GLONASS Evolution and Performance Improvement

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November 9—14, 2014
Prague, Czech Republic
Orbital Crystal
GLONASS Nominal Constellation

Constellation:
24 S/Cs (3 planes, 8 satellites per a plane)

Orbit type:
circular,
altitude - H = 19 100 km,
inclination - i = 64.8°

Orbital period: 11 h 15 min 44 sec
Orbital planes: spaced by 120° along equator
Service area: global, up to altitude of 2000 km

Orbital parameters allow high stability of GLONASS constellation over the entire satellite operational life time without additional maintenance costs & propellant
GLONASS Constellation

Status as of November 10, 2014

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>28 S/C</td>
</tr>
<tr>
<td>Operational</td>
<td>24 S/C</td>
</tr>
<tr>
<td>Orbital spare</td>
<td>2 S/C</td>
</tr>
<tr>
<td>Under flight test</td>
<td>1 S/C</td>
</tr>
<tr>
<td>Under Investigation</td>
<td>1 S/C</td>
</tr>
</tbody>
</table>

The launch is scheduled in December
Block K2s – «Glonass-K1» No.12
Glonass-M is the 2nd generation of Glonass family
First launch was in 2003
Glonass-K1 is the 3rd generation of Glonass family
It is the interim satellite intended to validate a completely new technology
First launch was in 2012
Glonass-K2

Design life time - 10 years;
- Mass - 1645 kg;
- Power consumption - 4370 W;
- Navigation payload:
  - Mass - 520 kg;
  - Power consumption - 2618 W;
- Accuracy of S/C attitude control - ± 0.25 deg;
- Solar arrays area - 33.84 m²;
- Stability of onboard frequency generator - 5×10⁻¹⁴ ÷ 5×10⁻¹⁵;
- S/C availability - 0.99;
- Mission tasks - 6
- Navigation signals: L1OF; L2OF; L1SF; L2SF; L1OC; L1SC; L2OC; L2SC; L3OC

Glonass-K2 is the 3rd generation of Glonass family
First launch is planned in 2016
Navigation Requirements

User requirements

- Better accuracy
- Continuous availability
- Interference immunity
- Navigation services ensured by system providers
- Navigation indoor, underwater, underground, in space between the Earth and the Moon

System Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Now</th>
<th>I phase</th>
<th>II phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of satellites in constellation</td>
<td>26</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Positioning accuracy in real-time mode (m)</td>
<td>2.8</td>
<td>1.1</td>
<td>0.6</td>
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<tr>
<td>Timing accuracy (ns)</td>
<td>5</td>
<td>2</td>
<td>1</td>
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</tbody>
</table>

Support System Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>System time scale referenced to UTC(SU) (ns)</td>
<td>1</td>
</tr>
<tr>
<td>UTC(SU) referenced to UTC (ns)</td>
<td>1</td>
</tr>
<tr>
<td>PZ-90 referenced to ITRS (m)</td>
<td>0.005</td>
</tr>
<tr>
<td>Accuracy of Earth Pole determination in real-time mode (m)</td>
<td>0.003</td>
</tr>
</tbody>
</table>

New requirements demand new technologies and new solutions
Improvement of GLONASS System Accuracy

Accuracy was improved ten times over the last decade
Tramlines of GLONASS performance improvement

- Constellation renewal with Glonass-K1 and Glonass-K2 satellites
- Improvement of navigation service accuracy due to:
  - New generation of the Ground Control Segment
  - The global network of one-way measuring stations
  - Crosslink functions for Ephemeris and Clock data provision
GLONASS Ground Segment Deployment

It includes:

- Deployment of measuring station network throughout the Russian territory
- Deployment of measuring station network in Antarctica
- Deployment of uplink station network throughout the Russian territory
- Deployment of global measuring station network outside the Russian territory
- Further use of crosslink functions for Ephemeris and Clock data provision
- Creation of high–stable Time Scale based on distributed frequency standards synchronized versus the state frequency standard.

Ground segment deployment ensures significant improvement of GLONASS system accuracy.
Prediction for launches of satellites with new CDMA signals

Number of satellites with the specified signals within GLONASS constellation

FDMA signals
L3 CDMA signal
L1, L2 CDMA signals
The GLONASS system was, is, and will be the foundation of the Russian navigation infrastructure for years.

Being a part of the global navigation infrastructure, the GLONASS system is providing the baseline services to all users free of charge.

Keeping up with competitors is the basis of mainstream use of GLONASS services worldwide.

International GNSS cooperation is aimed to assure mainstream use of GLONASS services worldwide.

Thank you for attention!