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Radiocommunication Sector of ITU

Recommendation ITU-R M.1831-1 (09/2015)

A coordination methodology for radionavigation-satellite service inter-system interference estimation

M Series
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and related satellite services**



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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R M.1831-1

**A coordination methodology for radionavigation-satellite service
inter-system interference estimation**

(Question ITU-R 217-2/4)

(2007-2015)

Scope

This Recommendation gives a methodology for radionavigation-satellite service (RNSS) intersystem interference estimation to be used in coordination between systems and networks in the RNSS. As Resolution **610 (WRC-03)** applies to all systems and networks in the RNSS and contains measures that are designed to facilitate RNSS inter-system compatibility determination, this Recommendation is applicable to the RNSS in the bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz and 5 010-5 030 MHz.

Keywords

RNSS, coordination methodology, intersystem interference estimation

Abbreviations/Glossary

ADC Analogue-to-Digital Converter

AGC Automatic Gain Control

PRN Pseudo-Random Noise

SSC Spectral Separation Coefficient

Related ITU Recommendations, Reports

- Recommendation ITU-R M.1318-1 Evaluation model for continuous interference from radio sources other than in the radionavigation-satellite service to the radionavigation-satellite service systems and networks operating in the 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz and 5 010-5 030 MHz bands
- Recommendation ITU-R M.1787-2 Description of systems and networks in the radionavigation-satellite service (space-to-Earth and space-to-space) and technical characteristics of transmitting space stations operating in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz
- Recommendation ITU-R M.1901-1 Guidance on ITU-R Recommendations related to systems and networks in the radionavigation-satellite service operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz
- Recommendation ITU-R M.1902-0 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.1903-0 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.1904-0 Characteristics, performance requirements and protection criteria for receiving stations of the radionavigation-satellite service (space-to-space) operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz
- Recommendation ITU-R M.1905-0 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
- Recommendation ITU-R M.1906-1 Characteristics and protection criteria of receiving space stations and characteristics of transmitting earth stations in the radionavigation-satellite service (Earth-to-space) operating in the band 5 000-5 010 MHz
- Recommendation ITU-R M.2030-0 Evaluation method for pulsed interference from relevant radio sources other than in the radionavigation-satellite service to the radionavigation-satellite service systems and networks operating in the 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz frequency bands
- Recommendation ITU-R M.2031-1 Characteristics and protection criteria of receiving earth stations and characteristics of transmitting space stations of the radionavigation-satellite service (space-to-Earth) operating in the band 5 010-5 030 MHz

The ITU Radiocommunication Assembly,

considering

- a) that systems and networks in the radionavigation-satellite service (RNSS) provide worldwide accurate information for many positioning and timing applications including critical ones related to safety of life;
- b) that WRC-03 adopted new and expanded allocations for the RNSS;
- c) that any properly equipped earth station may receive navigation information from systems and networks in the RNSS on a worldwide basis;
- d) that there are several operating and planned systems and networks in the RNSS and an increasing number of RNSS filings at the Radiocommunication Bureau proposing to use the RNSS allocations;
- e) that methods have been developed for use in coordination discussions which provide a common basis for the estimation of interference between such systems and networks in the RNSS,

recognizing

- a) that the bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz and 5 010-5 030 MHz are allocated on a primary basis to RNSS (space-to-Earth, space-to-space);
- b) that the bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz and 5 010-5 030 MHz are also allocated on a primary basis to other services;
- c) that Recommendation ITU-R M.1901 provides guidance on this and other ITU-R Recommendations related to systems and networks in the RNSS operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz;

- d) that technical and operational characteristics of, and protection criteria for, system and network receivers in the RNSS (space-to-Earth and space-to-space) in the bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz are provided in Recommendations ITU-R M.1905, ITU-R M.1902, ITU-R M.1903, ITU-R M.1904, ITU-R M.1906 and ITU-R M.2031;
- e) that technical and operational characteristics of system and network transmitters in the RNSS (Earth-to-space, space-to-Earth and space-to-space) in the bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz are provided in Recommendations ITU-R M.1787, ITU-R M.1906 and ITU-R M.2031;
- f) that Recommendation ITU-R M.1318 provides a model for evaluating interference from environmental sources into RNSS systems in the bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz and 5 010-5 030 MHz;
- g) that Recommendation ITU-R M.2030 provides an evaluation method for pulsed interference from relevant radio sources other than in the RNSS to the RNSS systems and networks operating in the 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz bands;
- h) that No. **4.10** of the Radio Regulations (RR) states that the safety aspects of RNSS “require special measures to ensure their freedom from harmful interference”;
- i) that under RR No. **5.328B** systems and networks in the RNSS intending to use the bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz and 5 010-5 030 MHz for which complete coordination or notification information, as appropriate, is received by the Radiocommunication Bureau after 1 January 2005 are subject to the application of the provisions of RR Nos. **9.12**, **9.12A** and **9.13**, and studies to determine additional methodologies and criteria to facilitate such coordination are being planned;
- j) that under RR No. **9.7**, stations in RNSS networks using the geostationary-satellite orbit are subject to coordination with other such stations, and studies to determine additional methodologies and criteria to facilitate such coordination are being planned,

further recognizing

that Resolution **610 (WRC-03)** applies to all systems and networks in the RNSS in the bands mentioned in recognizing a), and contains measures that are designed to facilitate the making of RNSS inter-system compatibility determinations,

recommends

- 1** that the methodology in Annex 1 should be used in carrying out coordination between RNSS systems operating or proposed to operate in one or more of the same frequency bands identified in *recognizing a)* (see Note 1);
- 2** that the guidance in Annexes 2 and 3 should be taken into account by RNSS system operators before and during RNSS coordination.

NOTE 1 – The methodology in Annex 1 may be difficult to apply to multi-satellite FDMA RNSS systems. In this case, Annex 2 may be implemented.

Annex 1

A method for estimating inter-system interference between systems and networks in the RNSS

TABLE OF CONTENTS

	<i>Page</i>
1 Introduction	5
2 Interference analysis methodology	5
3 Data used in the calculations	8
3.1 Constellation and satellite transmitter models	8
3.2 User receiver model	9
3.3 Interference and noise model	9
4 A simulation-based approach for calculating G^{agg}	10
5 A hypothetical example of the methodology's application	14
5.1 An assessment of interference levels	14
5.2 An assessment of effective carrier-to-noise ratios and related degradation	16
6 RNSS short-code spectrum characteristics and modelling.....	19
6.1 RNSS short-PRN code spectrum example	19
6.2 General aspects of detailed dynamic modelling for RNSS short PRN codes.....	20
7 Conclusion.....	21

1 Introduction

This methodology is intended to provide a technique of estimating the interference between systems and networks in the RNSS. As such, it is useful for inter-system RNSS coordination. (For the purpose of brevity, the word “system” will be used instead of “system or network” in the remainder of this document.) The methodology applies to RNSS systems that use CDMA and FDMA to allow sharing of RNSS bands, and recognizes that a simple summation of transmission power density is inadequate to determine what effect an RNSS system will have on others. Unlike RNSS CDMA systems, which typically have only one carrier per occupied band, FDMA systems have several carriers in a single occupied band. It may not be practical to apply the methodology below to each carrier frequency used in a multi-satellite FDMA system.

2 Interference analysis methodology

Typically, the post-correlator effective carrier-to-noise density ratio, C/N'_0 , is used to measure the impact of the interference from various sources on the operational performance of the intended receivers. C/N'_0 is dependent on the receiver, antenna and external noise from non-RNSS sources. However, it is used in assessing inter-system interference of RNSS systems.

For the case of continuous interference¹, C/N'_0 is given by:

$$\frac{C}{N'_0} = \frac{C}{vN_0 + I_{ref} + I_{int} + I_{ext}} \quad (1)$$

where:

- C : post-correlator received desired-signal power (W) from the satellite in the reference constellation including any relevant processing losses²
- N_0 : receiver pre-correlator thermal noise power spectral density (W/Hz)
- N'_0 : post-correlator effective receiver thermal noise power spectral density (W/Hz)
- I_{ref} : post-correlator effective white-noise power spectral-density (W/Hz) due to the aggregate interference from all the signals, except the desired signal, transmitted by all the in-view satellites in the reference constellation including any relevant processing losses
- I_{int} : post-correlator effective white-noise power spectral-density (W/Hz) due to the aggregate interference from all the signals transmitted in the frequency band of interest by all the in-view RNSS satellites other than those in the reference constellation, including any relevant processing losses
- I_{ext} : post-correlator effective white-noise power spectral-density (W/Hz) due to the aggregate interference from all radio signals other than those of the RNSS, including any relevant processing losses
- v : dimensionless effective thermal noise factor given by:

¹ When significant pulsed interference is present, equation (1) must be modified. Pulsed interference reduces signal-to-noise ratio by suppressing the desired signal and increasing the effective noise floor.

² Relevant processing losses include transmitter and receiver antenna gains; receiver implementation loss, such as filtering and quantization losses; and mismatch losses between the received signal and the reference code.

$$\nu = \int_{-\infty}^{\infty} |\overline{H}(f)|^2 S(f) df$$

$\overline{H}(f)$: normalized equivalent transfer function, at frequency f (Hz) given by:

$$\overline{H}(f) = \frac{H(f)}{\max_{\gamma} |H(\gamma)|}$$

$H(f)$: equivalent receiver filter transfer function (dimensionless), at frequency f (Hz), representing all of the pre-correlator receiver front-end filtering

$S(f)$: ideal equivalent two-sided power spectral density (W/Hz), at frequency f (Hz) of the unfiltered pre-correlator desired signal, normalized to unit power over an infinite bandwidth, and is computed assuming random spreading codes

γ : dummy variable.

The receiver's effective post-correlator thermal noise level, in the absence of external noise, reduces to $N'_0 = \nu N_0$. In addition, if H represents an ideal bandpass filter with bandwidth B_R (rather than the detailed magnitude transfer function of the receiver's front-end filter), then ν simplifies to:

$$\nu = \int_{-B_R/2}^{B_R/2} S(f) df \leq \int_{-\infty}^{\infty} S(f) df = 1$$

It should be noted that I_{int} (W/Hz) can be further broken down to consider the interference due to a specific RNSS system:

$$I_{int} = I_{alt} + I_{rem}$$

where:

I_{alt} : post-correlator effective noise power spectral-density (W/Hz) due to the aggregate interference from all the signals transmitted in the frequency band of interest by all the in-view satellites of a specific "alternate" constellation

I_{rem} : post-correlator effective noise power spectral-density (W/Hz) due to the aggregate interference from all the signals transmitted in the frequency band of interest by all the in-view "remaining" RNSS satellites; i.e. those that are not in either the reference constellation or the alternate constellation.

To calculate the effective noise power spectral densities we define the spectral separation coefficient, β (in units of 1/Hz), of an interfering signal from the n -th signal of the m -th satellite to a desired signal, x , as:

$$\int \beta_{m,n}^x = \int_{-\infty}^{\infty} |\overline{H}(f)|^2 \overline{S}_x(f) \overline{S}_{m,n}(f) df \quad (2)$$

where:

$\overline{S}_x(f)$: normalized (to unity over the transmission bandwidth) two-sided power spectral density (W/Hz), at frequency f (Hz) of the desired signal: