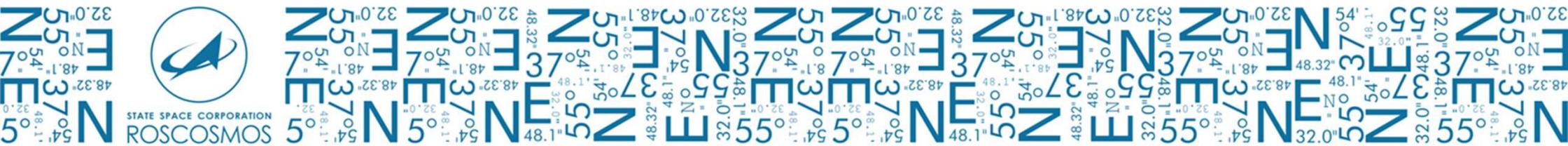


Global Navigation Satellite System (GLONASS): Status and Development

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UN-Nepal Workshop on the Applications of Global Navigation Satellite Systems
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Kathmandu, Nepal





- **NATIONAL SATELLITE NAVIGATION POLICY**
- **GLONASS STATUS**
- **GLONASS CONSTELLATION SUSTAINMENT**
- **SPACE SEGMENT MODERNIZATION**
- **GLONASS AUGMENTATIONS**
- **GNSS MONITORING AND PERFORMANCE ASSESSMENT SYSTEM**
- **GLONASS REFERENCE DOCUMENTS**
- **GLONASS USER INFORMATION SUPPORT**
- **SUMMARY**

NATIONAL SATELLITE NAVIGATION POLICY AND ORGANIZATION



- Presidential Decree of May 17, 2007 No. 638 “On Use of GLONASS (Global Navigation Satellite System) for the Benefit of Social and Economic Development of the Russian Federation”
- Federal Programme on GLONASS Sustainment, Development and Use for 2012-2020 – planning and budgeting instrument for national PNT activities
- Programme governance:



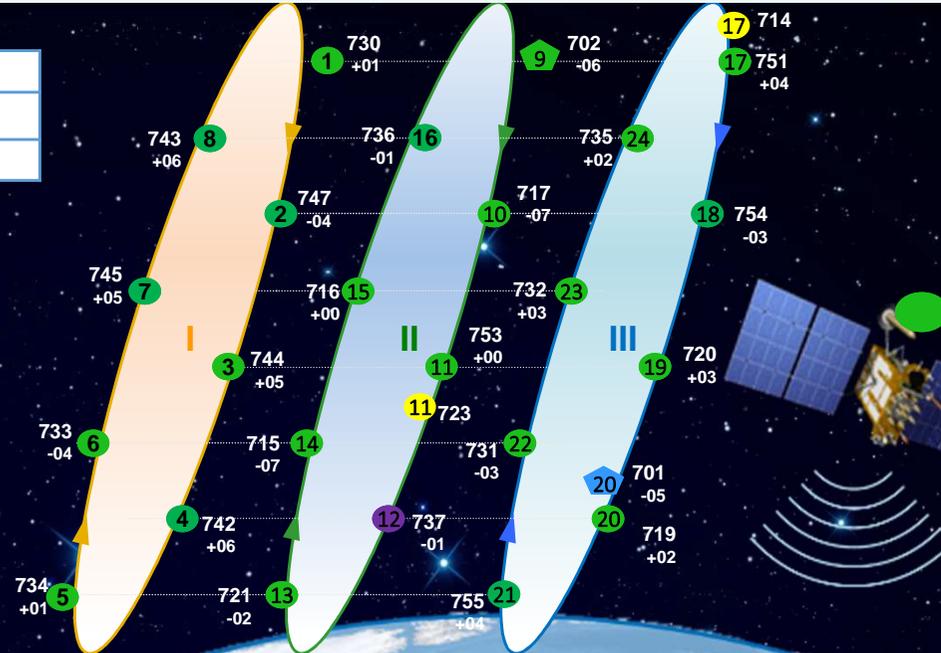
- Programme Goals:
 - Improving system performance in terms of accuracy and integrity
 - Ensuring guaranteed positioning, navigation and timing solutions in restricted visibility, interference and jamming conditions
 - Enhancing current application efficiency and broadening application domains

GLONASS STATUS (as of 24 November 2016)



SDCM GEO satellites

In total	3
Operational	2
Maintenance	1



In total	27
Operational	23
Maintenance	1
Orbital spares	2
Flight testing	1



SPACE-BASED AUGMENTATIONS

24 reference stations in Russia
8 reference stations abroad

GROUND CONTROL COMPLEX

- 2 System Control Centers
- 9 Reference Stations
- 6 Uplink Stations
- 3 Laser Ranging Stations

REGIONAL AND LOCAL AUGMENTATIONS

77 stations of Ministry of Transportation
4104 stations of Federal Service for State Registration, Cadastre and Cartography

FUNDAMENTAL FACILITIES

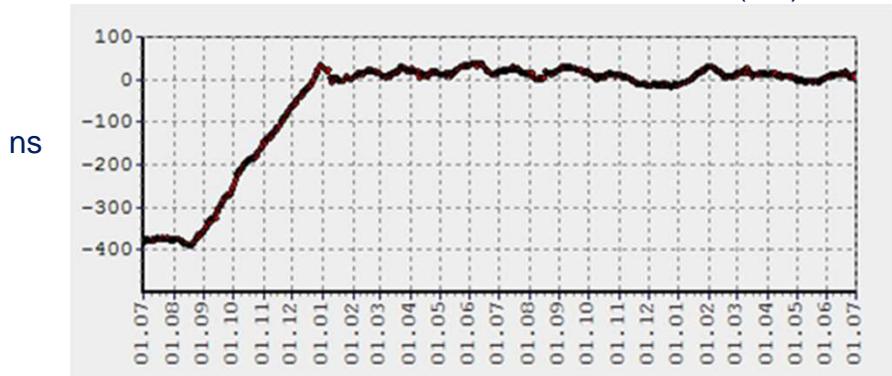
- 3 Telescopes (32 m)
- 2 Telescopes (7 m)
- 3 Correlators
- 1 Cold-atom Optical Frequency Reference
- 50 Astronomic and Geodetic Network Stations



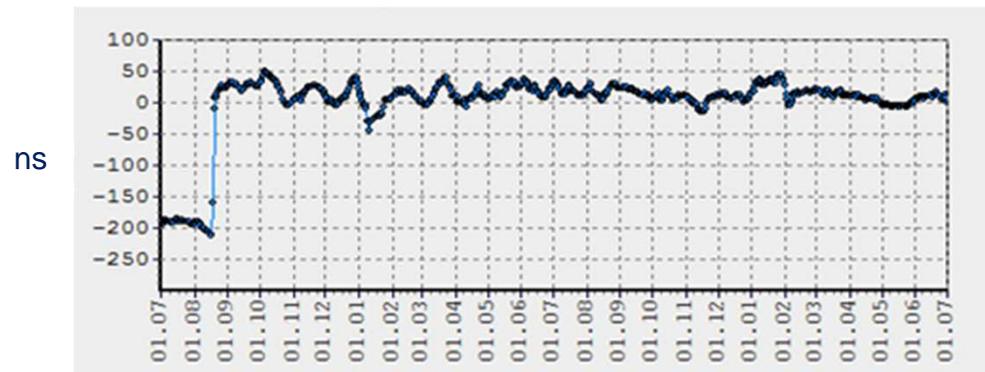
CURRENT STATUS OF GLONASS TIMESCALE AND UTC(SU) BROADCAST ACCURACY



GLONASS time offset relative to UTC(SU)

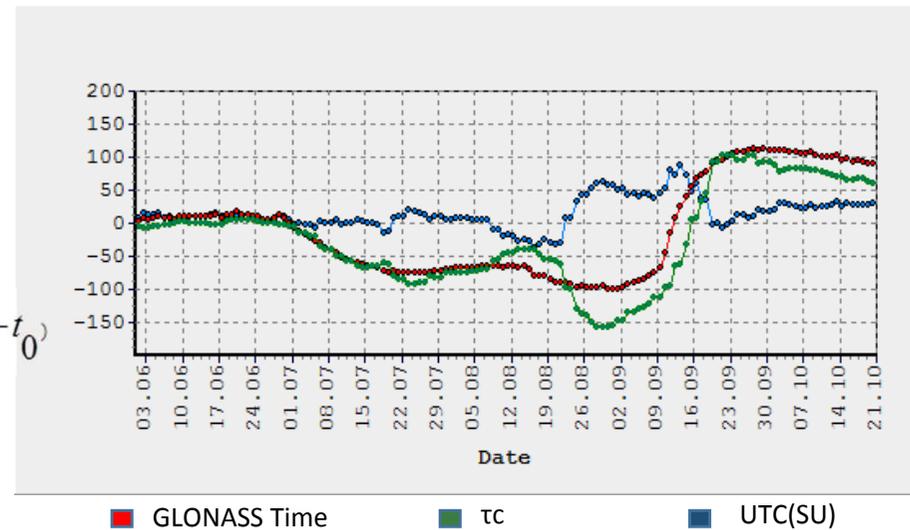


UTC(SU) broadcast error



- before Aug. 2014 ~400 ns offset between GLONASS Time and UTC(SU)
 - in compliance with Specs
 - but stopped meeting growing requirements of timing users
- Aug. 18, 2014 – start of correction activities
- 2015 – offset kept within 35 ns
- 1st half of 2016 – offset kept within 25 ns
- 2nd half of the 2016 – malfunctions of the Central Synchronizer → GLONASS System Time Generation disturbances → increased offset to UTC(SU)
- GLONASS Timescale is being corrected with an increment of ~ 2 ns per day by changing the control correction $\Delta T^{ymp}(t-t_0)$
- by the end of 2016:
 - GLONASS Time Offset relative to UTC(SU) is expected to reach ± 20 ns
 - UTC(SU) broadcast error is expected to reach ± 5 ns

- before Aug. 2014 ~200 ns UTC(SU) broadcast correction systematic error
- Aug. 18, 2014 – start of correction activities
- Aug. 2014 – Jun. 2016 – UTC(SU) broadcast error is within 10 ns



■ GLONASS Time ■ TC ■ UTC(SU)

GLONASS CONSTELLATION SUSTANMENT

Year	2016				2017				2018			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Total in constellation	28	28	27	25	25	24	24	24	24	24	24	25
Operational	24	24	24	24	24	24	24	24	24	24	24	24
↑	51	53			56 57 58	52	59	60	61			
												

Glennass-M

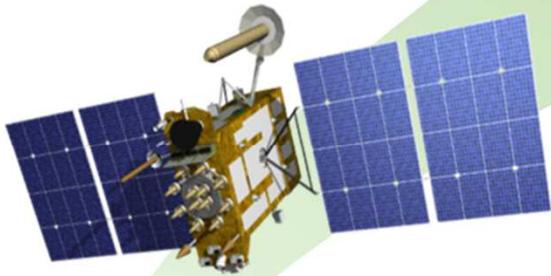
- 2 Glennass-M satellites decommissioned in 2016
- 2 Glennass-M satellites launched (07 Feb 16 and 29 May 16)
- a number of block M sats operate beyond their design life
- 7 Glennass-M sats in ground stock to be launched in 2016-2018 to replace those well beyond their design life

Glennass-K

- 2 Glennass-K in orbit
 - 1 undergoing flight testing
 - 1 commissioned in Feb 2016, operational

Current constellation and ground spares will provide robust system operation until new-generation satellites FOC





Glonass-K Evolution (K2)

- Single phased-array antenna for L1/L2/L3 FDMA and CDMA signals
- Advanced clocks – 5×10^{-14} – 5×10^{-15}
- Design to be finalized by the end 2016

Enhanced Glonass-K

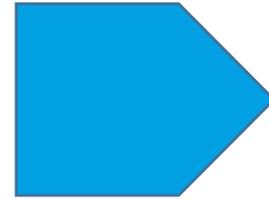
- Signals: L1/L2OF, L1/L2SF, L1/L2OC, L1/L2SC, L3OC
- 2 phased-array antennas (for FDMA and CDMA signals)
- New message structure
- Enhanced antijam capabilities of new CDMA signals
- Experimental clock – 5×10^{-14} – 5×10^{-15}
- Onboard one-way laser ranging
- More frequent ephemeris and clock data uploads, optical crosslinks
- 12.5 year design life
- SaR

Glonass-K Satellites

- Signals: L1/L2OF, L1/L2SF, L3OC
- 10 year design life
- Cs, Rb onboard clocks – 1×10^{-13}
- Unpressurized platform
- Enhanced service systems
- Advanced satellite command and control, ODTS
- SaR payload

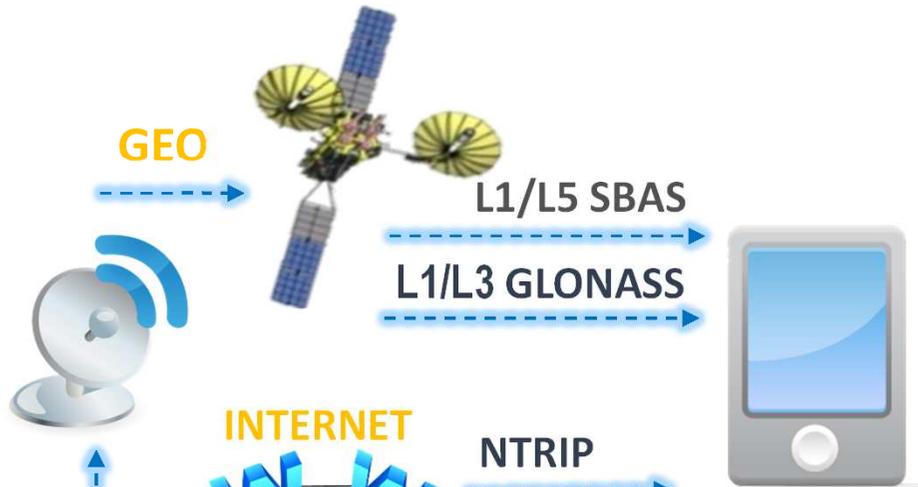


- All types of augmentations to support all types of high accuracy services developed and continue to expand



- network densification
- space segment modernization
- coverage extension

BROADCASTING FACILITIES



DATA PROCESSING FACILITY

- Master Center
- Back-Up Center



GNSS CONSTELLATION



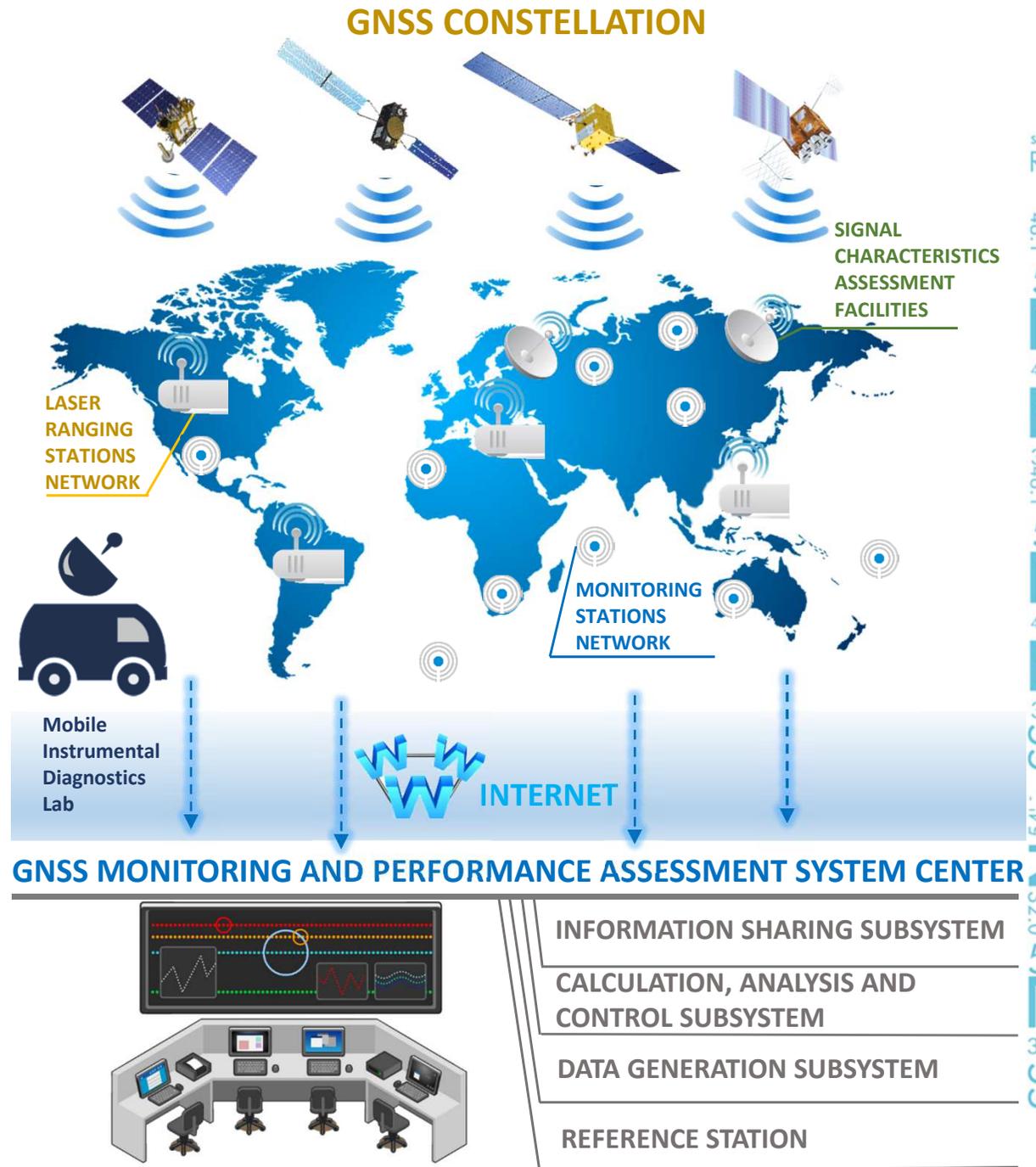
GLOBAL MONITORING NETWORK



PERFORMANCE MONITORING AND ASSESSMENT SYSTEM



- Independent monitoring and verification of performance characteristics versus system requirements documents of GLONASS and its constituent parts
- Generating input data to assess GLONASS Program KPIs
- Determining GLONASS performance at user level
- Calculating input data for GLONASS certification





4 GLONASS REFERENCE DOCUMENTS ARE TO BE RELEASED IN Q-4 2016

- Interface Control Document “General Description of the GLObal NAvigation Satellite System with the Code Division Multiple Access Signals”
- Interface Control Document “GLONASS L1 Open Service Code Division Multiple Access Signal”
- Interface Control Document “GLONASS L2 Open Service Code Division Multiple Access Signal”
- Interface Control Document “GLONASS L3 Open Service Code Division Multiple Access Signal”



Type of difference	FDMA signal reference documents	CDMA signal reference documents
Variable number of SVs	0 to 24	0 to 63
Message structure	Fixed structure “superframe/frame/string”	Continuous sequence of strings, non-fixed length, variable composition depending on the number of operational SVs, types of strings can be added, backward compatibility with receivers currently in use
Time stamp length	30 bits	12 bits
Value of LSB	0.4 m	0.001 m
Signal health status periodicity	1 per 4 sec	1 per 2 sec for L1 and L2 1 per 3 sec for L3



STATE SPACE CORPORATION
ROSCOSMOS

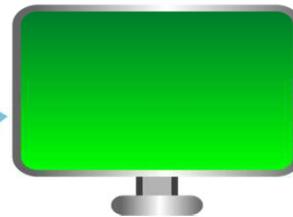


USER INFORMATION SUPPORT (WWW.GLONASS-IAC.RU)

PURPOSE: PROVIDING RUSSIAN AND INTERNATIONAL USERS WITH INFORMATION ABOUT GLONASS AND OTHER GNSS – ONE OF THE ROSCOSMOS ACTIVITIES

PRIMARY TASKS:

- GLONASS orbital constellation monitoring in real time
- Official GLONASS SCC bulletins
- Estimation and quality prediction for GLONASS and other GNSS radio-navigation fields
- GLONASS and other GNSS performance evaluation
- High-precision GLONASS and other GNSS ephemeris and time information
- Information and consultation service on satellite navigation



WWW.GLONASS-IAC.RU



- **GLONASS budgeting is planned through 2020, planning for the next period is underway**
- **Orbital constellation + Glonass-M ground spares will provide robust system operation until more new generation satellites come into service**
- **Phased approach to space segment modernization**
- **Activities focused at performance improvement underway**
- **All types of augmentations developed and continue to expand**
- **4 GLONASS reference documents are approved and to be publicly released in the nearest future**



Thank you!

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