RECOMMENDATION ITU-R M.1317

CONSIDERATIONS FOR SHARING BETWEEN SYSTEMS OF OTHER SERVICES OPERATING IN BANDS ALLOCATED TO THE RADIONAVIGATION-SATELLITE AND AERONAUTICAL RADIONAVIGATION SERVICES AND THE GLOBAL NAVIGATION SATELLITE SYSTEM (GLONASS-M)

(Questions ITU-R 201/8 and ITU-R 217/8)

(1997)

Summary

The information on technical characteristics of a typical GLONASS-M receiver and the technical description of the GLONASS-M system are presented in this Recommendation. This information is intended for use in the assessment of sharing with other services operating within the band used by GLONASS-M.

The ITU Radiocommunication Assembly,

considering

a) that the global navigation satellite system (GLONASS-M) provides worldwide precision navigation information in three dimensions to air, land and sea-based stations;

b) that the bands 1 215-1 260 MHz and 1 559-1 610 MHz are allocated on a primary basis respectively to the radiolocation and radionavigation-satellite services, and to the aeronautical radionavigation and radionavigation-satellite services in all three Regions;

c) that the band 1 610-1 626.5 MHz is allocated on a primary basis to the aeronautical radionavigation service and to the mobile-satellite service (MSS) (uplink) in all three Regions;

d) that many administrations additionally allocate the 1 215-1 260 MHz band on a primary basis to the fixed, mobile and radionavigation services and the 1 559-1 610 MHz band on a primary basis to the fixed service and the 1 610-1 626.5 MHz on a primary basis to the MSS;

e) that any properly equipped earth stations may receive navigation information from the GLONASS-M on a worldwide basis;

f) that the GLONASS-M system provides a radionavigation-satellite service according to No. S4.10 of the Radio Regulations (RR);

g) the provisions of RR No. S5.364,

recommends

1 that the characteristics and system description of Annexes 1 and 2 be used in assessing sharing between other services and the GLONASS-M system, taking into account provisions of RR No. S5.364;

2 that these characteristics for GLONASS-M receivers may be used as a basis for studies to determine if certain environments require more stringent receiver characteristics.

ANNEX 1

GLONASS-M receiver characteristics

(For a typical low-cost receiver)

L1, L2 carrier frequencies:	See § 1.1 of Annex 2
P code chip rate:	5.11 Mbit/s
C/A code chip rate:	0.511 Mbit/s
Navigation data rate:	50 bit/s
Undetected bit-error rate:	1×10^{-5}
Minimum received power level (L1, P, C/A):	–161 dBW
Minimum received power level (L2, P, C/A):	–167 dBW
Preamplifier limiting level:	–80 dBW
Preamplifier burnout level:	–1 dBW, average
Overload recovery time:	1 s
RF 3 dB filter bandwidth:	± 20 MHz
RF 30 dB filter bandwidth:	± 45 MHz
Permissible Interference/Signal (*I/S*) margin (L1, C/A):	15 dB (for acquisition)
Permissible *I/S* margin (L1, P):	25 dB (for acquisition).

The above values indicate current receiver characteristics. More stringent values of receiver characteristics (e.g., overload recovery time, *I/C*, etc.) may be required in certain environments (e.g., aeronautical or maritime).

ANNEX 2

Technical description and characteristics of the global navigation satellite system (GLONASS-M)

1 GLONASS-M system

1.1 Introduction

The GLONASS-M system consists of 24 satellites equally spaced in three orbital planes with eight satellites in each plane. The orbit inclination angle is 64.8°. Each satellite transmits navigation signals in both the L1 (1.6 GHz) and the L2 (1.2 GHz) frequency bands. The satellites are differentiated by carrier frequency; the same carrier frequency may be used by antipodal satellites located in the same plane. Navigation signals are modulated with a continuous bit stream (which contains information about the satellite ephemeris and time), and also a pseudo-random code for pseudo-range measurements. A user receiving signals from not less than four satellites is able to determine the three location coordinates and the three velocity vector constituents with high accuracy. Navigational determinations are possible when on or near the Earth’s surface.

1.1.1 Frequency requirements

The frequency requirements for the GLONASS-M systems were based upon ionosphere transparency, radio link budget, simplicity of user antennas, multipath suppression, equipment cost and RR provisions. The signals are a mixture of a carrier modulated with a C/A code and a carrier modulated with a P code with a 90° relative phase shift. The carrier frequencies vary by an integer multiple of 0.5625 MHz in the L1 band and by 0.4375 MHz in the L2 band. For each satellite, the ratio of frequencies transmitted in the L1 and L2 bands equals 9/7.

The GLONASS-M frequency plan will have three stages of development. Prior to 1998, 25 separate frequency carriers will be used in the L1 and L2 bands. The frequency range of the carriers is listed below. The L1 band will use carrier frequencies 1 602.00 MHz (lowest) to 1 615.50 MHz (highest) and the L2 band will use carrier frequencies 1 246.00 MHz (lowest) to 1 256.50 MHz (highest). However, carrier frequencies in the 1 610.6-1 613.8 MHz band will not be used.

During the second stage, 1998-2005, 21 carrier frequencies will be used in the L1 and L2 bands. The L1 band will use carrier frequencies 1 598.0625 MHz (lowest) to 1 609.3125 MHz (highest) and the L2 band will use carrier frequencies 1 242.9375 MHz (lowest) to 1 251.6875 MHz (highest). The highest carrier frequencies, 1 609.3125 MHz and 1 251.6875 MHz will be used only under exceptional circumstances.

After 2005, GLONASS-M will use 14 carrier frequencies. The highest two carriers of both L1 and L2 frequency bands will only be used as technical channels (for launch and test). Therefore, the GLONASS-M system in the L1 band will use carrier frequencies 1 598.0625 MHz (lowest) to 1 605.3750 MHz (highest) and the L2 band will use carrier frequencies from 1 242.9375 MHz (lowest) to 1 248.6250 MHz (highest). However, carrier frequencies 1 604.8125 MHz and 1 605.375 MHz in the L1 band and 1 248.1875 MHz and 1 248.6250 MHz in the L2 band will be used as technical channels when the satellite is over the Russian Federation.

GLONASS-M will provide a worldwide navigation service. The requirement for navigation safety demanded by such a service underscores the critical importance that other radio services do not cause harmful interference to GLONASS-M receivers.

1.2 System overview

The GLONASS-M system provides all-weather-continuous navigation and time signal transmission anywhere on or near the Earth’s surface.

The system operates on the principle of passive triangulation. The GLONASS-M user equipment measures the pseudo-ranges and radial pseudo-velocities relative to four satellites and receives information about the satellites’ ephemeris and clock parameters. On the basis of these data, the three coordinates of the user’s location and the three velocity vector constituents are calculated and user clock and frequency correction is made. Coordinate system PE-90 is used by GLONASS-M.

GLONASS-M provides two navigation accuracy levels: the Standard Accuracy Level (SAL) and the High Accuracy Level (HAL). The SAL uses C/A signals, and the HAL uses the P signals.

1.3 System description

The GLONASS-M system consists of three major segments: the space segment, the control segment and the user segment.

1.3.1 Space segment

The GLONASS-M system is comprised of 24 satellites located in three orbital planes with eight satellites in each plane. The planes are separated from each other by 120° relative to the equator, with an orbit inclination angle of 64.8°. The satellites are equally spaced by 45° in a plane. Their rotation period is 11 h 15 min. The height of the orbit is 19 100 km.

Each satellite has the following main equipment:

– an atomic frequency and time standard;

– a processor to calculate and store navigation data;

– a pseudo-random signal assembly;

– transmitters for both L1 and L2 bands, and

– transmitting antennas for both L1 and L2 bands.

1.3.2 Control segment

The control segment consists of the system control centre and a monitoring station network. These are located on the territory of the Russian Federation.

The monitoring stations measure the satellite's orbital parameters and clock shift relative to the main system clock. These data are transmitted to the system control centre. The centre calculates the ephemerides and clock correction parameters and then uploads messages to the satellites through the monitor stations on a daily basis.

1.3.3 User segment

The user segment consists of a great number of user terminals of different types. The user terminal consists of an antenna, a receiver, a processor and an input/output device. This equipment may be combined with other navigation devices to increase navigation accuracy and reliability. Such a combination can be especially useful for highly dynamic platforms.

1.4 Navigation signal structure

The C/A signal structure is the same for both L1 and L2 bands. It is a pseudo-random sequence which is modulo-2 added to a continuous digital data stream transmitted with a 50 bit/s rate. The pseudo-random sequence has a chip rate of 0.511 MHz and its period is 1 ms.

In the L1 band, the P signal is also a pseudo-random sequence but with a chip rate of 5.11 MHz modulo-2 added to a continuous data stream. The L2 P signal is different from the L1 P signal in that it has no digital data.

Digital data include information about the satellite's ephemerides, clock time and other useful information.

All navigation signals, in both L1 and L2 bands, use either 0° or 180° carrier bi-phase modulation.

1.5 Signal power and spectra

The GLONASS-M satellites employ a shaped-beam antenna that radiates near-uniform power to system users. Transmitted signals are elliptically right-hand polarized with an ellipticity factor no worse than 0.7 for L1 and L2 bands. The minimum guaranteed power of a signal at the input of a receiver (assumes a 0 dBic gain antenna) is specified as –161 dBW (–131 dBm) for both C/A and P signals in the L1 band and –167 dBW (–137 dBm) for both signals in L2 band.

The power spectrum envelope of the navigation signal is described by the function $(\sin x/x)^2$,

where:

$$x = \pi (f - f_c)/f_t$$

in which:

f: frequency considered

f_c: carrier frequency of the signal

f_t: 5.11 MHz for P code signals or

0.511 MHz for C/A code signals.

The main lobe of the spectrum forms the signal's operational spectrum. It occupies a bandwidth equal to $2f_t$. The lobes have a width equal to f_t. The first and second lobes are 13 dB and 18 dB lower than the maximum level of the main lobe, respectively.

2 Receiver characteristics

Navigation user equipment consists of an antenna, a receiver, a processor and an input/output device. The antenna has a zone of the vision, ±85° from local vertical (equivalent to 5° elevation angle), to receive signals from many visible satellites. However, the antenna, being omnidirectional, does not have much capability to discriminate spatially against interference.

The RF part to the receiver is typically comprised of a bandpass filter, a preamplifier and a multistage down converter. The bandpass filter is to provide rejection of out-of-band signals. The preamplifier has a diode limiter to protect the receiver from damage when a high-powered interference signal is present.

The digital part of the receiver and the processor provides the signal equalization, PN code tracking, carrier phase tracking, digital data demodulating and time marking. The receiver input bandwidth is ±20 MHz (–3 dB level) and ±45 MHz (–30 dB level), the noise temperature is 300 K (typical).

3 Interference thresholds

The GLONASS-M receiver is susceptible to two forms of interference:

– When high power pulse interference affects the receiver, preamplifier burnout is possible. To prevent this, the preamplifier has a diode limiter which can protect up to a maximum interference level of 0.8-1 W (from –1 to 0 dBW).

– Continuous interference causes an increase in the receiver noise temperature. The impact is estimated by permissible interference-to-signal ratio for acquisition that constitutes +15 dB for a C/A signal and +25 dB for the P code signal in the L1 band.

The most vulnerable operating state of the receiver to outside interference is the acquisition mode.

The criteria above consider real antenna patterns and situations when the wanted signal is received by the antenna pattern minimum and the interfering signal is received by its maximum.