GLONASS STATUS AND PROSPECTS OF DEVELOPMENT

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The 16th Meeting of International Committee on Global Navigation Satellite Systems
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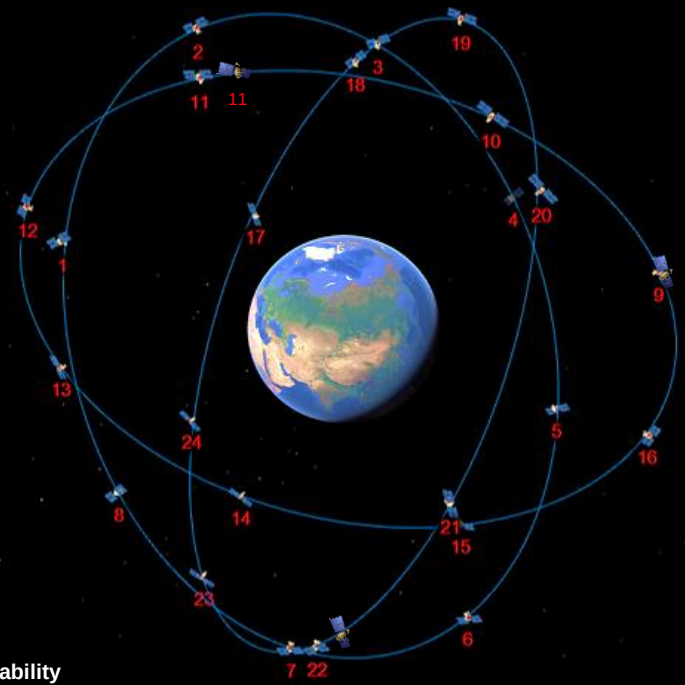
GLONASS SPACE SEGMENT STATUS

updated 06.10.2022



26 MEO satellites

22 operational

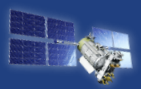
3 maintenance

1 in-orbit testing

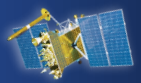
availability

99,95%

The constellation provides continuous global PNT service

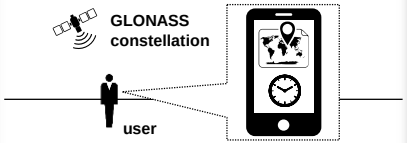
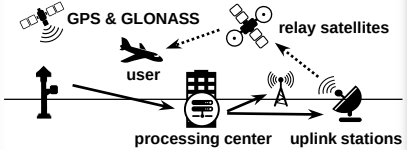
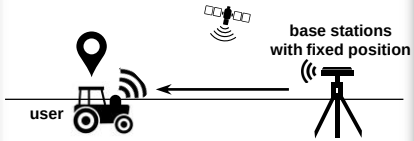
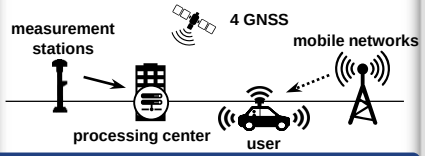


GLONASS-M batch



GLONASS-K batch

GLONASS CIVIL SERVICES

	Basic Service	Service of Improved Reliability and Accuracy	Relative Navigation Service	High-Accuracy Service
Channels	24 GLONASS satellites	2 LUCH relay satellites, ground networks	Stations of state agencies & corporations	Mobile networks
				
Technology	GNSS	SBAS, GBAS	RTK	PPP
Information provided	• Positioning, navigation and timing	• Differential corrections • Integrity • Ionospheric corrections	• Corrections	• Precise orbits and clocks
Service Area	Global	Russia	Local/regional in Russia	Currently – Russia
Status	Operational	Experimentally operational	Operational	Experimentally operational

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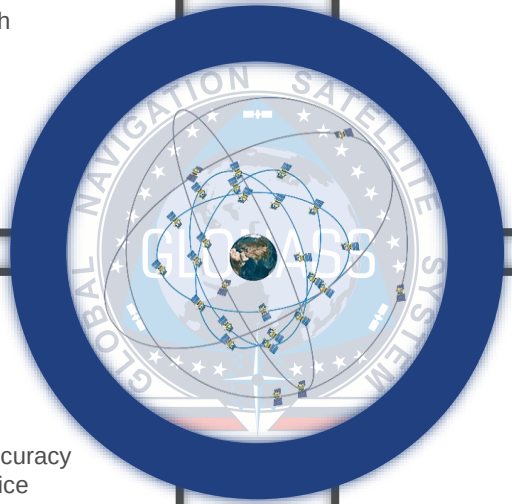
GLONASS DEVELOPMENT

Small-sized GLONASS satellites development

- Ability to launch 3 satellites with a Soyuz 2.1 launch vehicle for rapid constellation redeployment and reduced costs of launch services
- Onboard hydrogen clocks with expected stability ~ 5×10^{-15}
- Inter-satellite radio links equipment and all GLONASS CDMA signals transmission

High-Orbit GLONASS Complex deployment

- 6 satellites in inclined geosynchronous orbits
- Improved PDOP for better navigation in difficult conditions (e.g. dense urban areas) in the Eastern Hemisphere
- L3SVI capabilities to broadcast GLONASS High-Accuracy Service PPP corrections in the service area



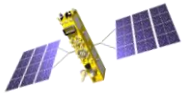
Augmentations development

- New tech: DFMC SBAS for Service of improved accuracy and reliability and PPP-AR for High-Accuracy Service
- L5 capabilities: at least 3 relay satellites to broadcast DFMC SBAS corrections
- L3SVI capabilities: 3 relay satellites to broadcast PPP corrections

GLONASS-K2 launch campaign

- First satellite is planned to be launched in 2022
- By 2030 at least 12 MEO satellites will be operational
- Enhanced clocks and introduction of L1OC, L2OC CDMA signals with flexible navigation message structure

GLONASS CONSTELLATION MODERNIZATION



GLONASS-K2 launch campaign

2022 – 2030

- By 2030 at least 12 MEO satellites will be operational
- broadcast of civil L1OC, L2OC, L3OC (CDMA) & L1OF, L2OF (FDMA) for backward receiver compatibility using a unified phased array antenna for all signals
- expected average SIS URE ~ 0.2 - 0.3 m
- expected clock stability ~ 5×10^{-15} due to new passive H-maser

Second and third generation constellation

GLONASS-K (3)

+ 7 satellites until 2025

GLONASS-M (23)

+ 1 satellite in 2023 or 2024

L3 capability

6 GLONASS-M & 10 GLONASS-K satellites in orbit will be capable to broadcast GLONASS L3OC CDMA signal by 2025

Ionospheric correction

Global ionospheric model is already broadcast via L3OC signal (in accordance with ICD) and will be broadcast L1OF & L2OF signals after its introduction to their ICD

Payloads

5 GLONASS-K satellites will carry COSPAS-SARSAT payload

New onboard capabilities

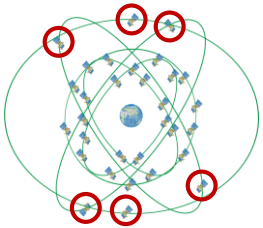
All GLONASS-K & GLONASS-K2 satellites will carry inter-satellite radio links equipment for ranging, prompt dissemination of orbit and clock corrections, thus improving SIS URE

Some GLONASS-K2 satellites will carry onboard laser equipment for inter-satellite laser ranging & data transfer

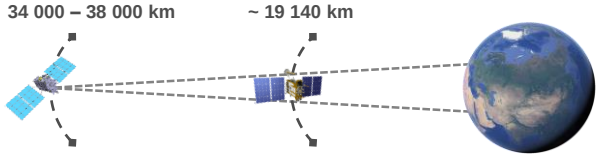
GLONASS-K2 satellites will be able to provide COSPAS-SARSAT SAR Return Link Service via L1OC signal

HIGH-ORBIT GLONASS SPACE COMPLEX

SVs in inclined geosynchronous orbits

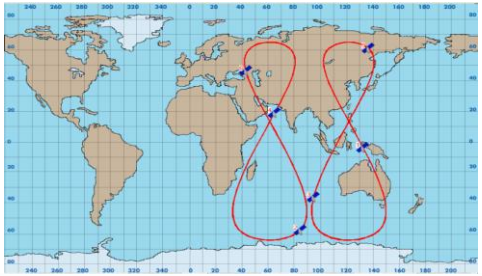


3 orbital planes



Orbital inclination	64.8°
Semi-major axis	42 164.142 km
Orbital period	86 164 s
Eccentricity	0.072

Ground tracks



Status

Preliminary Design Review is currently in progress.

First High-Orbit GLONASS satellite is planned to be launched in **2026**.

Complete constellation is planned to be deployed by **2030**.

Soyuz-2 rocket can be used as a launch vehicle

Results

Improved PDOP leads to 25% navigation accuracy improvement in the Eastern hemisphere

Increased availability in dense urban areas – user receives signals at elevation angles > 25°

Increased availability in high latitudes, including Artic region

Increased coverage and availability of GLONASS High-Accuracy Service

Expected capabilities

- Capabilities to broadcast PPP corrections via dedicated L3 SVI signal
- Integrity for GLONASS High-Accuracy Service

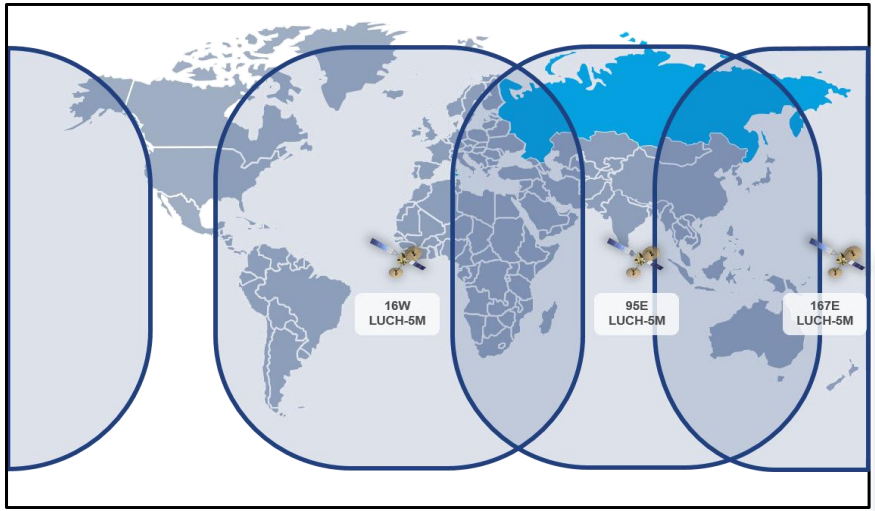
Expected SIS URE ~ 0.4 m (based on modelling)

Signals:

- L1OC CDMA
- L2OC CDMA
- L3SVI (for broadcasting PPP corrections)

GLONASS HIGH-ACCURACY SERVICE

Expected GLONASS High-Accuracy Service coverage by 2026



Corrections are currently provided for:

- GLONASS (L1OF, L2OF)
- GPS (L1 C/A, L2C)
- BeiDou (B1I, B2I)
- Galileo (E1, E5a)

Basis:

Independent Time Scale steered to UTC (SU) within 1 ns

PZ-90.11 Reference Frame

ICD for L3SVI signal is under development

Expected L3SVI characteristics:

Carrier frequency: 1202.025 MHz

Spectrum width**:** 10.23 MHz

Polarization**:** RHCP

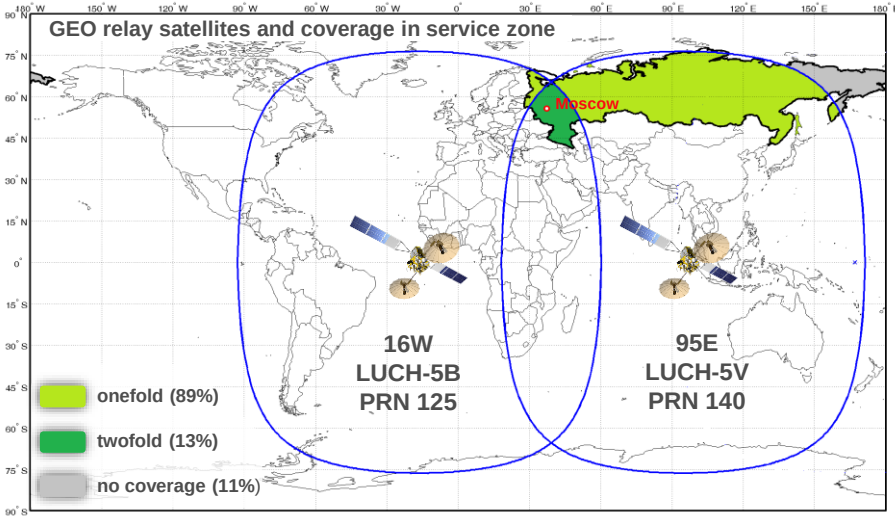
On-ground signal power**:** -156.6 dBW

Data rate**:** > 3 kbit/s

- Integrity and ambiguity resolution are planned to be provided
- Solar activity and geomagnetic activity indexes are to be defined, thus the ionospheric correction is considered to be provided

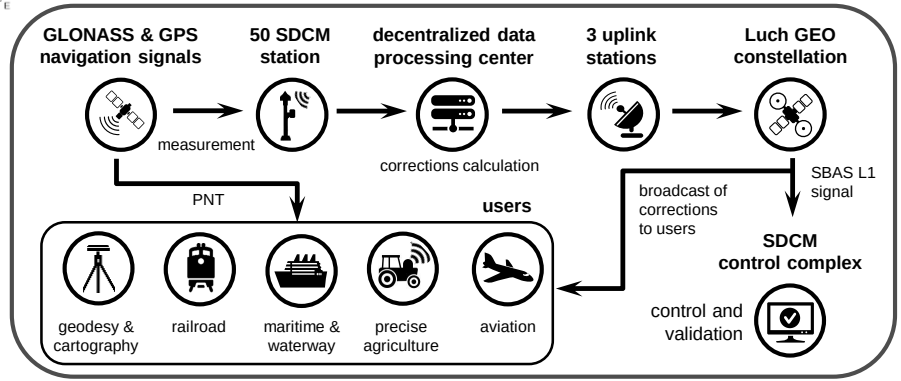
Processed civil signals		
• GLONASS: L1OF, L2OF, L3OC • GPS: L1 C/A, L2C, L5 • Galileo: E1, E5a, E5b • BeiDou: B1I, B2I, B2a	• GLONASS: L1OF, L2OF, L1OC, L2OC, L3OC • GPS: L1 C/A, L1C, L2C, L5 • Galileo: E1, E5a, E5b, E6 • BeiDou: B1I, B2b, B2a, B1C, B3I • NavIC: L5, S	TBD
Dedicated broadcast channels		
Internet & mobile networks	**+** 3 GEO LUCH-5M **(L3SVI)**	TBD
2022	**2025**	**2030**

STATUS OF SYSTEM FOR DIFFERENTIAL CORRECTION AND MONITORING



46 operational stations in Russia

4 operational stations in neighboring countries



Provided information in the SDCM service area:

Real-time differential correction

Integrity with alert time within 6 s

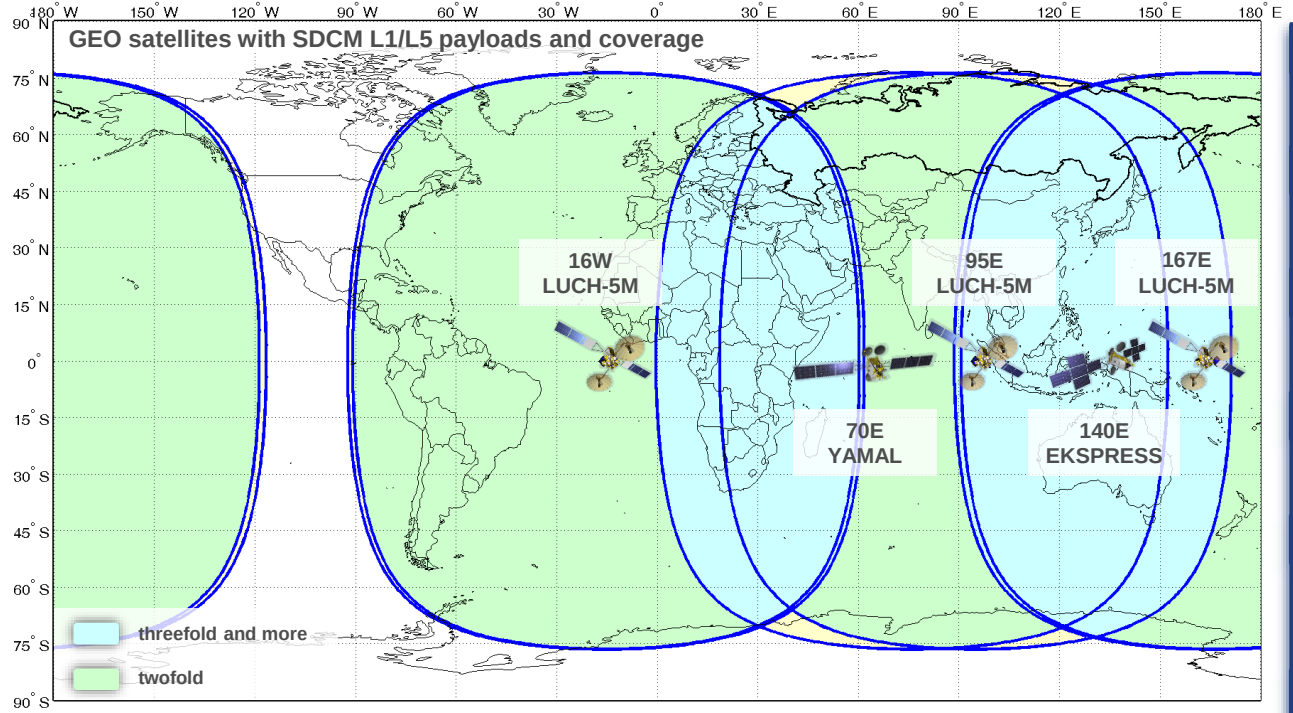
Ionospheric VTEC + grid

SDCM status

SDCM has been preliminary certified by Russian aviation regulatory body in accordance with ICAO APV-I and APV-II and is currently operational in a testing mode.

SDCM is an infrastructural basis for GLONASS Service of improved reliability and accuracy.

SDCM DEVELOPMENT BY 2030



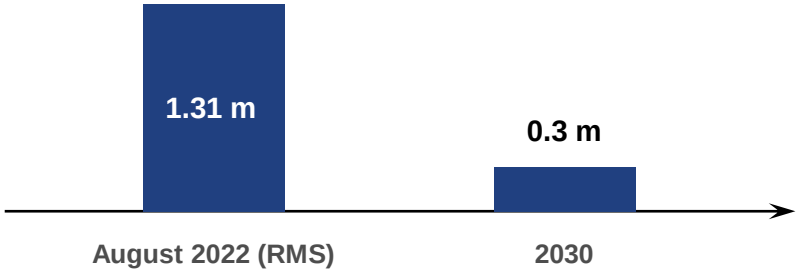
Technology
SBAS (L1) and DFMC SBAS (L5)
Signals
SBAS L1 & L5 250 bit/s
Coverage
Russia + surrounding territories
Availability in service zone
100 %
Augmented systems (DFMC)
GLONASS, BeiDou, GPS, Galileo
Integrity
6 seconds

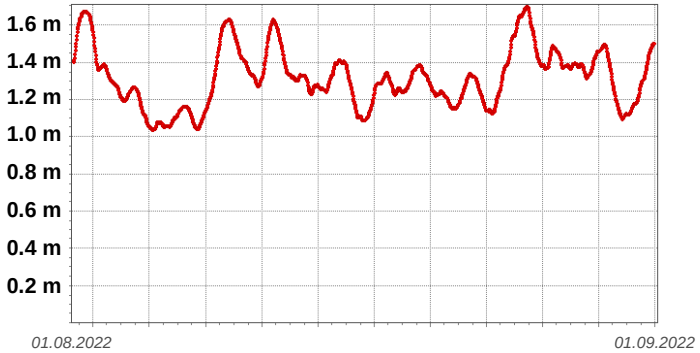
Measurement sources: 46 SDCM measurement stations in Russia + 11 SDCM stations abroad + other Roscosmos measurement stations

GLONASS PERFORMANCE

GLONASS Basic Service characteristics

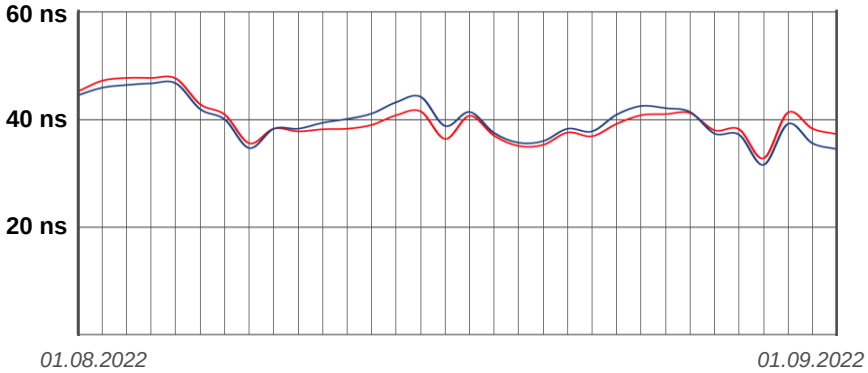
Expected SIS URE after GLONASS development effort





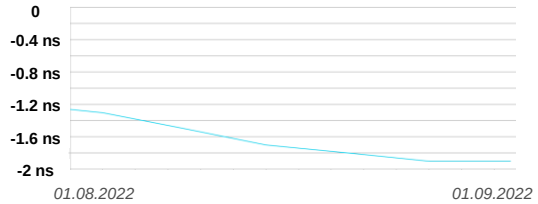
GLONASS daily SIS URE (RMS) ranging roughly from 1.0 m to 1.7 m
IAC PNT *assessments, 01.08.2022 – 01.09.2022*

GLONASS Time stability



GLONASS Time is steered to UTC(SU)
GLONASS Time – UTC(SU) measured difference (red) ranging from 32.8 ns to 47.7 ns
GLONASS Time – UTC(SU) offset (blue) is broadcast via GLONASS navigation signals and ranging from 31.6 ns to 46.7 ns
Maximum absolute UTCOE = 2.8 ns
VNIIFTRI *assessments, 01.08.2022 – 01.09.2022*

UTC – UTC(SU) difference within 2 ns (in absolute value)
BIPM *assessments, 01.08.2022 – 01.09.2022.*



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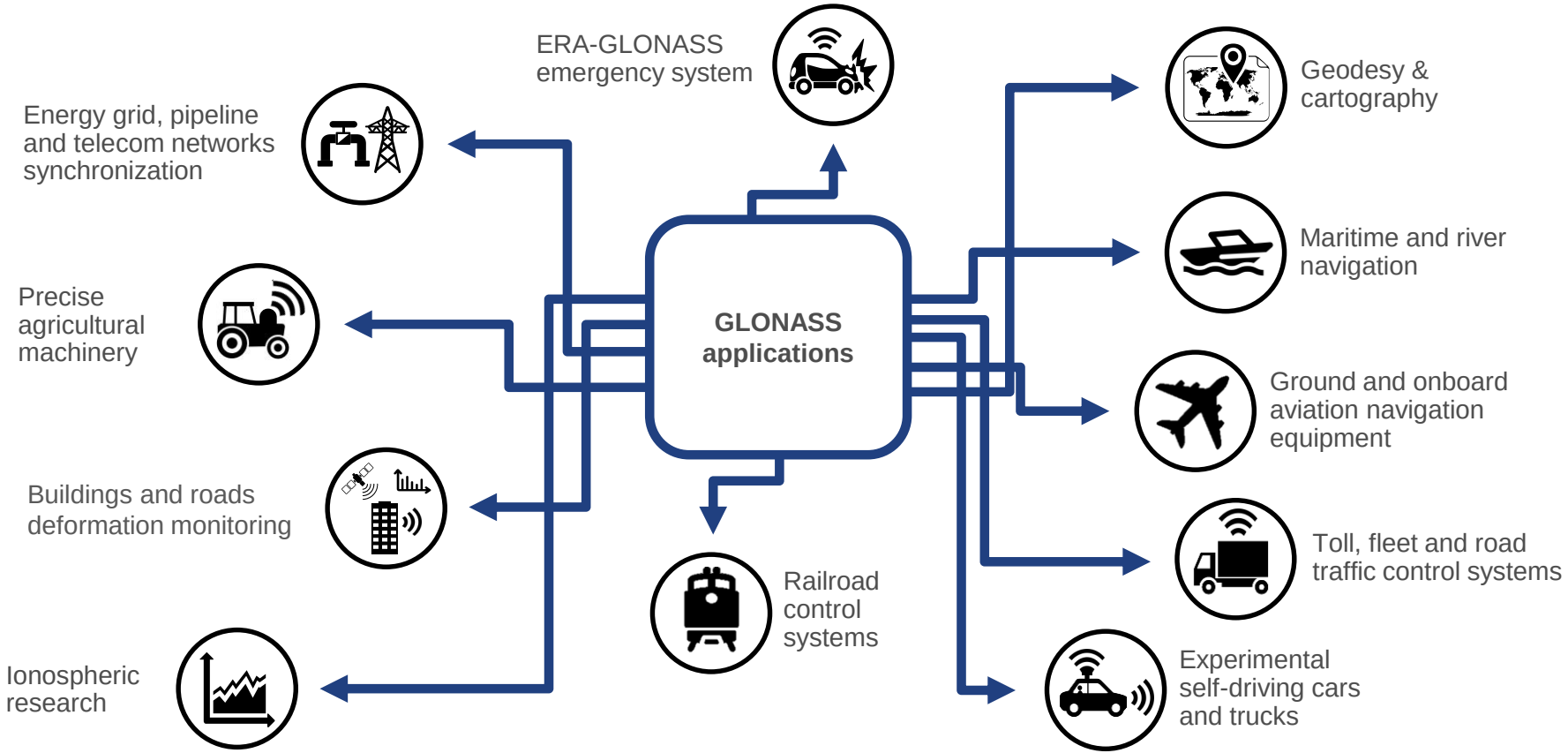
CURRENT GLONASS APPLICATIONS IN RUSSIA



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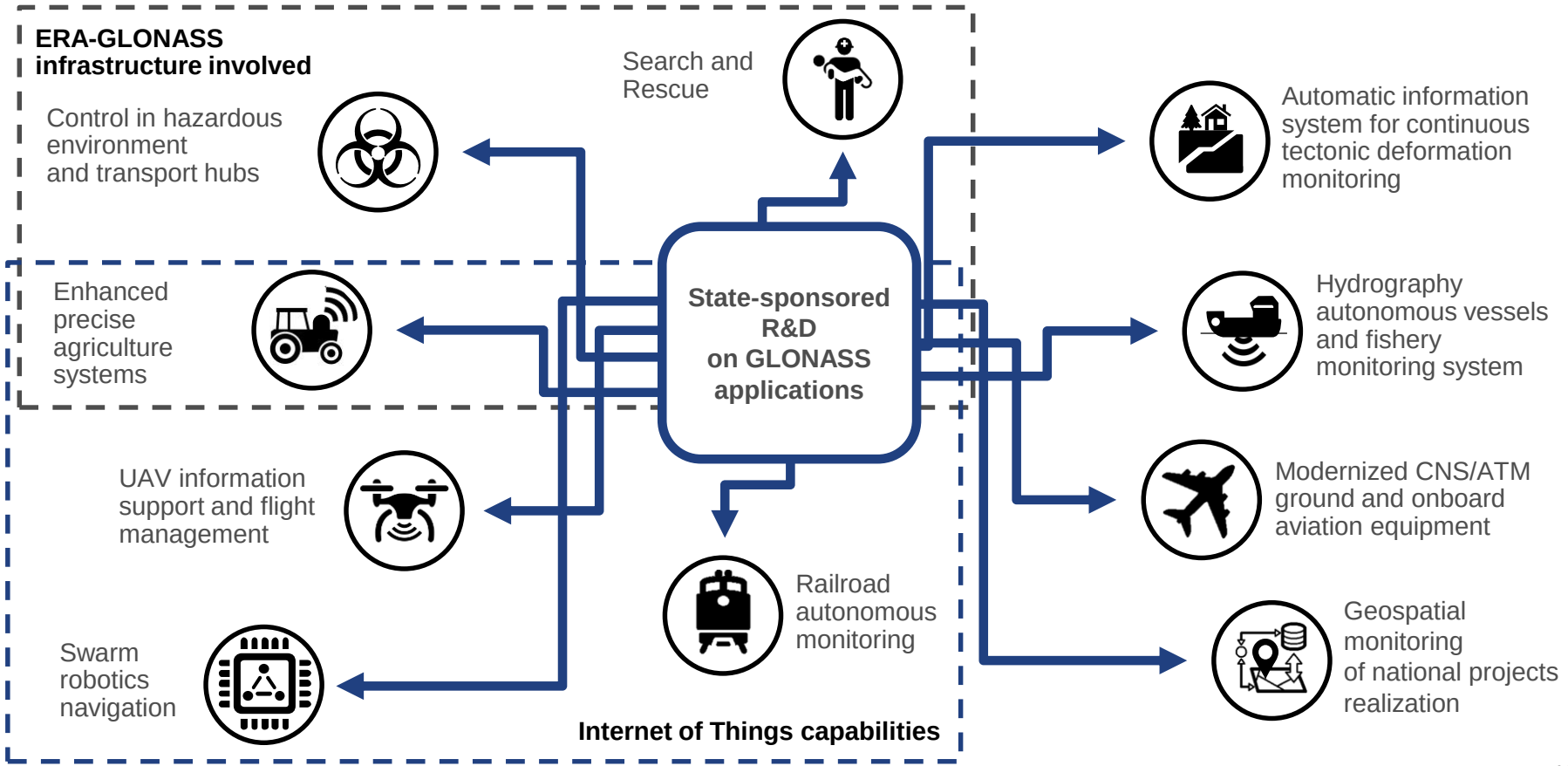
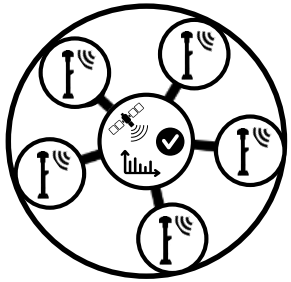
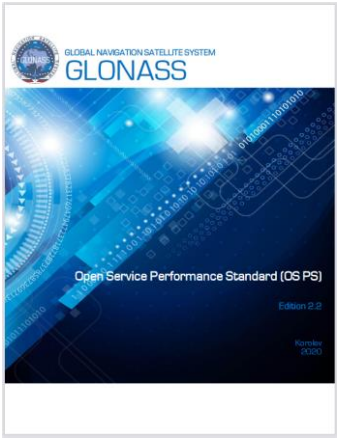
GLONASS APPLICATIONS DEVELOPMENT DIRECTIONS IN RUSSIA



GLONASS PERFORMANCE VERIFICATION AND USER SUPPORT



The Russian System for Performance Monitoring and Verification is continuously collecting global measurement data for nearly real-time GLONASS characteristics assessment to confirm their correspondence to the guaranteed levels defined in GLONASS Open Service Performance Standard (edition 2.2) and ensure that GLONASS domestic and foreign civil users are provided with PNT service of proper quality



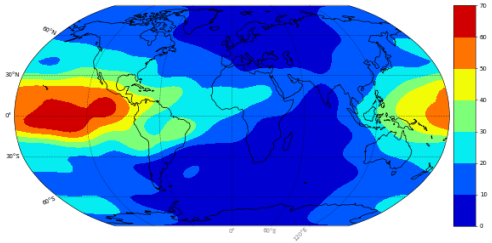
Information and Analysis Center for Positioning, Navigation and Timing (IAC PNT)

Applied User Center of Roscosmos State Space Corporation based on IAC PNT JSC TSNIIMASH is providing information support to GLONASS domestic and foreign civil users, including:

- assessed GLONASS characteristics based on the System for Performance Monitoring and Verification measurement data;
- up-to-date GLONASS constellation status and almanac;
- Notice Advisory to GLONASS Users (NAGU);
- GLONASS formal documents' links (ICDs and OS PS);
- Global ionospheric map by IAC PNT.

https://www.glonass-iac.ru/en/

IAC PNT GIM (for 17.09.2022 in TECu)



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GLONASS ROLE FOR SUSTAINABLE DEVELOPMENT

Open Basic GLONASS navigation service is provided unlimited, free of charge and with global guaranteed unselective availability. Such policy facilitates equality of nations' access to the satellite navigation and supports developing countries.

GLONASS civil services contribute to the following Sustainable Development Goals

Decent work and economic growth

Industry, innovation and infrastructure

Sustainable cities and communities

Responsible consumption and production

Life below water

Life on land

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Roscosmos State Space Corporation develops GLONASS for the benefit of all mankind.

Further bilateral and multilateral cooperation in satellite navigation is a priority.

Joint search for solutions of issues and new capabilities within bilateral and multilateral cooperation facilitates enhancing the quality of navigation for users globally.

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