GLObal Navigation Satellite System (GLONASS)

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- System description
  - Space segment
  - Ground segment
  - Signals
  - Performance
  - Timetable for system deployment. System Modernization

- Services provided and provision policies
- Perspective on compatibility and interoperability
- International cooperation
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System Description

GLONASS Overview

- **Orbit constellation:**
  - 24 satellites, 3 planes by 8 satellites
  - Orbit shift by 120° along the equator

- **Orbit parameters**
  - Orbit – circular
  - Height 19100 km
  - Inclination 64.8°
  - Revolution 11h15min

- **Two types of signal:**
  - Standard (open)
  - Special (authorized)
Main features

- Guaranteed life time: 7 years;
- Mass: 1415 kg;
- Clock stability: 1e-13;
- Attitude control accuracy: 0.5 deg;
- Level of unpredictable aclrs: 5e-11 m/c^2
- Navigations signals: 4 signals in L1 and L2 bands with FDMA

Main features

- Extended life time
- Second civil signal L2
- Increased board clock stability
- Improved attitude and the solar panel pointing accuracy
- Improved dynamic model
- Using Inter Satellite Link (ISL) measurements for improvement ephemeris and clock navigation data (test mode)
System Description

Ground Control Segment

- SCC – system control center
- TT&C – telemetry, tracking, commanding station
- ULS – upload station
- CC – central clock
- SLR – laser tracking station
- MS – monitoring and measuring station

New stations after 2010

Operational stations
In 2007-2008 12 GLONASS-M satellites launched

1st phase of Ground Control modernization

Refined geodesy reference implemented (PZ-90.02)

19 GLONASS-M Satellites in orbit (two civil signals in L1 и L2)

Next launches:
- September 2009 – 3 “Glonass-M” sats
- November 2009 – 3 “Glonass-M” sats
Existing GLONASS FDMA Signals

- **L2**
  - L2 open FDMA
  - L2 authorized FDMA

- **L1**
  - L1 open FDMA
  - L1 authorized FDMA

GLONASS will continue transmitting existing FDMA signals for the future.
GLONASS Constellation Status (14.09.2009)

17 satellites operational
Global availability is 87-95% (PDOP<6, $\gamma>5^\circ$)

Mean availability for a day

Instant availability
GLONASS Accuracy

- GLONASS accuracy has 5 times improved for the last three years.
- Now it is the same order of GPS.
- Next improvement phase is expected by 2011.

GLONASS accuracy has improved significantly over the past three years. In 2006, the accuracy was around 25 meters. By 2007, it improved to approximately 18 meters. In 2008, it further improved to around 15 meters. By 2009, the accuracy reached 5-7 meters, making it comparable to GPS. The next phase of improvement is expected by 2011.

Ideal receiver positioning accuracy:

- 20.02.2006: ~25 m (1 sigma)
- 20.02.2007: ~18 m (1 sigma)
- 20.02.2008: ~15 m (1 sigma)
- 20.02.2009: ~5-7 m (1 sigma)
New GLONASS Technical Requirements

- Precise Ephemeris and Clock System
- Earth Attitude and Rotation System
- GLONASS Space Complex
- Wide Area Augmentation SDCM
- Time Reference System UTC (SU)
- Geodesy Reference and Maps
- Regional Augmentations
- Special User Equipment
- Civil Users Equipment

Synergy of performance and requirements
GLONASS Strategy Planning

- Full constellation deployment in 2010
- Ground Control Segment modernization
- New GLONASS-K satellite (with improved performance) IOV start by 2010
- GLONASS will continue transmitting existing FDMA signals
- Additional new CDMA signals since GLONASS-K deployment
- GLONASS performance competitive ability provision plan
- GLONASS Federal Program extension until 2020
GLONASS Deployment Program

December, 2009
22 satellites.
99.7% global availability

December, 2010
24 satellites.
99.99% global availability
The direction of GLONASS navigation signals modernization

- Provide better potential accuracy for pseudorange and phase measurements
- Provide a better interference and multipath resistance of GLONASS signals
- Provide of greater interoperability with GPS and future GALILEO and other GNSS

Introduction of new CDMA signals since GLONASS-K deployment
SDCM General Architecture

- GEO satellite
- GPS satellites
- GLONASS satellites
- Differential and Integrity data
- Precise accuracy
- Standard accuracy
- Up-link station
- Central processing facility
- Reference Integrity monitoring stations network
SDCM Objectives

- GNSS Monitoring
  - Integrity monitoring
  - A posteriori detail analysis of system performance
- Differential corrections
- Service area – the Russian Federation
- **Reference stations (2008):**
  1. Moscow (Mendeleevo)
  2. Pulkovo
  3. Kislovodsk
  4. Norilsk
  5. Irkutsk
  6. Petropavlovsk-Kamchatka
  7. Khabarovsk
  8. Novosibirsk
  9. Gelenzhik

- **Reference stations (further development):**
  10. Tiksi
  11. Bilibino
  12. Magadan
  13. Yuzhno-Sakhalinsk
  14. Yakutsk
  15. Vladivostok
  16. Sverdlovsk
  17. Lovozero
  18. Voronezh
  19. Pechery

*First part of SDCM reference stations network was put into the test operation in 2007*
SDCM Space Segment

- **Mass**
  - 1000 kg
- **Life-time**
  - 10 years
- **Antenna pattern:**
  - Narrow
  - Re-steering
  - Omni directional
- **Longitudes:**
  - Luch-5A: 16° west
  - Luch-5B: 95° east

GEO «Luch – 5A» with L1 transponder
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- Perspective on compatibility and interoperability
- International cooperation
GLONASS is a part of the critical state PNT infrastructure providing national security and economy development

Creating, developing and sustaining the PNT infrastructure is a State responsibility

No direct user fees for civil GLONASS services

Open, free access to GLONASS information necessary to develop and build user equipment

GLONASS is used in combination with other GNSS, terrestrial radio navigation, other navigation means to increase reliability of navigation

International cooperation on GNSS compatibility and interoperability

Federal GLONASS Program is a basis for GLONASS sustainment, development and use
Federal GLONASS Program 2002-2011

- Provide full constellation of 24 satellites by 2010
- Improve GLONASS performance
- Implement new GLONASS signals
- Encourage the GLONASS worldwide use

Subprograms

1. GLONASS sustainment, development and deployment
2. User equipment development for civil users
3. Satellite navigation technique implementation in transport areas
4. Geodesy reference improvement
5. User equipment development for authorized users

Update of September 12, 2008
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- **Services provided and provision policies**

- **Perspective on compatibility and interoperability**

- **International cooperation**
Compatibility refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service.

- GNSS compatibility is mainly defined by radiofrequency compatibility of navigation signals.
- ITU provides procedure to resolve radiofrequency signal compatibility.
- ICG recommends for new signals to avoid spectral overlap between each system’s authorized service signals and other systems’ signals.
- Recognizing that spectral separation of authorized service signals and other systems’ signals practically not always feasible and its overlap exists now and might be in future, stakeholders (providers concerned) will resolve these issues by way of consultations and negotiations.
Interoperability refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system.

- Interoperability of systems and augmentations and their services is provided by interoperability of signals, geodesy and time references.

- Signal interoperability: depends on the user market both common and separated central frequencies of navigation signals are essential.
  - Signals with common central frequencies provide minimal cost, mass, size, power consumption of the user equipment.
  - Signals with separated central frequencies provide better reliability and robustness of the navigation service.

- Geodesy: all GNSS geodesy references should be coordinated between each other to the maximum extent practical.
  - PZ-90 used in GLONASS will continue improving in future.

- Time: all national and system UTC realizations should be coordinated with the international standard of UTC to the maximum extent practical.
  - GLONASS time scale will continue improving in future.

- Co-location of ground control segment monitoring stations of different GNSS is important to provide geodesy and time interoperability.
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International Cooperation

- **Goals:**
  - Promote GLONASS worldwide use
  - Provide GNSS compatibility and interoperability
  - Integrate GLONASS into the Global GNSS Infrastructure

- **Cooperation with GNSS providers**
  - The United States – GPS/GLONASS compatibility and interoperability
  - European Union – Galileo/GLONASS and augmentations compatibility and interoperability
  - India – GLONASS deployment support, augmentations interoperability
  - UN GNSS Providers Forum

- **GLONASS Use Cooperation**
  - Former USSR countries
  - Middle East, Australia, Latin America...
  - UN ICG
Summary

- GLONASS Program is the high priority of the Russian Government policy

- GLONASS Program is in progress, will be extended to 2020

- GLONASS improvement is a major objective:
  - Performance to be comparable with GPS by the end of 2011
  - Full constellation (24 sats) by the end of 2010
  - New signals implementation to improve the service for both military and civil users

- Compatibility and interoperability are the goals of international cooperation, as well as the GLONASS worldwide use
Thank you!

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History of the GLONASS Policy

- 1982: First launch of GLONASS SV
- 1986: Decree of the CPSU Central Committee and CM of the USSR № 136-46 from 27.01.1986 on GLONASS modernization
- 1993: Russian Federation (RF) Presidential Instruction №658 RPS from 24.09.1993 started the system operational with IOC
- 1995: The RF Governmental Decree № 237 from 07.03.1995 to start GLONASS operation with FOC
- 1998: RF Presidential Order to the Government of Russia on the GLONASS development plan
- 2001: RF Governmental Decree № 587 from 20.08.2001 adopted the Federal Program “Global Navigation System”
- 2007: Decree of the President of the Russian Federation on GLONASS development and use
GLONASS Status User Interface

- GLONASS Constellation Status
- GLONASS Performance
- GLONASS ICD
- Federal Official Documents
- GLONASS News

www.glonass-ianc.rsa.ru