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GLONASS Status, Development and Application

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International Committee on Global Navigation Satellite Systems (ICG)
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- **GLONASS State Policy**
- **GLONASS Architecture**
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- **International cooperation**
- **Summary**





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GLONASS State Policy



GNSS Features



□ GNSS become the global strategic utility used in many countries in the all areas of economy in many applications

- ↙ Presently the US GPS is widely in use. The Russian GLONASS has been fully deployed in 1995, now is in the reconstruction and development phase. The EU GALILEO is in progress to be deployed by 2012.
- ↙ GNSS systems are highly sensitive to interference and jamming

There is a risk to provide the reliable navigation and economy development for many countries when only one system is applied

To reduce the risk and to provide sustainable economy development:
- **Highly important to rely on two systems at least for redundancy**

GLONASS is a basis to reduce the risk and support sustainable development of economy





Basic principles of the GLONASS State Policy



- ❑ **GLONASS is an element of the critical state infrastructure ensuring national security and development of economy**
- ❑ **GLONASS is a dual use system**
- ❑ **Access to civilian GLONASS service is free of direct user fee**
- ❑ **Documentation on the open GLONASS service is available for user community, developers and manufacturers of the navigation equipment**
- ❑ **Support development and production of the combined receivers GLONASS/GPS**
- ❑ **Providing compatibility and interoperability with others GNSS and augmentations (GPS, GALILEO...)**
- ❑ **Encouraging the navigation mass market development**
- ❑ **Binding use of GLONASS or GLONASS/GPS combine receivers to the state users**





New Presidential Decree on GLONASS



- **Issued at May 18, 2007**
- **Main statements:**
 - ↙ Free access to the civil signals
 - ↙ GLONASS binding use for governmental and strategic applications
- **Recommended:**
 - ↙ GLONASS use for regional authorities and commercial companies
- **General coordination of GLONASS sustainment, development and application**
 - ↙ Federal Space Agency
- **To the Government:**
 - ↙ GLONASS promotion, including international cooperation
 - ↙ Digital maps issue to be resolved asap
 - ↙ Preparation of the new GLONASS Program for 2012 – 2020.





Federal GLONASS Program for 2002-2011



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 military users



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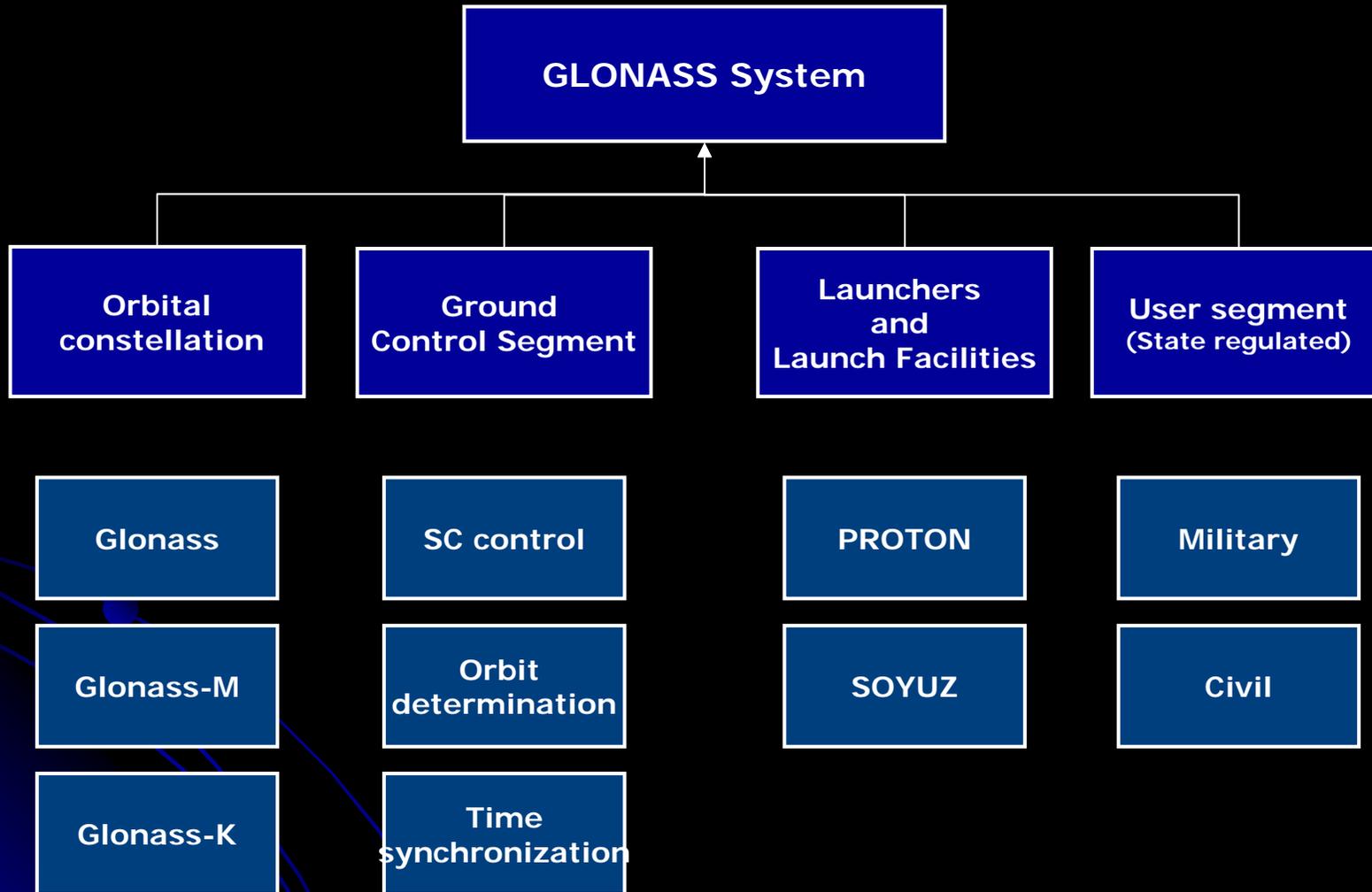
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GLONASS Architecture



GLONASS architecture





GLONASS Orbits



□ 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





Constellation Status



□ In orbit 17 satellites

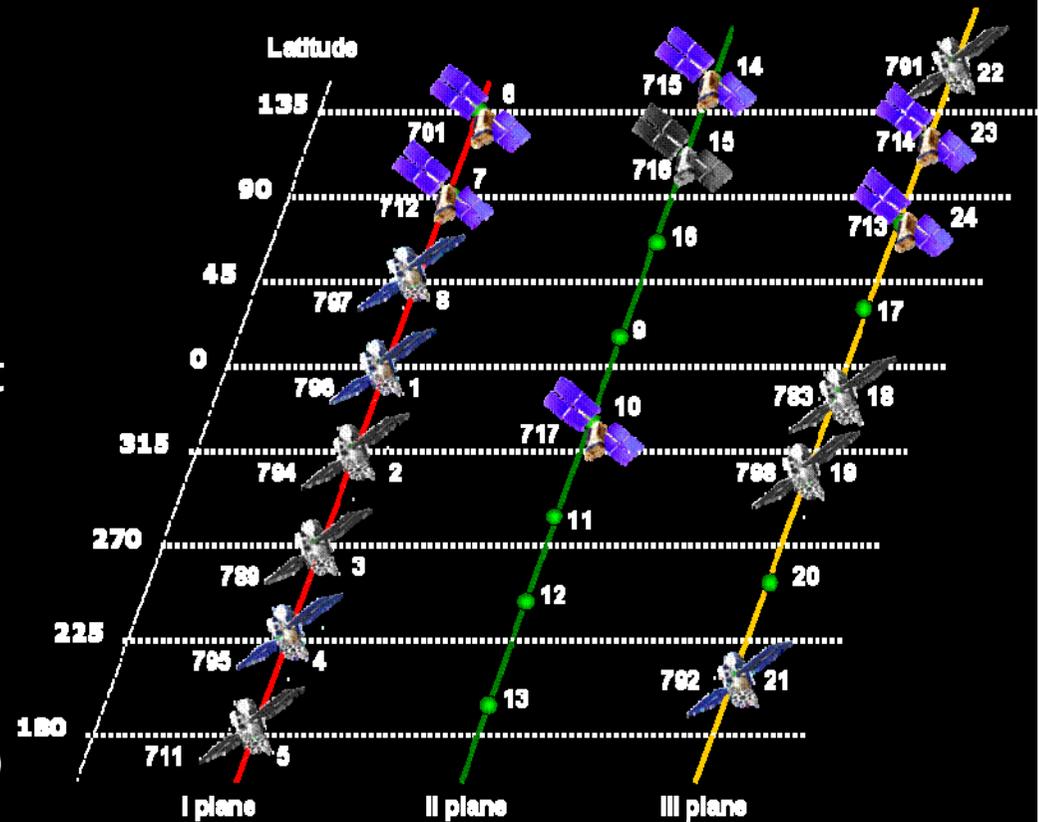
- ↪ 7 new GLONASS-M
- ↪ 10 old GLONASS

□ Healthy 10 sats

- ↪ In commissioning 1 sat
- ↪ In maintenance 1 sat
- ↪ In decommissioning 5 sats

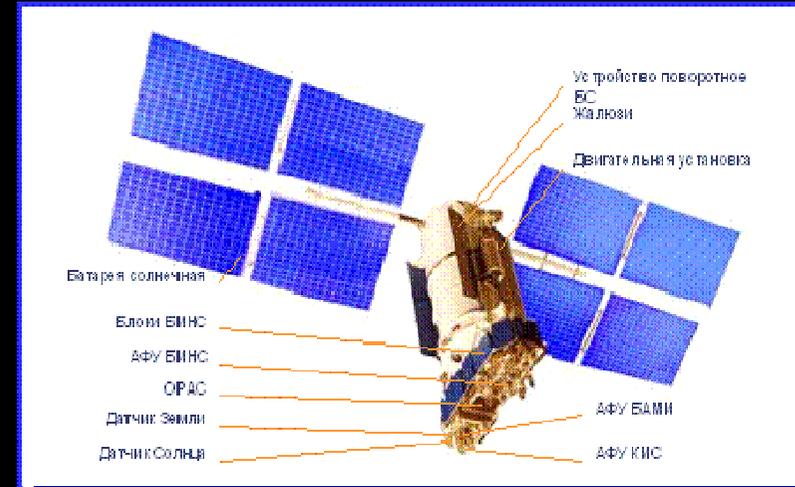
□ Launches in 2007:

- ↪ Block 36 (3 Glonass-M)
- ↪ Block 37 (3 Glonass-M)



□ Main Specifications

Guaranteed life time	7 years
Spacecraft mass	1415 kg
Power supply	1450 W
Navigation payload	
Mass	250 kg
Power consumption	580 W
Clock stability	$1 * 10^{-13}$
Attitude control accuracy	0.5 deg
Solar panel pointing accuracy	2 deg



□ Main features

- ↙ Extended life time
- ↙ Second civil signal L2
- ↙ Increased clock stability
- ↙ Better accuracy of the solar panel pointing
- ↙ Improved dynamic model



Antenna, power amplifiers, secondary control units

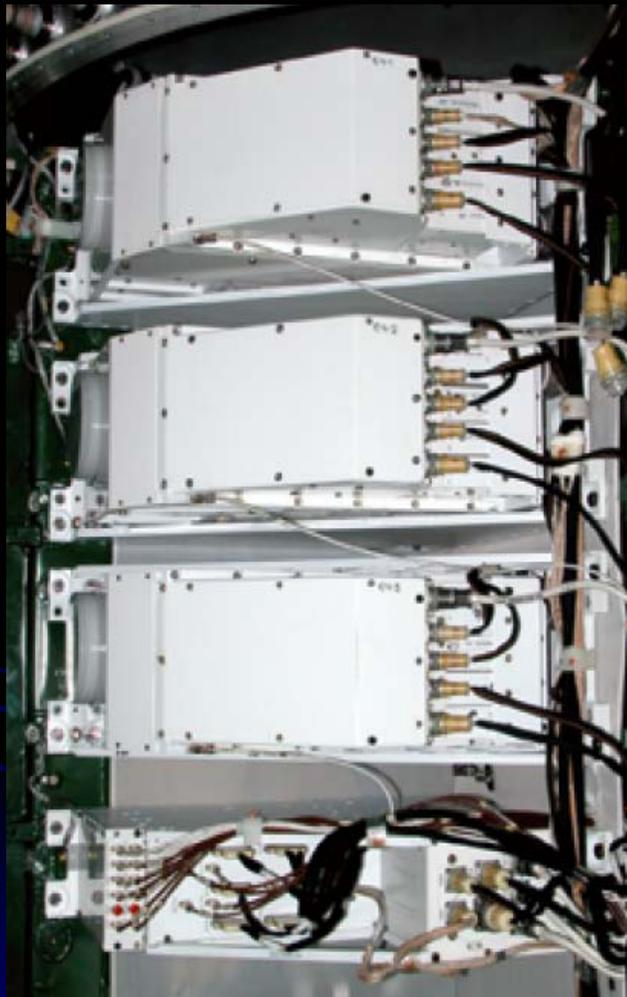
Signal generator specification:

Frequency band	
L1, MHz	1600
L2, MHz	1250
Radiating power	
L1, W	64
L2, W	40
Data rate at L1 и L2,	50



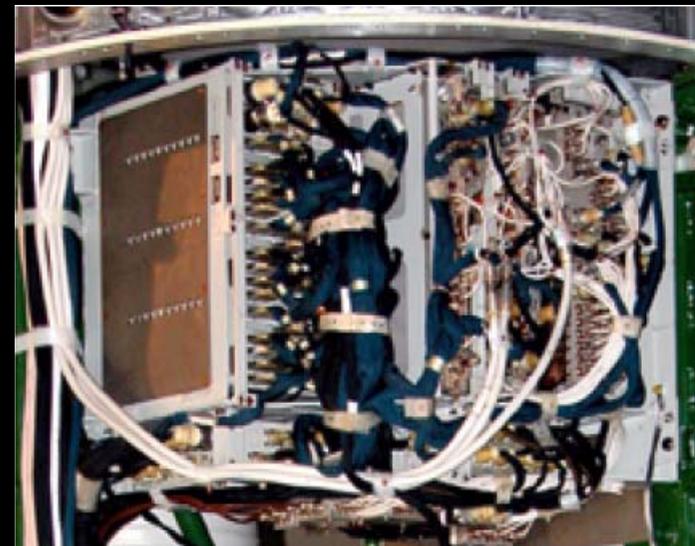
Navigation signal generator

On-board Clock



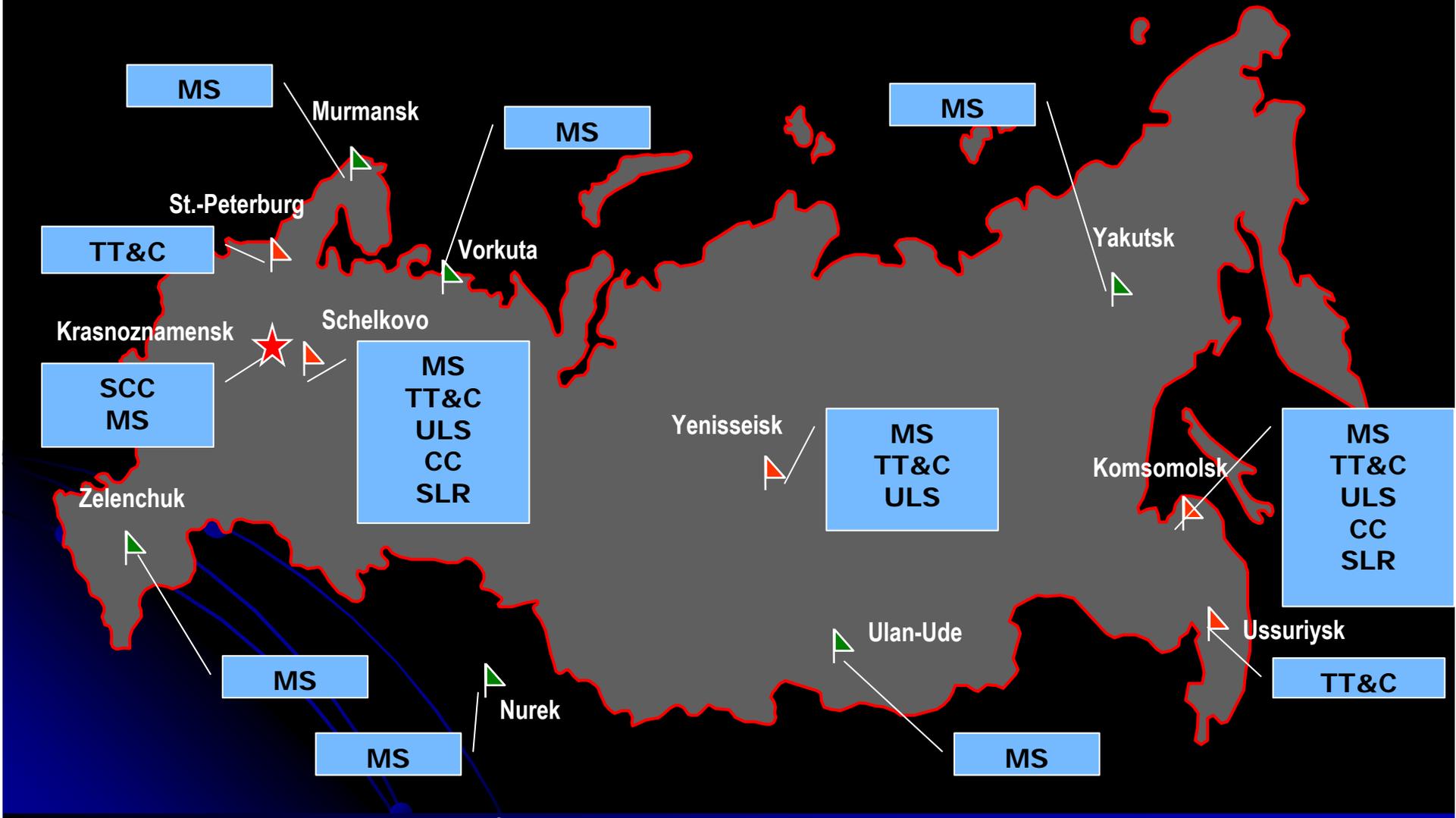
Three atomic frequency generators
Synchronization unit

Stability: $1 * 10^{-13}$





Ground Control Segment



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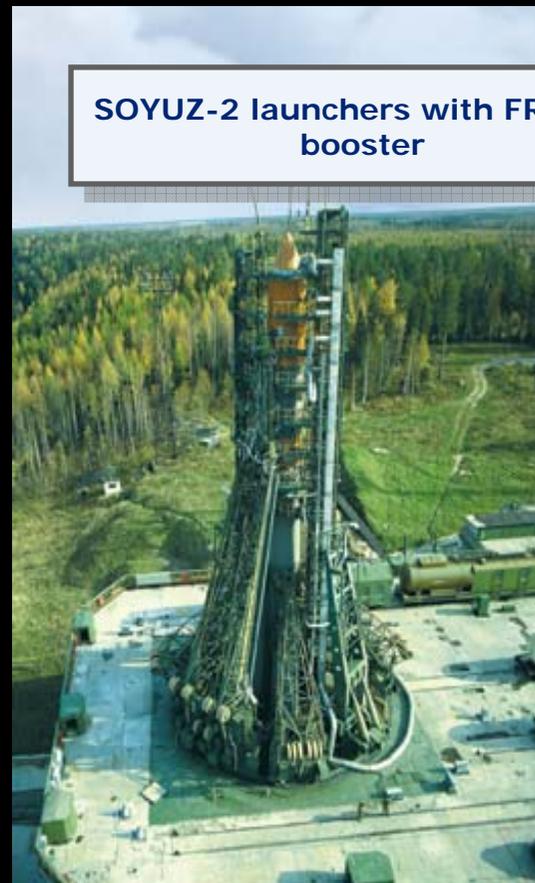
Launchers



PROTON-K launcher with «DM» booster



Baykonur



SOYUZ-2 launchers with FREGAT booster

Plesetsk





System of Differential Corrections and Monitoring (SDCM) – wide area augmentation



□ Main Objectives:

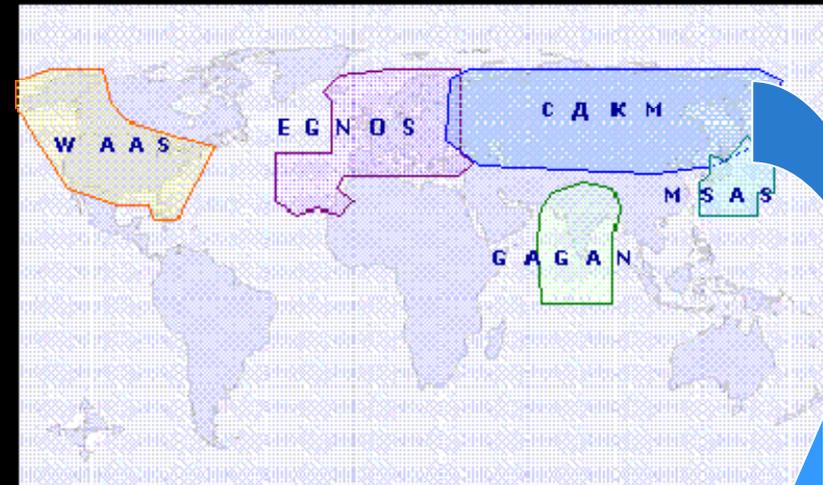
- ↪ Orbit and clock correction transmission to users
- ↪ Integrity provision

□ Status:

- ↪ Limited monitoring network deployed
- ↪ Operation tests

□ Validation

- ↪ 2010





User Equipment



- **GLONASS/GPS boards and chip sets**
- **User equipment**
 - ↖ Individual navigation
 - ↖ Aviation
 - ↖ Maritime
 - ↖ Geodesy
- **Integrated information navigation systems**





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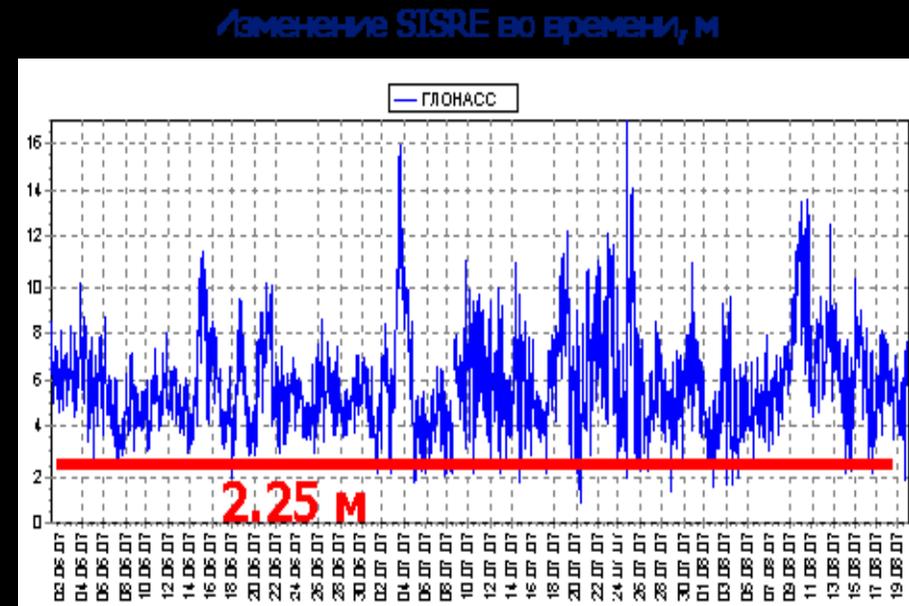
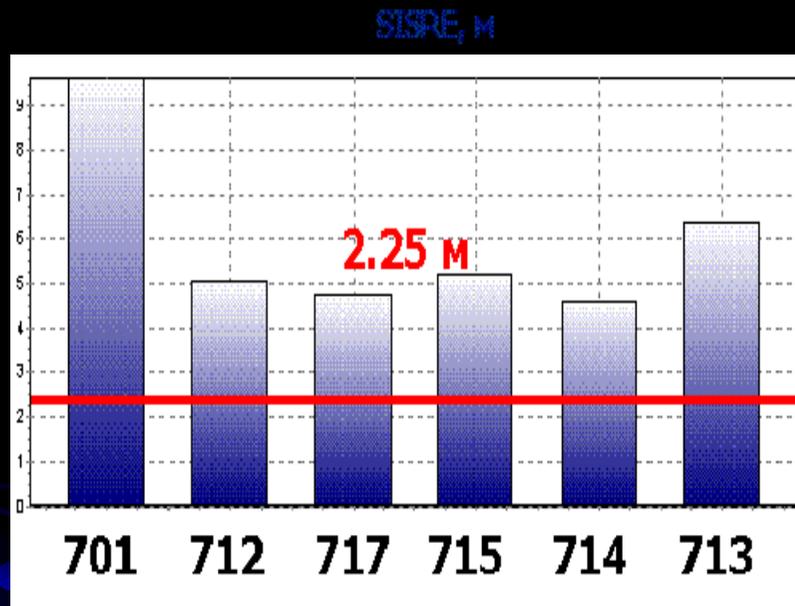
GLONASS-M Flight Test (not yet completed)



GLONASS-M SISRE (today status)



Flight test results



Main problem – clock synchronization





On-board clock stability (observed)



Requirement:

$$1 * 10^{-13}$$

Achieved results:

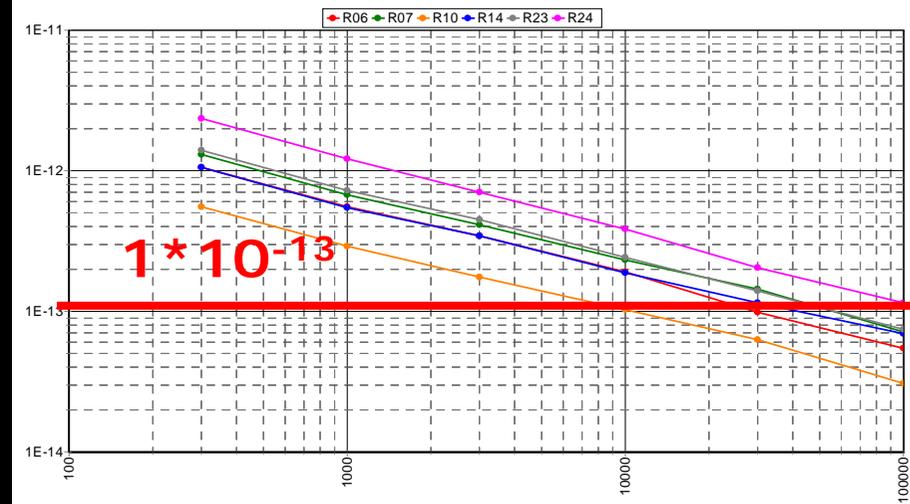
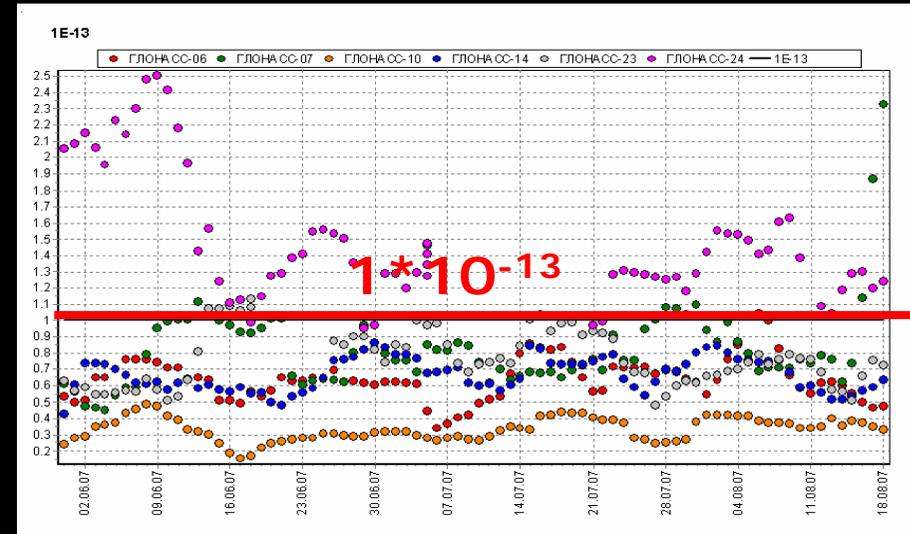
↙ For all GLONASS-M (without GI-M # 13)

$$< 1 * 10^{-13}$$

↙ GLONASS-M # 17

$$2-4 * 10^{-14}$$

Better than requirements





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GLONASS Modernization



GLONASS Requirement Document Update



- **Improved Accuracy (open service)**
 - ↪ SIS positioning and timing, all-in-view, full constellation (95%)
 - <1.6 horizontal
 - <2.6 vertical
 - <5 ns
- **New civil signals**
 - ↪ L3PT FDMA
 - ↪ L1CR and L5R interoperable with GPS and Galileo
- **Improved geodesy reference**
 - ↪ PZ-90.XX wrt ITRF < 5 cm
- **Improved time reference**
 - ↪ GloST wrt UTC (SU) <120 ns with accuracy 6 ns

Approval has to be done by the end of 2007

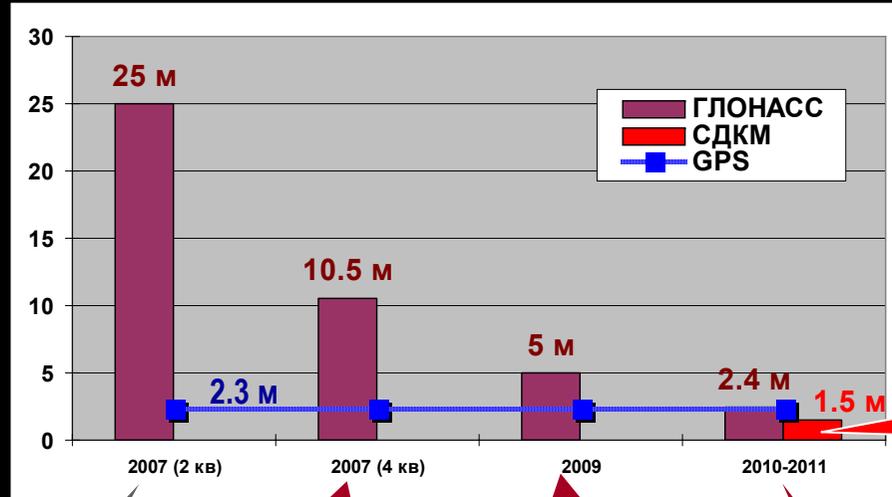




GLONASS Accuracy Improvement Program



positioning accuracy



Wide Area Augmentation

- Two-way technique for OD&TS
- Measurements:
 - 5 TT&C stations

- Combine Two-way and One-way OD&TS technique
- Measurements +
 - 3 MS
 - 1 ULS
- Geodesy reference update

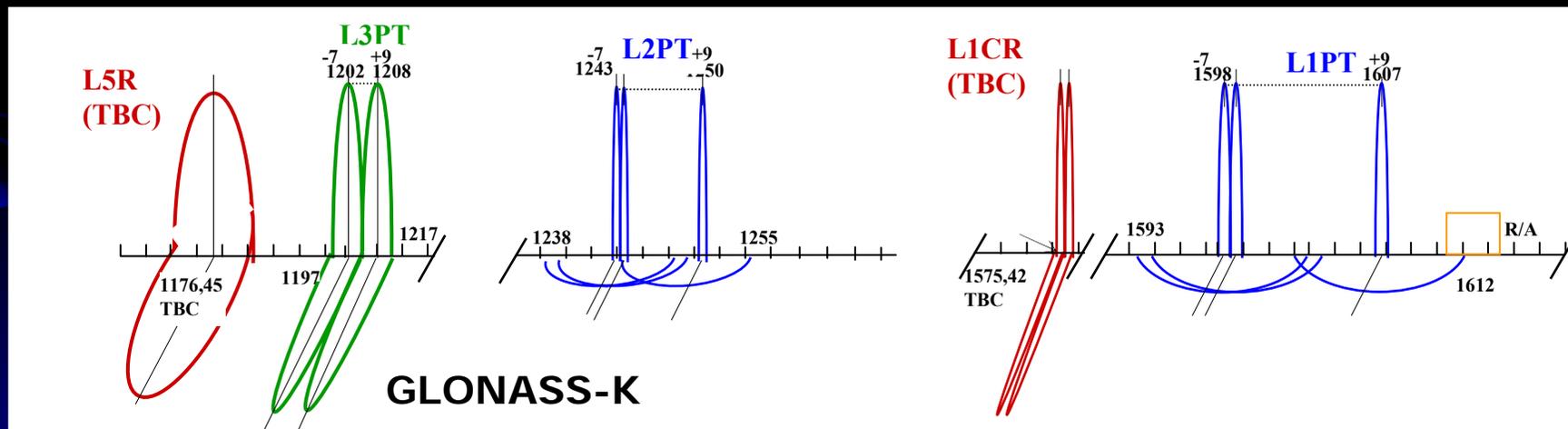
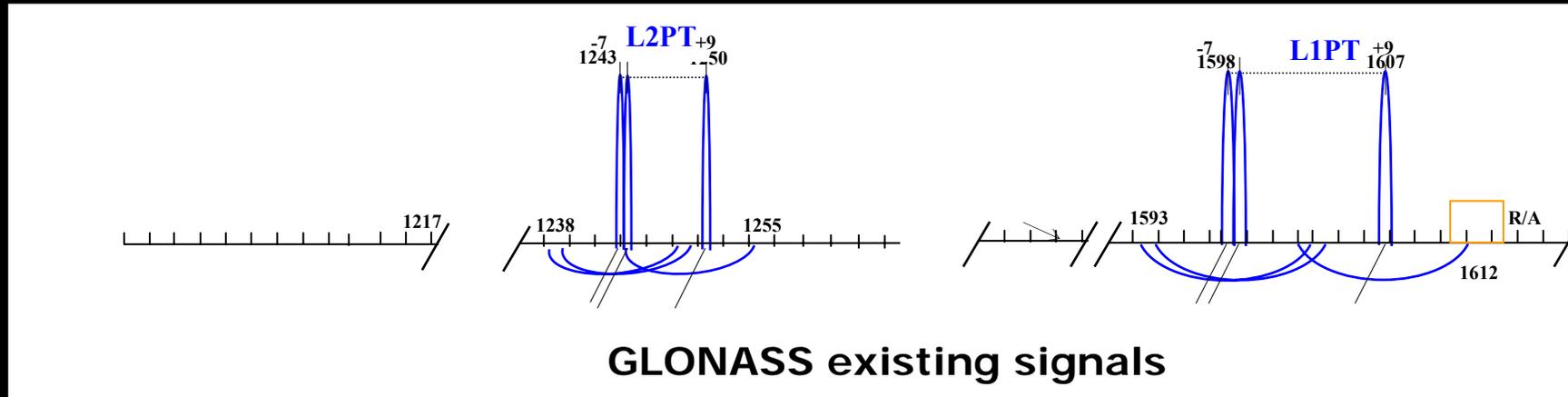
- Full constellation of 24 satellites
- Extension of monitoring network
- Measurements ++
 - 6 MS
 - 2 ULS

- On-board clock stability improvement to $5 \cdot 10^{-14}$
- Global MS network
- Measurements +++:
 - 6-10 stations outside Russia





Signal Modernization



L1CR, L5R: pending final decision





PZ-90.02



□ Governmental Decision of 20 June 2007:

- ↙ PZ-90.02 implementation in GLONASS
- ↙ Further permanent improvement toward ITRF

□ New geodesy reference in GLONASS

- ↙ To be introduced at 20 September 2007

□ PZ-90.02 coordination to ITRF:

- ↙ No rotation
- ↙ Delta X: -36 cm
- ↙ Delta Y: +8 cm
- ↙ Delta Z: +18 cm

GLONASS orbit accuracy improvement by 15-25 %





GLONASS Development Program



- **Continuous global navigation by 2010**
 - ↳ 24 satellites in constellation
- **GLONASS performance to be comparable with GPS (2010)**
- **Ground control segment modernization**
 - ↳ Monitoring station network extension (Russia)
 - ↳ System time scale improvement
 - ↳ Monitoring network outside Russia
- **Signal modernization**
 - ↳ Third civil signal at L3 (since GLONASS-K in 2009-2010)
 - ↳ New interoperable signals at L1 (L1CR) and L5 (L5R)
- **Interoperability with GPS and future GALILEO**
 - ↳ Geodesy system
 - ↳ Time system
- **Further modernization of GLONASS based on new GLONASS-KM satellite**



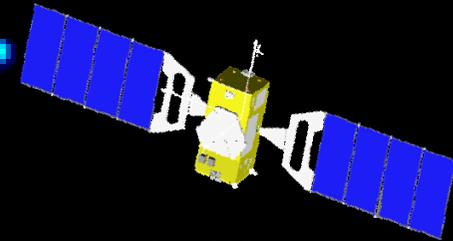


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GPS



Galileo



International cooperation



Objective background for international cooperation



□ GNSS become the global strategic utility for

- ↪ National security
- ↪ Economy development

□ Necessity to coordinate activity between system providers during the system development and modernization

□ Necessity to provide compatibility and interoperability to benefit users when the combine receivers are in use





Benefits of the combine use



- ❑ Improved availability in the city canyons
- ❑ Increase robustness in the interfering conditions
- ❑ Reliability of service





International Cooperation Principles



- ❑ Encouraging of GLONASS use all over the world to sustainable development
- ❑ Open access of all users to the civil signals free of direct user charge
- ❑ GLONASS compatibility and interoperability with other GNSS and augmentations (GPS, Galileo, WAAS, EGNOS, IRNSS/GAGAN, QZSS...)
- ❑ Ensure the interests of the Russian Federation having in mind the dual use status of GLONASS as an element of the strategic state infrastructure

International cooperation concept is to be completed by the end of 2007





Priority direction of the International Cooperation in GNSS



- ❑ Radio frequency compatibility
- ❑ RNSS frequency band protection
- ❑ Interoperability with GPS and GALILEO and augmentations in sense of signals, geodesy reference and time reference
- ❑ Development of common standards for GNSS application
- ❑ GNSS service certification
- ❑ Advance SatNav technology development
- ❑ Search and rescue service implementation on GNSS
- ❑ Integrity monitoring





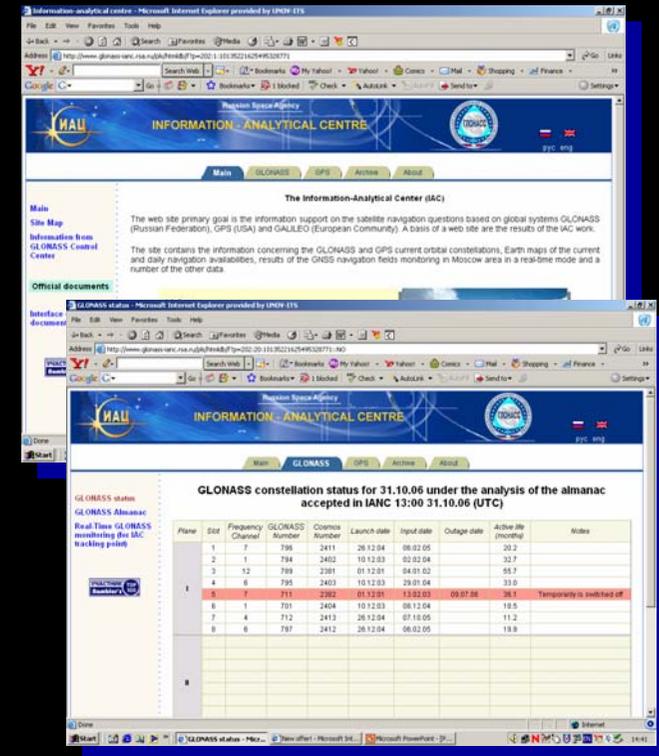
User Interface



www.glonass-ianc.rsa.ru

Information Analysis Center of Positioning, Navigation and Time support (division of the Central Research Institute of Roscosmos)

- ↪ Daily bulletins on GLONASS and GPS status based on global data
- ↪ GLONASS control center official information
- ↪ Monthly bulletin with detail analysis of system performance
- ↪ Navigation news
- ↪ GLONASS iCD



IAC PNT – feed back in the GLONASS control loop



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Summary



Summary



- **GLONASS system is an element of the critical state infrastructure, ensuring national security and economy development, remains being a dual use system**
- **Urgent GLONASS restoration, development and mass use is one of priorities of the Russian State policy**
- **GLONASS – essential element of the international GNSS to secure sustainable development and economy growth**





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Thank you for your attention !