GLONASS PROGRAMME UPDATE

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Roscosmos State Space Corporation

11th Meeting of the International Committee on Global Navigation Satellite System
November 7, 2016
Sochi, Russian Federation
- NATIONAL SATELLITE NAVIGATION POLICY
- GLONASS STATUS
- GLONASS CONSTELLATION SUSTAINMENT
- SPACE SEGMENT MODERNIZATION
- PERFORMANCE IMPROVEMENT ACTIVITIES:
  - ONBOARD CLOCK
- GLONASS AUGMENTATIONS
- GNSS MONITORING AND PERFORMANCE ASSESSMENT SYSTEM
- GLONASS REFERENCE DOCUMENTS
- GLONASS USER INFORMATION SUPPORT
- SUMMARY

Federal Programme on GLONASS Sustainment, Development and Use for 2012-2020 – planning and budgeting instrument for national PNT activities

Programme governance:

- 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 7 November 2016)

SPACE-BASED AUGMENTATIONS
24 reference stations in Russia
8 reference stations abroad

In total 27
Operational 21
Orbital spares 2
Flight testing 1
Maintenance 3

Glonass-M
Glonass-K

GROUND CONTROL COMPLEX
2 System Control Centers
9 Reference Stations
6 Uplink Stations
3 Laser Ranging Stations

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

REGIONAL AND LOCAL AUGMENTATIONS
77 stations of Ministry of Transportation
4104 stations of Federal Service for State Registration, Cadastre and Cartography
CURRENT STATUS OF GLONASS TIMESCALE AND UTC(SU) BROADCAST ACCURACY

- 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 was kept within 35 ns
- 1st half of 2016 – offset was 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 $\Delta T^{\text{yr}}(t-t_c)$
- 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
<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>Total in constellation</td>
<td>28</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td>Operational</td>
<td>24</td>
<td>24</td>
<td>24</td>
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**Glonass-M**

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

**Glonass-K**

- 2 Glonass-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
**SPACE SEGMENT MODERNIZATION**

**Glonass-K Satellites**
- Signals: L1/L2OF, L1/L2SF, L1/L2OC, L1/L2SC, L3OC
- 10 year design life
- Cs, Rb onboard clocks – $1 \times 10^{-13}$
- Unpressurized platform
- Enhanced service systems
- Advanced satellite command and control, ODTS
- SaR payload

**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 – $5 \times 10^{-14}$–$5 \times 10^{-15}$
- Onboard one-way laser ranging
- More frequent ephemeris and clock data uploads, optical crosslinks
- 12.5 year design life
- SaR

**Glonass-K Evolution (K2)**
- Single phased-array antenna for L1/L2/L3 FDMA and CDMA signals
- Advanced clocks – $5 \times 10^{-14}$–$5 \times 10^{-15}$
- Design to be finalized by the end 2016
Enhanced Glonass-K PHM
- Designed within GLONASS Programme
- Performance confirmed with extensive testing
- Overall dimensions: 360 mm × 180 mm × 630 mm
- Power consumption: < 54 Вт
- Mass: 25 kg
- Design life: 13.5 years

Glonass-K2 PHM
- Enhanced long-term stability
- Lower in mass and size
- Overall dimensions: 476 mm × 220 mm × 160 mm
- Power consumption: < 50 Вт
- Mass: 12 kg
- Design life: 15 years

Allan Deviation

- Glonass-K2 PHM
- Enhanced Glonass-K PHM
- Best Glonass-M AFS
- Average Glonass-M AFS
- Glonass-M Spec
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**

- GEO
- L1/L5 SBAS
- L1/L3 GLONASS

**INTERNET**

- NTRIP

**DATA PROCESSING FACILITY**

- Master Center
- Back-Up Center

**GNSS CONSTELLATION**

**GLOBAL MONITORING NETWORK**

**GLONASS AUGMENTATIONS**
- Independent monitoring and verification of performance characteristics wrt system requirements documents for GLONASS and its constituent parts
- Generating input data to assess GLONASS Program target indicators and performance
- Determining user level GLONASS performance
- 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”

<table>
<thead>
<tr>
<th>Type of difference</th>
<th>FDMA signal reference documents</th>
<th>CDMA signal reference documents</th>
</tr>
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<tbody>
<tr>
<td>Variable number of SVs</td>
<td>0 to 24</td>
<td>0 to 63</td>
</tr>
<tr>
<td>Message structure</td>
<td>Fixed structure “superframe/frame/string”</td>
<td>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</td>
</tr>
<tr>
<td>Time stamp length</td>
<td>30 bits</td>
<td>12 bits</td>
</tr>
<tr>
<td>Value of LSB</td>
<td>0.4 m</td>
<td>0.001 m</td>
</tr>
<tr>
<td>Signal health status periodicity</td>
<td>1 per 4 sec</td>
<td>1 per 2 sec for L1 and L2, 1 per 3 sec for L3</td>
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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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