any circumstances 0,0001 % with some margin. This includes the transmitter off-time between pulse sequences.

The usage density of the systems, e.g. within one city, is considered to be low. Even in the biggest European cities, it can be assumed that only a very low number of systems is operated simultaneously.

Annex B:
Technical information

B.1 Detailed technical description

The short range, location application described in the present document uses short direct-pulsed spread spectrum modulation with pulse length in the order of 250 picoseconds. The short pulse length is needed for the provision of the required positioning accuracy of objects inside buildings, which is less than one meter. The use of direct pulsed spread spectrum modulation is aimed at position finding. In addition, the modulation is characterized by on-/off- keying, e.g. single pulses are removed from individual pulse sequences.

The positioning information is updated at a frequency of three updates per second.

As a result of the short pulse length, a bandwidth of about 2 GHz within the frequency range from 3 GHz to 5 GHz is needed.

The maximum operating distance (in-buildings) that is required by emergency services is 75 meters.

The spread spectrum modulation provides the primary source for indoor positioning. The system will consist of two mobile reference stations (transmitter/receiver). The first station positioned on a point close to the building works as master reference. A second station (slave reference) is located at the snap point which will set up a baseline for two dimensional positioning of the target inside the building (locator), which is also equipped with an spread spectrum modulated mobile station (see figure B.1.1). The path of the locator (represented by the orange line in figure B.1.1) will be tracked by the reference stations by range measurements with update rates of 3 Hz or lower (dependent on the specific situation. The range data as well the locator identification is sent to the commander where the positions of the locators are computed and displayed. If more targets are positioned in the building, an "ad hoc" network can be established (see figure B.1.2) using e.g. two locators as reference for a third one (this can be handled due to the slow motion of the locators). For 3D positioning, a third reference station would be needed (which can be one of the locators).

As a new feature, the transmitter of the reference stations broadcasts with variable transmitting power, which can be adapted to the specific operational conditions (dynamic power control). In this way an adjustment of the transmission to the environmental conditions is enabled while on the other side the impact on existing radio services and applications can be avoided as far as possible.

The required maximum average transmitting power (e.i.r.p.) of 0 dBm/MHz is required for this system to achieve a good performance for positioning in case of obstruction by walls, etc. However, the following technical measures and conditions will mitigate the impact of the high transmitting power on other radio services:

- usage only permitted for emergency services;
- a very low, required duty cycle of less than 0,0001 %;
- temporary operation at disaster locations only;
- dynamic power control with a dynamic range of 60 dB;
- propagation area limited by reference stations using directional antennas achieved by electronic beam shaping.

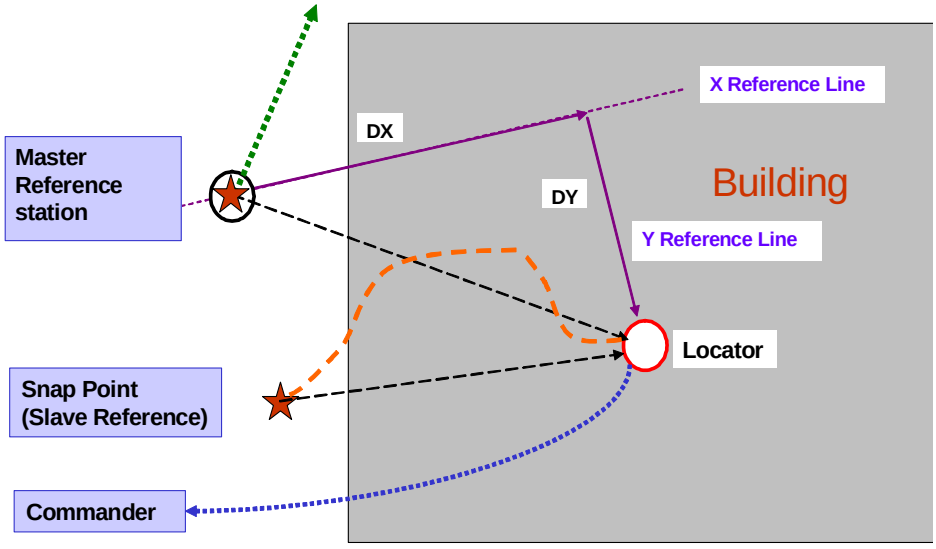
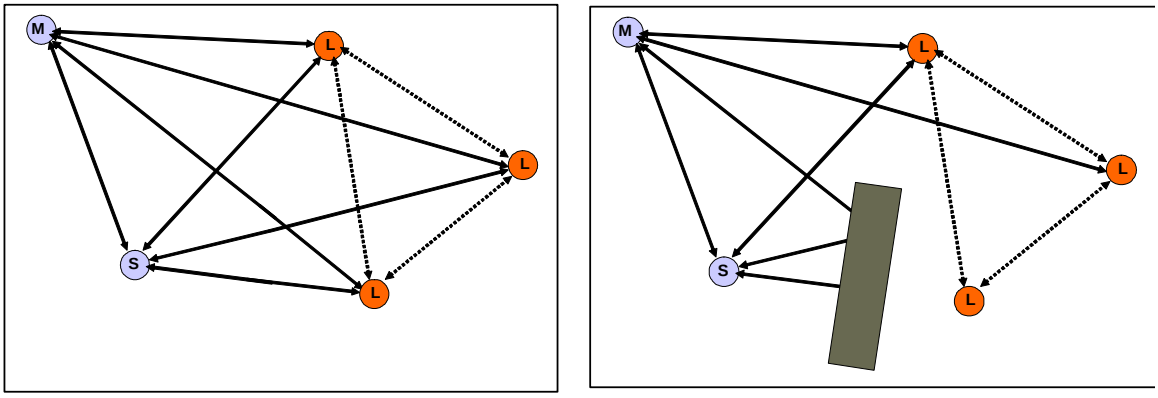


Figure B.1.1: Components of 2D positioning



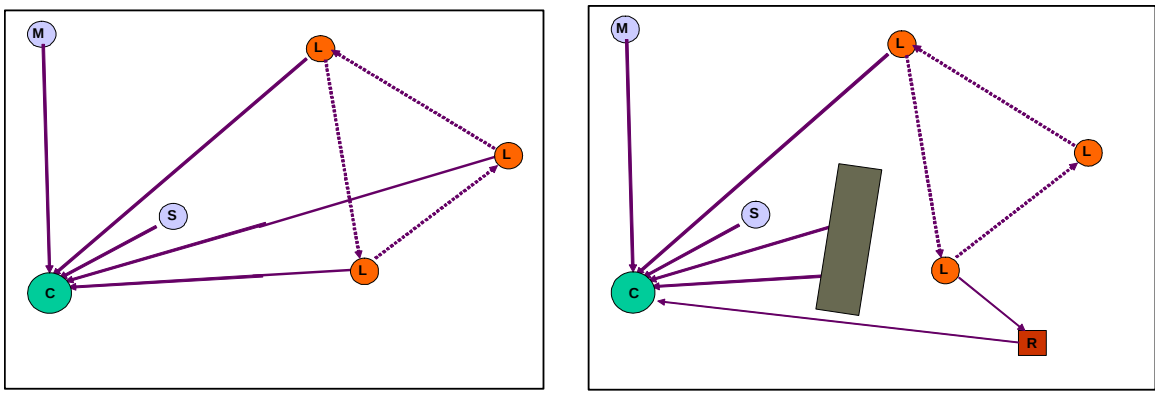
(a) without blocking **(b) with blocking**

Figure B.1.2: Positioning Network with/without blocking

Figure B.1.2 shows schematically the signal paths of the positioning network for 2D measurements. If a free line of sight exists between the master reference (M), the slave reference (S), and the moving locators (L), then direct links can be used to measure the travel times of the signal from the references to the locators and vice versa. In this way the ranges of the locators with respect to the references can be determined, and a two dimensional position can be calculated.

In the case of blocking by walls etc. (as in figure B.1.2b), the system uses range signals (achieved by measurement of the signal travelling time) which are transmitted between the locators. Thus, the position of locators can be determined using the 'mobile network' (see also above) where the locators calculate their positions from all stations received (references and other locators). The position determination will be less accurate with increasing time, however, in this way a gap can be bridged until the visibility of the reference is given again. As a further consequence, the required average transmitting power can be limited.

The system can also be combined with the LORAN-C (100 kHz long wave H-field component) long-range positioning system.



(a) without blocking **(b) with blocking**

Figure B.1.3: Communication Network with/ without blocking

Finally, the communication links (e.g. TETRA) are shown in figure B.1.3. The data needed for position calculation are transmitted to a commander unit (C) where the data processing is performed. For this, communication existing PMR systems will be used.

As shown in figure B.1.3, a bi-directional communication among the locators is established. This is preferably used when the signal path to the commander is disturbed so that the complete data sets of all locators can be transmitted using an undisturbed link from one locator to the commander. For particular difficult environments, it is planned to also use a repeater station (R) for communication (see figure B.1.3b).

The system described here can be seen as a part of a general multiple sensor concept which combines radio navigation components used for global, regional and local positioning with other sensor systems, such as Inertial Navigation Systems (INS) or velocimeters. In addition, communications links and e.g. sensors for measurements of environmental conditions can also be provided. The system is based on a modular concept, so that the components can be combined arbitrarily dependent on the specific application. Figure B.1.4 shows this general concept for the multiple sensor system. The components framed by the red lines define the current development.

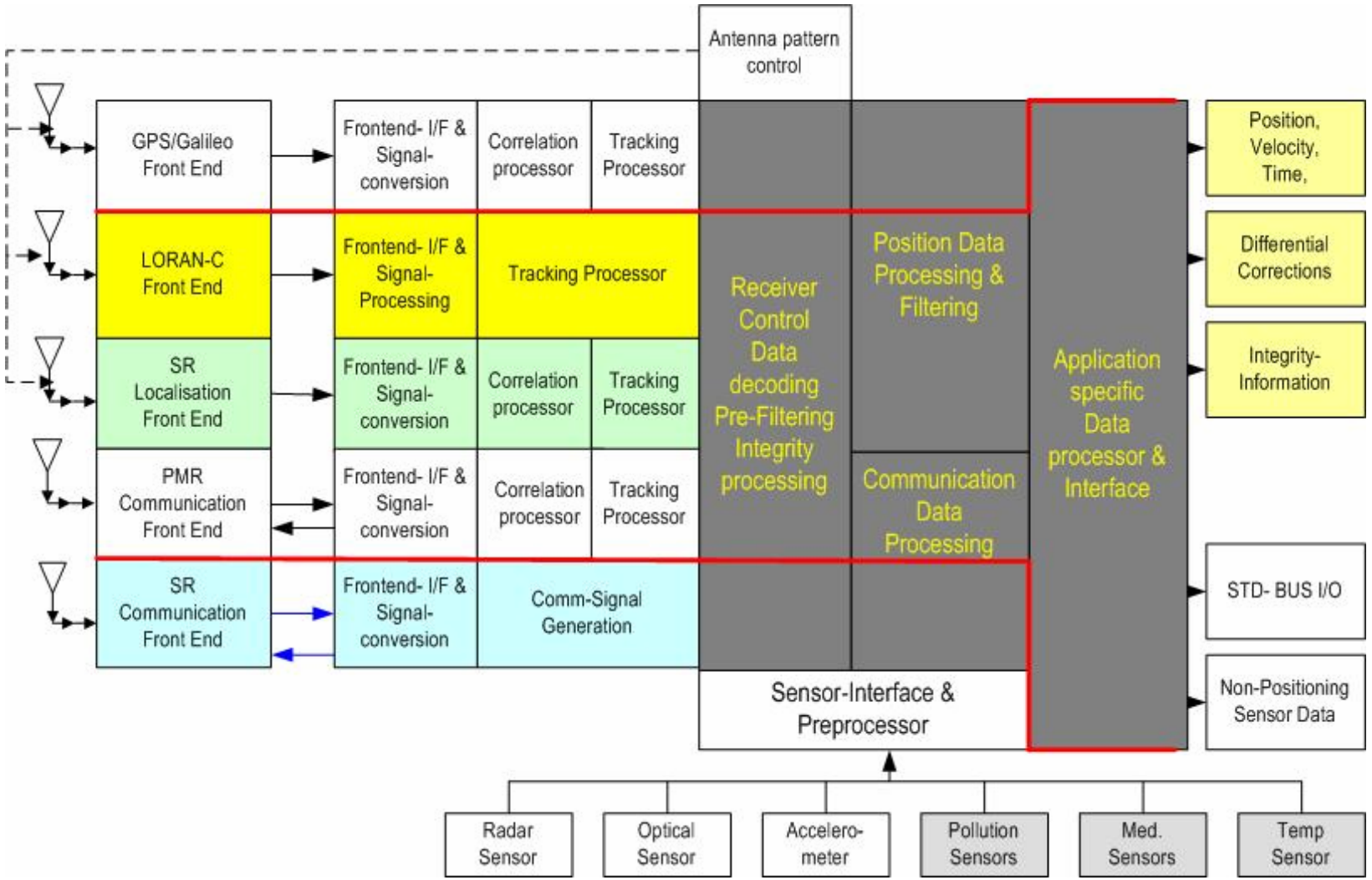


Figure B.1.4: Enhanced Multiple Sensor Concept

B.2 Limits for RF parameters

The requested maximum average power limits (e.i.r.p.) are shown in table B.2.1.

Table B.2.1: Maximum average power (e.i.r.p.)

Parameter	Limit
Frequency range for intended emissions	3 GHz to 5 GHz
Maximum average power (e.i.r.p.) spectral density during transmission time of each transmitter (5,5 nsec)	0 dBm/MHz
Maximum average power (e.i.r.p.) spectral density during transmission cycle time of a system with 20 locators and 2 reference stations (1 290 nsec)	-10 dBm/MHz
Maximum average power (e.i.r.p.) spectral density created by a system with 20 locators and 2 reference stations during update time (1/3 sec)	-65 dBm/MHz
Maximum average power (e.i.r.p.) spectral density during update time of each transmitter (1/3 sec)	-78 dBm/MHz
Maximum average power (e.i.r.p.) spectral density outside the frequency range from 3 GHz to 5 GHz	-60 dBc/MHz (i.e. 60 dB below the above values, e.g. maximum average power during transmission time does not exceed –70 dBm/MHz)
NOTE: This does not include the additional mitigation provided by the use of dynamic power control and antenna beam shaping.	

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.

The penetration loss of 25 dB is given as the average of values achieved by experiments performed e.g. within the DARPA program and by theoretical calculations [add reference]. This loss will be typical for environmental effects in large offices. Thus, the calculation shows that a maximum average power (e.i.r.p.) spectral density of 0 dBm/MHz is required.

The required (relative) accuracy has to be lower than 1 meter. This can be achieved only by the use of SRD using GHz-frequencies. In this way, measurements of signal travelling times measurements are possible which have an accuracy in the range of less than one nanoseconds (1nsec = 30 cm).

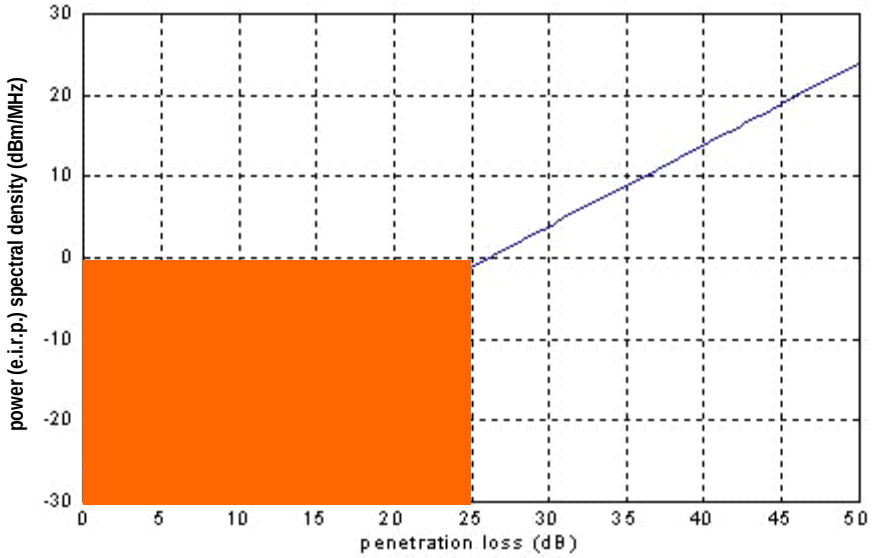


Figure B.3.1: Estimation of maximum average power (e.i.r.p.) spectral density needed for positioning service (model: SNR = 10 dB, Environmental Temperature = 310 K, Distance = 30 m); assumption is a penetration loss of 25 dB

Annex C:
Expected compatibility issues

C.1 Coexistence issues

The operators routinely will also operate with a GPS/Galileo and/or LORAN-C antenna mounted directly upon device, so that the all the available positioning information of the operator can be accurately and automatically recorded. 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.

The antenna of the reference stations is not omnidirectonal (electronic beam shaping is used) and will be directly aligned towards the building in which the rescue or disaster relief measure is carried out. This also will decrease the risk of interference to other existing radio services. In addition, automatic dynamic power control is used.

C.1.1 Current allocations in the frequency band from 3 GHz to 5 GHz

The following radio services are allocated in the frequency band proposed for operation of the location application equipment.

Table C.1.1.1: European Common Allocations and Applications in the 3 GHz to 5 GHz band

Frequency band	European Common Allocation [5]	Applications [6]
2900 - 3100 MHz	RADIOLOCATION RADIONAVIGATION 5.426 5.424A EU2 5.425 5.427	Aeronautical navigation Radiolocation (civil) Radiolocation (military) (2900,0 - 3500.0 MHz)
3100 - 3300 MHz	RADIOLOCATION Earth Exploration-Satellite (active) Space Research (active) 5.149 EU2	Radiolocation (military) (2900,0 - 3500.0 MHz) Active sensors (satellite)
3300 - 3400 MHz	RADIOLOCATION 5.149 EU2	Radiolocation (military) (2900,0 - 3500.0 MHz)
3400 - 3500 MHz	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE Amateur Radiolocation	Radiolocation (military) (2900,0 - 3500.0 MHz) Amateur Fixed links SAP/SAB and ENG/OB (3400,0 - 3600.0 MHz) Point-to-Multipoint (3400,0 - 3800,0 MHz)
3500 – 3600 MHz	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE	SAP/SAB and ENG/OB (3400,0 - 3600.0 MHz) Point-to-Multipoint (3400,0 - 3800,0 MHz) Fixed links
3600 – 4200 MHz	FIXED FIXED-SATELLITE (space-to-Earth)	Point-to-Multipoint (3400,0 - 3800,0 MHz) FSS Earth stations Point-to-Point
4200 – 4400 MHz	AERONAUTICAL RADIONAVIGATION 5.438 5.440 EU18	Altimeters Earth exploration-satellite
4400 – 4500 MHz	FIXED MOBILE EU2 EU27	Point-to-Point (4400,0 - 4800,0 MHz) Defence systems (4400,0 - 5000,0 MHz) SAP/SAB and ENG/OB (4400,0 - 5000,0 MHz)
4500,0 – 4800,0 MHz	FIXED FIXED-SATELLITE (space-to-Earth) 5.441 MOBILE EU27	Point-to-Point (4400,0 - 4800,0 MHz) Defence systems (4400,0 - 5000,0 MHz) SAP/SAB and ENG/OB (4400,0 - 5000,0 MHz) FSS Earth stations

Frequency band	European Common Allocation [5]	Applications [6]
4800 – 4990 MHz	FIXED MOBILE except Aeronautical Mobile Radio Astronomy 5.149 EU27 5.339	Defence systems (4400,0 - 5000,0 MHz) SAP/SAB and ENG/OB (4400,0 - 5000,0 MHz) Passive sensors (satellite) Continuum measurements (4800,0 - 5000,0 MHz) VLBI observations (4800,0 - 5030,0 MHz)
4990 – 5000 MHz	FIXED MOBILE except Aeronautical Mobile RADIO ASTRONOMY 5.149 EU27	Defence systems (4400,0 - 5000,0 MHz) SAP/SAB and ENG/OB (4400,0 - 5000,0 MHz) Continuum measurements (4800,0 - 5000,0 MHz) VLBI observations (4800,0 - 5030,0 MHz)

5.149 In making assignments to stations of other services to which the bands:
…
3 260-3 267 MHz,
3 332-3 339 MHz,
3 345.8-3 352.5 MHz,
4 825-4 835 MHz,
4 950-4 990 MHz,
4 990-5 000 MHz,
…
are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 4.5 and 4.6 and Article 29).

5.339	The bands 1 370 - 1 400 MHz, 2 640 - 2 655 MHz, 4 950 - 4 990 MHz and 15.20 - 15.35 GHz are also allocated to the space research (passive) and earth exploration-satellite (passive) services on a secondary basis.
5.424A	In the band 2 900-3 100 MHz, stations in the radiolocation service shall not cause harmful interference to, nor claim protection from, radar systems in the radionavigation service. (WRC 03)
5.425	In the band 2 900 - 3 100 MHz, the use of the shipborne interrogator-transponder system (SIT) shall be confined to the sub-band 2 930 -2 950 MHz.
5.426	The use of the band 2 900 - 3 100 MHz by the aeronautical radionavigation service is limited to ground-based radars.
5.427	In the bands 2 900 - 3 100 MHz and 9 300 - 9 500 MHz, the response from radar transponders shall not be capable of being confused with the response from radar beacons (racons) and shall not cause interference to ship or aeronautical radars in the radionavigation service, having regard, however, to No. 4.9 of these Regulations.
5.438	Use of the band 4 200 - 4 400 MHz by the aeronautical radionavigation service is reserved exclusively for radio altimeters installed on board aircraft and for the associated transponders on the ground. However, passive sensing in the earth exploration-satellite and space research services may be authorized in this band on a secondary basis (no protection is provided by the radio altimeters).
5.440	The standard frequency and time signal-satellite service may be authorized to use the frequency 4 202 MHz for space-to-Earth transmissions and the frequency 6 427 MHz for Earth-to-space transmissions. Such transmissions shall be confined within the limits of 2 MHz of these frequencies, subject to agreement obtained under No. 9.21.
5.441	The use of the bands 4 500-4 800 MHz (space-to-Earth), 6 725-7 025 MHz (Earth-to-space) by the fixed-satellite service shall be in accordance with the provisions of Appendix 30B. The use of the bands 10.7-10.95 GHz (space-to-Earth), 11.2-11.45 GHz (space-to-Earth) and 12.75-13.25 GHz (Earth-to-space) by geostationary-satellite systems in the fixed-satellite service shall be in accordance with the provisions of Appendix 30B. The use of the bands 10.7-10.95 GHz (space-to-Earth), 11.2-11.45 GHz (space-to-Earth) and 12.75-13.25 GHz (Earth-to-space) by a non-geostationary-satellite system in the fixed-satellite service is subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non-geostationary-satellite system in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the fixed-satellite service operating in accordance with the Radio Regulations, irrespective of the dates of receipt by the Bureau of the complete coordination or notification information, as appropriate, for the non-GSO FSS systems and of the complete coordination or notification information, as appropriate, for the GSO networks, and No. 5.43A does not apply. Non-geostationary-satellite systems in the fixed-satellite service in the above bands shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated.
EU2	Civil-military sharing
EU18	This aeronautical radionavigation band shall be subject to further study to ascertain future requirements and developments.
EU27	A frequency band that is in general military use in Europe and identified for major military utilization in the ECA. Such a frequency band forms a basis for military use and planning. The band can be shared between civil and military users according to national requirements and legislation.

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

The unwanted emissions of the equipment outside of the frequency range from 3 GHz to 5 GHz is 60 dB/MHz below the maximum average power (e.i.r.p.) spectral density inside the frequency band from 3 GHz to 5 GHz (as given in table B.2.1), provided also by additional out-of-band filtering or optimization of the pulse train. Operation takes place only as a temporary measure at a disaster location performed by emergency services.

C.1.3 Duty Cycle

The system uses a very low duty cycle, and therefore the duty cycle is considered as important mitigation factor to achieve coexistence. The following system description depicts typical system parameters for the pulse signal. It is to note that the calculations take into account a system with 20 locators, whereas the commercial assumption in annex A is an on-average number of 8 locator devices per system.

Table C.1.3.1: System parameters for pulse signal for one network with two references and 20 locators, covering a maximum distance of 75 m, with an update rate for positioning = 3 Hz

Parameter	Value
Pulse sequence	10 pulses
Pulse duration	0,2431 nsec (corresponding to a bandwidth of 2 GHz)
Pulse repetition interval	0,5 nsec
Broadcast technique	TDMA

Thus the following values can be calculated.

Table C.1.3.2: Time frames for transmissions within one network with two references and 20 locators, covering a maximum distance of 75 m, with an update rate for positioning = 3 Hz, and using pulse parameters given in table C.1.3.1

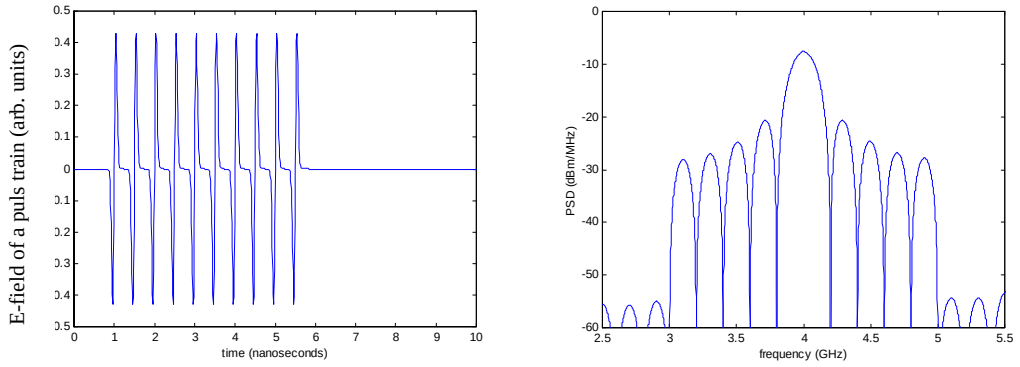
Parameter	Value
Master reference signal pulse group duration	5,5 nsec
Slave reference signal pulse group duration	5,5 nsec
Time delay to slave	10 nsec
Signal travelling time to locator	≤ 250 nsec
Locator n internal time delay n=1 to 20	500 +10 × (n-1) nsec
Duration of 20 locator signals to master	110 nsec
Duration of 20 locator signals to slave ref	110 nsec
Signal travelling time from locator to master references	≤ 250 nsec
Overall cycle time for 20 locators	1 290 nsec
Overall transmission time	110 nsec

The quotients between the different time periods and the resulting maximum average power can be seen in the table C.1.3.3.

Table C.1.3.3: Duty cycle and maximum average power spectral density of one network with two references and 20 locators, covering a maximum distance of 75 m, with an update rate for positioning = 3 Hz, and using pulse parameters given in table C.1.3.1

Parameter	value
Percentage of transmission to cycle time	8,5271 %
Update time of the system	1/3 sec
Percentage of transmission to update time (relevant for the duty cycle)	3,3e-005 %
Maximum average power spectral density during transmission time of each transmitter (5,5 nsec) (e.i.r.p.) (see note)	0 dBm/MHz
Maximum average power (e.i.r.p.) spectral density during transmission cycle time of a system with 20 locators and 2 reference stations (1 290 nsec)	-10 dBm/MHz
Maximum average power (e.i.r.p.) spectral density created by a system with 20 locators and 2 reference stations during update time (1/3 sec)	< -65 dBm/MHz
Maximum average power (e.i.r.p.) spectral density during update time of each transmitter (1/3 sec)	< -78 dBm/Mhz
NOTE: Peak to average ratio does not exceed a typical value of 5 dB (10 log (t_{on} / (t_{on} + t_{off})) of a single pulse.	

Figure C.1.3.1 shows a single pulse train as well as the non-optimized power spectral density (PSD).



(a) pulse train **(b) power spectral density**

Figure C.1.3.1: Pulse train and power spectral density

C.2 Current ITU-R allocations

There is no current ITU-R allocation corresponding to these devices. The present document assumes operation according to a provision of the Radio Regulations (RR4.4), that does not require any new allocation (i.e. on a non-protected basis and causing no harmful interference).

C.3 Sharing issues

Sharing is required with all radio services allocated within the frequency range of 3 GHz to 5 GHz.

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

- operation takes place only as a temporary measure at a disaster location and is performed by emergency services under individual licensing;
- only a very low duty cycle of less than 0,0001 % is required,
- dynamic power control with dynamic range of 60 dB is used,
- the propagation area is limited by reference stations using directional antennas, i.e. the emission is only directed to the building in which the locators (indoor) are in operation,
- the locators are predominantly used only indoors.

History

Document history		
V1.1.1	June 2005	Publication