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| **Radiocommunication Study Groups** |  |
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| **22 May 2023** |
| **English only** |
| Annex 5 to Working Party 5A Chairman’s Report  |
| PRELIMINARY DRAFT NEW REPORT ITU-R M.[AMATEUR.CHARACTERISTICS] |
| Amateur and amateur-satellite services characteristics and usage in the 1 240-1 300 MHz frequency band |

# 1 Introduction

The frequency band 1 240-1 300 MHz is allocated worldwide to the amateur service on a secondary basis and is 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 and space-to-space direction on a primary basis. Many RNSS systems are operational, and various types of RNSS receivers are being used. Report ITU-R M.2458 summarizes the RNSS applications in this frequency band and Recommendation ITU-R M.1902 gives the technical characteristics and protection criteria of the RNSS (space-to-Earth) receivers in the frequency band 1 240-1 300 MHz.

The number of RNSS receivers in the frequency band will increase significantly with the ubiquitous deployment of receivers used in many applications.

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.

This report responds to *resolves* 1 of Resolution **774 (WRC-19**) to perform a detailed review of the different systems and applications used in the amateur service and amateur-satellite service allocations in the frequency band 1 240-1 300 MHz.

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# 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#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) |
| RNSS | Radio Navigation-Satellite Service |
| 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) |

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

Recommendation [ITU-R M.1732-3](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.2034-0](http://www.itu.int/rec/R-REC-M.2034/en) - Telegraphic alphabet for data communication by phase shift keying at 31 baud in the amateur and amateur-satellite services.

Report [ITU-R M.2458-0](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 [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

# 4 Amateur and amateur-satellite service band plans in the 1 240‑1 300 MHz frequency band

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[[1]](#footnote-1) (IARU) develops such band plans on behalf of all amateur services.

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 Hz.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[[2]](#footnote-2) operation (incl. EME). |
| Machine Generated Modes e.g. RTTY, SSTV[[3]](#footnote-3), PSK31[[4]](#footnote-4), WSJT[[5]](#footnote-5)  | Yes | Yes |  | Yes | 6 to 2 700 HzMode dependent | Local and long distance tropospheric weak signal communications. (incl. EME). Imaging |
| Data e.g. AFSK 1k2, FSK 9k6, D‑STAR[[6]](#footnote-6), Digital Data 128 kbit/s | Yes | Yes (Mobile) | Yes |  | 12.5 to 150 kHzMode 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[[7]](#footnote-7) 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 dBi32 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[[8]](#footnote-8). 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[[9]](#footnote-9) | Beamwidth in the azimuth plane. |
| Various (e.g. linear slot, co-linear array, horn, flat panel etc.) | Minimum = 2.15 dBiMedian = 13 dBiMaximum: 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% |

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[[10]](#footnote-10) 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[[11]](#footnote-11) 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(in the 1 296-1 297 MHz portion) | 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(in the 1 296-1 297 MHz portion) | 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 (in any portion identified for ATV applications) | 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. |

The figures presented in Table 8 can be used to estimate the amount of time over a one year period when certain parts of the band (depending on the activity) are at their busiest with the highest number of actively transmitting amateur stations. For those activities concentrated in the 1 296-1 297 MHz portion of the band and assuming the moon is visible for 24 hours (an over estimation) then the following can be deduced:

Total narrowband ‘busy hour’ activity period = 108 hours (1.2% of a year).

Total EME ‘busy hour’ activity period = 120 hours (1.4% of a year).

For the wideband activities taking place in the identified parts of the band plan, the following can be deduced:

Total wideband ‘busy hour’ activity period = 120 hours (1.4% of a year).

Table 8 also shows that the number of active stations involved in the EME and wideband activities is considerably lower than those active in the narrow band activities.

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.

In addition, it is noted that there is a tendency for more stations to be active in areas of higher population density. Therefore, a range of density values may be considered appropriate to more accurately reflect the pattern of activity across a country. Based on a more detailed analysis the following active station density can be observed:

3) Home station and temporary “portable” station

– For narrow-band activity periods the maximum density of transmitting stations can range from 0.00006 to 0.0016 stations/km2.

**[**

*20230511 Ed: this section (5.8) is related to the Annex and its inclusion depends upon the result of discussion by WP 4C.*

## 5.8 Impact of Amateur Station Emissions

Using the parameters and operational data in the sections above, simulations have been carried out to assess the impact of certain amateur station emissions on a deployment simulation of a large number of one type of co-frequency RNSS (space-to-Earth) receivers. These are detailed in Annex 1.

**]**

## 5.9 Table of transmitter characteristics and parameters (extracted from Recommendation [ITU-R M.1732](https://www.itu.int/rec/R-REC-M.1732/en))

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) | 150HA1A150HJ2A60H0J2B250HF1B | 2K70J3E11K0F3E16K0F3E20K0F3E | 2K70G1D6K00F7D16K0D1D150KF1W2M50G7W |
| 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. |

## 5.10 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 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. |

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

Table 14 provides the IARU Region 1 recommended usage of the allocations 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 |
| --- | --- | --- | --- |
| 1 240.0001 240.500 | 2 700 Hz | All modes | Reserved for future |
| 1 240.5001 240.750 | 500 Hz | Telegraphy and MGM | Beacons (reserved for future) |
| 1 240.7501 241.000 | 20 kHz | FM Digital Voice | Reserved for the future |
| 1 241.0001 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)  |
| 1 243.2501 260.000 | \* | ATV/Digital ATV | 1 258.150-1 259.350 repeater output |
| 1 260.0001 270.000 | \* | Satellite Service |  |
| 1 270.0001 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) |
| 1 272.0001 290.994 | \* | ATV/Digital ATV |  |
| 1 290.9941 291.481 | 20 kHz | FM digital voicerepeater input | RM1 (1 291.000) – RM19 (1 291.475) 25 kHz spacing |
| 1 291.4941 296.000 | \* | All modes | 1 293.150-1 294.350 repeater input (R20-R68) |
| 1 296.0001 296.150 | 500 Hz | Telegraphy MGM | 1 296.000-1 296.025 moon bounce1296.128 PSK21 centre of activity |
| 1 296.1501 296.800 | 2 700 Hz | Telegraphy SSB MGM | 1 296.200 narrowband centre of activity1 296.400.1 296.600 linear transponder input1 296.500 fax1 296.600 narrowband centre of activity (MGM, RTTY)1 296.600-1 296.700 linear transponder input1 296.750-1 296.600 local beacons |
| 1 296.8001 296.994 | 500 Hz | Telegraphy MGM | beacons exclusive |
| 1 296.9941 297.481 | 20 kHz | FM digital voicerepeater output | RM0 /1 297.000) – RM19 (1 297.475) 25 kHz spacing |
| 1 297.4941 297.981 | 20 kHz | FM digital voice | 1 297.500 SM201 297.500 centre of FM activity1 297.725 digital voice calling frequency1 297.900-1 297.975 Simplex FM internet gateways1 297.975 SM39 |
| 1 298.0001 299.000 | 20 kHz | All modes | General mixed analogue or digital use 25 kHz spacing1 298.025 RS11 298.975 RS39 |
| 1 299.0001 299.750 | 150 MHz | All modes | Arranged as 5x 150 kHz channels for high-speed DD useCentres: 1 299.075, 1 299.225, 1 299.375, 1 299.525, 1 299.675 (+/- 75 kHz) |
| 1 299.7501 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 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.

# 7 Summary

The amateur and amateur-satellite service characteristics provided in this report have been used in studies 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 which are presented in [Report ITU-R M. 2513-0](https://www.itu.int/pub/R-REP-M/publications.aspx?lang=en&parent=R-REP-M.2513)

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 in a Recommendation that is developed by ITU-R. The Recommendation provides 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 and with amateur applications power limitations to enhance the protection of RNSS receivers in the bands under consideration.

*20230511 Ed: This annex needs to be assessed by WP 4C before inclusion in this report or another report. Notify WP 4C via a liaison statement.*

[

Annex 1

Assessing the impact of certain amateur station emissions on a deployment simulation of a large number of one type of co-frequency
RNSS (space-to-Earth) receivers

# 1 Introduction

This study aims to quantify the extent of interference occurring between a station of the amateur service and a population of RNSS receivers around that station. Simulations assuming the following scenarios have been carried out:

a) Fixed narrow band amateur “Home” station and static RNSS receivers in fixed locations where the number of receivers is based on the population density and an estimated RNSS receiver “ownership” factor.

b) Fixed narrow band amateur “Home” station and mobile RNSS receivers, on board moving cars.

c) Fixed broadband amateur “Home” station (ATV) and mobile RNSS receivers, on board moving cars.

d) Fixed narrow band amateur “Permanent” station (e.g. voice repeater output channel) and mobile RNSS receivers, on board moving cars.

e) Fixed broadband amateur “Permanent” station (e.g. ATV repeater output channel) and mobile RNSS receivers, on board moving cars.

Each simulation calculates the signal level received by the individual RNSS receivers from an amateur station transmitter. The simulation area depends upon the amateur station density and the number of RNSS receivers placed in the area is based on assumptions about the population and ownership factor.

In case a) above the RNSS receivers remain fixed but are re-positioned for each run of the simulation. In the remaining cases b) to e) the mobile RNSS receivers are moved between each set of calculations according to a vehicle speed and trajectory across the simulation area. For each simulation run a new set of vehicle starting positions and speed assignments are made.

The received levels are compared to the protection criteria and if above this level the receiver is labelled ”impacted” so that the statistics of the impacted receivers can be collated to determine the mean percentage of impacted receivers from the simulation population.

# 2 Fixed Home Station and Fixed RNSS Receiver Scenario

In this simulation fixed amateur home stations and fixed RNSS receivers are considered. The number of receivers is based on the population density and an estimated “ownership” factor. RNSS receivers are considered to be in fixed locations and the number of receivers is based on the population density and an estimated RNSS receiver “ownership” factor.

## 2.1 Simulation areas and propagation model parameters

The amateur station densities are the same as those documented in section 5 of the main report.

The amateur station density assumed in all simulations:

• Average Home Station and Portable station density = 1 station / 5 000 km2

• Minimum Home Station and Portable station density = 1 station / 16,700 km2

• Maximum Home Station and Portable station density = 1 station / 625 km2

The simulation area according to each amateur station density:

• Average Home Station and Portable station density = 70 x 70 km

• Minimum Home Station and Portable station density = 130 x 130 km

• Maximum Home Station and Portable station density = 25 x 25 km

The propagation model parameters are:

• Recommendation ITU-R P.1546 Matlab code provided by ITU. Latest update (3rd May 2019) is available from <https://www.itu.int/md/R15-WP3K-C-0289/en>.

• Location variability: 50%

• Required percentage time: 1%

## 2.2 Population Density

The study was based on population data for France, based on National Institute for Statistics (INSEE):

Figure 1

Population density data extract for France



Three different population densities are identified:

1 “Rural”, typically Bourgogne, with a density of 58 inhabitants / km2

2 “Urban”: Paris & direct suburbs (Ile de France), 1022 inhabitants / km2

3 “Average”: France average is 119 inhabitants / km2

## 2.3 Simulation Parameters

The following parameters were assumed for the amateur home station and the RNSS receivers:

• Average, minimum and maximum home station density.

• Simulation area: According to the station density.

• Transmitter frequency: 1 297 MHz

• Transmitter Antenna gain: 18 dBi

• Transmitter power: 150 Watts

• Effective height of the amateur station antenna: 12 meters

• Receiver antenna height: 1.5 meters

• Narrow band receiver max interference threshold: –134.5 dBW

• Receiver antenna gain: –6 dBi, 0 dBi and 3 dBi omnidirectional.

• Polarisation Loss = 3 dB

• Rec. ITU-R P.1546 ‘area’ parameter: rural, urban and dense urban

• Rec. ITU-R P.1546 clutter height: 10 m, 20 m and 30 m (according to rural, urban or dense urban area parameter respectively).

• Location variability: 50%

• Required percentage time: 1%

• Use ratio: 10% of the population is using the RNSS receiver at simulation time.

The potential number of victim receivers (***N***) = (Simulation area) \* (Population density) \* (Use ratio)

## 2.4 Simulation Method

At each simulation iteration step (one run), the victim receivers are randomly placed in the simulation area. The (x, y) coordinates of each receiver are initialized from two distinct random uniform distributions.

For each receiver we compute:

• Distance to the transmitter,

• Angle to the main lobe of the transmitter antenna.

From the angle to the main lobe, the antenna gain is estimated according to Recommendation ITU-R F.1336-5. Then the received level is computed as:

• Received level = (transmitter power) + (transmitter antenna gain) + (receiver antenna gain) - (path loss)

Where the path loss value is provided by the ITU-R P.1546 Matlab code.

Each time the received level is above the RNSS receiver interference threshold the receiver is counted as “**impacted**”.

At the end of one simulation step, we have ***m*** receivers impacted from a potential number of victim receivers ***N***.

The percentage of impacted receivers from the simulation step is then defined as (***m*** / ***N***) \* 100.

The simulation is performed 1 000 times and ends with 1 000 distinct values for the percentage of impacted receivers. From these the mean percentage of impacted RNSS receivers can be calculated.

## 2.5 Simulation Results

Mean percentage of fixed RNSS receivers within the simulation area impacted by one static amateur station operating as defined above:

Table 1

Mean Percentage of impacted fixed RNSS receivers and Standard Deviation

**RNSS Receiver Antenna Gain = -6 dBi**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Minimum amateur station density | Average amateur station density | Maximum amateur station density |
| Area setting and population density | % Impacted RNSS Rx | Standard Deviation | % Impacted RNSS Rx | Standard Deviation | % Impacted RNSS Rx | Standard Deviation |
| Rural | 0.06% | 0.01% | 0.20% | 0.03% | 1.62% | 0.21% |
| Urban | 0.02% | 0.004% | 0.08% | 0.01% | 0.65% | 0.09% |
| Dense urban | 0.02% | 0.001% | 0.06% | 0.001% | 0.45% | 0.02% |

**RNSS Receiver Antenna Gain = 0 dBi**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Minimum amateur station density | Average amateur station density | Maximum amateur station density |
| Area setting and population density | % Impacted RNSS Rx | Standard Deviation | % Impacted RNSS Rx | Standard Deviation | % Impacted RNSS Rx | Standard Deviation |
| Rural | 0.118% | 0.011% | 0.396% | 0.039% | 3.177% | 0.306% |
| Urban | 0.048% | 0.005% | **0.161%1** | 0.017% | 1.287% | 0.134% |
| Dense urban | 0.033% | 0.001% | 0.111% | 0.005% | 0.889% | 0.037% |

**RNSS Receiver Antenna Gain = 3 dBi**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Minimum amateur station density | Average amateur station density | Maximum amateur station density |
| Area setting and population density | % Impacted RNSS Rx | Standard Deviation | % Impacted RNSS Rx | Standard Deviation | % Impacted RNSS Rx | Standard Deviation |
| Rural | 0.163% | 0.013% | 0.544% | 0.043% | 4.385% | 0.35% |
| Urban | 0.067% | 0.006% | **0.224%1** | 0.019% | 1.779% | 0.154% |
| Dense urban | 0.047% | 0.002% | 0.157% | 0.005% | 1.249% | 0.042% |

Note 1: The “% impacted” figures in bold can also be identified in the Figure 2 below.

Figure 2



Based on the amateur home station and fixed RNSS receiver scenario for the average amateur station density and the urban environment, Figure 2 shows the % of impacted receivers having a signal "**greater or equal than x dBW**".

Depending on the RNSS receiver antenna gain, the protection threshold can be adjusted accordingly to read off the impacted percentage of receivers on the y-axis.

# 3 Fixed Amateur Home Station and Mobile RNSS Receivers Scenario

In this section the impact on moving RNSS receivers located in cars is considered. Both the amateur service narrow band emission and amateur service broadband emission with the appropriate interference threshold value are considered.

## 3.1 Simulation Method

The first simulation step selects random locations for each car according to the vehicle density and simulation area, assigning them a random speed (from 10 to 50 km/h in urban area) and a random direction. Each car then moves along the selected heading for 15 minutes (maximum assumed amateur transmission duration). Every 5 seconds (180 individual time steps in 15 minutes), the received level is computed and compared to the RNSS receiver maximum interference threshold.

Figure 3

Mobile RNSS receiver simulation scenario



At the end of each simulation step we compute:

The percentage of “impacted” RNSS receivers that have faced interference above the protection threshold.

This process is repeated 100 times and the mean percentage and standard deviation are calculated and presented in the results.

## 3.2 Narrow Band Amateur Home Station

### 3.2.1 Simulation parameters

The same section 2.3 simulation parameters were used here with the addition of the following vehicular assumptions:

• Car density: 330 vehicles/km2 (according to ECC Report 351 for the urban case)

• Percentage of cars having an active RNSS receiver during the simulation: 50%

• Speed distribution: uniform, from 5 to 50 km/h,

• Simulated drive path duration for each simulation step: 15 minutes,

• Time step for the drive path: 5 seconds, leading to 180 steps for 15 minutes.

**Note:** In this simulation, if a RNSS receiver moves outside of the simulation area, it turns around back into the area. Thus the number of RNSS receivers inside the simulation remains constant.

### 3.2.2 Simulation Results

Mean percentage of mobile RNSS receivers impacted by one fixed narrowband amateur home station:

Table 2

Narrow Band Amateur Home Station: Mean Percentage of impacted mobile RNSS
receivers and Standard Deviation

|  |  |  |  |
| --- | --- | --- | --- |
|  | Minimum amateur station density | Average amateur station density | Maximum amateur station density |
| Area Setting Parameter | % Impacted RNSS Rx | Standard Deviation | % Impacted RNSS Rx | Standard Deviation | % Impacted RNSS Rx | Standard Deviation |
| Rural | 0.15% | 0.002% | 0.50% | 0.008% | 3.94% | 0.058% |
| Urban | 0.079% | 0.001% | 0.27% | 0.006% | 2.10% | 0.046% |
| Dense urban | 0.06% | 0.0015% | 0.21% | 0.0047% | 1.67% | 0.038% |

## 3.3 Broadband Amateur Home Station

### 3.3.1 Simulation Parameters

The same simulation parameters and vehicular assumptions were used as detailed in section 3.2.1 but in this case using the RNSS receiver broadband interference threshold:

For the amateur service broadband emission:

• Broadband emission bandwidth: 2 MHz (DATV signal)

• Broadband RNSS receiver max interference threshold: –140 dBW/MHz

### 3.3.2 Simulation Results

Mean percentage of mobile RNSS receivers impacted by one fixed broadband amateur home station:

Table 3

Broadband Amateur Home Station: Mean Percentage of impacted mobile
RNSS receivers and Standard Deviation

|  |  |
| --- | --- |
|  | Average amateur station density |
| Area Setting Parameter | % Impacted RNSS Rx | Standard Deviation |
| Rural | 0.612% | 0.008% |
| Urban | 0.325% | 0.006% |
| Dense urban | 0.26% | 0.01% |

# 4 Permanent Amateur Station and Mobile RNSS Receivers Scenario

In this simulation, the amateur station parameters are changed to those appropriate for a fixed permanent station (repeater station output channel) and the impact on moving RNSS receivers located in cars is considered from both a narrow band amateur emission and a broadband amateur emission.

## 4.1 Simulation Method

The same simulation method was followed as used in the fixed amateur home station and mobile RNSS receiver scenario in section 3.1.

## 4.2 Narrow Band Amateur Permanent Station

### 4.2.1 Simulation Parameters

The following parameters identified in section 5 of the main report were assumed for the amateur permanent station and the RNSS receivers:

• Average permanent station density = 1 station / 3 333 km2

• Simulation area: According to the station density = 58 x 58 km

• Transmitter frequency: 1297 MHz

• Transmitter e.i.r.p.: 25 Watts

• Effective height of the amateur station antenna: 25 meters

• Receiver antenna height: 1.5 meter

• Narrow band receiver max interference threshold: –134.5 dBW

• Receiver antenna gain: –6 dBi, omnidirectional.

• Rec. ITU-R P.1546 ‘area’ parameter: Rural, Urban and Dense Urban

• Rec. ITU-R P.1546 clutter height: 10 m, 20 m and 30 m (according to the rural, urban or dense urban area parameter respectively)

• Location variability: 50%

• Required percentage time: 1%

Vehicular assumptions:

• Car density: 330 vehicles/km2

• Percentage of cars having an active RNSS receiver during the simulation: 50%

• Speed distribution: uniform, from 5 to 50 km/h,

• Simulated drive path duration for each simulation step: 15 minutes,

Time step for the drive path: 5 seconds, leading to 180 steps for 15 minutes.

**Note:** Again, if a RNSS receiver moves outside of the simulation area, it turns around back into the area. Thus the number of RNSS receivers inside the simulation remains constant.

**4.2.2 Simulation Results**

Mean percentage of mobile RNSS receivers impacted by one fixed narrow band permanent amateur station:

Table 4

Narrow Band Amateur Permanent Station: Mean Percentage of impacted mobile
RNSS receivers and Standard Deviation

|  |  |  |
| --- | --- | --- |
| Area Setting Parameter | % Impacted RNSS Rx  | Standard Deviation |
| Rural | 0.24% | 0.01% |
| Urban | 0.13% | 0.005% |
| Dense urban | 0.1% | 0.005% |

## 4.3 Broadband Amateur Permanent Station

### 4.3.1 Simulation parameters

The same simulation parameters and vehicular assumptions were used as detailed in section 4.2.1 but in this case using the RNSS receiver broadband interference threshold:

For the amateur service broadband emission:

• Broadband emission bandwidth: 2 MHz (DATV signal)

• Broadband RNSS receiver max interference threshold: –140 dBW/MHz

### 4.3.2 Simulation Results

Mean percentage of mobile RNSS receivers impacted by one fixed broadband amateur permanent station:

Table 5

Broadband Amateur Permanent Station: Mean Percentage of impacted mobile
RNSS receivers and Standard Deviation

| Area Setting Parameter | % Impacted RNSS Rx | Standard Deviation |
| --- | --- | --- |
| Rural | 0.68% | 0.01% |
| Urban | 0.34% | 0.01% |
| Dense urban | 0.26% | 0.01% |

## 5 Observations

In the fixed RNSS receivers and static amateur home station case the percentage of impacted receivers in the simulation area population is less than 1% for all the most likely combinations of area setting and amateur station density. One case returns a value of 1.62% but this is considered an unlikely combination of maximum amateur station density and a rural propagation model setting. Generally, the percentage of impacted receivers is higher for the highest amateur station density case but even in the urban setting the percentage is less than 0.5%.

This trend is true also for the mobile RNSS receiver case and the percentages are again higher for the maximum amateur station density case. However in the most likely combinations of area setting and station density, the percentage of impacted receivers in the simulation area population is mostly less than 1%. For an amateur station with an assumed broadband emission, the mean percentage of impacted RNSS receivers for an average amateur station density (based on narrowband station density) remains below 1%.

For the permanent amateur station (narrow band or broadband repeater output channel) and mobile RNSS receiver case only a single average density figure is available. All the mean percentage results for impacted RNSS receivers are less than 1%.

To ensure their statistical validity, the simulations employ a large population of RNSS receivers. For example, in the mobile RNSS receiver simulation for the average amateur station density over 2.75 million active RNSS mobiles are considered in the simulation area. The low standard deviation figures provide good confidence in the results.

These results should be considered alongside the operational data estimating the amount of time that amateur stations are actively transmitting. For example, and for narrow band operations this amounts to less than 3% of time across a year.

These simulations consider any improvement in interference resilience brought about by frequency offset from the RNSS system centre frequency. In addition, the continuous transmitting time of 15 minutes assumed in the simulations is excessive for a home station although it could be reasonable for a permanent station.

# 6 Conclusions

This study shows that the percentage of a population of one type of fixed or mobile RNSS receivers that might suffer interference from either a Home Station or a Permanent Station operating in the amateur service is very low.

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1. 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. [↑](#footnote-ref-1)
2. 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-2)
3. Slow Scan Television (SSTV) is an imaging protocol which is used 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-3)
4. 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-4)
5. 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-5)
6. 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-6)
7. 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-7)
8. 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-8)
9. Feeder loss not included which may be up to 3 dB. [↑](#footnote-ref-9)
10. 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-10)
11. The analysed results were published by the national radio amateur societies in several European countries. [↑](#footnote-ref-11)