CEPT ECC
Electronic Communications Committee

ECC Report 201

Compatibility study between MBANS operating in the 2400 - 2483.5 MHz and 2483.5 - 2500 MHz bands and other systems in the same bands or in adjacent bands

September 2013

0 EXECUTIVE SUMMARY

This report deals with the analysis of the compatibility between Medical Body Area Network Systems (MBANS) and other systems operating in the same or adjacent frequency band. It has been developed in response to ETSI system reference document TR 101 557 [1].

The ETSI system reference document suggested ECC to consider a total spectrum portion of 40 MHz within the 2360-2500 MHz range for use by MBANS, of which 30 MHz was intended for use in healthcare facilities. However the studies in this report have been deliberately carried out in the 2400-2500 MHz range.

Three MBANS categories are considered by the studies: Healthcare facility, ambulance and home MBANS. Healthcare facility MBANS are restricted to indoors. Ambulance MBANS are for use only inside the vehicle. Home MBANS are intended for indoor use (inside the patient's home), however they can be occasionally outdoors (few meters away from home). No mitigation technique(s) has been considered for the co-existence studies given in this Report. The compatibility results presented are to be understood in such context. Mitigation measures such as adaptive frequency selection, listen-before-talk, adaptive power control and other features may improve the compatibility of MBANS with other systems and are subject to future work. Table 1 below, summarizes the results of the compatibility studies, mainly based on average-case SEAMCAT simulations, for all scenarios and considered frequency bands.

Table 1: Overview of risk of interference for the various co-existence scenarios

<table>
<tr><th colspan="2"></th><th colspan="3">Risk of interference from MBANS</th></tr>
<tr><th colspan="2">MBANS category</th><th>Healthcare facility MBANS</th><th>Home MBANS</th><th>Ambulance MBANS</th></tr>
<tr><th colspan="2">Tx-power, DC</th><th>1 mW, 10% DC</th><th>20 mW, 2% DC</th><th>1 mW, 10% DC</th></tr>
<tr><th colspan="2">Description of MBANS application and restriction</th><th>Only indoor, within healthcare facility</th><th>Primarily indoor, within patient home. Occasionally outdoor, few meters from home</th><th>Only inside vehicle</th></tr>
<tr><td rowspan="3">2400 – 2483.5 MHz</td><td>Wideband Data</td><td>Very low</td><td>Very low</td><td>Very low</td></tr>
<tr><td>Amateur and Amateur Satellite</td><td>Low</td><td>Medium
(Note 1)</td><td>Low</td></tr>
<tr><td>BWS (adjacent LTE below 2400 MHz)</td><td colspan="3">Low
(Note 1, Note 3)</td></tr>
<tr><td rowspan="6">2483.5 – 2500 MHz</td><td>LP-AMI</td><td>Medium
(Note 2)</td><td>Low</td><td>Medium
(Note 2)</td></tr>
<tr><td>MSS</td><td>Low
(Note 4)</td><td>Very low</td><td>Very low
(Note 5)</td></tr>
<tr><td>CGC</td><td>Low</td><td>Very low</td><td>Very low
(Note 5)</td></tr>
<tr><td>RNSS/RDSS</td><td>Low</td><td>Low</td><td>Low</td></tr>
<tr><td>SAP/SAB</td><td>Low</td><td>Low</td><td>Low</td></tr>
<tr><td>Wideband Data (adjacent)</td><td>Very low</td><td>Very low</td><td>Very low</td></tr>
</table>

		Risk of interference from MBANS		
MBANS category		**Healthcare facility MBANS**	**Home MBANS**	**Ambulance MBANS**
Tx-power, DC		**1 mW, 10% DC**	**20 mW, 2% DC**	**1 mW, 10% DC**
Description of MBANS application and restriction		**Only indoor, within healthcare facility**	**Primarily indoor, within patient home. Occasionally outdoor, few meters from home**	**Only inside vehicle**
	BWS (adjacent LTE above 2500MHz)	Low (average case) High (specific case)	MBANS indoor: Low (average case) High (specific case) MBANS outdoor: Low/Medium (avrg.) High (specific case)	Low (average case) High (specific case)

Risk of interference or average bitrate degradation:

- very low: ≤1 %
- low: >1 %, ≤5 %
- medium: >5 %, ≤10 %
- high: >10 %

Note 1: The impact of existing systems operating in accordance with Annex 1 and Annex 3 of ERC/REC 70-03, such as WLAN systems, are expected more critical than MBANS interference.

Note 2: Interference mitigation measures will be needed. The future MBANS ETSI standard may specify some means of detecting LP-AMI for improving coexistence.

Note 3: Even though it was suggested to use the entire 2400-2500 MHz band for MBANS, the 2400-2410 MHz portion of this range was excluded from the studies in order to improve adjacent band coexistence with the BWS system to be operated in the 2300-2400 MHz band.

Note 4: The impact of healthcare facility MBANS to Globalstar fixed terminals used for emergency back-up communications inside the hospital premises was not specifically studied in Section 5.3.1. Such use of Globalstar is reported in one administration. The CGC study results (Section 5.4.1) may however be applicable to such situation, leaving the conclusions unaltered.

Note 5: The impact of ambulance MBANS to Globalstar terminals used for emergency back-up communications inside the same ambulance vehicle was not studied. Such use of Globalstar is reported in one administration.

For the 2400-2483.5 MHz band the compatibility study results suggest that wideband data systems (WLAN) could significantly interfere with MBANS deployed in hospitals and patient homes. However, inside the premises of health care facilities, which are commonly operated and controlled by the facility management, there could be some possibility to coordinate the MBANS and WLAN channels. The practicality of implementing such approach is unclear, as the proponent industry observed in own hospital surveys that the 2400-2483.5 MHz band may be too crowded, unpredictable, and not easily manageable by hospitals. Additionally, there may be a medium risk of interference from home MBANS into amateur systems in the lower part of the band (2400-2450 MHz), but it should be noted the impact of existing WLAN systems is expected to be more critical than MBANS interference.

The studies conducted in the 2483.5-2500 MHz band showed that MBANS can coexist with the existing systems using the band except for

- LP-AMI: Co-channel compatibility between MBANS and LP-AMI in healthcare facilities is not given, since significant interference levels are expected, even when both systems are operated in different rooms;
- adjacent BWS systems, if MBANS are used outdoors

However, it is assumed that mechanism(s) for MBANS and LP-AMI to detect each other when operated in close proximity, or other measures, could address the issue of compatibility between MBANS and LP-AMI. Interference effects and possible implant battery life reduction have been identified, thus reducing time frame before implant replacement surgery, especially when MBANS operates in the same room or on the same body as LP-AMI. Interference mitigation measures will be needed. The future MBANS ETSI standard may specify some means of detecting LP-AMI for improving coexistence. Other measures, such as warnings on the devices, may be considered to achieve better co-existence between LP-AMI and MBANS.

In the case of BWS, MBANS should consider the possibility of preventing outdoor usage. The restriction may be de-facto enabled by requiring MBANS sensors to periodically check that they are within operating distance of their MBANS hub. When the MBANS hub is not reachable, MBANS data transmission is stopped. That simple mechanism is part of the light licensing concept proposed in the FCC ruling for MBANS operation in the USA [3].

In the light that ECC WG FM decided not to consider the 2360-2400 MHz band for MBANS, the 2483.5-2500 MHz band could be considered sufficient for the initial introduction of MBANS, even though the initial requirement was set to 30 MHz for healthcare facility usage.

Therefore, by considering the results of statistical simulations of realistic deployment scenarios, it may be concluded that the most promising band for MBANS applications would be 2483.5-2500 MHz, as only mitigation measures are required for the protection of BWS and coexistence with LP-AMI.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
AFA	Adaptive Frequency Agility
AMPS	Advanced Mobile Phone System
AP	Access Point
APC	Active Power Control
ATV	Amateur TV
BS	Base Station
BWS	Broadband Wireless Systems
CEPT	European Conference of Postal and Telecommunications Administrations
CGC	Complementary Ground Component
C/I	Carrier-to-Interference ratio
dB	Decibel
dBi	Decibel isotropic
dBW	Decibel Watt
DL	Downlink
ECA	European Common Allocation Table (ERC Report 25)
ECC	Electronic Communications Committee
e.i.r.p	equivalent isotropically radiated power
ENG/OB	Electronic News Gathering / Outside Broadcasting
FDD	Frequency Division Duplex
FSL	Free Space Loss
GSO	Geo-Stationary Orbit
GSM	Global System for Mobile Communications
I/N	Interference-to-Noise ratio
IMT	International Mobile Telecommunications system
ISM	Industrial, Scientific and Medical applications
LBT	Listen Before Talk
LoS	Line-of-Sight
LP-AMI	Low Power - Active Medical Implant
LTE	Long Term Evolution
MBANS	Medical Body Area Network System
MCL	Minimum Coupling Loss
MES	Mobile Earth Station, a user terminal within MSS
MS	Mobile Station, handheld user terminal used within mobile communication system
MSS	Mobile Satellite Service
NFD	Net Filter Discrimination
NLoS	Non-Line-of-Sight
NMT	Nordic Mobile Telephony
OFDMA	Orthogonal Frequency Division Multiple Access
Pfd	Power flux density
PPDR	Public Protection and Disaster Relief

RDSS	Radiodetermination Satellite Service
RNSS	Radionavigation Satellite Service
Rx	Receiver
SAP/SAB	Services Ancillary to Programme making / Services Ancillary to Broadcasting
SRD	Short Range Device
TACS	Total Access Communication System
TDD	Time Division Duplex
Tx	Transmitter
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
VoIP	Voice over Internet Protocol (IP)
WiMAX	Worldwide interoperability for Microwave Access
WLAN	Wireless Local Area Network
WRC	World Radiocommunication Conference

1 INTRODUCTION

This report deals with the analysis of the compatibility between Medical Body Area Network Systems (MBANS) and other systems operating in the same or adjacent frequencies. It has been developed in response to ETSI system reference document TR 101 557 [1].

MBANS referred to in this Report is a low power radio system used for the transmission of non-voice data to and from medical devices for the purposes of monitoring, diagnosing and treating patients by authorized healthcare professionals. Initially MBANS will be mostly deployed in healthcare facilities, such as hospitals or emergency care facilities. However they will later extend into the patient's home in order to enable home healthcare. In addition, MBANS are also expected to be used in ambulances for monitoring patient vital signs during patient transportation.

The studies consider, more specifically, the following frequency bands: (1) 2400-2483.5 MHz, and (2) 2483.5-2500 MHz. A third band 2360-2400 MHz was also partially considered, but later on excluded of the scope of this Report. A total spectrum portion of 40 MHz in those bands was originally requested for MBANS operation, of which 30 MHz was intended for use in healthcare facilities.

The studies[1] covered with this Report encompass:

- Sharing scenarios within the 2400-2500 MHz band between MBANS and incumbent services, and
- Adjacent band scenarios between MBANS to be operated in parts of the frequency band 2400-2500 MHz and other services operating either below 2400 MHz or above 2500 MHz.

In this context, three MBANS categories are considered in this Report for operational purposes:

a) MBANS operating in healthcare facility
b) MBANS operating in patient home
c) MBANS operating in ambulance

The following studies were conducted for these three MBANS categories based on the characteristics given in this Report:

1. Sharing between MBANS and wideband data transmission systems (WLAN) operating in the 2400-2483.5 MHz band;
2. Sharing between MBANS and amateur and amateur satellite service systems in the 2400-2450 MHz band;
3. Sharing between MBANS and Low Power–Active Medical Implants (LP-AMI) in the 2483.5-2500 MHz band;
4. Sharing between MBANS and Mobile satellite service (MSS) system (Globalstar) in the 2483.5-2500 MHz band;
5. Sharing between MBANS and Complementary Ground Component (CGC) of MSS systems in the 2483.5-2500 MHz band;
6. Sharing between MBANS and Radiodetermination Satellite Service (RDSS) system (Galileo) in the 2483.5-2500 MHz band;
7. Sharing between MBANS and Services Ancillary to Programme making/Services Ancillary to Broadcasting (SAP/SAB) in the 2483.5-2500 MHz band;
8. Compatibility between MBANS operating in the 2400-2483.5 MHz band and Broadband Wireless System (BWS) operating in the adjacent 2300-2400 MHz band;
9. Compatibility between MBANS operating in the 2483.5-2500 MHz band and wideband data transmission systems (WLAN) operating in the adjacent 2400-2483.5 MHz band;
10. Compatibility between MBANS operating in the 2483.5 - 2500 MHz band and Broadband Wireless System (BWS) operating in the adjacent 2500-2690 MHz band.

[1] The studies are based on MCL and SEAMCAT analyses. For MCL results, the term "interference distance" refers to the minimal separation distance required to exclude interference.

2 ALLOCATIONS IN THE BANDS 2400-2483.5 MHz AND 2483.5-2500 MHz AND CONSIDERED SERVICES / APPLICATIONS

The following table summarises the allocations in the 2400-2500 MHz frequency range according to ERC Report 25 [2]

Table 2: Use of the bands according to ERC Report 25 (ECA Table)

Frequency Range	Utilisation	ERC/ECC Documentation	European Standard
2400 – 2450 MHz	Amateur	-	EN 301 783
	Amateur satellite	-	-
	ISM	-	EN 55011
	Non-specific SRDs	ERC/REC 70-03	EN 300 440
	Radiodetermination applications	ERC/DEC/(01)08 ERC/REC 70-03	EN 300 440
	RFID	ERC/REC 70-03	EN 300 440 EN 300 761
	Wideband data transmission systems	ERC/REC 70-03	EN 300 328
2450 – 2483.5 MHz	ISM	-	EN 55011
	Non-specific SRDs	ERC/REC 70-03	EN 300 440
	Radiodetermination applications	ERC/DEC/(01)08 ERC/REC 70-03	EN 300 440
	RFID	ERC/REC 70-03	EN 300 440 EN 300 761
	Wideband data transmission systems	ERC/REC 70-03	EN 300 328
2483.5 – 2500 MHz	Active medical implants	ERC/REC 70-03	EN 301 559
	IMT-2000 satellite component	-	-
	ISM	-	EN 55011
	Land mobile	-	-
	MSS Earth stations	ECC/DEC/(07)04 ECC/DEC/(07)05 ERC/DEC/(09)02	EN 301 441 EN 301 473
	PMSE (SAP/SAB)	ERC/REC 25-10	EN 302 064

Note 1: This table from ERC Report 25 is not exhaustive. Some applications may be missing.

The following table lists typical incumbent services/applications within or adjacent to the 2400-2500 MHz frequency range considered in the compatibility studies, either as adjacent or co-channel:

Table 3: Considered services/applications for compatibility studies

MBANS candidate band	Typical services / applications potentially relevant for MBANS	Comments
2390 – 2400 MHz	Mobile Service Applications (LTE TDD/FDD, WiMAX TDD)	Adjacent
2400 – 2483.5 MHz	Wideband data transmission systems - WLAN EN 300 328 (IEEE-802.11)	Co-channel
	ISM	Co-channel
	Non-specific SRDs	Co-channel
	RFID	Co-channel

MBANS candidate band	Typical services / applications potentially relevant for MBANS	Comments
	Amateur/ amateur satellite (2400-2450 MHz)	Co-channel
2483.5 – 2500 MHz	Active medical implants (LP-AMI)	Co-channel
	ISM	Co-channel
	MSS (Globalstar mobile phones)	Co-channel
	CGC (Complementary Ground Component of MSS systems)	Co-channel
	RDSS (Galileo)	Co-channel
	SAP/SAB (ENG/OB) video links	Co-channel
2500 – 2510 MHz	Mobile Service Applications (LTE TDD/FDD, WiMAX TDD)	Adjacent

Note 1: Some applications may be missing. Detailed information on such systems was not available at the time of writing this report.

Note 2: For the lower and upper edges of the 2400-2500 MHz frequency range, an adjacent region of 10 MHz was considered. Frequencies beyond 10 MHz from the edges are in the MBANS spurious emissions region.

3 CHARACTERISTICS OF MBANS

Medical Body Area Network System (MBANS) is a low power radio system used for the transmission of non-voice data to and from medical devices for the purposes of monitoring, diagnosing and treating patients by duly authorized healthcare professionals.

A MBANS consists of one or more on-body wireless sensors—to simultaneously collect multiple vital sign parameters—and/or medical actuator devices that can communicate with a monitoring device placed on/around (up to 10 meters from) the human body. Implantable devices are not part of MBANS. For those implantable devices (LP-AMI) the band 2483.5-2500 MHz is already identified in ERC/REC 70-03 [25] .

Monitoring devices, in their role of MBANS hub, display and process vital sign parameters from MBANS devices and may also forward them (e.g. to a central nurse station) by using wired or wireless technologies other than MBANS. MBANS hubs also control MBANS devices for the purpose of providing monitoring, diagnosis and treatment of patients. It is expected that, as most typical configuration, a MBANS hub will be associated to only one patient; in the same fashion as a patient monitor is typically wired up to a single patient today. Two MBANS examples are depicted below.

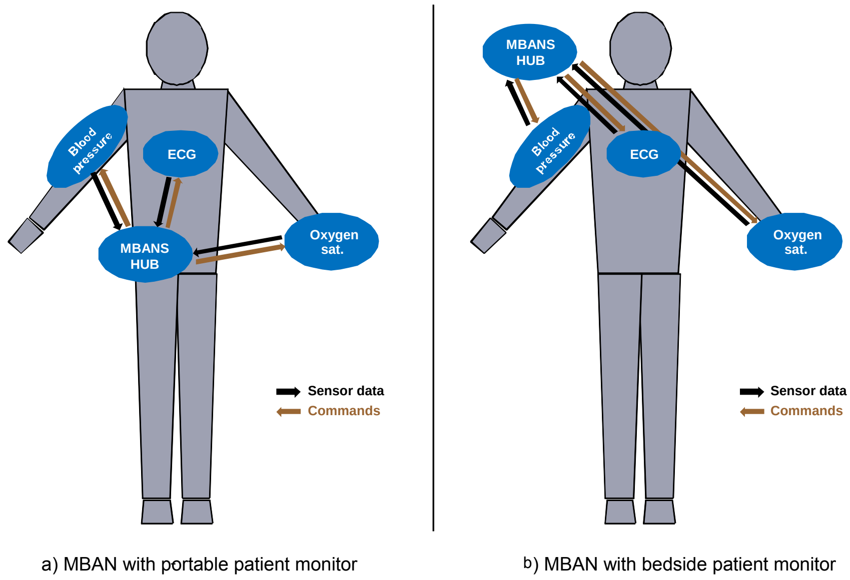


Figure 1: Typical MBANS examples

The typical number of sensor or actuator devices that communicate with an MBANS hub is in the range of 1 to 5 in healthcare facilities and ambulances. In patient homes, the typical number of sensors is expected to be lower, ranging from 1 to 3.

In most cases the location of MBANS hubs will be rather static and in the immediate proximity of the patient, as depicted in Figure 1 (part b). This applies to MBANS used in healthcare facilities, ambulances, and the patient's home. Within healthcare facilities, it is however expected that some patients carry a portable MBANS hub on their body.

In the remainder of the document, and without any loss of generality, MBANS are depicted in simplified manner consisting of an on-body sensor and an off-body hub.

3.1 OPERATION SCENARIO

ETSI TR 101 557 [1] discusses the possible environments in which MBANS are expected to operate and clusters MBANS into two differentiated types: ‘healthcare facility MBANS’ and ‘location independent MBANS’. The latter refers to ambulance and home monitoring scenarios, which in fact present some use case and parameter differences. Whereas the MBANS expected to be used in healthcare facilities and ambulances are fairly similar to each other, the MBANS expected to be used in homes have distinctive requirements, which make them de facto a distinct type of MBANS. For compatibility study purposes, it was considered most appropriate to treat home MBANS and ambulance MBANS as different cases, abandoning so the use of the generic term ‘location independent’. The term “category” is used in this Report to differentiate between ‘healthcare facility MBANS’, ‘home MBANS’, and ‘ambulance MBANS’. The three MBANS categories are schematically depicted in Figure 2, Figure 3, and Figure 4.

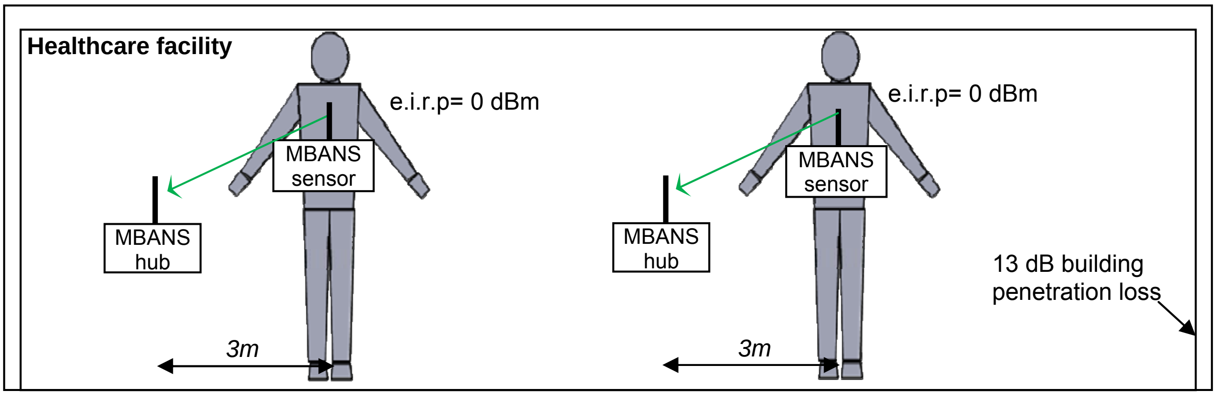


Figure 2: MBANS operating in healthcare facility

Healthcare facility MBANS operate exclusively indoor and inside a healthcare facility, in which several MBANS are simultaneously used on a subset of patients. The restriction to indoor operation within healthcare facilities may be de-facto enabled by requiring MBANS sensors to periodically check that they are within operating distance of their MBANS hub. When the MBANS hub is not reachable, MBANS data transmission is stopped. That simple mechanism is part of the light licensing concept proposed in the FCC ruling for MBANs operation in the USA [3].

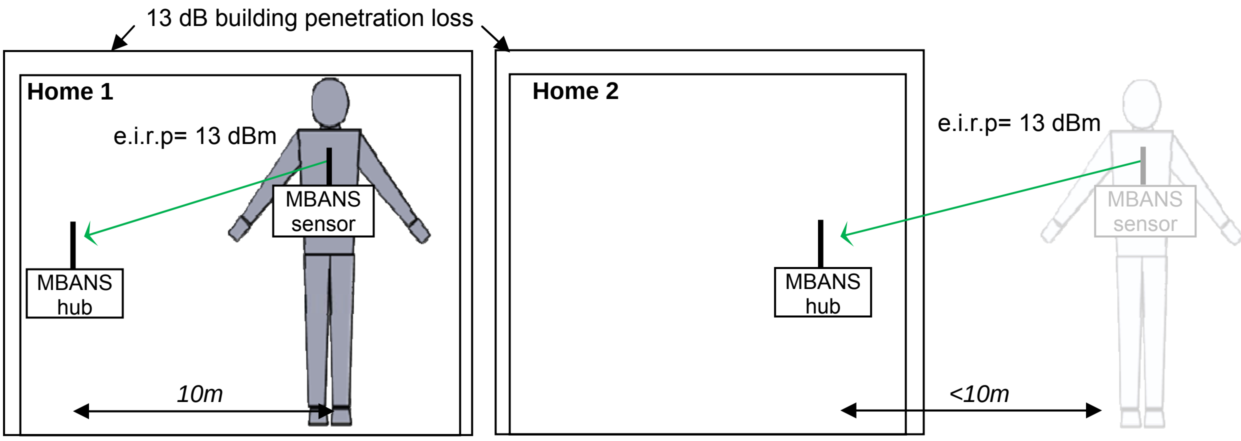


Figure 3: MBANS operating in patient homes

Home MBANS operate in patient homes, in which an MBANS hub is installed. The patient is mostly inside the home too. However, in a few cases, the patient can be outdoor (e.g. in the backyard) while still in range of the MBANS hub, as depicted in the right part of Figure 3. Worst case interference analyses within this document consider such possibility. The required range and transmit power for home MBANS is higher than for healthcare facility MBANS.

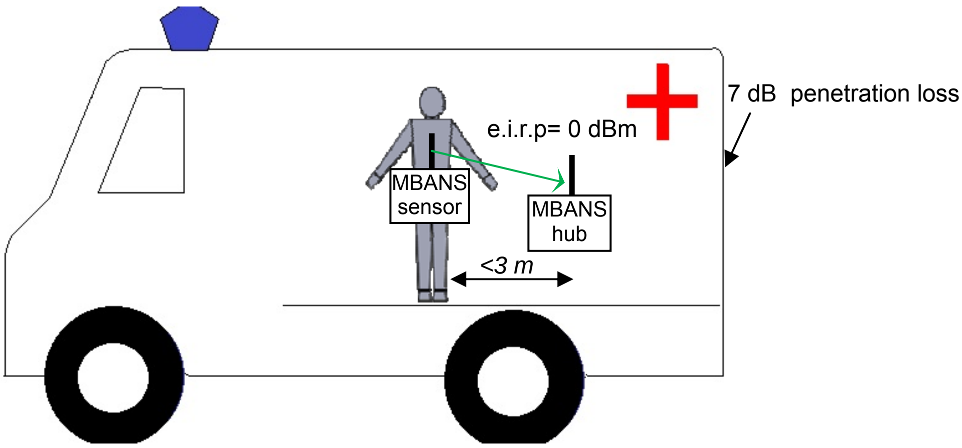


Figure 4: MBANS operating in ambulance

Ambulance MBANS are similar to healthcare facility MBANS in terms of transmit power, and type and amount of data to be transmitted. Their mobility and the lower shielding from the environment are the main differences. It is expected that only one MBANS be used per ambulance.

An overview of the MBANS parameters used for the present study is presented in the table below. They were selected from the System Reference document ETSI TR 101 557 v1.1.1 [1].

Table 4: MBANS parameters

Parameter	Healthcare Facility MBANS	Home MBANS	Ambulance MBANS
Max Tx power (dBm)	0	13	0
Operation environment	Indoor only	Mostly indoor. Outdoor possible.	Inside vehicle only
Tx-density (Km^{-2}) (Note 1)	40	10	5
Duty cycle per hour	< 10 %	< 2 %	< 10 %
Coverage radius (m)	3	10	3
Antenna gain(dBi)	0 (omnidirectional)		
Antenna height (m)	1.5		
Bandwidth (MHz)	1 – 5 (here 3 MHz is used)		
Noise floor (dBm)	-93.2		
Receiver sensitivity (dBm)	-81.9		
Emission mask	See Figure 5		
Interference criterion	C/I = 15dB		

Note 1: ETSI TR 101 557 provides a range of MBANS density values for compatibility studies. For healthcare facility MBANS, 30-50 MBANS/Km^2 are suggested. For other MBANS, and especially for home MBANS, 5-20 MBANS/Km^2 are suggested. Ambulance MBANS densities are not specifically considered. For the elaboration of this report, a single density value of 40 healthcare-facility-MBANS/Km^2 was assumed. Such value is in the middle of the range suggested by ETSI TR 101 557 and corresponds, for example, to the expected average density of MBANS in hospitals within the environment of a city or a part thereof. Since ambulance MBANS are expected to lead to low density values, 5 ambulance-MBANS/Km^2 was assumed—as lowest value in the range 5-20 MBANS/Km^2. For home MBANS, a factor 4 lower density than for healthcare facility MBANS was assumed, which corresponds to 10 MBANS/Km^2.

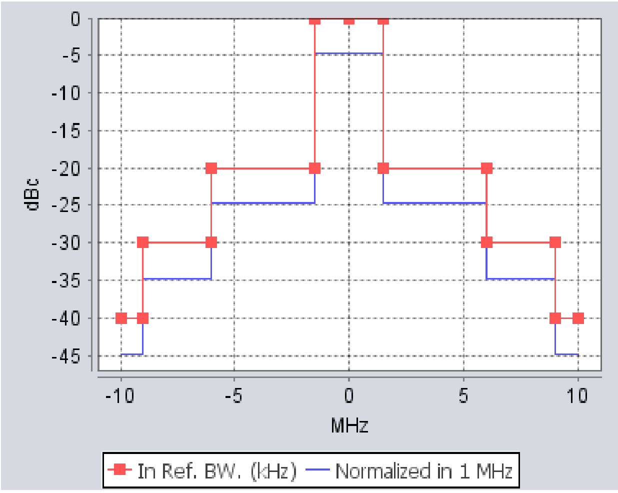


Figure 5: MBANS emission mask (reference BW 3 MHz)

4 COMPATIBILITY STUDY FOR THE BAND 2400-2483.5 MHz

Most compatibility studies presented in this section are structured in the following way:

- Section 4.x: Introduction of the radio service / application analysed in that subsection, including all relevant technical parameters for the studies. MCL calculations may also be included.
- Section 4.x.1: Compatibility with healthcare facility MBANS, including SEAMCAT simulations. MCL calculations may also be included.
- Section 4.x.2: Compatibility with home MBANS, including SEAMCAT simulations. MCL calculations may also be included.
- Section 4.x.3: Compatibility with ambulance MBANS mode, including SEAMCAT simulations. MCL calculations may also be included.
- Section 4.x.4: Summary and conclusions for the analysed radio service / application

4.1 WIDEBAND DATA TRANSMISSION SYSTEMS

WLAN systems based on the IEEE 802.11 b/g standard [19] have been selected as the most representative system for co-existence analysis with MBANS applications. Such systems have extremely proliferated both in residential and hospital areas, having achieved a large install base of Access Points (AP) for wireless data connectivity—e.g. enabling medical personnel to use their smartphones or similar devices for wirelessly accessing the hospital databases, localising medical equipment, download-uploading patients journal's data, establishing VoIP communications, etc.

For the MCL studies, the typical WLAN was considered to operate with 20 MHz channel bandwidth (at -20dB) and 17 dBm e.i.r.p. Note also that because in the worst-case scenarios MBANS and WLAN Access Point (AP) are located inside the same building, direct LOS coupling should be assumed, suggesting the use of the Free Space Model for path loss calculations. The results of calculated MCL interference distances for the identified critical WLAN applications in the band 2400-2483.5 MHz are presented in Table 5 below.The interference distances obtained with the MCL method made it clear that a more detailed analysis with the SEAMCAT simulation tool was necessary.

Table 5: MCL calculation in 2400-2483.5 MHz band between MBANS and WLAN

Scenario		1	2	3
Victim characteristics	**Units**	**WLAN 802.11 AP**	**WLAN 802.11 AP**	**MBANS**
Receiver bandwidth	MHz	20	20	3
Receiver noise figure	dB	10	10	10
Receiver antenna height	m	3	3	1.5
Receiver antenna gain	dBi	5	5	0
Operating frequency	MHz	2420	2420	2420
N, receiver thermal noise	dBm	-90.82	-90.82	-99.1
I/N objective	dB	0	0	0
Interferer's characteristics	**Units**	**MBANS (healthcare facility)**	**MBANS (home)**	**WLAN 802.11 AP**
e.i.r.p	dBm	0	13	17
Bandwidth	MHz	1 – 5 (Note 1)	1 – 5 (Note 1)	20
BW correction factor	dB	0	0	-8.24
NFD (adjacent band interf.)	dB	0	0	0
Antenna height	m	1.5	1.5	3
Minimum path loss	**dB**	**95.8**	**108.8**	**107.8**
Interference distance FSL model	**km**	**0.61**	**2.72**	**2.43**

Note 1: Any bandwidth in the indicated range is applicable. Interference distance result is not affected by choice.

Table 6: Wideband data transmission systems (WLAN) parameters

	Parameter	Value	
WLAN Transmitter (AP)	Bandwidth (MHz)	20 (IEEE 802.11b/g)	40 (IEEE 802.11n)
	Max Tx power (dBm)	17	
	Antenna gain (dBi)	5 (omnidirectional assumed)	
	Antenna height (m)	3	
WLAN Receiver	Receiver sensitivity (dBm)	-82	-79
	Antenna gain (dBi)	0 (omnidirectional)	
	Antenna height (m)	1.5	
	C/I objective (dB)	10	

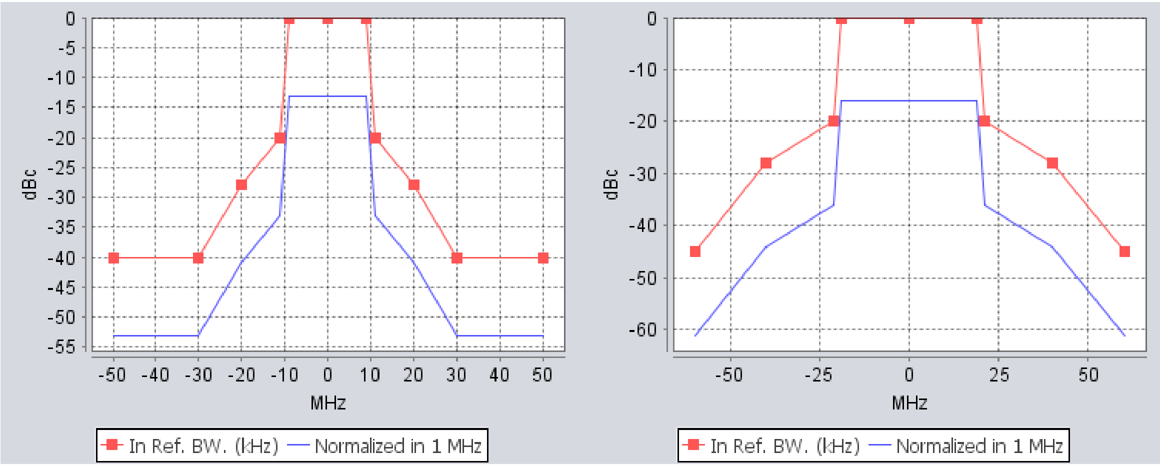


Figure 6: WLAN emission masks. Left: IEEE 802.11g (20 MHz). Right: IEEE 802.11n (40 MHz)

4.1.1 Healthcare facility MBANS

4.1.1.1 Interference from MBANS to wideband data transmission systems

Table 7: Interference from healthcare facility MBANS into WLAN- Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK): WLAN		
VLK frequency	2420 MHz	
VLK bandwidth	20 MHz	40 MHz
VLT → VLR path	Extended Hata, urban, indoor→indoor, below roof (user-defined radius, 20 m)	
Interfering Link (ILK): MBANS		
ILK frequency	2420 MHz	
ILK bandwidth	3 MHz	
ILT Tx power	0 dBm (10% probability)	
ILT density	40/km^2	
ILT probability of transmission	1	
ILT → VLR interfering path	Extended Hata, urban, indoor→indoor, below roof	
ILT → VLR positioning mode	Uniform density	

Simulation input/output parameters	Settings/Results
ILT → VLR number of transmitters	1 (for 90 m simulation radius)
Simulation results	
dRSS, dBm (Std.dev., dB)	-53.75 (14)
iRSSunwanted, dBm (Std.dev., dB)	-304.08 (64.99)
Probability of interference (%) (C/I = 10 dB)	**0.2**

4.1.1.2 Interference from wideband data transmission systems to MBANS

Table 8: Interference from WLAN into healthcare facility MBANS - Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK): MBANS		
VLK frequency	2420 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 3 m)	
Interfering Link (ILK): WLAN		
ILK frequency	2420 MHz	
ILK bandwidth	20 MHz	40 MHz
ILT Tx power	17 dBm (60% probability)	
ILT density	625/km^2	
ILT probability of transmission	1	
ILT → VLR interfering path	Extended Hata, urban, indoor→indoor, below roof	
ILT → VLR positioning mode	Uniform density	
ILT → VLR number of transmitters	16 (for 90 m simulation radius)	
Simulation results		
dRSS, dBm (Std.dev., dB)	-45.3 (4.42)	-45.35 (4.43)
iRSSunwanted, dBm (Std.dev., dB)	-69.68 (13.99)	-72.48 (14.21)
Probability of interference (%) (C/I = 15 dB)	**23.2**	**19.0**

4.1.2 Home MBANS

4.1.2.1 Interference from MBANS to wideband data transmission systems

Table 9: Interference from home MBANS into WLAN- Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK): WLAN		
VLK frequency	2420 MHz	
VLK bandwidth	20 MHz	40 MHz
VLT → VLR path	Extended Hata, urban, indoor→indoor, below roof (user-defined radius, 20 m)	

Simulation input/output parameters	Settings/Results
Interfering Link (ILK): MBANS	
ILK frequency	2420 MHz
ILK bandwidth	3 MHz
ILT Tx power	13 dBm (2% probability)
ILT density	10/km^2
ILT probability of transmission	1
ILT → VLR interfering path	Extended Hata, urban, indoor→indoor, below roof
ILT → VLR positioning mode	Uniform density
ILT → VLR number of transmitters	1 (for 180 m simulation radius)
Simulation results	
dRSS, dBm (Std.dev., dB)	-53.74 (14.15)
iRSSunwanted, dBm (Std.dev., dB)	-341 (38.7)
Probability of interference (%) (C/I = 10 dB)	**0.1**

4.1.2.2 Interference from wideband data transmission systems to MBANS

Table 10: Interference from WLAN into home MBANS - Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK): MBANS		
VLK frequency	2420 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 10 m)	
Interfering Link (ILK): WLAN		
ILK frequency	2420 MHz	
ILK bandwidth	20 MHz	40 MHz
ILT Tx power	17 dBm (60% probability)	
ILT density	625/km^2	
ILT probability of transmission	1	
ILT → VLR interfering path	Extended Hata, urban, indoor→indoor, below roof	
ILT → VLR positioning mode	Uniform density	
ILT → VLR number of transmitters	16 (for 90 m simulation radius)	
Simulation results		
dRSS, dBm (Std.dev., dB)	-42.72 (4.58)	-42.79 (4.49)
iRSSunwanted, dBm (Std.dev., dB)	-69.77 (14.11)	-72.92 (14.04)
Probability of interference (%) (C/I = 15 dB)	**18.8**	**14.5**

4.1.3 Ambulance MBANS

The use of WLAN in ambulances is regarded as marginal, due to the mobility of ambulances and its detrimental effect on WLAN communications. Therefore it is considered unnecessary to analyse compatibility with ambulance MBANS in further detail. The physical distance between in-building WLANs and in-ambulance MBANS—together with the attenuation added by the building wall and ambulance chassis—provide enough evidence to expect good coexistence.

4.1.4 Summary wideband data transmission systems

Healthcare facility MBANS and home MBANS:

According to the results presented above, in worst-case situations—modelled with MCL calculations—the interference distance between wideband data transmission systems and MBANS is:

- 0.6 km (healthcare facility MBANS as interferer)
- 2.7 km (home MBANS as interferer)
- 2.4 km (MBANS as victim).

The simulation-based average-case analysis yielded ≤0.2% interference probability from MBANS into wideband data transmission systems. In the other coexistence direction, the obtained results lie in the range of 15% - 23% probability of interference from wideband data transmission systems.

Co-channel compatibility is not given between wideband data transmission systems and MBANS in healthcare facilities and homes. Average case simulation results unveiled significant interference levels from wideband data transmission systems into MBANS.

Due to the widespread deployment of wideband data transmission systems (such as WLANs), separation-based mitigation measures are not practicable, especially in patient homes. Inside the premises of healthcare facilities, which are operated and controlled by the facility management, there could be some possibility to coordinate the MBANS and WLAN channels. Such coordination mechanism should however not be taken for granted in view of the following findings by the MBANS proponent industry during hospital surveys and installation and maintenance of hospital patient monitoring equipment:

- Hospitals are using a wide range of devices radiating in the 2.4GHz spectrum: WLAN (VoIP phones, access points, tablets, medical devices, wireless cameras, etc.), Bluetooth (medical devices, phones, etc.), ZigBee (medical devices, lighting control, etc.), proprietary RF (computer accessories), RF-ID (equipment tracking), and industrial/commercial microwave ovens. All this is often a significant source of interference.
- Most hospitals are not able to proactively manage the spectrum well, largely because of the vast amount of devices using a wide range of wireless technologies that demand access to the 2.4 GHz spectrum.
- As hospitals do not have the skill to cope with such a complex and crowded spectrum, WLAN is typically deployed with dynamic channel selection. This makes sharing this spectrum with low power devices like MBANS impractical or even impossible.
- There is a clear trend towards the further intensification of WLAN spectrum needs. IEEE 802.11n-based devices with channel bonding, mobile Wi-Fi hotspots (e.g. tethered cell phones used by patients and visitors) and Wi-Fi Direct enjoy increasing popularity.
- Wireless equipment belonging to patients and visitors (using e.g. Bluetooth, WiFi Direct, etc.) makes it very difficult, in practice, to implement any spectrum management possibility by the hospital management.

Ambulance MBANS:

Due to the absence or very low footprint of wideband data transmission systems within ambulances, co-channel compatibility with ambulance MBANS can be expected.

4.2 ISM

Some of the examples of ISM applications that could be considered as potential interferers to MBANS for the hospital environment would be e.g. cauterising tools used as surgery aids in hospitals or microwave ovens, which may be found both in hospitals and patient homes. Regarding the cauterising tools, this study could not get hold of any reliable data that would allow deterministic characterising of RF emissions from these devices. Regarding microwave ovens, as discussed in previous ECC reports (such as ECC Report 149 [4]), it appears that the leakage of RF power from microwave ovens is very small (e.g. 0.2 mW/cm^2 quoted in some sources [5]) compared to other applications such as WLAN APs.Therefore for the above described reasons, both of these ISM devices were left out of this study.

4.3 NON-SPECIFIC SRDS

It was decided not to explicitly consider the compatibility between MBANS and non-specific Short Range Devices (SRDs) beyond the considerations in Section 4.1, since WLAN systems are considered as the most critical representative of SRDs for co-existence analysis.

4.4 RFID

It was decided not to explicitly consider the compatibility between MBANS and RFID (including railway applications thereof) beyond the considerations in Section 4.1, since WLAN systems are considered to be a more critical system for co-existence analysis.

4.5 AMATEUR AND AMATEUR SATELLITE

The range 2400-2450 MHz is allocated to both the amateur and amateur satellite service on a secondary basis. This section explicitly analyses compatibility with amateur service and amateur satellite service.

The operational characteristics of amateur service vary significantly. However based on the IARU Region-1 VHF Managers Handbook [6] and studies for ECC Report 172 [7], they can be categorised as data, multimedia, and TV repeaters (point-to-point links and area systems). For studies in the 2400-2450 MHz range, it can be assumed that the Amateur Radio stations in this band are used for receiving signals over terrestrial paths (and are unlikely to involve narrowband systems, unless displaced by BWS from their original 2300-2400 MHz range). Recommendation ITU-R M.1732-1 [8] contains parameter ranges for different usage models and frequency bands. The typical parameters of the multimedia and TV repeater operation modes were chosen to represent Amateur Radio in the 2400-2450 MHz range.

Table 11 summarizes the parameter value choices. Besides ITU-R M.1732-1 [8], ECC Report 172 [7], and ECC Report 064 [9] were also consulted for parameter selection.

Table 11: Amateur Radio parameters (terrestrial)

	Parameter	Value (Multimedia)	Value (ATV Repeater)
Amateur Transmitter	Bandwidth (MHz)	0.150	6
	Max Tx power (dBm)	40	43
	Antenna gain (dBi)	16 (directional)	10 (omnidirectional)
	Antenna height (m)	10	30
Amateur Receiver	Receiver sensitivity (dBm)	-110	-94
	Antenna gain (dBi)	16 (directional)	10 (omnidirectional)
	Antenna height (m)	10	
	C/I objective (dB)	20	

Note: Typical antennas for Repeaters and Beacons are omnidirectional in Azimuth, 10dB gain in Elevation. For directional antennas (e.g for data/multimedia links), 0dBi is assumed in side-lobes.

Recommendation ITU-R M.1732-1 [8] provides characteristics for stations operating in the amateur satellite service. They are summarized in Table 12.

Table 12: Characteristics of Amateur-Satellite systems in the space-to-Earth direction

Parameter	CW-Morse	SSB, FM, Digital Voice, Data

Parameter	CW-Morse	SSB, FM, Digital Voice, Data
Transmitter Power (Note 1) (dBW)	10	10
Transmitter Feeder Loss (dB)	0.2 – 1	0.2 – 1
Transmitting antenna gain (dBi).	0 – 6	0
Typical e.i.r.p.(dBW)	0 – 15	9 – 15
Antenna polarisation	Horizontal, Vertical, LHCP, RHCP	Horizontal, Vertical, LHCP, RHCP
Receiver IF bandwidth (kHz)	0.4	2.7, 16, 50, 100
Receiver Noise Figure (Note 2) (dB)	1 – 3 (typically: 1)	1 – 3 (typically: 2)

Note 1: Maximum power levels are determined by each administration.

Note 2: Receiver noise figures for bands above 50 MHz assume the use of low-noise preamplifiers.

In contrast to the assumptions in ITU M.1732-1 [8], most current amateur satellites are typically picosats (also called 'cubesats'), which occupy slightly elliptical Sun-Synchronous low Earth orbits (LEO) of 600-800 km altitude. These smaller satellites have relatively low power and antenna gain. Whilst these are most typical, other scenarios can include reception of Digital Amateur TV downlinks from the International Space Station, and weak signal reception of longer range satellites.It may be noted that most amateur satellite communications are internationally coordinated and harmonized towards the lower end of the 2400-2450 MHz range in order to minimise ISM/WLAN interference.

For sharing studies 0 dBW Tx-power, 100 kHz bandwidth (BW), 0.5 dB feeder loss, and 3 dB antenna gain for a patch antenna are assumed for the satellite; and the amateur receiving ground station is assumed to be similar to the amateur service (100 kHz BW, 2dB noise figure). Table 13 summarizes the parameter choices for sharing studies.

The compatibility scenario considered in this section is the reception of a satellite downlink by an amateur radio ground station. MBANS may be in the side-lobe of the amateur receiving station, for which 0dBi gain can be assumed.

Cumulative MBANS transmissions to an overhead LEO satellite uplink receiver are not studied, as it is reasonable to assume a proportionately low power density compared to existing WLANs/ISM equipment. Interference from Amateur TV into MBANSis not studied either, since a preliminary assessment hinted at the absence of coexistence issues.

Table 13: Radio parameters (Amateur Satellite)

	Parameter	Value (Amateur Satellite)
Amateur Transmitter	Bandwidth (MHz)	0.100
	Max Tx power (dBm)	30
	Antenna gain (dBi)	0
	Antenna height (m)	n.a.
Amateur Receiver (Note 1)	Receiver sensitivity (dBm)	-112
	Antenna gain (dBi)	20 (main beam), 0 (side-lobes)
	Antenna height (m)	10
	C/I objective (dB)	20

Note 1: For the ground station in the downlink scenario

4.5.1 Healthcare facility MBANS

Table 14: MCL calculation in 2400-2450 MHz band between healthcare facility MBANS and Amateur Multimedia / ATV Repeater and Amateur Satellite

Scenario		1	2	3	4	5
Victim characteristics	**Units**	**Multimedia**	**MBANS**	**ATV Receiver**	**MBANS**	**Amateur Satellite**
Receiver bandwidth	MHz	0.150	3	6	3	0.100
Receiver noise figure	dB	2	10	2	10	2
Receiver antenna height	m	10	1.5	10	1.5	10
Receiver antenna gain	dBi	16	0	10	0	0
Operating frequency	MHz	2420	2420	2420	2420	2420
N, receiver thermal noise	dBm	-120.1	-99.1	-104.0	-99.1	-121.8
I/N objective	dB	-10	0	-10	0	-10
Interferer's characteristics	**Units**	**MBANS**	**Multimedia**	**MBANS**	**ATV Repeater**	**MBANS**
e.i.r.p	dBm	0	56	0	53	0
Bandwidth	MHz	3	0.150	3	6	3
BW correction factor	dB	-13	0	0	-3	-14.8
NFD (adjacent band interf)	dB	0	0	0	0	0
Wall attenuation	dB	13	13	13	13	13
Antenna height	m	1.5	10	1.5	30	1.5
Minimum path loss	**dB**	**120.1**	**142.1**	**111.0**	**136**	**104.1**
Interference distance FSL model	**km**	**9.9**	**125.6**	**3.5**	**63**	**1.6**

4.5.1.1 Interference from MBANS to Amateur

The considered interference scenarios (both terrestrial and satellite) are depicted together in Figure 7 and have been simulated in SEAMCAT. The simulation settings and results are summarized in Table 15.

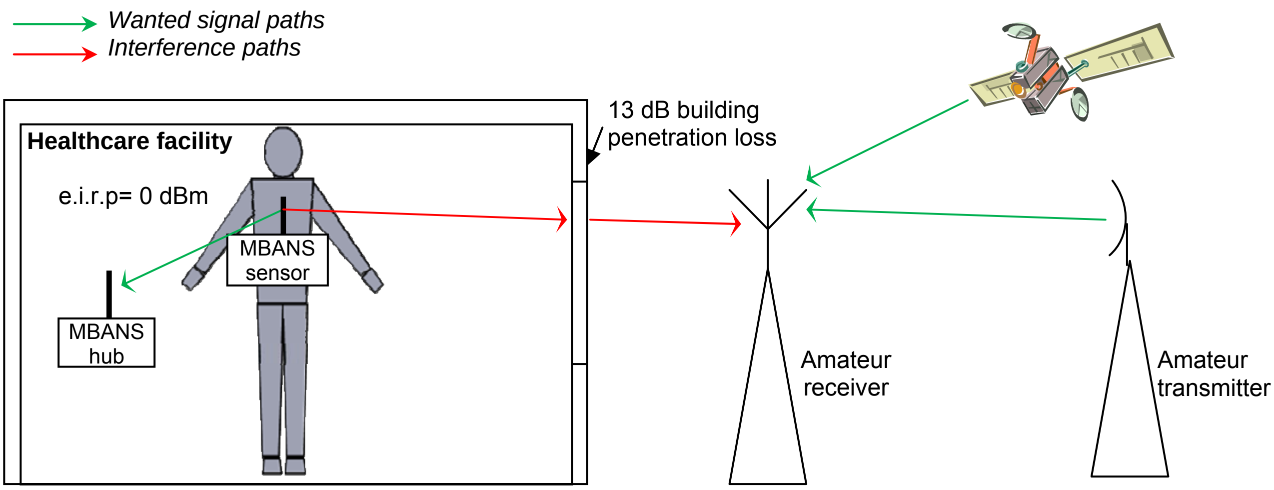


Figure 7: Interference scenario – healthcare facility MBANS into Amateur

Table 15: Interference from healthcare facility MBANS to Amateur Radio - Settings and results

Simulation input/output parameters	Settings/Results (Multimedia)	Settings/Results (ATV Repeater)	Settings/Results (Amateur Satellite)
Victim Link (VLK): Amateur			
VLK frequency	2420 MHz		
VLK bandwidth	150 kHz	6 MHz	100 kHz
VLT → VLR path	Extended Hata, urban, outdoor→indoor, above roof	Extended Hata, suburban, outdoor→indoor, above roof	FSL (VLR dRSS =-100 dBm)
	User-defined radius 5 km	User-defined radius 40 km	
Interfering Link (ILK): MBANS			
ILK frequency	2420 MHz		
ILK bandwidth	3 MHz		
ILT Tx power	0 dBm		
ILT density	40/km^2		
ILT probability of transmission	0.1		
ILT → VLR interfering path	Extended Hata, urban, indoor→outdoor, above roof		
ILT → VLR positioning mode	Closest interferer		
Simulation results			
dRSS, dBm (Std.dev., dB)	-67.32 (11.9)	-88.99 (13.19)	-100 (0)
iRSSunwanted, dBm (Std.dev., dB)	-140.37 (16.6)	-133.05 (16.65)	-157.98 (16.59)
Probability of interference (%) (C/I = 20 dB)	**1.3**	**5.2**	**2.6**

4.5.1.2 Interference from Amateur to MBANS

The considered interference scenario is depicted in Figure 8 and has been simulated in SEAMCAT. The simulation settings and results are summarized in Table 16. The interference probability from Amateur into MBANS is very low.

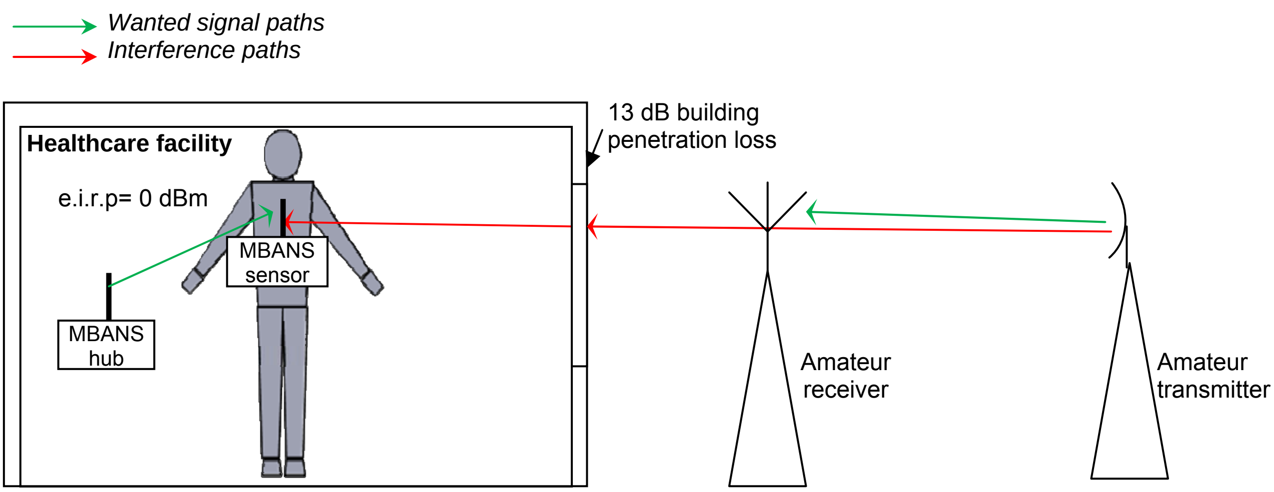


Figure 8: Interference scenario – Amateur into healthcare facility MBANS

Table 16: Interference from Amateur to healthcare facility MBANS - Settings and results

Simulation input/output parameters	Settings/Results (Multimedia)	Settings/Results (ATV Repeater)
Victim Link (VLK): MBANS		
VLK frequency	2420 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 3 m)	
Interfering Link (ILK): Amateur		
ILK frequency	2420 MHz	
ILK bandwidth	150 kHz	6 MHz
ILT Tx power	40 dBm (10% probability)	43 dBm
ILT density	0.2/km^2	0.001/km^2
ILT probability of transmission	1	
ILT → VLR interfering path	Extended Hata, urban, outdoor→indoor, above roof	Extended Hata, suburban, outdoor→indoor, above roof
ILT → VLR positioning mode	Uniform density	
Simulation results		
dRSS, dBm (Std.dev., dB)	- 45.32 (4.39)	- 45.3 (4.37)
iRSSunwanted, dBm (Std.dev., dB)	- 316.9 (72.96)	- 125.62 (12.82)
Probability of interference (%) (C/I = 15 dB)	**0.1**	**0.01**

4.5.2 Home MBANS

Table 17: MCL calculation in 2400-2450 MHz band between home MBANS and Amateur Multimedia / ATV Repeater

Scenario		1	2	3	4	5
Victim characteristics	**Units**	**Multimedia**	**MBANS**	**ATV Receiver**	**MBANS**	**Amateur Satellite**
Receiver bandwidth	MHz	0.150	3	6	3	0.100
Receiver noise figure	dB	2	10	2	10	2
Receiver antenna height	m	10	1.5	10	1.5	10
Receiver antenna gain	dBi	16	0	10	0	0
Operating frequency	MHz	2420	2420	2420	2420	2420
N, receiver thermal noise	dBm	-120.1	-99.1	-104.0	-99.1	-121.8
I/N objective	dB	-10	0	-10	0	-10
Interferer's characteristics	**Units**	**MBANS**	**Multimedia**	**MBANS**	**ATV Repeater**	**MBANS**
e.i.r.p	dBm	13	56	13	53	13
Bandwidth	MHz	3	0.150	3	6	3
BW correction factor	dB	-13	0	0	-3	-14.8
NFD (adjacent band interf)	dB	0	0	0	0	0
Wall attenuation (Note 1)	dB	0 (outdoor)	0 (outdoor)	0 (outdoor)	0 (outdoor)	0 (outdoor)
Antenna height	m	1.5	10	1.5	30	1.5
Minimum path loss	**dB**	**146.1**	**155.1**	**137.0**	**149.0**	**130.1**
Interference distance FSL model	**km**	**198**	**558**	**70**	**280**	**31.4**

Note 1: Worst case configuration assumed, in which MBANS transmitter or receiver is outdoors.

4.5.2.1 Interference from MBANS to Amateur

The considered interference scenarios (both terrestrial and satellite) are depicted together in Figure . The SEAMCAT simulation settings and results are summarized in Table 18.

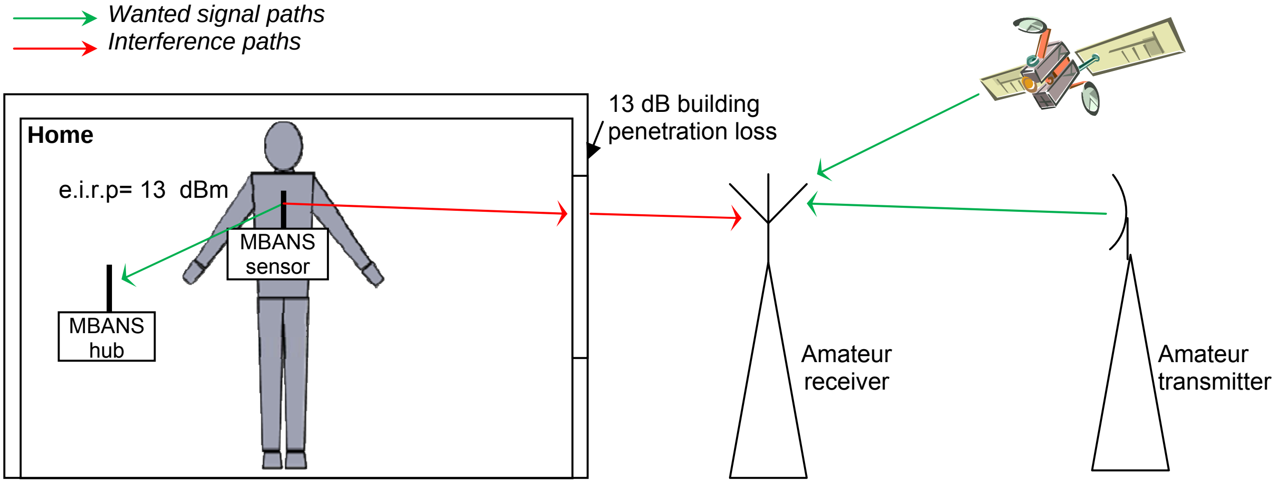


Figure 9: Interference scenario – home MBANS into Amateur

Table 18: Interference from home MBANS to Amateur Radio - Settings and results

Simulation input/output parameters	Settings/Results (Multimedia)	Settings/Results (ATV Repeater)	Settings/Results (Amateur Satellite)
Victim Link (VLK): Amateur			
VLK frequency	2420 MHz		
VLK bandwidth	150 kHz	6 MHz	100 kHz
VLT → VLR path	Extended Hata, urban, outdoor→indoor, above roof	Extended Hata, suburban, outdoor→indoor, above roof	FSL (VLR dRSS =-100 dBm)
	User-defined radius 5 km	User-defined radius 40 km	
Interfering Link (ILK): MBANS			
ILK frequency	2420 MHz		
ILK bandwidth	3 MHz		
ILT Tx power	13 dBm		
ILT density	10/km^2		
ILT probability of transmission	0.02		
ILT → VLR interfering path	Extended Hata, urban, indoor→outdoor, above roof		
ILT → VLR positioning mode	Uniform density		
Simulation results			
dRSS, dBm (Std.dev., dB)	-67.29 (11.91)	-89.16 (13.02)	-100 (0)
iRSSunwanted, dBm (Std.dev., dB)	-141 (13.37)	-133.98 (13.35)	-158.67 (13.38)
Probability of interference (%) (C/I = 20 dB)	**0.5**	**2.6**	**1.0**

4.5.2.2 Interference from Amateur to MBANS

The considered interference scenario is depicted in Figure 10 and has been simulated in SEAMCAT. The simulation settings and results are summarized in

Table 19. The interference probability from Amateur into MBANS is very low.

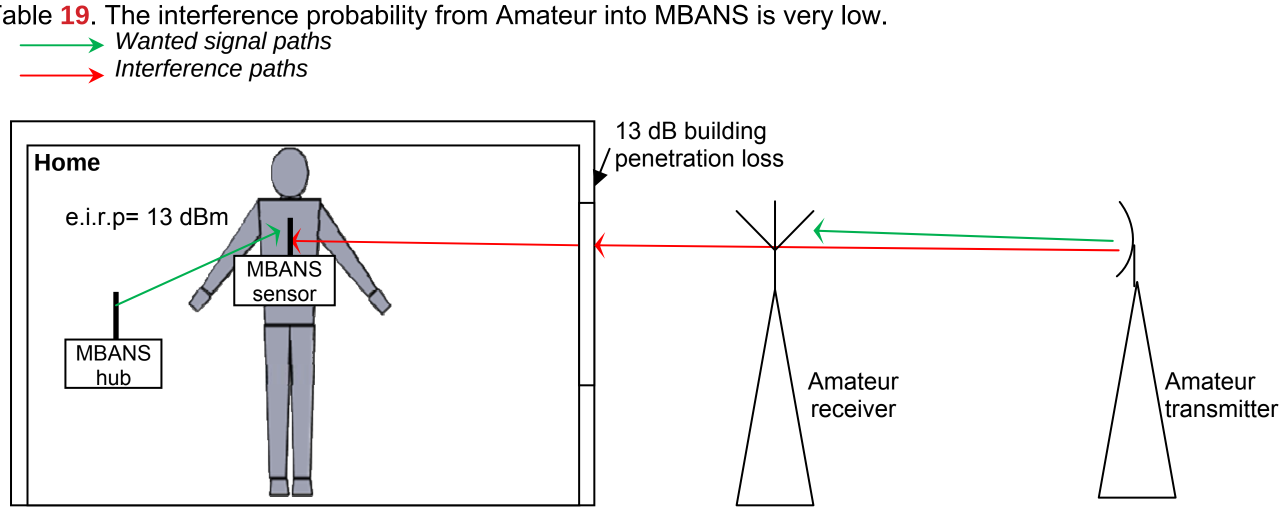


Figure 10: Interference scenario – Amateur into healthcare facility MBANS

Table 19: Interference from from Amateur to home MBANS - Settings and results

Simulation input/output parameters	Settings/Results (Multimedia)	Settings/Results (ATV Repeater)
Victim Link (VLK): MBANS		
VLK frequency	2420 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 10 m)	
Interfering Link (ILK): Amateur		
ILK frequency	2420 MHz	
ILK bandwidth	150 kHz	6 MHz
ILT Tx power	40 dBm (10% probability)	43 dBm
ILT density	0.2/km^2	0.001/km^2
ILT probability of transmission	1	
ILT → VLR interfering path	Extended Hata, urban, outdoor→indoor, above roof	Extended Hata, suburban, outdoor→indoor, above roof
ILT → VLR positioning mode	Uniform density	
Simulation results		
dRSS, dBm (Std.dev., dB)	-42.82 (4.4)	-42.75 (4.47)
iRSSunwanted, dBm (Std.dev., dB)	-317.46 (72.61)	-125.91 (12.81)
Probability of interference (%) (C/I = 15 dB)	**0.1**	**0.03**

4.5.3 Ambulance MBANS

Table 20: MCL calculation in 2400-2450 MHz band between ambulance MBANS and Amateur Multimedia / ATV Repeater

Scenario		1	2	3	4	5
Victim characteristics	**Units**	**Multimedia**	**MBANS**	**ATV Receiver**	**MBANS**	**Amateur Satellite**
Receiver bandwidth	MHz	0.150	3	6	3	0.100
Receiver noise figure	dB	2	10	2	10	2
Receiver antenna height	m	10	1.5	10	1.5	10
Receiver antenna gain	dBi	16	0	10	0	0
Operating frequency	MHz	2420	2420	2420	2420	2420
N, receiver thermal noise	dBm	-120.1	-99.1	-104.0	-99.1	-121.8
I/N objective	dB	-10	0	-10	0	-10
Interferer's characteristics	**Units**	**MBANS**	**Multimedia**	**MBANS**	**ATV Repeater**	**MBANS**
e.i.r.p	dBm	0	56	0	53	0
Bandwidth	MHz	3	0.150	3	6	3
BW correction factor	dB	-13	0	0	-3	-14.8
NFD (adjacent band interf)	dB	0	0	0	0	0
Wall attenuation	dB	7	7	7	7	7
Antenna height	m	1.5	10	1.5	30	1.5
Minimum path loss	**dB**	**126.1**	**148.1**	**117**	**142.0**	**110.1**
Interference distance FSL model	**km**	**20**	**250**	**7.0**	**125**	**3.14**

4.5.3.1 Interference from MBANS to Amateur

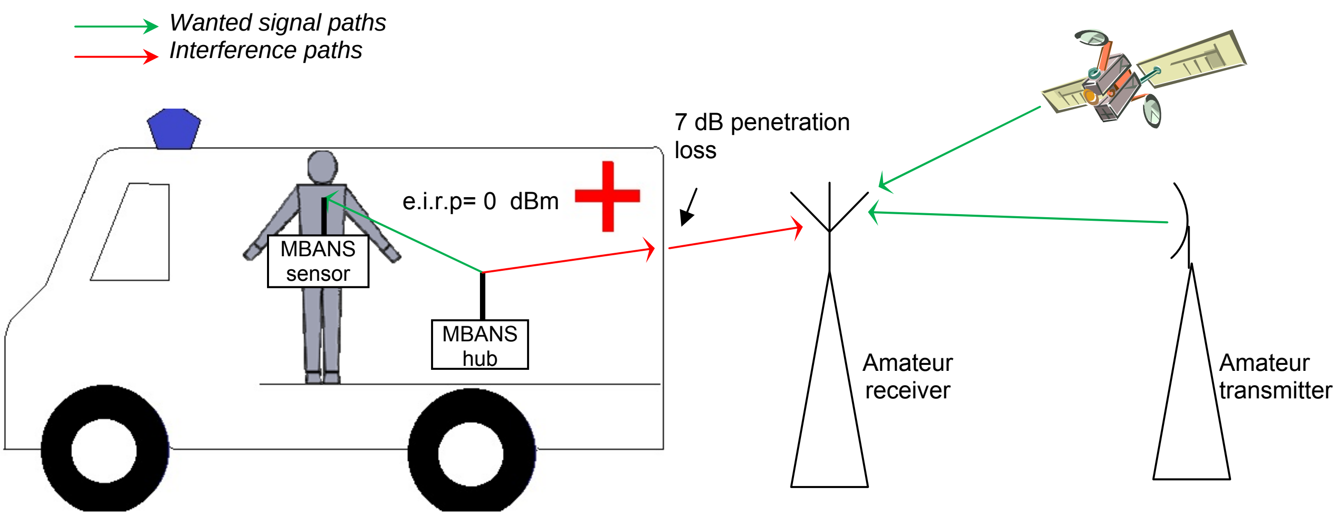


Figure 11: Interference scenario – Ambulance MBANS into amateur

Table 21: Interference from ambulance MBANS to Amateur Radio - Settings and results

Simulation input/output parameters	Settings/Results (Multimedia)	Settings/Results (ATV Repeater)	Settings/Results (Amateur Satellite)
Victim Link (VLK): Amateur			
VLK frequency	2420 MHz		
VLK bandwidth	150 kHz	6 MHz	100 kHz
VLT → VLR path	Extended Hata, urban, outdoor→outdoor, above roof	Extended Hata, suburban, outdoor→outdoor, above roof	FSL (VLR dRSS =-100 dBm)
	User-defined radius 5 km	User-defined radius 40 km	
Interfering Link (ILK): MBANS			
ILK frequency	2420 MHz		
ILK bandwidth	3 MHz		
ILT Tx power	0 dBm		
ILT density	5/km^2		
ILT probability of transmission	0.1		
ILT → VLR interfering path	Extended Hata, urban, indoor→outdoor, above roof		
ILT → VLR positioning mode	Uniform density		
Simulation results			
dRSS, dBm (Std.dev., dB)	-67.32 (12.04)	-89.15 (13.15)	-100 (0)
iRSSunwanted, dBm (Std.dev., dB)	-138.10 (12.36)	-131.24 (12.32)	-155.96 (12.14)
Probability of interference (%) (C/I = 20 dB)	**0.7**	**3.2**	**1.3**

4.5.3.2 Interference from Amateur to MBANS

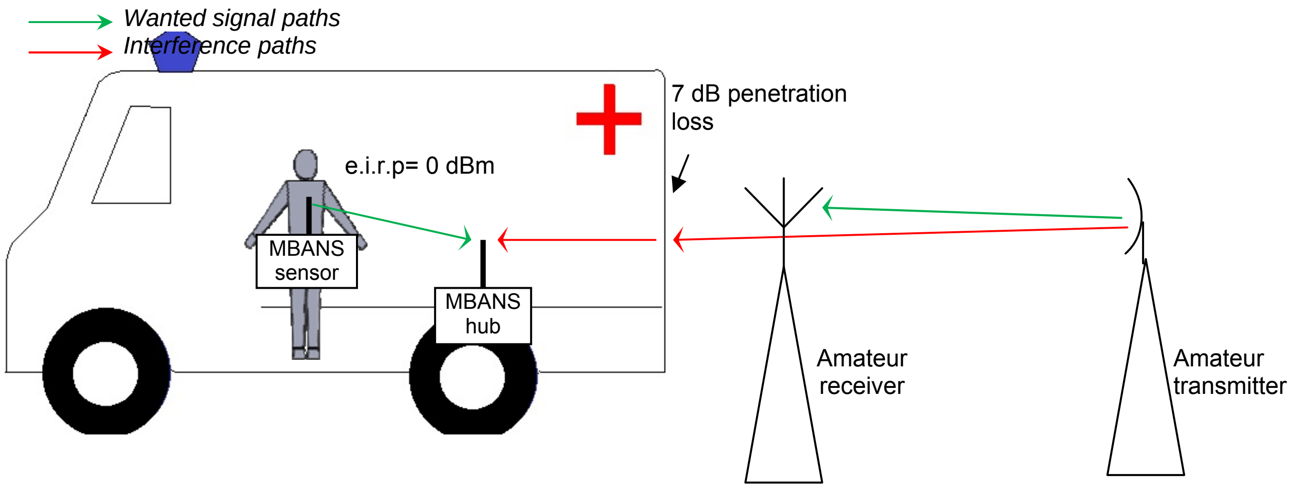


Figure 12: Interference scenario – Amateur into ambulance MBANS

Table 22: Interference from Amateur to ambulance MBANS - Settings and results

Simulation input/output parameters	Settings/Results (Multimedia)	Settings/Results (ATV Repeater)
Victim Link (VLK): MBANS		
VLK frequency	2420 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 3 m)	
Interfering Link (ILK): Amateur		
ILK frequency	2420 MHz	
ILK bandwidth	150 kHz	6 MHz
ILT Tx power	40 dBm (10% probability)	43 dBm
ILT density	0.2/km^2	0.001/km^2
ILT probability of transmission	1	
ILT → VLR interfering path	Extended Hata, urban, outdoor→outdoor, above roof	Extended Hata, suburban, outdoor→outdoor, above roof
ILT → VLR positioning mode	Uniform density	
Simulation results		
dRSS, dBm (Std.dev., dB)	-45.38 (4.37)	-45.2 (4.36)
iRSSunwanted, dBm (Std.dev., dB)	-316.05 (74.24)	-119.48 (12.85)
Probability of interference (%) (C/I = 15 dB)	**0.1**	**0.1**

4.5.4 Summary Amateur and Amateur Satellite

Healthcare facility MBANS:

According to the results presented above, in worst-case situations—modelled with MCL calculations and using an interference criterion of I/N=-10dB for Amateur systems and I/N=0dB for MBANS—the interference distance between Amateur and MBANS is in the range of 2 km – 10 km (MBANS as interferer) and 63 km – 126 km (Amateur as interferer). The three different simulation-based average-case analyses yielded 1.3%, 2.6%, and 5.2% probability of interference from MBANS. In the other coexistence direction, the obtained result is ≤0.1% probability of interference from Amateur systems.

Average case simulation results suggest co-channel coexistence between Amateur systems in the 2400-2450 MHz band and healthcare facility MBANS, if an average interference probability up to 5% would be accepted.

Home MBANS:

In worst-case situations—modelled with MCL calculations—the interference distance between Amateur and MBANS is in the range of 70 km – 200 km (MBANS as interferer). The simulation-based average-case analyses yielded 0.5% to 2.6% probability of interference from MBANS. In the other coexistence direction, the obtained result is ≤0.1% probability of interference from Amateur systems.

Average case simulation results suggest co-channel coexistence between Amateur systems in the 2400-2450 MHz band and home MBANS if an average interference probability up to 3% would be accepted. However in unfavorable conditions (e.g. when an MBANS is located just outside the patient's home), the required protection distances between Amateur receivers and home MBANS transmitters reach 200 km. The interference potential should not be disregarded and, hence, coexistence cannot be guaranteed.

Ambulance MBANS:

In worst-case situations—modelled with MCL calculations—the interference distance between Amateur and MBANS is in the range of 7 km – 20 km (MBANS as interferer). The simulation-based average-case analyses yielded 0.7% to 3.2% probability of interference from MBANS. In the other coexistence direction, the obtained result is ≤0.1% probability of interference from Amateur systems.

Average case simulation results suggest co-channel coexistence between Amateur systems in the 2400-2450 MHz band and ambulance MBANS, if an average interference probability up to 3% would be accepted.

It should be noted the existing WLAN systems operating in the 2400-2450 MHz band are expected to be more critical than MBANS with respect to interference into Amateur and Amateur Satellite communications.

4.6 ADJACENT BROADBAND WIRELESS SYSTEMS (BWS)

LTE systems operating in the whole band as well as the upper segment of the 2300-2400 MHz band, for example at 2395 MHz, is subject to adjacent band interference from MBANS operating in the lowest segment of the 2400-2483.5 MHz band. Since the amount of spectrum available in the latter band is significantly higher than the amount sought for MBANS operation, it was regarded appropriate to limit the operational frequency for MBANS to a subrange of the 2400 -2483.5 MHz band that excludes the lowest 10 MHz. Thus the frequency separation between the LTE band edge and MBANS channel centre frequency would be equal to or greater than 11.5 MHz. Despite the frequency separation of both adjacent systems, a preliminary investigation of MBANS co-existence was performed. The MBAN spectrum mask was extended with a constant value (-40 dBc) beyond the range defined in Section 3.1. The result indicated that interference is in general acceptable, but cannot be always excluded.

In view of (1) the preliminary results using an estimated extended spectrum mask, (2) the frequency separation between LTE and MBANS, (3) the higher levels of interference into LTE originated from WLAN systems, (4) the expectation that MBANS will implement additional mitigation measures, and (5) the possibility revising the levels of spurious from MBANS, it was not judged necessary to further investigate adjacent band compatibility in the proximity of 2400 MHz. Adjacent band compatibility with BWS uplinks is considered in Section 5.8, in the proximity of 2500 MHz.

5 COMPATIBILITY STUDY FOR THE BAND 2483.5-2500 MHz

Most compatibility studies presented in this section are structured in the following way:

- Section 5.x: Introduction of the radio service / application analysed in that subsection, including all relevant technical parameters for the studies. MCL calculations may also be included;
- Section 5.x.1: Compatibility with healthcare facility MBANS, including SEAMCAT simulations. MCL calculations may also be included;
- Section 5.x.2: Compatibility with home MBANS, including SEAMCAT simulations. MCL calculations may also be included;
- Section 5.x.3: Compatibility with ambulance MBANS mode, including SEAMCAT simulations. MCL calculations may also be included;
- Section 5.x.4: Summary and conclusions for the analysed radio service / application.

5.1 ACTIVE MEDICAL IMPLANTS

Low Power – Active Medical Implants (LP-AMI) are application-specific SRDs allowed to operate in the 2483.5 – 2500 MHz band. Due to the physical proximity of MBANS and LP-AMI devices (possibly on the same patient's body) and their common usage scenarios (e.g. hospital wards, elderly care houses, and medical ambulatories), it was considered necessary to study the compatibility with LP-AMI.

LP-AMI is used for implantable device applications and related external telemetry medical products and is composed by two integral components: (1) LP-AMI implantable device and (2) Peripheral interrogator unit – LP-AMI-P. In general, LP-AMI may transmit only when queried by an LP-AMI-P device, a stationary device installed indoors. In practice, this restriction ensures indoor operation for all LP-AMI components.

The transmit power of battery-driven LP-AMI is anticipated to be lower than that of mains-driven LP-AMI-P. Additionally LP-AMI are attenuated some 20-30 dB or more due to body loss as reported in ETSI TR 102 655 [10], when the implant is located 10 mm or deeper inside the patient's body.

Based on ETSI TR 102 655 [10], the LP-AMI was assumed to be implanted at 3 cm depth, with the corresponding body attenuation (27 dB). The wanted signal received from LP-AMI-P was taken as constant for a constant distance of 5 m between LP-AMI and LP-AMI-P. Some safety margin to tolerate LOS obstruction by people around the LP-AMI patient was also accounted for.

LP-AMI-P is in most cases required [11] to use LBT and AFA when is transmitting. To model this functionality in SEAMCAT, a random uniform frequency channel selection within the 2484-2499 MHz band was used. This approach was also utilized for the elaboration of ECC Report 149 [4].

According to ETSI EN 301 559-1 [11], when a Medical Implant Event occurs, the LP-AMI implant may immediately transmit time critical data associated with that Medical Implant Event to a LP-AMI-P without regard to channel occupancy. This operation mode—without utilizing LBT and AFA—is limited to 0.83% of any 1-hour period. Moreover it is limited to emergency situations, such as heart attacks, Medical Implant Events are treated differently in subsections 5.1.1, 5.1.2, and 5.1.3, due to the differences in the operational environment.

The main system parameters for LP-AMI are presented in Table 23.

Table 23: LP-AMI parameters

	Parameter	Value
LP-AMI transmitter	Bandwidth (MHz)	Usually 1. Occasionally 3.
	Frequency distribution (MHz)	Uniform (2484-2499) with step 1
	Max Tx power (dBm)	10
	Antenna gain (dBi)	0
	Antenna height (m)	1.5
LP-AMI receiver	User defined dRSS (dBm/MHz)	-80 (Note 1)
	Antenna gain (dBi)	0
	Antenna height (m)	1.5
	C/I objective (dB)	12

Note 1: In ECC Report 149, a dRSS value of -75.3 dBm/MHz is assumed, at an operational range of 10 m between LP-AMI-P and the implant. For the elaboration of this Report, newer information from LP-AMI industry representatives was received and considered. Consequently it was regarded appropriate to assume a dRSS value of -80 dBm/MHz. The following orientative link budget justifies the choice: 0 dBm LP-AMI-P Tx power, -5 dB antenna gain loss, -8 dB tissue attenuation, -7 dB skin-air interface loss, -60 dB loss over 3m operational range (using attenuation exponent n=2.5).

5.1.1 Healthcare facility MBANS

Table 24 shows the MCL calculations for the minimum interference distances between LP-AMI-P and MBANS (both for same and next room) and between LP-AMI and MBANS (same room). Since the obtained distances do not guarantee coexistence, a more detailed analysis via SEAMCAT simulations is presented in the remainder of the subsection.LP-AMI may use the aggregation of 3 channels (equivalent to 1 channel of 3 MHz) for download sessions of recorded data. This mode of communication should not influence the DC of LP-AMI and is referred to as ‘turbo mode’ in the remainder of the report. The turbo mode is expected to be used mainly in hospitals. Hence this additional case is considered in the simulations of this subsection.

Table 24: MCL calculation in 2483.5-2500 MHz band between healthcare facility MBANS and LP-AMI

Scenario		1	2	3	4	5	6
Victim characteristics	**Units**	**LP-AMI-P**		**MBANS**		**LP-AMI**	**MBANS**
Receiver bandwidth	MHz	1		3		1	3
Receiver noise figure	dB	10		10		10	10
Receiver antenna height	m	1.5		1.5		1.5	1.5
Receiver antenna gain	dBi	0		0		0	0
Operating frequency	MHz	2490		2490		2490	2490
N, receiver thermal noise	dBm	-103.8		-99.1		-103.8	-99.1
I/N objective	dB	0		0		0	0
Interferer's characteristics	**Units**	**MBANS**		**LP-AMI-P**		**MBANS**	**LP-AMI**
e.i.r.p	dBm	0		10		0	10
Bandwidth	MHz	3		1		3	1
BW correction factor	dB	-4.77		0		-4.77	0
NFD (adjacent band interf)	dB	0		0		0	0
Wall attenuation	dB	10(next room)	0	10(next room)	0	27(body)	27(body)
Antenna height	m	1.5		1.5		1.5	1.5
Minimum path loss	**dB**	**89.1**	**99.1**	**99.1**	**109.1**	**72.1**	**82.1**
Interference distance FSL model	**km**	**0.27**	**0.86**	**0.86**	**2.72**	**0.04**	**0.12**

5.1.1.1 Interference from MBANS to LP-AMI-P

The considered scenarios (next and same room) are depicted in Figure 13 and Figure 14 correspondingly. For the neighbouring room case, an attenuation of 10 dB is applied to the free space propagation model as result of the indoor wall. The simulations analyse several point-to-point interference scenarios at different MBANS-LP-AMI separation distances. Medical Implant Events are not considered in this healthcare facility scenario. The settings for all cases and their results are summarized in Table 25.

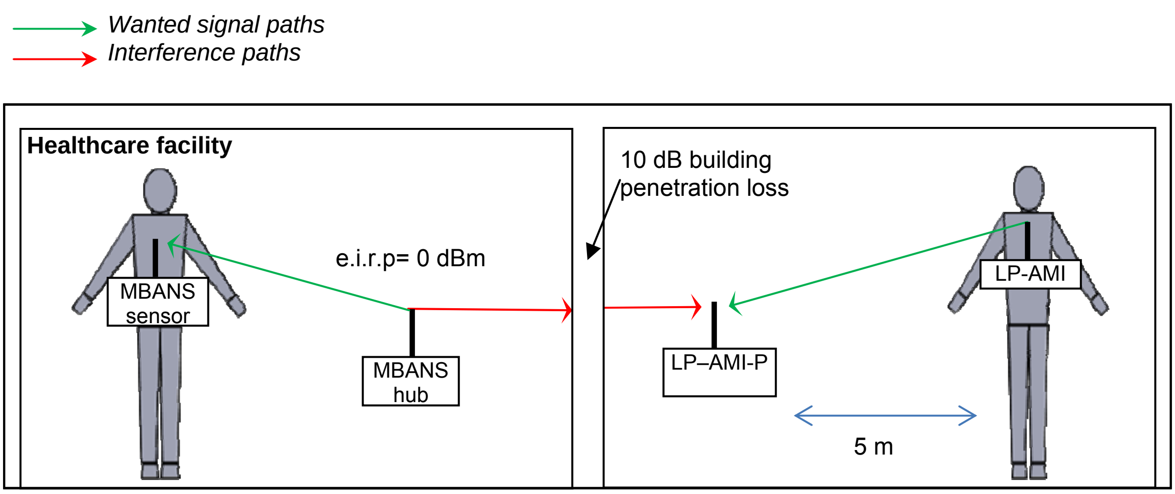


Figure 13: Interference scenario – healthcare facility MBANS into LP-AMI-P (next room)

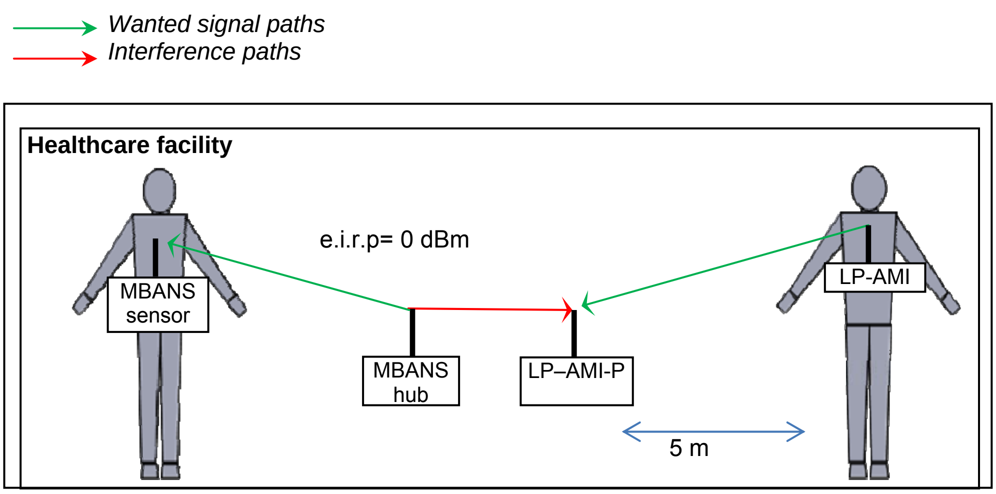


Figure 14: Interference scenario – healthcare facility MBANS into LP-AMI-P (same room)

Table 25: Interference from healthcare facility MBANS to LP-AMI-P - Settings and results

Simulation input/output parameters	Settings/Results					
Victim Link (VLK): LP-AMI TO LP-AMI-P						
VLK frequency	Uniform 2484-2499 MHz					
VLK bandwidth	1 MHz (normal mode)			3 MHz (turbo mode)		
VLR dRSS	-80 dBm/1 MHz			-75.3 dBm/3 MHz		
Interfering Link (ILK): MBANS						
ILK frequency	2490 MHz					
ILK bandwidth	3 MHz					
ILT Tx power	0 dBm (10% probability)					
ILT → VLR positioning mode	Correlated					
ILT → VLR interfering path	FSL					
ILT → VLR distance	1 m	5 m	10 m	1 m	5 m	10 m
Probability of interference (%) (same room) (C/I = 12 dB)	**10.2**	**10.1**	**-**	**10.1**	**9.9**	**-**
Probability of interference (%) (next room) (C/I = 12 dB)	**-**	**7.8**	**2.7**	**-**	**8.3**	**4.6**

5.1.1.2 Interference from MBANS to LP-AMI

A worst-case scenario was considered in which LP-AMI and MBANS are used simultaneously on the same user (patient) and in the same part of the body. In such scenario—depicted in Figure 15—the MBANS transmitter is located directly over the LP-AMI device, which is implanted at 3 cm depth. An attenuation of 27.04 dB was applied to the free space propagation model to model the attenuation caused by the body tissue.

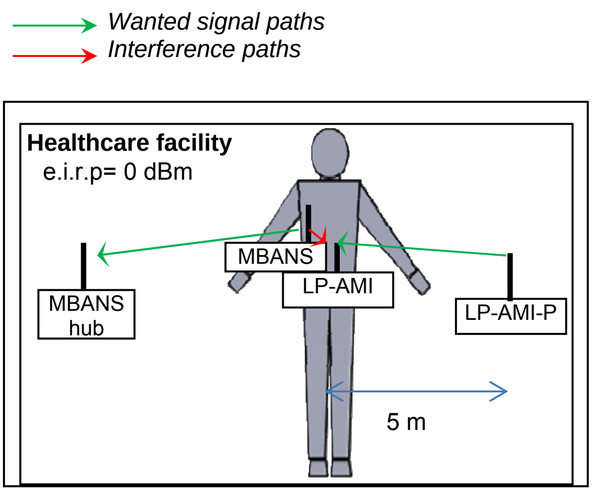


Figure 15: Interference scenario – healthcare facility MBANS into LP-AMI

The SEAMCAT parameters of the MBANS wearable transmitter and the LP-AMI receiver are identical to those shown in Table 25 except for the interfering path, which is FSL with an offset -27.04 dB, and the ILT-VLR distance, which is 3 cm. The resulting interference probability is **10%**, both for normal and turbo mode.

5.1.1.3 Interference from LP-AMI-P to MBANS

The considered interference scenarios are depicted in Figure 16 and Figure 17. The simulation approach is equivalent to that used in Section 5.1.1.1. The simulation settings and results are summarized in Table 26.

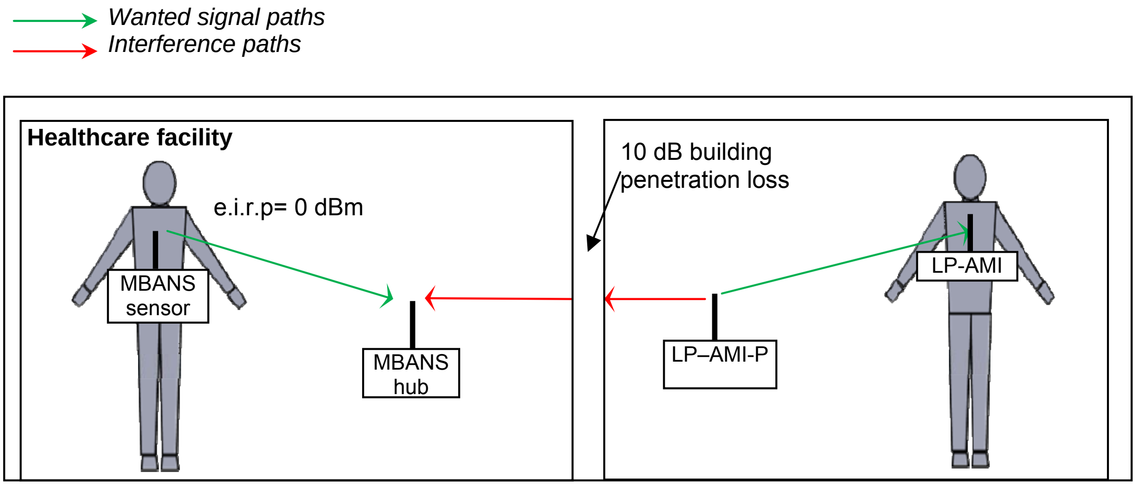


Figure 16: Interference scenario – LP-AMI-P into healthcare facility MBANS (next room

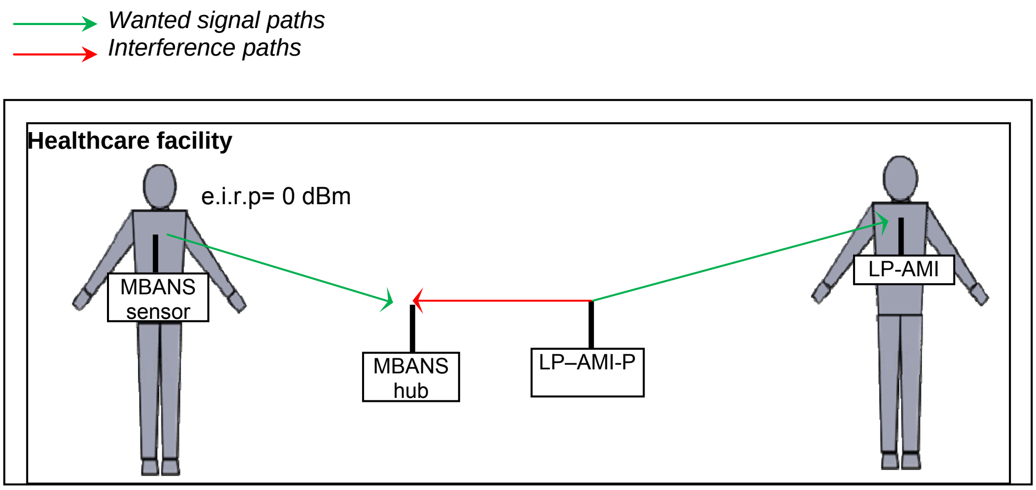


Figure 17: Interference scenario – LP-AMI-P into healthcare facility MBANS (same room)

Table 26 : Interference from LP-AMI-P to healthcare facility MBANS - Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK): MBANS		
VLK frequency	2490 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 3 m)	
Interfering Link (ILK): LP-AMI-P TO LP-AMI		
ILK frequency	Uniform 2484-2499 MHz	
ILK bandwidth	1 MHz (normal mode)	3 MHz (turbo mode)

Simulation input/output parameters	Settings/Results					
ILT Tx power	10 dBm (10% probability)					
ILT → VLR positioning mode	Correlated					
ILT → VLR interfering path	FSL					
ILT → VLR distance	1 m	5 m	10 m	1 m	5 m	10 m
Probability of interference (%) (same room) (C/I = 15 dB)	**3**	**2.7**	**-**	**4.9**	**4.8**	**-**
Probability of interference (%) (next room) (C/I = 15 dB)	**-**	**2.2**	**1.3**	**-**	**4**	**2.8**

5.1.1.4 Interference from LP-AMI to MBANS

Similarly to Section 0, a worst-case scenario is considered in which LP-AMI and MBANS are used simultaneously on the same user (patient) and in the same part of the body. The scenario is depicted in Figure 18.

The parameters of the MBANS wearable transmitter and the LP-AMI receiver are identical to those in Table 26, except for the interfering path, which is FSL with an offset -27.04 dB, and the MBANS-LP-AMI separation distance, which is 3 cm. The resulting interference probability is **3.4%**. For the turbo mode, when LP-AMI uses 3 MHz bandwidth, the interference probability is **5.7 %.**

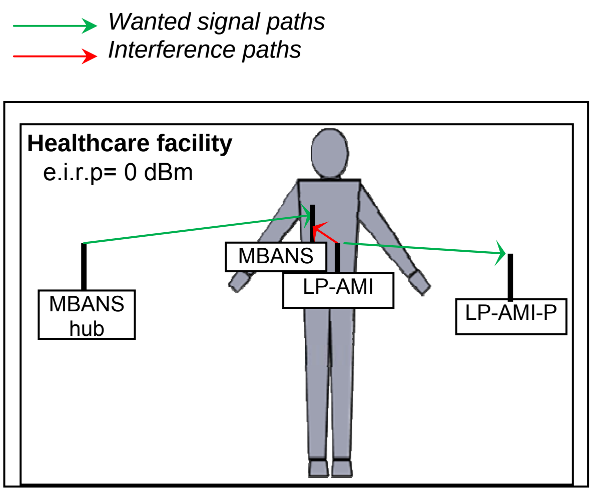


Figure 18: Interference scenario – LP-AMI into healthcare facility MBANS

5.1.2 Home MBANS

Table 27 shows the MCL calculations for the minimum interference distances between LP-AMI-P and home MBANS (both for same and next rooms) and between LP-AMI and home MBANS (same room). Only the one direction of interference is presented; MBANS on LP-AMI(-P). The complementary calculations—LP-AMI(-P) on MBANS—are the same as for the healthcare facility case presented in Table 24, since the MBANS interference criterion remains unaffected. The obtained distances do not guarantee coexistence. Therefore a more detailed analysis via SEAMCAT simulations is presented in the remainder of the subsection.

Table 27: MCL calculation in 2483.5-2500 MHz band between home MBANS and LP-AMI (P)

Victim characteristics	Units	LP-AMI-P		LP-AMI
Receiver bandwidth	MHz	1		1
Receiver noise figure	dB	10		10
Receiver antenna height	m	1.5		1.5
Receiver antenna gain	dBi	0		0
Operating frequency	MHz	2490		2490
N, receiver thermal noise	dBm	-103.8		-103.8
I/N objective	dB	0		0
Interferer's characteristics		MBANS		MBANS
e.i.r.p	dBm	13		13
Bandwidth	MHz	3		3
BW correction factor	dB	-4.77		-4.77
NFD (adjacent band interf)	dB	0		0
Wall attenuation	dB	10(next room)	0	27(body)
Antenna height	m	1.5		1.5
Minimum path loss	**dB**	**102.1**	**112.1**	**85.1**
Interference distance FSL model	**km**	**1.22**	**3.84**	**0.17**

5.1.2.1 *Interference from MBANS to LP-AMI-P*

The assumed scenarios are the same as in Section 5.1.1.1. In this case the turbo mode is not considered in the analysis. The simulation parameters and the results for the point-to-point interference scenarios are summarized in Table 28.

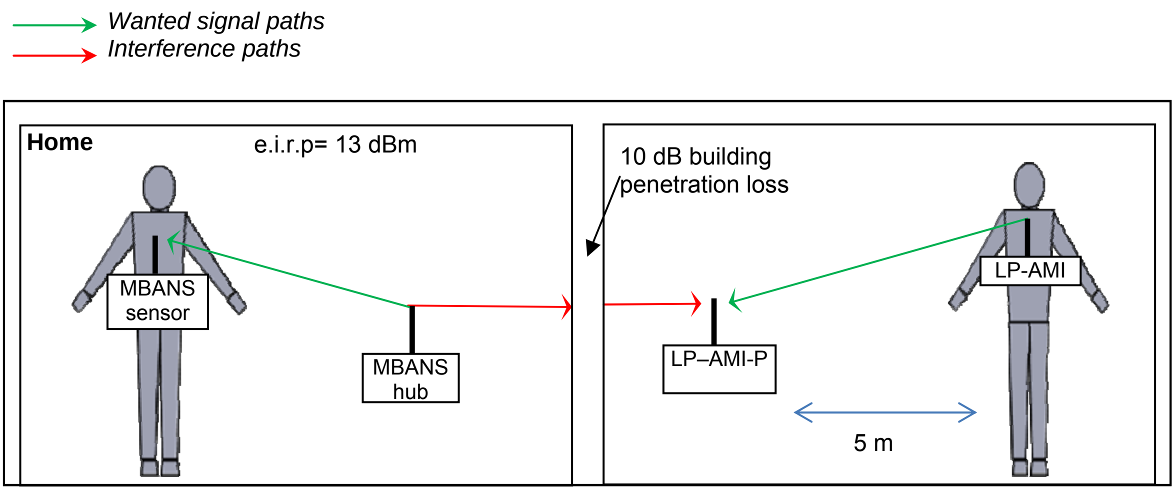


Figure 19: Interference scenario – home MBANS into LP-AMI-P (next room)

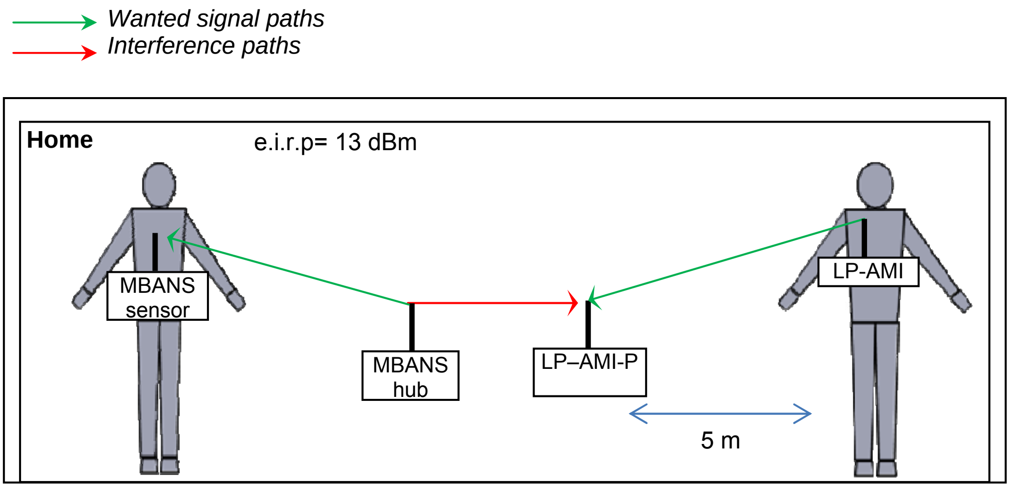


Figure 20: Interference scenario – home MBANS into LP-AMI-P (same room

Table 28: Interference from home MBANS to LP-AMI-P - Settings and results

Simulation input/output parameters	Settings/Results		
Victim Link (VLK): LP-AMI TO LP-AMI-P			
VLK frequency	Uniform 2484-2499 MHz		
VLK bandwidth	1 MHz		
VLR dRSS	-80 dBm/1 MHz		
Interfering Link (ILK): MBANS			
ILK frequency	2490 MHz		
ILK bandwidth	3 MHz		
ILT Tx power	13 dBm		
ILT → VLR positioning mode	Correlated		
ILT → VLR interfering path	FSL		
ILT → VLR distance	1 m	5 m	10 m
Probability of interference (%) (same room) (C/I = 12 dB)	**2.1**	**2**	**-**
Probability of interference (%) (next room) (C/I = 12 dB)	**-**	**1.7**	**1.9**

Note 1: Medical Implants Events have also been considered by changing the victim link (VLK) central frequency to a fixed value of 2490 MHz. The obtained interference probability values do not differ and are hence not explicitly presented.

5.1.2.2 Interference from MBANS to LP-AMI

Here the same justification applies as in case 0. The resulting interference probability is **2.1** %.

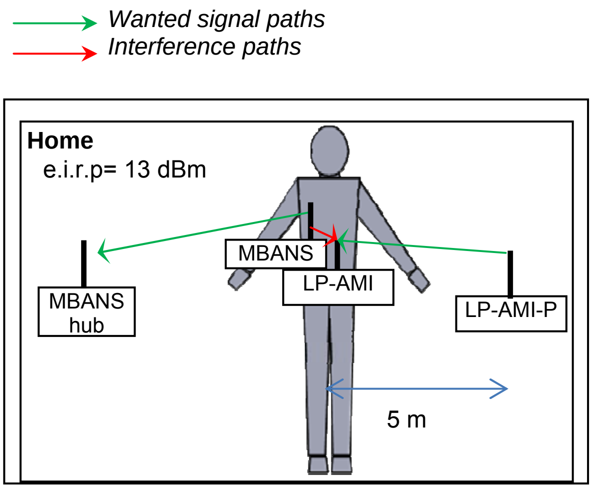


Figure 21: Interference scenario – home MBANS into LP-AMI

5.1.2.3 Interference from LP-AMI-P to MBANS

The assumed scenarios are the complementary to those of Section 5.1.2.1 and are depicted in Figure 22 and Figure 23. The simulation parameters and the corresponding results are in Table 29.

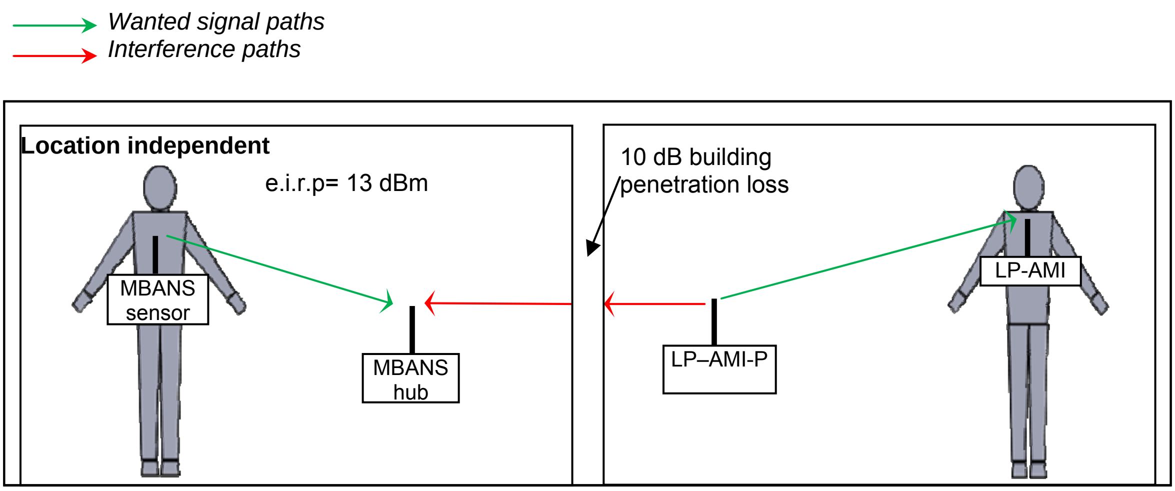


Figure 22: Interference scenario – LP-AMI-P into home MBANS (next room)

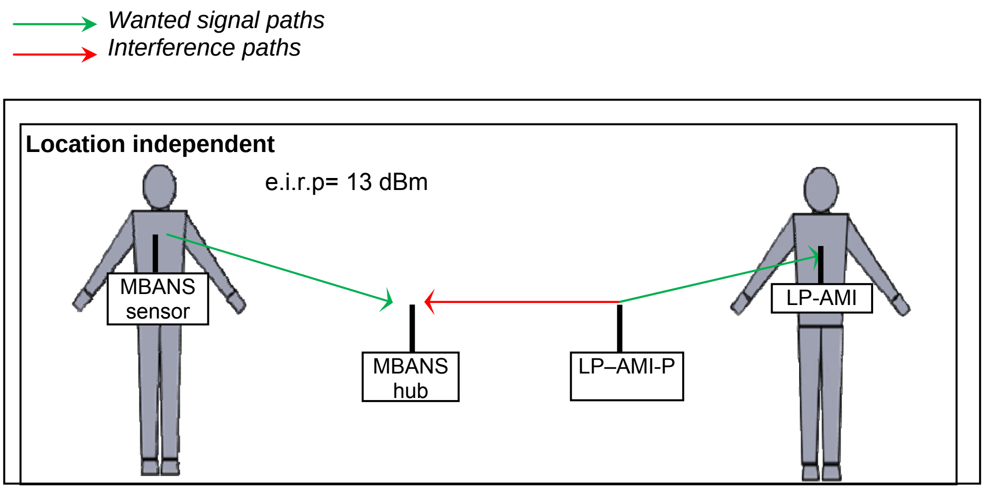


Figure 23: Interference scenario – LP-AMI-P into home MBANS (same room)

Table 29: Interference from LP-AMI-P to home MBANS - Settings and results

Simulation input/output parameters	Settings/Results		
Victim Link (VLK): MBANS			
VLK frequency	2490 MHz		
VLK bandwidth	3 MHz		
VLT → VLR path	FSL (user-defined radius, 10 m)		
Interfering Link (ILK): LP-AMI-P TO LP-AMI			
ILK frequency	Uniform 2484-2499 MHz		
ILK bandwidth	1 MHz		
ILT Tx power	10 dBm		
ILT → VLR positioning mode	Correlated		
ILT → VLR interfering path	FSL		
ILT → VLR distance	1 m	5 m	10 m
Probability of interference (%) (same room) (C/I = 15 dB)	**2.8**	**2.6**	**-**
Probability of interference (%) (next room) (C/I = 15 dB)	**-**	**2**	**0.5**

5.1.2.4 Interference from LP-AMI to MBANS

Here the same justification applies as in Section 5.1.1.4. The resulting interference is **3.7 %.**

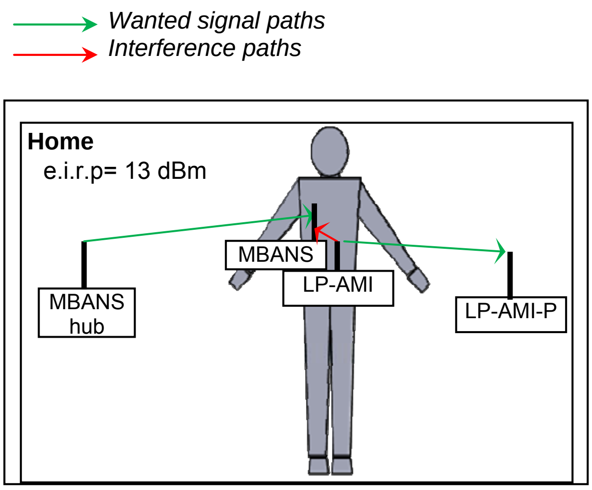


Figure 24: Interference scenario – LP-AMI into home MBANS

5.1.3 Ambulance MBANS

The compatibility situation may be equivalent to the situation within healthcare facilities.Therefore the conclusions of Section 5.1.1 are also applicable for the ambulance MBANS case.

5.1.4 Summary Active Medical Implants

<u>Healthcare facility and ambulance MBANS</u>:

According to the results presented above, in worst-case situations—modelled with MCL calculations—the interference distance between active medical implants (LP-AMI) and MBANS is 40 m - 860 m (MBANS as interferer) and 120 m – 2.7 km (LP-AMI as interferer). The simulation-based analysis yielded 2.7% - 8.3% probability of interference from MBANS into LP-AMI, when both systems are located in a neighbouring room and up to a distance of 10 m from one another. When operated in the same room or on the same patient, the probability of interference from MBANS into LP-AMI raises to approximately 10%. In the other coexistence direction, the probability of interference from LP-AMI into MBANS lies in the ranges of 1.3% - 4% (neighbouring room and up to a distance of 10 m), 2.7% - 4.9% (same room), and 3.4% - 5.7% (same patient).

Co-channel compatibility between MBANS and LP-AMI in healthcare facilities is not given, since significant interference levels are expected, even when both systems are operated in different rooms. Mitigation measures will hence be required and should be specified by ETSI standards (primarily by the future MBANS ETSI standard).

ETSI is considering mitigation measure possibities—with regard to both intereference effects and implant battery life reduction—and is expected to provide CEPT with the results of their considerations.

<u>Home MBANS</u>:

In worst-case situations—modelled with MCL calculations—the interference distance between active medical implants (LP-AMI) and MBANS is 170 m – 3.8 km (MBANS as interferer). The simulation-based analysis yielded around 2% probability of interference from MBANS into LP-AMI, when both systems are located in the same room or on the same patient. In the other coexistence direction, the probability of interference from

LP-AMI into MBANS lies in the range of 2.6% - 3.7%, when both systems are located in the same room or on the same patient.

Co-channel compatibility between MBANS and LP-AMI in patient homes appears possible, based on the obtained simulation results, because of the much lower duty cycle and density of home MBANS.

5.2 ISM

ISM devices are left out of the study, as explained in Section 4.2.

5.3 MSS SYSTEMS (GLOBALSTAR MOBILE PHONES)

The band 2483.5-2500 MHz is used for MSS communications in the direction Space-to-Earth, paired with 1610-1626.5 MHz for transmissions Earth-to-Space. Today this MSS allocation is being utilised by the Globalstar system, which is based on CDMA IS-95 technology and serves around 500000 reported subscribers worldwide.

The danger of interference from MSS into MBANS may be discarded based on the following analysis:

- Globalstar downlink signal should comply with maximum Pfd limit (for single satellite) of -124.5 dBW/m^2/MHz on the ground;
- Effective antenna area at 2483.5 MHz is -30.2 dB(m^2), MBANS receiver bandwidth 5 MHz;
- Resulting MSS downlink signal power in MBANS receiver is -147.7 dBW= -117.7 dBm;
- Even considering power summation from multiple Globalstar satellites, the resulting interfering power compares favourably with the noise floor of MBANS receiver of -91 dBm.

It thus may be concluded that MSS downlink should not pose any danger to MBANS operations. Therefore it was decided to limit the statistical study only to the case of interference from MBANS to Globalstar MES (Mobile Earth Station) receivers, as considered by previous studies [4]. The relevant parameters for Globalstar MES to be used in statistical study were taken from the ECC Report 165 [12].

5.3.1 Healthcare facility MBANS

Table 30: MCL calculation in 2483.5-2500 MHz band between healthcare facility MBANS and MSS

Victim characteristics	Units	MSS MES	
Receiver bandwidth	MHz	1.23	
Receiver noise figure	dB	3	
Receiver antenna height	m	1.5	
Receiver antenna gain	dBi	0	
Operating frequency	MHz	2490	
N, receiver thermal noise	dBm	-109.9	
I/N objective	dB	-12	
Interferer's characteristics	**Units**	**MBANS**	
e.i.r.p	dBm	0 (single MBANS)	13 (additive contribution of 20 MBANS)
Bandwidth	MHz	3	
BW correction factor	dB	-3.9	
NFD (adjacent band interf)	dB	0	
Wall attenuation	dB	13	
Antenna height	m	1.5	
Minimum path loss	**dB**	**105.1**	**118.1**
Interference distance FSL model	**km**	**1.72**	**7.67**
Interference distance P.452 model with 50% probability	**km**	**0.65**	**1.65**

Table 30 presents interference distances considering the impact of a single MBANS and the impact of several MBANS (area with high density). The latter is calculated assuming that a significant part of the MBANS concentrated in a hospital are next to the wall that separates the hospital from the street on which the MSS MES (MSS terminal) is located. The assumed 20 MBANS are not shielded by the hospital inner clutter and their e.i.r.p values are added.

Using the propagation model described in Recommendation ITU-R P.452 [13]—which is valid for point-point propagation on the Earth surface for frequencies above 0.7 GHz—the minimum distances are lower than using FSL, as shown in the last row of Table 30. The propagation distance was calculated with the P.452 model with a probability of 50%.A probability of 50% means that the propagation loss could be lower than the given value 50% of the time and should be higher or equal 50% of the time. Therefore the given distance will be sufficient or more than needed at least 50% of the time.

5.3.1.1 Interference from MBANS to Globalstar MES receivers

The considered scenario is depicted in Figure 25 and simulation settings are in Table 31.

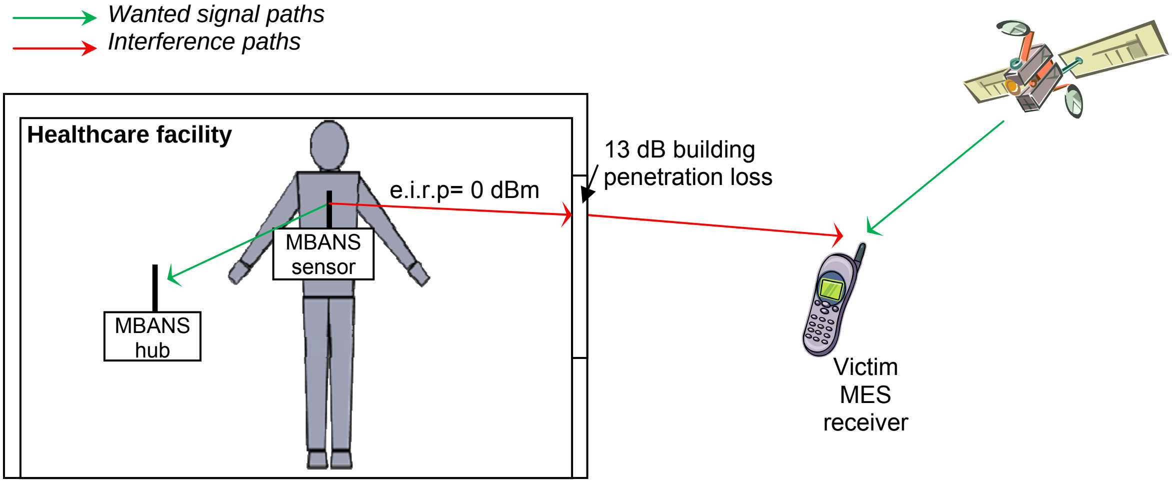


Figure 25: Interference scenario – healthcare facility MBANS into MSS MES

Table 31: Interference from healthcare facility MBANS to MSS MES - Settings and results

Simulation input/output parameters	Settings/Results
Victim Link (VLK): MSS SATELLITE TO MSS MES	
VLK frequency	2490 MHz
VLK bandwidth	1.23 MHz
VLR dRSS	-100 dBm
VLR noise floor	-110 dBm
Interfering Link (ILK): MBANS	
ILK frequency	2490 MHz
ILK bandwidth	3 MHz
ILT Tx power	0 dBm
ILT density	40/km^2
ILT probability of transmission	0.1
ILT → VLR interfering path	Extended Hata, urban, indoor→outdoor, below roof
ILT → VLR positioning mode	Closest interferer
Simulation results	
dRSS, dBm (Std.dev., dB)	-100 (0)
iRSSunwanted, dBm (Std.dev., dB)	-163.25 (19.82)
Probability of interference (%) (I/N = -12 dB)	**3.6**

5.3.2 Home MBANS

Table 32: MCL calculation in 2483.5-2500 MHz band between home MBANS and MSS

Victim characteristics	Units	MSS MES
Receiver bandwidth	MHz	1.23
Receiver noise figure	dB	3
Receiver antenna height	m	1.5
Receiver antenna gain	dBi	0
Operating frequency	MHz	2490
N, receiver thermal noise	dBm	-109.9
I/N objective	dB	-12
Interferer's characteristics	**Units**	**MBANS**
e.i.r.p	dBm	13
Bandwidth	MHz	3
BW correction factor	dB	-3.9
NFD (adjacent band interf)	dB	0
Wall attenuation	dB	0 (outdoor) (Note 1)
Antenna height	m	1.5
Minimum path loss	**dB**	**131.1**
Interference distance FSL model	**km**	**34.26**
Interference distance P.452 model with 50% probability	**km**	**4.76**

Note 1: Worst case configuration assumed, in which MBANS transmitter or receiver is outdoors.

According to the MCL calculations, home MBANS could interfere with MSS receivers located less than 4.8 km around the MBANS. Since such a distance was regarded problematic the probability of interference is analysed in further detail in the following subsections.

5.3.2.1 Interference from MBANS to Globalstar MES receivers

Scenario is depicted in Figure 26 and simulation settings are in Table 33.

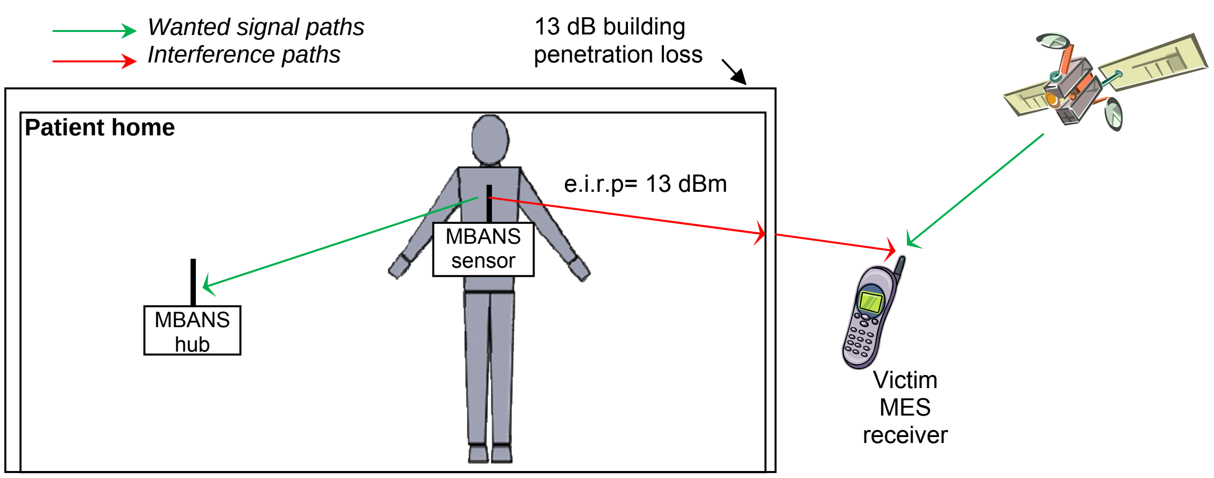


Figure 26: Interference scenario – home MBANS into MSS MES

Table 33: Interference from home MBANS to MSS MES - Settings and results

Simulation input/output parameters	Settings/Results
Victim Link (VLK): MSS SATELLITE TO MSS MES	
VLK frequency	2490 MHz
VLK bandwidth	1.23 MHz
VLR dRSS	-100 dBm
VLR noise floor	-110 dBm
Interfering Link (ILK): MBANS	
ILK frequency	2490 MHz
ILK bandwidth	3 MHz
ILT Tx power	13 dBm (2% probability)
ILT density	10/km^2
ILT probability of transmission	1
ILT → VLR interfering path	Extended Hata, urban, indoor→outdoor, below roof
ILT → VLR positioning mode	Uniform density
ILT → VLR number of transmitters	785 (for 5 km simulation radius)
Simulation results	
dRSS, dBm (Std.dev., dB)	-100 (0)
iRSSunwanted, dBm (Std.dev., dB)	-158.76 (10.48)
Probability of interference (%) (I/N = -12 dB)	**1.1**

5.3.3 Ambulance MBANS

Table 34: MCL calculation in 2483.5-2500 MHz band between healthcare facility MBANS and MSS

Victim characteristics	Units	MSS MES
Receiver bandwidth	MHz	1.23
Receiver noise figure	dB	3
Receiver antenna height	m	1.5
Receiver antenna gain	dBi	0
Operating frequency	MHz	2490
N, receiver thermal noise	dBm	-109.9
I/N objective	dB	-12
Interferer's characteristics	**Units**	**MBANS**
e.i.r.p	dBm	0
Bandwidth	MHz	3
BW correction factor	dB	-3.9
NFD (adjacent band interf)	dB	0
Wall attenuation	dB	7 (ambulance)
Antenna height	m	1.5
Minimum path loss	**dB**	**111.1**
Interference distance FSL model	**km**	**3.43**
Interference distance P.452 model with 50% probability	**km**	**0.98**

5.3.3.1 Interference from MBANS to Globalstar MES receivers

Scenario is depicted in Figure 27 and simulation settings are on Table 35.

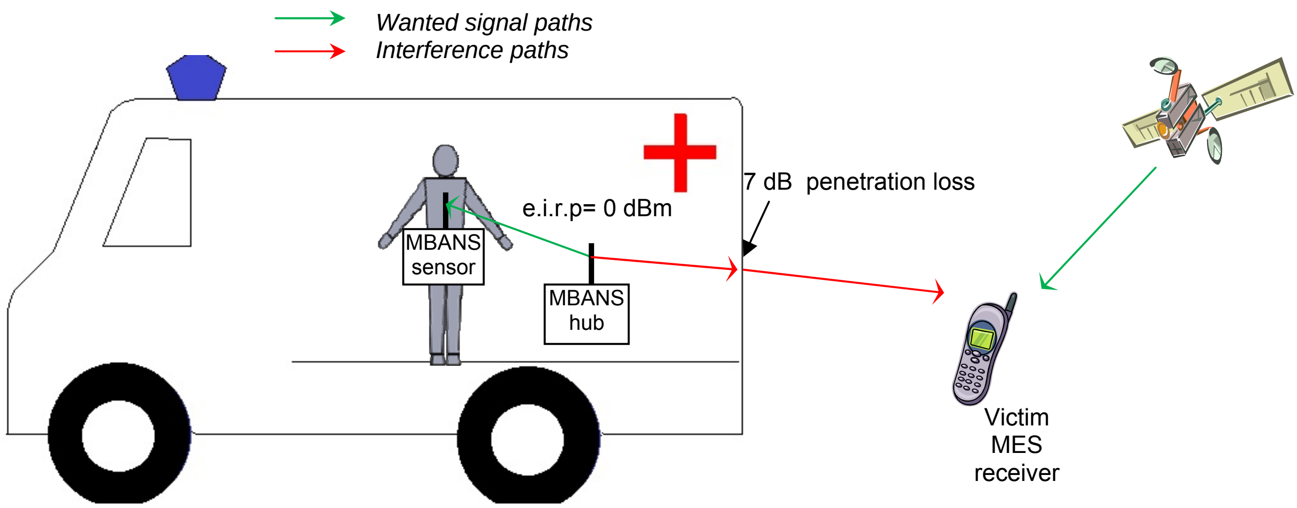


Figure 27: Interference scenario – ambulance MBANS into MSS MES

Table 35: Interference from ambulance MBANS to MSS MES- Settings and results

Simulation input/output parameters	Settings/Results
Victim Link (VLK): MSS SATELLITE TO MSS MES	
VLK frequency	2490 MHz
VLK bandwidth	1.23 MHz
VLR dRSS	-100 dBm
VLR noise floor	-110 dBm
Interfering Link (ILK): MBANS	
ILK frequency	2490 MHz
ILK bandwidth	3 MHz
ILT Tx power	0 dBm
ILT density	5/km^2
ILT probability of transmission	0.1
ILT → VLR interfering path	Extended Hata, urban, intdoor→outdoor, below roof
ILT → VLR positioning mode	Uniform density
ILT → VLR number of active transmitters	2 (for 1 km simulation radius)
Simulation results	
dRSS, dBm (Std.dev., dB)	-100 (0)
iRSSunwanted, dBm (Std.dev., dB)	-166.88 (14.7)
Probability of interference (%) (I/N = -12 dB)	**1.4**

5.3.4 Summary MSS Systems

Healthcare facility MBANS:

According to the results presented above, in worst-case situations—modelled with MCL calculations—the interference distance between MSS and MBANS is 0.7 km - 1.7 km (single MBANS as interferer) and 1.7 km - 7.7 km (multiple MBANS as interferers). The simulation-based average-case analysis yielded 3.6% interference probability from MBANS into MSS.

MSS systems operating in the 2483.5-2500 MHz range and healthcare facility MBANS operating in the same range can coexist, assuming that an interference probability of about 3% would be acceptable.

Home and ambulance MBANS:

In worst-case situations—modelled with MCL calculations—the interference distance between MSS and MBANS is 4.8 km - 34 km (home MBANS as interferer) and 980 m – 3.4 km (ambulance MBANS as interferer). The simulation-based average-case analysis yielded an interference probability into MSS of 1.1% (from home MBANS) and 1.4% (from ambulance MBANS).

MSS systems operating in the 2483.5-2500 MHz range and home and ambulance MBANS operating in the same range can coexist.

5.4 CGC (COMPLEMENTARY GROUND COMPONENT OF MSS SYSTEMS)

The CGC is an emerging future possible idea of supplementary evolution of the MSS networks whereas terrestrial base stations would be installed in order to improve the coverage of MSS signals, e.g. within conditions of dense urban environments where very low sky observation angles severely hamper reliable reception of MSS satellite signals (so called “city canyon” scenario). A detailed description of intended operation of CGC as a part of Globalstar system may be found in ECC Report 165 [12].

For systems to be considered in the studies related to the introduction of CGC associated with non GSO MSS systems in the bands 1.6 and 2.5 GHz, it was decided to limit the studies to the GLOBALSTAR case in the band 2483.5-2500 MHz and IRIDIUM and GLOBALSTAR in the band 1610-1626.5 MHz, for which parameters were received by CEPT.

An important feature of CGC to be considered in this study is that CGC would be operated in a portion of the same frequency bands as their satellite-based mother-systems. In other words, the CGC for Globalstar system deployed in the frequency band 2483.5-2500 MHz would also operate in the same band but just on a sub-set of available radio channels. Therefore when analysing CGC as part of co-existence analysis with MBANS applications, we still need to consider the same MSS MES device as victim receiver, but now we need to consider CGC BS (Base Station) emissions as potential interferer to the MBANS receiver. Previous studies in ECC Report 149 [4] have selected CGC BS transmitters as the largest source of interference. The required parameters of CGC BS emissions are taken from ECC Report 165 [12]. It should be also noted that, when used with CGC, the MES will have better link budget and could be therefore operated indoors.

5.4.1 Healthcare facility MBANS

Table 36: MCL calculation in 2483.5-2500 MHz band between healthcare facility MBANS and MSS-CGC

Victim characteristics	Units	CGC MES	MBANS
Receiver bandwidth	MHz	1.23	3
Receiver noise figure	dB	3	10
Receiver antenna height	m	1.5	1.5
Receiver antenna gain	dBi	0	0
Operating frequency	MHz	2490	2490
N, receiver thermal noise	dBm	-109.9	-99.1
I/N objective	dB	-12	0
Interferer's characteristics		**MBANS**	**CGC BS Tx**
e.i.r.p	dBm	0	17
Bandwidth	MHz	3	1.23
BW correction factor	dB	-3.9	0
NFD (adjacent band interf)	dB	0	0
Wall attenuation	dB	n.a. (indoor)	13
Antenna height	m	1.5	30
Minimum path loss	**dB**	**118.1**	**103.1**
Interference distance FSL model	**km**	**7.67**	**1.36**
Interference distance P.452 model with 50% probability	**km**	**1.65**	**1.36**

5.4.1.1 Interference from MBANS to Globalstar MES receivers in CGC mode

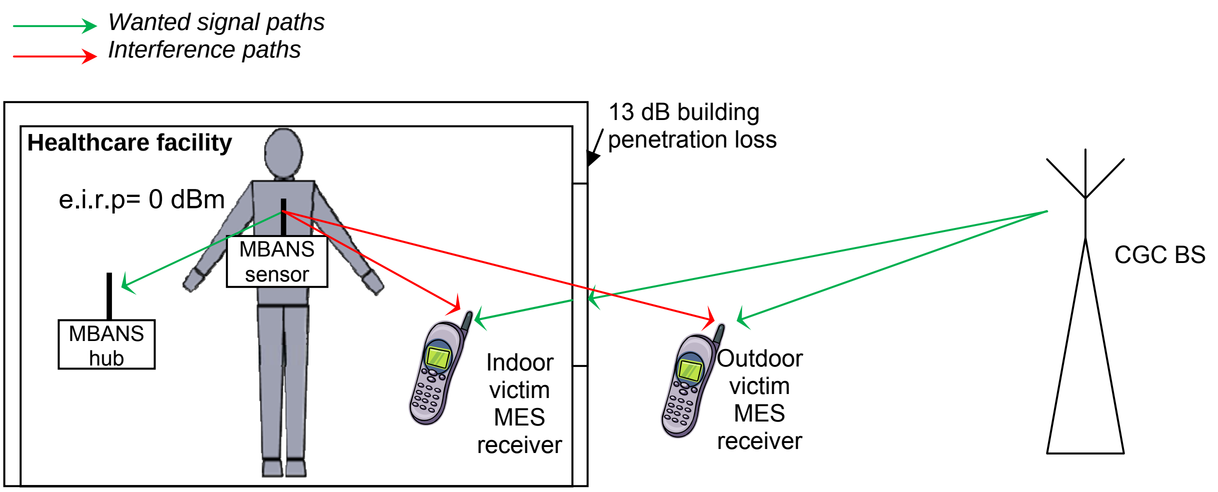


Figure 28: Interference scenario – healthcare facility MBANS into CGC MES

Table 37: Interference from healthcare facility MBANS to CGC MES - Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK): CGC BASE STATION TO CGC MES		
VLK frequency	2490 MHz	
VLK bandwidth	1.23 MHz	
VLR dRSS	-100 dBm	
VLR noise floor	-110 dBm	
Interfering Link (ILK): MBANS		
ILK frequency	2490 MHz	
ILK bandwidth	3 MHz	
ILT Tx power	0 dBm	
ILT density	40/km^2	
ILT probability of transmission	0.1	
ILT → VLR interfering path	Extended Hata, urban, below roof	
	indoor→indoor	indoor→outdoor
ILT → VLR positioning mode	Closest interferer	
Simulation results		
dRSS, dBm (Std.dev., dB)	-100 (0)	-100 (0)
iRSSunwanted, dBm (Std.dev., dB)	-176.25 (21.43)	-163.27 (19.81)
Probability of interference (%) (I/N = -12 dB)	**1.9**	**3.6**

5.4.1.2 Interference from CGC base station to MBANS

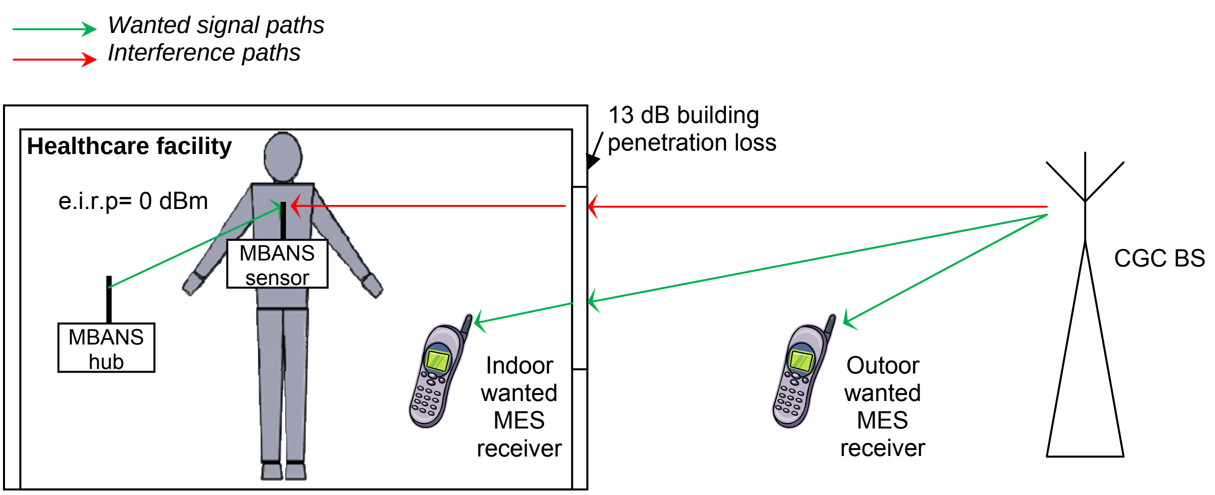


Figure 29: Interference scenario – GC BS into healthcare facility MBANS

Table 38: Interference from CGC BS to healthcare facility MBANS - Settings and results

Simulation input/output parameters	Settings/Results
Victim Link (VLK): MBANS	
VLK frequency	2490 MHz
VLK bandwidth	3 MHz
VLT → VLR path	FSL (user-defined radius, 3 m)
Interfering Link (ILK): CGC link (BS to MES)	
ILK frequency	2490 MHz
ILK bandwidth	5 MHz
ILT Tx power	43 dBm
ILT peak antenna gain	19 dBi
ILT density	$0.02/km^2$
ILT probability of transmission	1
ILT → VLR interfering path	Extended Hata, urban, outdoor→indoor, above roof
ILT → VLR positioning mode	Uniform density
ILT → VLR number of active transmitters	1
Simulation results	
dRSS, dBm (Std.dev., dB)	-45.61 (4.39)
iRSSunwanted, dBm (Std.dev., dB)	-103.23 (12.9)
Probability of interference (%) (C/I = 15 dB)	**0.4**

5.4.2 Home MBANS

Table 39: MCL calculation in 2483.5-2500 MHz band between home MBANS and MSS-CGC

Victim characteristics	Units	CGC MES	MBANS
Receiver bandwidth	MHz	1.23	3
Receiver noise figure	dB	3	10
Receiver antenna height	m	1.5	1.5
Receiver antenna gain	dBi	0	0
Operating frequency	MHz	2490	2490
N, receiver thermal noise	dBm	-109.9	-99.1
I/N objective	dB	-12	0
Interferer's characteristics		**MBANS**	**CGC BS Tx**
e.i.r.p	dBm	13	17
Bandwidth	MHz	3	1.23
BW correction factor	dB	-3.9	0
NFD (adjacent band interf)	dB	0	0
Wall attenuation (Note 1)	dB	0 (indoor)	0 (outdoor)
Antenna height	m	1.5	30
Minimum path loss	**dB**	**131.1**	**116.1**
Interference distance FSL model	**km**	**34.26**	**6.09**
Interference distance P.452 model with 50% probability	**km**	**4.76**	**5.24**

Note 1: Worst case configuration assumed, in which MBANS transmitter or receiver is outdoors.

5.4.2.1 Interference from MBANS to Globalstar MES receivers in CGC mode

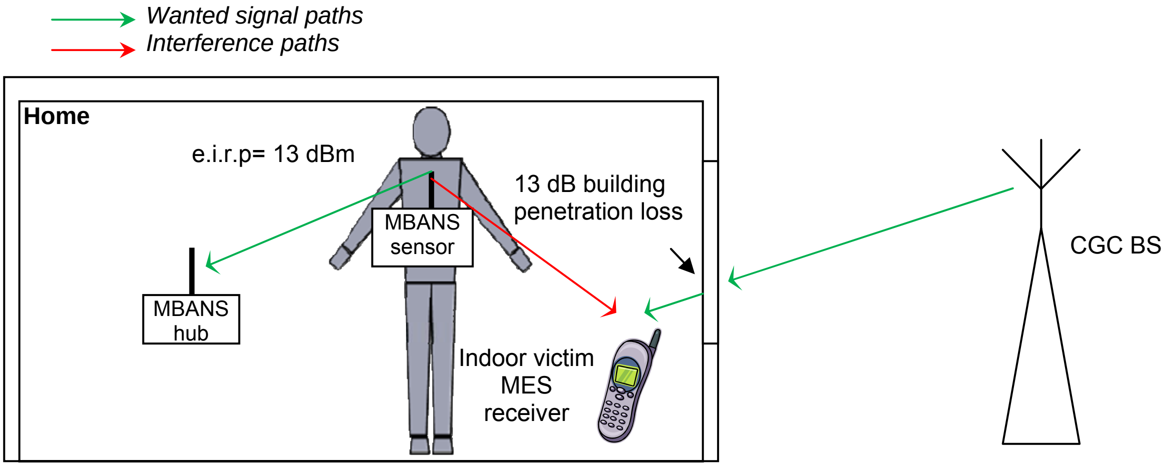


Figure 30: Interference scenario – home MBANS into CGC MES

Table 40: Interference from home MBANS to CGC MES - Settings and results

Simulation input/output parameters	Settings / Results	
Victim Link (VLK): CGC BASE STATION TO CGC MES		
VLK frequency	2490 MHz	
VLK bandwidth	1.23 MHz	
VLR dRSS	-100 dBm	
VLR noise floor	-110 dBm	
Interfering Link (ILK): MBANS		
ILK frequency	2490 MHz	
ILK bandwidth	3 MHz	
ILT Tx power	13 dBm (2% probability)	
ILT density	10/km^2	
ILT probability of transmission	1	
ILT → VLR interfering path	Extended Hata, urban, below roof	
	indoor→indoor	indoor→outdoor
ILT → VLR positioning mode	Uniform	
ILT → VLR number of transmitters	785 (for 5 km simulation radius)	
Simulation results		
dRSS, dBm (Std.dev., dB)	-100 (0)	-100 (0)
iRSSunwanted, dBm (Std.dev., dB)	-167.97 (10.98)	-158.81 (10.48)
Probability of interference (%) (I/N = -12 dB)	**0.5**	**1.1**

5.4.2.2 Interference from CGC base station to MBANS

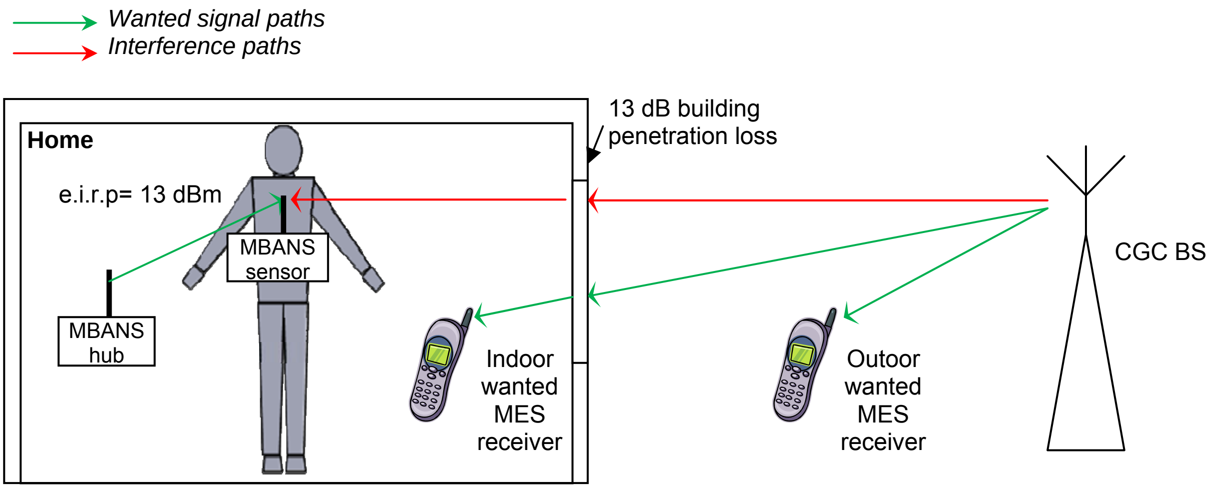


Figure 31: Interference scenario – CGC BS into home MBAN

Table 41: Interference from CGC BS to home MBANS - Settings and results

Simulation input/output parameters	Settings/Results
Victim Link (VLK): MBANS	
VLK frequency	2490 MHz
VLK bandwidth	3 MHz
VLT → VLR path	FSL (user-defined radius, 10 m)
Interfering Link (ILK): CGC link (BS to MES)	
ILK frequency	2490 MHz
ILK bandwidth	5 MHz
ILT Tx power	43 dBm
ILT peak antenna gain	19 dBi
ILT density	0.02/km^2
ILT probability of transmission	1
ILT → VLR interfering path	Extended Hata, urban, outdoor→indoor, above roof
ILT → VLR positioning mode	Uniform density
ILT → VLR number of active transmitters	1
Simulation results	
dRSS, dBm (Std.dev., dB)	-44.2 (4.44)
iRSSunwanted, dBm (Std.dev., dB)	-103.84 (12.92)
Probability of interference (%) (C/I = 15 dB)	**0.3**

5.4.3 Ambulance MBANS

Table 42: MCL calculation in 2483.5-2500 MHz band between ambulance MBANS and MSS-CGC

Victim characteristics	Units	CGC MES	MBANS
Receiver bandwidth	MHz	1.23	3
Receiver noise figure	dB	3	10
Receiver antenna height	m	1.5	1.5
Receiver antenna gain	dBi	0	0
Operating frequency	MHz	2490	2490
N, receiver thermal noise	dBm	-109.9	-99.1
I/N objective	dB	-12	0
Interferer's characteristics		**MBANS**	**CGC BS Tx**
e.i.r.p	dBm	0	17
Bandwidth	MHz	3	1.23
BW correction factor	dB	-3.9	0
NFD (adjacent band interf)	dB	0	0
Wall attenuation	dB	7	7
Antenna height	m	1.5	30
Minimum path loss	**dB**	**111.1**	**109.1**
Interference distance FSL model	**km**	**3.43**	**2.72**
Interference distance P.452 model with 50% probability	**km**	**0.98**	**2.71**

5.4.3.1 Interference from CGC base station to MBANS

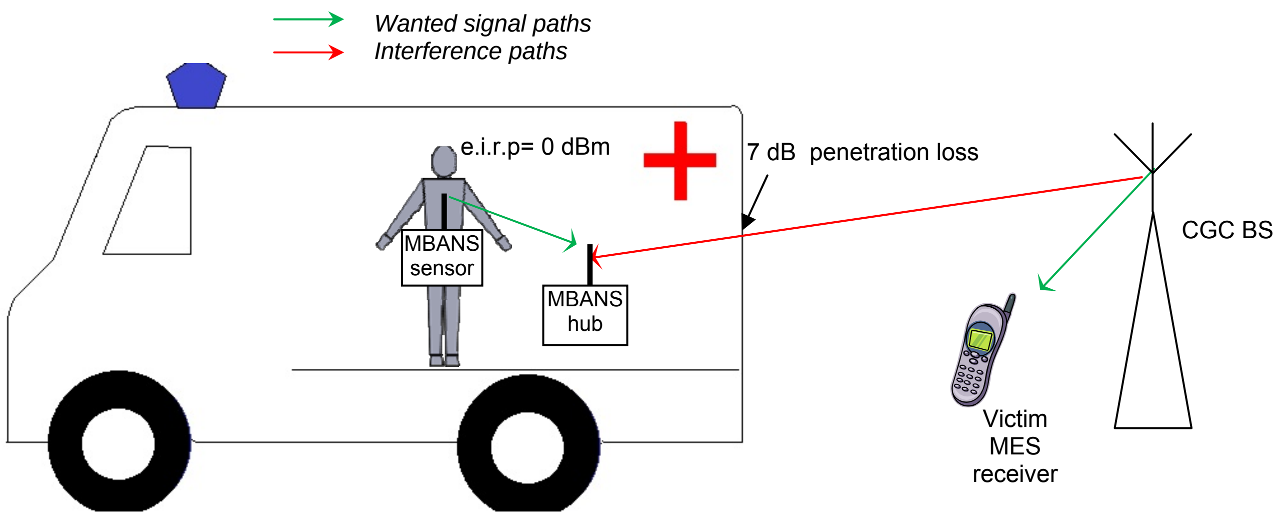


Figure 32: Interference scenario – CGC BS into ambulance MBAN

Table 43: Interference from CGC BS to ambulance MBANS - Settings and results

Simulation input/output parameters	Settings/Results
Victim Link (VLK): MBANS	
VLK frequency	2490 MHz
VLK bandwidth	3 MHz
VLT → VLR path	FSL (user-defined radius, 3 m)
Interfering Link (ILK): CGC link (BS to MES)	
ILK frequency	2490 MHz
ILK bandwidth	5 MHz
ILT Tx power	43 dBm
ILT peak antenna gain	19 dBi
ILT density	0.02/km^2
ILT probability of transmission	1
ILT → VLR interfering path	Extended Hata, urban, outdoor→indoor, above roof
ILT → VLR positioning mode	Uniform density
ILT → VLR number of active transmitters	1
Simulation results	
dRSS, dBm (Std.dev., dB)	-46.8 (4.44)
iRSSunwanted, dBm (Std.dev., dB)	-97.84 (12.82)
Probability of interference (%) (C/I = 15 dB)	**0.9**

5.4.3.2 Interference from MBANS to Globalstar MES receivers in CGC mode

This interference situation is believed to be equivalent to that analyzed in 5.3.3.1. The same results apply, namely 1.4% probability of interference.

5.4.4 Summary CGC

Healthcare facility MBANS:

According to the results presented above, in worst-case situations—modelled with MCL calculations—the interference distance between CGC and MBANS is 1.7 km - 7.7 km (MBANS as interferer) and 1.4 km (CGC BS as interferer). The simulation-based average-case analysis yielded 1.9% - 3.6% interference probability from MBANS into CGC (i.e. MSS terminal in CGC mode). In the other coexistence direction, the probability of interference from CGC into MBANS is 0.4%.

CGC systems operating in the 2483.5-2500 MHz range and healthcare facility MBANS operating in the same range appear to be compatible, if we assume that about 3% interference probability would be acceptable.

Home MBANS:

In worst-case situations—modelled with MCL calculations—the interference distance between CGC and MBANS is 4.8 km - 34 km (MBANS as interferer) and 5.2 km – 6.1 km (CGC BS as interferer). The simulation-based average-case analysis yielded 0.5% - 1.1% interference probability from MBANS into CGC (i.e. MSS terminal in CGC mode). In the other coexistence direction, the probability of interference from CGC into MBANS is 0.3%.

CGC systems operating in the 2483.5-2500 MHz range and home MBANS operating in the same range appear to be compatible.

<u>Ambulance MBANS</u>:

In worst-case situations—modelled with MCL calculations—the interference distance between CGC and MBANS is 980 m – 3.4 km (MBANS as interferer) and 2.7 km (CGC BS as interferer). The simulation-based average-case analysis yielded 1.4% interference probability from MBANS into CGC (i.e. MSS terminal in CGC mode). In the other coexistence direction, the probability of interference from CGC into MBANS is <1%.

CGC systems operating in the 2483.5-2500 MHz range and ambulance MBANS operating in the same range appear to be compatible.

5.5 RDSS/RNSS (GALILEO)

The upgrading of Radiodetermination Satellite Service (RDSS) in this frequency band to primary status on a global basis has been agreed by WRC-12. The approved global primary allocation is intended to facilitate new navigation signals for the next generation of Galileo satellites in subject frequency band. The band 2483.5-2500 MHz, because of its proximity to the mobile service allocations above 2.5 GHz, may offer attractive synergies of Radionavigation-satellite (RNSS) with terrestrial mobile systems due to improved antenna efficiencies and use of shared hardware not possible with other RNSS bands. Although upgrading of allocation is conditional on the new service being able to prove its compatibility with other primary services already existing in the band, it was regarded as necessary to consider the co-existence between MBANS and RNSS.

The interference scenario with RDSS/RNSS is very similar to the scenario with MSS discussed in Section 5.3. RNSS would also be operated in downlink mode only, and interference from the satellite signal to MBANS receivers may be disregarded. For that reason, only the interference from an MBANS transmitter to a RNSS receiver is considered. Another similarity with the MSS case is that also RNSS victim receivers are supposed to be operated outdoors only.

The relevant technical RNSS-receiver parameters used for the study were collected from ECC Rep 150 [14]. ECC Rep 165 [12] and ECC Rep149 [4] were also consulted.

Table 44: RNSS (Galileo) system parameters

	Parameter	Value	
Satellite Transmitter	Bandwidth (MHz)	1 (reference value) (from ECC Report 165 and ECC Report 149)	4 (from range of values in ECC Report 150)
	Max power on ground (dBm/MHz)	-116	
Mobile Receiver	Maximum interference value	-116 (dBm/MHz)	-110 (dBm/4MHz)
	Antenna height (m)	1.5	
	Antenna gain (dBi)	0	

5.5.1 Healthcare facility MBANS

Table 45: MCL calculation in 2483.5-2500 MHz band between healthcare MBANS and RNSS

Victim characteristics	Units	RNSS Receiver	
Receiver bandwidth	MHz	1	4
Receiver antenna height	m	1.5	
Receiver antenna gain	dBi	0	
Operating frequency	MHz	2490	
Maximum interference value	dBm/BWv	-116	-110
Interferer's characteristics	**Units**	MBANS	
e.i.r.p	dBm	0	
Bandwidth	MHz	3	
BW correction factor	dB	-4.77	0
NFD (adjacent band interf)	dB	0	
Wall attenuation	dB	13	
Antenna height	m	1.5	
Minimum path loss	**dB**	**98.2**	**97**
Interference distance FSL model (propagation exponent n=2)	**km**	**0.78**	**0.68**
Interference distance FSL model (propagation exponent n=3)	**km**	**0.08**	**0.08**

5.5.1.1 Interference from MBANS to RNSS receivers (Galileo)

The considered interference scenario is depicted in Figure 33 and the simulation settings and results are summarized in Table 46.

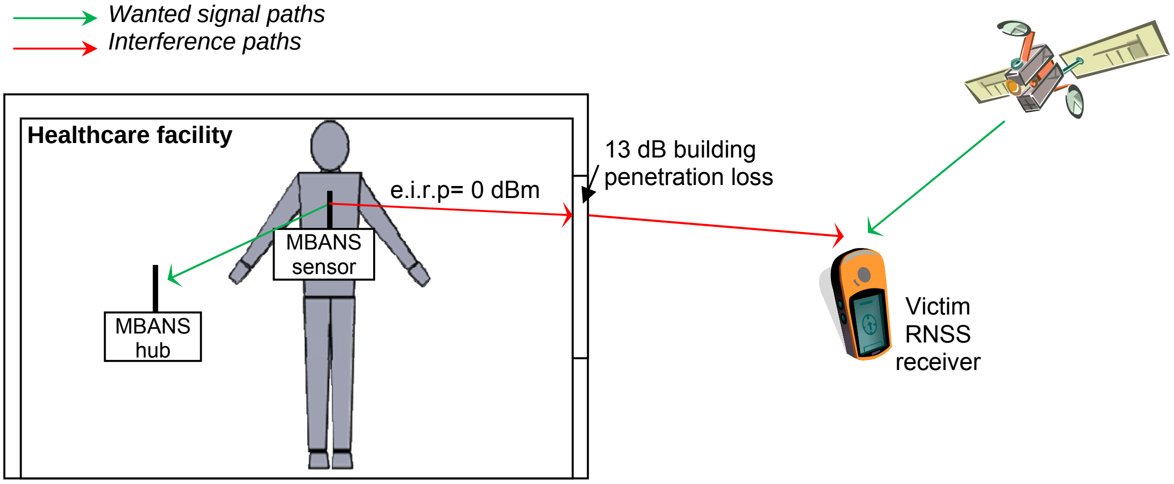


Figure 33: Interference scenario – healthcare facility MBANS into RNSS receiver

Table 46: Interference from healthcare facility MBANS to RNSS - Settings and results

Simulation input/output parameters	Settings/Results			
Victim Link (VLK): RNSS DL (satellite to mobile receiver)				
VLK frequency	2490 MHz			
VLK bandwidth	1 MHz		4 MHz	
VLR Noise floor	-116 dBm/MHz		-110 dBm/4MHz	
Interfering Link (ILK): MBANS				
ILK frequency	2490 MHz			
ILK bandwidth	3 MHz			
ILT Tx power	0 dBm			
ILT density	40/km^2			
ILT probability of transmission	0.1			
ILT → VLR interfering path	Extended Hata, indoor→outdoor, below roof			
	Urban	Suburban	Urban	Suburban
ILT → VLR positioning mode	Closest interferer			
Simulation results				
dRSS, dBm (Std.dev., dB)	-100 (0)			
iRSSunwanted, dBm (Std.dev., dB)	-164.04 (19.86)	-152.24 (18.88)	-159.38 (19.94)	-147.46 (18.88)
Probability of interference(%) (I/N = 0 dB)	**2.6**	**4.5**	**2.6**	**4.2**

5.5.2 Home MBANS

Table 47: MCL calculation in 2483.5-2500 MHz band between home MBANS and RNSS

Victim characteristics	Units	RNSS Receiver	
Receiver bandwidth	MHz	1	4
Receiver antenna height	M	1.5	
Receiver antenna gain	dBi	0	
Operating frequency	MHz	2490	
Maximum interference value	dBm/BWv	-116	-110
Interferer's characteristics	**Units**	MBANS	
e.i.r.p	dBm	13	
Bandwidth	MHz	3	
BW correction factor	dB	-4.77	0
NFD (adjacent band interf)	dB	0	
Wall attenuation (Note 1)	dB	0 (outdoor)	
Antenna height	M	1.5	
Minimum path loss	**dB**	**124.2**	**123**
Interference distance FSL model (propagation exponent n=2)	**Km**	**15.6**	**13.51**
Interference distance FSL model (propagation exponent n=3)	**Km**	**0.62**	**0.57**

Note 1: Worst case configuration assumed, in which MBANS transmitter or receiver is outdoors.

5.5.2.1 Interference from MBANS to RNSS receivers (Galileo)

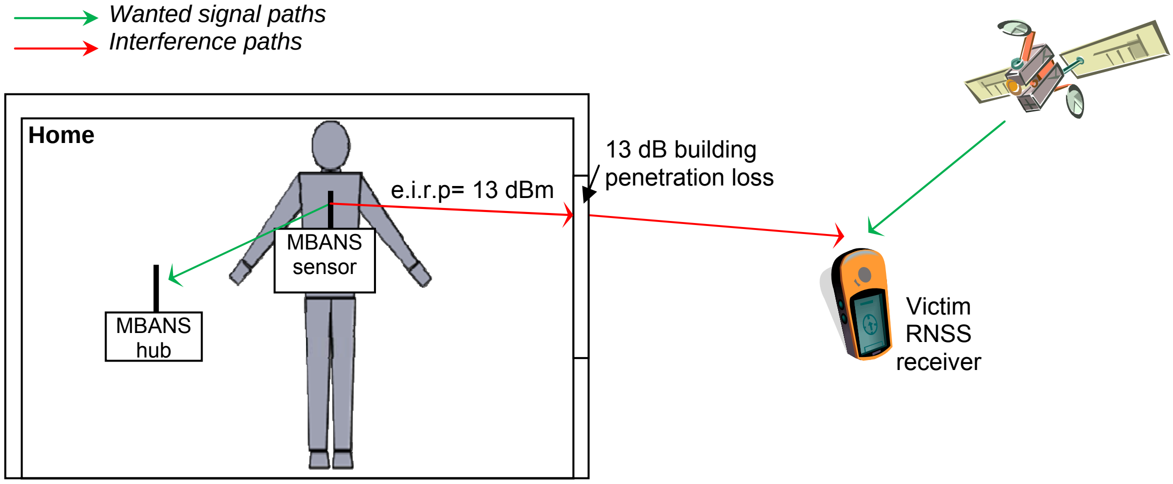


Figure 34: Interference scenario – home MBANS into RNSS receiver

Table 48: Interference from home MBANS to RNSS - Settings and results

Simulation input/output parameters	Settings/Results			
Victim Link (VLK): RNSS DL (satellite to mobile receiver)				
VLK frequency	2490 MHz			
VLK bandwidth	1 MHz		4 MHz	
VLR Noise floor	-116 dBm/MHz		-110 dBm/4MHz	
Interfering Link (ILK): Home MBANS				
ILK frequency	2490 MHz			
ILK bandwidth	3 MHz			
ILT Tx power	13 dBm			
ILT density	10/km^2			
ILT probability of transmission	0.02			
ILT → VLR interfering path	Extended Hata, indoor→outdoor, below roof			
	Urban	Suburban	Urban	Suburban
ILT → VLR positioning mode	Uniform			
Simulation results				
dRSS, dBm (Std.dev., dB)	-100 (0)			
iRSSunwanted, dBm (Std.dev., dB)	-166.56 (14.13)	-153.25 (13.8)	-160.41 (14.15)	-148.27 (13.93)
Probability of interference (%) (I/N = 0 dB)	**0.7**	**1.5**	**0.6**	**1.5**

5.5.3 Ambulance MBANS

Table 49: MCL calculation in 2483.5-2500 MHz band between ambulance MBANS and RNSS

Victim characteristics	Units	RNSS Receiver	
Receiver bandwidth	MHz	1	4
Receiver antenna height	m	1.5	
Receiver antenna gain	dBi	0	
Operating frequency	MHz	2490	
Maximum interference value	dBm/BWv	-116	-110
Interferer's characteristics	**Units**	Ambulance MBANS	
e.i.r.p	dBm	0	
Bandwidth	MHz	3	
BW correction factor	dB	-4.77	0
NFD (adjacent band interf)	dB	0	
Wall attenuation	dB	7	
Antenna height	m	1.5	
Minimum path loss	**dB**	**104.2**	**103**
Interference distance FSL model (propagation exponent n=2)	**km**	**1.56**	**1.35**
Interference distance FSL model (propagation exponent n=3)	**km**	**0.13**	**0.12**

5.5.3.1 Interference from MBANS to RNSS receivers (Galileo)

The considered interference scenario is depicted in Figure 35 and the simulation settings and results are summarized in Table 50.

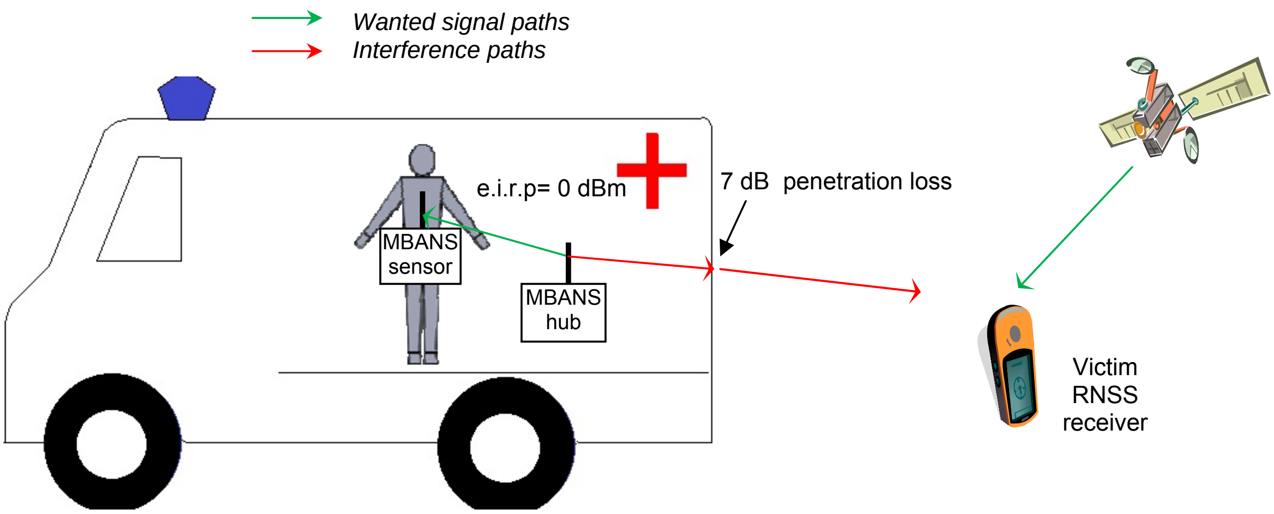


Figure 35: Interference scenario ambulance MBANS into RNSS receiver

Table 50: Interference from MBANS (ambulance mode) to RNSS - Settings and results

Simulation input/output parameters	Settings/Results			
Victim Link (VLK): RNSS DL (satellite to mobile receiver)				
VLK frequency	2490 MHz			
VLK bandwidth	1 MHz		4 MHz	
VLR Noise floor	-116 dBm/MHz		-110 dBm/4MHz	
Interfering Link (ILK): ambulance MBANS				
ILK frequency	2490 MHz			
ILK bandwidth	3 MHz			
ILT Tx power	0 dBm			
ILT density	5/km^2			
ILT probability of transmission	0.1			
ILT → VLR interfering path	Extended Hata, indoor→outdoor, below roof			
	Urban	Suburban	Urban	Suburban
ILT → VLR positioning mode	Uniform			
Simulation results				
dRSS, dBm (Std.dev., dB)	-100 (0)			
iRSSunwanted, dBm (Std.dev., dB)	-164.2 (13.88)	-150 (13.08)	-157.51 (13.71)	-145.25 (13.36)
Probability of interference (%) (I/N = 0 dB)	**1.1**	**2.2**	**1.0**	**2.2**

5.5.4 Summary RDSS/RNSS

According to the results presented above, in worst-case situations—modelled with MCL calculations—the interference distance between RNSS and MBANS is 80 m - 780 m (healthcare facility MBANS), 570 m - 15 km (home MBANS), and 120 m – 1.6 km (ambulance MBANS). The simulation-based average-case analysis yielded probability of interference levels of ≤4.5% from healthcare facility MBANS, ≤1.5% from home MBANS, and ≤2.2% from ambulance MBANS.

RDSS/RNSS systems operating in the 2483.5-2500 MHz range and MBANS operating in the same range appear to be compatible, if we assume that 5% interference probability could be accepted.

5.6 SAP/SAB (ENG/OB) VIDEO LINKS

The SAP/SAB (ENG/OB) tuning range extends up to 2500 MHz. Although ECC Report 002 [15] shows that most of the SAP/SAB use is concentrated below 2400 MHz, some CEPT countries have reported using the entire tuning range for SAP/SAB operations, which leads to the consideration of SAP/SAB as incumbent in the 2483.5-2500 MHz band.

Services Ancillary to Programme making / Services Ancillary to Broadcasting (SAP/SAB) are also known as Electronic News Gathering / Outside Broadcasting (ENG/OB). According to ECC Report 002 [15], typical SAP/SAB applications in this frequency range are the video reportage links, with signal being transmitted to transportable studio from handheld or vehicle mounted cameras. Sometimes such links might be also used in airborne configuration, e.g. with the reportage camera being mounted on board a helicopter. However in this case the receiver is still a ground-based studio.

The parameters of SAP/SAB links as victim receivers used in this study were mainly taken from ECC Report 100 [16], which considers interference to similar SAP/SAB links in the 3400-3600 MHz band. ECC Report 02 [15], ERC Report 38 [17] and ETSI EN 300 744 [18] were also consulted.

Two different types of SAP/SAB video links are considered, the parameters of which are summarized in the following tables.

Table 51: SAP/SAB video link parameters (Type 1 - mobile link, airborne)

	Parameter	Value
Airborne Transmitter	Bandwidth (MHz)	8
	Max Tx power (dBm)	30
	Antenna gain (dBi)	4 (omnidirectional)
	Antenna height (m)	Up to 700 (375 assumed)
Ground Receiver (on vehicle)	Receiver sensitivity (dBm)	-89.8
	Antenna gain (dBi)	10 (omnidirectional)
	Antenna height (m)	3
	C/I objective (dB)	16

Table 52: SAP/SAB video link parameters (Type 2 - terrestrial link)

	Parameter	Value
Transmitter	Bandwidth (MHz)	8
	Max Tx power (dBm)	43
	Antenna gain (dBi)	0 (omnidirectional)
	Antenna height (m)	1.5
Receiver	Receiver sensitivity (dBm)	-99
	Antenna gain (dBi)	17 (directional)
	Antenna diagram	See Figure 36
	Antenna height (m)	1.5
	C/I objective (dB)	10

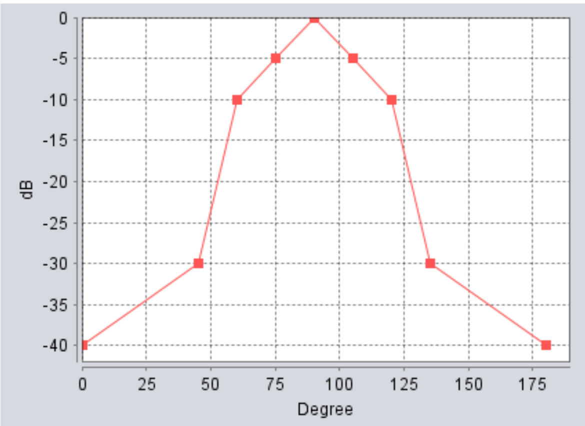


Figure 36: Antenna radiation diagram of SAP/SAB receiver (Type 2)

According to ERC Report 38 [17], SAP/SAB receivers on the roof of communications vehicles can use both omnidirectional and directional antennas. For 'type 1' video links, omnidirectional antennas have been assumed as worst case scenario. The use of directional antennas would lead to significantly lower levels of interference from MBANS to SAP/SAB and vice versa.

5.6.1 Healthcare Facility MBANS

Table 53: MCL calculation in 2483.5-2500 MHz band between healthcare facility MBANS and SAP/SAB video links

Scenario		1	2	3	4
Victim characteristics	**Units**	**SAP/SAB (type 1)**	**MBANS**	**SAP/SAB (type 2)**	**MBANS**
Receiver bandwidth	MHz	8	3	8	3
Receiver noise figure	dB	5	10	2	10
Receiver antenna height	m	3	1.5	1.5	1.5
Receiver antenna gain	dBi	10	0	17	0
Operating frequency	MHz	2490	2490	2490	2490
N, receiver thermal noise	dBm	-99.8	-99.1	-102.8	-99.1
I/N objective	dB	-6	0	-6	0
Interferer's characteristics	**Units**	**MBANS**	**SAP/SAB (type 1)**	**MBANS**	**SAP/SAB (type 2)**
e.i.r.p	dBm	0	34	0	43
Bandwidth	MHz	3	8	3	8
BW correction factor	dB	0	-4.3	0	-4.3
NFD (adjacent band interf)	dB	0	0	0	0
Wall attenuation	dB	13	13	13	13
Antenna height	m	1.5	375	1.5	1.5
Minimum path loss	**dB**	**102.8**	**115.8**	**112.8**	**124.8**
Interference distance FSL model (propagation exponent n=2)	**km**	**1.3**	**5.9**	**4.2**	**16.7**
Interference distance FSL model (propagation exponent n=3)	**km**	**0.12**	**0.33**	**0.26**	**0.65**

5.6.1.1 Interference from MBANS to SAP/SAB video links

The considered interference scenario is depicted in Figure 37 and has been simulated in SEAMCAT. The simulation settings and results are summarized in Table 54. The interference probability from MBANS into SAP/SAB is low.

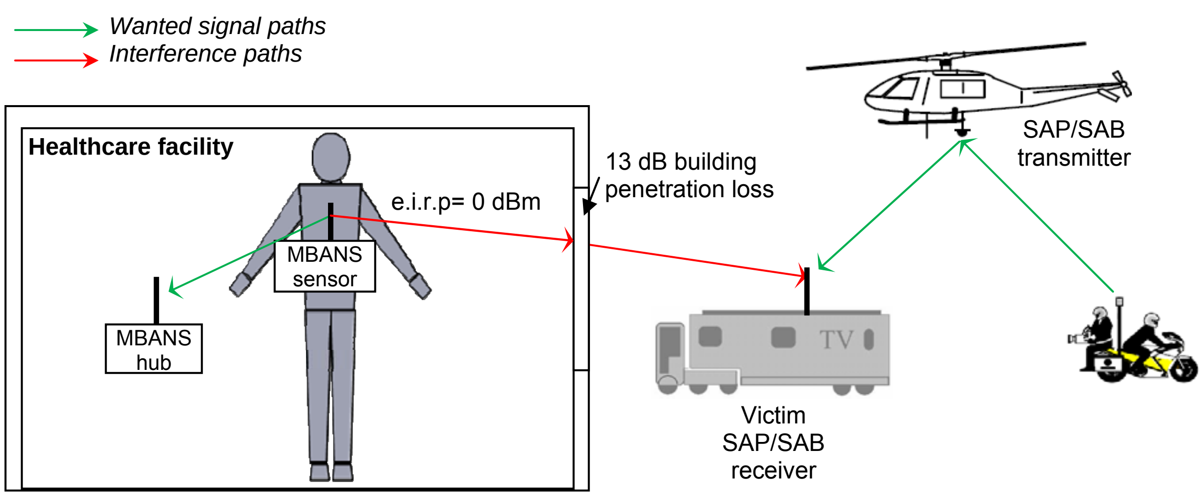


Figure 37: Interference scenario – healthcare facility MBANS into SAP/SAB video link (type1)

Table 54: Interference from healthcare facility MBANS to SAP/SAB - Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK):	**SAP/SAB (type 1)**	**SAP/SAB (type 2)**
VLK frequency	2490 MHz	
VLK bandwidth	8 MHz	
VLT → VLR path	FSL (user-defined radius, 10 Km)	Extended Hata, urban, outdoor→outdoor, below roof (user-defined radius, 500 m)
Interfering Link (ILK):	**MBANS**	
ILK frequency	2490 MHz	
ILK bandwidth	3 MHz	
ILT Tx power	0 dBm	0 dBm (10% probability)
ILT density	40/km^2	
ILT → VLR number of active Tx	-	31
ILT probability of transmission of all Tx	0.1	1
ILT → VLR simulation radius	-	500 m
ILT → VLR interfering path	Extended Hata, urban, indoor→outdoor, below roof	
ILT → VLR positioning mode	Closest interferer	None
Simulation results		
dRSS, dBm (Std.dev., dB)	-72.06 (4.36)	-125.59 (17.79)
iRSSunwanted, dBm (Std.dev., dB)	-143.29 (19.26)	-144.61 (38.64)
Probability of interference (%) (C/I = 16 dB, type 1) (C/I = 10 dB, type 2)	**1.5**	**4.3**

5.6.1.2 Interference from SAP/SAB video links to MBANS

The considered interference scenario is depicted in Figure 38 and has been simulated in SEAMCAT. The simulation settings and results are summarized in Table 55. The interference probability from SAP/SAB into MBANS is very low.

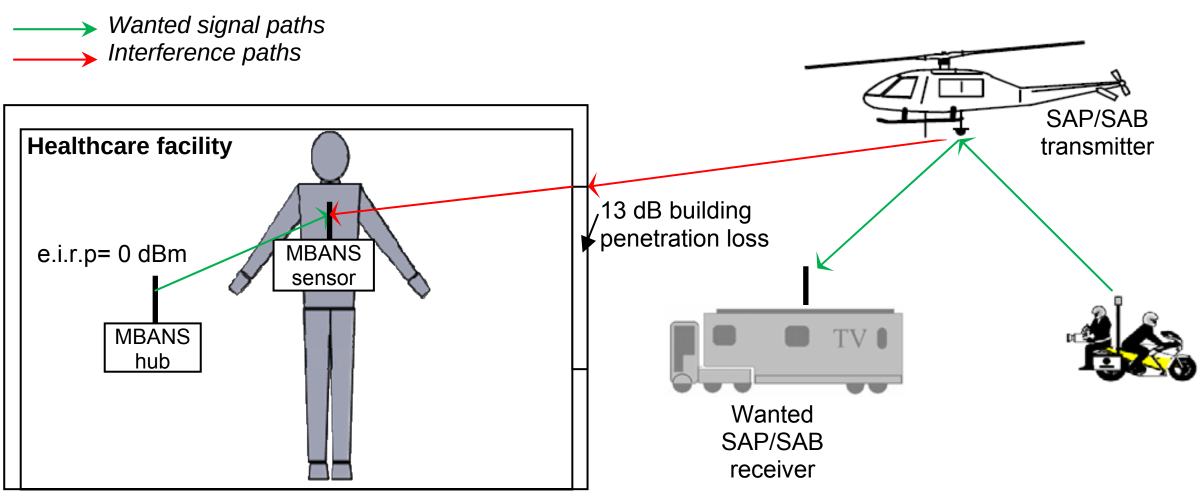


Figure 38: Interference scenario – SAP/SAB video link (type 1) into healthcare facility MBANS

Table 55: Interference from SAP/SAB to healthcare facility MBANS - Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK):	**MBANS**	
VLK frequency	2490 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 3 m)	
Interfering Link (ILK):	**SAP/SAB (type 1)**	**SAP/SAB (type 2)**
ILK frequency	2490 MHz	
ILK bandwidth	8 MHz	
ILT Tx power	30 dBm	43 dBm
ILT density	$1/km^2$	
ILT probability of transmission	1	1
ILT → VLR number of active Tx	1	1
ILT → VLR simulation radius	564 m	500 m
ILT → VLR interfering path	Extended Hata, urban, outdoor→indoor, above roof	Extended Hata, urban, outdoor→indoor, below roof
ILT → VLR positioning mode	Uniform density	None
Simulation results		
dRSS, dBm (Std.dev., dB)	45.51 (4.52)	-45.56 (4.44)
iRSSunwanted, dBm (Std.dev., dB)	-94.02 (12.81)	-120 (18.63)
Probability of interference (%) (C/I = 15 dB)	**0.9**	**1.1**

5.6.2 Home MBANS

Table 56: MCL calculation in 2483.5-2500 MHz band between home MBANS and SAP/SAB video links

Scenario		1	2	3	4
Victim characteristics	**Units**	**SAP/SAB (type 1)**	**MBANS**	**SAP/SAB (type 2)**	**MBANS**
Receiver bandwidth	MHz	8	3	8	3
Receiver noise figure	dB	5	10	2	10
Receiver antenna height	m	3	1.5	1.5	1.5
Receiver antenna gain	dBi	10	0	17	0
Operating frequency	MHz	2490	2490	2490	2490
N, receiver thermal noise	dBm	-99.8	-99.1	-102.8	-99.1
I/N objective	dB	-6	0	-6	0
Interferer's characteristics	**Units**	**MBANS**	**SAP/SAB (type 1)**	**MBANS**	**SAP/SAB (type 2)**
e.i.r.p	dBm	13	34	13	43
Bandwidth	MHz	3	8	3	8
BW correction factor	dB	0	-4.3	0	-4.3
NFD (adjacent band interf)	dB	0	0	0	0
Wall attenuation (Note 1)	dB	0 (outdoor)	0 (outdoor)	0 (outdoor)	0 (outdoor)
Antenna height	m	1.5	375	1.5	1.5
Minimum path loss	**dB**	**128.8**	**128.8**	**138.8**	**137.8**
Interference distance FSL model (propagation exponent n=2)	**km**	**26.4**	**26.4**	**83.5**	**74.4**
Interference distance FSL model (propagation exponent n=3)	**km**	**0.9**	**0.9**	**1.9**	**1.8**

Note 1: Worst case configuration assumed, in which MBANS transmitter or receiver is outdoors.

5.6.2.1 Interference from MBANS to SAP/SAB video links

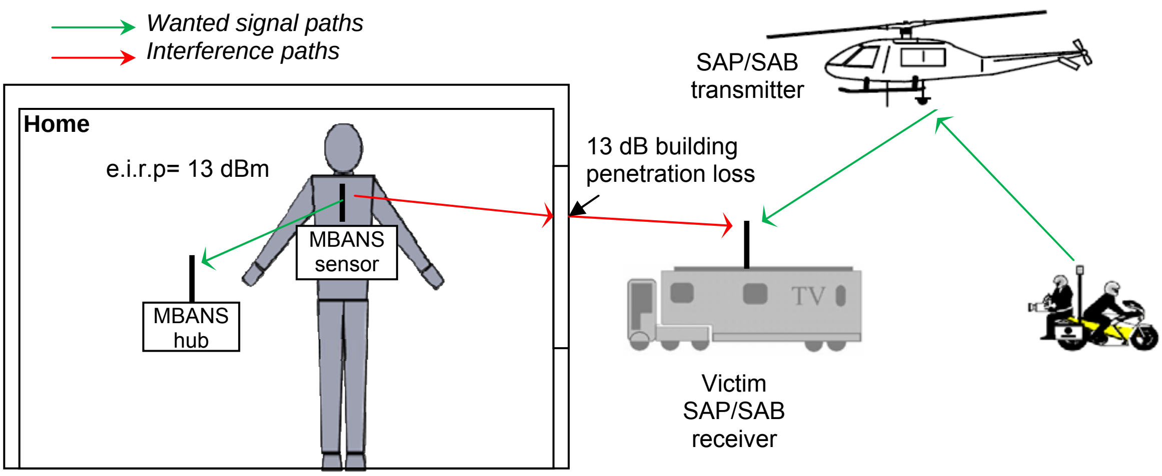


Figure 39: Interference scenario – healthcare facility MBANS into SAP/SAB video link (type 1

Table 57: Interference from home MBANS to SAP/SAB - Settings and results

Simulation input/output parameters	Settings/Results			
Victim Link (VLK):	**SAP/SAB (type 1)**	**SAP/SAB (type 2)**		
VLK frequency	2490 MHz			
VLK bandwidth	8 MHz			
VLT → VLR path	FSL (user-defined radius, 10 Km)	Extended Hata, outdoor→outdoor, below roof (user-defined radius, 500 m)		
		urban	suburban	rural
Interfering Link (ILK):	**MBANS**			
ILK frequency	2490 MHz			
ILK bandwidth	3 MHz			
ILT Tx power	13 dBm	13 dBm (2% probability)		
ILT density	10/km^2			
ILT → VLR number of active Tx	1	8		
ILT probability of transmission of all TX	0.02	1		
ILT → VLR simulation radius	1.26 km	500 m		
ILT → VLR interfering path	Extended Hata, urban, indoor→outdoor, below roof	Extended Hata, indoor→outdoor, below roof		
		urban	suburban	rural
ILT → VLR positioning mode	Uniform density	None		
Simulation results				
dRSS, dBm (Std.dev., dB)	-72.08 (4.3)	-125.7	-125.67	-125.75
iRSSunwanted, dBm (Std.dev., dB)	-144.34 (14.02)	-294.71	-283.01	-264.6
Probability of interference (%) (C/I = 16 dB, type 1) (C/I = 10 dB, type 2)	**0.5**	**0.5**	**1.0**	**3.4**

5.6.2.2 Interference from SAP/SAB video links to MBANS

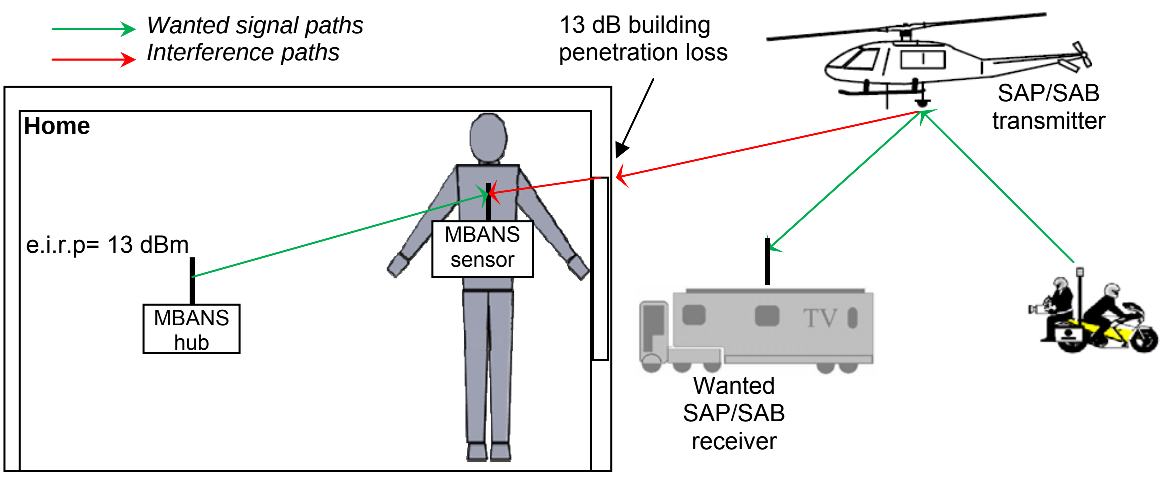


Figure 40: Interference scenario – SAP/SAB video link (type 1) into home MBANS

Table 58: Interference from SAP/SAB to home MBANS - Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK):	**MBANS**	
VLK frequency	2490 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 10 m)	
Interfering Link (ILK):	**SAP/SAB (type 1)**	**SAP/SAB (type 2)**
ILK frequency	2490 MHz	
ILK bandwidth	8 MHz	
ILT Tx power	30 dBm	43 dBm
ILT density	1/km^2	
ILT probability of transmission	1	
ILT → VLR number of active Tx	1	
ILT → VLR simulation radius	564	500
ILT → VLR interfering path	Extended Hata, urban, outdoor→indoor, above roof	Extended Hata, urban, outdoor→indoor, below roof
ILT → VLR positioning mode	Uniform density	None
Simulation results		
dRSS, dBm (Std.dev., dB)	-43 (4.45)	-43.05 (4.47)
iRSSunwanted, dBm (Std.dev., dB)	-93.93 (12.86)	-119.97 (18.53)
Probability of interference (%) (C/I = 15 dB)	**0.6**	**1.0**

5.6.3 Ambulance MBANS

Table 59: MCL calculation in 2483.5-2500 MHz band between ambulance MBANS and SAP/SAB video links

Scenario		1	2	3	4
Victim characteristics	**Units**	**SAP/SAB (type 1)**	**MBANS**	**SAP/SAB (type 2)**	**MBANS**
Receiver bandwidth	MHz	8	3	8	3
Receiver noise figure	dB	5	10	2	10
Receiver antenna height	m	3	1.5	1.5	1.5
Receiver antenna gain	dBi	10	0	17	0
Operating frequency	MHz	2490	2490	2490	2490
N, receiver thermal noise	dBm	-99.8	-99.1	-102.8	-99.1
I/N objective	dB	-6	0	-6	0
Interferer's characteristics	**Units**	**MBANS**	**SAP/SAB (type 1)**	**MBANS**	**SAP/SAB (type 2)**
e.i.r.p	dBm	0	34	0	43
Bandwidth	MHz	3	8	3	8
BW correction factor	dB	0	-4.3	0	4.3
NFD (adjacent band interf)	dB	0	0	0	0
Wall attenuation	dB	7	7	7	7
Antenna height	m	1.5	375	1.5	1.5
Minimum path loss	**dB**	**108.8**	**121.8**	**118.8**	**130.8**
Interference distance FSL model (propagation exponent n=2)	**km**	**2.6**	**11.8**	**8.4**	**33.3**
Interference distance FSL model (propagation exponent n=3)	**km**	**0.19**	**0.52**	**0.41**	**1.0**

5.6.3.1 Interference from MBANS to SAP/SAB video links

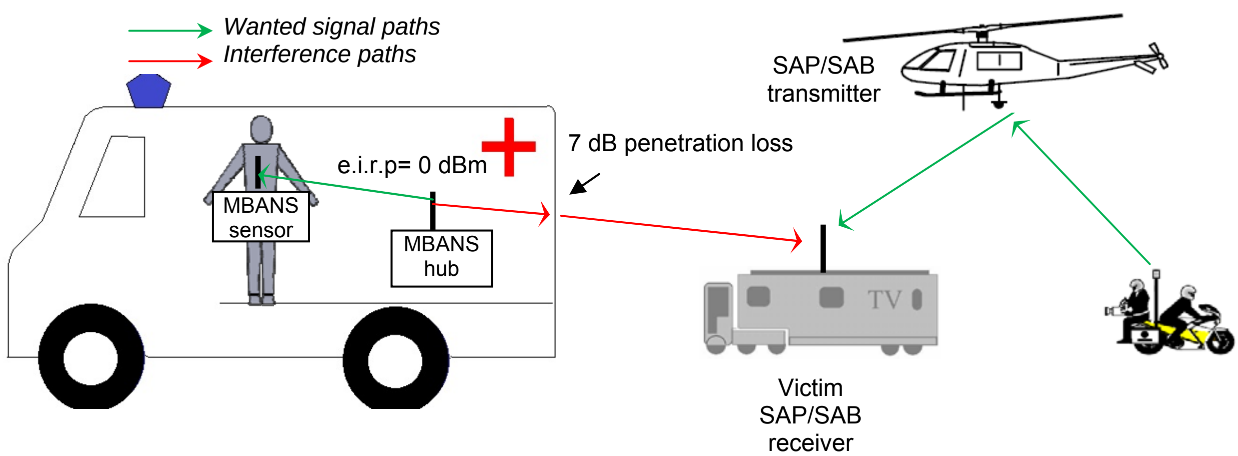


Figure 41: Interference scenario – ambulance MBANS into SAP/SAB video link (type 1)

Table 60: Interference from ambulance MBANS to SAP/SAB - Settings and results

Simulation input/output parameters	Settings/Results	
Victim Link (VLK):	**SAP/SAB (type 1)**	**SAP/SAB (type 2)**
VLK frequency	2490 MHz	
VLK bandwidth	8 MHz	
VLT → VLR path	FSL (user-defined radius, 10 Km)	Extended Hata, urban, outdoor→outdoor, below roof (user-defined radius, 500 m)
Interfering Link (ILK):	**MBANS**	
ILK frequency	2490 MHz	
ILK bandwidth	3 MHz	
ILT Tx power	0 dBm	0 dBm (10% probability)
ILT density	5/km^2	
ILT → VLR number of active Tx	2	4
ILT probability of transmission of all Tx	0.1	1
ILT → VLR simulation radius	1.13	500 m
ILT → VLR interfering path	Extended Hata, urban, indoor→outdoor, below roof	
ILT → VLR positioning mode	Uniform density	None
Simulation results		
dRSS, dBm (Std.dev., dB)	-72.1 (4.32)	-125.61 (18.02)
iRSSunwanted, dBm (Std.dev., dB)	-141.4 (13.45)	-264.96 (86.64)
Probability of interference (%) (C/I = 16 dB, type 1) (C/I = 10 dB, type 2)	**0.7**	**0.8**

5.6.3.2 Interference from SAP/SAB video links to MBANS

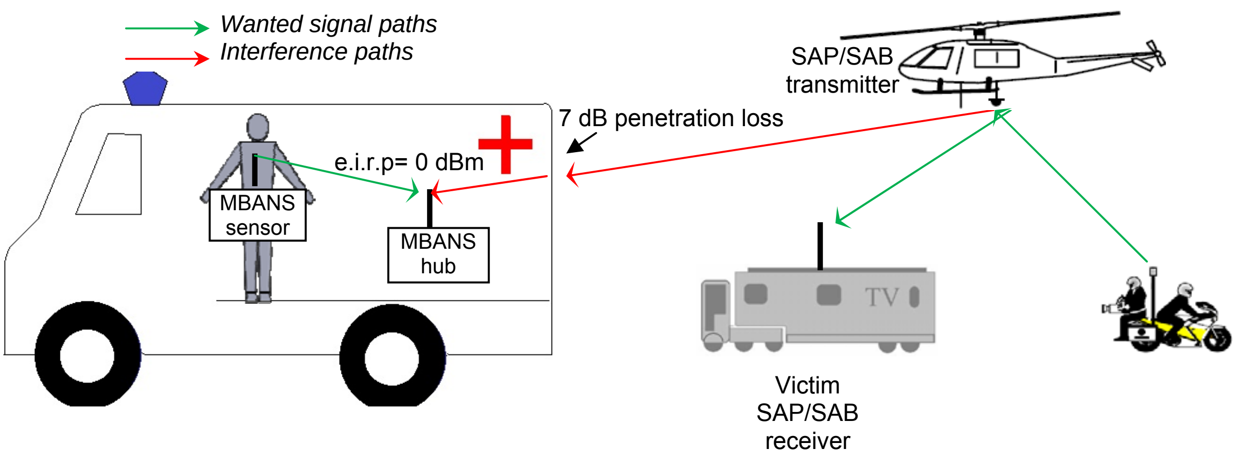


Figure 42: Interference scenario – SAP/SAB video link (type 1) into healthcare facility MBANS

Table 61: Interference from SAP/SAB to ambulance MBANS - Settings and result

Simulation input/output parameters	Settings/Results	
Victim Link (VLK):	**MBANS**	
VLK frequency	2490 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 3 m)	
Interfering Link (ILK):	**SAP/SAB (type 1)**	**SAP/SAB (type 2)**
ILK frequency	2490 MHz	
ILK bandwidth	8 MHz	
ILT Tx power	30 dBm	43 dBm
ILT density	1/km^2	
ILT probability of transmission	1	
ILT → VLR number of active Tx	1	
ILT → VLR simulation radius	564 m	500 m
ILT → VLR interfering path	Extended Hata, urban, outdoor→indoor, above roof	Extended Hata, urban, outdoor→indoor, below roof
ILT → VLR positioning mode	Uniform density	None
Simulation results		
dRSS, dBm (Std.dev., dB)	-45.61 (4.36)	-45.55 (4.47)
iRSSunwanted, dBm (Std.dev., dB)	-88 (12.93)	-113.9 (18.81)
Probability of interference (%) (C/I = 15 dB)	**2.6**	**1.6**

5.6.4 Summary SAP/SAB

In absence of available SAP/SAB information specific for the 2483.5-2500 MHz band, the typical system parameters of SAP/SAB video links operating in the band 2360-2400 MHz band were used for this compatibility study.

Healthcare facility MBANS:

Average case simulation results suggest coexistence between SAP/SAB and healthcare facility MBANS. Even in unfavorable conditions, the required distances between SAP/SAB and healthcare facilities are in a range that corresponds to most situations in practice. Therefore coexistence with MBANS within healthcare facilities appears possible.

Home MBANS:

Average case simulation results suggest good coexistence between SAP/SAB and home MBANS. However in unfavorable conditions, the required distances between SAP/SAB and the homes of MBANS users would be unpractical. Such potential interference to SAP/SAB applications—even with low deployment values of 10 MBANS per km^2—lead to the conclusion that coexistence might be possible in areas where SAP/SAB is used in the 2483.5-2500 MHz band but cannot be guaranteed without additional mitigation measures.

Ambulance MBANS:

Average case simulation results suggest good coexistence between SAP/SAB and ambulance MBANS. However in unfavorable conditions, the required distances between SAP/SAB and ambulances could not be guaranteed, due to the high mobility of the latter. The potential interference to SAP/SAB applications—even with low deployment values of 5 MBANS per km^2—lead to the conclusion that coexistence might be possible in areas where SAP/SAB is used in the 2483.5-2500 MHz band but cannot be guaranteed without additional mitigation measures

5.7 ADJACENT WIDEBAND DATA TRANSMISSION SYSTEMS

This section studies the compatibility between MBANS operating in the 2483.5-2500 MHz range and wideband data transmission systems–represented by WLAN– operating in the adjacent 2400-2483.5 MHz range. Due to the equivalence to the co-channel compatibility study in Section 4.1, this section is presented in compact form. More details and considerations can be found in Section 4.1.

Based on the WLAN standard [19] the last channel of wideband data transmission on the upper side of the band ends at 2482 MHz that results in 1.5 MHz guard band between WLAN and the possible MBANs implementation in the band studied in this section (2483.5-2500 MHz). However, it was considered appropriate to also study possible interference between these technologies in these two adjacent bands. The MCL calculations for 20 MHz WLAN channel bandwidth are presented in Table 62.The same approach as in the co-channel compatibility analysis in Section 4.1 was used.

Table 62: Adjacent MCL calculation in 2483.5 MHz band limits between MBANS and WLAN

Scenario		1	2	3
Victim characteristics	**Units**	**WLAN 802.11 AP**	**WLAN 802.11 AP**	**MBANS**
Receiver bandwidth	MHz	20	20	3
Receiver noise figure	dB	10	10	10
Receiver antenna height	m	3	3	1.5
Receiver antenna gain	dBi	5	5	0
Operating frequency	MHz	2472	2472	2485
N, receiver thermal noise	dBm	-90.82	-90.82	-99.1
I/N objective	dB	0	0	0
Interferer's characteristics	**Units**	**MBANS (healthcare facility)**	**MBANS (home)**	**WLAN 802.11 AP**
e.i.r.p	dBm	0	13	17
Bandwidth	MHz	3	3	20
BW correction factor	dB	0	0	-8.24
NFD (adjacent band interf.)	dB	-25	-25	-40
Antenna height	m	1.5	1.5	3
Minimum path loss	**dB**	**70.8**	**83.8**	**67.8**
Interference distance FSL model	**km**	**0.03**	**0.15**	**0.02**

5.7.1 Healthcare facility MBANS

The SEAMCAT simulations are summarized in the following table. The study approach is identical to that Section 4.1.1. The parameter and scenario choices are described in that section of the report. For obtaining the interference probability in SEAMCAT, the combination of unwanted and blocking response was used. A value of 30 dB blocking response was used for MBANS.

Table 63: Interference in 2483.5 MHz band limits between healthcare facility MBANS and WLAN – Simulation results

Interferer	Victim	Interferer central frequency (MHz)	Victim central frequency (MHz)	Simulation parameters	Interference probability
MBANS	WLAN (20 MHz)	2485	2472	See Section 4.1.1.1	0.1 %
	WLAN (40 MHz)		2462		0 %
WLAN (20 MHz)	MBANS	2472	2485	See Section 4.1.1.2	4.2 %
WLAN (40 MHz)		2462			3.9 %

5.7.2 Home MBANS

The SEAMCAT simulations are summarized in the following table. The study approach is identical to that Section 4.1.1. The parameter and scenario choices are described in that section of the report. For obtaining the interference probability in SEAMCAT, the combination of unwanted and blocking response was used. A value of 30 dB blocking response was used for MBANS.

Table 64: Interference in 2483.5 MHz band limits between home MBANS and WLAN –Simulation results

Interferer	Victim	Interferer central frequency (MHz)	Victim central frequency (MHz)	Simulation parameters	Interference probability
MBANS	WLAN (20 MHz)	2485	2472	See Section 4.1.2.1	0 %
	WLAN (40 MHz)		2462		0.1 %
WLAN (20 MHz)	MBANS	2472	2485	See Section 4.1.2.2	3.1 %
WLAN (40 MHz)		2462			3 %

5.7.3 Summary ADJACENT wideband data transmission systems

All simulation-based average-case analyses yielded ≤0.1% probability of interference from MBANS. In the other coexistence direction, the obtained results range from 3% to 4.2% probability of interference from wideband data transmission systems.

Wideband data transmission systems operating in the 2400-2483.5 MHz range and MBANS in healthcare facilities, homes, and ambulances operating in the 2483.5-2500 MHz range are compatible.

5.8 ADJACENT BROADBAND WIRELESS SYSTEMS (BWS)

The first international mobile communication system was the analogue NMT system which was introduced in the Nordic countries in 1981, at the same time analogue AMPS was introduced in North America and TACS and J-TACS deployed worldwide. In Europe, the telecommunication administrations in CEPT initiated the GSM project. GSM is the most popular standard for mobile telephony systems in the world. The third generation mobile system UMTS was designed to enable voice and data services in addition to richer mobile multimedia services, including internet access. It started to be deployed in 2001, and by now has 300+ networks deployed, and the number of UMTS connections is estimated to be over 520 million including HSPA (Q1 2010).

The next steps in the 3GPP standardisation of mobile communications systems are referred to as LTE (3GPP technology) and mobile WiMAX (IEEE technology). The main target for the evolution of 3G mobile communication is to provide the possibility for significantly higher end user data rates compared to what is achievable with for example the first release of the 3G standard. This includes the possibility for higher peak data rate even more possibility for significantly higher data rates over the entire cell area as well as users at the cell edge. Network quality and performance is becoming a clear competitive advantage, as usage and traffic patterns change. With the rapid uptake of smartphones mobile data traffic is expected to grow 15 times by 2017. This enormous amount of data traffic puts requirements on both optimal performance of mobile systems and on emissions from other coexisting technologies.

The investigated frequency allocation is shown in Figure 43. There are allocations adjacent to IMT bands. LTE-TDD and FDD is now gaining market traction in all regions as it is commonly considered in the evolution path of any wireless cellular technology, especially TDD (TD-SCDMA, UTRA-TDD and WiMAX™). Globally, many LTE networks were launched in different countries between December 2009 and June 2012. In the indicated 2500-2570 MHz band 7, the BS is receiving, and the UE is transmitting, which reduces the number of scenarios.

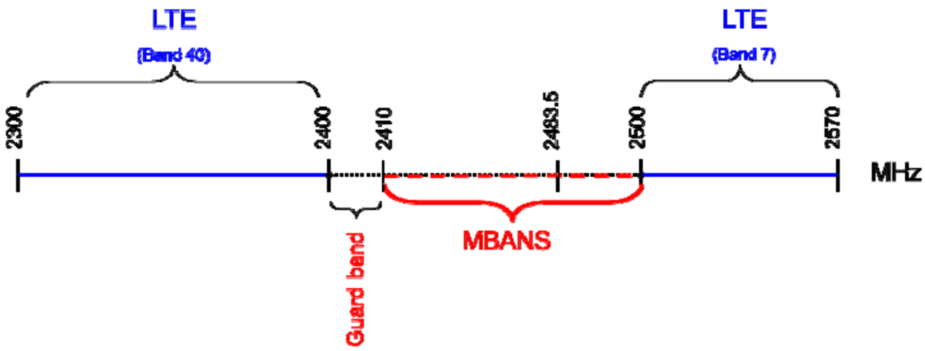


Figure 43: Spectrum allocation for LTE and the proposed MBANS designation

Most of the LTE parameters considered in this report are based on 3GPP TS 36-series documents, describing the LTE standard, as it is the technology adopted for the utilization of IMT-A framework. More specifically the documents TS 36.101 [20], TS 36.104 [21] and TS 36.942 [22] were used, accompanied by the Report ITU-R M.2039-2 (11/2010) [23] for sharing studies. SEAMCAT is equipped with an OFDMA module specifically designed for LTE. The basis for the SEAMCAT simulations was the similar studies by ECC Report 172 [7]. An overview of LTE parameters is presented in Table 65. The definition used for cell radius in SEAMCAT is illustrated in Figure 44 and the patterns of the base station antennas, which are taken from the LTE standard, are shown in Figure 45.

In this section the coexistence of LTE systems and MBANS is evaluated. Results from both MCL calculations and SEAMCAT simulations are presented.

Table 65: LTE parameters

	Parameter	Value
Base Station (BS)	Bandwidth (MHz)	10 (Note 1)
	Max Tx power (dBm)	46
	Antenna gain (dBi)	17
	Antenna height (m)	30 (Note 2)
	Antenna tilt (deg)	-3
	Feeder loss (dB)	3
	ACLR (dB)	Wide area BS: the least stringent of 45 dB and -15 dBm/MHz. Local area BS: the least stringent of 45 dB and -32 dBm/MHz. Home BS: the least stringent of 45 dB and -50 dBm/MHz
	Spurious emissions (dBm/MHz)	-30(beyond 10MHz outside operating band)
	Receiver ACS (dB)	46

	Parameter	Value
	Noise figure (dB)	5
	Interference criterion I/N (dB)	-6
User Equipment (UE)	Bandwidth (MHz)	10 (Note 1)
	Max Tx power (dBm)	23
	Antenna gain (dBi)	0 (omnidirectional)
	Antenna height (m)	1.5
	ACLR (dB)	30 (1st adjacent channel)
	Spurious emissions (dBm/MHz)	-30 (beyond 10MHz outside operating band)
	Receiver ACS (dB)	33
	Noise figure (dB)	9
	Interference criterion I/N (dB)	-6
System	Cell Radius R (m)	250 (in urban scenarios) 500 (in suburban scenarios)
	Cell Layout	2 tiers, Tri-sector
	Bandwidth of Resource Block (kHz)	180

Note 1: Other bandwidth values are possible according to the LTE standard. 10 MHz was selected as most representative value.

Note 2: Varies between 10 m - 37.5 m above clutter height. 30 m was selected as most representative value.

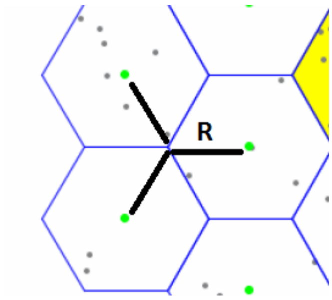
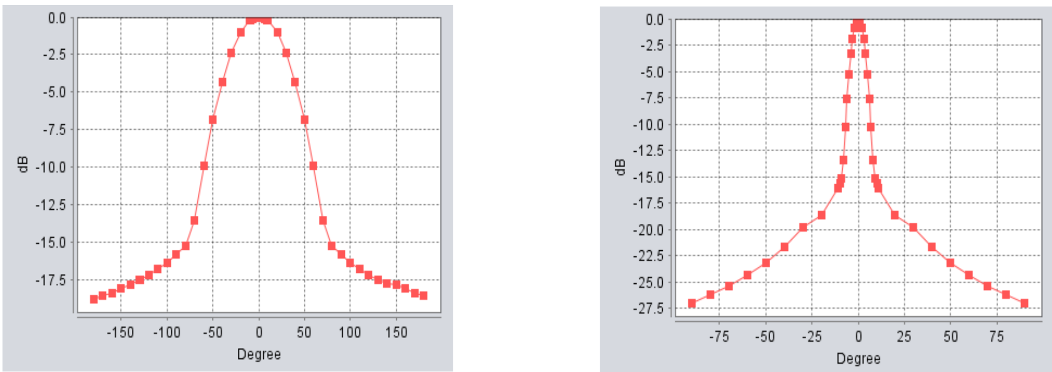


Figure 44: Cell Radius as defined in SEAMCAT



(a) **(b)**

Figure 45: Tri-sector antenna (a) horizontal and (b) vertical pattern

The total emission mask of the system is taken from the standard TS 36.101 [20] and implemented in SEAMCAT as shown in Figure 46.

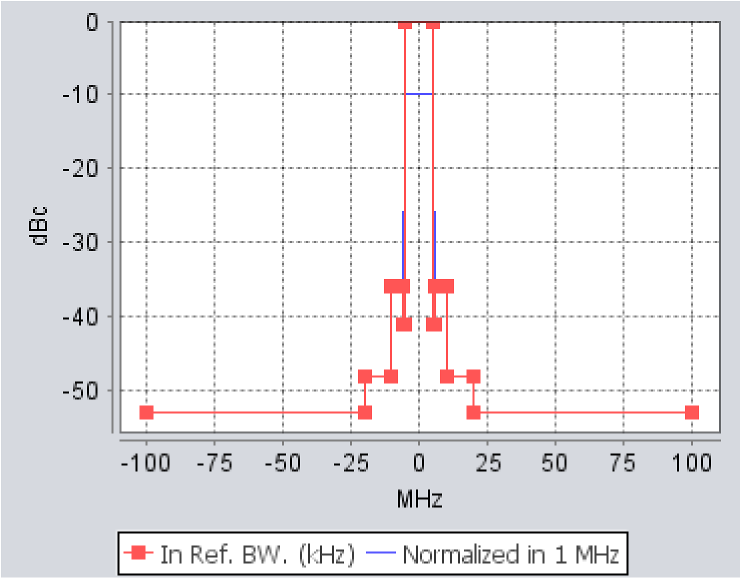


Figure 46: Unwanted emission mask of LTE UE

This section presents an adjacent band compatibility study. The worst case was considered in terms of frequency separation, in which both technologies are utilizing the edge of their allocated (or presumably designated) spectrum without any guard bands. The ACLR values of LTE devices were taken from the LTE standard. The ACLR value for MBANS is taken as the average of the adjacent band emissions in the considered spectrum of 10 MHz for LTE.

5.8.1 Healthcare facility MBANS

The MCL calculations for minimum interference distances between MBANS and LTE are shown in Table 66.

Table 66: MCL calculation in 2483.5 – 2500 MHz band between healthcare facility MBANS and LTE UL

Victim characteristics	Units	MBANS		LTE UL
Receiver bandwidth	MHz	3		10
Receiver noise figure	dB	10		5
Receiver antenna height	m	1.5		30
Receiver antenna gain	dBi	0		14
Operating frequency	MHz	2498.5		2505
N, receiver thermal noise	dBm	-99.1		-98.8
I/N objective	dB	0		-6
Interferer's characteristics		LTE UL		MBANS
e.i.r.p	dBm	23		0
Bandwidth	MHz	10		3
BW correction factor 10 MHz	dB	-5.2		0
NFD (adjacent band interf)	dB	-30		-25 (Note 1)
Wall attenuation	dB	0	**13 (UE outdoor)**	13
Antenna height	m	**1.5**		1.5
Minimum path loss	**dB**	**86.9**	**73.9**	**80.7**
Interference distance FSL model	**km**	**0.21**	**0.047**	**0.10**
Interference distance Hata suburban model	**km**	**n.a.**		**0.02**
Interference distance IEEE 802 model C	**km**	**0.047**	**0.018**	**n.a.**

Note 1: The chosen NFD/ACLR value is an approximation of the average value experienced by the directly-adjacent victim over its entire channel bandwidth. -25 dB was chosen to represent the LTE victim case, assuming 10 MHz channel bandwidth for LTE and ≥3 MHz channel bandwidth for the MBANS.

5.8.1.1 Interference from LTE DL to MBANS

The frequency separation between the LTE DL and MBANS makes it possible to disregard this scenario.

5.8.1.2 Interference from MBANS to LTE DL

The frequency separation between the LTE DL and MBANS makes it possible to disregard this scenario.

5.8.1.3 Interference from LTE UL to MBANS

The distance between MBANS and the reference Base Station (BS) was chosen as half of the LTE cell radius. The considered interference scenario is depicted in Figure 47 and the simulation settings and results are summarized in Table 67.

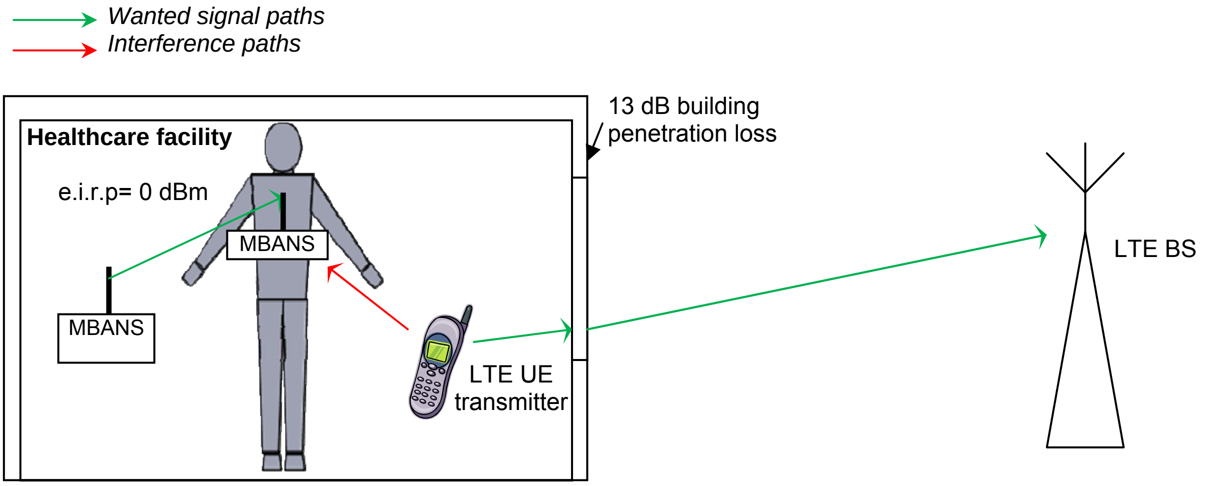


Figure 47: Interference scenario – LTE UL into healthcare facility MBANS

Table 67: Interference from LTE UL to healthcare facility MBANS - Settings and results

Simulation input/output parameters	Settings / Results	
Victim Link (VLK): MBANS		
VLK frequency	2498.5 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 3 m)	
Interfering Link (ILK): LTE UL (UE to BS)		
ILK frequency	2505 MHz	
ILT → VLR interfering path	Extended Hata, indoor→indoor, below roof	
	urban	suburban
ILT → VLR positioning mode	Correlated (interfering BS ref. cell)	
Delta X	0.125 km (R/2)	0.250 km (R/2)
Delta Y	0	
Max allowed power of UE	23 dBm	
Receiver noise figure (BS)	5 dB	
ILK system bandwidth	10 MHz	
Max subcarriers per BS	51	

Simulation input/output parameters	Settings / Results	
Number subcarriers per UE	17	
Simulation results		
Probability of interference (%) (C/I = 15 dB)	**1.7**	**0.4**

5.8.1.4 Interference from MBANS to LTE UL

The considered interference scenario is depicted in Figure 48 and the simulation settings and results are summarized in Table 68.

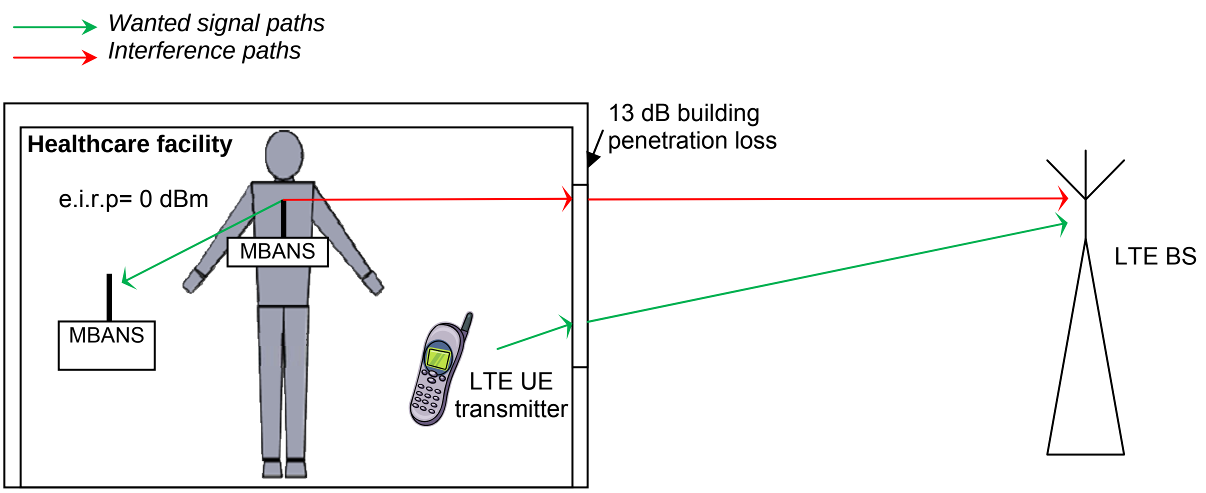


Figure 48: Interference scenario – healthcare facility MBANS into LTE UL

Table 68: Interference from healthcare facility MBANS to LTE UL - Settings and results

Simulation input/output parameters	Settings / Results	
Victim Link (VLK): LTE UL (UE to BS)		
VLK frequency	2505 MHz	
VLT → VLR path	Extended Hata, indoor→outdoor, above roof	
	urban	suburban
Receiver Noise Figure	5 dB	
ILK system bandwidth	10 MHz	
Max subcarriers per BS	51	
Number subcarriers per UE	17	
Max allowed power of UE	23 dBm	
Interfering Link (ILK): MBANS		
ILK frequency	2498.5 MHz	
ILK bandwidth	3 MHz	
ILT Tx power	0 dBm	
ILT density	40/km^2	
ILT probability of transmission	0.1	
ILT → VLR interfering path	Extended Hata, indoor→outdoor, above roof	
	urban	suburban

Simulation input/output parameters	Settings / Results	
ILT → VLR positioning mode	Closest interferer (origin: victim BS ref. cell)	
Simulation results		
Average bit rate degradation (%)	**0.4**	**1.9**

Note 1: The implementation of OFDMA uplink power control in SEAMCAT v4.0.1 sets a certain percentage of the terminals to maximum output power. This might not be representative for all network configurations and could for some configurations (especially for small cells) hide impact from external interferers.

It was regarded as unnecessary to consider the placement of the LTE UE outside, since it the impact of MBAN would be equal or lower.

5.8.2 Home MBANS

The MCL calculations for worst-case minimum interference distances are presented in Table 69.

Table 69: MCL calculation in 2483.5-2500 MHz band between home MBANS and LTE UL

Victim characteristics	Units	MBANS		LTE UL	
Receiver bandwidth	MHz	3		10	
Receiver noise figure	dB	10		5	
Receiver antenna height	m	1.5		30	
Receiver antenna gain	dBi	0		14	
Operating frequency	MHz	2498.5		2505	
N, receiver thermal noise	dBm	-99.1		-98.8	
I/N objective	dB	0		-6	
Interferer's characteristics		LTE UL		MBANS	
e.i.r.p	dBm	23		13	
Bandwidth	MHz	10		3	
BW correction factor	dB	-5.2		0	
NFD (adjacent band interf)	dB	-30		-25 (Note 2)	
Wall attenuation	dB	0 dB (Note 1)	13 dB	0 dB	13 dB (complementary case)
Antenna height	m	1.5		1.5	
Minimum path loss	**dB**	**86.9**	**73.9**	**106.8**	**93.8**
Interference distance FSL model	**km**	**0.21**	**0.047**	**2.1**	**0.47**
Interference distance Hata suburban model	**km**	**n.a.**	**n.a.**	**0.106**	**0.045**
Interference distance IEEE 802 model C	**km**	**0.047**	**0.018**	**n.a.**	**n.a.**

Note 1: Worst case configuration assumed, in which both MBANS patient and LTE UE are outdoors.

Note 2: The chosen NFD/ACLR value is an approximation of the average value experienced by the directly-adjacent victim over its entire channel bandwidth. -25 dB was chosen to represent the LTE victim case, assuming 10 MHz channel bandwidth for LTE and ≥3 MHz channel bandwidth for the MBANS.

5.8.2.1 Interference from LTE DL to MBANS

The frequency separation between the LTE DL and MBANS makes it possible to disregard this scenario.

5.8.2.2 Interference from MBANS to LTE DL

The frequency separation between the LTE DL and MBANS makes it possible to disregard this scenario.

5.8.2.3 Interference from LTE UL to MBANS

Scenario is depicted in Figure 49 and simulation settings are in Table 70.

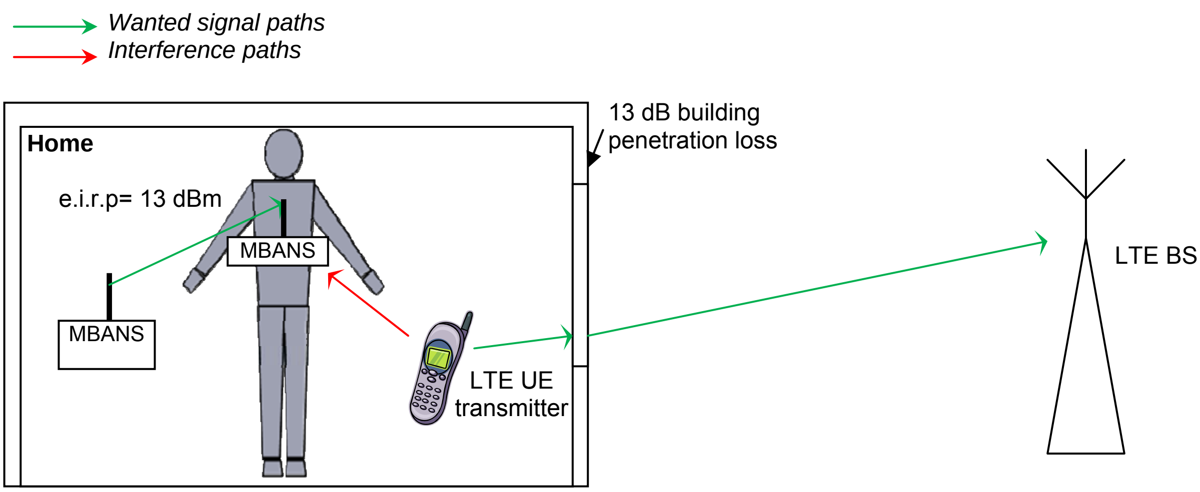


Figure 49: Interference scenario – LTE UL into home MBANS

Table 70: Interference from LTE UL to home MBANS - Settings and results

Simulation input/output parameters	Settings / Results	
Victim Link (VLK): MBANS		
VLK frequency	2498.5 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 10 m)	
Interfering Link (ILK): LTE UL (UE to BS)		
ILK frequency	2505 MHz	
ILT → VLR interfering path	Extended Hata, indoor→indoor, below roof	
	urban	suburban
ILT → VLR positioning mode	Correlated (interfering BS ref. cell)	
Delta X	0.125 km (R/2)	0.250 km (R/2)
Delta Y	0	
Max allowed power of UE	23 dBm	
Receiver noise figure (BS)	5 dB	
ILK system bandwidth	10 MHz	
Max subcarriers per BS	51	
Number subcarriers per UE	17	
Simulation results		
Probability of interference (%) (C/I = 15 dB)	**0.7**	**0.1**

5.8.2.4 Interference from MBANS to LTE UL

For this scenario it was considered necessary to study two cases, with the home MBANS located both indoors and outdoors. Figure 50 and Figure 51 depict these cases. The simulation settings and the results are shown in Table 71.

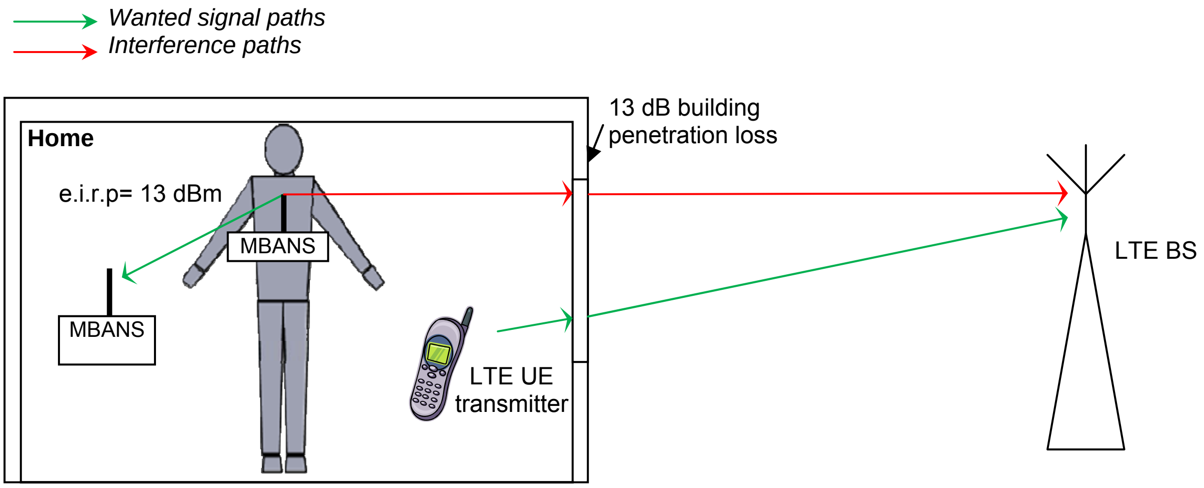


Figure 50: Interference scenario – home MBANS (indoors) into LTE UL

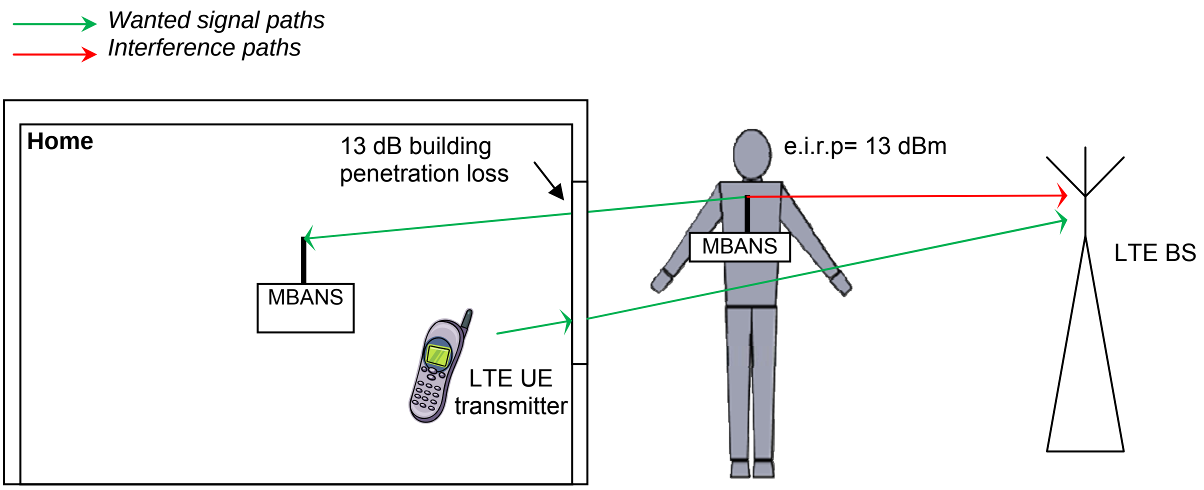


Figure 51: Interference scenario – home MBANS (outdoors) into LTE UL

Table 71: Interference from home MBANS to LTE UL - Settings and results

Simulation input/output parameters	Settings / Results	
Victim Link (VLK): LTE UL (UE to BS)		
VLK frequency	2505 MHz	
VLT → VLR path	Extended Hata, indoor→outdoor, above roof	
	urban	suburban
Receiver Noise Figure	5 dB	
ILK system bandwidth	10 MHz	
Max subcarriers per BS	51	
Number subcarriers per UE	17	
Max allowed power of UE	23 dBm	
Interfering Link (ILK): MBANS		
ILK frequency	2498.5 MHz	
ILK bandwidth	3 MHz	
ILT Tx power	13 dBm	
ILT density	10/km^2	
ILT probability of transmission	0.02	
ILT → VLR interfering path	Extended Hata, indoor/outdoor →outdoor, above roof	
	urban	suburban
ILT → VLR positioning mode	Uniform density (origin: victim BS ref. cell)	
Simulation results		
Average bit rate degradation (%) (MBANS indoor, most cases)	**0.6**	**1.7**
Average bit rate degradation (%) (MBANS outdoor, occassionally)	**1.7**	**5.4**

Note 1: The implementation of OFDMA uplink power control in SEAMCAT v4.0.1 sets a certain percentage of the terminals to maximum output power. This might not be representative for all network configurations and could for some configurations (especially for small cells) hide impact from external interferers.

5.8.2.5 Interference for an apartment scenario

In this subsection the compatibility situation in the case the MBANS and LTE are operated in an apartment building is investigated. The scenario when MBANS are applied to a person living in an apartment is quite similar to the case when the person is living in a house. The possible interference scenarios internal to the apartment (house) and to and from the outside are considered the same as in the case of a house. The difference, having neighbours above and below, was investigated using MCL calculations. The propagation model used for an apartment building was ITU-R P.1238-7 [24].

The MCL calculations indicate that a MBANS which is 1 level away need 21 meters distance from the UE in order to function properly. This indicates possible interference from the UE towards MBANS for the adjacent channel case.

Table 72: Interference from LTE UL into home MBANS in an apartment building – MCL calculations

Victim characteristics	Units	MBANS
Receiver bandwidth	MHz	3
Receiver noise figure	dB	10
Receiver antenna height	m	1.5
Receiver antenna gain	dBi	0
Operating frequency	MHz	2498.5
N, receiver thermal noise	dBm	-99.1
I/N objective	dB	0
Interferer's characteristics	**Units**	LTE UL
e.i.r.p	dBm	23
Bandwidth	MHz	10
BW correction factor	dB	-5.2
NFD (adjacent band interf)	dB	-30
Antenna height	m	1.5
Minimum path loss	**dB**	**86.9**
Interference Distance ITU-R P.1238-7 (km) N (number of floors) = 1	**km**	**0.021**
Interference Distance ITU-R P.1238-7 (km) N (number of floors) = 2	**km**	**0.009**
Interference Distance ITU-R P.1238-7 (km) N (number of floors) = 3	**km**	**0.004**

5.8.3 Ambulance MBANS

Table 73: MCL calculation in 2483.5-2500 MHz band between ambulance MBANS and LTE

Victim characteristics	Units	LTE UL	MBANS
Receiver bandwidth	MHz	10	3
Receiver noise figure	dB	5	10
Receiver antenna height	m	30	1.5
Receiver antenna gain	dBi	14	0
Operating frequency	MHz	2505	2498.5
N, receiver thermal noise	dBm	-98.8	-99.1
I/N objective	dB	-6	0
Interferer's characteristics	**Units**	MBANS	LTE UL
e.i.r.p	dBm	0	23
Bandwidth	MHz	3	10
BW correction factor	dB	0	-5.2
NFD (adjacent band interf)	dB	-25 (Note 1)	-30
Wall attenuation	dB	7	7
Antenna height	m	1.5	1.5
Minimum path loss	**dB**	**86.8**	**79.9**
Interference distance FSL model	**km**	**0.21**	**0.093**
Interference distance Hata suburban model	**km**	**0.003**	**n.a.**
Interference distance IEEE 802 model C	**km**	**n.a.**	**0.026**

Note 1: The chosen NFD/ACLR value is an approximation of the average value experienced by the directly-adjacent victim over its entire channel bandwidth. -25 dB was chosen to represent the LTE victim case, assuming 10 MHz channel bandwidth for LTE and ≥3 MHz channel bandwidth for the MBANS.

5.8.3.1 *Interference from LTE DL to MBANS*

The frequency separation between the LTE DL and MBANS makes it possible to disregard this scenario.

5.8.3.2 *Interference from MBANS to LTE DL*

The frequency separation between the LTE DL and MBANS makes it possible to disregard this scenario.

5.8.3.3 *Interference from LTE UL to MBANS*

Due to low density of MBANS and the way SEAMCAT work, an area as small as an ambulance is expected to have no active LTE transmitters inside the ambulance. This is reasonable, since in any case this can be controlled by the personnel of the ambulance. As for the interference coming from LTE UE outside the ambulance, the scenario is shown in Figure 52 and the parameters and results in Table 74.

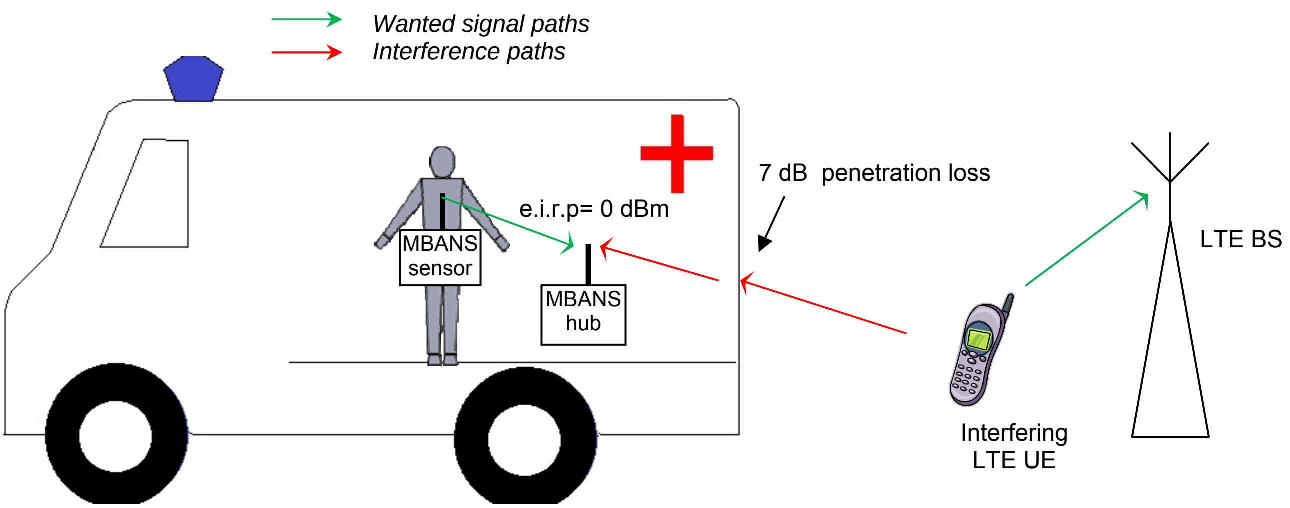


Figure 52: Interference scenario – LTE UL into ambulance MBANS

Table 74: Interference from LTE UL to ambulance MBANS - Settings and results

Simulation input/output parameters	Settings / Results	
Victim Link (VLK): MBANS		
VLK frequency	2498.5 MHz	
VLK bandwidth	3 MHz	
VLT → VLR path	FSL (user-defined radius, 3 m)	
Interfering Link (ILK): LTE UL (UE to BS)		
ILK frequency	2505 MHz	
ILT → VLR interfering path	Extended Hata, outdoor→indoor, below roof	
	Urban	suburban
ILT → VLR positioning mode	Correlated (interfering BS ref. cell)	
Delta X	0.125 km (R/2)	0.250 km (R/2)
Delta Y	0	
Max allowed power of UE	23 dBm	
Receiver noise figure (BS)	5 dB	
ILK system bandwidth	10 MHz	

Simulation input/output parameters	Settings / Results	
Max subcarriers per BS	51	
Number subcarriers per UE	17	
Simulation results		
Probability of interference (%) (C/I = 15 dB)	**2.8**	**0.9**

5.8.3.4 Interference from MBANS to LTE UL

The scenario is depicted in Figure 53 and the parameters and results in Table 75.

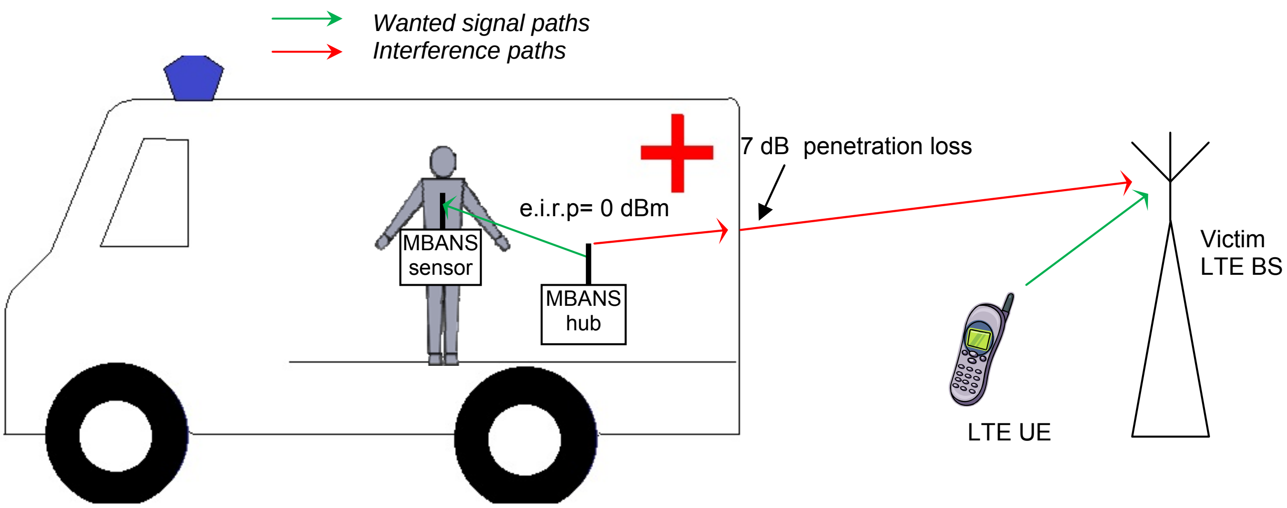


Figure 53: Interference scenario – ambulance MBANS into LTE UL

Table 75: Interference from ambulance MBANS to LTE UL - Settings and results

Simulation input/output parameters	Settings / Results	
Victim Link (VLK): LTE UL (UE to BS)		
VLK frequency	2505 MHz	
VLT → VLR path	Extended Hata, outdoor→outdoor, above roof	
	urban	suburban
Receiver Noise Figure	5 dB	
ILK system bandwidth	10 MHz	
Max subcarriers per BS	51	
Number subcarriers per UE	17	
Max allowed power of UE	23 dBm	
Interfering Link (ILK): MBANS		
ILK frequency	2498.5 MHz	
ILK bandwidth	3 MHz	
ILT Tx power	0 dBm	
ILT density	5/km^2	
ILT probability of transmission	0.1	
ILT → VLR interfering path	Extended Hata, indoor →outdoor, above roof	

Simulation input/output parameters	Settings / Results	
	Urban	suburban
ILT → VLR positioning mode	Uniform density (origin: victim BS ref. cell)	
Simulation results		
Average bit rate degradation (%) (MBANS indoor)	**0.1**	**0.3**

Note 1: The implementation of OFDMA uplink power control in SEAMCAT v4.0.1 sets a certain percentage of the terminals to maximum output power. This might not be representative for all network configurations and could for some configurations (especially for small cells) hide impact from external interferers.

5.8.4 Summary ADJACENT BWS

5.8.4.1 MCL calculations

Below are compiled tables for the MCL calculations with MBANS as an interferer to LTE UL. It can be seen that for the UL, MBANS in the patient's home used out door require 2.1 km distance in order not to interfere using the free space model. MBANS in the health care facilities or in an ambulance require in the order of 100-200 meters.

Table 76: Summary of MCL values for MBANS interfering LTE UL

Victim	LTE UL			
Interferer	**MBANS (healthcare)**	**MBANS (patient home, MBANS out door)**	**MBANS (patient in apartment)**	**MBANS (ambulance)**
Interference Distance based on FSL model (km)	0.10	2.1	N/A*	0.21
Interference Distance based on Extended sub-urban Hata model (km)	0.02	0.11	N/A*	0.03
Document section	5.8.1	5.8.2	5.8.2.5	5.8.3

* Considered similar to MBANS in patient's home

In the LTE UL to MBANS cases, MBANS in the health care unit, MBANS in the home used outdoors and MBANS in the ambulance, 100-200 meters are needed. For the adjacent apartment case, the distance is 20 meters, which is larger than the distance between adjacent floors.

Table 77: Summary of MCL values for LTE UL interfering MBANS

Victim	MBANS			
Interferer	**LTE UL (healthcare)**	**LTE UL (patient home, MBANS and LTE UE outdoors)**	**LTE UL (patient in apartment)**	**LTE UL (ambulance)**
Interference Distance based on FSL model (km)	0.21	0.21	N/A	0.09
Interference Distance based on Extended sub-urban Hata model (km)	N/A	N/A	N/A	N/A
Interference Distance based on IEEE802 (model C) model (km)	0.05	0.05	N/A	0.03
ITU-R P.1238-7 (km)*	N/A	N/A	0.02	N/A
Document section	5.8.1	5.8.2	5.8.2.5	5.8.3

* All these calculations are based on two adjacent floors. By increasing the number of floors, the interference impact decreases.

5.8.4.2 Simulations

The table below shows the compiled results from the simulations performed previously in this subsection for the different cases. In this case the LTE victim system was modelled using the OFDMA mode in SEAMCAT, and the BS is the victim. The simulator does not in this case control how far MBANs will be dropped from the BS victim.

In the OFDMA mode simulations, the distance between the MBANS interferer and the LTE victim may be considerably larger than the reference cell size. This setting represents a larger geographical area, where the interference in the reference cell is the sum from all the interfering devices. However, since the probability of being in close range is small, the results represent an average of the interference situation for the BS.

By simulating the victim LTE system with the SEAMCAT simulation mode GENERIC (instead of OFDMA), it is possible to obtain the probability of a specific BS being interfered when a MBANS in the same cell is transmitting, since the distance between the interferer and the victim can be controlled. Also, for the healthcare facility case, the expected higher density of MBANS was taken into account. On the other hand, the use of generic model underestimates the robustness against interference of victim OFDMA-based systems, such as LTE. The exact parameters for these simulations are given in Annex 1. The distance between MBANS and a BS is assumed between 6m and 500 m.

The presented OFDMA mode results represent the interference from MBANS to LTE BS, from an area considerably larger than one cell, whereas the generic mode results consider interference from MBANS to a specific LTE BS when MBANS is situated in the cell. This explains the differences in results presented in the table below.

Table 78: Summary of SEAMCAT simulation results

Interferer	Victim	Average bit rate loss [%] (victim uses OFDMA mode)	Probability of interf. [%] (victim uses generic mode)
Healthcare facility MBANS	LTE UL	0.4 – 1.9	27.6 (I/N = -6 dB)
Home MBANS (indoors)		0.6 – 1.7	52.7 (I/N = -6 dB)
Home MBANS (outdoors)		1.7 – 5.4	83.7 (I/N = -6 dB)
Ambulance MBANS		0.1 – 0.3	-
LTE UL	Healthcare facility MBANS	n.a.	0.4 – 1.7 (C/I = 15 dB)
	Home MBANS (indoors)	n.a.	0.1 – 0.7 (C/I = 15 dB)
	Ambulance MBANS	n.a.	0.9 – 2.8 (C/I = 15 dB)

Note 1: OFDMA mode simulations consider an unrestricted interfering MBANS deployment. Generic mode mode simulations consider a distance-restricted interfering MBANS deployment.

5.8.4.3 Conclusions

<u>Healthcare facility MBANS</u>:

The MCL calculations suggest that in order to co-exist some separation distances are needed. One of the simulation methods used showed tolerable levels of interference, with an average LTE bit rate loss below 2%. The other simulation method showed 28% probability of interference, which suggest that interference from MBANS cannot be discarded. The coexistence with MBANS within healthcare facilities appears possible, and mitigation techniques would further improve the situation.

Home MBANS:

Since home MBANS may be used also in the vicinity of the home, the outdoor case was used. The MCL calculations suggest that a 2 km distance is needed in order to separate the LTE BS from the home MBANS. Simulation results confirmed that interference levels can be above tolerable levels. MBANS could consider the possibility of preventing outdoor usage. Co-existence without interference issues would otherwise not be expected.

When MBANS operation is restricted to indoor cases, the coexistence with MBANS within homes appears possible in most situations. In the MCL analysis specific to apartment scenarios indicated that devices on adjacent floors may experience interference. As discussed in Section 4.6, considering a MBANS emission mask with lower spurious emission levels would further improve the coexistence situation with home MBANS.

Ambulance MBANS:

Just as in the previous cases, MCL calculations suggest that some distances are needed in order to separate especially the LTE BS from the ambulance MBANS. The conclusion from the simulation-based study is the same as for healthcare facility MBANS—i.e. coexistence appears possible, although interference cannot be discarded in all cases.

In addition, it should be noted that the mobility of ambulance MBANS would lead to short periods of potential interference for most LTE BS, whereas a higher interference likelihood would be expectable for those LTE BS that are installed in the proximity of a healthcare facility. Also, an interference which follows the ambulance through the LTE cell grid, jumping from cell to cell, might raise undetermined LTE network effects.

6 CONCLUSIONS

The ETSI system reference document TR 101 557 [1] suggested ECC to consider three sub bands within the 2360-2500 MHz range for use by Medical Body Area Network Systems (MBANS): 2360-2400 MHz, 2400-2483.5 MHz and 2483.5-2500 MHz. The study of co-existence of MBANS with other systems has been carried out in these three sub-bands. Towards the finalisation of the studies, ECC WG FM decided to exclude the 2360-2400 MHz band from the co-existence studies. Therefore, the focus was given to the other two bands only.

Three MBANS categories are considered by the studies: Healthcare facility, ambulance, and home MBANS. Healthcare facility MBANS are restricted to indoors by means of suitable mechanism to prevent outdoor usage. Ambulance MBANS is for use only inside the vehicle. Home MBANS are intended for indoor use (inside the patient's home), however they can be occasionally outdoors (few meters away from home).

For MBANS transmitters, operating within the healthcare facility (indoor) and ambulance, the maximum transmitted power over the emission bandwidth is 1 mW (e.i.r.p.), while it is 20 mW (e.i.r.p.) for home MBANS.

In accordance with ETSI TR 101 557 [1], typically, the MBANS duty cycle lies around or below 10% for healthcare facility and ambulance applications, and around 2% or below for home (-healthcare) applications. Therefore, the duty cycle has been assumed 10% for healthcare facility and ambulance applications, and 2% for home MBANS throughout the studies given in this report. ETSI TR 101 557 mentions a maximum of 25% duty cycle for future applications. Due to the uncertainty of future application requirements these co-existence studies only consider the aforementioned typical maximum value of 10%. A higher duty cycle would lead to higher interference from MBANS operating in healthcare facilities.

No mitigation technique(s) has been considered for the co-existence studies given in this Report. The compatibility results presented are to be understood in such context. Mitigation measures such as adaptive frequency selection, listen-before-talk, adaptive power control and other features may improve the compatibility of MBANS with other systems and are subject to future work.

Table 79 below, summarizes the results of the compatibility studies, mainly based on average-case SEAMCAT simulations, for all scenarios and considered frequency bands.

Table 79: Overview of risk of interference for the various co-existence scenarios

		Risk of interference from MBANS		
MBANS category		Healthcare facility MBANS	Home MBANS	Ambulance MBANS
Tx-power, DC		1 mW, 10% DC	20 mW, 2% DC	1 mW, 10% DC
Description of MBANS application and restriction		Only indoor, within healthcare facility	Primarily indoor, within patient home. Occasionally outdoor, few meters from home	Only inside vehicle
2400 – 2483.5 MHz	**Wideband Data**	Very low	Very low	Very low
	Amateur and Amateur Satellite	Low	Medium (Note 1)	Low
	BWS (adjacent LTE below 2400 MHz)	Low (Note 1, Note 3)		

MBANS category		Risk of interference from MBANS: Healthcare facility MBANS	Risk of interference from MBANS: Home MBANS	Risk of interference from MBANS: Ambulance MBANS
Tx-power, DC		1 mW, 10% DC	20 mW, 2% DC	1 mW, 10% DC
Description of MBANS application and restriction		Only indoor, within healthcare facility	Primarily indoor, within patient home. Occasionally outdoor, few meters from home	Only inside vehicle
2483.5 – 2500 MHz	LP-AMI	Medium (Note 2)	Low	Medium (Note 2)
	MSS	Low (Note 4)	Very low	Very low (Note 5)
	CGC	Low	Very low	Very low (Note 5)
	RNSS/RDSS	Low	Low	Low
	SAP/SAB	Low	Low	Low
	Wideband Data (adjacent)	Very low	Very low	Very low
	BWS (adjacent LTE above 2500MHz)	Low (average case) High (specific case)	MBANS indoor: Low (average case) High (specific case) MBANS outdoor: Low/Medium (avrg.) High (specific case)	Low (average case) High (specific case)

Risk of interference or average bitrate degradation:
- very low: ≤1 %
- low: >1 %, ≤5 %
- medium: >5 %, ≤10 %
- high: >10 %

Note 1: The impact of existing systems operating in accordance with Annex 1 and Annex 3 of ERC/REC 70-03, such as WLAN systems, are expected more critical than MBANS interference.

Note 2: Interference mitigation measures will be needed. The future MBANS ETSI standard may specify some means of detecting LP-AMI for improving coexistence.

Note 3: Even though it was suggested to use the entire 2400-2500 MHz band for MBANS, the 2400-2410 MHz portion of this range was excluded from the studies in order to improve adjacent band coexistence with the BWS system to be operated in the 2300-2400 MHz band.

Note 4: The impact of healthcare facility MBANS to Globalstar fixed terminals used for emergency back-up communications inside the hospital premises was not specifically studied in Section 5.3.1. Such use of Globalstar is reported in one administration. The CGC study results (Section 5.4.1) may however be applicable to such situation, leaving the conclusions unaltered.

Note 5: The impact of ambulance MBANS to Globalstar terminals used for emergency back-up communications inside the same ambulance vehicle was not studied. Such use of Globalstar is reported in one administration.

For the 2400-2483.5 MHz band the compatibility study results suggest that wideband data systems (WLAN) could significantly interfere with MBANS deployed in hospitals and patient homes. However, inside the premises of health care facilities, which are commonly operated and controlled by the facility management, there could be some possibility to coordinate the MBANS and WLAN channels. The practicality of implementing such approach is unclear, as the proponent industry observed in own hospital surveys that the 2400-2483.5 MHz band may be too crowded, unpredictable, and not easily manageable by hospitals. Additionally, there may be a medium risk of interference from home MBANS into amateur systems in the lower part of the band (2400-2450 MHz), but it should be noted the impact of existing WLAN systems is expected to be more critical than MBANS interference.

The studies conducted in the 2483.5-2500 MHz band showed that MBANS can coexist with the existing systems using the band except for

- LP-AMI: Co-channel compatibility between MBANS and LP-AMI in healthcare facilities is not given, since significant interference levels are expected, even when both systems are operated in different rooms;
- adjacent BWS systems, if MBANS are used outdoors.

However, it is assumed that mechanism(s) for MBANS and LP-AMI to detect each other when operated in close proximity, or other measures, could address the issue of compatibility between MBANS and LP-AMI. Interference effects and possible implant battery life reduction have been identified, thus reducing time frame before implant replacement surgery, especially when MBANS operates in the same room or on the same body as LP-AMI. Interference mitigation measures will be needed. The future MBANS ETSI standard may specify some means of detecting LP-AMI for improving coexistence. Other measures, such as warnings on the devices, may be considered to achieve better co-existence between LP-AMI and MBANS.

In the case of BWS, MBANS should consider the possibility of preventing outdoor usage. The restriction may be de-facto enabled by requiring MBANS sensors to periodically check that they are within operating distance of their MBANS hub. When the MBANS hub is not reachable, MBANS data transmission is stopped. That simple mechanism is part of the light licensing concept proposed in the FCC ruling for MBANs operation in the USA [3].

In the light that ECC WG FM decided not to consider the 2360-2400 MHz band for MBANS, the 2483.5-2500 MHz band could be considered sufficient for the initial introduction of MBANS, even though the initial requirement was set to 30 MHz for healthcare facility usage.

Therefore, by considering the results of statistical simulations of realistic deployment scenarios, it may be concluded that the most promising band for MBANS applications would be 2483.5-2500 MHz, as only mitigation measures are required for the protection of BWS and coexistence with LP-AMI.

ANNEX 1: PARAMETERS FOR SIMULATIONS OF GENERIC CASE

This Annex contains the parameters for the simulations carried out in Section 5.8.

Table 80: Parameters for generic mode simulations in Section 5.8

Simulation input	Settings
Victim Link (VLK):	**LTE UL**
System selection	Generic
VLK frequency	CoCh 2,380 MHz /Adjacent Ch 2,395 MHz
VLT → VLR path	Extended Hata, suburban, outdoor-outdoor, above roof
Receiver Noise Figure	5 dB
Receiver Bandwidth	10 MHz
Noise Floor (dBm)	-99.43
Receiver Blocking mask	Constant 46dB
Receiver Antenna peak gain	17 dBi
Receiver Coverage Radius	500 m
Receiver Antenna Heigth	30 m
Receiver I/N	-6 dB
Max allowed power for Tx	23 dBm
Interfering Link (ILK):	**MBANS**
ILK frequency	CoCh 2,380 MHz /Adjacent Ch 2,401.5 MHz
ILK bandwidth	3 MHz
ILK Tx power	Healthcare 0dBm and Home 13dBm
Active Tx	1
ILK density	Healthcare 40/Km2 and Home 10/Km2
ILK probability of transmission	Healthcare 0.1 and Home 0.02
Distance ILK Tx from VLK Receiver	6-500 m
ILK → VLR interfering path	Extended Hata, suburban outdoor-indoor/outdoor, above roof
ILK → VLR positioning mode	None, relative to Victim Receiver

Note 1: The density of MBANS in the healthcare facility case was increased by using 1 MBANS which was transmitting continuously

ANNEX 2: LIST OF REFERENCES

[1] ETSI TR 101 557 V1.1.1 (2012-02): System Reference document (SRdoc);Medical Body Area Network Systems (MBANS) in the 1 785 MHz to 2 500 MHz range
[2] ERC Report 25: European Common Allocation Table (ECA)
[3] FCC Rule for MBANs operation in the USA : https://www.federalregister.gov/articles/2012/09/11/2012-21984/medical-area-body-network
[4] ECC Report 149 : Compatibility of LP-AMI applications within 2360-3400 MHz, in particular for the band 2483.5-2500 MHz, with incumbent services
[5] Consumer information provided by the Canadian Centre for Occupational Health and Safety: http://www.ccohs.ca/oshanswers/phys_agents/microwave_ovens.html
[6] IARU Region-1 VHF Manager's Handbook: http://www.iaru-r1.org/index.php?option=com_content&view=article&id=914:vhfuhfmw-handbook-edition-600&catid=42:vhf&Itemid=100
[7] ECC Report 172: Broadband Wireless Systems Usage in 2300-2400 MHz
[8] Recommendation ITU-R M.1732-1: Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies
[9] ECC Report 64: Generic UWB applications below 10.6 GHz
[10] ETSI TR 102 655 V1.1.1 (2008-11): System reference document;Short Range Devices (SRD);Low Power Active Medical Implants (LP-AMI) operating in a 20 MHz band within 2 360 MHz to 3 400 MHz
[11] ETSI EN 301 559-1: Low Power Active Medical Implants (LP-AMI) operating in the frequency range 2 483,5 MHz to 2 500 MHz;Part 1: Technical characteristics and test methods.
[12] ECC Report 165 : Compatibility study between MSS CGC operating in the bands 1610.0-1626.5 and 2 483.5-2 500.0 MHz and other systems in the same bands or in adjacent bands
[13] Recommendation ITU-R P.452-14 : Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz (10/2009)
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[17] ERC Report 38 : Handbook on radio equipment and systems video links for ENG/OB use
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[19] ISO/IEC 8802-11:2005(E), IEEE Std 802.11-2003: 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.
[20] 3GPP TS 36.101: LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception.
[21] 3GPP TS 36.104: LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception.
[22] 3GPP TS 36.942: LTE; Evolved Universal Terrestrial Radio Access (E-UTRA);Radio Frequency (RF) system scenarios.
[23] Report ITU-R M.2039-2 : Characteristics of terrestrial IMT-2000 systems for frequency sharing/interference analyses
[24] Recommendation ITU-R P.1238-7: Propagation data and prediction methods for the planning of indoor radiocommunication systems and radio local area networks in the frequency range 900 MHz to 100 GHz.
[25] ERC Recommendation 70-03 Short Range Devices (SRD)