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| **Radiocommunication Study Groups** |  |
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| Source: Document 5A/TEMP/176 | **Annex 10 to Document 5A/491-E** |
| **26 November 2021** |
| **English only** |
| Annex 10 to Working Party 5A Chairman’s Report | |
| Preliminary Draft New Report ITU-R M.[AMATEUR.CHARACTERISTICS] | |
| **[Existing proposal] Amateur and amateur-satellite services characteristics and usage in the 1 240-1 300 MHz frequency band**  **[New proposal] service characteristics, 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** | |

*24/11/2021 Editor's note: One administration expressed its reservations about the structure and purpose of this document.*

# 1 Introduction

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

The frequency band 1 240-1 300 MHz is also allocated worldwide to the Radionavigation-Satellite Service (RNSS) in the space-to-Earth direction on a primary basis. Many RNSS systems are operational and various types of RNSS receivers are being in use. Report ITU-R M.2458 summarizes the RNSS applications in this frequency band.

Some cases of harmful interference to RNSS (space-to-Earth) receivers from emissions by stations in the amateur service have been observed. Furthermore, the number of interference cases may increase unless proper guidelines to protect RNSS (space-to-Earth) from the amateur and amateur-satellite services are implemented. Thus, this potential interference issue need to be studied.

In this regard, Resolution **774 (WRC-19)** invites ITU-R to study possible technical and operational measures to ensure the protection of RNSS (space-to-Earth) receivers from the amateur and amateur-satellite services in the frequency band 1 240-1 300 MHz, without considering the removal of these amateur and amateur-satellite service allocations.

TABLE OF CONTENTS

***Page***

[1 Introduction 1](#_Toc89080437)

[2 Abbreviations and definitions 4](#_Toc89080438)

[3 Relevant publications (ITU Recommendations and Reports and others) 5](#_Toc89080439)

[4 Amateur and amateur-satellite service band plans in the   
1 240‑1 300 MHz frequency band 6](#_Toc89080440)

[5 Applications and typical operational characteristics of the amateur and amateur-satellite services operating in the frequency band 1 240‑1 300 MHz 7](#_Toc89080441)

[5.1 Amateur and amateur-satellite applications and station categories 7](#_Toc89080442)

[5.2 Typical amateur station antenna characteristics in the 1 240‑1 300 MHz band 10](#_Toc89080443)

[5.3 Typical amateur station power level distribution in the 1 240‑1 300 MHz band 11](#_Toc89080444)

[5.4 Representative antenna heights 12](#_Toc89080445)

[5.5 Amateur station 1 240-1 300 MHz band usage patterns 12](#_Toc89080446)

[5.6 Activity factors of amateur transmitting stations in the 1 240‑1 300 MHz band 13](#_Toc89080447)

[5.7 User density of amateur transmitting stations in the 1 240-1 300 MHz band 14](#_Toc89080448)

[5.8 Table of transmitter characteristics and parameters [extracted from   
Recommendation ITU-R M.1732] 14](#_Toc89080449)

[5.9 Band plan(s) 15](#_Toc89080450)

[5.9.1 IARU-R1 band plan for the frequency band 1 240-1 300 MHz 16](#_Toc89080451)

[6 Relationship between RNSS system frequencies in 1 240-1 300 MHz and   
amateur service application band plans 18](#_Toc89080452)

[7 RNSS Characteristics 19](#_Toc89080454)

[7.1 System Description 19](#_Toc89080455)

[7.2 Characterization of the RNSS receivers 19](#_Toc89080456)

[7.2.1 Table of technical characteristics and protection criteria for RNSS   
(space-to-Earth) receivers 19](#_Toc89080457)

[7.2.2 Statistical distribution of receivers 19](#_Toc89080458)

[7.3 Calculation of actual interference levels 20](#_Toc89080459)

[8 Reported Interference cases and subsequent measurements of the impact of amateur   
and amateur-satellite services on RNSS (space-to-Earth) receivers in the frequency  
band 1 240-1 300 MHz 20](#_Toc89080460)

[8.1 Determination of sources of possible interference 20](#_Toc89080461)

[8.2 Reported interference and measurement campaign 21](#_Toc89080462)

[8.2.1 Reported interferences 21](#_Toc89080463)

[8.2.1.1 Interference event 1 21](#_Toc89080464)

[8.2.2 Interference event 2 22](#_Toc89080466)

[8.2.2.1 Measurement campaign with Reference RNSS Receivers 23](#_Toc89080467)

[9 Simulations on the impact of amateur and amateur-satellite services on RNSS   
(space-to-Earth) receivers in the frequency band 1 240-1 300 MHz 24](#_Toc89080468)

[9.1 Propagation model 24](#_Toc89080469)

[9.2 Methodology 24](#_Toc89080470)

[9.2.1 Calculation of the interference exceedance level 25](#_Toc89080471)

[9.2.1.1 Computation of the gain of the amateur antenna station 25](#_Toc89080472)

[9.2.1.2 Computation of the transmission losses 25](#_Toc89080473)

[9.3 Analysis for geographical extent of interference 27](#_Toc89080474)

[9.3.1 Study 1 27](#_Toc89080475)

[9.3.2 Study 2 27](#_Toc89080476)

[10 Results of studies 28](#_Toc89080477)

[10.1 Separation Distance 28](#_Toc89080478)

[10.2 Amateur applications/transmitter modes causing interference 28](#_Toc89080479)

[10.3 Evaluation of device deployment throughout the Regions 28](#_Toc89080480)

[10.3.1 RNSS Receivers 28](#_Toc89080481)

[10.3.2 [relevant] Amateur transmitters 28](#_Toc89080482)

[10.4 [One set of measurements][Actual measurements of interference thresholds] 29](#_Toc89080483)

[11 Technical and operational measures possibly employed to ensure the protection   
of RNSS receivers 29](#_Toc89080484)

[Annexes 29](#_Toc89080485)

# 2 Abbreviations and definitions

|  |  |
| --- | --- |
| AFSK | Audio Frequency Shift Keying |
| AMSAT | International Amateur Satellite Organisation(s) |
| BNetzA | Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway |
| C4FM | Proprietary standard for digital voice and data communication ([YAESU](http://www.yaesu.com/indexVS.cfm?cmd=DisplayProducts&ProdCatID=249&encProdID=8B1A771611E9963B6AB769C0EC0F6B68&DivisionID=65&isArchived=0)) |
| CEPT | Conference Européenne des Administration 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](http://www.dlr-gfr.de) ) |
| DMR | Digital Mobile Radio ([ETSI Standard](http://www.etsi.org/website/document/technologies/leaflets/digitalmobilradio.pdf)) |
| D-Star | Digital Smart Technology for Amateur Radio (Proprietary standard for digital voice and data communication ([ICOM](http://www.icomeurope.com/files/HAM_D-STAR_Europe_BRO_E_20150526.pdf))) |
| e.i.r.p. | Effective isotropic radiated power |
| FM ATV | Analogue (FM) Amateur TV |
| FSK | Frequency Shift Keying |
| IARU | [International Amateur Radio Union](http://www.iaru.org/regions.html) |
| [ICD](https://www.gsc-europa.eu/electronic-library/programme-reference-documents" \l "Galileo%20pub) | Open Service Interface Control Document [Issue 1.3](https://www.gsc-europa.eu/system/files/galileo_documents/Galileo-OS-SIS-ICD.pdf) 12/2016 (EU Galileo) |
| [ISTA](https://www.unibw.de/lrt9) | 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](http://rsgb.org/main/get-started-in-amateur-radio/operating-your-new-station/psk31-work-the-world-with-low-power/) | 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](http://www.physics.princeton.edu/pulsar/K1JT/wsjt.html) | Weak Signal Propagation Reporter |
| [WSJT-X](https://physics.princeton.edu/pulsar/k1jt/wsjtx.html) | Weak signal narrow-band data communication (Joe Taylor, K1JT) |

*{Editor’s note: Table to be updated at a later stage}*

# 3 Relevant publications (ITU Recommendations and Reports and others)

Recommendation ITU-R [M.1732](https://www.itu.int/rec/R-REC-M.1732/en) – Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies

Recommendation ITU-R [M.1787](https://www.itu.int/rec/R-REC-M.1787/en) – 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](https://www.itu.int/rec/R-REC-M.2030/en) – 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](https://www.itu.int/pub/R-REP-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](https://www.itu.int/pub/R-QUE-SG04.288) – 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](https://www.itu.int/pub/R-QUE-SG05.48) – 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](https://www.itu.int/pub/R-HDB-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](https://www.itu.int/rec/R-REC-S.465/en) – 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](https://www.itu.int/pub/R-REP-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](https://www.itu.int/pub/R-REP-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](https://www.itu.int/pub/R-REP-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](https://www.itu.int/rec/R-REC-M.1902/en) – 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](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1904-1-201909-I!!PDF-E.pdf) [add hyperlink]- 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 1 559-1 610 MHz

Report ITU-R [M.2220](https://www.itu.int/pub/R-REP-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 ground‑based receivers operating in those frequency bands

Recommendation ITU-R [P.1546](https://www.itu.int/rec/R-REC-P.1546/en)-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 Amateur and amateur-satellite service band plans in the 1 240‑1 300 MHz frequency band

{Editor’s Note: Considering that in the report of WP5A the chapter of the amateur and amateur-satellite service is more developed it is proposee by France to keep just the WP5A chapter and to do not add also the WP4C chapter about amateur characteristics. Chapter 2 of the WP5A is proposed to be kept and Chapter 7 of the WP4C to be removed because it is redundant and contains the same information is a summary manner.}

Before going into the details of the individual amateur and amateur-satellite services applications in the 1 240-1 300 MHz frequency band it is necessary to understand the general way in which amateur and amateur-satellite services activities are organised to maximise usage of the various frequency bands and minimise interference between incompatible amateur service applications. This is achieved through the use of band plans which recommend where particular applications are used within each amateur and amateur-satellite service allocations. The International Amateur Radio Union (IARU) develops such band plans on behalf of all amateur services.

[The IARU coordinates and represents the interests of radio amateurs through its national member-associations. Three IARU regional organizations correspond to the ITU Radio Regions and are recognized as representing the amateur and amateur-satellite services by the regional telecommunications organizations.] [*20210429 Ed: Keep for now*]

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 Table 1.

The usage of the frequency range by the amateur and amateur-satellite services is driven by the varied operational and experimental interests of the users themselves. To support this, each regional band plan is developed to maintain order, avoid conflict and interference between amateur service applications, provide understanding of the most suitable frequencies for specific activities and form a basis for intra and inter-service coordination when required.

The band plans are not mandatory in regional regulations but are strongly recommended for adoption and in general are followed by the individual national societies. In some cases, the regional IARU band plan may be adopted to some extent in national regulations, and it may need to be adjusted on a national basis to facilitate national coordination and sharing with other services in the band.

Respecting the band plan is common practice in the amateur service and is necessary to facilitate successful radio contacts especially between countries and for inter-regional communications.

The band plan is reviewed periodically and may be adjusted to reflect new technologies and evolving applications in the amateur services. External influences driven by the requirements to share with other services can also be taken into account. The regional band plans are maintained, published and approved by the IARU regional bodies.

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.

Furthermore, 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.

Table 1

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 data modes up to 3 kHz. | Focused on narrowband weak 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. |

# 5 Applications and typical operational characteristics of the amateur and amateur-satellite services operating in the frequency band 1 240‑1 300 MHz

## 5.1 Amateur and amateur-satellite applications and station categories

The detailed list of amateur and the amateur-satellite services applications in the band 1 240‑1 300 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. Tables 2 and 3 provide a matrix of the amateur and amateur-satellite applications versus station categories:

Table 2

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]](#footnote-1) operation (incl. EME). |
| Machine Generated Modes e.g. RTTY, SSTV[[2]](#footnote-2), PSK31[[3]](#footnote-3), WSJT[[4]](#footnote-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]](#footnote-5), Digital Data 128 kbit/s | Yes | Yes (Mobile) | Yes |  | 12.5 to 150 kHz  Mode dependent | Local neighbourhood communication links. |

Table 3

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 DVB-S/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 little as 500 kHz.

## 5.2 Typical amateur station antenna characteristics in the 1 240‑1 300 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 EME[[6]](#footnote-6) 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 4 contains the antenna details:

Table 4

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)  Dish antenna (for EME) | 21 dBi  32 dBi (4 m diameter) | 10°  4° |

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 topography[[7]](#footnote-7). Table 5 summarizes antenna characteristics with indications of minimum, median and maximum parameter values of a typical installation.

Table 5

Antenna characteristic of a typical permanent installation

|  |  |  |
| --- | --- | --- |
| Antenna types | Gain[[8]](#footnote-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.

## 5.3 Typical amateur station power level distribution in the 1 240‑1 300 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 6

Transmitter power ranges in use

|  |  |  |
| --- | --- | --- |
| Transmitter power  (watts) | % 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% |

{France comment: It would be necessary to specify in Table 6 what transmitter power corresponds to what type of signal (narrowband, wideband). These specifications would be useful for the simulations scenarios to be considered by WP 4C 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 ERP. Table 7 summarises information on stations in current use extracted from published information from a number of countries:

Table 7

Transmitter radiated power ranges in use

| ERP  (watts) | % propagation beacons | % repeaters |
| --- | --- | --- |
| Up to 10 | 69% | 16% |
| 11 – 25 | 8% | 76% |
| 26 – 100 | 20% | 8% |
| 101 – 300 | 1% | 0% |
| Over 300 | 1% | 0% |

According to the information in Table 7, no repeater is currently in use with an ERP 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 W[[9]](#footnote-9) ERP, 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.

## 5.4 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.

## 5.5 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 8 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 results[[10]](#footnote-10) can be consulted to determine the number of transmitting stations that were active during any one activity or contest period.

Table 8

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 9.

Table 9

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. |
| 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. |

## 5.6 Activity factors of amateur transmitting stations in the 1 240‑1 300 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.

## 5.7 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 8.

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.

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

TABLE 10

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 emission (emission designator) | 150HA1A 150HJ2A 60H0J2B 250HF1B | 2K70J3E 11K0F3E 16K0F3E 20K0F3E | 2K70G1D 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. | | | |

TABLE 11

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.  *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 12

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 (emission designator) (2) | 2K70J3E, 2K70J2E, 16K0F3E, 44K2F1D, 88K3F1D, 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. | |

## 5.9 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. (From Document [5A/276](https://www.itu.int/md/R19-WP5A-C-0276/en))

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. (From Document 5A/276)

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

TABLE 13

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 data modes up to 3 kHz. | Focused on narrowband weak 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.

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

Table XX provides the IARU Region 1 recommended usage of the allocations ([Band Plan](https://www.iaru-r1.org/index.php/spectrum-and-band-plans/uhf/23-centimeter)) by operators in the Amateur and Amateur-Satellite Services. National versions of this band plan may slightly differ due to national frequency allocations.

Table 14

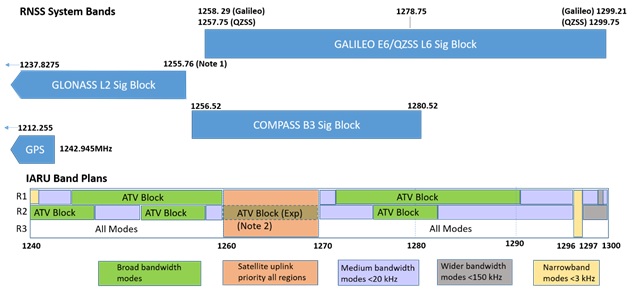
IARU Region 1 UHF Band plan for 1 240-1 300 MHz (Varna, 2014)

| Frequency (MHz) | Maximum Bandwidth | Mode | Usage |
| --- | --- | --- | --- |
| 1240.000  1240.500 | 2700 Hz | All modes | Reserved for future |
| 1240.500  1240.750 | 500 Hz | Telegraphy and MGM | Beacons (reserved for future) |
| 1240.750  1241.000 | 20 kHz | FM Digital Voice | Reserved for the future |
| 1241.000  1243.250 | 20 kHz | All Mode | 1242.025-1242.250 repeater output (RS1-10)  1242.275-1242.700 repeater output (RS11-28)  1242.725-1243.250 Digital communications (RS29-50) |
| 1243.250  1260.000 | \* | ATV/Digital ATV | 1258.150-1259.350 repeater output |
| 1260.000  1270.000 | \* | Satellite Service |  |
| 1270.000  1272.000 | 20 kHz | All mode | 1270.025-1270.700 repeater output (RS1-28)  1270.725-1271.250 Digital communications (RS29-50) |
| 1272.000  1290.994 | \* | ATV/Digital ATV |  |
| 1290.994  1291.481 | 20 kHz | FM digital voice  repeater input | RM1 (1291.000) – RM19 (1291.475) 25 kHz spacing |
| 1291.494  1296.000 | \* | All modes | 1293.150-1294.350 repeater input (R20-R68) |
| 1296.000  1296.150 | 500 Hz | Telegraphy MGM | 1296.000-1296.025 moon bounce  1296.128 PSK21 centre of activity |
| 1296.150  1296.800 | 2700 Hz | Telegraphy SSB MGM | 1296.200 narrowband centre of activity  1296.400.1296.600 linear transponder input  1296.500 fax  1296.600 narrowband centre of activity (MGM, RTTY)  1296.600-1296.700 linear transponder input  1296.750-1296.600 local beacons |
| 1296.800  1296.994 | 500 Hz | Telegraphy MGM | beacons exclusive |
| 1296.994  1297.481 | 20 kHz | FM digital voice  repeater output | RM0 /1297.000) – RM19 (1297.475) 25 kHz spacing |
| 1297.494  1297.981 | 20 kHz | FM digital voice | 1297.500 SM20  1297.500 centre of FM activity  1297.725 digital voice calling frequency  1297.900-1297.975 Simplex FM internet gateways  1297.975 SM39 |
| 1298.000  1299.000 | 20 kHz | All modes | General mixed analogue or digital use 25 kHz spacing  1298.025 RS1  1298.975 RS39 |
| 1299.000  1299.750 | 150 MHz | All modes | Arranged as 5x 150 kHz channels for high speed DD use  Centres : 1299.075, 1299.225, 1299.375, 1299.525, 1299.675 (+/- 75 kHz) |
| 1299.750  1300.000 | 20 kHz | All modes | 8x 25 kHz channels (available for FM/DV use)  Centres : 1299.775-1299.975 |
| \* Bandwidth limits according to national regulations | | | |

# 6 Relationship between RNSS system frequencies in 1 240-1 300 MHz and amateur service application 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.

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 above). 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 section 4 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.

# 7 RNSS Characteristics

## 7.1 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 and the Japanese QZSS 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.

## 7.2 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 draft revision of Recommendation ITU-R M.1902-1][Recommendation ITU-R M.1902-2].

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).

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

[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, in case that interfering equipment employ pulsed emissions, Recommendation ITU-R M.2030 and Report ITU-R M.2220 may be taken into account.]

### 7.2.2 Statistical distribution of receivers

RNSS receivers are deployed on a worldwide and ubiquitous basis.

## 7.3 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 ITU‑R 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.

# 8 Reported Interference cases and subsequent measurements of the impact of amateur and amateur-satellite services on RNSS (space-to-Earth) receivers in the frequency band 1 240-1 300 MHz

*Editor’s Note: It was necessary to have information available on interference levels arising from the amateur services, which would degrade the RNSS receiver performance. This was facilitated, also with the assistance from WP 5A, by information provided from administrations experiencing the interferences, including the characteristics of such emissions.*

*It was worth considering, for the later studies on possible scenarios, whether those interferences are caused either by continuous or pulse and/or burst emissions. Such emissions could be categorized in alignment with information from Recommendation ITU-R M.1732 providing characteristics of the currently used equipment of the radio amateur service in the band 1 240‑1 300 MHz.*

*Furthermore, other sources of emissions in the band 1 240‑1 300 MHz, namely the primary Earth Exploration-Satellite Service (active) and the Radiolocation Service (RLS), but also the Fixed Service (FS), the Mobile service (MS) and the Radionavigation Service (RNS) due to the additional allocations via Nos* ***5.330*** *and* ***5.331*** *were considered. This assessment further limited the scope of the considerations towards a better understanding, which applications or modes of the amateur equipment are likely to be interfering with the RNSS receivers.*

## 8.1 Determination of sources of possible interference

[Noting the IARU band plan as introduced in Table XX in section 7.9.1 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 radioamateur service can be noted.This difference may lower the impact of amateur emissions on RNSS receivers, as it can be generalised that the level of interference decreases with the frequency separation between the radio amateur emissions and the relevant RNSS centre frequency.This impact will obviously also depend on the RNSS receiver bandwidth. Some RNSS receivers use very large bandwidth, up to 40 MHz to provide better performances.

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.

One of the most prominent measures for improving the coexistence situation between RNSS-services and the radio amateur services is the spectral separation between those signals.

Annex 5 takes the most relevant results from the German measurements and provides a brief look on their meaning from a frequency planning point of view under consideration of the current DRR of Recommendation ITU-R M.1902-1

]



*USA Comment: The text above is not agreed, and is misleading. If it is not deleted, it has to be put into square brackets as shown. The 1 dB degradation C/N0 is not allocated to one source of interference, but is the aggregate from all sources. The analysis here is flawed in that there could be any number of amateur stations, operating different amateur applications as per the table, each causing at least 1 dB degradation, and that doesn’t work. Also, the center frequency observation is misleading, as GNSS receivers use their entire bandwidth, and thus need protection from band edge to band edge to avoid performance penalties.*

USA Comment: The contents of this section belong in the summary of results section above for Study 1. It is premature to generalize any “conclusions” at this point, based on one study – especially when there is a second study that appears not to have been included in these results. The U.S. proposes either that this section be integrated into Section 11.1.10 or placed into square brackets pending further analysis.

## 8.2 Reported interference and measurement campaign

## 8.2.1 Reported interferences

Evidence of reported 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.

### 8.2.1.1 Interference event 1

{Comment from Germany: In this section an overview should be created, to prove free of doubt, sources of possible interferences to the relevant RNSS receivers. This measure will significantly reduce the necessary study work supporting WRC-19 AI 9.1 topic b) and also help with the further considerations.}

USA Comment: Are the interference situations planned for Section 12.2 different from the interference scenarios planned for Section 10 above? If so, how and why are they different?

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 1 260‑1 300 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.

## 8.2.1.1.1 Measurement campaign with a 30 MHz bandwidth RNSS Receiver

Therefore, 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 and 5 to this Report.

Geodetic receiver

– approximately 30 MHz Rx bandwidth;

– interferer signal inserted at antenna input port (live signals from various amateur radio stations in different applications);

– measurements done at 1 278.75 MHz and with frequency offset as low as possible, while sticking to the IARU band plan (offsets depends on application);

– mapping of receiver input levels to the input of a 0 dBi Antenna with noise figure 2 dB (representative value for high grade geodetic antennas);

– several levels of degradation measured (parameter of interest: *C*/*N*0) (−1 dBHz; −1.5 dBHz; −5 dBHz) as function of interfering signal power;

– interference model can be extrapolated to different *C/N*0 by modelling equation (Q‑factor); validity of equation proven for all measurement scenarios;

– results independent of uninterfered *C/N*0 (uninterfered *C/N*0 chosen to be 45 dBHz);

– all measurements via wired connections.

{Editor’s note: This evidence(s) and the related measurements should provide the basis for further consideration instead of a generalized approach towards all types of amateur transmitters.}

## 8.2.2 Interference event 2

Further evidence of interference have 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 4, 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 1297.3 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 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/N0 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 21st 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 11.3] and within annex 4.

## 8.2.2.1 Measurement campaign with Reference RNSS Receivers

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, 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 E6-B C/N0, 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 ITU-R M.1902 (40.92 MHz receiver bandwidth) and therefore should be taken as a reference in the context of this compatibility assessment.

Figure 2

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

|  |  |
| --- | --- |
| D:\matlab-work\e6_compatibility\myMat_CN0_drops\fig\5.png | D:\matlab-work\e6_compatibility\myMat_CN0_drops\fig\6.png |

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/N0 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, 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 1280 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 provides a comprehensive overview of the testing setup, assumptions, KPIs and results for the different receivers under and for all the scenarios considered.

# 9 Simulations on the impact of amateur and amateur-satellite services on RNSS (space-to-Earth) receivers in the frequency band 1 240-1 300 MHz

Values and characteristics in these studies were selected from those provided in Section 2.

### 9.1 Propagation model

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 field‑strength 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.

{Editor’s Note: Working parties 3K and 3M that have been identified as contributing groups with respect to the application of propagations models for compatibility studies relevant to Resolution **774 (WRC-19)** have sent a replay liaison statement to working party 4C that advised the usage of Recommendation ITU-R P.1546 for applicability to interference prediction studies.

### 9.2 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.

## 9.2.1 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);

*Lb*: transmission losses calculated using Recommendation ITU-R P.1546 (dB);

: polarization loss (dB);

: bandwidth specified depending on the type of signal (BW=100 kHz for narrowband signals, BW=1 MHz for broadband signals).

In this setting, an IEL value less than -134.5 dBW (for narrowband signals) and less than -140 dBW (for broadband signals) implies compliance with the respective recommended ITU-R limit of interference specified in Recommendation ITU-R M.1902.

### 9.2.1.1 Computation of the gain of the amateur antenna station

Following the procedures set forth in Recommendation ITU-R F.1336-v5, 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, θ3, *G*0 and *k* are defined and expressed in *recommends* 2.1 of Recommendation ITU-R F. 1336-v5. 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-v5.

### 9.2.1.2 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:

*Lb*: basic transmission loss (dB)

*E*: field strength (dB(μV/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 12m for Home station 1, 3m for Home station 2 and 25m for the Permanent installation);

h2 [m]: receiving antenna height above the ground (for the studies the height above the ground of the RNSS receiver it was considered 1.5m);

R2 [m]: representative clutter height above ground (for the studies 0m or 10m);

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 (*Lb*) from equation (1) can be determined using equation (3) and Annex 5 of Recommendation ITU-R P.1546.

#### 9.2.1.2.1 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.

#### 9.2.1.2.2 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 ITU-R 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 50x50 m wide. Assume that the maximum tolerable interfering power for the RNSS receiver is . 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 . For instance, when its value is exactly equal 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 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 50x50 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 50x50 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.

## 9.3 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.

### 9.3.1 Study 1

In Annex 1 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 would exceed the protection criterion of the Galileo E6 receiver.

### 9.3.2 Study 2

An initial simulation-based study were conducted to assess the geographical extent of interference caused by emissions from ATV 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, and the typical parameters of which are given in Table 15 and Figure 3 below.

TABLE 15

ATV repeater station parameters

|  |  |
| --- | --- |
| Parameters | Value |
| Antenna | 13 dBi gain, 60° 3dB beamwidth |
| TX power | 1 W |
| Antenna height above ground | 25 meters |
| Polarization | Vertical |

Figure 3

Antenna diagram, ATV repeater station

Chart, diagram

Description automatically generatedChart, line chart

Description automatically generated

The parameters of COMPASS B3 general purpose receivers are given in the Table 1 of section 6.2.1 in this Report.

The simulations indicate interference areas around an ATV station with an extent of several km, depending on the case.

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

# 10 Results of studies

## 10.1 Separation Distance

Simulations indicate interference areas around radio amateur stations with an extent of [XXX] km, depending on the case.

## 10.2 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 (see Annex X and Y) 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.

Some simulations using parameters for home stations indicate interference areas around radio amateur stations with an extent of several km, depending on the case.

## 10.3 Evaluation of device deployment throughout the Regions

### 10.3.1 RNSS Receivers

– Specific monitoring receivers.

– Ubiquitously deployed RNSS receivers, as part of other devices i.e. cars or phones but also as standalone navigation implementation.

### 10.3.2 [relevant] Amateur transmitters

Amateur transmitters, analogue and digital, are generally falling 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.}

*USA Comment: If this section (Section 14) is to be about device deployment, there should be no need for Section 14.4 or its subsections. In fact, how is deployment in this section different from what is mentioned at the top of the document? Perhaps this entire section should be deleted or relocated earlier in the document – when parameters are introduced.*

## 10.4 [One set of measurements][Actual measurements of interference thresholds]

Actual measurement results have been made available of interference thresholds on a single geodetic Galileo E6‑B/C RNSS receiver, as a function of different amateur radio transmission modes. It appears that, apart from analogue amateur television (ATV) (in a bandwidth of 10 MHz), there is a significant margin (greater than 30 dB) between the power at the antenna input required to degrade the carrier-to-noise density, *C/N*0, at the output of the tracking loop for every single satellite’s signal by 1 dB, as compared to the threshold value [*20210430 Ed: Need more details about frequency separation*]. This set of measurements suggests that while wideband analogue TV transmissions may be a problematic source of interference for the Galileo RNSS receivers considered, narrowband transmissions may be less likely to cause interference and may enable coexistence with RNSS systems. Whether these results are more generally applicable to other RNSS systems, needs be to confirmed with further studies.

]

# 11 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 identifypossible 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, and related results might be used to recommend a guidance for Administrations how to deal with the issue on a national level.

{Editor’s note: Most likely there is no need for measures for all of the introduced scenarios, since the applications/modes used will probably define the possible interference and not a single scenario see also section 13.}

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)











1. See the [ITU Amateur and amateur-satellite](https://www.itu.int/pub/R-HDB-52-2014) handbook for further details of radiosport activities. [↑](#footnote-ref-1)
2. Slow Scan Television (SSTV) is an imaging protocol which us 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. [↑](#footnote-ref-2)
3. See Recommendation [ITU-R M.2034-0](http://www.itu.int/rec/R-REC-M.2034/en) which establishes a telegraphic alphabet and transmission protocols for phase shift keying at 31 baud (PSK31) in the amateur and amateur-satellite services. [↑](#footnote-ref-3)
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. [↑](#footnote-ref-4)
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. [↑](#footnote-ref-5)
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. [↑](#footnote-ref-6)
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. [↑](#footnote-ref-7)
8. Feeder loss not included which may be up to 3 dB. [↑](#footnote-ref-8)
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 ERP of more than 100 W. [↑](#footnote-ref-9)
10. The analysed results were published by the national radio amateur societies in several European countries. [↑](#footnote-ref-10)