Defending the Amateur Service Allocation at 23cm

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Over the past several years commercial demands on the amateur microwave allocations have increased significantly. This is not simply a matter to be resolved in the United States but rather globally within the framework of the International Telecommunication Union (ITU) where consensus on the radio regulations is to be reached among almost 200 countries.

One current item involves our allocation at 1.2 GHz where we have a secondary allocation. This document describes some historical aspects of the ITU and the International Amateur Radio Union (IARU) as well as the process and the current status of the 23cm issue that is on the agenda for the World Radiocommunication Conference later this year.

International Telecommunication Union

The ITU is a specialized agency of the United Nations responsible for many matters related to information and communication technologies. It was established on 17 May 1865 as the International Telegraph Union, making it the first international organization.

The ITU was initially aimed at helping connect telegraphic networks between countries, with its mandate consistently broadening with the advent of new communications technologies; it adopted its current name in 1932 to reflect its expanded responsibilities over radio and the telephone. On 15 November 1947, the ITU entered into an agreement with the newly created United Nations to become a specialized agency within the UN system, which formally entered into force on 1 January 1949.

The ITU promotes the shared global use of the radio spectrum, facilitates international cooperation in assigning satellite orbits, assists in developing and coordinating worldwide technical standards, and works to improve telecommunication infrastructure in the developing world. It is also active in the areas of broadband Internet, wireless technologies, aeronautical and maritime navigation, radio astronomy, satellite-based meteorology, TV broadcasting, amateur radio, and next-generation networks.

Based in Geneva, Switzerland, the ITU's global membership includes 193 countries and around 900 businesses, academic institutions, and international and regional organizations.

Most radio amateurs are familiar, at least in part, with ITU's World Radiocommunication Conference, formerly known as a World Administrative Radio Conference (WARC). The WARC held in 1979 was a technical conference where delegates from member nations of the ITU met to revise or amend the entire international radio regulations pertaining to all telecommunication services throughout the world. That year the conference was held in Geneva, Switzerland. One outcome of the 1979 meeting was the allocation of three new amateur radio bands at 10 MHz, 18 MHz, and 24 MHz still affectionately, but incorrectly, referred to by hams as the “WARC bands”! Others included a new band in ITU Region 2 at 902 MHz, several amateur-satellite allocations, and new allocations above 40 GHz,

In 1993 the ITU changed the name of the conference to the World Radiocommunication Conference with the charge to review and, as necessary, revise the Radio Regulations, the international treaty governing the use of the radio-frequency spectrum as well as geostationary and non-geostationary satellite orbits. The conferences are now held every three to four years.

International Amateur Radio Union

In the early 1920s it was generally assumed that radiocommunication could only take place over long distances using very long waves — the lower the frequency, the better. Very large antennas and very high power were the rule at commercial and government stations. Then, radio amateurs found that short-wave signals could be heard all over the world. The rush soon began to exploit this newly discovered phenomenon. Radio amateurs, the very people whose experiments had revealed the value of the short waves in the first place, were in grave danger of being pushed aside.

At the time there were very few countries in which radio amateurs had been able to organize themselves into national associations. In many countries amateur radio operation was actively discouraged or even illegal. Fortunately, there were far-sighted individuals who understood the problem and were able to find a solution. In 1925 they met in Paris and formally created the International Amateur Radio Union, or IARU.

Initially the IARU had individual members. Once there were enough members in a given country to do so, a section of the IARU would be formed. Soon there were enough sections of the IARU that it became a federation of national associations.

The first major challenge for the IARU occurred in 1927 at the Washington International Radiotelegraph Conference. Radio amateurs easily could have been forced into bands that would have been too narrow to support future growth. Instead, allocations were won that we still know today as 160, 80, 40, 20, and 10 meters, with a 5-meter band that was moved to 6 meters after World War II. The other amateur bands we now enjoy were the result of decades of patient effort through the IARU. From less than 30,000 radio amateurs who were licensed as of 1927, the amateur radio movement has grown to three million. From the representatives of 25 countries who formed the IARU in 1925, the IARU has grown to include 160 national associations representing virtually every country with enough amateurs to form an organization.

Individual radio amateurs support the work of the IARU through their membership in their own national IARU member-society. ARRL is the national member society in the United States and also serves as the IARU International Secretariat. The support of the national radio societies around the world is vital to the future of amateur radio. The IARU is recognized by the International Telecommunication Union (ITU) as the representative of the interests of radio amateurs throughout the world. It is amateur radio's voice in the offices and meeting rooms of the ITU and regional telecommunications organizations, where the decisions affecting our future access to the radio spectrum are made.

The representatives of the IARU at these meetings are volunteers. The combined budgets of the IARU and its regional organizations amount to just pennies per month per licensed radio amateur. Unfortunately, not all radio amateurs are members of IARU member-societies so the burden falls onto those who are.

Representation at the ITU is not an easy task. The work moves slowly and WRC agendas are developed over a several year cycle. One does not simply walk in, sit down at the table, and begin to direct agenda items or positions. It took IARU several years to earn the respect afforded to amateur radio today. IARU's WRC-23 team, led by Vice President Ole Garpestad, LA2RR, literally works year round to coordinate and attend the required meetings and prepare input documents for consideration.

Further, the Amateur Services are facing and will continue to face enormous challenges to our existing spectrum, especially above 30 MHz. There will be constraints on our existing spectrum discussed at the WRC this year (Agenda Item 9.1(b) 23cm) and the threat of further constraints in the future is very real. Many amateurs are unaware of and unprepared for such changes. IARU cannot do this alone and will continue to work with member societies to effectively explain the challenges to amateurs.

The Amateur Service Allocation at 1.2 GHz (23cm)

The 23cm is, without question, the most popular amateur radio microwave allocation. The band enjoys an extensive array of amateur activity from narrow band terrestrial weak signal analog and digital modes, FM repeaters, amateur television (ATV), point to point data links, and EME globally.

Our allocation is secondary. Even though we have an extensive presence our transmissions must not cause interference to the primary users. The Amateur Service has a long-documented history of non-interference with primary users, most notably in the microwave regions. We have coexisted very well for more than 70 years. However, a new primary service introduced more recently poses a difficult challenge.

One of several primary allocations at 23cm is to the Radionavigation Satellite Service (RNSS). This global satellite service encompasses several systems from several different countries including Galileo (EU), GLONASS (Russia), BeiDou (China), and QZSS (Japan), among others. The United States Global Positioning System operates in the 1215-1240 MHz band, among others, but not in the 1240-1300 MHz band.

At the WRC in 2019 the backers of Galileo pressed for an agenda item for WRC-23 to address their concern about possible interference from the amateur service to RNSS receivers planned to be widely deployed using the band. Agenda Item 9.1 (b) considers a "*Review of the amateur service and the amateur-satellite service allocations in the frequency band 1240 - 1300 MHz to determine if additional measures are required to ensure protection of the radionavigation-satellite (space-to-Earth) service operating in the same band in accordance with Resolution 774 (WRC-19);*"

For the past three years the IARU has been participating in ITU Working Parties that are studying the issue.

The IARU maintains the view that the likelihood of widespread and persistent interference from amateur radio activities to RNSS (e.g. Galileo) receivers in the 23cm band is minimal. The WRC-23 preparatory studies carried out in the ITU-R study groups have only considered static one-to-one estimations using a minimum coupling loss approach. These studies do not consider the effect of an amateur transmitter on a population of RNSS receivers deployed around an amateur transmitting station.

IARU's global WRC-23 9.1b team, led by Barry Lewis, G4SJH, and volunteers have carried out a "Monte Carlo" style study simulating scenarios assuming a fixed and mobile population of RNSS receivers deployed around an amateur station. A 100W amateur 'home station' and a 25W EIRP 'repeater station' have been assumed.

The simulation results suggest that at most only around 1% of a population of fixed and mobile RNSS receivers randomly situated around a transmitting amateur station location would have a small chance of receiving a signal level above the RNSS protection threshold identified in the relevant ITU-R Recommendations. In most scenarios, the percentage of RNSS receivers impacted by interference above the threshold within the "simulation area" is far less than 1%. Even in the densest areas of amateur station activity and with the lowest clutter model the percentages remain less than 5%.

The study assumed that an amateur station is transmitting throughout the whole "Monte Carlo" trial period. However, event data collected by the IARU shows that even in the busiest amateur communities the amount of time during which these sporadic transmissions are most likely to occur amounts to less than 2% of time over a one-year period.

Therefore, the IARU maintains its position that the potential for widespread and persistent interference between amateur radio transmissions and RNSS receivers is minimal. Nevertheless, because our status is only secondary a plan has been developed to provide administrations with guidance on those parts of the band where power, bandwidth, and other limitations on amateur transmissions may be desirable, while maintaining amateur access to the band for most existing activities.

ITU-R Working Party 5A, the group charged with developing the 23cm amateur band and RNSS coexistence measures related to WRC-23 Agenda Item 9.1b, recently met to progress the issue. G4SJH reported that two deliverables are under discussion:

1) Draft ITU-R Report M.[AMATEUR_CHARACTERISTICS] – this reports on the specific 23cm band amateur and amateur satellite service technical parameters and operational characteristics used in the studies now published in ITU-R Report M.2513–0.

2) Draft ITU-R Recommendation M.[AS_GUIDANCE] – this will recommend guidance that national administrations can take to facilitate the protection of the radio navigation satellite service from harmful interference from amateur radio stations.

Ahead of this WP5A meeting the IARU global WRC-23 9.1b team developed and submitted two contributions, one for each deliverable above. As usual, the IARU participated in the meeting to present the contributions and take part in the ongoing discussion and negotiations. The IARU contribution to the Guidance recommendation proposed specific limits for EME operation in the range 1298 – 1300 MHz. The IARU contribution to the "characteristics" report proposed an annex containing a Monte Carlo style study assessing the impact of a range of amateur transmissions on a population of RNSS receivers around the amateur station.

The development of the recommendation is proving challenging although many of the IARU proposals remain in the draft document for further discussion at the final meeting of WP5A in September, prior to WRC-23 in November. Challenges are arising from other proposals that could be judged to go beyond the original mandate for the work. In addition, some proposals for technical and operational measures seem impractical from both an administration and amateur station perspective.

The outcome of this item at WRC-23 is yet to be determined however there will most likely be changes to the way we utilize our secondary allocation at 1.2 GHz. A specific recommendation providing guidance to administrations is still development. The European Council is the main force behind this, to protect their Galileo RNSS system. The IARU has communicated the issue in various media since 2019 however; any changes will most likely come as a surprise to most amateurs, including many in the United States.

Current reports and up to date info can be found on the IARU global web page at www.iaru.org

International Amateur Radio Union

Statistical Study on the potential for interference between amateur radio transmissions and a population of radio navigation satellite service (RNSS) receivers operating in the band 1240 – 1300 MHz (23cm).

WRC23 Agenda Item 9.1b

February 2023

EXECUTIVE SUMMARY

The static ITU-R studies and minimum coupling loss estimations reported in ITU-R Report M.2513 have shown there is a potential for interference between an amateur station and co-frequency terrestrial RNSS receivers. However, even in the most active amateur community scenarios the density of transmitting amateur stations operating in the 1240- 1300MHz band is very low. This information has been submitted by the IARU to the ITU-R studies following due process but the resulting low probability of interference is ignored in the studies documented in the ITU-R report cited above. The "interference distances" estimated using the propagation model are based on a low (1%) probability of the estimated interefering signal level exceeding the RNSS "protection threshold" in just 50% of locations. Even this "protection threshold" identified in the relevant ITU-R Recommendation is some 10dB below the minimum receiver level specified for the Galileo receivers.

The statistical study detailed in the attachment to this paper has been carried out by the IARU using 'Monte Carlo' techniques and suggests that at most only around 1% of a population of fixed and mobile RNSS receivers randomly situated around a transmitting amateur station location would have a small chance of receiving a signal level above the protection threshold identified in the relevant ITU-R Recommendations. In some scenarios, the percentage of RNSS receivers impacted by interference above the threshold within the simulation area is far less than 1%. Even in the densest areas of amateur station activity and with the lowest clutter model the percentage remains less than 5%.

Minimum Amateur Station Density	**Average Amateur Station Density**	**Maximum Amateur Station Density**
% Impacted	% Impacted	% Impacted
0.02%	0.07%	0.54%

Example 1: Percentages of fixed RNSS receivers in a dense urban environment that might receive an interfering signal above the RNSS protection level.

Minimum Amateur Station Density	Average Amateur Station Density	Maximum Amateur Station Density
% Impacted	% Impacted	% Impacted
0.068%	0.23%	1.83%

Example 2: Percentages of mobile RNSS receivers in a dense urban environment that might receive an interfering signal above the RNSS protection level.

The study assumed that an amateur station is transmitting throughout the whole "Monte Carlo" trial period. However in practice, amateur radio transmissions in this band consist of short sporadic "overs" and event data collected by the IARU shows that even in the busiest amateur communities the amount of time during which these sporadic transmissions are most likely to occur amounts to less than 2% of time over a one year period.

Therefore the IARU maintains its position that the potential for widespread and persistent interference between amateur radio transmissions and RNSS receivers is minimal.

ATTACHMENT: IARU MONTE-CARLO STUDY

INTRODUCTION

In the 2023 World Radio Conference (WRC-23) preparatory processes underway in ITU-R and the regional telecommunication bodies (e.g CEPT in region 1), the potential for interference between amateur transmissions and ground-based RNSS receivers (e.g. GALILEO) is being considered. The outcome may lead to a recommendation on technical or operational measures to be applied to the amateur and amateur satellite services. These measures may constrain the use of the band and the conditions of usage by the amateur stations across the 23cm band.

The IARU statistical study presented here uses parameters for amateur stations and RNSS receivers that have been agreed in the relevant work in ITU-R and CEPT. It aims to assess the number of ”impacted RNSS receivers” from a population of RNSS receivers located around a transmitting amateur station. The following scenarios have been considered:

> a) Fixed 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 amateur ”Home” station and mobile RNSS receivers, onboard moving cars.
> c) Fixed amateur ”Permanent” station (repeater output channel) and mobile RNSS receivers, onboard moving cars.

An ”impacted RNSS receiver” is one that is estimated to receive a level of co-frequency interference above the protection threshold given in the relevant ITU-R Recommendation (Recommendation ITU-R M.1902).

This study underpins the IARU view that the probability of interference to a large population of active RNSS receivers from amateur radio transmissions is low.

HOW THE SIMULATIONS WORK

Each simulation run calculates the signal level received at 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. The simulation is repeated many times until the results converge and stabilise.

In case a) above the RNSS receivers remain fixed but are re-positioned for each run of the simulation. In cases b) and c), 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 statisitics of the impacted receivers can be collated. In the case of the mobile receivers the amount of time as a percentage of the simulation time can be evaluated also.

SCENARIO A): FIXED HOME STATION AND FIXED RNSS RECEIVER SIMULATION

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.

Simulation areas

The amateur station densities have been identified in the ITU-R work and the following are assumed in all the fixed simulations:

- Average Home Station and Portable station density = 1 stn / 5000 km^2
- Minimum Home Station and Portable station density = 1 stn / 16,700 km^2

- Maximum Home Station and Portable station density = 1 stn / 625 km^2

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 simulation considers RNSS receivers populating an area around a single amateur station according to the station densities assumed.

Propagation Model parameters

The propagation model parameters are:

- P1546 Matlab code provided by ITU (v14 11APR19 Ivica Stevanovic, OFCOM) as available online November the 8th, 2022.
- Location variability: 50%
- Required percentage time: 1%

Population Density

The population density of potential RNSS receiver users has been based on population data for France, based on National Institute for Statistics (INSEE):

Population par région

	Estimations de population au 1er janvier 2020[1] en milliers	Variation annuelle moyenne 20/12 en %			Densité moyenne au 1er janvier 2020 en hab/km²		
		Totale	Due au solde naturel	Due au solde apparent des entrées et des sorties[2]			
Auvergne-Rhône-Alpes	8 032.4	0.5	0.3	0.2	115		
Bourgogne-Franche-Comté	2 783.0	-0.2	0.0	-0.2	58	<	mini
Bretagne	3 340.4	0.4	0.0	0.4	123		
Centre-Val de Loire	2 559.1	0.0	0.1	-0.1	65		
Corse	344.7	1.1	-0.1	1.2	40		
Grand Est	5 511.7	-0.1	0.1	-0.2	96		
Hauts-de-France	5 962.7	0.0	0.3	-0.3	187		
Île-de-France	12 278.2	0.4	0.9	-0.5	1 022	<	maxi
Normandie	3 303.5	-0.1	0.1	-0.2	110		
Nouvelle-Aquitaine	6 000.0	0.4	-0.1	0.5	71		
Occitanie	5 924.9	0.6	0.1	0.5	81		
Pays de la Loire	3 801.8	0.6	0.2	0.4	119		
Provence-Alpes-Côte d'Azur	5 055.7	0.3	0.2	0.1	161		
France métropolitaine	**64 898.0**	**0.3**	**0.3**	**0.0**	**119**	<	average
Guadeloupe	376.9	-0.8	0.4	-1.2	221		
Guyane	290.7	2.4	2.4	0.0	3		
La Réunion	860.0	0.4	1.1	-0.7	343		
Martinique	358.7	-1.0	0.2	-1.2	318		
Mayotte	279.5	nd	nd	nd	747		
France y c. Mayotte	**67 063.7**	**nd**	**nd**	**nd**	**106**		
France hors Mayotte	**66 784.2**	**0.3**	**0.3**	**0.0**	**106**		

nd : donnée non disponible.

1. Résultats provisoires arrêtés fin 2019.

2. Le solde apparent des entrées et des sorties est calculé comme la différence entre la variation de population et le solde naturel.

Sources : IGN ; Insee, estimations de population, code officiel géographique.

Figure 1: Population density data extract for France

Three different types of densities are identified:

1. "rural", typically Bourgogne, with a density of 58 habitants / km^2
2. "Urban": Paris & direct suburbs (Ile de France), 1022 habitants / km^2
3. "Average": France average is 119 habitants / km^2

10% of the population is assumed to be using the RNSS receiver at simulation time.

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: 1297 MHz
- Transmitter Antenna gain: 18 dBi
- Transmitter power: 100 Watts
- Effective height of the amateur station antenna: 12 meters
- Receiver antenna height: 1.5 meter
- Receiver max interference threshold: -134.5 dBW
- Receiver antenna gain: -6 dBi, omnidirectional.
- Polarisation Loss: 0dB
- P1546 'area' parameter : Rural, urban and dense urban
- P1546 clutter height: 10m, 20m and 30m (according to the area parameter).
- Use ratio: 10% of the population is using the RNSS receiver at simulation time

The population of RNSS receivers ***N*** is defined as: (Simulation area) * (Population density) * (Use ratio)

Simulation Method

At each iteration step, the RNSS 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 ITU-R Recommendation 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 the simulation area population of RNSS receivers ***N***.

The impact rate (%) is then defined as **100 *** (m / N).

The simulation is performed over 1000 runs and ends with 1000 distinct values of the "impact rate", as defined previously.

Simulation Results

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

Population density	Minimum Amateur Station Density		Average Amateur Station Density		Maximum Amateur Station Density	
	% Impacted	S. Dev	% Impacted	S. Dev	% Impacted	S. Dev
Rural	0.07%	0.008%	0.24%	0.029%	1.90%	0.228%
Urban	0.03%	0.004%	0.10%	0.011%	0.78%	0.11%
Dense urban	0.02%	0.001%	0.07%	0.003%	0.54%	0.031%

Table 1: Percentage of impacted fixed RNSS receivers and Standard Deviation

SCENARIO B): FIXED AMATEUR HOME STATION AND MOBILE RNSS RECEIVERS

In this simulation the impact on moving RNSS receivers located in cars is considered.

Simulation parameters

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

- Car density: 330 vehicles/km^2 (according to **Draft 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 "bounces" back into the area thereby ensuring that the number of RNSS receivers inside the simulation remains constant.

Simulation Method

The elementary simulation step consists in selecting random locations for the cars 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 heading direction. Each car is then moving along the selected heading direction for 15 minutes (maximum assumed amateur transmission duration). At each time step, the received level is computed and compared to the threshold.

Number of simulations: 100, each simulating 180 individual time steps (15 minutes/5 seconds).

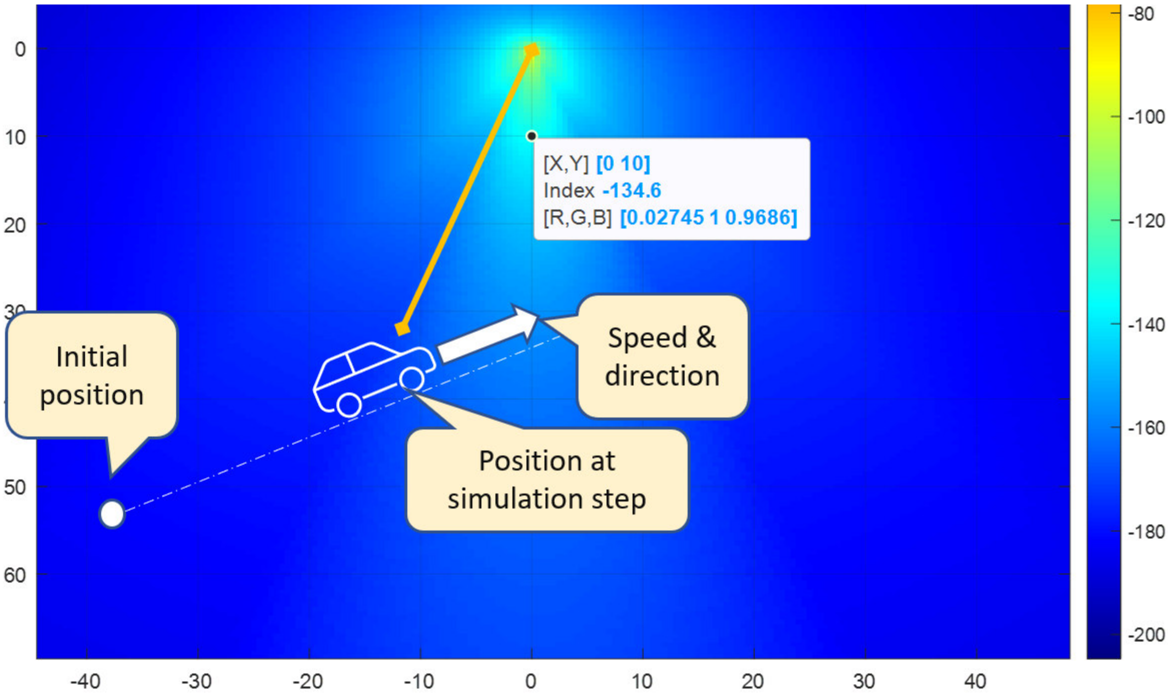

Figure 2: Mobile RNSS receiver simulation scenario

Then, at the end of each elementary simulation step we compute:

- Number of "impacted" RNSS receivers that have faced interference above the protection threshold,
- For these "impacted" RNSS receivers:
  - The cumulative duration of the interference,
  - The standard deviation

Simulation Results

Percentage of mobile RNSS receivers within the simulation area impacted by one static amateur station operating as defined above.

Area Setting Parameter	**Minimum Amateur Station Density**		**Average Amateur Station Density**		**Maximum Amateur Station Density**	
	% Impacted	S. Dev	% Impacted	S. Dev	% Impacted	S. Dev
Rural	0.163%	0.003%	0.54%	0.01%	4.33%	0.06%
Urban	0.086%	0.002%	0.29%	0.007%	2.31%	0.045%
Dense urban	0.068%	0.002%	0.23%	0.005%	1.83%	0.037%

Table 2: Amateur Home Station and Impacted Mobile RNSS receiver results

For the small number of impacted RNSS receivers in Table 2 above, the mean percentage of the aggregated simulation time during which they were impacted can be evaluated:

Area Setting Parameter	**Minimum Amateur Station Density**		**Average Amateur Station Density**		**Maximum Amateur Station Density**	
	Impacted RNSS receiver time percentage	S. Dev	Impacted RNSS receiver time percentage	S. Dev	Impacted RNSS receiver time percentage	S. Dev
Rural	43.12%	0.43%	43.17%	0.42%	43.15%	0.44%
Urban	32.24%	0.48%	32.1%	0.47%	32.26%	0.54%
Dense urban	28.28%	0.49%	28.22%	0.51%	28.25%	0.50%

Table 3: Impacted RNSS receiver time percentage

Of course, in the real world it is entirely possible that the amateur station would not be transmitting for the entire time of the simulation which would reduce the impacted receiver time percentages.

Video files examples created by the simulations provide further insight into the process and can be downloaded from here: https://storage.iaru-r1.org/index.php/s/Yg7KnGTsM9K35i3

SCENARIO C: PERMANENT AMATEUR STATION (REPEATER OUTPUT) AND MOBILE RNSS RECEIVERS

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.

Simulation Parameters

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

- Average permanent station density = 1 stn / 3333 km^2
- Simulation area: According to the station density = 58 x 58 km
- Transmitter frequency: 1297 MHz
- Transmitter antenna gain: 13 dBi
- Transmitter eirp: 25 Watts
- Effective height of the amateur station antenna: 25 meters
- Receiver antenna height: 1.5 meter
- Receiver max interference threshold: -134.5 dBW
- Receiver antenna gain: -6 dBi, omnidirectional.
- Polarisation Loss: 0dB
- P1546 ‘area’ parameter: Rural, Urban and Dense Urban
- P1546 clutter height: 10m, 20m and 30m (according to the area parameter)

Vehicular assumptions:

- Car density[1]: 330 vehicles/km^2
- 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,

[1] This figure is based upon peak hours vehicle density data linked to ITU-R Recommendation SM.2057 relating to automotive radars.

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 “bounces” back into the area thereby ensuring that the number of RNSS receivers inside the simulation remains constant.

Simulation Method
The same simulation method was followed as used in scenarios A) and B) above.

Simulation Results
Percentage of mobile RNSS receivers impacted by one fixed permanent amateur station:

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

Table 4: Amateur Permanent Station and Impacted Mobile RNSS receiver results

For the small number of impacted RNSS receivers in Table 4 above, the mean percentage of the aggregated simulation time during which they were impacted can be evaluated:

Area Setting Parameter	Impacted RNSS receiver time percentage	Standard Deviation
Rural	24.54%	0.50%
Urban	15.96%	0.48%
Dense urban	13.49%	0.40%

Table 5: Impacted RNSS receiver time percentage

OBSERVATIONS FROM THESE SCENARIOS
In the fixed RNSS receivers and static amateur home station scenario the percentage of impacted receivers in the simulation area population is always less than 1% with one exception. This is the case where the amateur station density is highest (i.e. simulation area smallest) and the propagation model environment is set to ”rural” (i.e. lowest clutter height). This is logical as more of the RNSS receivers are closer to the amateur radio transmitter. However even in this case it is still less than 2%. Generally the percentage of impacted receivers in the simulation area is higher for the highest amateur station density case.

This trend is true also for the mobile RNSS receiver scenario and the percentages are again higher for the maximum amateur station density case. In this case up to 4.3% of mobile receivers are impacted and the figures are highest because the density of mobile receivers remains the same in all cases but relative to the overall RNSS receiver population, more receivers pass closer to the amateur transmitter in the smaller simulation area. In the other amateur station densities the percentage of impacted receivers is always far less than 1%.

The mean cumulative time percentage of the impacted RNSS receivers remains nearly the same for all propagation model settings and amateur station densities. This is logical as the amateur station parameters and the vehicle speeds do not change.

For the permanent amateur station (repeater output channel) and mobile RNSS receiver scenario only a single average density figure is available. The results show smaller impacted receiver and time percentages compared to home station simulations due to the lower transmitter power in this case despite the higher installation height.

In all simulations the low standard deviation figures provide good confidence in the convergence of the results.

ADDITIONAL CONSIDERATIONS

These simulations have assumed a co-frequency situation and have not considered any improvement in interference resilience brought about by frequency offset from the RNSS system centre frequency.

Consideration of the results should be over laid with the activity factors for the amateur stations in order to develop a complete picture of the likelihood of interference into RNSS active receivers.

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