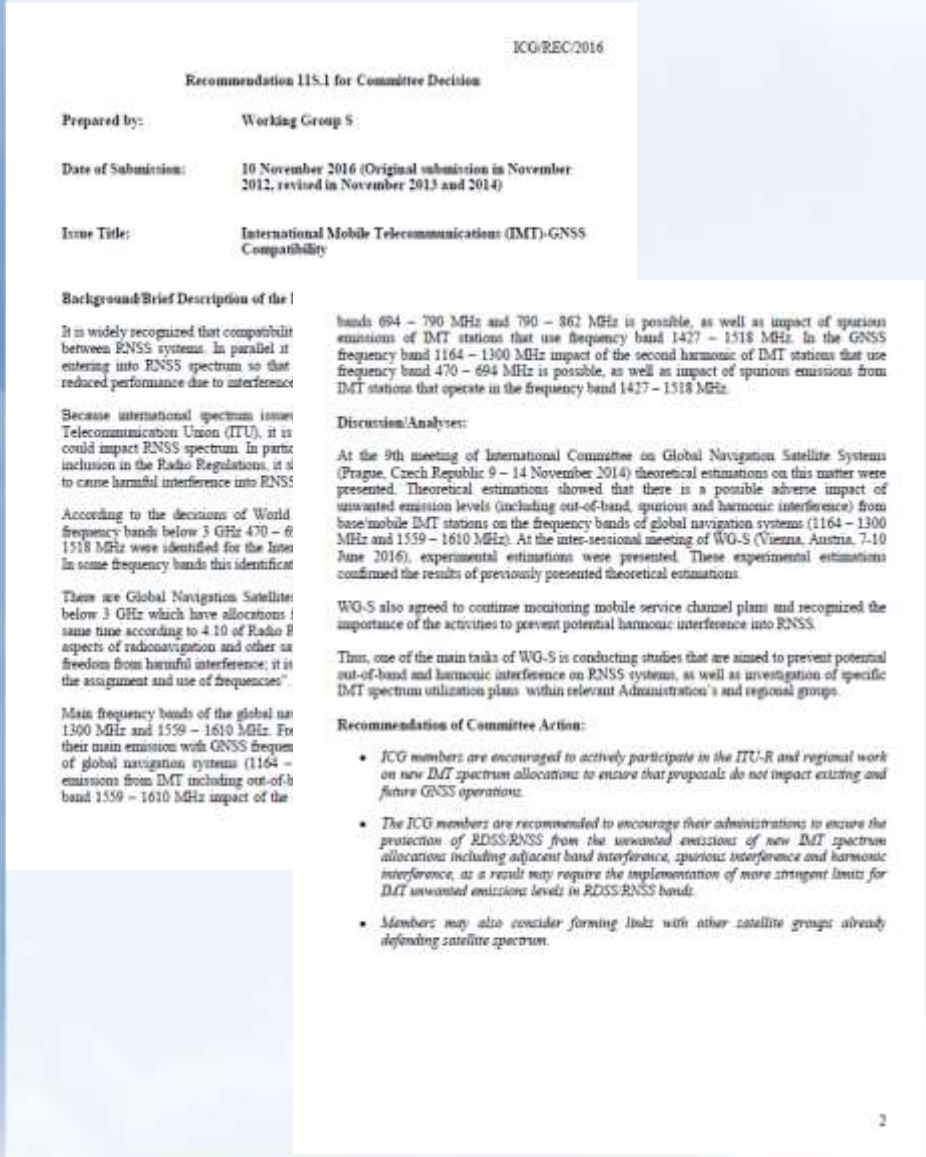
Proposals on issue of Interference Detection and Mitigation in GNSS spectrum

Dr. Aronov D.

Baska, Croatia 6-9 May 2018

Recommendation 11S.1 «IMT-GNSS compatibility»



ICG/REC/2016

Recommendation 11S.1 for Committee Decision

Prepared by: Working Group S

Date of Submission: 10 November 2016 (Original submission in November 2012, revised in November 2013 and 2014)

Issue Title: International Mobile Telecommunications (IMT)-GNSS Compatibility

Background/Brief Description of the I

It is widely recognized that compatibilit
between RNSS systems. In parallel it
entering into RNSS spectrum so that
reduced performance due to interferenc

Because international spectrum issue
Telecommunication Union (ITU), it is
could impact RNSS spectrum. In partic
inclusion in the Radio Regulations, it s
to cause harmful interference into RNS

According to the decisions of World
frequency bands below 3 GHz 470 – 6
1518 MHz were identified for the Inte
In some frequency bands this identificat

There are Global Navigation Satellite
below 3 GHz which have allocations
same time according to 4.10 of Radio R
aspects of radionavigation and other sa
freedom from harmful interference; it is
the assignment and use of frequencies".

Main frequency bands of the global na
1300 MHz and 1559 – 1610 MHz. Fr
their main emission with GNSS frequen
of global navigation systems (1164 –
emissions from IMT including out-of-b
band 1559 – 1610 MHz impact of the

bands 694 – 790 MHz and 790 – 862 MHz is possible, as well as impact of spurious emissions of IMT stations that use frequency band 1427 – 1518 MHz. In the GNSS frequency band 1164 – 1300 MHz impact of the second harmonic of IMT stations that use frequency band 470 – 694 MHz is possible, as well as impact of spurious emissions from IMT stations that operate in the frequency band 1427 – 1518 MHz.

Discussion/Analyses:

At the 9th meeting of International Committee on Global Navigation Satellite Systems (Prague, Czech Republic 9 – 14 November 2014) theoretical estimations on this matter were presented. Theoretical estimations showed that there is a possible adverse impact of unwanted emission levels (including out-of-band, spurious and harmonic interference) from base/mobile IMT stations on the frequency bands of global navigation systems (1164 – 1300 MHz and 1559 – 1610 MHz). At the inter-sessional meeting of WG-S (Vienna, Austria, 7-10 June 2016), experimental estimations were presented. These experimental estimations confirmed the results of previously presented theoretical estimations.

WG-S also agreed to continue monitoring mobile service channel plans and recognized the importance of the activities to prevent potential harmonic interference into RNSS.

Thus, one of the main tasks of WG-S is conducting studies that are aimed to prevent potential out-of-band and harmonic interference on RNSS systems, as well as investigation of specific IMT spectrum utilization plans within relevant Administration's and regional groups.

Recommendation of Committee Action:

- *ICG members are encouraged to actively participate in the ITU-R and regional work on new IMT spectrum allocations to ensure that proposals do not impact existing and future GNSS operations.*
- *The ICG members are recommended to encourage their administrations to ensure the protection of RDSS/RNSS from the unwanted emissions of new IMT spectrum allocations including adjacent band interference, spurious interference and harmonic interference, as a result may require the implementation of more stringent limits for IMT unwanted emissions levels in RDSS/RNSS bands.*
- *Members may also consider forming links with other satellite groups already defending satellite spectrum.*

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At ICG-11 (November 2016, Sochi, Russia), Recommendation 11S.1 "IMT-GNSS compatibility" was approved.

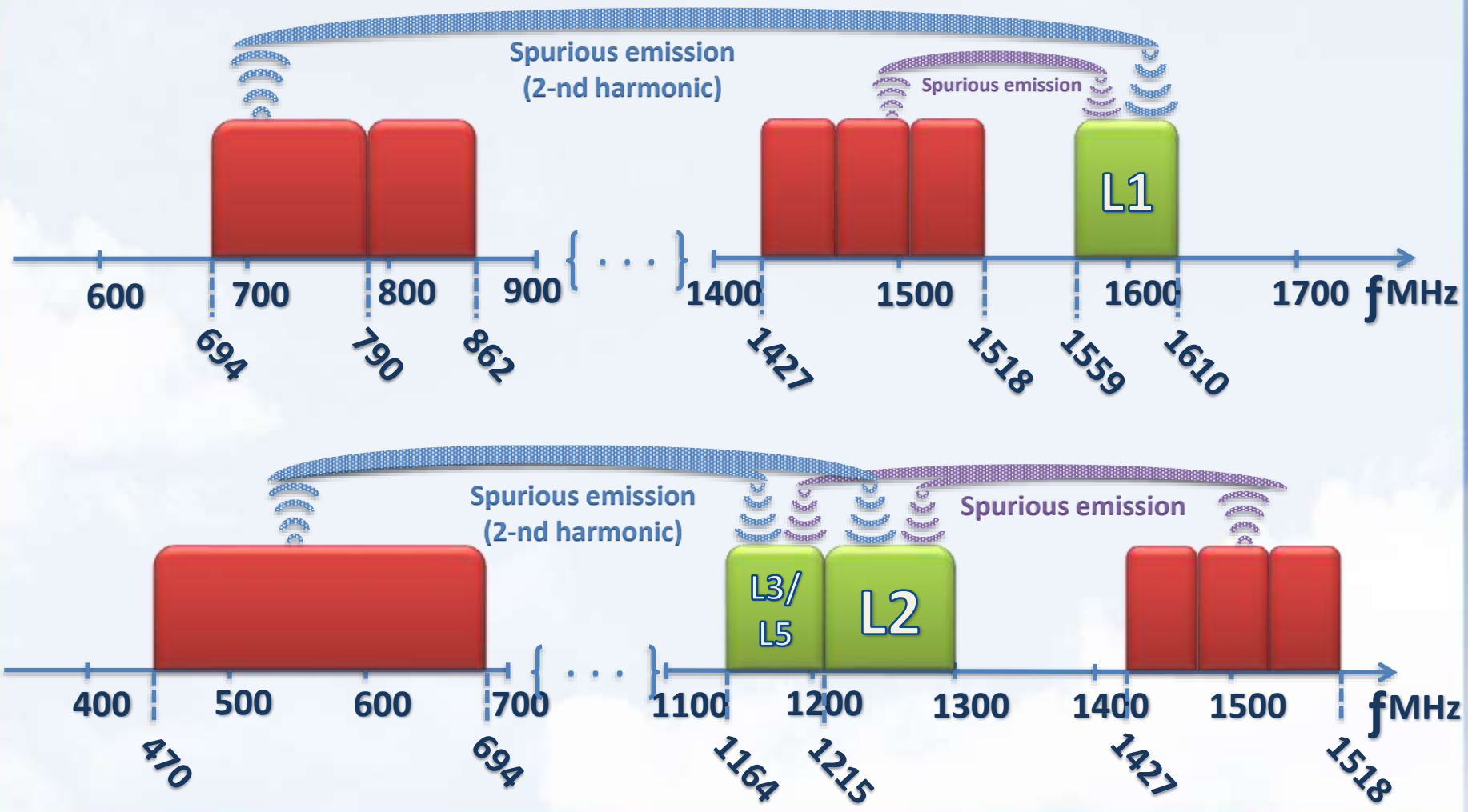
Objectives of Recommendation 11S.1 «IMT-GNSS Compatibility»

- The ICG members are encouraged to actively participate in the ITU-R and regional work on new IMT spectrum allocations to ensure that proposals do not impact existing and future GNSS operations.

- The ICG members are recommended to encourage their administrations to ensure the protection of RDSS/RNSS from the unwanted emissions of new IMT spectrum allocations including adjacent band interference, spurious interference and harmonic interference, as a result may require the implementation of more stringent limits for IMT unwanted emissions levels in RDSS/RNSS bands.

- Members may also consider forming links with others satellite groups already defending satellite spectrum.

Potential impact from IMT frequency bands to GNSS frequency bands



Protection criteria for GNSS receivers

Acquisition mode threshold power density level of aggregate wideband interference at the passive antenna output (dB(W/MHz))	L1	L2	L3/L5
	-142… -148	-127… -156	-146… -156

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

- Recommendation ITU-R M.1903 «Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) and receivers in the aeronautical radionavigation service operating in the band 1 559 –1 610 MHz»;

- Recommendation ITU-R M.1905 «Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 164–1 215 MHz».

The estimation results of interference from IMT on GNSS

Estimation results of IMT stations (mobile/base) unwanted emissions impact to RNSS systems in the frequency band 1 164 -1 215 MHz

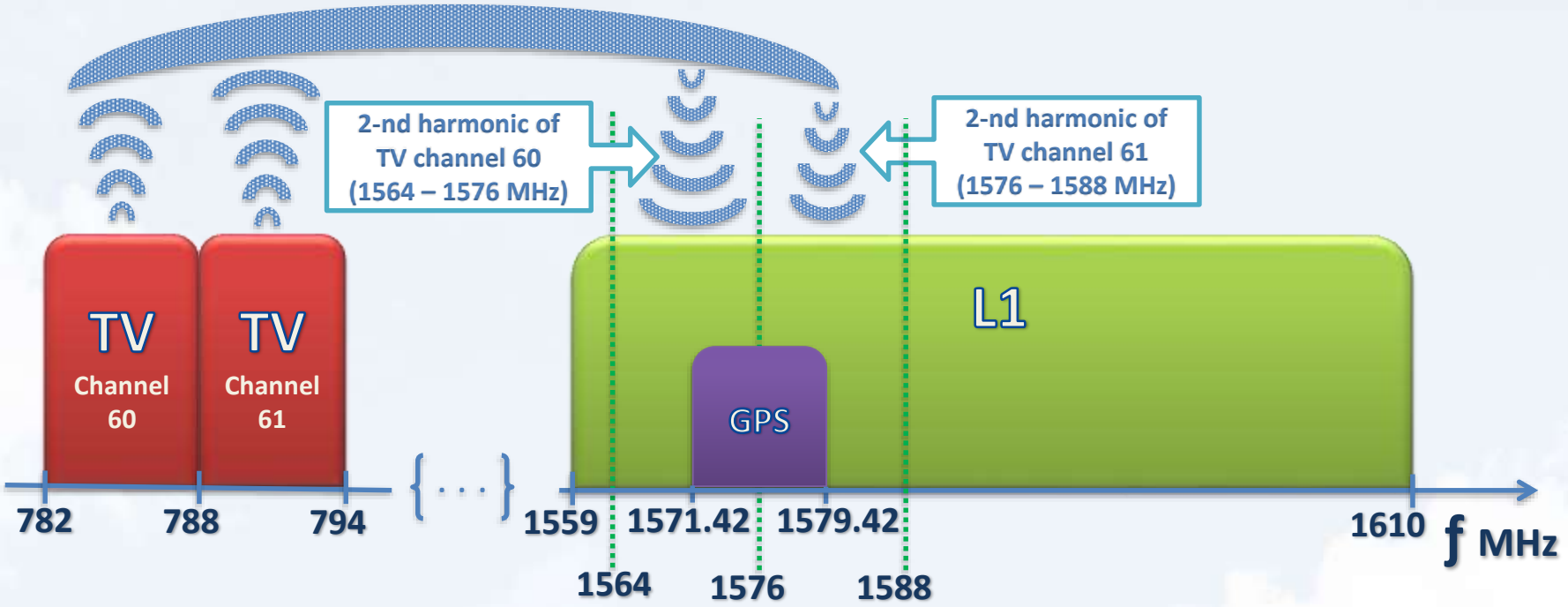
	1	2	3	4	5
Parameter	**Air-navigation receiver №1**	**Aeronautical navigation receiver №2**	**High-precision receivers**	**Indoor positioning**	**General purpose**
Maximum receiver antenna gain in upper hemisphere (dBi)	3	7			
Spurious emissions level (dB(W/MHz))	**-60**	**-60**			
Interference power at the receiver antenna output (dB(W/MHz))	-57	-53			
Tracking mode threshold power density level of aggregate wideband interference at the passive antenna output (dB(W/MHz))	−144.8	−140			
Required attenuation (dB)	**87.8**	**87**			
Separation distance (m)	**498**	**444**			
Acquisition mode threshold power density level of aggregate wideband interference at the passive antenna output (dB(W/MHz))	−148.7	−146			
Required attenuation (dB)	**91.7**	**93**			
Separation distance (m)	**780**	**885**			

Estimation results of unwanted emissions impact from IMT stations (mobile/base) to RNSS receivers in the frequency band 1 215 -1 300 MHz

	1	2	3	4	5	6	7
Parameter	**SBAS ground reference receiver***	**High-precision semi-codeless receiver***	**High-precision receiver using L2C***	**Air-navigation receiver (Note 10)**	**Indoor positioning**	**Others**	**General purpose**
Maximum receiver antenna gain in upper hemisphere (dBi)	-2.0	3.0	3.0	7	6	6	6
Spurious emissions level (dB(W/MHz))	**-60**	**-60**	**-60**	**-60**	**-60**	**-60**	**-60**
Interference power at the receiver antenna output (dB(W/MHz))	**-62**	**-57**	**-57**	**-53**	**-54**	**-54**	**-54**
Tracking mode threshold power density level of aggregate wideband interference at the passive antenna output (dB(W/MHz))	−147.3	−147.4	−147.4	−140	−150	−121	-139
Required attenuation (dB)	**85.3**	**90.4**	**90.4**	**87**	**96**	**67**	**85**
Separation distance (m)	**366**	**644**	**644**	**429**	**1227**	**42**	**346**
Acquisition mode threshold power density level of aggregate wideband interference at the passive antenna output (dB(W/MHz))	-147.4	-147.4	−147.4	−146	−156	−127	−145
Required attenuation (dB)	**85.4**	**90.4**	**90.4**	**93**	**102**	**73**	**91**
Separation distance (m)	**362**	**644**	**644**	**856**	**2448**	**83**	**690**

The estimation results show that the required attenuation of unwanted emissions from mobile/base station is from 67 dB to 102 dB. These attenuation values correspond to the separation distances from 42 m to 2446 m.

Potential impact of television frequency bands on the L1 GNSS frequency band, using the example of a GPS receiver



Considered at the 4th International Conference on Integrated Navigation Systems (St. Petersburg, 26-28 May 1997) «Analysis of potential interference sources and assessment of present solutions for GPS/GNSS receivers» (René Jr. Landry и Alain Renard).

The result of estimating the interference from the television station to the L1 GNSS frequency band, using the example of a GPS receiver

The results of the assessment showed that the required separation distance to attenuate unwanted emissions from the television station would be from 3 to 15 km. (for the case where the EIRP of the television station is about 1 kW).

As one of the mechanisms to reduce the effect of interference in the GNSS frequency spectrum, it is proposed to install filters on television stations.

ANALYSIS OF POTENTIAL INTERFERENCE SOURCES AND ASSESSMENT OF PRESENT SOLUTIONS FOR GPS/GNSS RECEIVERS

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ABSTRACT

Many experiments are presently being carried out on the future DGPS-based approach and landing systems to improve the quality of aircraft navigation. The use of C/A-code receivers for aeronautical applications requires high reliability and integrity. This study is an investigation of the potential sources of electromagnetic interference for the Standard Positioning Service of the GPS receivers using the C/A code and navigating inside an avionic environment. Radio-frequency emissions from several communication systems using frequencies adjacent to the GPS and GLONASS bands present considerable problems for the GNSS reception.

An overcrowded frequency spectrum and weak GPS signals make RF interference from a variety of sources a potential threat that must be examined with care.

This paper intends to give an overview of the potential sources of interference and their solutions. These sources of RFI are identified, and the vulnerability of GPS and GNSS to that interference is assessed. The study procures a quantitative comprehension of the impact of interference. The most important sources of interference are studied in terms of their technical characteristics, their jamming distance and the isolation or the rejection requirements needed to keep the good performance of the receiver. Candidate mitigation techniques are also examined, and selected techniques are recommended for adoption in appropriate standards.

Keywords: Interferences, Jammers, GPS, Navigation, Aviation.

1. INTRODUCTION

The typical signal available to the commercial GPS receiver is -160 dBW (-130 dBm compared with -134.5dBm specified by ARINC) at the antenna input, spreaded over about 2MHz bandwidth (8MHz for Narrow Correlator) by the spread spectrum code, at though most of the power can be found in the central 2MHz section. The thermal noise power (kTB) in 2MHz , derived from the Boltzman's constant k (-228.6dBW/HzK), is -141 dBW at 300°K using a perfect receiver, or -137dBW if the radio front end achieves a 4dB noise figure. Thus the receiver starts with a theoretical signal to noise ratio of about -23dB in 2MHz. In practice, the antenna may have a few dB of gain and the GPS Signal level is higher. To give an idea of the received power, -160dBW into 50Ω is equivalent, as a single CW carrier, to about 71nV. A good VHF receiver expects almost a 1uV. But the GPS receiver must take the signal in 2MHz of bandwidth, compared with 25KHz for the VHF communication receivers, so it gets 80 times the noise power. Thus the GPS receiver has to separate a 71nV signal (equivalent) from under about 1uV (-137dBW) of equivalent noise which is quite a challenge. This exemple illustrates the vulnerability of GPS signal to Narrow Band Interferences and the power levels in consideration in this paper.

Different kinds of jammers can be found if we look carefully in the frequency spectrum of a spread spectrum system which will affect the reception of the useful signal. This paper is not related with analysis of intelligent or non-intelligent jammers rather with occasional interferences.

1.1 IMPACT OF NARROW BAND INTERFERENCES

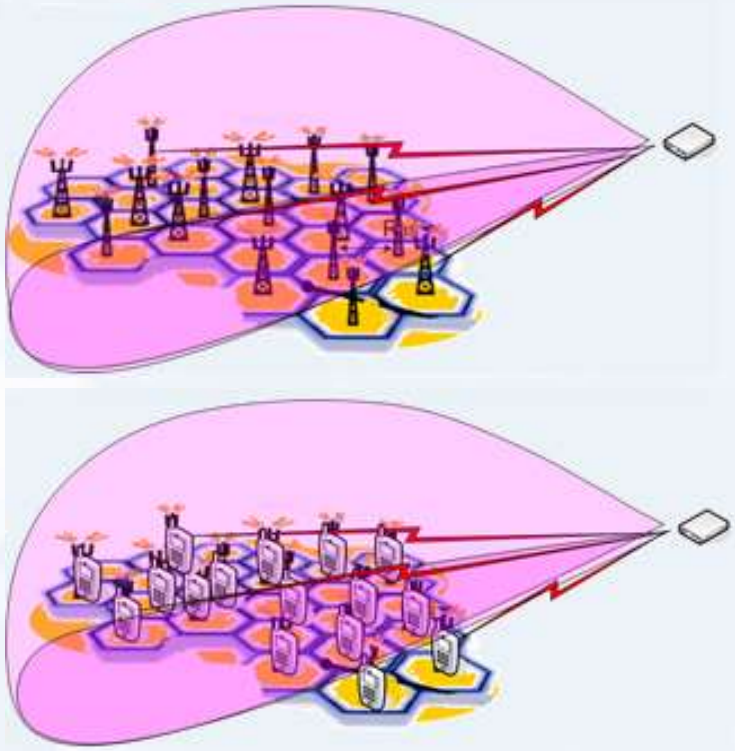
The Figure 1.1 shows the spectral representation of the situation where GPS signal is in the presence of an interference.

Figure 1.1: Interference in the GPS Band.

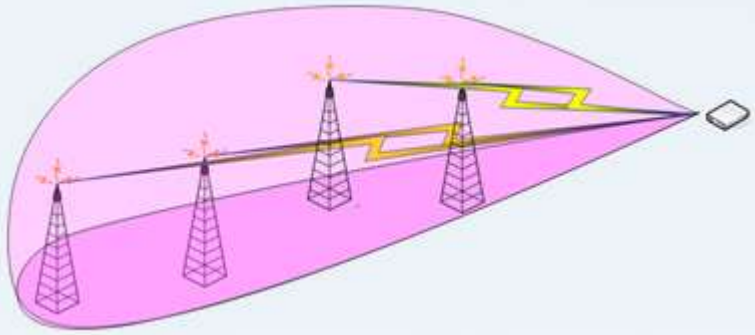
4th Saint-Petersburg on INS, May 26-28 1997

Comparison of the IMT impact on GNSS and TV on GNSS estimation results

IMT ⟹ GNSS



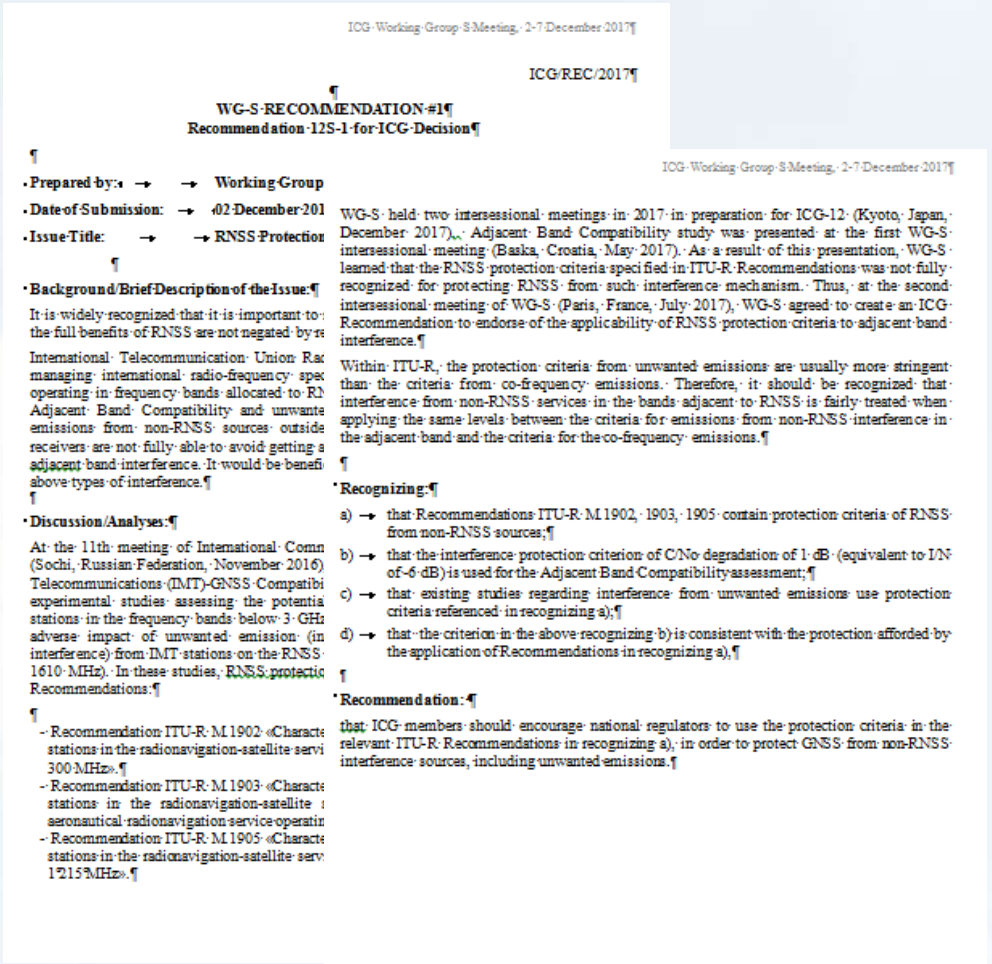
TV ⟹ GNSS



Separation distance from 42 m to 2446 m.

Separation distance from 3000 m to 15000 m. (for low-power television stations)

Recommendation 12S.1 «RNSS protection criteria»



ICG Working Group S Meeting, 2-7 December 2017

ICG/REC/2017

WG-S RECOMMENDATION #1
Recommendation 12S-1 for ICG Decision

- **Prepared by:** → Working Group
- **Date of Submission:** → 02 December 201
- **Issue Title:** → RNSS Protection

- **Background/Brief Description of the Issue:**

It is widely recognized that it is important to
the full benefits of RNSS are not negated by r

International Telecommunication Union Ra
managing international radio-frequency spe
operating in frequency bands allocated to R
Adjacent Band Compatibility and unwante
emissions from non-RNSS sources outside
receivers are not fully able to avoid getting a
adjacent band interference. It would be benefi
above types of interference.

- **Discussion/Analyses:**

At the 11th meeting of International Comm
(Sochi, Russian Federation, November 2016)
Telecommunications (IMT)-GNSS Compatibi
experimental studies assessing the potentia
stations in the frequency bands below 3 GHz
adverse impact of unwanted emission (in
interference) from IMT stations on the RNSS
1610 MHz). In these studies, RNSS protectio
Recommendations:

- Recommendation ITU-R M.1902 «Characte
stations in the radionavigation-satellite servi
300 MHz».
- Recommendation ITU-R M.1903 «Characte
stations in the radionavigation-satellite
aeronautical radionavigation service operatin
- Recommendation ITU-R M.1905 «Characte
stations in the radionavigation-satellite serv
1215 MHz».

ICG Working Group S Meeting, 2-7 December 2017

WG-S held two intersessional meetings in 2017 in preparation for ICG-12 (Kyoto, Japan, December 2017),. Adjacent Band Compatibility study was presented at the first WG-S intersessional meeting (Baska, Croatia, May 2017). As a result of this presentation, WG-S learned that the RNSS protection criteria specified in ITU-R Recommendations was not fully recognized for protecting RNSS from such interference mechanism. Thus, at the second intersessional meeting of WG-S (Paris, France, July 2017), WG-S agreed to create an ICG Recommendation to endorse of the applicability of RNSS protection criteria to adjacent band interference.

Within ITU-R, the protection criteria from unwanted emissions are usually more stringent than the criteria from co-frequency emissions. Therefore, it should be recognized that interference from non-RNSS services in the bands adjacent to RNSS is fairly treated when applying the same levels between the criteria for emissions from non-RNSS interference in the adjacent band and the criteria for the co-frequency emissions.

- **Recognizing:**

a) → that Recommendations ITU-R M.1902, 1903, 1905 contain protection criteria of RNSS from non-RNSS sources;

b) → that the interference protection criterion of C/No degradation of 1 dB (equivalent to I/N of -6 dB) is used for the Adjacent Band Compatibility assessment;

c) → that existing studies regarding interference from unwanted emissions use protection criteria referenced in recognizing a);

d) → that the criterion in the above recognizing b) is consistent with the protection afforded by the application of Recommendations in recognizing a),

- **Recommendation:**

that ICG members should encourage national regulators to use the protection criteria in the relevant ITU-R Recommendations in recognizing a), in order to protect GNSS from non-RNSS interference sources, including unwanted emissions.

At ICG-12 (December 2017, Kyoto, Japan), Recommendation 12S.1 "RNSS protection criteria" was approved.

Objectives of Recommendation 12S.1 «RNSS protection criteria»

ICG members should encourage their national regulators to use the protection criteria from the relevant ITU-R Recommendations (M.1902, M.1903, M.1905) to protect GNSS from non-RNSS interference sources, including unwanted emissions.

Proposals to consider

Proposal: Development of a new ICG Recommendation

Objective: GNSS spectrum protection from non-RNSS radio services interference.

Issues under consideration:

- **Acceptable levels of protection from interference and measurement methods**
- **Monitoring of interference environment**
- **Identification of interference sources**
- **Recommendations on the elimination/minimization of interference impact**

In this regard, it is advisable to begin the preparatory work on the systematization of available information on this issue. As an example, it is proposed to start from the following:

- **Systematization and categorization of various types of interference;**
- **Systematization and categorization of various types of GNSS receivers.**

Participants are invited to discuss and include priority steps in the list.

Thank you for your attention!

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