GLONASS system development and use

ROSCOSMOS
State Space Corporation

December 2-7, 2017
Kyoto, Japan
NATIONAL SATELLITE NAVIGATION POLICY AND ORGANIZATION


- Federal Program on GLONASS Sustainment, Development and Use for 2012-2020 – planning and budgeting instrument for GLONASS development and use

- Budget planning for the forthcoming decade – Global Navigation System – 2030

- Program governance:

  - Roscosmos State Space Corporation
  - Government Contracting Authority – Program Coordinator
  - Government Contracting Authorities
  - Program Scientific and Coordination Board

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

by means of:

- Ground Segment modernization
- introduction of new onboard atomic frequency standards with enhanced performance
- introduction of advanced satellite control and command, orbit and clock determination technologies based on intersatellite crosslinks in RF and optical bands
- transition to PZ-90.11 Geodetic System aligned to the ITRF with mm error level
- synchronization of GLONASS Time Scale with UTC(SU) at less than 2 ns
GLONASS STATUS (as of 27.11.2017)

AUGMENTATIONS of ROSCOSMOS
24 stations in Russia
9 stations abroad

AUGMENTATIONS of Federal authorities and state corporations
FASO Russia – 20
Rosgidromet – 145
Rosreestr – 30
Rosstandart – 5
Mintrans – 220

GEO satellites

<table>
<thead>
<tr>
<th>In total</th>
<th>3 KA</th>
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<tbody>
<tr>
<td>Operational</td>
<td>2 KA</td>
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<tr>
<td>Maintenance</td>
<td>1 KA</td>
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MEO satellites

<table>
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<td>Operational</td>
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<tr>
<td>Maintenance</td>
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<tr>
<td>Flight testing</td>
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GEO satellites:

- 3 KA
- 2 KA
- 1 KA

MEO satellites:

- 24 KA
- 0 KA
- 1 KA

The constellation provides global continuous navigation
**Glonass-M**

- 2016 - 2 Glonass-M satellites launched (07 Feb 16 and May 29)
- 22.09.2017 – 1 Glonass-M

**Glonass-K**

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

Glonass-M Launch on September 22, 2017
GLONASS REFERENCE DOCUMENTS

4 GLONASS REFERENCE DOCUMENTS RELEASED

- 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>
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<td>Variable number of SVs</td>
<td>0 to 24</td>
<td>0 to 63</td>
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<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>
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<tr>
<td>Time stamp length</td>
<td>30 bits</td>
<td>12 bits</td>
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<tr>
<td>Value of LSB</td>
<td>0.4 m</td>
<td>0.001 m</td>
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<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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</table>
GLONASS AUGMENTATIONS

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

BROADCASTING FACILITIES

GEO

L1/L5 SBAS

L1/L3 GLONASS

INTERNET

NTRIP

DATA PROCESSING FACILITY

- Master Center
- Back-Up Center

GNSS CONSTELLATION

GLOBAL MONITORING NETWORK

- network densification
- space segment modernization
- coverage extension
- Independent monitoring and verification of performance characteristics against system requirements
- Generating input data to assess GLONASS Program KPIs
- Measuring user level GLONASS performance
- Providing input data for GLONASS certification
GLONASS CIVIL SERVICES

1 BASIC OPEN SERVICE
Navigation in absolute regime using open CDMA signals

2 SERVICE OF IMPROVED RELIABILITY AND ACCURACY
Navigation in absolute regime using CDMA signals and augmentations from regional and local augmentation systems

3 RELATIVE NAVIGATION SERVICE
Navigation in relative regime using phase measurements and a reference receiver (reference station)

4 HIGH-PRECISION SERVICE
Navigation in absolute regime using phase measurements (PPP) on a commercial basis

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<thead>
<tr>
<th>Name</th>
<th>Users</th>
<th>Current value</th>
<th>Means</th>
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<td>Gonets SC</td>
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<td>In-port maneuvering</td>
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<td>Unmanned transport</td>
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<td>Mapping</td>
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<td>Earth remote sensing</td>
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<td>GEO-IK SC</td>
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<td><a href="http://www.glonass-iac.ru">www.glonass-iac.ru</a></td>
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</table>

Daily RMS SISRE, m

1 m SYSTEM FOR DIFFERENTIAL CORRECTION AND MONITORING

0.03 m NATIONAL SYSTEM FOR HIGH-ACCURACY POSITIONING

0.1 m HIGH-PRECISION SYSTEM FOR OBTAINING THE NAVIGATION AND EPHEMERIS-AND-TIME INFORMATION
PROVIDING USERS WITH GLONASS-BASED SERVICES

ORBITAL CONSTELLATION
- SATELLITES DESIGN AND MANUFACTURING
  - ROSCOSMOS

LAUNCHERS
- LAUNCHERS DESIGN AND MANUFACTURING
  - LAUNCH SERVICES
  - ROSCOSMOS

GROUND CONTROL COMPLEX
- DESIGN, MANUFACTURING, MAINTENANCE
  - ROSCOSMOS

DESIGN, MANUFACTURING, MAINTENANCE
- OPERATION

SERVICES
- GLONASS UNION
  - JSC GLONASS
  - + PRIVATE COMPANIES

  - ROSCOSMOS
  - Rostec
  - Almaz – Antey Air and Space Defence Corporation
  - + PRIVATE COMPANIES

USER NAVIGATION EQUIPMENT

USERS
- Transport
- Precise agriculture
- Energy
- Geodesy, mapping
- Construction
- Recreation
KEY GLONASS APPLICATION PROJECTS DURING
GLONASS FEDERAL PROGRAMS REALIZATION IN 2002-2017

GROUND ROAD TRANSPORT

- ~2.1 million of cars is GNSS-equipped
- 52 regional navigation-informational systems
- ERA-GLONASS – plan for 100% coverage of car fleet in Russia:
  up to 42 million onboard GNSS-terminals;
- Platon – all cargo trucks exceeding 12 tons of gross vehicle weight:
  up to 2 million onboard GNSS-terminals;

RAILROAD TRANSPORT

- 14 thousand of rolling stock is GNSS-equipped
- 49 ground local reference stations for differential correction to support high-precision coordinate systems and shunting

ROCKET & SPACE

GLONASS-based technologies have become primary navigation tool for put-into-orbit operations of:
- Progress-MS cargo SC;
- Soyuz-MS manned SC;
- Resurs Earth Remote Sensing SC;
- Kanopus Earth Remote Sensing SC.

GLONASS technologies are used at:
- Kondor-E SC;
- Meteor-M SC;
- Bars-M SC and others.

MARINE TRANSPORT

- Over 40 control and correction stations at the sea and river ports

MARINE TRANSPORT

- 94 civil airports equipped with GLONASS ground-based augmentations systems (GBAS)

AGRICULTURE

- 3 thousand of agriculture machinery is GNSS-equipped

R&D

- 6 research and development works aimed at GLONASS-based soft-, hardware and complex systems development in transport industry
- In operation since January 1, 2016, nation-wide
- All domestically manufactured or imported vehicles are to be equipped with ERA-GLONASS since January 1, 2017
- 30% reduction of time emergency services respond to an accident
- 347 thousand calls processed, 854 thousand vehicles equipped since start of operation
- Social-and-economic effect: saving more than 4 thousand people annually
  (an estimation provided that 100% of the Russian vehicle fleet is equipped)
- Emergency call is free of charge
- Commercial application potential: smart insurance, property and crime protection, traffic monitoring, toll collection, distant diagnostics and etc.
FEDERAL TOLL COLLECTION SYSTEM FOR COMMERCIAL CARGO TRUCKS – PLATON

- PLATON – nation-wide GLONASS/GPS based automatic toll collection system
- In operation since November 15, 2015
- All trucks over 12 tons
- All Federal-owned highways – 50.774 km in total
- 88% of the total fleet – 330 thousand cargo companies and 900 thousand trucks registered
- 32,9 billion rubles collected for road infrastructure support
**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
Thank you for attention!