GLOBAL NAVIGATION SATELLITE SYSTEM

GLONASS

Open Service Performance Standard (OS PS)

Edition 2.2

Korolev
2020

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OPEN SERVICE PERFORMANCE STANDARD (OS PS)

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INTRODUCTION

This document is based on the intergovernmental standard GOST 32454–2013 “GLObal Navigation Satellite System. Parameters of the Radionavigation Field. Technical Requirements and Testing Techniques” and defines the levels of performance of the GLONASS Open Service (OS). The levels of performance for the GLONASS OS are concordantly agreed by the Ministry of Defense of the Russian Federation (the Russian Defense Ministry) and the Roscosmos State Corporation. The document has been drafted by the Information and Analysis Center for Positioning, Navigation and Timing (PNT IAC of the Central Research Institute of Machine Building), coordinated within and approved by the Russian Defense Ministry and the Roscosmos State Corporation. The GLONASS OS performance is monitored, assessed and verified in PNT IAC. Please refer any questions or comments, using the feedback form on the webpage www.glonass–iac.ru/feedback/ or, in writing, to the e–mail: iianc@glonass–iac.ru

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EXECUTIVE SUMMARY

The GLObal NAvigation Satellite System (GLONASS) Open Service (OS) gives a free access to the GLONASS-generated radionavigation field whose performance corresponds to that associated with the Channel of Standard Accuracy (CSA). The radionavigation field is generated by the aggregate of navigation signals (NS) delivered by the navigation space vehicles (SV) of the GLONASS orbital constellation (OC) within the service volume. At any point of this service volume, a user with the navigation receiver exploiting one-way ranging techniques can determine his state vector (position, velocity vector components as related to the assumed coordinate system (CS), and timing offsets to the user's time scale defined by his receiver's clock). CSA provides the positioning, navigation, and timing accuracy available to any GLONASS OS user without restrictions continuously and worldwide.

This OS PS specifies standards for the GLONASS CSA performance neglecting receiver biases, signal propagation and reception biases (in terms of performance metrics used to specify system performance that is taking into account the GLONASS space segment and the GLONASS ground segment contributions to the performance).

This OS PS defines the performance levels of the GLONASS OS SIS which is the aggregate of open FDMA NS broadcast in L1 and L2. This OS PS applies to single frequency (L1, L2) and dual frequency (L1/L2) operation modes. This OS PS assumes the 24-slot GLONASS OC as nominal.

This OS PS is coordinated and approved by the Ministry of Defense of the Russian Federation (Russian Defense Ministry) and the Roscosmos State Corporation as per the Russian Federation Government Decision № 323 of 30 April, 2008 (rev. of 27 October, 2017) on Delegation of Responsibilities for GLONASS Sustainment, Development and Use to Federal Executive Authorities and the Federal Law on the Roscosmos State Space Corporation.

PNT IAC continuously monitors, assesses and verifies actual GLONASS OS performance (www.glonass-center.ru).

The up-to-date and prediction information on the GLONASS OC status is published at the official websites of the Roscosmos State Corporation — www.glonass-center.ru, and the Russian Ministry of Defense — www.glonass-svoevp.ru.

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Section 1. GLONASS Open Service

GLObal NAvigation System (GLONASS) is a navigation system owned by the Russian Federation Government and used to provide positioning, navigation and timing services to an unlimited number of air, marine, land and space users on a continuous worldwide basis at any point on the Earth's surface and the near–Earth space regardless of meteorological conditions.

The Open Service (OS) gives a free access to the GLONASS–generated radionavigation field whose performance is associated with that of the Channel of Standard Accuracy (CSA).

The radionavigation field is generated by the aggregate of signals–in space (SIS) delivered by the navigation space vehicles (SV) of the GLONASS orbital constellation (OC) within the service volume. At any point of this service volume, a user with the navigation receiver exploiting one–way ranging techniques can determine his state vector (position, velocity vector components as related to the assumed coordinate system (CS), and timing offsets to the user's time scale defined by his receiver's clock).

CSA provides the positioning, navigation, and timing accuracy available to any GLONASS OS user without restrictions continuously and worldwide.

This OS PS defines the performance levels of the GLONASS OS SIS which is the aggregate of open FDMA SIS broadcast on L1 and L2. This OS PS applies to single frequency (L1, L2) and dual frequency (L1/L2) operation modes. This OS PS assumes the 24–slot GLONASS OC as nominal.

1.1 Purpose

GLONASS OS PS serves as a high–level mainframe document specifying the values of the achieved GLONASS performance characteristics plus the significant guaranteed margin. These coupled with the signal reception environment and a priori estimation of user equipment (UE) performance characteristics can further be translated into end user performance which a user can expect to achieve while solving his specific navigation task. This GLONASS OS PS is a basis for GLONASS services certification, lower level UE and GLONASS–based services standards development, as well as for international standards development like those of International Civil Aviation Organization (ICAO) and International Maritime Organization (IMO) and others.

Using the unified set of operation parameters and calculation methods for all GNSS, including GLONASS, GPS, Galileo, and BDS is a conventional practice. The similar standards for GPS, Galileo, and BDS have been published and are regularly updated.

In fact, this GLONASS OS PS is the second after the Interface Control Document (ICD) baseline interface between GLONASS and UE manufacturers and the GLONASS–based services developers in contrast to the 2012–2020 GLONASS Sustainment, Development and Use Federal Program and the GLONASS Mission Requirements which are the interface between the Customer (represented by the Russian Federation) and the Contractor Authorities (represented by the Roscosmos State Corporation and the Ministry of Defense). As distinct from the Federal Program, performance standards described in this document do not specify the averaged requirements to the product to be assessed and accepted by the Customer but the minimum performance that can be achieved by users with the high level of trust based on the long–term statistical history.

This OS PS specifies standards for the GLONASS OS Signal–in–Space (SIS) performance neglecting receiver biases, signal propagation and reception biases (in terms of performance metrics used to specify system performance that is taking into account the GLONASS space segment and the GLONASS ground segment contributions to the performance). This OS PS is a basis for certification of GLONASS services and GLONASS–based systems including the System of Differential Corrections and Monitoring (SDCM) and the System of Precise Orbit and Clock Determination (SPOCD), as well as UE for use in aviation and other domains.

The OS PS provides an overview of the GLONASS System plus an overview of the OS SIS and specifies the values of the performance characteristics for the CSA SIS, and lists the legal documents used to compile this OS PS.

1.2 Procedures for coordination and revision

The Information and Analysis Center for Positioning, Navigation and Timing of the Roscosmos State Corporation's Head Research Institute (The Central Scientific and Research Institute for Machine Building Joint Stock Company, TsNIIMash JSC) defined as the GLONASS OS PS issuer is responsible for its preparation, coordination, updating, sustaining and official distribution.

The GLONASS OS PS is coordinated between and approved by the authorized representatives of the Russian Federation Ministry of Defense and the Roscosmos State Corporation supported by the entities in charge if needed.

The OS PS will be updated periodically in terms of the set and the specific GLONASS performance values as GLONASS modernizes its civilian services or the international legal base revises. The changes to the previously agreed version of the OS PS can be initiated by any of the parties in charge, and shall be coordinated between and approved by all the parties in charge. The OS PS issuer is responsible for the coordination of any revisions between all the parties in charge, as well as for the preparation of a new version of the document with the proposed revisions.

1.3 Scope

This GLONASS OS PS defines standards for the GLONASS OS SIS performance (Section 3.0).

The OS PS defines the performance parameters such as availability, continuity, integrity and accuracy in terms of performance metrics used to specify system performance that is taking into account the GLONASS space and ground control segments while neglecting receiver biases, signal propagation and reception biases. We use the term 'signal-in-space' (SIS) to describe the above mentioned performance parameters. Thus, SIS is an ideal radionavigation signal unaffected by propagation environment (ionosphere, troposphere), UE biases, multipath and interference.

The OS PS describes standards associated with the CSA that is the parameters of the radionavigation field generated by the aggregate of open service FDMA SIS broadcast on L1 and L2. This OS PS applies to the single frequency (L1, L2) and dual frequency (L1/L2) operation modes. It does not address future signals which will be broadcast by the next generation satellites.

1.4 GLONASS OS Definition

The OS is a positioning and timing service with the open access provided by way of the aggregate ranging FDMA signals generated by the GLONASS OC, broadcast at L1 and L2, and whose performance is associated with that of CSA in the GLONASS service volume. At any point of this service volume, a user with the navigation receiver exploiting one–way ranging techniques can determine his state vector (position, velocity vector components as related to the assumed CS, and timing offsets to the user's time scale defined by his receiver's clock). The ranging signals contain navigation data message, whose composition is specified in the current version of the Interface Control Document "Navigational radiosignal in bands L1, L2". The OS with the associated CSA performance is available to any user globally and continuously.

1.5 GLONASS Overview

GLONASS consists of three main subsystems:

- GLONASS Space Vehicle Subsystem which is a segment of the global satellite navigation system (GNSS), including the constellation of navigation SVs placed in the several orbital planes;
- GLONASS Command and Control Subsystem is a segment of GNSS, including the set of the ground–based facilities used to provide command and control of the navigation satellite;
- UE subsystem is a segment of GNSS including the whole variety of GLONASS user receivers.

This document covers system performance associated with the GLONASS CSA that is applicable to the area of responsibility limited to the Navigation Space Vehicle Subsystem and the Command and Control Subsystem. The two GLONASS subsystems are described below.

1.5.1 GLONASS Space Vehicle Subsystem

The GLONASS Space Vehicle Subsystem nominally consists of 24 SVs placed in three roughly circular (e=0±0,01) orbits inclined at 64.8±0.3° to the equator with an altitude of 18,840…19,440 km (the nominal obit altitude is 19,100 km) and the orbital period of 11h 15 min 44 sec ±5 sec. The orbital planes are separated by the 120° right ascension of the ascending node. 8 SVs are equally spaced in each plane with the 45°

argument of latitude. The orbital planes have an argument of latitude displacement of 15° relative to each other. Such constellation configuration provides for continuous global coverage of the Earth's surface and near–Earth space.

The interface between the SVs and the OS receivers includes radio frequency links (figure 1.5.1). Utilizing these links, each GLONASS SV provides NSs in two sub–bands of the L–band (L1 ~ 1,6 GHz, L2 ~ 1,25 GHz).

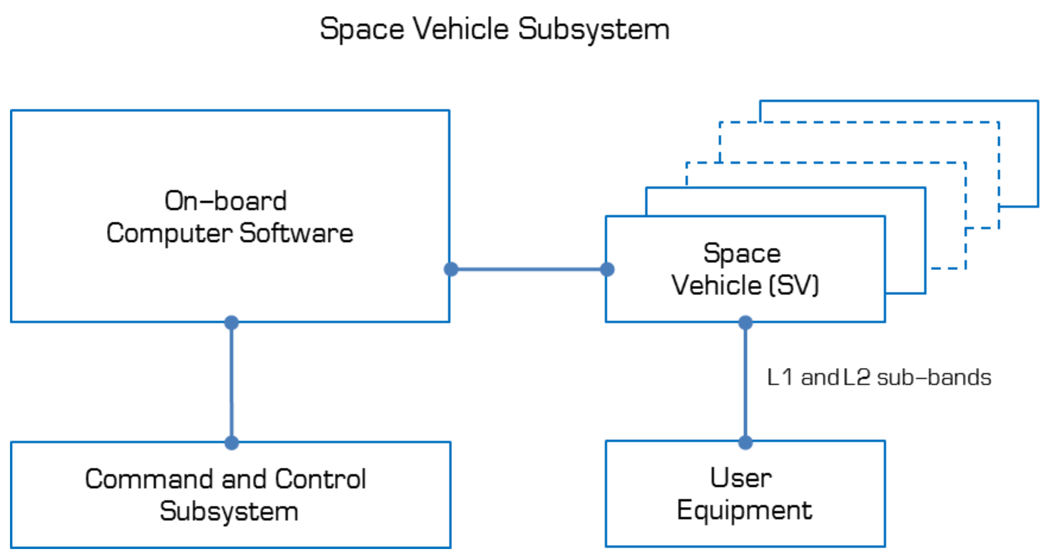

Figure 1.5.1 — Interface between SVs and UE

Each GLONASS SV broadcasts at its own frequencies in L1 and L2 sub–bands. Two SVs contained in the opposite slots of the plane (the antipode SVs) can broadcast at the same frequency.

Each SV broadcasts two types of NS in both the L1 and L2 sub–bands – the open access signal available to any user and the restricted (regulated) access signal available to the authorized users.

The restricted access signals are modulated with the special code (high accuracy code, HA–code) and are not recommended to be used without coordination with the Ministry of Defense of the Russian Federation.

The open access signals are modulated with the open code and available for use by the unlimited number of civil users, including international users.

The NS broadcast by each SV at its own carrier frequency in L1 and L2 sub–bands is a multicomponent BPSK NS. The phase shift keying of the carrier is performed at π radians with the maximum error ±0,2 radians.

The carrier of L1 and the carriers of L1 and L2 are modulated by a binary sequence which is a composite generated by the modulo–2 addition of the pseudo–random noise (PRN) ranging code, the downlink system data (navigation data message), and the auxiliary meander sequence.

The on–board atomic frequency standard is the basis for generation of the above mentioned components of NS.

The PRN ranging code is the sequence of the maximum length shift register (M–sequence) with 1 mses period transmitted at 511 kbps.

The navigation data consists of immediate and non–immediate data. The immediate data refers to the SV broadcasting this data. The non–immediate data (the system almanac) refers to all the SVs within the Space Vehicle Subsystem.

The navigation data is transmitted at 50 bps.

The nominal L1 and L2 carriers are defined using the following equations:

$F_{K1} = f_{01} + K\Delta f_1$;

$F_{K2} = f_{02} + K\Delta f_2$;

where:

K are the numbers of the L1 and L2 carriers:

f_{01} = 1,602 MHz;

Δf_1 = 562.5 kHz for L1;

f_{02} = 1,246 MHz;

Δf_2 = 437.5 kHz for L2.

The performance specifications in this version of the OS PS apply only to users of the GLONASS L1 and L2 open access FDMA signals.

1.5.2 GLONASS Command and Control Subsystem

The GLONASS Command and Control Subsystem is comprised of the System Control Center, the Central Synchronizer, the Tracking, Telemetry and Command Stations including Two–Way Ranging Facilities, Monitor Facilities, and Laser Ranging Facilities.

The GLONASS Command and Control Subsystem includes the following major facilities (Figure 1.4.2):

- System Control Center (SCC);
- Ground Command Facility (GCF);
- Central Synchronizer (CS);
- SIS Monitoring Facilities (SMF);
- Timescale Monitoring Facilities (TMF);
- TT&C Facilities;
- Laser Ranging Facilities (LRF)).

Figure 1.5.2 — The GLONASS Command and Control Subsystem

An overview of the GLONASS Command and Control Subsystem Functions is provided in Figure 1.5.3.

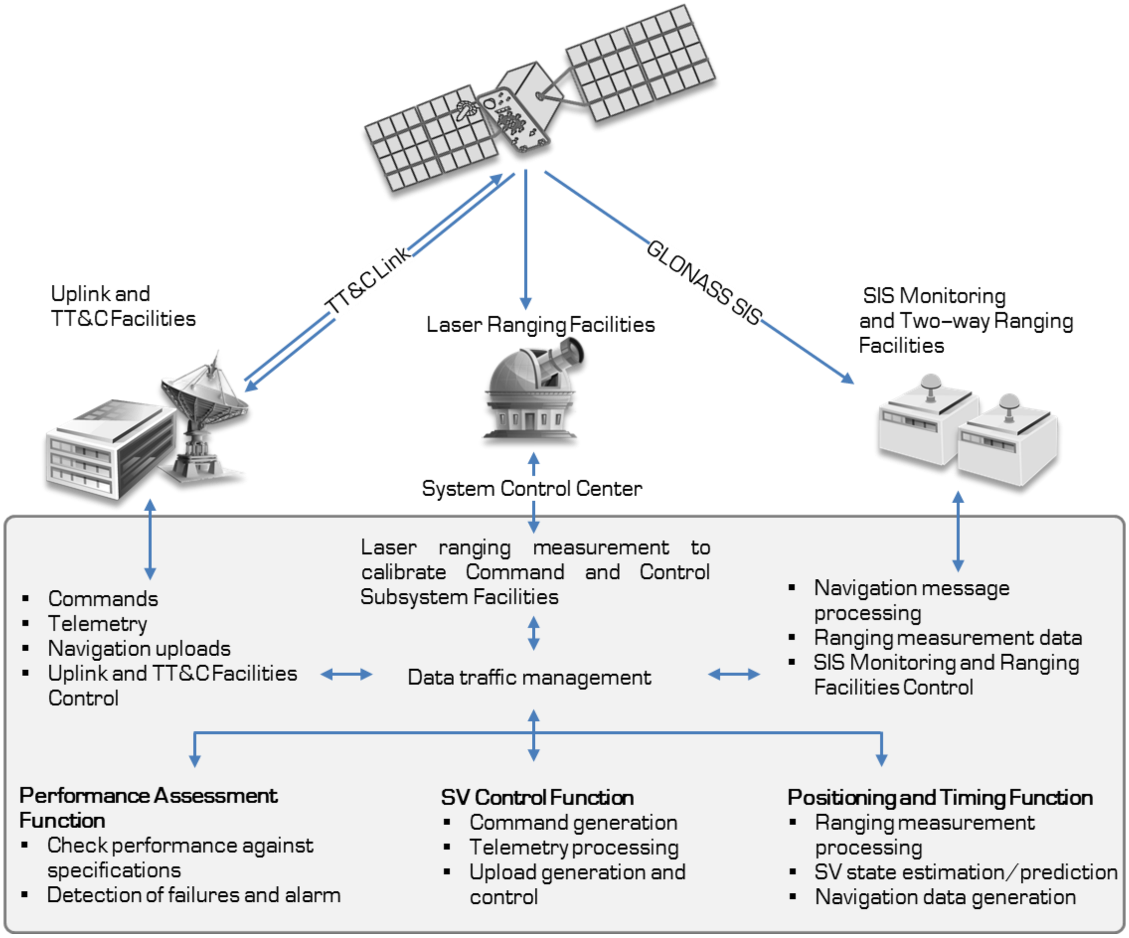

Figure 1.5.3 — Overview of the GLONASS Command and Control Subsystem

The SCC is the central control node for the GLONASS satellite constellation responsible for all aspects of OC continuous command and control, to include:

- routine SV mission control;
- management of GLONASS SIS performance in support of the current version of ICD (The GLONASS Interface Control Document "Navigation radiosignal in band L1, L2" as for the date of approval of this OS PS) and this OS PS;
- navigation message data generation and upload operations as required to sustain performance in accordance with the operational documents and the required SIS parameters;

- timely detecting and responding to GLONASS constellation and Command and Control Subsystem failures.

The Command and Control Subsystem uses TT&C and Uplink Facilities to provide tracking, telemetry and control for the GLONASS SVs, i.e. TT&C interface between each SV and the SCC.

The TT&C Facilities also perform range measurements and range rate measurements (using two–way ranging), to be used to determine a SV's orbit and clock parameters. Simultaneously the Command and Control Subsystem uses a network of distributed SIS Monitoring Facilities (stations). One–way ranging measurements collected by these SMFs are used to calculate a SV's orbit and clock data.

The Command and Control Subsystem in its working zone also continuously monitors the GLONASS SIS performance in real–time.

All the Command and Control Subsystem facilities are located in the Russian Federation, except for the LSF in Uzbekistan. Each GLONASS SV is observable by the Command and Control Subsystem facilities for 13 hours a day, thus during each orbit the SV is not visible for the Command and Control Subsystem for 5.5 hours.

Section 2. CSA SIS Characteristics and Minimum Usage Assumptions

This section provides an overview of the GLONASS interface characteristics specified in the GLONASS ICD and the GLONASS CSA SIS performance characteristics, and the assumptions made as to their usage. The interface characteristics and some CSA SIS performance characteristics (availability, continuity and health) are applicable to both NS and SIS. The other CSA SIS performance characteristics (accuracy, probability of a major service failure) are applicable to SIS only. That is why to avoid ambiguity we will only use the term "signal–in–space" (SIS).

The representative UE characteristics, provided below, are used to provide a framework for defining the CSA SIS performance characteristics. They are not intended to impose any minimum requirements on manufacturers of receivers, employing GLONASS or GLONASS–based systems, although they are necessary attributes to achieve the CSA SIS performance described in this document. UE characteristics used in this standard are required in order to establish a frame of reference in which the CSA SIS performance can be described.

2.1 CSA SIS Interface Control Document (ICD) Requirements

The CSA SIS shall comply with the technical requirements related to the interface between the SV Subsystem and the GLONASS OS UE as established by the current revision of the GLONASS ICD. The OS PS provides a short summary on the GLONASS interface characteristics. In the event of conflict between the CSA SIS interface characteristics described in this document and the ICD (for example, during the period between updates of the documents), defer to the ICD.

2.2 Overview of CSA SIS Interface Characteristics

This section provides an overview of the SPS SIS interface characteristics. SPS SIS interface characteristics are allocated to two categories:

– carrier and modulation radio frequency (RF) characteristics,

– the structure, protocols, and contents of the NAV message.

2.2.1 CSA SIS RF Characteristics

The SVs transmit CSA SIS at the frequency known as L1, L2 as specified in the current version of ICD (Edition 5.1 as to the date of this OS PS approval). The SISs are multicomponent BPSK. The phase shift keying of the carrier is performed at π radians with the maximum error ±0,2 radians. The carriers of L1 and L2 are modulated by a binary sequence which is a composite generated by the modulo–2 addition of the pseudo–random noise (PRN) ranging code, the downlink system data (navigation data message), and the auxiliary meander sequence. The PRN ranging code is the sequence of the maximum length shift register (M–sequence) with 1 msec period transmitted at 511 kbps.

The received SIS power level at the output of a 3dBi linearly polarized antenna is between –161 and –155.2 dBW for L1 sub–band provided that the satellite is observed at an angle of 5° or more. For L2 sub–band received SIS power level is not less than –167 dBW.

SIS broadcast by each GLONASS SV in L1 and L2 is a right–handed circularly polarized. Each GLONASS SV transmits SIS at its own carrier frequency. The SISs are Binary Phase Shift Key modulated (BPSK). The phase shift keying of the carrier is performed at π radians with the maximum error ±0,2 radians. The PRN ranging code is repeated every 1 msec.

The binary sequence, used to modulate the carriers of L1 and L2 of the OS SIS is a composite generated by the modulo–2 addition of:

- pseudo–random noise (PRN) ranging code broadcast at 511 kbps;
- navigation data message broadcast at 50 bps;
- auxiliary meander sequence broadcast at 100 bps.

The total allowable correlation loss due to SV modulation and filtering imperfections, which is a function of signal, shall be less than or equal to 0.8 dB.

The intrasystem interference is caused by the inter–correlation properties of the PRN ranging code and FDMA technique utilized in GLONASS. When receiving SIS at a frequency channel K = n, the interference caused by the SIS transmitted at K = n–1 or K = n+1 frequency channels shall not be reduced by not less than 48 dB as related to the power of the SIS transmitted at K=n provided that the transmitting SVs are visible to a user.

For a particular Space Vehicle (SV), all transmitted signal components are coherently derived from the same on-board frequency source.

See the current version of ICD (Edition 5.1 as to the date of this OS PS approval) for the detailed information on the CSA SIS RF characteristics.

2.2.2 GLONASS OS SIS Navigation Message Characteristics

The GLONASS OS SIS navigation message includes immediate non immediate data.

The immediate data refers to the SV broadcasting SIS and consists of:

- digital tag of SV time;
- SV time to GLONASS time offset;
- relative offset of the broadcast SIS carrier to the nominal value;
- SV ephemerides and other parameters.

The non-immediate data includes system almanac covering:

- almanac for all SVs (status almanac);
- each SV time to GLONASS time offset (phase almanac);
- all SVs orbit parameters (orbit almanac);
- GLONASS time to UTC(SU) offset and other parameters.

The navigation message is transmitted as a stream of digital data coded by the Hamming code and translated into the relative code. Structurally the data stream is generated as continuously repeated superframes. A superframe consists of frames, and a frame consists of strings. The boundaries of strings, frames and superframes for different GLONASS SVs are synchronized with an error of less than 2 msec.

A superframe is of 2.5 min duration and consists of 5 frames. A frame is of 30 sec duration and consists of 15 strings. A sting is of 2 sec duration. A superframe carries the full set of non-immediate data (almanac) for all the 24 SVs. The superframe content overview is provided in Figure 2.2.1.

The frame is a part of the supeframe. It is of 30 sec duration and consists of 15 strings of 2 sec each. The frame carries the full set of the immediate data for the broadcasting SV and the limited set of non-immediate data. Frames 1 to 4 data is identical. Strings 1 to 4 data is related to the broadcasting SV (immediate data). This data is the same for each data frame within a superframe. Strings 6 to 15 data contain non–immediate data (almanac) for 24 SVs: for 5 SVs in frames 1 to 4 and for 4 SVs if frame 5. Non–immediate data (almanac) for one SV occupies two strings. String 5 data within a frame relates to non–immediate data and is repeated in each frame within a superfame.

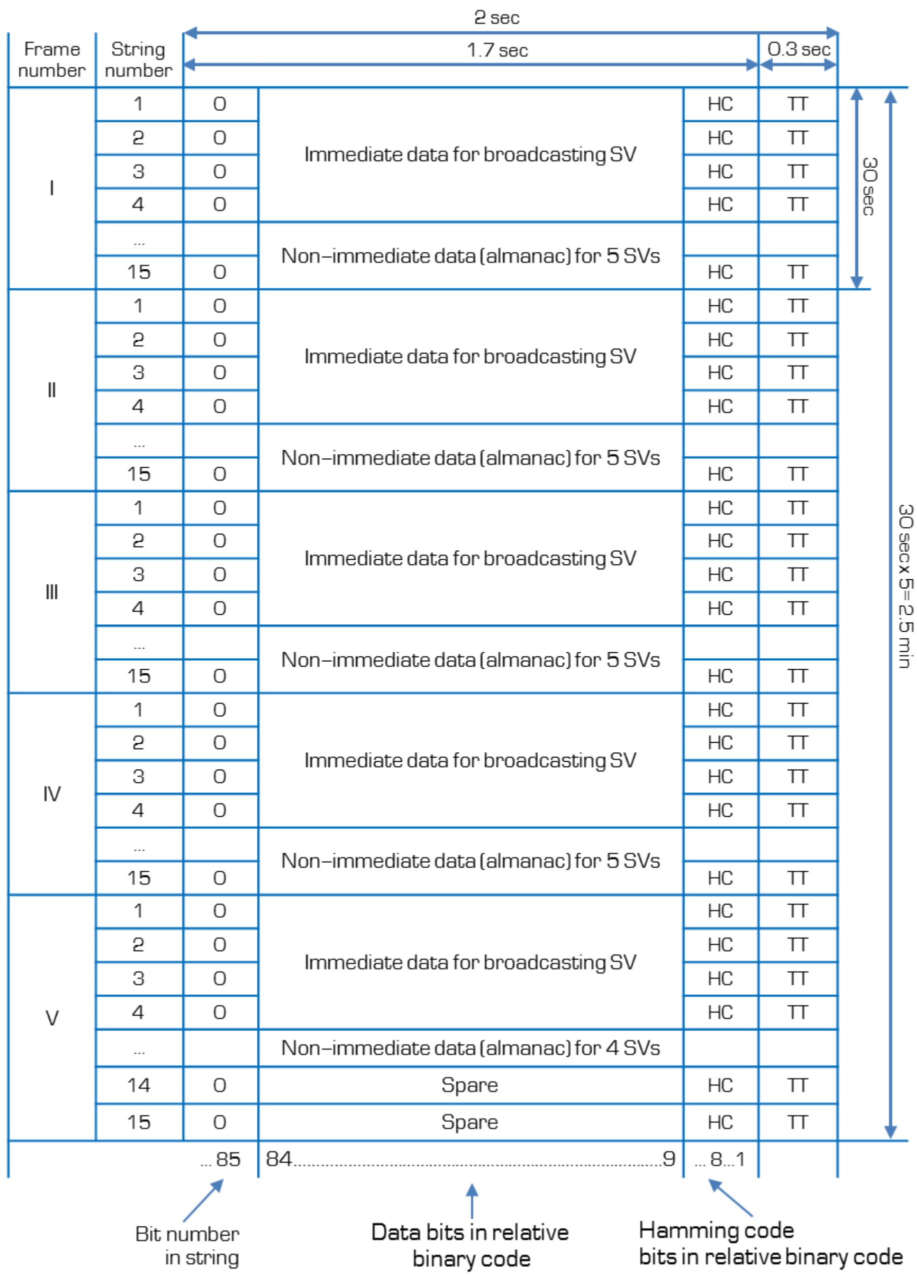

Figure 2.2.1 — Superframe content and overview

The distribution of almanac between frames is provided in Table 2.2.1.

Table 2.2.1 — Distribution of GLONASS almanac between frames within a superframe

Frame Number	Number of SV for which almanac is broadcast
1	1 – 5
2	6 – 10
3	11 – 15
4	16 – 20
5	21 – 24

The GLONASS Command and Control Subsystem periodically determines ephemerides of SVs and uploads them to all SVs.

See the current version of ICD (Edition 5.1 as to the date of this OS PS approval) for the detailed information on the navigation frame and message.

2.3 Overview of CSA SIS Performance Characteristics

The GLONASS CSA SIS performance characteristics are described below. The CSA SIS performance characteristics are health, availability, accuracy, probability of a major service failure, continuity, and UTC(SU) accuracy.

This overview of the CSA SIS performance characteristics follows a logical progression relative to the output of the CSA SIS from a SV. Most fundamentally, a SV's CSA SIS is considered either trackable or untrackable. A trackable SIS is a SIS which can be preprocessed by a user receiver sufficiently to be categorized as either healthy or unhealthy. Note that only a trackable and healthy CSA SIS has performance standards for accuracy, probability of a major service failure, and continuity. The last characteristic in this section relating GLONASS time to UTC(SU) applies at the system level and is independent of the output of the CSA SIS from any particular SV.

2.3.1 CSA SIS Health

The CSA SIS Health is the status given by the real–time health–related information broadcast by each SV as an integral part of the CSA SIS. The CSA SIS Performance Standard will look at two SIS health conditions as given below:

- Healthy SIS: The CSA SIS health is healthy when all of the following conditions are present simultaneously:
  - The transmitted L1 OS SIS is trackable,
  - The transmitted L2 OS SIS is trackable (only when assessing performance of L1/L2 dual frequency operation),
  - SIS broadcasts a navigation message of the specified structure and with the specified content,
  - SV is indicated as healthy in the immediate ephemeris and clock data,
  - SV is indicated as healthy in almanac.
- Unhealthy SIS: The CSA health is unhealthy when any one or more of the following conditions is or are present:
  - No SV's ephemerides are present,
  - Ephemerides unhealthy flag is present,
  - SV is indicated as unhealthy in almanac,
  - The transmitted L1 OS SIS is not trackable;
  - The transmitted L2 OS SIS is not trackable (only when assessing performance of L1/L2 dual frequency operation).

To summarize the above, a healthy SIS is always trackable, but a trackable SIS is not necessarily healthy. An unhealthy SIS can either be trackable or untrackable.

2.3.2 CSA SIS Availability

The CSA SIS Availability is the probability that the slots in the GLONASS constellation will be occupied by operational SVs transmitting a trackable and healthy CSA SIS. For this OS PS, there are two components of availability as follows:

- SIS Per-slot Availability. The ability of the system to sustain a SV that is transmitting a healthy SIS in an operational slot. The characteristic describes the fraction of time at a specified interval that a slot in the GLONASS nominal constellation will be occupied by a SV that is transmitting a trackable and healthy CSA SIS,
- SIS Constellation Availability. The ability of the system to sustain a specified number of SVs transmitting a healthy CSA SIS to maintain specified PDOP characteristics. The characteristic describes the

fraction of time that a specified number of slots in the GLONASS nominal constellation are occupied by SVs that are transmitting a trackable and healthy CSA SIS.

There are spare SVs in the GLONASS System. The spare SVs are represented by SVs that do not occupy the slots in the constellation but reside in the neighborhood of the operational slots. These SVs are not present in the almanac and do not transmit a healthy SIS. The spare SVs can be introduced into the orbital constellation in timely manner to substitute a failed SV (or SVs removed from service). The spare SVs are not subject for this OS PS. Their performance characteristics can only be assessed as they are introduced into the nominal orbital constellation.

2.3.3 CSA SIS Accuracy

The CSA SIS Accuracy is described in two statistical ways; one way is as the 95th percentile (95% Global Average SIS user range error (URE) at the ergodic interval, the other is as the limit 95% Global Average SIS URE and the worst point SIS URE provided the specified level of reliability. Other accuracy-related CSA SIS performance parameters include the SIS User Range Rate Error (URRE) defined as the 95% Global Average SIS URRE and the SIS User Range Acceleration Error defined as the 95% Global Average SIS URAE.

2.3.4 Probability of a Major Service Failure for CSA SIS

The Probability of a Major Service Failure for CSA SIS is a simplified characteristic of integrity. In contrast to integrity this characteristic lacks such component as the time to alert and the not-to-exceed tolerance is made not on the position accuracy but on the SIS URE. This particular characteristic was chosen because of the lack of the GNSS facilities to be used for alerting on the loss of integrity in timely manner (with characteristics required for safety critical applications). The safety critical applications are those connected with the safety-of-life applications. The main means for enabling integrity are the Receiver Autonomous Integrity Monitoring and the GNSS augmentations like SBAS. The Probability of a Major Service Failure can be used as input data for testing the above mentioned augmenting techniques.

The term “Major Service Failure” is introduced in the Annex 10 SARPs ICAO for GLONASS and correlates with the ICAO risk classification (the Safety Management Manual, Doc. 9859), that is the Major Service Failure may lead to a complete failure of significant/major on-board systems or result in emergency procedures. The Major

Service Failure for CSA SIS is defined as an event over a specified time interval during which a SV health indication in the navigation message is false, that is the SIS's instantaneous URE exceeds the tolerance limit without a timely indication of unhealthy SV being issued.

This OS PS provides the following characteristics of the Major Service Failure – the Probability of a Major Service Failure and a not-to-exceed (NTE) tolerance on the SIS URE.

Probability of a Major Service Failure for CSA SIS. Defined as a percentage of time when the healthy CSA SIS's instantaneous URE exceeds the SIS URE NTE tolerance.

SIS URE NTE Tolerance. The healthy CSA SIS NTE Tolerance is 70 m. It is not specified for unhealthy CSA SIS.

2.3.5 CSA SIS Continuity

The CSA SIS Continuity is the probability that the healthy SV will continue to be healthy without unscheduled interruption over a specified time interval. Scheduled interruptions which are announced at least 48 hours in advance do not contribute to a loss of continuity. Scheduled CSA SIS interruptions are announced by way of the System Control Center issuing a "Notice Advisory to GLONASS Users" (NAGU) – on-line bulletins issued at the official websites of the Roscosmos State Corporation — www.glonass-center.ru, and the Russian Ministry of Defense — www.glonass-svoevp.ru.

2.3.6 CSA SIS UTC(SU) Accuracy

The CSA SIS UTC(SU) Accuracy for a healthy CSA SIS is defined to be the 95% error in UTC(SU) – GLONASS Time offset contained in that SPS SIS relative to the true offset value over a specified time interval.

2.4 Overview of CSA SIS Performance Characteristics in Position/Time Domain

Below is the overview of the CSA SIS Performance Characteristics in Position/Time Domain – PDOP Availability, Position Service Availability and Position/Time Service Accuracy.

The GLONASS CSA PDOP Availability is the ability of the GLONASS System to maintain position dilution of precision (PDOP) standard. PDOP is assessed using healthy

CSA SISs. The CSA PDOP Availability is a fraction of time at a specified interval when the PDOP obtained using healthy CSA SISs, is equal to or below the specified value. PDOP is the magnifying effect on GLONASS position error induced by mapping URE into a position solution within the specified coordinate system, through the relative SV–to–SV geometry.

The GLONASS CSA Position Service Availability is the ability of the GLONASS System to provide position/time solution in UE meeting the specified standard. This OS PS addressed two components of the Position Service Availability, namely:

- Horizontal Service Availability, which is a fraction of time at a specified interval when the horizontal position accuracy is equal to or below a specified value,
- Vertical Service Availability which is a fraction of time at a specified interval when the vertical position accuracy is equal to or below a specified value.

The OS PS addresses two Position/Time Service Accuracy characteristics in this Section. These are:

- CSA Positioning Accuracy defined by two components:
  - 95% Global Average Horizontal (Vertical) Error over a specified interval,
  - 95% Worst Site Horizontal (Vertical) Error Accuracy over a specified interval.
- CSA Time Accuracy defined as Global Average Time Transfer Error over a specified interval with a specified reliability.

2.5 Usage Assumptions for CSA Performance Standards

This OS PS is conditioned upon certain assumptions regarding use of the CSA SIS. Those assumptions are as follows.

2.5.1 CSA User

This OS PS assumes an OS CSA user with an CSA receiver.

This OS PS assumes the GLONASS receiver complies with the technical requirements related to the interface between the GLONASS Space Vehicle Subsystem and CSA receivers as established by the current version of ICD (Edition 5.1 as to the date of approval of this OS PS).

2.5.2 L1, L2 SIS

This OS PS assumes the GLONASS receiver is tracking, processing, and using the SISs transmitted by the GLONASS SVs in L1, L2 sub-bands. Pseudorange measurements are assumed to be made by SIS code tracking. Carrier phase measurement processing is not assumed.

2.5.3 Use of CSA SIS

This OS PS assumes a GLONASS receiver will only consider using a CSA SIS whose health status is indicated as healthy.

2.5.4 SV Health Data

2.5.4.1 SV Health Data

This OS PS assumes a GLONASS receiver will determine a SV health status using a set of real-time health-related information broadcast by that SV or any other SV as part of the CSA SIS (in its immediate data and in its almanac). In accordance with the GLONASS ICD a GLONASS receiver shall determine a SV health status using both the immediate and non-immediate navigation message data.

2.5.4.2 Timely Application of SPS SIS Health Information

This OS PS assumes a GLONASS receiver will monitor, process, and apply the real-time health-related information transmitted by each SV each time the information is transmitted. For real-time health-related information broadcast as part of the navigation message data, the assumed time of application is 2.0 seconds after the end of the navigation message frame which contains the particular piece of real-time health-related information.

2.5.5 Excluded Errors

The performance standards in Section 3.0 of this OS PS do not take into consideration any error source that is not under direct control of the Space Vehicle Subsystem and the Command and Control Subsystem. Specifically excluded errors include those due to the effects of:

- CSA SIS distortions caused by ionospheric and/or tropospheric scintillation
- Residual receiver ionospheric delay compensation errors
- Residual receiver tropospheric delay compensation errors

- Receiver noise (including received signal power and interference power)
- Receiver hardware/software faults
- Multipath of SIS propagation
- User antenna effects
- Operator (user) error.

Section 3. CSA SIS Performance Standards, Conditions and Constrains

This section establishes CSA SIS performance standards for GLONASS.

3.1 Overview

The CSA SIS performance is specified in terms of minimum performance standards for each performance parameter. Each standard includes a definition of conditions and constraints applicable to the provision of the specified service. The phrase "any healthy CSA SIS", when listed as a condition or constraint for any of the performance standards in this section, refers to the individual signal–in–space transmission from each SV.

The detailed formalized CSA performance parameters calculation methods are provided in Appendix A.

CSA SIS performance standards do not include any element not under the direct control of the GLONASS Command and Control/Space Vehicles Subsystems. Any performance parameters not specified in this section are not considered to be part of the CSA SIS performance standards.

These CSA SIS performance standards do not directly represent the end performance that users will experience. This OS PS establishes the GLONASS performance standards that, when combined with a SIS reception environment and assumptions concerning the GLONASS receiver, allow users to define for themselves the end performance they can expect for their particular application.

These metrics have little direct meaning to the average end user (e.g., pilot, navigator, driver), but they are absolutely essential for GNSS receiver designers, system integrators, application engineers, infrastructure and augmentation system developers, and space vehicle/command and control subsystems operators.

3.2 Nominal Constellation Definitions

The GLONASS nominal orbital constellation consists of 24 slots in three orbital planes with eight slots per plane. The GLONASS space vehicles will be placed in the orbital slots defined by Table 3.2.1. The reference orbit parameters for the GLONASS SVs are provided in Table 3.2.2. Slots for the GLONASS nominal OC are specified in terms of the Right Ascension of the Ascending Node (RAAN, (Ω)) and the Argument of

Latitude (u) for a defined epoch. Tables 3.2.1 и 3.2.2 define the nominal, properly geometrically spaced 24–slot constellation for GLONASS.

Table 3.2.1 — 24–Slot Constellation Slot Assignments as of the Defined Epoch.

Slot	Ω, deg	u, deg	Slot	Ω, deg	u, deg
1	251º15'00"	145º26'37"	13	11º15'00"	340º26'37"
2	251º15'00"	100º26'37"	14	11º15'00"	295º26'37"
3	251º15'00"	55º26'37"	15	11º15'00"	250º26'37"
4	251º15'00"	10º26'37"	16	11º15'00"	205º26'37"
5	251º15'00"	325º26'37"	17	131º15'00"	175º26'37"
6	251º15'00"	280º26'37"	18	131º15'00"	130º26'37"
7	251º15'00"	235º26'37"	19	131º15'00"	85º26'37"
8	251º15'00"	190º26'37"	20	131º15'00"	40º26'37"
9	11º15'00"	160º26'37"	21	131º15'00"	355º26'37"
10	11º15'00"	115º26'37"	22	131º15'00"	310º26'37"
11	11º15'00"	170º26'37"	23	131º15'00"	265º26'37"
12	11º15'00"	25º26'37"	24	131º15'00"	220º26'37"

Note: Reference epoch: 00^h 00^m 00^s UTC (SU) 1 January 1983

Note that the actual constellation RAAN values will change over each SV's lifetime due to perturbation forces and precession rate of orbital planes. The mean precession rate is $-0.59251 \cdot 10^{-3}$ rad/day.

Table 3.2.2 — Reference Orbit Parameters

Reference orbit parameter	Nominal Value	Operational Range
Semi–Major Axis, km	25508.2	–
Eccentricity	0	0 – 0.005
Inclination, deg	64.8	±3
RAAN, deg	See Table 3.2.1	±180
Argument of Perigee, deg	0.0	±180
Argument of Latitude, deg	See Table 3.2.1	±180

Note: The semi–major axis value reflects the unperturbed SV orbit with the period equal to the nominal draconic period (40,544 sec). The draconic period tolerance is ±0.5 s.

The repeatability interval for SVs' tracks and zones of radiovisibility of SVs by the ground control facilities is 17 orbits (7 days 23 hours 27 min 28 sec).

The maximum SV drift as related to the ideal position in orbit is ±5 degrees.

3.3 CSA SIS Coverage

This section provides the CSA SIS coverage standards.

There are two components of CSA SIS coverage: (1) the per–slot coverage, and (2) the 24–slot constellation coverage. These two components are interrelated.

The per–slot coverage is defined as the volume of space in which the SIS from one particular SV is transmitted and the CSA SIS performance is assessed. The per–slot coverage depends primarily on the satellite antenna subsystem design, the on–orbit satellite pointing accuracy, and the satellite altitude (where the allowed range of satellite altitudes is defined by the 24–slot constellation architecture).

The constellation coverage is defined as the volume of space covered by the aggregate of SISs transmitted by all the SVs of the constellation, in which the CSA SIS performance is assessed. The constellation coverage depends primarily on the per–slot coverage coupled with the nominal 24–slot constellation architecture.

3.3.1 Per–slot coverage

The service volume for per–slot coverage comprises the portion of the near–Earth region which extends from the surface of the Earth up to an altitude of 2,000 km above the surface of the Earth which is visible from the satellite's orbital position. The per–slot coverage performance standards apply at the worst–case SV antenna pointing angle relative to the Earth.

The extended service volume for per–slot coverage comprises the near–Earth region which extends from an altitude of 2,000 km above the surface of the Earth up to and including 36,000 km above the Earth's surface which is visible from the SV's orbital position.

The per–slot coverage shall be as specified in Table 3.3.1.

Таблица 3.3.1 — CSA SIS Per–Slot Coverage Standards

SIS Per–Slot Coverage Standard	Conditions and Constraints
Service volume: • 100%–Coverage Extended service volume: • No coverage performance specified	• For any operational SV irrespective of its health status

Note: The per–slot coverage is also characterized by the minimum user–received CSA SIS power levels for the service volume which are specified in the current version of ICD (Edition 5.1 as to the date of approval of this OS PS).

The minimum received SIS power level at the output of a 3dBi linearly polarized antenna is –161 for L1 and –167 dBW for L2 at viewing angles above 5 degrees above the local horizon.

3.3.2 Constellation Coverage

The service volume for the constellation coverage comprises the entire surface of the Earth and the near–Earth region which extends from the surface of the Earth up to an altitude of 2,000 km above the surface of the Earth.

The extended service volume for the constellation coverage comprises the near–Earth region which extends from an altitude of 2,000 km above the surface of the Earth up to and including 36,000 km above the Earth's surface.

The constellation coverage shall be as specified in Table 3.3.2.

Table 3.3.2 — CSA SIS Nominal 24–satellite Constellation Coverage Standards.

SIS Constellation Coverage Standards	Conditions and Constrains
Service volume: • 100%–Coverage Extended service volume: • No coverage performance specified	• For any operational SV irrespective of its health status

3.4 CSA SIS Accuracy

This section provides the CSA SIS accuracy standards. The CSA SIS accuracy standards apply to the SIS portion of the GLONASS error budgets for the user equivalent range error (UERE).

There are four main aspects of CSA accuracy. The standards for each of these aspects are given in this section. The four main aspects are:

- the pseudorange data set accuracy (i.e., "SIS User Range Error" or SIS URE)
- the time derivative of the URE (i.e., "User Range Rate Error" or SIS URRE)
- the second time derivative of URE (i.e., "User Range Acceleration Error" or SIS URAE)
- The UTC(SU) – GLONASS Time Offset Error (UTCOE).

The standards for each of the four main aspects of CSA SIS accuracy are given in terms of a "global average". In this case, "global average" means instantaneous root–mean–square (rms) across the portion of the globe in view of one SV at a specified instant. Then a statistic parameter is assessed using an aggregate of instantaneous global averages. Most of the CSA SIS performance standards in this section are expressed at the 95% probability level over an interval of 1 to 30 days. 95% global average can by assessed either for every SV separately or for the constellation.

When assessing threshold SIS URE with a specified reliability level, the worst site SIS URE is also used along with the global average SIS URE. The worst site SIS URE is assessed as a maximum SIS URE across a specified portion of the globe at a specified instant. The detailed information on assessment global average SIS URE and worst site SIS URE is provided in Section B.1 of Appendix B.

The CSA SIS accuracy standards given in the following tables apply to the CSA SIS from healthy SVs.

Notes:

1. *The accuracy performance standards do not apply beyond the defined bounds of CSA SIS coverage (see Section 3.3).*
2. *The ergodic period is defined as an interval sufficient to accumulate the representative sampling that is it contains the minimum number of samples sufficient for the independent performance assessment over any period which is greater than ergodic period.*
3. *The SIS URE ergodic period is 30 days for each SV. The SIS URE ergodic period for the constellation is 1 day.*

3.4.1 CSA SIS URE Accuracy Standards

The CSA SIS URE accuracy shall be as specified in Table 3.4.1.

Table 3.4.1 — CSA SIS URE Accuracy Standards

SIS Accuracy Standard	Conditions and Constrains
Single frequency (L2): • ≤ 11.7 m 95% Global Average SIS URE for any healthy SIS	• For any healthy SIS • Based on measurement interval of 30 days • Neglecting ionospheric errors
Dual frequency L1/L2: • ≤ 11.7 m 95% Global Average SIS URE for any healthy SIS	• For any healthy SIS • Based on measurement interval of 30 days • Neglecting intra–frequency and inter–frequency delay errors induced by satellite on–board equipment and receiver
Single frequency L1 (L2): • ≤ 7.8 m 95% Global Average SIS URE over all healthy SIS over 1 day interval	• Over all healthy SIS • Based on measurement interval of 1 day • Neglecting ionospheric errors
Dual frequency L1/L2: • ≤ 7.8 m 95% Global Average SIS URE over all healthy SIS	• Over all healthy SIS • Based on measurement interval of 1 day • Neglecting intra–frequency and inter–frequency delay errors induced by satellite on–board equipment and receiver

SIS Accuracy Standard	Conditions and Constrains
Single frequency L1 (L2): • ≤ 18 m 99.37% Global Average SIS URE • ≤ 18 m 99.14% Worst Case Single Point Average SIS URE)	• For any healthy SIS • Based on measurement interval of one year; average of daily values within the service volume • Neglecting ionospheric errors
Dual frequency L1/L2: • ≤ 18 m 99.37% Global Average SIS URE • ≤ 18 m 99.14% Worst Case Single Point Average SIS URE	• For any healthy SIS • Based on measurement interval of one year; average of daily values within the service volume • Neglecting intra-frequency and inter-frequency delay errors induced by satellite on-board equipment and receiver

Notes:

1. This OS PS establishes SIS URE standards irrespective of AOD. The "Irrespective of AODs", performance standards are the ones which are the most directly representative of the URE experienced by CSA receivers.

2. The ≤ 7.8 m 95% Global Average SIS URE over all healthy SIS is equivalent to a ≤ 4.0 m rms SPS SIS URE performance standard, assuming a normal distribution with zero mean.

3. It is possible to use the single frequency L2 only. In this case, the L1-L2 inter-frequency delay correction shall be accounted for, which is broadcast as a part of the CSA SIS as per the ICD.

4. There can be differences in calibration of mission facilities used to calculate the orbit and clock data and the great variety of receivers. That is why an inter-frequency delay correction broadcast as a part of the CSA SIS is less effective than calibration of receivers. Thus the dual frequency SIS Accuracy Standards are provided for the calibrated receivers neglecting intra-frequency and inter-frequency delay errors induced by satellite on-board equipment and receivers.

3.4.2 CSA SIS URRE Accuracy Standards

The CSA SIS URRE accuracy shall be as specified in Table 3.4.2.

Table 3.4.2 — CSA SIS URRE Accuracy Standards

SIS URRE Accuracy Standard	Conditions and Constrains
• $\leq$ 0.014 m/sec 95% Global Average SIS URRE	• For any healthy CSA SIS • Based on measurement interval of 30 days • Neglecting all perceived pseudorange rate errors attributable to pseudorange step changes caused by navigation message data cutovers

Note: The normal operations performance standards are consistent with a GLONASS SV's clock stability over the 3-sec interval.

3.4.3 CSA SIS URAE Accuracy Standards

The CSA SIS URAE accuracy shall be as specified in Table 3.4.3.

Table 3.4.3 — CSA SIS URAE Accuracy Standards

SIS URAE Accuracy Standard	Conditions and Constrains
• $\leq$ 0.005 m/sec/sec 95% Global Average SIS URAE	• For any healthy CSA SIS • Neglecting all perceived pseudorange acceleration errors attributable to pseudorange step changes caused by navigation message data cutovers • Based on measurement interval of 30 days

Note: The normal operations performance standards are consistent with a GLONASS SV's clock stability over the 3-sec interval.

3.4.4 CSA SIS UTCOE Accuracy Standards

The CSA SIS UTCOE accuracy shall be as specified in Table 3.4.4.

Table 3.4.4 —CSA SIS UTCOE Accuracy

CSA SIS UTCOE Accuracy Standard	Conditions and Constrains
• $\leq$ 40 nsec 95% Global Average UTCOE	• For any healthy CSA SIS • Based on measurement interval of 30 days

3.5 Probability of a Major Service Failure for CSA SIS

3.5.1 Probability of a Major Service Failure for CSA SIS URE

The Probability of a Major Service Failure for CSA SIS URE shall be as specified in Table 3.5.1.

Table 3.5.1 — Probability of a Major Service Failure for CSA SIS URE

Probability of a Major Service Failure for CSA SIS URE Standard	Conditions and Constrains
For the single independent loss (Psat): • $\leq 10^{-4}$ Probability of the CSA SIS Instantaneous URE Exceeding the NTE Tolerance	• An average for all healthy SVs • Based on measurement interval of 1 year • CSA SIS URE NTE tolerance defined to be 70 m • Worst case for delayed alert is 16 hours
For the simultaneous loss of two or more SVs (Pconst): • $\leq 10^{-4}$ Probability of the CSA SIS Instantaneous URE Exceeding the NTE Tolerance	• An average for all healthy SVs • Based on measurement interval of 1 year • CSA SIS URE NTE tolerance defined to be 70 m • Worst case for delayed alert is 16 hours

Notes:

1. *Following the acceptance of the GLONASS into nominal operation, the Probability of the CSA SIS Instantaneous URE Exceeding the NTE Tolerance due to the simultaneous loss of two or more SVs shall be* $\le 1 \cdot 10^{-4}$.
2. *The Probability of the CSA SIS Instantaneous URE Exceeding the NTE Tolerance due to the loss of two or more SVs is based on the specified measurement interval starting in 2010. The choice for start of the measurement interval is connected to the completion of the ground control facilities modernization phase.*

3.5.2 Probability of a Major Service Failure for CSA SIS URRE

The Probability of a Major Service Failure for CSA SIS URRE shall be as in Table 3.5.2.

Table 3.5.2 — Probability of a Major Service Failure for CSA SIS URRE

Probability of a Major Service Failure for CSA SIS URRE Sandard	Conditions and Consrains
• No Performance Specified	• A future version of this OS PS may establish a standard

Note: Short–term fluctuations in the ionosphere can produce very large CSA SIS instantaneous URREs.

3.5.3 Probability of a Major Service Failure for CSA SIS URAE

The Probability of a Major Service Failure for CSA SIS URAE shall be as specified in Table 3.5.3.

Table 3.5.3 — Probability of a Major Service Failure for CSA SIS URAE

Probability of a Major Service Failure for CSA SIS URAE Stanadard	Conditions and Constrains
• No Performance Specified	• A future version of this OS PS may establish a standard

Note: Short–term fluctuations in the ionosphere can produce very large CSA SIS instantaneous URAE.

3.6 CSA SIS Continuity

This section provides the CSA SIS continuity standards. The CSA SIS continuity for a healthy CSA SIS is the probability that the CSA SIS will continue to be healthy without unscheduled interruption over a specified time interval.

Planned interruptions of the CSA are subject to a minimum of 48–hour advance notice provided by the Command and Control Subsystem to the Civil Users Support Systems. Unscheduled interruptions resulting from system malfunctions or maintenance occurring outside the scheduled period will be announced to the Civil Users Support Systems as soon as possible. Scheduled interruptions which are announced at least 48 hours in advance do not constitute a loss of continuity.

3.6.1 CSA SIS Continuity Standards – Unscheduled Interruptions

The CSA SIS continuity for the composite of all unscheduled interruptions in service shall be as specified in Table 3.6.1.

Table 3.6.1 — CSA SIS Unscheduled Interruption Continuity Standards

SIS Continuity Standard	Conditions and Constrains
• ≥ 0.998 Probability Over Any Hour of Not Losing the SPS SIS Availability from a Slot Due to Unscheduled Interruption	• An average for all SIS in OC • Based on measurement interval of 1 year • Given that the CSA SIS is available from the slot at the start of the hour

3.6.2 CSA SIS Scheduled and Unscheduled Interruptions Reporting Standards

The CSA SIS Scheduled and Unscheduled Interruptions Reporting Standards shall be as specified in Table 3.6.2.

Table 3.6.2 — CSA SIS Scheduled and Unscheduled Interruptions Reporting Standards

CSA SIS Scheduled and Unscheduled Interruptions Reporting Standard	Conditions and Constrains
Scheduled interruptions: • Appropriate notice advisory issued to the Information and Analysis Center for Positioning, Navigation and Timing (PNT IAC of the Central Research Institute of Machine Building) and the SPOCD of the Russian Ministry of Defense at least 48 hours prior to the event	• For any healthy SIS
Unscheduled interruptions (system failures, malfunctions influencing CSA SIS, etc.): • Appropriate notice advisory issued to the PNT IAC and SPOCD as soon as possible after the event F	• For any healthy SIS

Note:Unscheduled maintenance interruptions may be classified in a future version of this OS PS (long–term hard failures, short term hard failures, and soft failures).

3.7 CSA SIS Availability

This section provides the CSA SIS availability standards.

There are two components of CSA SIS availability:

- SIS Per–slot Availability. The characteristic describes the fraction of time over a specified interval that a slot in the GLONASS nominal constellation will be occupied by a SV that is transmitting a trackable and healthy CSA SIS.
- SIS Constellation Availability. The characteristic describes the fraction of time that a specified number of slots in the GLONASS nominal constellation are occupied by SVs that are transmitting trackable and healthy CSA SIS.

3.7.1 CSA SIS Per–slot Availability Standards

The CSA SIS per–slot availability shall be as specified in Table 3.7.1.

Table 3.7.1 — CSA SIS Per–Slot Availability Standards

SIS Per–Slot Availability Standard	Conditions and Constrains
• ≥ 0.95 Probability that a Slot will be Occupied by a SV Broadcasting a Healthy CSA SIS	• an average over all slots in the constellation • based on measurement interval of 1 year

3.7.2 CSA SIS Constellation Availability

The CSA SIS constellation availability shall be as specified in Table 3.7.2.

Table 3.7.2 — CSA SIS Constellation Availability Standards

SIS Constellation Availability Standard	Conditions and Constrains
• ≥ 0.98 Probability that at least 21 Slots will be Occupied Either by a Satellite Broadcasting a Healthy CSA SIS	• based on measurement interval of 1 year

3.8 CSA Position/Time Domain Standards

This section provides the CSA position/time domain performance standards.

CSA position/time domain performance standards are based on a specific set of user assumptions. The user assumptions include the error exclusions identified in paragraph 2.5.4 as well as the following CSA receiver assumptions.

The use of a representative SPS receiver that:

- is designed in accordance with the GLONASS Interface Control Document "Navigation radiosignal in band L1, L2" as for the date of approval of this OS.
- is tracking the CSA SIS from all SVs in view above a 5° mask angle with respect to the local horizon (no local obscura are considered). It is assumed

the receiver is operating in a nominal noise environment that does not interrupt receiver acquisition and tracking capabilities.

- accomplishes satellite position and geometric range computations in the most current realization of the Earth–Centered, Earth–Fixed (ECEF) coordinate system (PZ–90.11 for the time of approval of this OS PS).
- generates a position and time solution from data broadcast by all SVs in view.
- processes the health–related information in the SIS and excludes unhealthy SISs from the position solution.
- ensures the use of up–to–date and internally consistent ephemeris and clock data for all SVs it is using in its position solution.
- is operating at a surveyed location (for a time transfer receiver).

As specified in paragraph 2.5.5 the position standards are established for the characteristics regardless the propagation medium and receiver induced biases. The resulting error budget for dual frequency operations will not be notably influenced by the residual errors of ionosphere–free combination. While the resulting error budget for single frequency operations, will significantly be affected by ionospheric errors.

3.8.1 PDOP Availability Standards

The commitments for maintaining the constellation (Sections 3.2 and 3.7) and coverage (Section 3.3) result in support for position dilution of precision (PDOP) standards as presented in Table 3.8.1. PDOP is the magnifying effect on GLONASS position error induced by mapping URE into a position solution within the specified coordinate system, through the relative SV–to–SV geometry.

Table 3.8.1 — PDOP Availability Standards

PDOP Availability Standard	Conditions and Constrains
• $\geq$ 0.98 global PDOP of 6 or less • $\geq$ 0.84 worst site PDOP of 6 or less	• Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24–hour interval.

3.8.2 Position Service Availability Standards

The commitments for maintaining PDOP (Table 3.8.1) and CSA SIS URE accuracy (Table 3.4.1) result in support for position service availability standards as presented in Table 3.8.2.

Table 3.8.2 — Position Service Availability Standards

Position Service Availability Standard	Conditions and Constrains
• ≥ 0.99 Horizontal Service Availability, average location • ≥ 0.99 Vertical Service Availability, average location	• 12 m horizontal (SIS only) 95% threshold • 25 m vertical (SIS only) 95% threshold • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval
• ≥ 0.90 Horizontal Service Availability, worst-case location • ≥ 0.90 Vertical Service Availability, worst-case location	• 12 m horizontal (SIS only) 95% threshold • 25 m vertical (SIS only) 95% threshold • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval

3.8.3 CSA Position/Time Service Accuracy Standards

The commitments for maintaining PDOP (3.8.1) and CSA SIS URE accuracy (Table 3.4.1) result in support for position service accuracy standards as presented in Table 3.8.3.

Table 3.8.3 — CSA Position/Time Accuracy Standards

Position/Time Accuracy Standard	Conditions and Constrains
Global Average Positioning Error: • ≤ 5 m 95% Horizontal Error • ≤ 9 m 95% Vertical Error	• Defined for a position/time solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume (RMS)

Worst Site Positioning Error: • ≤ 12 m 95% Horizontal Error • ≤ 25 m 95% Vertical Error	• Standard based on a measurement interval of 24 hours for any point in the service volume • Defined for a position/time solution meeting the representative user conditions
Global Average Time Transfer Error: • ≤ 40 nsec time transfer error 95% of time (SIS only))	• Defined for a time transfer solution meeting the representative user conditions • Standard based on a measurement interval of 24 hours averaged over all points in the service volume • UTC(SU) to GLONASS Offset Error is accounted for

Abbreviations and Acronyms

BPSK	Binary Phase Shift Key
CSA	Chanel of Standard Accuracy
CS	Central Synchronizer
GCF	Ground Control Facility
GNSS	Global Navigation Satellite System
HDOP	Horizontal Dilution Of Precision
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
IGS	International GNSS Service
LRF	Laser Ranging Facility
NAGU	Notice Advisory to GLONASS Users
NS	Navigation Signal
OC	Orbital Constellation
OS	Open Service
OS	Open Service
PDOP	Position Dilution of Precision
RAIM	Receiver Autonomous Integrity Monitoring
RMS	Root–Mean–Square
SARPs	Standards and Recommended Practices
SBAS	Space Based Augmentation System
SCC	System Control Center
SDCM	System of Differential Correction and Monitoring
SIS	Signal In Space
SMF	Signal–in–space Monitoring Facilities
SPOCD	System of Precise Orbit and Clock Determination
SPS	Standard Positioning Service
SV	Space Vehicle
TMF	Time Monitoring Facility
TT&C Facility	Telemetry, Tracking and Control Facilities
UE	User Equipment
URAE	User Range Acceleration Error
URE	User Range Error

URRE	User Range Rate Error
UTC	Universal Time Coordinated
UTC(SU)	Universal Time Coordinated (Soviet Union)
UTCOE	UTC(SU) Offset Error
VDOP	Vertical Dilution Of Precision

Key Terms and Definitions

95% Global Average SIS URE	A statistical measurement of the Global Average SIS URE performance sampled over some interval.
A Major Service Failure for SIS URE	An event over a specific time period during which the health status in the navigation message is false, that is a condition during which a healthy CSA SIS's instantaneous URE exceeds the SIS URE not–to–exceed (NTE) tolerance without a timely alert (alarm or warning) being provided.
Almanac	A set of data that every navigation space vehicle transmits within the navigation message. It includes non–immediate information about the system time, time of all the satellites, state (health) of the entire constellation and the ephemeris data.
Authorized Access Navigation Signal	The navigation signal provided for the special authorized users.
Channel of Standard Accuracy (CSA)	The channel which provides the specified level of positioning and timing performance available to any GLONASS user on continuous and global basis.
Constellation	The set of navigation space vehicles which is the part of the satellite navigation system including usable space vehicles and temporally not usable space vehicles.
Constellation coverage	The volume of space covered by the radionavigation field in which the CSA SIS performance is assessed.
Continuity	Continuity is the ability of a system to provide services to users without interruptions or outages over a specified interval.
DOP	The magnifying effect on GPS position error induced by mapping URE into a position solution within the specified coordinate system, through the relative satellite–to–receiver geometry. The DOP may be expressed in any user local coordinate system desired. Examples include HDOP for local horizontal, VDOP for local vertical, PDOP for local horizontal and vertical together, and TDOP for time.
Ergodic Period	The time span containing the minimum number of samples such that the sample statistic is representative of the population statistic.
Global Average	The rms value of an algebraically signed performance metric or characteristic (e.g., instantaneous URE) over the specified coverage.
Global Average SIS URE	The rms value of SIS URE over the specified coverage and over a specified interval.

GLObal NAvigation Satellite System (GLONASS)	GLObal NAvigation Satellite System (GLONASS), operated by the Russian Federation.
Global Navigation Satellite System (GNSS)	The standard generic term for satellite navigation systems that provide autonomous geo–spatial positioning, velocity vector components, clock corrections and user clock correction rate with global coverage at any point on the Earth's surface, World ocean, airspace and near–Earth space. *Note* — In terms of receiver manufactures and system providers this OS PS addresses GNSS as a single system (not including any augmentations), operated by a separate state, i.e. GLONASS is one of GNSSs. As per ICAO concept for GNSS, GLONASS is one of the main orbital constellations, while GNSS is a worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers and system integrity monitoring, augmented as necessary to support the required navigation performance for the intended operation.
GLONASS Open Service	The Open Service (OS) gives a free access to the GLONASS–generated radionavigation field generated by L1 and L2 FDMA navigation signals, whose performance is associated with that of the Channel of Standard Accuracy (CSA).
Healthy SIS	SIS with parameters and structure as specified in the Interface Control Document which is trackable and identified as healthy based on health attributes in navigation message data.
Healthy SV	A space vehicle which is transmitting a trackable and healthy CSA SIS.
Instantaneous User Range Acceleration Error, URAE	The second time derivative of the URE.
Instantaneous User Range Error, URE	An instantaneous URE is the difference between the pseudorange measured at a given location assuming a receiver clock that is perfectly calibrated to GLONASS time and the expected pseudorange as derived from the navigation message data for the given location and the assumed receiver clock.
Instantaneous User Range Rate Error, URRE	The time derivative of the URE.
Interface Control Document (ICD)	The Document which defines the parameters related to the navigation signals as well as the structure and the format of the broadcast navigation messages.

Navigation Message	The data provided to a GLONASS receiver via each SV's SIS. The detailed definitions of the navigation data are provided in ICD.
Navigation Signal	The electromagnetic signal originating from a navigation space vehicle and containing data about its time and navigation message data to be used by users of this navigation satellite system.
Navigation Space Vehicle (SV)	The space vehicle equipped with the equipment used to generate and transmit navigation signals which a user can employ to determine his position coordinates and time offset relative to GLONASS time, velocity coordinates and frequency offset relative to GLONASS time.
Open Access Navigation Signal	The navigation signal provided for civil users to be used for social, economic, and scientific applications on a free basis.
Operational slot	A fixed slot in the constellation structure which can be occupied by a navigation space vehicle.
Broadcast Clock and Ephemeris Data	The aggregate of navigation message data originating from a navigation space vehicle and used to determine a user's position coordinates and time offset relative to GLONASS time, velocity coordinates and frequency offset relative to GLONASS time.
PDOP Availability	The ability of the system to maintain specific PDOP measured using healthy SVs.
Per–slot coverage	The volume of space in which the SIS from one particular SV is transmitted and the CSA SIS performance is assessed.
Position Service Availability	The ability of the GLONASS System to provide position/time solution in UE meeting the specified standard.
Positioning Accuracy	Accuracy is defined to be the statistical difference between the estimate or measurement of a user's position and the true value of this position for any point within the service volume over some interval of time.
Pseudorange Measurement	The difference between the PRN code time of reception (as defined by the receiver's clock) and the PRN code time of transmission (as defined by the satellite's clock) multiplied by the speed of light.
Radionavigation Field	The electromagnetic field generated by the aggregate of navigation signals delivered by the navigation space vehicles of the GLONASS orbital constellation within the service volume.

Reliability	Reliability is the ability of a system to perform its required functions over a specified time interval during which URE is within the specified margin for any site within the constellation coverage zone for all healthy SVs.
Service Failure	A condition over a time interval during which one or more SPS performance standards are not satisfied and of which users are not announced of in due time.
Service Interruption	A condition over a time interval during which one or more SPS performance standards are not satisfied and of which users are announced of in due time.
Signal–in–Space (SIS)	SIS is an ideal radionavigation signal unaffected by propagation environment (ionosphere, troposphere), UE biases, multipath and interference.
Signal–in–Space URE	The SIS URE includes only those pseudorange data set error budget components assigned to the GLONASS Space Vehicle Subsystem and the Command and Control Subsystem. The SIS URE can be expressed in different ways; e.g., on an instantaneous basis (instantaneous URE) or on a statistical basis (rms URE).
SIS Constellation Availability	The ability of the system to sustain a SV that is transmitting a healthy SIS in an operational slot.
SIS Continuity	SIS Continuity is defined to be the probability that a healthy CSA SIS will continue to be healthy without unscheduled interruption over a specified time interval.
SIS Per–slot Availability	The ability of the system to sustain a specified number of SVs transmitting a healthy CSA SIS to maintain specified PDOP characteristics.
SIS Positioning Error	A PVT Solution Error which includes only those pseudorange data set error budget components assigned to the SV and Command and Control Segments (i.e., not including the error budget components assigned to UE, signal propagation and reception).
SV Visibility	The condition when a navigation SV is observable at an elevation angle above or equal to the minimum tolerable value.
System Time	The timescale used to tie all the processes in all the subsystems of the navigation satellite system including the processes attributable to defining the time of transmission and the time of reception for pseudorange measurements.
Time Transfer Accuracy	Is defined to be the error of determining the difference between a receiver's clock timescale and the UTC(SU).
Trackable SIS	An CSA SIS that can be preprocessed and categorized as either healthy or unhealthy by a CSA receiver.

User	The object of navigation accomplishing the PVT solution by means of receiving and processing navigation signals originating from navigation space vehicles.
User Equipment (UE)	The equipment, used to receive and process navigation signals and extract navigation messages to determine position coordinates and time offset relative to GLONASS time, velocity coordinates and frequency offset relative to GLONASS time.
User Positioning	The process of determining a user's spatial coordinates.
UTC(SU Offset Error), UTCOE	The CSA SIS UTC(SU) time accuracy is defined to be the statistical difference, between the parameters contained in the CSA SIS which relate GLONASS time to UTC and the true value of the difference between GLONASS time and UTC(SU).
Worst Site Single Point Average	A maximum value of any parameter across a specified portion of the globe at a specified instant.
Worst Site Single Point Average SIS URE	The worst site SIS URE is assessed as a maximum SIS URE across a specified portion of the globe at a specified instant.

References

This section identifies the documents explicitly referenced in or related to the content of this OS PS.

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