



Source: Document 4C/TEMP/131
Subject: WRC-23 agenda item 9.1, topic b)
Resolution **774 (WRC19)**

**Annex 1 to
Document 4C/333-E
13 May 2022
English only**

Annex 1 to Working Party 4C Chairman's Report

PRELIMINARY DRAFT NEW REPORT ITU-R M.[AMATEUR-RNSS]

Studies [and guidelines] regarding the protection of the primary radionavigation-satellite service (space-to-Earth) by the secondary amateur and amateur-satellite services in the frequency band 1 240-1 300 MHz

*{Editor's note: May need to address the above title at the September 2022 WP 4C meeting.
Alternatively, it was proposed to refer to the title of Resolution 774(WRC-19).}*

1 Background

Some cases of harmful interference caused by emissions from the stations in the amateur service into radionavigation-satellite service (RNSS) (space-to-Earth) receivers have been observed at least by two Administrations, and that Administrations documented and reported the harmful interference. The sources of interferences have been identified and one of the relevant amateur service transmitters was shut down and the interference was ceased. Report evidence is available in Section 9.

To avoid such cases of interference in the future, proper guidelines for the use of the frequency band 1 240-1 300 MHz by stations of the amateur and amateur-satellite services should be considered. The potential interference issues need to be studied in detail to identify those stations and modes possibly causing harmful interference, and to propose measures to assure the further protection of the RNSS.

In this regard, WRC-19 invited the ITU-R to review the amateur and amateur-satellite services applications in the frequency band 1 240-1 300 MHz, without considering the removal of these allocations, to determine if additional measures are required to ensure protection of the RNSS (space-to-Earth) operating in the same band in accordance with Resolution **774 (WRC-19)**. The results of this review shall be included in the Director's Report to WRC-23 under agenda item 9.1, topic b).

This Report is therefore devoted to these studies.

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{Editor's note: Update ToC based on any changes made due to comments below. Even now, the list of sections here does not correspond fully with the rest of the Report.}

2 Introduction

The frequency band 1 240-1 300 MHz is allocated worldwide to Earth exploration-satellite service (active), radiolocation service (RR No. **5.329** applies), the space research service and the radionavigation-satellite service (RNSS) in the space-to-Earth direction on a co-primary basis. The frequency band 1 240-1 300 MHz is also allocated worldwide to RNSS in the space-to-space direction on a co-primary basis. Additional services are allocated in some countries by footnotes RR No. **5.330** (fixed and mobile) and RR No. **5.331** (radionavigation).

Many RNSS systems and networks are operational in or adjacent to the 1 240-1 300 MHz portion of the 1 215-1 300 RNSS (space-to-Earth) and (space-to-space) primary allocations, as described in Recommendation ITU-R M.1787, and various types of RNSS receivers are used with those systems and networks. Report ITU-R M.2458 summarizes the RNSS applications in this frequency band.

The band 1 240-1 260 MHz is currently used by the Russian Federation GLONASS system, while the band 1 250-1 280 MHz is used by the Chinese COMPASS system and the band 1 260-1 300 MHz is used by the European Galileo system as well as the Japanese QZSS system. The same band is also planned to be used by the Korean KPS. Some transmissions of the United States' Global Positioning System in the 1 215-1 240 MHz band also extend above 1 240 MHz.

The frequency band 1 240-1 300 MHz is also allocated worldwide to the amateur service on a secondary basis and is being used for a range of applications. The amateur-satellite service (Earth-to-space) operates in the frequency band 1 260-1 270 MHz on a secondary basis under No. **5.282** of the Radio Regulations.

The RNSS, amateur and amateur-satellite services characteristics and parameters are provided in the relevant ITU-R recommendations (see section 3 below). Those were completed by additional information from administrations on current and planned systems of the RNSS, amateur and amateur-satellite services to WPs 4C and 5A. The full set of characteristics, parameters and protection criteria to be used for interference studies are given in sections 5 and 6. Technical and operational measures that could be employed to ensure the protection of RNSS are presented, and conclusions are drawn with regard to the coexistence studies.

3 Relevant publications (ITU Recommendations and Reports and others)

Recommendation ITU-R [M.1732](#) – *Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies*

Recommendation ITU-R [M.1787](#) – *Description of systems and networks in the radio-navigation-satellite service (space-to-Earth and space-to-space) and technical characteristics of transmitting space stations operating in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz*

Recommendation ITU-R [M.2030](#) – *Evaluation method for pulsed interference from relevant radio sources other than in the radionavigation-satellite service to the radionavigation-satellite service systems and networks operating in the 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz frequency bands*

Report ITU-R [M.2458](#) – *Radionavigation-satellite service applications in the 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz frequency bands*

Study Question ITU-R [288/4](#) – *Related results of the WP 4C work on the Study Question on characteristics and operational requirements of radionavigation-satellite systems*

Study Question ITU-R [48-7/5](#) – *Related results of the WP 5A work on the Study Question on techniques and frequency usage in the amateur service and amateur-satellite service*

Handbook [ITU-R 52](#) – *Amateur and amateur-satellite services*

IARU R1 band plan for the band 1 240-1 300 MHz

<http://iaru-r1.org/index.php/spectrum-and-band-plans/uhf/23-centimeter>

Recommendation ITU-R [S.465](#) – *Reference radiation pattern of earth station antennas in the fixed satellite service for use in coordination and interference assessment in the frequency range from 2 to 31 GHz*

Report ITU-R [RS.2311](#) – *Pulsed radio frequency signal impact measurements and possible mitigation techniques between Earth exploration-satellite service (active) systems and RNSS systems and networks in the band 1 215-1 300 MHz*

Report ITU-R [M.2305](#) – *Consideration of aggregate radio frequency interference event potentials from multiple Earth exploration-satellite service systems on radionavigation-satellite service receivers operating in the 1 215-1 300 MHz frequency band*

Report ITU-R [M.2284](#) – *Compatibility of radio-navigation satellite service (space-to-Earth) systems and radars operating in the frequency band 1 215-1 300 MHz*

Recommendation ITU-R [M.1902](#) – *Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 215-1 300 MHz*

Recommendation [ITU-R M.1904](#) – *Characteristics, performance requirements and protection criteria for receiving stations of the radionavigation-satellite service (space-to-space) operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 5591 610 MHz*

Report ITU-R [M.2220](#) – *Calculation method to determine aggregate interference parameters of pulsed RF systems operating in and near the bands 1 164-1 215 MHz and 1 215-1 300 MHz that may impact radionavigation-satellite service airborne and groundbased receivers operating in those frequency bands*

Recommendation ITU-R [P.1546-6](#) – *Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4 000 MHz*

{Editor's note: An appropriate order of the publications should be taken into account}

4 Abbreviations and definitions

AFSK	Audio Frequency Shift Keying
AMSAT	International Amateur Satellite Organisation(s)
Bd	Baud (symbol per second)
BNetzA	Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway
C4FM	Proprietary standard for digital voice and data communication (YAESU)
CEPT	Conférence Européenne des Administrations des postes et des télécommunications
CEPT ECC	Electronic Communications Committee (CEPT)

ECC WGFM	Working Group Frequency Management (CEPT ECC)
ECC WGSE	Working Group Spectrum Engineering (CEPT ECC)
CSI	Galileo Expert Group on Compatibility, Signals and Interoperability
CW	Continuous wave (Amateur Service: Morse coded on-off keying of carrier)
DARC e.V.	Deutscher Amateur-Radio-Club e.V., Baunatal
DATV	Digital Amateur TV (applying DVB-S and DVB-S2 Standards)
DLR RfM	Deutsche Agentur für Luft-und Raumfahrt – Raumfahrt Management (German Aerospace Center)
DLR GfR	Certified Air Navigation Service Provider Galileo Control Center Oberpfaffenhofen (www.dlr-gfr.de)
DMR	Digital Mobile Radio (ETSI Standard)
D-Star	Digital Smart Technology for Amateur Radio (Proprietary standard for digital voice and data communication (ICOM))
e.i.r.p.	Effective isotropic radiated power
EME	Earth-Moon-Earth
FM ATV	Analogue (FM) Amateur TV
FSK	Frequency Shift Keying
IARU	International Amateur Radio Union
ICD	Open Service Interface Control Document Issue 1.3 12/2016 (EU Galileo)
ISTA	Institute of Space Technology & Space Applications, Universität der Bundeswehr
ITU-R	International Telecommunication Union
JRC	EU Joint Research Centre, Ispra, Italy
MGM	Machine generated modes
PSK31	Phase Shift Keying Mode (31Hz)
RTTY	Radio Teletyping
SATV	Amateur Satellite TV
SSTV	Slow Scan TV
TDMA	Time Division Multiple Access
WPM	Words per minute (Morse telegraphy)
WSPR	Weak Signal Propagation Reporter
WSJT-X	Weak signal narrow-band data communication (Joe Taylor, K1JT)

5 RNSS Characteristics and Protection Criteria

5.1 System Description

RNSS systems and networks provide location, navigation, and timing services to a globally deployed set of user devices that can range from installations in professional systems to portable consumer devices.

As described in Recommendation ITU-R M.1787, the frequency range 1 240-1 260 MHz, is used by the Russian Federation GLONASS system, the frequency range 1 250-1 280 MHz is used by the Chinese COMPASS system and the frequency range 1 260-1 300 MHz, is used by the European Galileo system for the provision of radio navigation-satellite service (RNSS) in the space-to-Earth and space-to-space directions. Some transmissions of the United States' Global Positioning System centered in the 1 215-1 240 MHz frequency also extend above 1 240 MHz.

For a description of RNSS applications, please see Report ITU-R M.2458.

5.2 Characterization of the RNSS receivers

The technical characteristics and protection criteria of the RNSS (space-to-Earth) receivers in the frequency band 1 240-1 300 MHz are listed in Recommendation ITU-R M.1902, which contains the protection criteria from non-pulse radio emissions. Some key parameters are summarized in Table 1 of the Recommendation ITU-R M.1902-2, as shown in Section 5.2.1 below.

The characteristics, performance requirements, and protection criteria of the RNSS (space-to-space) receivers in the frequency band 1 240-1 300 MHz are listed in Recommendation ITU-R M.1904, which contains the protection criteria from non-pulse radio emissions. Some key parameters and thresholds for continuous and/or pulsed interference are summarized in Tables 1-3 of Recommendation ITU-R M.1904-1 (not shown below).

5.2.1 Table of technical characteristics and protection criteria for RNSS (space-to-Earth) receivers

TABLE 1 OF RECOMMENDATION ITU-R M.1902-2

Technical characteristics and protection criteria for RNSS receivers (space-to-Earth) operating in the band 1 2151 300 MHz

Parameter	2	3	3a	3b		4		5				6			
	High-precision semi-codeless receiver*	High-precision receiver using L2C*	High-precision receiver using B3 and B3A	High-accuracy and authentication receiver using E6-BC/L6		Air-navigation receiver (Note 10)		Indoor positioning				General purpose			
Signal frequency range (MHz)	1 227.6 ± 15.345	1 227.6 ± 15.345	1 268.52 ± 12	1 278.75 ± 21		1 246 + 0.4375*K ± 5.11, where K = -7, ..., +6 (Note 8)	1 248,0 6 ± 7.7	1 227.6 ± 12	1 246 + 0.4375* K ± 5.11 where K = -7, ..., +6	1 248,0 6 ± 7.7	1 268.52 ± 12		1 248,06 ± 7.7	1 268.52 ± 12	
Maximum receiver antenna gain in upper hemisphere (dBi)	3.0 circular	3.0 circular	3.0 circular	3 circular		7 circular (Note 11)		6		3			6		3
Maximum receiver antenna gain in lower hemisphere (dBi)	-7 linear (< 10° elev.)	-7 linear (< 10° elev.)	-7 linear (< 10° elev.)	-6 circular (Note 15)		-10 circular		6 (Note 12)		-9			6 (Note 12)		-10
RF filter 3 dB bandwidth (MHz)	24.0	24.0	24.0	40.92 (Note 18)	42.0 (Note 18)	30		32	30		24		32	24	
Pre-correlation filter 3 dB bandwidth (MHz)	20.46	20.46	20.46	40.92 (Note 18)	42.0 (Note 18)	20	25	2	20	25	20.46	2	20	25	20.46
Receiver system noise temperature (K)	513	513	513	722 (Note 18)	645 (Note 18)	400		645		330			645		330
Thresholds for continuous interference															
Tracking mode threshold power level of aggregate narrow-band interference at the passive antenna output (dBW)	-137.4 (P(Y)) (Note 1)	-151.4 (Note 1)	-157.4 (Note 2)	-134.5 (Note 16)		-149 (Note 1) (Note 9)		-193 (Note 1)		-193 (Note 2)			-158 (Note 1)		-150 (Note 2)

Acquisition mode threshold power level of aggregate narrow-band interference at the passive antenna output (dBW)	See Note 5	-157.4 (Note 1)	-157.4 (Note 2)	See Note 17	-155 (Note 1) (Note 9)	-199 (Note 1)	-199 (Note 2)	-164 (Note 1)	-156 (Note 2)
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TABLE 1 OF RECOMMENDATION ITU-R M.1902-2 (end)

	1	2	3	3a	3b	4	5		6	
Parameter	SBAS ground reference receiver*	High-precision semi-codeless receiver*	High-precision receiver using L2C*	High-precision receiver using B3 and B3A	High-accuracy and authentication receiver using E6-BC/L6	Air-navigation receiver (Note 10)	Indoor positioning		General purpose	
Tracking mode threshold power density level of aggregate wideband interference at the passive antenna output (dB(W/MHz))	-147.5 (P(Y)) (Note 1)	-147.4 (P(Y)) (Note 1)	-147.4 (Note 1)	-147.4 (Note 2)	-140 (Note 16)	-140 (Note 1) (Note 9)	-150 (Note 1)	-145 (Note 2)	-139 (Note 1)	-140 (Note 2)
Acquisition mode threshold power density level of aggregate wideband interference at the passive antenna output (dB(W/MHz))	See Note 4	See Note 5	-147.4 (Note 1)	-147.4 (Note 2)	See Note 17	-146 (Note 1) (Note 9)	-156 (Note 1)	-151 (Note 2)	-145 (Note 1)	-146 (Note 2)
Thresholds for pulsed interference (see Note 14)										
Receiver input saturation level (dBW) (Note 14)	-135.0 (Note 6) (Note 13)	-120 (Note 6)	-120 (Note 6)	-120 (Note 6)	-120 (Note 6)	-80	-70	-100	-70	-100
Receiver survival level (dBW) (Note 14)	-10.0 (Note 7)	-20	-20	-20	-20	-1	-20	-17	-20	-17
Overload recovery time (s) (Note 14)	1.0×10^{-6}	1.0×10^{-6}	1.0×10^{-6}	1.0×10^{-6}	1.0×10^{-6}	$(1 \text{ to } 30) \times 10^{-6}$	30×10^{-6}		30×10^{-6}	

Notes to Table 1:

* These columns cover characteristics and thresholds for RNSS receivers that operate in the 1 215-1 300 MHz band. (Receivers of this type operate with the signals described in Annex 2 to Recommendation ITUR M.1787.) For characteristics and protection criteria for the receiver operation in the bands 1 5591 610 MHz and/or 1 1641 215 MHz, refer also to the associated table columns in Recommendations ITUR M.1903 and/or ITUR M.1905, respectively.

Note 1: For P(Y) signal processing, including that using semi-codeless techniques, narrow-band interference is considered to have less than a 100 kHz bandwidth and wideband interference has greater than a 1 MHz bandwidth. For L2C signal processing, narrow-band interference is considered to have less than a 1 kHz bandwidth and wideband interference has greater than a 1 MHz bandwidth. For FDMA and CDMA (carrier frequency 1 248.06 MHz) signals processing, narrow-band continuous interference is considered to have less than a 1 kHz bandwidth, and wideband continuous interference is considered to have greater than a 500 kHz bandwidth. Thresholds for interference bandwidths between 100 kHz (for P(Y)) or 1 kHz (for L2C and FDMA/CDMA (carrier frequency 1 248.06 MHz)) to 1 MHz (or for FDMA to 500 kHz) are undefined and may require further study.

Note 2: Narrow-band continuous interference is considered to have a bandwidth less than 700 Hz. Wideband continuous interference is considered to have a bandwidth greater than 1 MHz. Thresholds for interference bandwidths between 700 Hz and 1 MHz may require further study.

Note 3: The listed maximum upper hemisphere gain value applies for 30° elevation (i.e. maximum expected RFI arrival angle). The listed maximum lower hemisphere gain value applies for 5° elevation.

Note 4: Signal acquisition is performed using the L1 C/A signal. See the appropriate acquisition threshold row in Recommendation ITUR M.1903 Annex 2, Table 22, “SBAS Ground Reference Receiver” column.

Note 5: Signal acquisition is performed using the L1 C/A signal. See the appropriate acquisition threshold row in Recommendation ITUR M.1903 Annex 2, Table 22, “High-precision” column.

Note 6: These receiver input saturation levels apply over the corresponding RF filter 3-dB bandwidth.

Note 7: This survival level is the peak power level for a pulsed signal with a 10% maximum duty factor.

Note 8: This receiver type operates on several RNSS signal carrier frequencies simultaneously. The carrier frequencies are defined by f_c (MHz) = 1 246.0 + 0.4375 K , where K = - 7 to + 6.

Note 9: This threshold should account for the aggregate power of all interference. The threshold value does not include any safety margin.

Note 10: Given values represent typical characteristics of receivers. Under certain conditions more rigid values for some parameters could be required (e.g. recovery time after overload, threshold values of aggregate interference, etc.).

Note 11: Minimum receiver antenna gain at 5 degrees elevation angle is -5.5 dBic.

Note 12: Because the antenna in some RNSS receiver applications could potentially be pointed in almost any direction, the maximum antenna gain in the lower hemisphere could (under worst-case conditions) be equal to that for the upper hemisphere.

Note 13: This receiver input saturation level is for power in a 1 MHz bandwidth.

Note 14: The values in these rows are to be used for assessment of interference from pulsed sources in conjunction with the methodology given in Recommendation ITU-R M.2030.

Note 15: The maximum lower hemisphere gain value applies for 5° elevation angle.

Note 16: Narrow-band continuous interference is considered to have a bandwidth less than 128 kHz. Wideband continuous interference is considered to have a bandwidth greater than 1 MHz. Thresholds for interference with a bandwidth between 128 kHz and 1 MHz may require further study.

Note 17: For E6-BC, signal acquisition is performed using the E1-BC signal. See the appropriate acquisition threshold row in Recommendation ITUR M.1903 Annex 2, Table 22, “High-precision” column. For L6 signal, some receivers perform signal acquisition using the signals in L1 band and other receivers are expected to have 6 dB smaller threshold for the acquisition mode than for the tracking mode.

Note 18: Bandwidth of 40.92 MHz is for E6-BC receiver and that of 42.0 MHz is for L6 receiver. Noise temperature of 722 K is for E6-BC receiver and that of 645 K is for L6 receiver.

For the protection of RNSS receivers from pulse type emissions, Recommendation ITU-R M.2030 and Report ITU-R M.2220 can be referenced. Thus, if interfering transmitters employ pulsed emissions, Recommendation ITU-R M.2030 and Report ITU-R M.2220 may be taken into account.

5.2.2 Statistical distribution of receivers

RNSS receivers are deployed on a worldwide and ubiquitous basis.

5.3 Calculation of actual interference levels

To complete the analysis, the probability of interference arriving at the input of a RNSS receiver must be evaluated. This will take into account up-to-date propagation models and path factors, which are described in the ITUR P-Series Recommendations and Reports. It is likely that a single model will suffice for all possible applications. The transmission loss calculation will also include factors such as absorption losses, diffraction losses, scattering loss, polarization coupling loss, and the effect of multipath. Also, both aggregate and single-entry interference levels may need to be considered.

6 Applications and typical operational characteristics of the amateur and amateur-satellite service operating in the frequency band 1 2401 300 MHz

6.1 Amateur and amateur-satellite applications and station categories

The detailed list of amateur and the amateur-satellite service applications in the band 1 2401 300 MHz can be divided into three categories:

1) Home station

This refers to equipment located at the station licence holder's home address.

2) Temporary "portable" station

A temporarily sited station is usually located in an advantageous position (usually high ground) away from a home station location and operational for a short period radiosport contest, an experimental long-distance communication test or a time-limited special activity event.

3) Permanent installation (sometimes referred to as "automatic" or "unmanned" stations)

Permanent installations refer to stations installed away from a home station. They operate as propagation beacons, voice, amateur television (ATV) or data repeaters. As permanently installed stations, these are licensed by the national authority in their own right for their designated location, operating frequency and output power. The licence and responsibility of the station operation are usually associated with an already licensed radio amateur operator known as the "keeper" of the installation.

Propagation beacons are usually intended to operate continuously and are required to transmit a short repeating message using on/off keying or a narrow-band FSK signal with call sign ID and location information.

Voice repeaters usually re-transmit narrow-band analogue and digital voice traffic when activated with a signal on the input frequency and are mostly associated with extending geographic coverage area. Data and ATV repeater stations transmit wider bandwidth amateur signals and ATV repeater stations may transmit test signals when not being accessed by a user station on the input channel. All repeater stations are required by national regulations to transmit identification information.

Satellite communications (1 260-1 270 MHz, Earth-to-space only; see RR No. **5.282**) and mobile stations are possible, but these are rare in this frequency band. TABLE 1 and TABLE 2 provide a matrix of the amateur and amateur-satellite applications versus station categories:

TABLE 1
Narrow-band amateur and amateur-satellite applications against the station category

Application	Station type				Max. bandwidth	Comments
	Home	Temporary	Installation			
			Repeater	Beacon		
Voice (Analogue SSB)	Yes	Yes			2 700 Hz	Long distance tropospheric weak signal communications. Radiosport operation (incl. EME).
Voice (Analogue NBFM)	Yes	Yes	Yes		12 500 and 25 000 Hz (channel width dependent)	Local neighbourhood communications. Satellite communications.
Voice (Digital)	Yes		Yes		12 500 Hz	Local neighbourhood communications
Telegraphy (Morse code On/Off keying)	Yes	Yes		Yes	500 Hz	Long distance tropospheric weak signal communications. Radiosport ¹ operation (incl. EME).
Machine Generated Modes e.g. RTTY, SSTV ² , PSK31 ³ , WSJT ⁴	Yes	Yes		Yes	6 to 2 700 Hz Mode dependent	Local and long distance tropospheric weak signal communications. (incl. EME). Imaging
Data e.g. AFSK 1k2, FSK 9k6, D-STAR ⁵ , Digital Data 128 kbit/s	Yes	Yes (Mobile)	Yes		12.5 to 150 kHz Mode dependent	Local neighbourhood communication links.

1 See the [ITU Amateur and amateur-satellite](#) handbook for further details of radiosport activities.

2 Slow Scan Television (SSTV) is an imaging protocol which is issued to transmit images at a relatively low speed by using a frequency modulated subcarrier or digital encoding. Such transmissions are designed to fit within the bandwidth of a voice channel.

3 See Recommendation [ITU-R M.2034-0](#) which establishes a telegraphic alphabet and transmission protocols for phase shift keying at 31 baud (PSK31) in the amateur and amateur-satellite services.

4 These WSJT applications consist of a number of highly structured data modes which send a limited amount of data with strong Forward Error Correction which allows the data to be recovered at very low signal-to-noise ratios. WSJT modes –Weak Signal Joe Taylor– are named after their inventor Dr Joe Taylor.

5 D-STAR (Digital Smart Technologies for Amateur Radio) is a digital voice and data protocol specification for amateur radio. The system was developed in the late 1990s by the Japan Amateur Radio League and uses minimum-shift keying in its packet-based standard.

TABLE 2
Wide band amateur applications against the station category

Application	Station type				Max. bandwidth	Comments
	Home	Temporary	Installation			
			Repeater	Beacon		
Analogue ATV (FM-TV)	Yes	Yes	Yes		20 MHz	Legacy technology, deployments decreasing.
Digital ATV (DVB Standards)	Yes	Yes	Yes		1-8 MHz Symbol rate dependent	State of the art technology, deployments increasing

Modern ATV installations employ spectrally efficient digital TV transmitters based on DVBS/MPEG-2 signals. Symbol rates of 2 MBd or 4 MBd operate in lower bandwidth channels and further experimentation continues to increase the spectrum efficiency of amateur TV signals. It has been shown possible to transmit HD MPEG-4 signals with symbol rates less than 333 kBd in a bandwidth as low as 500 kHz. *Note: Bd = Baud (symbol per second)*

6.2 Typical amateur station antenna characteristics in the 1 2401 300 MHz band

There is no standard amateur station and in most cases the antenna installation at any individual amateur station is constrained or influenced by the physical location and town planning restrictions. The following antenna types are typical and based on deployments detailed in published information relating to activity periods and reports from radiosport contests. In general home and temporary stations use highly directional, narrow beam width antennas in this frequency range.

1) Home station and temporary “portable” station antennas

Home stations generally use a single directional antenna, however in a few cases multiple antennas are combined to increase the array gain. This is more usual for EME⁶ operators for whom high antenna gain is essential for overcoming the high path and reflection loss. A higher performance EME station might use instead a medium size dish antenna. TABLE 3 contains the antenna details:

TABLE 3
Typical home station and temporary “portable” station antennas

Antenna type	Gain	3 dB beam width
Single Yagi beam (23 to 55 element)	18 to 21 dBi	18° to 10°
Multiple Yagi beams (for EME)	21 dBi	10°
Dish antenna (for EME)	32 dBi (4 m diameter)	4°

⁶ Earth-Moon-Earth (EME) communications use the Moon as a passive reflector which allows long distance communications between stations that have a simultaneous view of the moon. The reflected signals are very weak, though modern digital signal processing techniques and structured data modes reduce the need for high power transmitters.

2) Permanent installation antennas

Permanent installations operate for different applications using a variety of antenna types characterized by different gain and directivity figures. However, most permanent installations antennas are less directional and (in the case of repeaters) are generally intended to provide coverage over a local area. It should be noted that the antenna type used depends not only on the application but also on the local topography⁷. TABLE 4 summarizes antenna characteristics with indications of minimum, median and maximum parameter values of a typical installation.

TABLE 4
Antenna characteristic of a typical permanent installation

Antenna types	Gain ⁸	Beamwidth in the azimuth plane
Various (e.g. linear slot, co-linear array, horn, flat panel etc.)	Minimum = 2.15 dBi Median = 13 dBi Maximum: refer to footnote 7 for information	Median = 60° (-3 dB) Maximum = Omnidirectional

Antennas with linear polarization are mainly used, but occasionally circular polarization can also be found.

6.3 Typical amateur station power level distribution in the 1 2401 300 MHz band

Typical power level distribution can be derived from published information about the stations that submit information resulting from national activity periods and reports from radiosport contests.

Note: In the following tables the power is specified differently because of the different sources of information.

1) Home station and temporary “portable” station

TABLE 5
Transmitter power ranges in use

Transmitter power (watt)	% home stations	% temporary stations
Up to 10	47%	61.5%
11-25	9%	7.5%
26-100	26%	7.5%
101-300	12%	15%
Over 300	6%	7.5%

⁷ According to the extract from the database of one administration on unmanned amateur radio stations parameters, the antenna gain for 25th percentile, median and 75th percentile are 8.1 dBi, 11.2 dBi and 12.7 dBi. Minimum and maximum gain are found to be 2.15 dBi and 21.5 dBi. However, a gain of 21.5 dBi is exceptionally high in this application. It should be noted that those installations mostly operate in hilly and mountainous areas.

⁸ Feeder loss not included which may be up to 3 dB.

{Editor's note: An administration thinks that it would be useful to be specified what transmitter power corresponds to what type of signal (narrowband, wideband) and to which antenna gain. These specifications would be useful for the simulations scenarios to be considered and for avoiding any confusion.}

2) Permanent installation

Propagation beacon and repeater station directories can be consulted to gather information on the permanent stations deployed within a territory. They are usually licensed to operate at a specific e.r.p. TABLE 6 summarises information on stations in current use extracted from published information from a number of countries:

TABLE 6
Transmitter radiated power ranges in use

e.r.p. (watt)	% propagation beacons	% repeaters
Up to 10	69%	16%
11-25	8%	76%
26-100	20%	8%
101-300	1%	0%
Over 300	1%	0%

{Editor's note: An administration thinks that it would be useful to be specified what e.r.p corresponds to what type of signal (narrowband, wideband) and to which antenna gain. These specifications would be useful for the simulations scenarios to be considered and for avoiding any confusion.}

According to the information in TABLE 6, no repeater is currently in use with an e.r.p. of more than 100 W. However, based on the extract from the license database of one administration on unmanned amateur radio stations parameters, it is indicated that some repeater / relay – stations are licensed to operate with a radiated power up to 380 W⁹ e.r.p., but the operational status of these stations is unknown. Note that there is a limit on the radiated power of unmanned stations given by national regulation and licensing conditions.

6.4 Representative antenna heights

The following antenna heights are representative of typical amateur station installations.

- Typical antenna height for a home station = 12 m above ground level.
- Typical antenna height for a temporary station = 3 m to 15 m above ground level.
- Typical height for a permanent installation station = 25 m above ground level.

Permanent installation stations are often installed at an advantageous location so as to take advantage of elevated local terrain or tall structures in order to increase the effective antenna height.

⁹ According to the extract from the license database of one administration on unmanned amateur radio stations parameters, 30% of repeaters are licensed to operate with an e.r.p. of more than 100 W.

6.5 Amateur station 1 240-1 300 MHz band usage patterns

For all home and temporary “portable” station applications, narrow-band or wideband, the highest number of actively transmitting amateur stations can be found during the scheduled operating and radiosport contest periods. TABLE 7 summarises the total scheduled operating and contest periods scheduled in one region for a typical year. As these activities are usually formalised in the amateur operator calendars, the published national results¹⁰ can be consulted to determine the number of transmitting stations that were active during any one activity or contest period.

TABLE 7
Scheduled operating periods and active operating station numbers

Usage type	Annual scheduled operating periods	Total active stations per scheduled operating period	Active temporary stations per scheduled operating period
Narrow-band activity period and radiosport	Total, on average 108 hours over a year	From 9 to 140 maximum depending on the country reviewed.	15 to 20 maximum depending on the country reviewed.
EME activity	5 × 24-hour contest periods	Up to 10 maximum depending on the country reviewed. (Maximum < 70 across the European area)	None
Wideband (typically ATV) activity period and radiosport	Total, on average 120 hours over a year	From 1 to 24 maximum depending on the country reviewed. (Maximum < 100 across the European area)	10 maximum depending on the country reviewed.

Permanent installation stations present a different scenario when considering the operational time. Unmanned amateur radio stations are more or less in continuous operation, while manned stations only transmit intermittently. Propagation beacon and repeater station directories from a representative region can be consulted to develop the summary presented in TABLE 8.

TABLE 8
Permanent Installation station operating periods in a typical year

Usage type	Annual operation	Active installations
Narrow-band propagation beacons	Transmitting continuously usually.	From 4 to 20 depending on the country reviewed. Region 1 = 88 in total.
Narrow-band repeaters	Low and only when activated on the input frequency by a user station. May transmit more regularly if a beacon mode is present.	From 9 to 19 depending on the country reviewed.

¹⁰The analysed results were published by the national radio amateur societies in several European countries.

ATV repeaters (the users are usually home stations)	Low and only when activated on the input frequency by a user station in a random and sporadic manner. May transmit more regularly if a beacon mode is present.	From 10 to 18 depending on the country reviewed. 5 to 10 users within the local coverage area transmitting one at a time.
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6.6 Activity factors of amateur transmitting stations in the 1 2401 300 MHz band

Activity factor considers the amount of time that any particular station is transmitting during any operational period of activity. All applications involve two-way communication requiring periods of reception as well as transmission. It is usual practice for any home station or temporary portable station to spend more time receiving than transmitting.

Maximum Activity Factor for home station and temporary “portable” stations = 50% and typically less. Any permanent installation station operating in a beacon mode will exhibit a 100% activity factor.

6.7 User density of amateur transmitting stations in the 1 240-1 300 MHz band

1) Home station and temporary “portable” station

- For narrow-band activity periods the maximum density of transmitting stations = 0.000 2 stations/km².
- For wideband activity periods the maximum density of transmitting stations = 0.000 1 stations/km².
- For EME operations the maximum density of transmitting stations = 0.000 013 stations/km².

Recognising that not all active stations may submit a record of their activities, a 33% uplift has been added to the total active stations per scheduled operating period from TABLE 7.

2) Permanent installation

- For narrow-band data and voice repeaters the average density of transmitting stations = 0.000 3 stations/km².
- For wideband ATV repeaters, the average density of transmitting stations = 0.000 1 stations/km².
- For propagation radio beacon stations, the average density of transmitting stations = 0.000 1 stations/km².

The general characteristics of the amateur and amateur-satellite stations are listed in Recommendation ITU-R M.1732.

6.8 Table of transmitter characteristics and parameters [extracted from Recommendation ITU-R M.1732]

TABLE 9
Characteristics of amateur systems*

Parameter	Value		
Applications	Morse on-off keying, PSK31, NBDP	Analogue voice systems	Data, digital voice and multimedia systems
Frequency range ⁽¹⁾	0.902-3.5 GHz	0.902-3.5 GHz	0.902-3.5 GHz
Necessary bandwidth and class of	150HA1A	2K70J3E	2K70G1D

Parameter	Value		
emission (emission designator)	150HJ2A 60H0J2B 250HF1B	11K0F3E 16K0F3E 20K0F3E	6K00F7D 16K0D1D 150KF1W 2M50G7W
Transmitter power (dBW) ⁽²⁾	3 to 31.7	3 to 31.7	3 to 31.7
Feeder loss (dB)	1 to 6	1 to 6	1 to 6
Transmitting antenna gain (dBi)	10 to 42	10 to 42	10 to 42
Typical e.i.r.p. (dBW) ⁽³⁾	1 to 45	1 to 45	1 to 45
Antenna polarization	Horizontal, vertical	Horizontal, vertical	Horizontal, vertical

⁽¹⁾ Amateur bands within the frequency ranges shown conform to RR Article 5.

⁽²⁾ Maximum powers are determined by each administration.

⁽³⁾ May be limited by RR Article 5 in some cases.

* Notwithstanding the frequency range in this Table, this Report is only addressing amateur systems in the 1 240-1 300 MHz band and amateur-satellite systems in the 1 260-1 270 MHz band

{Editor's note: An administration is of the view that these parameters presented in TABLE 9 need to be clarified in order to realize studies that are in concordance with reality. Considering that these parameters so far are not well clarified, the studies realized might not represent reality. It would be best to have a table where the transmitter power, e.i.r.p, density and type of signal (narrow band or wide band) could be defined in connection so that the studies done can reflect real stations.}

TABLE 10

Characteristics of Earth-Moon-Earth (EME) systems*

Parameter	Value
Frequency range ⁽¹⁾	1.24-3.5 GHz
Necessary bandwidth and class of emission (emission designator)	50H0A1A, 50H0J2A, 1K80F1B
Transmitter power (dBW) ⁽²⁾	17 to 31.7
Feeder loss (dB)	1 to 4
Transmitting antenna gain (dBi)	25 to 40
Typical e.i.r.p. (dBW)	40 to 68
Antenna polarization	Horizontal, vertical, LHCP, RHCP

⁽¹⁾ Amateur bands within the frequency ranges shown conform to RR Article 5.

⁽²⁾ Maximum powers are determined by each administration.

* Notwithstanding the frequency range in this Table, this Report is only addressing amateur systems in the 1240-1300 MHz band and amateur-satellite systems in the 1 260-1 270 MHz band

Usage note: Main antenna beam direction can be assumed to be pointing above the horizon.

Emission note: EME increasingly employs digital "Weak Signal Modes" which are structured for very basic communications with low data rates and narrow bandwidth for best weak signal performance.

TABLE 11

Characteristics of amateur-satellite systems in the Earth-to-space direction*

Parameter	Value
Frequency range ⁽¹⁾	1.24-3.5 GHz
Necessary bandwidth and class of emission (emission designator)	150HA1A, 150HJ2A
Necessary bandwidth and class of emission	2K70J3E, 2K70J2E, 16K0F3E, 44K2F1D, 88K3F1D,

Parameter	Value
(emission designator) ⁽²⁾	350KF1D,2M50G7W
Transmitter power (dBW) ⁽³⁾	3 to 31.7
Feeder loss (dB)	1 to 2
Transmitting antenna gain (dBi)	10 to 42
Typical e.i.r.p. (dBW)	3 to 45
Antenna polarization	Horizontal, vertical, RHCP, LHCP

⁽¹⁾ Amateur bands within the frequency ranges shown conform to RR Article 5.

⁽²⁾ Any mode with a necessary bandwidth greater than 44 kHz may require higher e.i.r.p values than shown in the table to achieve a satisfactory link budget.

⁽³⁾ Maximum powers are determined by each administration.

* Notwithstanding the frequency range in this Table, this Report is only addressing amateur systems in the 1 240-1 300 MHz band and amateur-satellite systems in the 1 260-1 270 MHz band

6.9 Band plan(s)

Amateur and amateur-satellite services band planning is achieved on a regional basis in order to take into account the regional differences with the frequency allocations. The current IARU recommended band plans for the frequency range 1 240-1 300 MHz across the three regions are summarized in the table below.

The published band plans for each of the three regions may differ and may not be fully harmonised at the detailed level for every amateur service application. However, it is necessary to harmonise parts of the band for specific applications where these could involve inter-regional communications. This applies particularly to parts of the band recommended for narrowband weak signal applications.

The three recommended band plans across each of the IARU regions can be summarized according to the table below:

TABLE 12

Global Summary of amateur service and amateur-satellite-service IARU band plans

Frequency range (MHz)	Applications	Comments
1 240-1 260	Low bandwidth telegraphy, voice and data modes up to around 20 kHz. Amateur TV (ATV using Analogue or Digital technologies).	Organised into channelized groups for voice and data applications in some regions. One 16.75 MHz block is identified for ATV in this range in Region 1. Two 6 MHz blocks are identified for ATV in Region 2.
1 260-1 270	Satellite uplink band.	In Region 2 simplex ATV is also identified for experimental use in this range.
1 270-1 296	Low bandwidth telegraphy, voice and data modes up to around 20 kHz. Amateur TV (ATV using Analogue or Digital technologies).	Organised into channelized groups for voice and data applications in some regions. One 18.994 MHz block is identified for ATV in this range in Region 1. Two 6 MHz blocks are identified for ATV in Region 2.
1 296-1 297	Low bandwidth telegraphy, voice and	Focused on narrowband weak

Frequency range (MHz)	Applications	Comments
	data modes up to 3 kHz.	signal applications in all three regions including beacons. No channelization.
1 297-1 300	Low bandwidth voice and data modes up to around 20 kHz. Medium bandwidth data up to 150 kHz bandwidth.	Organized into channelized groups for voice and data applications in some regions.

Note 1: The blocks identified for ATV use can accommodate a number of systems depending on the bandwidth occupied by the technology in use. The actual assignments are planned on a national basis.

6.9.1 IARU-R1 band plan for the frequency band 1 240-1 300 MHz

TABLE 13 provides the IARU Region 1 recommended usage of the allocations ([Band Plan](#)) by operators in the amateur and amateur-satellite services. National versions of this band plan may slightly differ due to national frequency allocations.

{Editor's note: The link that should give the band plan in the amateur and amateur-satellite services is not working.}

TABLE 13
IARU Region 1 UHF Band plan for 1 240-1 300 MHz (Varna, 2014)

Frequency (MHz)	Maximum bandwidth	Mode	Usage
1 240.000 1 240.500	2 700 Hz	All modes	Reserved for future
1 240.500 1 240.750	500 Hz	Telegraphy and MGM	Beacons (reserved for future)
1 240.750 1 241.000	20 kHz	FM Digital Voice	Reserved for the future
1 241.000 1 243.250	20 kHz	All Mode	1 242.025-1 242.250 repeater output (RS1-10) 1 242.275-1 242.700 repeater output (RS11-28) 1 242.725-1 243.250 Digital communications (RS29-50)
1 243.250 1 260.000	*	ATV/Digital ATV	1 258.150-1 259.350 repeater output
1 260.000 1 270.000	*	Satellite Service	
1 270.000 1 272.000	20 kHz	All mode	1 270.025-1 270.700 repeater output (RS1-28) 1 270.725-1 271.250 Digital communications (RS29-50)
1 272.000 1 290.994	*	ATV/Digital ATV	
1 290.994 1 291.481	20 kHz	FM digital voice repeater input	RM1 (1 291.000) – RM19 (1 291.475) 25 kHz spacing
1 291.494 1 296.000	*	All modes	1 293.150-1 294.350 repeater input (R20-R68)
1 296.000 1 296.150	500 Hz	Telegraphy MGM	1 296.000-1 296.025 moon bounce 1 296.128 PSK21 centre of activity

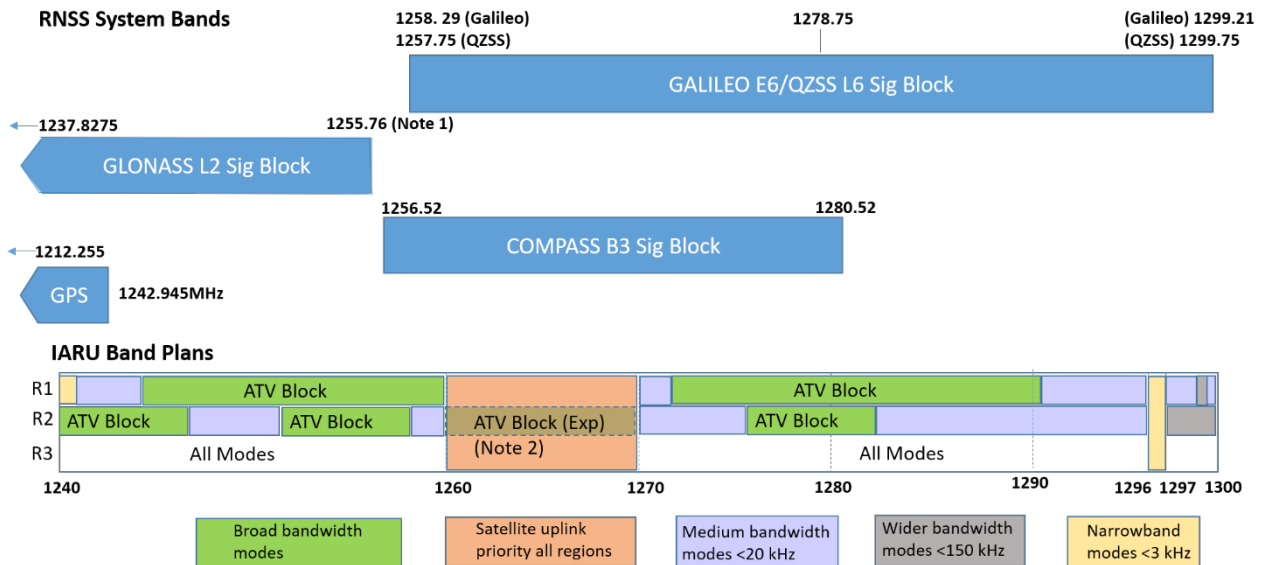
Frequency (MHz)	Maximum bandwidth	Mode	Usage
1 296.150 1 296.800	2 700 Hz	Telegraphy SSB MGM	1 296.200 narrowband centre of activity 1 296.400-1 296.600 linear transponder input 1 296.500 fax 1 296.600 narrowband centre of activity (MGM, RTTY) 1 296.600-1 296.700 linear transponder input 1 296.750-1 296.600 local beacons
1 296.800 1 296.994	500 Hz	Telegraphy MGM	beacons exclusive
1 296.994 1 297.481	20 kHz	FM digital voice repeater output	RM0 / 1 297.000) – RM19 (1 297.475) 25 kHz spacing
1 297.494 1 297.981	20 kHz	FM digital voice	1 297.500 SM20 1 297.500 centre of FM activity 1 297.725 digital voice calling frequency 1 297.900-1 297.975 Simplex FM internet gateways 1 297.975 SM39
1 298.000 1 299.000	20 kHz	All modes	General mixed analogue or digital use 25 kHz spacing 1 298.025 RS1 1 298.975 RS39
1 299.000 1 299.750	150 MHz	All modes	Arranged as 5x 150 kHz channels for high-speed DD use Centres: 1 299.075, 1 299.225, 1 299.375, 1 299.525, 1 299.675 (± 75 kHz)
1 299.750 1 300.000	20 kHz	All modes	8x 25 kHz channels (available for FM/DV use) Centres: 1 299.775-1 299.975

* Bandwidth limits according to national regulations

6.9.2 Relationship between RNSS system frequencies in 1 240-1 300 MHz and the IARU band plans

The figure below highlights the relationship between the various RNSS systems usage across the range 1 240-1 300 MHz and the IARU band plans:

FIGURE 1



Note 1: GLONASS navigation receivers manufactured before 2006 can receive navigation signals in frequency band from 1 237.8275 MHz to 1 260.735 MHz.

Note 2: In Region 2 ATV is also identified for experimental use in this range.

Noting the IARU band plan as introduced in TABLE 13 in section 6.9.1 and noting the RNSS receiver characteristics of the various systems in the frequency band 1 260-1 300 MHz, a difference between the centre frequencies of certain RNSS systems and the various applications of the radio amateur service can be noted. This difference may lower the impact of amateur emissions on leads to high margins relating to the RNSS receivers in certain cases. Whether this observation has any impact on amateur compatibility with RNSS will obviously also depend on the RNSS receiver bandwidth. Some RNSS receivers use very large bandwidth, up to 40 MHz to provide better performances.

7 Propagation models

The goal is to estimate the dimension of interference areas. For doing so, several propagation models can be used; such as ITU-R P.452, ITU-R P.1546 or other models used for mobile radio planning, such as Okumura-Hata.

For each of the models cited above, the following considerations can be made:

- Okumura-Hata is relatively easy to use and it is well known for its general reliability, but it has the limitation that ideally the transmitting station should be at least 30 m above the ground. The model is intended to calculate the median loss over a pixel of terrain at distance d from the transmitter. Because of this, if the model is used to calculate interference area, a margin factor should be inserted in the analysis in order to take into account the spatial variability of the electromagnetic field. If one applies Okumura-Hata, he must be aware of the limitations on its parameters, including a maximum distance of 10 km, a minimum BS antenna height of 30 m. On the other side, since Okumura-Hata is conceived for frequencies up to 1 500 MHz, its frequency range suits the case at hand.
- ITU-R P.1546 does not have the limitation on antenna height of the transmitter (it can be as low as 10 m), but it has a limitation on the minimum distance, that should be at least 1 km. This model has the advantage of having built in location and time

probabilities, so that it can be directly used for the analysis of interference areas. For the model ITU-R P.1546 a tested MATLAB implementation is available to ITU members.

In this report, the propagation loss has been calculated using Recommendation ITU-R P.1546. This Recommendation describes a method for point-to-area radio propagation predictions for terrestrial services in the frequency range 30 MHz to 4 000 MHz. It is intended for use on tropospheric radio circuits over land paths, sea paths and/or mixed land-sea paths up to 1 000 km length for effective transmitting antenna heights less than 3 000 m. The method is based on interpolation/extrapolation from empirically derived fieldstrength curves as functions of distance, antenna height, frequency and percentage of time. The propagation curves represent the field-strength values exceeded for 50%, 10% and 1% of time at 50% of locations. The calculation procedure also includes corrections to the results obtained from this interpolation/extrapolation to account for terrain clearance and terminal clutter obstructions and percentages of location other than 50%. It should be noted that in Section 9 of Annex 5 of Recommendation ITU-R P.1546, there is a clutter correction for the receiving terminal. This method cannot be combined with Recommendation ITU-R P.2108.

8 Methodology

In this section, a description of the analytical methodology used for the compatibility studies between the RNSS characterized in Section 6 and the amateur stations identified in Section 7 are detailed. This primary deals with the computation of the amateur antenna radiation pattern listed in Recommendation ITU-R F.1336 as well as the interference exceedance level (IEL) quantity stipulated from the link budget.

8.1 Calculation of the interference exceedance level

As the protection criteria can vary from service to service, the IEL metric which will be the primary focus of the compatibility studies in this report is the interference exceedance level (IEL) defined below:

(1)

Here, we have:

- IEL: interference exceedance level (dB)
- : power of the amateur station (W)
- : gain of the amateur antenna station calculated using Recommendation ITU-R F.1336 (dBi)
- L_b : transmission losses calculated using Recommendation ITU-R P.1546 (dB)
- : polarization loss (dB)
- : bandwidth specified depending on the type of signal $BW > 1$ MHz.

{Editor's note: For narrow band amateur stations the protection criteria for GALILEO does not depend on the bandwidth, so Equation (1) should be used without the BW parameter.}

In this setting, an IEL value should be compared with the respective recommended ITU-R limit of interference specified in Recommendation ITU-R M.1902.

8.1.1 Computation of the gain of the amateur antenna station

Following the procedures set forth in Recommendation ITU-R F.1336-5, in the case of average side-lobe patterns referred to in *considering c)*, the gain of the amateur antenna station from equation (1) can be calculated as follows:

(2)

with:

where θ , θ_3 , G_0 and k are defined and expressed in *recommends* 2.1 of Recommendation ITU-R F.1336-5. For the studies considered in this report because they are typical antennas that operate in the 400 MHz to 3 GHz range, the parameter k is defined as 0.7.

All other parameters involved in the calculation of the amateur antenna station as described in equation (2) can be determined from Recommendation ITU-R F.1336-5.

8.1.2 Computation of the transmission losses

From Recommendation ITU-R P.1546, the basic transmission loss can be determined from the field strength for 1 kW e.r.p. as follows:

(3)

where:

- L_b : basic transmission loss (dB)
- E : field strength (dB(μ V/m)) for 1 kW e.r.p.
- f : frequency (MHz).

The E field strength from equation (3) can be determined starting from:

- $Freq$ [MHz]: Desired frequency (for the studies it was considered 1 300 MHz)
- t [%]: Required percentage of time (for the studies it was considered 1% or 50%)
- $heff$ [m]: effective height of the transmitting antenna (for the studies it was considered 12 m for Home station 1, 3 m for Home station 2 and 25 m for the Permanent installation)
- h_2 [m]: receiving antenna height above the ground (for the studies the height above the ground of the RNSS receiver it was considered 1.5 m)
- R_2 [m]: representative clutter height above ground (for the studies 0 m or 10 m);
- $Area$: Area around receiver (for the studies: Suburban);
- $Dist$ [km]: Vector of horizontal path lengths over different path zones starting from the transmitter terminal;
- $Path$: Path zone for each given path length (in the studies it was considered 'Land')
- q [%]: Location variability (in the studies it was considered 1% or 50%).

The transmission loss (L_b) from equation (1) can be determined using equation (3) and Annex 5 of Recommendation ITU-R P.1546.

8.1.2.1 Required percentage of time

Due to the variation in the atmospheric and propagation conditions, such as ducting, the received interfering signal will generally vary with time. These phenomena are taken into account by Recommendation ITU-R P.1546. However, these time variations are most relevant over long distances, while at short distances they tend to be negligible.

8.1.2.2 Location variability

Another aspect to be considered is the spatial variability of the electromagnetic field. By the way it is conceived, a propagation model usually gives the estimated median value of the received power

in a given pixel of terrain. This is the case, for instance, of the curves given by Recommendation ITUR P.1546.

Inside this pixel of terrain, you can still have slow fading and fast fading. The effect of local statistical variations of the EM field also needs to be taken into account.

To appreciate this fact, consider a pixel of terrain 50×50 m wide. Assume that the maximum tolerable interfering power for the RNSS receiver is P_{max} . To declare that the pixel is free from interference it is not sufficient to verify that the interfering received power from the amateur radio station, calculated with the chosen propagation model, is equal to or below P_{max} . For instance, when its value is exactly equal to P_{max} this means that 50% of the locations inside the pixel will still be above this value. For this reason, the analysis of interference shall be conducted in such a way that, for a given pixel to be declared to have an acceptably low level of interference, the interfering EM field shall be below the reference threshold P_{ref} for, say, $X=99\%$ of its locations.

It is therefore necessary to have an appropriate statistical model of the spatial variability of the EM field for each pixel. In general, such a variation is modelled as a slow variation (slow fading) plus fast variation (fast fading), that is due to multipath effects.

A characterization of the spatial variability of the field strength in various frequency bands and for different propagation scenarios (the clutter in the vicinity of the RX plays a fundamental role), is described in section 12, Annex 5 of Recommendation ITU-R P.1546-6.

Recommendation ITU-R P.1546 gives curves of basic propagation loss for different location probability. The curve of propagation loss given for 50% of probability means that, for that given pixel, 50% of the locations will actually have a propagation loss lower than the value given by the model and 50% a propagation loss higher than that. If, on the other hand one considers the curves referring to a location probability equal to 1%, this means that for a given pixel and a corresponding propagation loss, for 99% of the locations inside that pixel the propagation loss will actually be higher (and, therefore, interference lower).

In other words, if one calculates the contour of the interference area with the model set at 50% location probability, the contour will be the focus where, for a pixel of terrain, say 50×50 m wide, half of the surface will receive above-threshold interference and half will receive below-threshold interference. Inside the contour, of course, the interference probability will be higher, and outside it will be lower. On the other hand, if one traces the contour with the model set at 1% location probability, the contour will be the focus where, for a pixel 50×50 m wide, 99% of the locations inside that pixel will have an acceptably low level of interference. Outside the contour the interference probability will be progressively higher.

9 Reported Interference

9.1 Reported harmful interference (Germany)

Evidence of reported harmful interference was/were provided by/an Administration(s). This included an assessment of the interference situation, the related emissions, and their impact to the RNSS receiver.

At an RNSS reference receiver, located near Munich (Germany), some amateur applications caused harmful interference to the RNNS reference receiver operating in the frequency range 1 2601 300 MHz.

The first assessment identified Amateur TV emissions (analogue and digital), leading to the conclusion that these applications may further interfere with this specific type RNSS receiver and might be constrained by a minimum separation distance to allow for the further use in the bands.

However, the amateur and amateur-satellite services comprises several applications, which are expected to be further used in the bands 1 240-1 300 MHz and a separation distance is not considered practicable for the protection of RNSS receivers ubiquitously used in this band.

Consecutive measurement report covering the above interference case are attached as Annex 2 – Measurements realized in Germany.

9.2 Reported harmful interference (Region of Varese, Italy)

Further evidence of harmful interference has been provided referring to multiple events observed in May/June 2021 in the region of Varese (Italy) and assessed by the Joint Research Centre (JRC) of the European Commission. As widely documented in Annex 6 – Reported Interference (Italy), several high-end GNSS receivers were interfered during a data collection dealing with the testing of the new Galileo High Accuracy Service (HAS), currently in a pre-operational testing phase of its Signal in Space (SiS) and transmitted in the 1 260-1 300 MHz band. It was found out that the interference was caused by a strong narrow-band emission received at 1 297.3 MHz and characterised by a strong power, being more than 40 dB above the noise floor. The emission was analysed and it was identified to be an FM modulated signal transmitted by an Amateur Radio Repeater. The repeater was identified through the Ministerial identifier transmitted through the signal, which included also a code specifying its position.

The elements provided in Annex 6 – Reported Interference (Italy) clearly demonstrate how the presence of such an emission in the band induced a major degradation of the performance of the GNSS receivers, causing a degradation of the C/N_0 of up to 20 dB, also for very long period of time, corresponding to a harmful interference.

Within the annex it is shown that the emission has the potential to interfere a wide and densely populated area. It is also explained that the events as described have been reported to the competent authorities in Italy (Ministero dello Sviluppo Economico, MISE) on 21 June 2021.

Following the events reported and using them as a reference, further measurements have been performed within the JRC laboratories in the effort to characterize the effect of different AS emission types (at various carrier frequencies and power levels) on multiple GNSS receivers. Results are provided in section 11.1 Compatibility Analysis with Reference GNSS Receivers (EC JRC)) and within Annex 4 – Measurement Campaign (JRC)).

10 Simulations

Values and characteristics in these studies were selected from those provided in Section 6 *Applications and typical operational characteristics of the amateur and amateur-satellite service operating in the frequency band 1 240 1 300 MHz.*

10.1 Analysis for geographical extent of interference

Multiple analyses are conducted for the assessment of the geographical extent of the interference from transmitting amateur stations into some RNSS receivers.

10.1.1 Study 1 (France)

In Annex 1 – Simulations (France) a study that provides the assessment of the geographical extent of the interference caused by transmitting station of the amateur service into Galileo E6 receivers is presented. The annex considers several types of transmitting amateur radio stations and calculates the area around them where they received interference that would exceed the protection criterion of the Galileo E6 receiver.

From the simulation studies in Annex 1 – Simulations (France) some initial aspects were extracted and they are presented below. Firstly, the maximum distance where the RNSS protection criteria was not respected was determined for different amateur stations and for all 3 Regions. This determination has been performed depending on the amateur application, bandwidth and frequency band.

Secondly, for specific chosen distances, it was determined in the direction of the maximum amateur antenna gain the exact value of the RNSS protection criteria exceedance.

Both studies have been performed for the following amateur stations:

TABLE 14
Amateur antenna characteristics

	Home station 1 (also for Satellite Uplink)	Permanent installation	Home station 2 (only for EME signals)
Antenna	Single Yagi, 18 dBi gain, 18° 3 dB aperture	13 dBi gain, 60° 3 dB beam width	Dish (4 m), 32 dBi gain, 4° 3 dB aperture
TX power	1 W - 300 W	1 W - 300 W	1 W - 300 W
Antenna height above ground	12 meters	25 meters	3 meters
Polarization	Linear	Linear	Linear

Furthermore, no cluttering has been considered in order to consider the worse-case scenario and on the RNSS side, an antenna with a gain of -6 dBi located at 1.5 meters from the ground has been used. The polarization loss used was of 3 dB and the noise figure also of 3 dB. The studies have been done only in a suburban area with a location probability of 50%.

In conclusion, the analysis below is based on the results from Annex 1 where the RNSS protection criteria was chosen to be -134.5 dBW for narrow band amateur applications and -140 dBW/MHz for broadband amateur applications.

Using the amateur antennas presented above various amateur applications were studied depending on the frequency band as it can be seen in the figure below.

TABLE 15
Region 1 – Galileo

Freq [MHz]	1 260-1 270	1 270-1 271	1 271-1 290	1 290-1 296	1 296-1 297	1 297-1 298.5	1 298.5-1 299	1 299-1 300
Amateur application	Wider bandwidth mode	Medium bandwidth mode	Broad bandwidth mode	Medium bandwidth mode	Narrowband mode / Satellite uplink	Medium bandwidth mode	Wider bandwidth mode	Medium bandwidth mode
Amateur antenna	Home station 1 Permanent station				Home station 1, 2 Permanent station	Home station 1 Permanent station		
Bandwidth [MHz]	128 kHz	15 kHz	1.7 MHz	15 kHz	1 kHz/128 kHz	15 kHz	128 kHz	15 kHz
RNSS protection criteria	-134.5 dBW	-134.5 dBW	-140 dBW/MHz	-134.5 dBW	-134.5 dBW	-134.5 dBW	-134.5 dBW	-134.5 dBW

TABLE 16
Region 2 – Galileo

Freq [MHz]	1 260-1 270	1 270-1 276	1 276-1 282	1 282-1 296	1 296-1 297	1 297-1 300
Amateur application	Wider bandwidth mode	Medium bandwidth mode	Broad bandwidth mode	Medium bandwidth mode	Narrowband mode / Satellite uplink	Wider bandwidth mode
Amateur antenna	Home station 1 Permanent station				Home station 1, 2 Permanent station	Home station 1 Permanent station
Bandwidth [MHz]	128 kHz	15 kHz	1.7 MHz	15 kHz	1 kHz / 128 kHz	128 kHz
RNSS protection criteria	-134.5 dBW	-134.5 dBW	-140 dBW/MHz	-134.5 dBW	-134.5 dBW	-134.5 dBW

TABLE 17
Region 3 – Galileo

Freq [MHz]	1 260-1270	1 270-1 296	1 296-1 297	1 297-1 300
Amateur application	Wider bandwidth modes	Broad bandwidth mode	Narrowband mode / Satellite uplink	Broad bandwidth mode
Amateur antenna	Home station 1 Permanent station		Home station 1, 2 Permanent station	Home station 1 Permanent station
Bandwidth [MHz]	128 kHz	10 MHz	1 kHz / 128 kHz	10 MHz
RNSS protection criteria	-134.5 dBW	-140 dBW/MHz	-134.5 dBW	-140 dBW/MHz

10.1.1.1 Maximum interference distance extracted from the propagation model studies

10.1.1.1.1 Home station 1

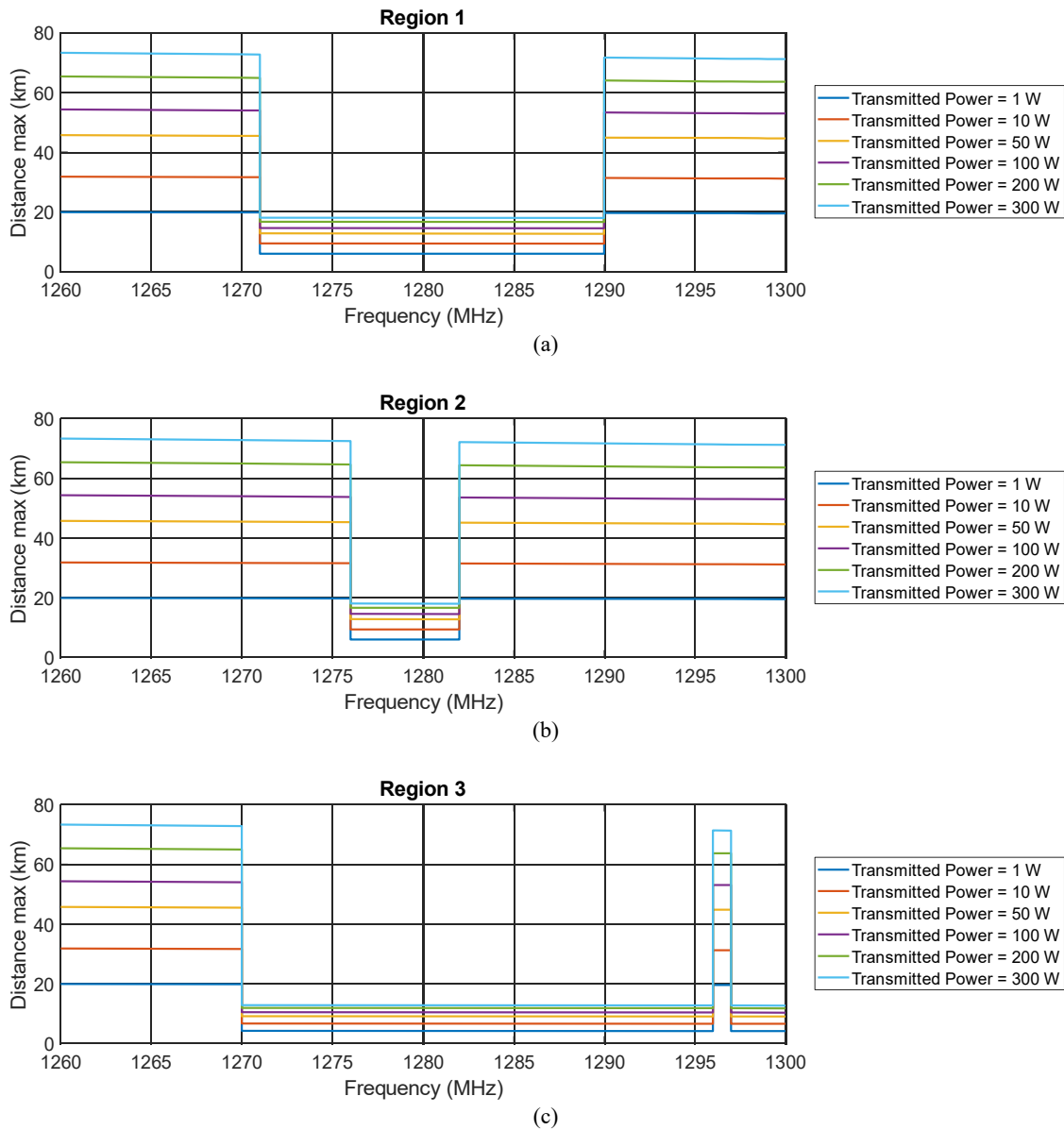
An amateur antenna with a gain of 18 dBi, an aperture of 18° and located 12 meters above ground was used. Also, depending on the region the values from TABLE 15 to TABLE 17 were used for different amateur transmission powers.

The results in the figures below were obtained by taking the maximum distance, in the direction of the maximum amateur antenna gain, where the protection criteria of the RNSS is exceeded.

It is obvious that the highest interference level is obtained in the frequency band 1 296-1 297 MHz where there are narrow band amateur applications that are shared in between the three regions. For an amateur transmission power of 300 W the maximum interference distance can arrive till 70 km in that specific frequency band. It is also important to mention that for broadband amateur applications (example: in Region 1, the frequency band 1 270-1 290 MHz) the maximum distance where the RNSS protection criteria was not respected was of 10 km. From the results obtained in Region 1 it is clear to see that the frequency bands where there is the highest probability of interference it will be for narrow band amateur applications that are shared in between the 3 regions. With respect to the choice of the frequency band, it was seen that for same amateur applications in different bands the results coincided. The conclusion that can be obtained from Region 1 is that the amateur application is very important and depending on the choice then the impact on RNSS in that frequency band will vary accordingly.

FIGURE 2

Maximum interference distance for Galileo extracted from the propagation model studies for Home station 1 in:
(a) Region 1, (b) Region 2 and (c) Region 3



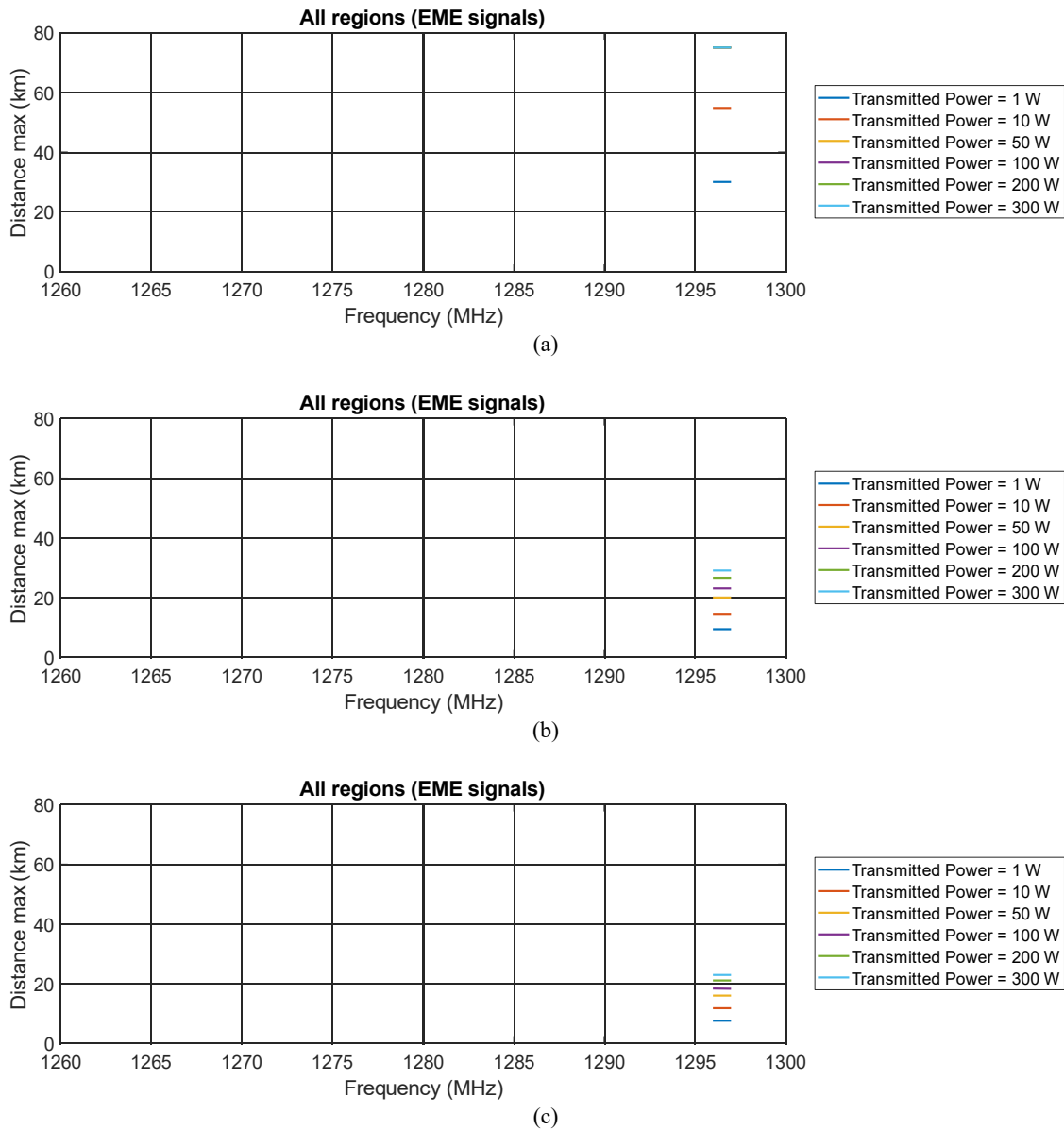
For Region 2 the same conclusions can be made as for Region 1. The frequency band that is shared in between the 3 regions presents the highest probability for interference. The only difference in between the two regions is the repartition of amateur applications in the band. Same conclusions for Region 3.

10.1.1.1.2 Home station 2

The amateur station called 'Home station 2' is only used for EME transmissions and in only specific frequency bands because the antenna gain for this amateur station is of 32 dBi. In the E6 frequency band EME amateur transmissions only occur in between 1 296-1 297 MHz so this is why we have only done the study in this frequency band and the results can be observed below.

FIGURE 3

Maximum interference distance for Galileo extracted from the propagation model studies for Home station 2 in all 3 Regions for an elevation angle of: (a) 0°, (b) 45° and (c) 90°.



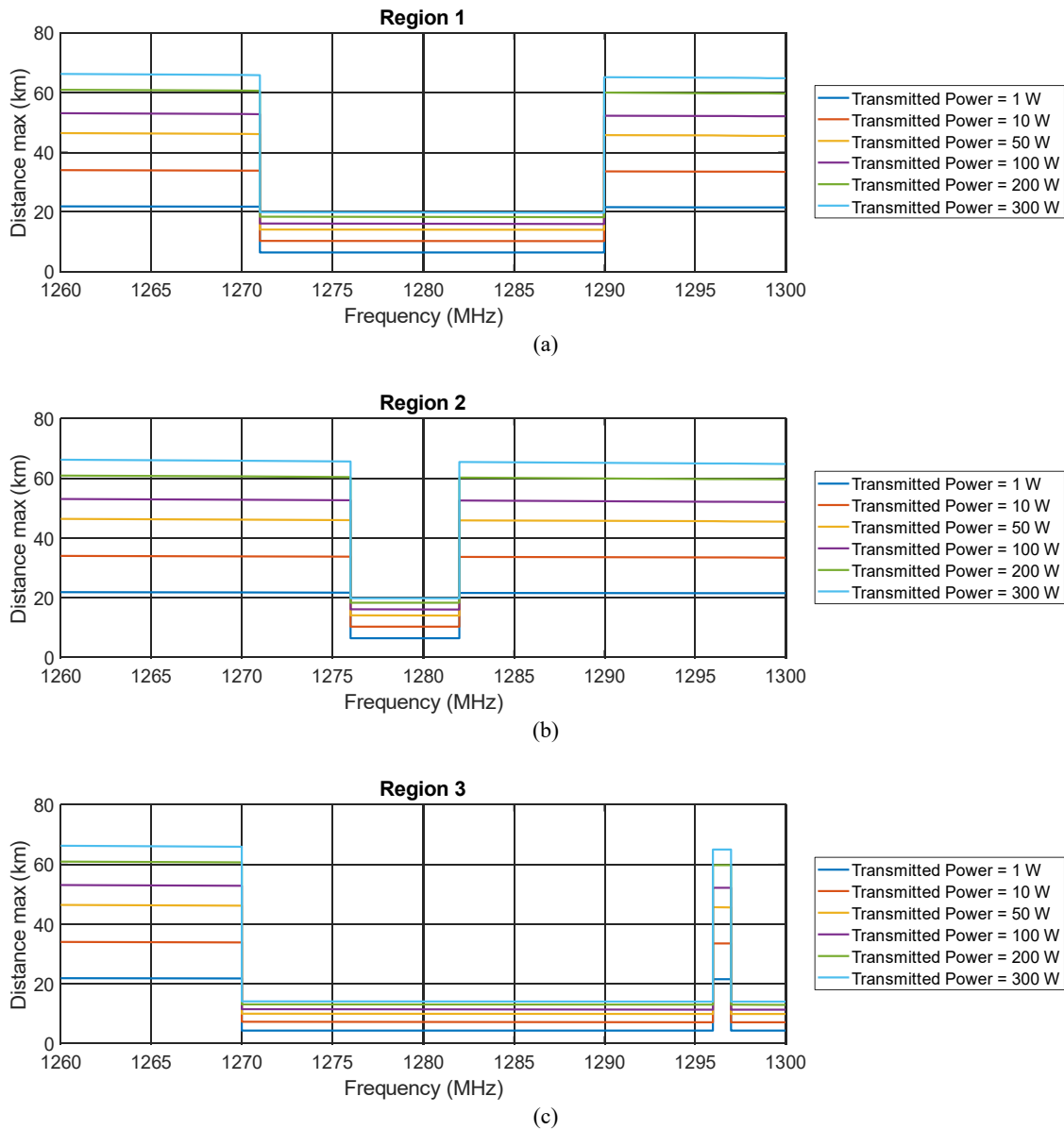
It was considered in this case an amateur bandwidth of 128 kHz and different transmission powers from 1W till 300 W. It can be seen that the maximum distance where the RNSS protection criteria is not respected is of 37 km for a transmission power of 300 W. It is also important to mention that depending on frequency the distance doesn't vary which leads us to conclude that no matter in which part of the band 1 260-1 300 MHz we would have these amateur applications the results will coincide.

10.1.1.3 Permanent station

The same type of study has been done for another type of amateur station that has a slightly different antenna gain lower than 'Home station 1', of 13 dBi, but also it is more directive. In this case it was considered the same configuration for the 3 Regions and the maximum distance where the protection criteria of the RNSS was not respected was determined.

FIGURE 4

Maximum interference distance for Galileo extracted from the propagation model studies for permanent station in: (a) Region 1, (b) Region 2 and (c) Region 3.



In conclusion, from this study it was determined that the highest interference distance is obtained in the frequency band 1 296-1 297 MHz that is shared by the amateur's community in between the three Regions.

In the next section, the same type of study has been done but now it was determined the exceedance protection level at specific distance from the chosen amateur station.

10.1.1.2 Galileo protection criteria exceedance extracted from the propagation model studies

From the studies presented in Annex 1, it was also extracted the level of protection criteria exceedance for different distances from the amateur station, different amateur antenna stations and different amateur applications depending on the frequency band.

The same amateur antenna stations presented in Virhe: Viitteen lähde ei löydy were used here in order to have consistency over the results.

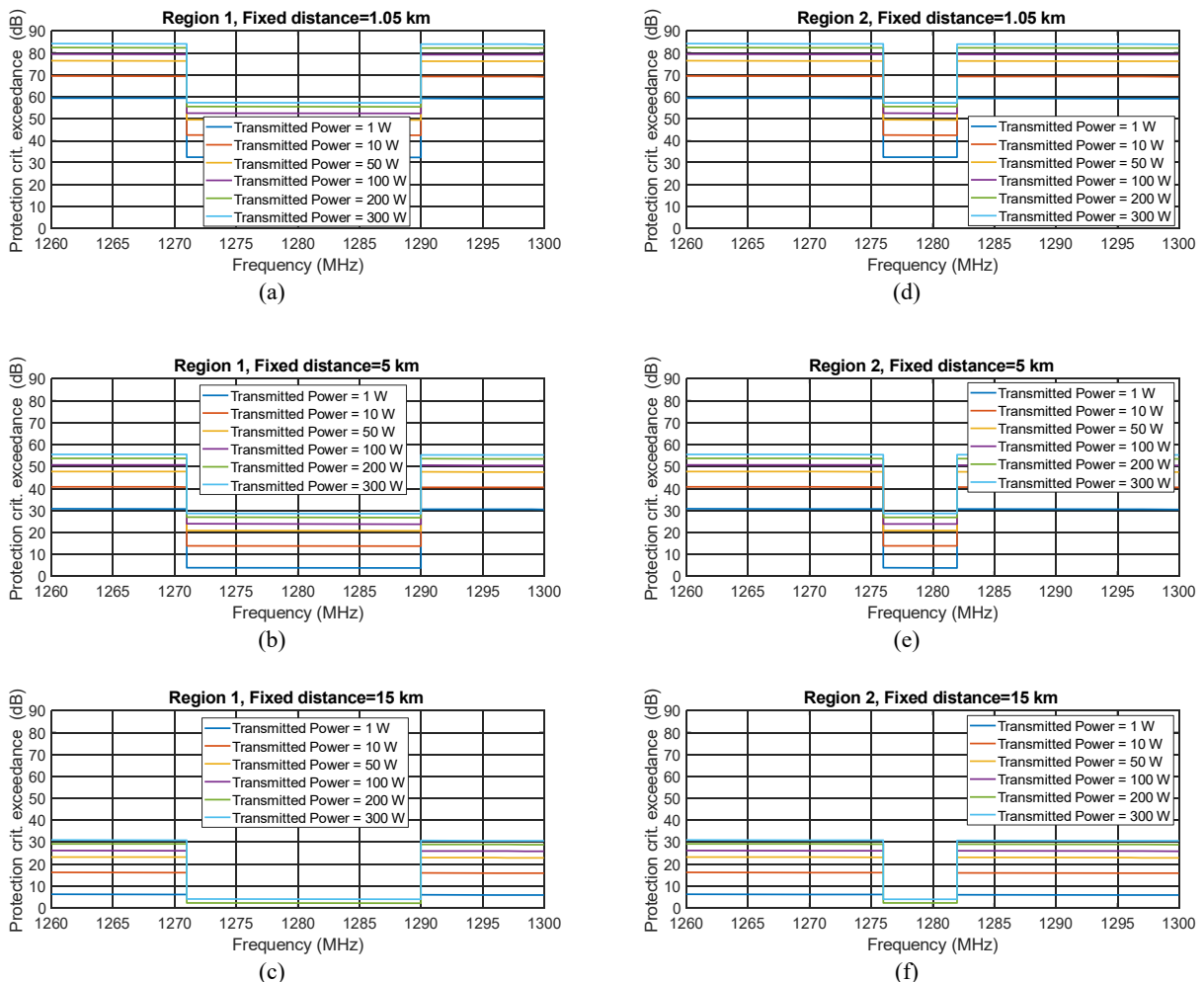
10.1.1.2.1 Home station 1

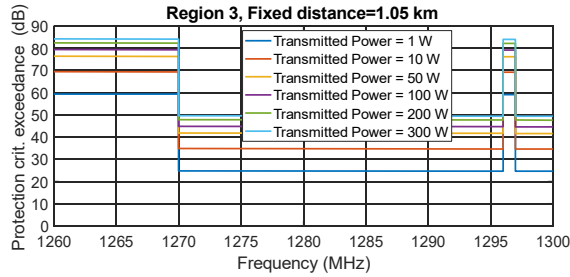
For the amateur 'Home station 1' antenna, 3 distances were chosen and the RNSS protection criteria was determined depending on the type of amateur application. For narrowband amateur applications the RNSS protection criteria considered was of -134.5 dBW and for broadband amateur antenna applications was of -140 dBW/MHz. The minimum distance where the interference exceedance level was able to be calculated was of 1.05 km because of the limits of the proposed propagation model from Recommendation ITU-R P.1546.

In the figure below, it was determined the protection criteria exceedance for 'Home station 1' in Region 1 depending on 3 chosen distances: 1.05 km, 5 km and 15 km. In order to consider the worst-case scenario, the determination has been done for the maximum amateur gain and from the results it is clear to see that the highest interference exceedance has been obtained for the frequency band 1 296-1 297 GHz for the 3 distances and that it has arrived to maximum 80 dB exceedance level with respect to the protection criteria for 1.05 km. The bigger the distance the lower the exceedance level. It is also important to mention that for 1W transmission power, at 15 km, the protection criterion was not exceeded in the frequency bands 1 260-1296 MHz and 1 297-1 300 MHz.

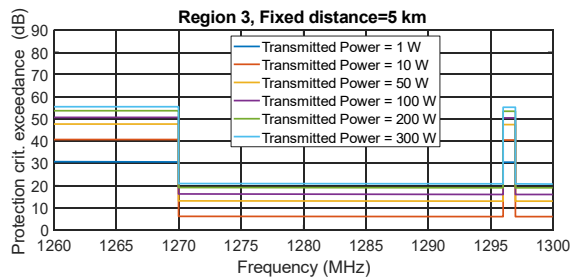
FIGURE 5

Galileo protection criteria exceedance extracted from the propagation model studies for Home station 1 in:
(a) Region 1 at 1.05 km, (b) Region 1 at 5 km, (c) Region 1 at 15 km, (d) Region 2 at 1.05 km, (e) Region 2 at 5 km, (f) Region 2 at 15 km, (g) Region 3 at 1.05 km, (h) Region 3 at 5 km and (i) Region 3 at 15 km.

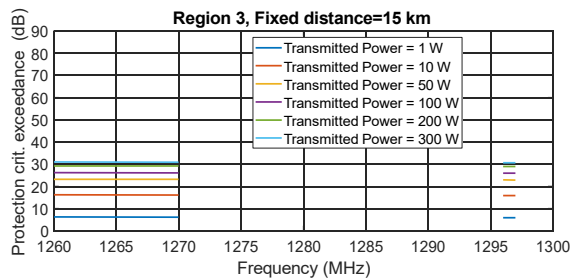




(g)



(h)



(i)

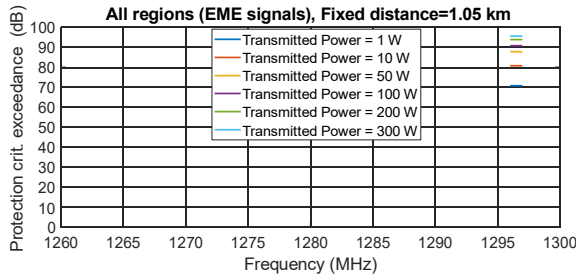
In the figure above, it was also determined the protection criteria exceedance for 'Home station 1' in Regions 2 and 3 depending on 3 chosen distances: 1.05 km, 5 km and 15 km. It is important to mention that for 1W transmission power, at 15 km, the protection criterion was not exceeded in the frequency bands 1 260-1 296 MHz and 1 297-1 300 MHz.

10.1.1.2.2 Home station 2

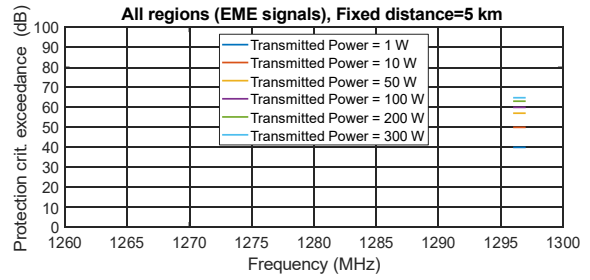
In the figure below, it was determined the protection criteria exceedance for 'Home station 2' in all Regions depending on 3 chosen distances: 1.05 km, 5 km and 15 km. It is important to mention that for 1W transmission power, at 15 km, the protection criterion was not exceeded in the entire E6 frequency band but the level was exceeded for 1.05 km by 50 dB.

FIGURE 6

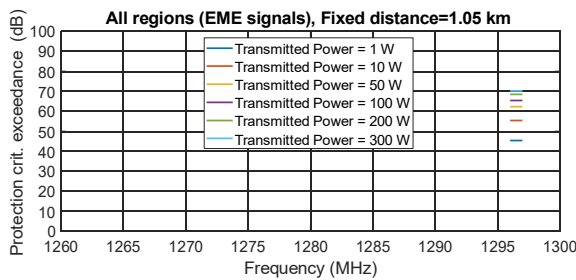
Galileo protection criteria exceedance in all 3 Regions extracted from the propagation model studies for Home station 2 at: (a) 1.05 km and 0°, (b) 1.05 km and 45°, (c) 1.05 km and 90°, (d) 5 km and 0°, (e) 5 km and 45°, (f) 5 km and 90°, (g) 15 km and 0°, (h) 15 km and 45° and (i) 15 km and 90°.



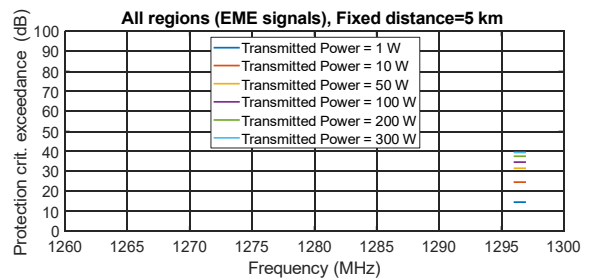
(a)



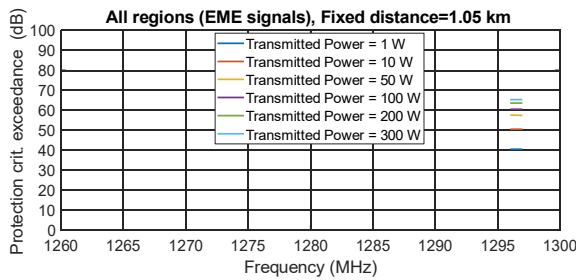
(d)



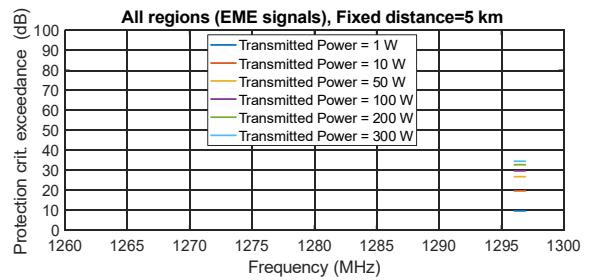
(b)



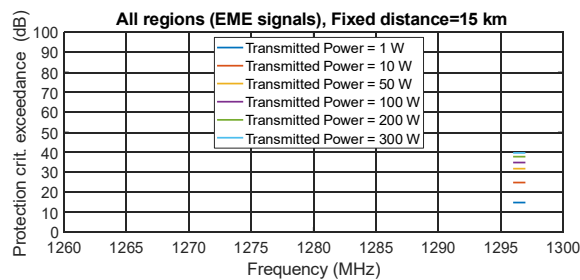
(c)



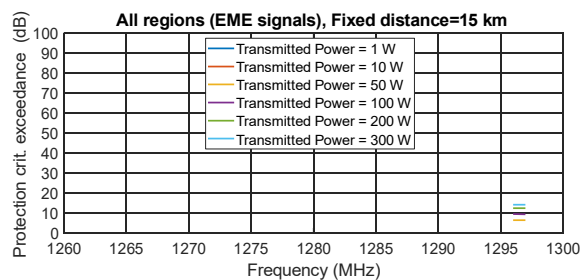
(e)



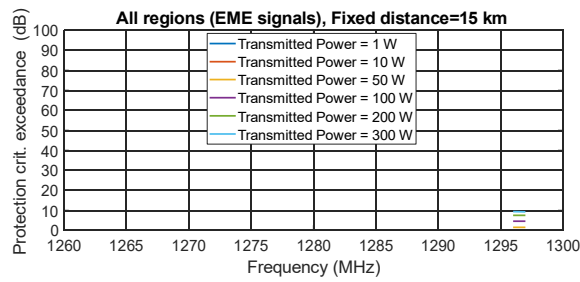
(f)



(g)



(h)



(i)

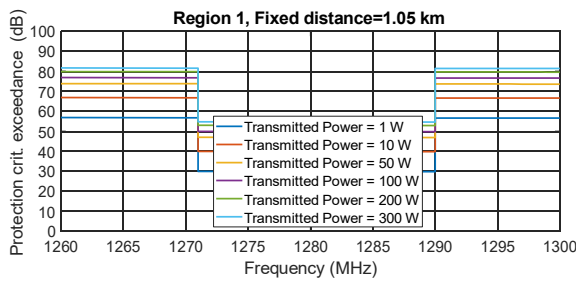
10.1.1.2.3 Permanent station

In the figure below, it was determined the protection criteria exceedance for 'Permanent station' in Region 1 depending on 3 chosen distances: 1.05 km, 5 km and 15 km. It is important to mention that for 1W transmission power, at 15 km, the protection criterion was not exceeded in the frequency bands 1 260-1 296 MHz and 1 297-1 300 MHz. So the same conclusions can be drawn here as for 'Home station 1'.

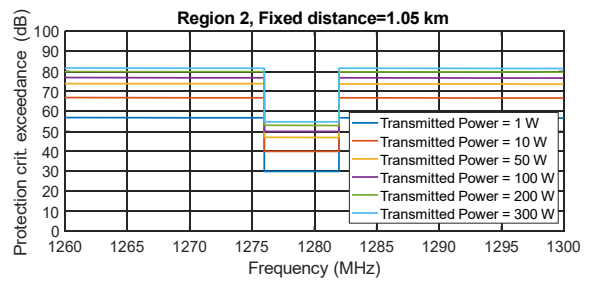
Furthermore, it was also determined the protection criteria exceedance for 'Permanent station' in Regions 2 and 3 depending on 3 chosen distances: 1.05 km, 5 km and 15 km. It is important to mention that for 1W transmission power, at 15 km, the protection criterion was not exceeded in the frequency bands 1 260-1 296 MHz and 1 297-1 300 MHz.

FIGURE 7

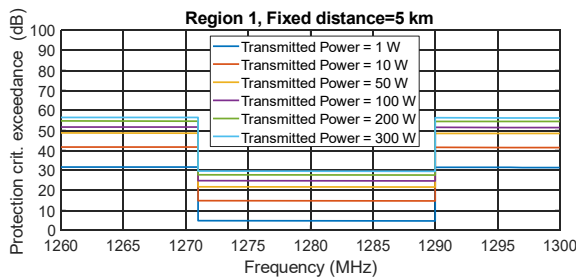
Galileo protection criteria exceedance extracted from the propagation model studies for Permanent station in: (a) Region 1 at 1.05 km, (b) Region 1 at 5 km, (c) Region 1 at 15 km, (d) Region 2 at 1.05 km, (e) Region 2 at 5 km, (f) Region 2 at 15 km, (g) Region 3 at 1.05 km, (h) Region 3 at 5 km and (i) Region 3 at 15 km.



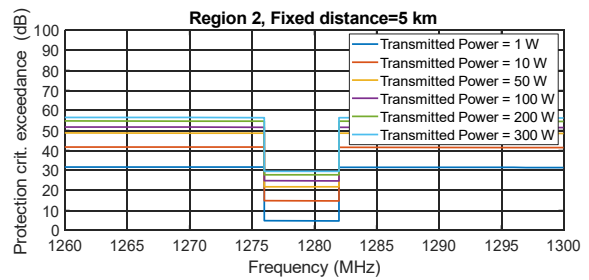
(a)



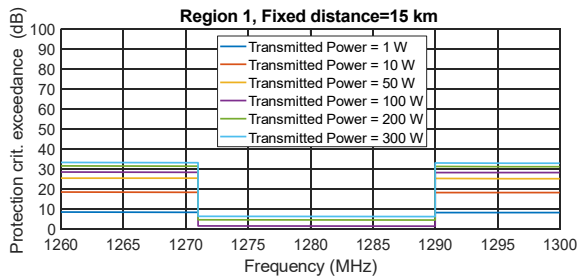
(d)



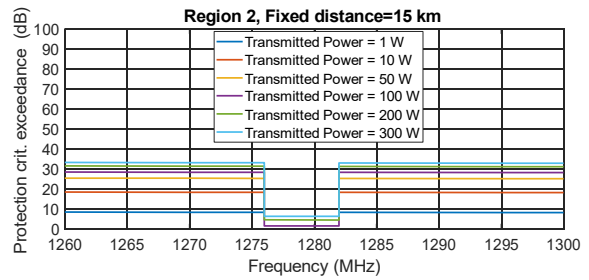
(b)



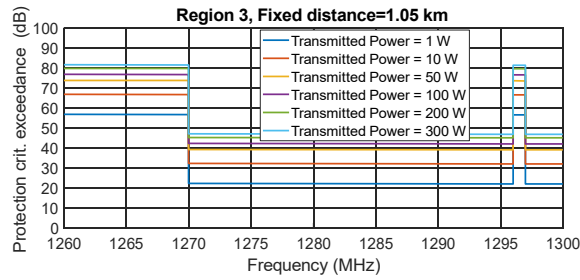
(e)



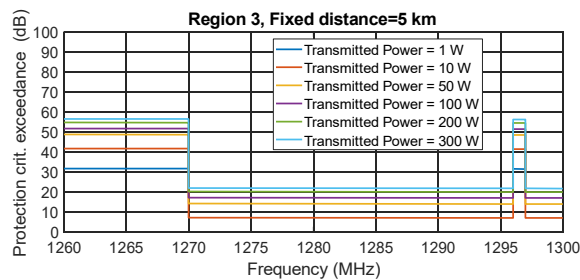
(c)



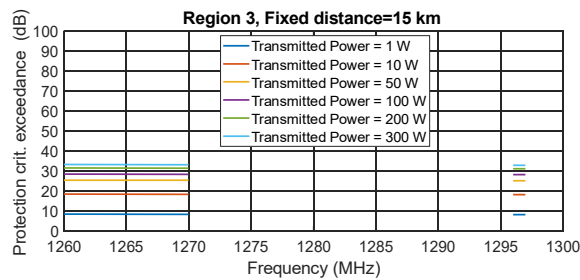
(f)



(g)



(h)



(i)

10.1.2 Study 2 (China)

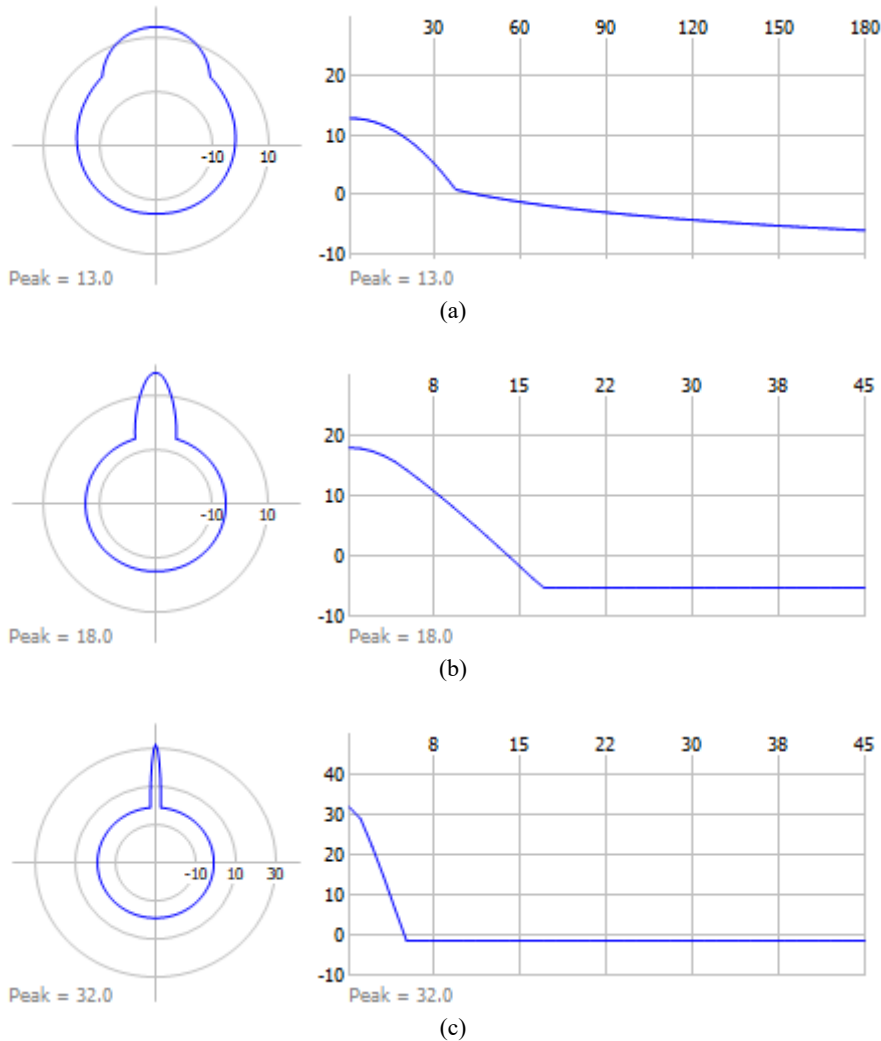
An initial simulation-based study was conducted to assess the geographical extent of interference caused by emissions from ATV, narrow-band application, amateur-satellite uplink and Earth-Moon-Earth communication transmitting stations into COMPASS B3 general purpose receivers.

The ATV stations in this study operate in the frequency bands 1 240-1 260 MHz and 1 270-1 296 MHz; Narrow-band application, amateur-satellite uplink and EME communication are set to operate at 1 270 MHz, 1 265 MHz and 1 272 MHz respectively with bandwidth less than 700 Hz., and three typical stations have been selected regarding the specific application and are given in TABLE 18 and Figure 8 below.

TABLE 18
Amateur and amateur-satellite service station parameters

Application	ATV	Narrow-band application	Amateur-satellite uplink	EME communication
Station types	Permanent installation		Home station	Home station
Parameters	Value			
Antenna	13 dBi gain, 60° 3-dB beam width		Single Yagi, 18 dBi gain, 18° 3 dB beam width	Dish (4 m), 32 dBi gain, 4° 3 dB aperture
TX power	1 W		1 W	50 W
Antenna height above ground	25 meters		12 meters	3 meters
Polarization	Vertical		Vertical	Vertical

FIGURE 8
Antenna diagram: (a) ATV /Narrow-band application station, (b) Amateur-satellite uplink station, (c) EME communication station



The parameters of COMPASS B3 general purpose receivers are given in the Table of section 5.2.1 in this Report.

The simulations indicate interference areas around an amateur and amateur-satellite station with an extent of several km, depending on the case.

The details of this study are attached as Annex 3 – China contribution to this Report.

10.1.3 Study 3 (the Russian Federation)

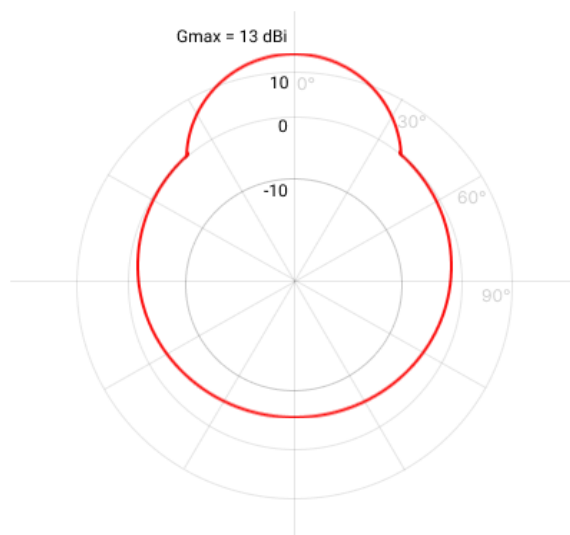
The simulation-based study was conducted to assess the geographical extent of interference area caused by emissions from amateur television (ATV) stations into GLONASS general purpose receiver and also to GLONASS air- navigation receiver.

The typical parameters of ATV stations are given in Table 19 and Figure 9 below:

TABLE 19
ATV repeater parameters

Parameters	Value
Antenna gain	13 dBi
Beamwidth	60°
TX power	1 W
Bandwidth	16.75 MHz
Antenna height above the ground	25 m
Polarization	Vertical

FIGURE 9
ATV repeater antenna pattern



The GLONASS receiver parameters are presented in Recommendation ITU-R M.1902 and provided in Table 1 in Section 6.2 of this document.

The simulation results show the geographical extent of interference areas from the ATV repeater into GLONASS receivers of two types:

- for the GLONASS general purpose receiver the interference area extend to several kilometres;

- for the GLONASS air- navigation receiver the interference area can vary from several tens km (for the receiver height of 100 m) up to more than 100 km (for the receiver height form 1 to 10 km)

It is also worth noting that the results obtained are valid in the direction of the maximum of the ATV repeater antenna pattern. In other directions the potential interference area will be much smaller.

In the study, the entire margin of the aggregate broadband interference level to protect the RNSS receiver was given only to the amateur service. However, it should be noted that in the considered frequency band, in addition to the primary RNSS radio service and the secondary amateur service, the following primary radio services operate: the radiolocation, EESS, SRS. So, in the current study, interference from other services other than the amateur service was not taken into account.

The detailed study results are given in Annex 7 to this Report.

11 Measurements

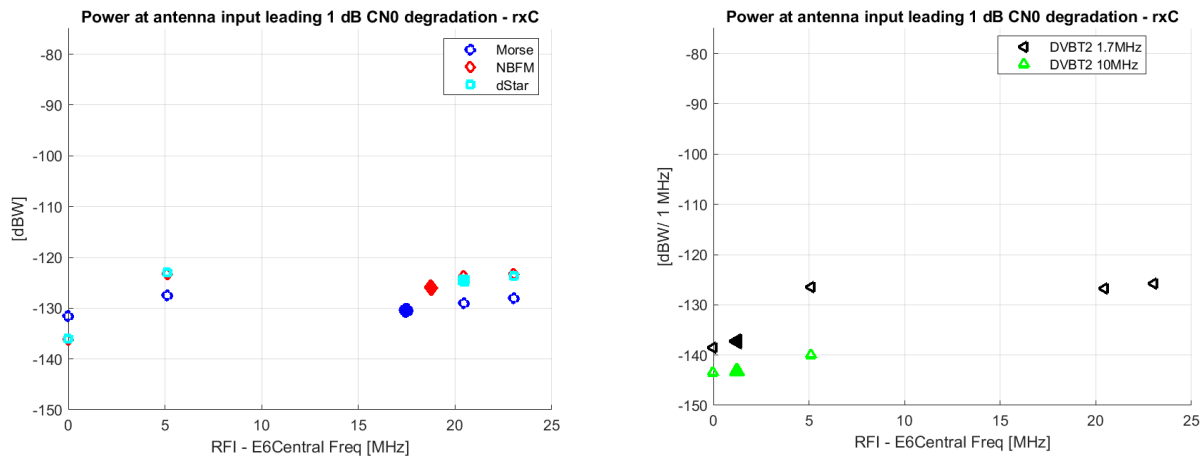
11.1 Compatibility Analysis with Reference GNSS Receivers (EC JRC)

In Q2/Q3-2021 the Joint Research Centre of the European Commission carried out an extensive testing campaign within its premises in order to assess the impact of all different AS modes on a batch of high grade GNSS receivers under different conditions. The main scope of the activity is to study in detail the effect of AS emissions with different power levels at the input of the GNSS antenna and at different central frequencies. At this scope, for the various AS emissions, on top of the typical centre frequencies provided within the IARU band plan, other frequencies across the E6 band have been tested. This was done at the scope of providing the most complete possible picture on the compatibility potential between the two services. In particular, the different receivers under test are characterised by different front-end bandwidth (spanning approximately from 30 MHz to the full 40 MHz).

As documented in Annex 4 – Measurement Campaign (JRC), the tests provide a characterisation for many different test scenarios, providing for each case and each AS emission type the minimum power (at the input of the GNSS receiving antenna) which is causing a 1 dB degradation of the Galileo E6B C/N_0 , as provided by the different receivers under test. As it is explained in the annex, the three receivers under test are all high-end professional receivers available in the market, and each of those has specific characteristics, including different RF bandwidth. It is also explained how the receiver C is the one which is more representative of E6-BC receiver assumptions within Recommendation ITUR M.1902 (40.92 MHz receiver bandwidth) and therefore should be taken as a reference in the context of this compatibility assessment.

FIGURE 10

Test results – Narrow-band (left) and wide-band (right) AS emissions – Receiver C



Results are provided also for the specific AS centre frequencies as detailed in the IARU band plan. The results for those centre frequencies for the receiver C are provided in the following table.

	Application	Centre Frequency	Bandwidth	Power at antenna input resulting in 1 dB C/N_0 degradation
1	Telegraphy	1 296.2 MHz	< 1 kHz	-130.5 dBW
3	NBFM	1 297.5 MHz	11.1 kHz	-126 dBW
4	Digital Data 128 kBit/s	1 299.2 MHz	128 kHz	-124.5 dBW
5	DVB-T2	1 280.0 MHz	1 MHz	-137.3 dBW/1 MHz
6	DVB-T2	1 280.0 MHz	10 MHz	-143.25 dBW/1 MHz

As detailed in Annex 4 – Measurement Campaign (JRC), out of the IARU band plan, the two services requiring the highest power to cause the 1 dB degradation (and therefore exhibiting a higher compatibility potential) are NBFM and Digital Data. Still, it is evident that power levels higher than those resulting out of the measurements would cause an unacceptable degradation to the GNSS receivers.

At the same time, the two Amateur TV wide-band services are impacting the GNSS receiver even with a relatively low power. This suggests a very small compatibility potential within the E6 band. This remains true almost for any of the considered receivers, also considering that the 1 280 MHz centre frequency is extremely close to the E6 carrier frequency, and as such the result seems almost independent from the specific GNSS receiver bandwidth.

Annex 4 – Measurement Campaign (JRC) provides a comprehensive overview of the testing setup, assumptions, KPIs and results for the different receivers under and for all the scenarios considered.

11.2 Measurements realized in Germany

Considering the reported interference in Germany, described in section 9.1, a test plan was developed to describe a set of measurements to determine the technical and operational conditions for the future use of the Amateur Service in this band. The measurements were defined under static operational conditions, a fixed ratio of signal power level of both services at the input of a

representative RNSS receiver. The simulated signal comprised the superposition of ten RNSS signals “in view” of the receiver at a typical mix of receive level at the surface of the Earth.

Potential conclusions on the statistical impact, especially under dynamic operational conditions, need to take into account the statistics of potential occurrence of these cases. Further considerations will have to take into account the number and geographical spread of potential operations by radio amateurs and estimate its occurrence over time.

This test plan and consecutive measurement report covering the above interference case are attached as Annex 2 – Measurements realized in Germany and Annex 5 – Contribution from Germany to this Report. [Consequently, certain of the radio amateur emissions will have negative impact on the different RNSS receivers, depending on the centre frequency of the amateur emission, of the RNSS system considered, and of the type of RNSS receiver considered within this system.]

{Editor’s note: The above paragraph should be reflected elsewhere in this document.}

12 Summary

12.1 Interference Areas

Simulations indicate areas around radio amateur stations which show the potential for harmful interference into RNSS receivers, depending on the case (see Annexes 1, 3, 5, 7).

12.2 Amateur applications/transmitter modes causing interference

Evidence of reported and managed inference provided by one Administration highlighted the application ATV relays as the cause of the reported events. Related measurements (Annex 2 – Measurements realized in Germany and Annex 5 – Contribution from Germany) provided further substance to this matter, concluding that ATV emissions with higher bandwidths in part of the band, namely 1 272.00-1 292.994 MHz, were interfering with the RNSS receivers under certain conditions.

Further evidence of interference has also been observed in a second Administration. This related interference is better described in Annex 6 – Reported Interference (Italy), and shows that also narrow band amateur emissions (FM) can cause interference. It was identified that an FM modulated signal transmitted by an Amateur Radio Repeater was used. The emission was observed to last about 15 seconds, and repeating regularly every 2/3 minutes causing a degradation of more than 20 dB to the Galileo E6 receivers located at the JRC Ispra site.

12.3 Evaluation of device deployment throughout the Regions

12.3.1 RNSS Receivers

- Specific monitoring receivers.
- Ubiquitously deployed RNSS receivers (as part of other devices e.g., cars or phones but also as standalone navigation and other implementations).

12.3.2 Amateur transmitters

{Editor’s note: Noting section 6.6, additional consideration in the studies should be given to the operational characteristics of the various amateur applications, in particular elements such as activity factor.}

Amateur transmitters, analogue and digital, are generally covered under a national licensing scheme for given locations and characteristics. The national frequency allocation tables and relevant national regulations provide the necessary information.

{Editor's note: For an adequate later conclusion it is not necessary to consider the deployment of all possible transmitters of the amateur radio service – Only the result reflected under section 9.2 should be taken into account.}

12.4 Technical and operational measures possibly employed to ensure the protection of RNSS receivers

As per Resolution 774 (WRC-19), the scope of this study is to identify possible technical and operational measures to ensure the protection of RNSS (space-to-Earth) receivers from the amateur and amateur-satellite services within the frequency band 1 240-1 300 MHz, without considering the removal of the Amateur and Amateur-Satellite Service allocations. This section examines the technical and operational measures secondary service users may employ to prevent harmful interference from amateur and amateur-satellite services into RNSS receivers., Results might be used within the ITU-R to recommend a guidance for Administrations on how to deal with the issue on a national level.

ITU-R is developing a Recommendation, which intends to provide guidelines for the use of the frequency band 1 240-1 300 MHz by stations of the amateur and amateur-satellite services, in order to encourage the use of specific sub-bands with sufficient frequency offsets from RNSS signals to enhance the protection of RNSS receivers in the bands under consideration.

ANNEXES

Annex 1 – Simulations (France)

Annex 2 – Measurements realized in Germany

Annex 3 – China contribution

Annex 4 – Measurement Campaign (JRC)

Annex 5 – Contribution from Germany

Annex 6 – Reported Interference (Italy)

Annex 7 – Russian Federation Study