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# GLONASS Status, Development and Application

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International Committee on Global Navigation Satellite Systems (ICG)  
Second Meeting, September 4-7, 2007, Bangalore, India



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- **GLONASS Architecture**
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- **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.





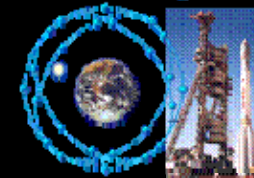
# Federal GLONASS Program for 2002-2011



## 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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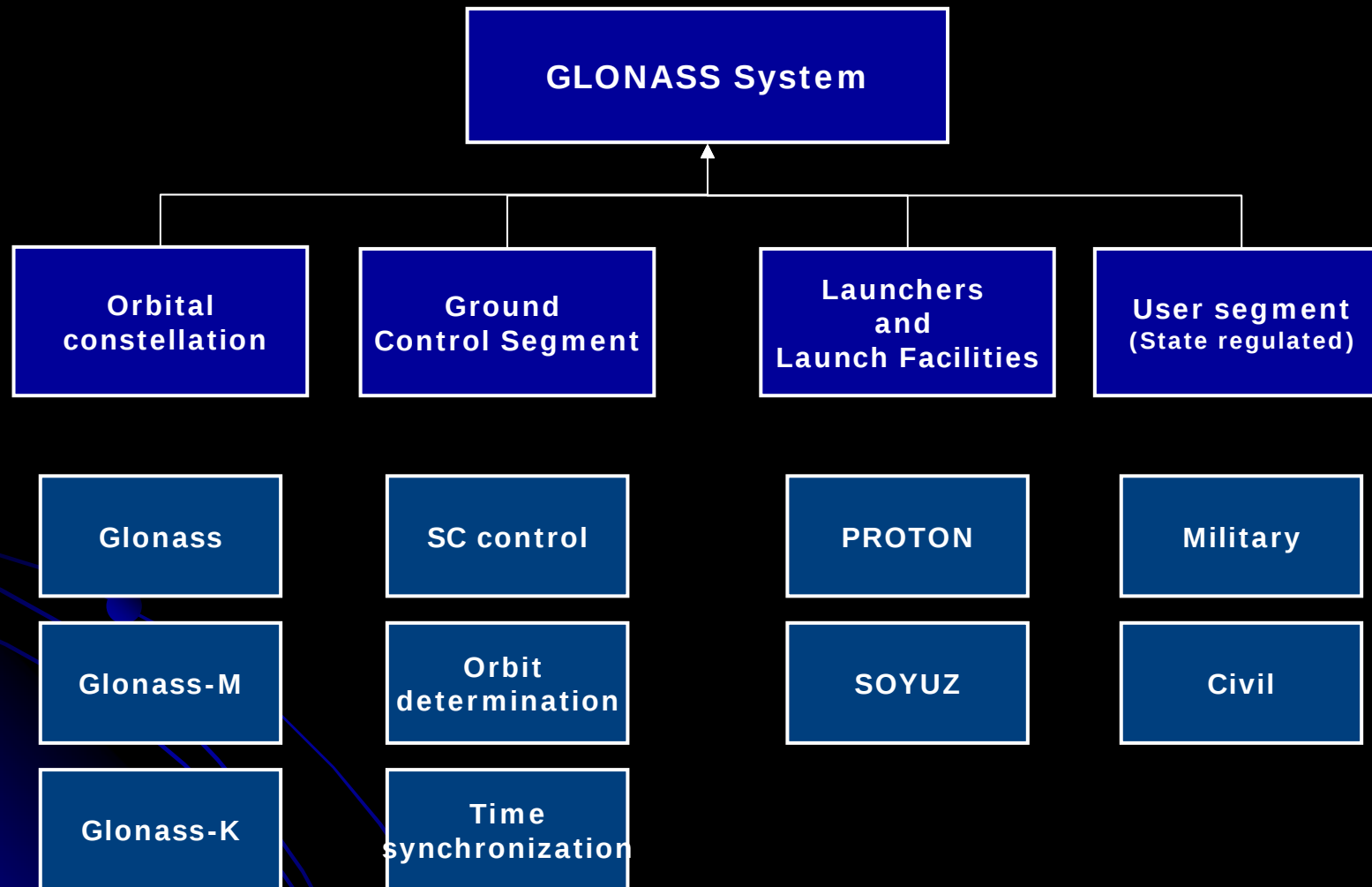
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# GLONASS Architecture



# GLONASS architecture





# GLONASS Orbits

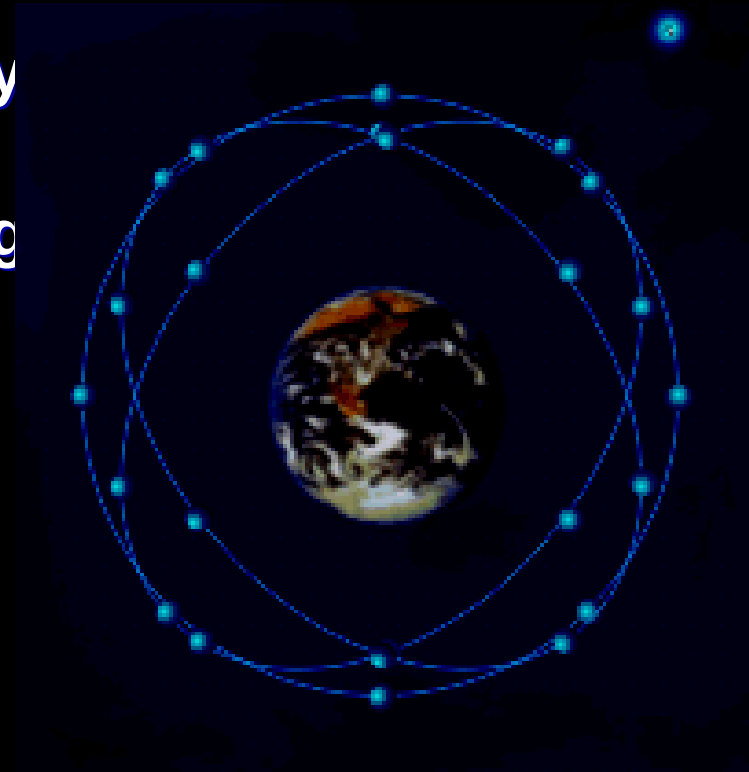


## □ Orbit constellation:

- ✦ 24 satellites, 3 planes by 8 satellites
- ✦ Orbit shift by  $120^\circ$  along the equator

## □ Orbit parameters

- ✦ orbit – circular
- ✦ height 19100 km
- ✦ inclination  $64.8^\circ$
- ✦ revolution 11h15min





# Constellation Status



## □ In orbit 17 satellites

↪ 7 new GLONASS-M

↪ 10 old GLONASS

## □ Healthy 10 sats

↪ In commissioning 1 sat

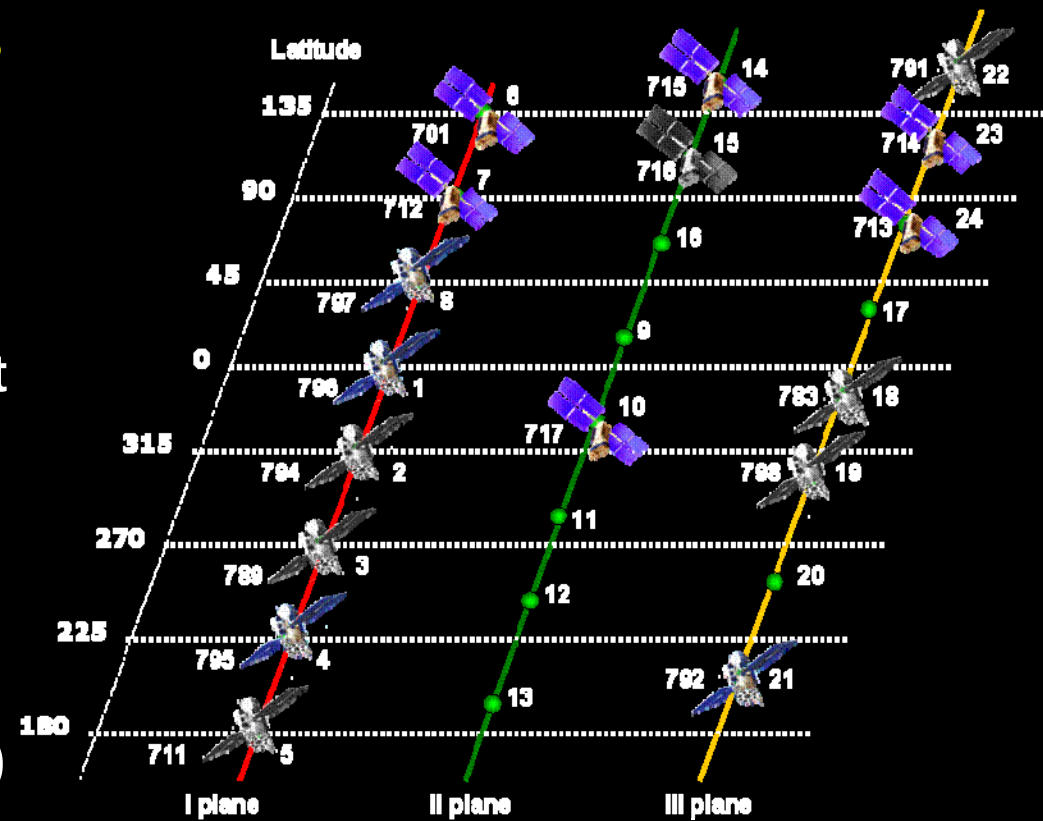
↪ In maintenance 1 sat

↪ In decommissioning 5 sats

## □ Launches in 2007:

↪ Block 36 (3 Glonass-M)

↪ Block 37 (3 Glonass-M)



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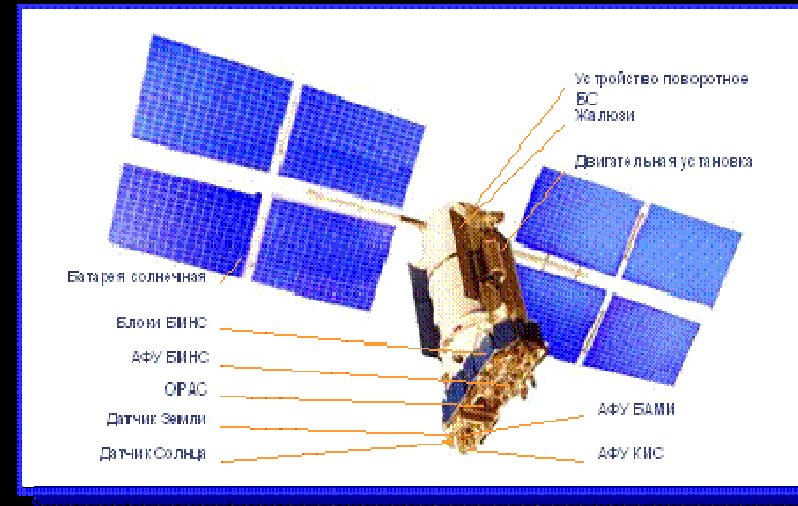
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## □ Main Specifications

|                                      |                                      |
|--------------------------------------|--------------------------------------|
| <b>Guaranteed life time</b>          | <b>7 years</b>                       |
| <b>Spacecraft mass</b>               | <b>1415 kg</b>                       |
| <b>Power supply</b>                  | <b>1450 W</b>                        |
| <b>Navigation payload</b>            |                                      |
| <b>Mass</b>                          | <b>250 kg</b>                        |
| <b>Power consumption</b>             | <b>580 W</b>                         |
| <b>Clock stability</b>               | <b><math>1 \cdot 10^{-13}</math></b> |
| <b>Attitude control accuracy</b>     | <b>0.5 deg</b>                       |
| <b>Solar panel pointing accuracy</b> | <b>2 deg</b>                         |



## □ Main features

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

# Navigation Payload



Antenna, power amplifiers, secondary control units

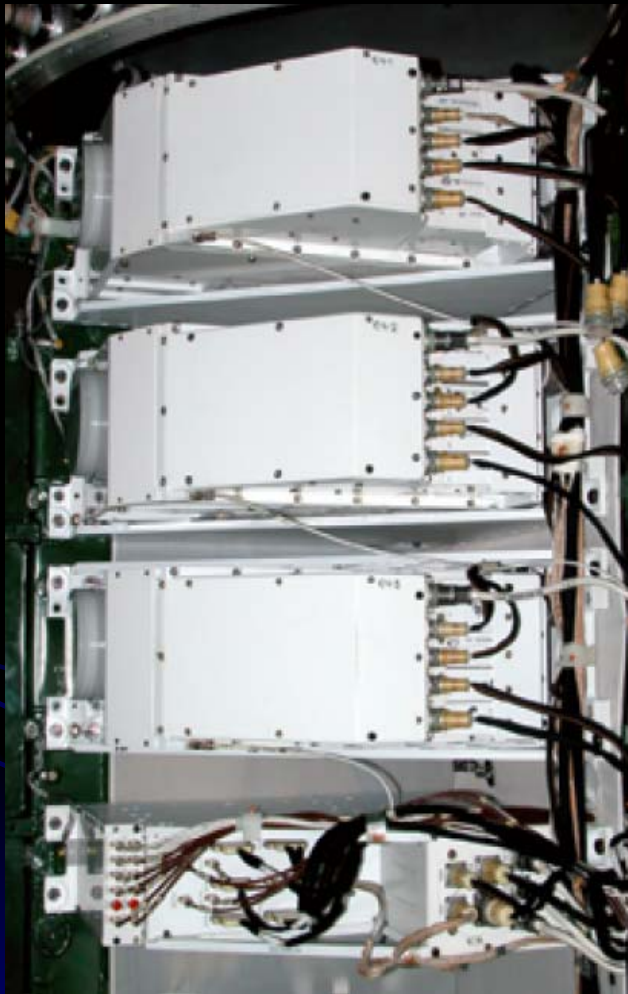
Signal generator specification:

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



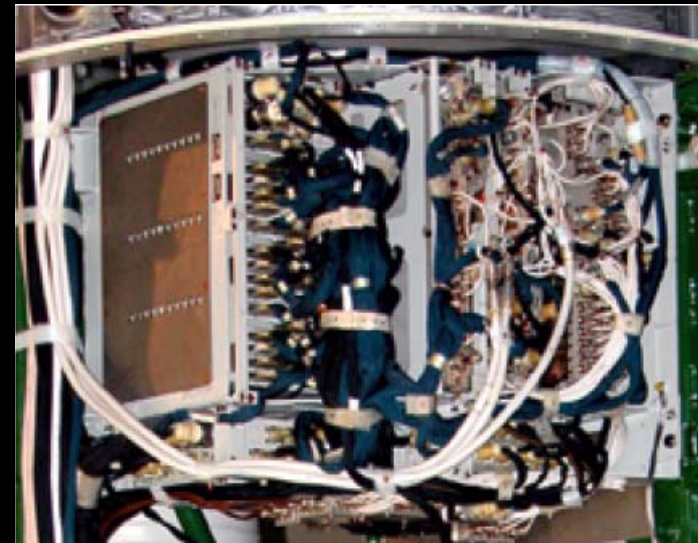
Navigation signal generator

# On-board Clock



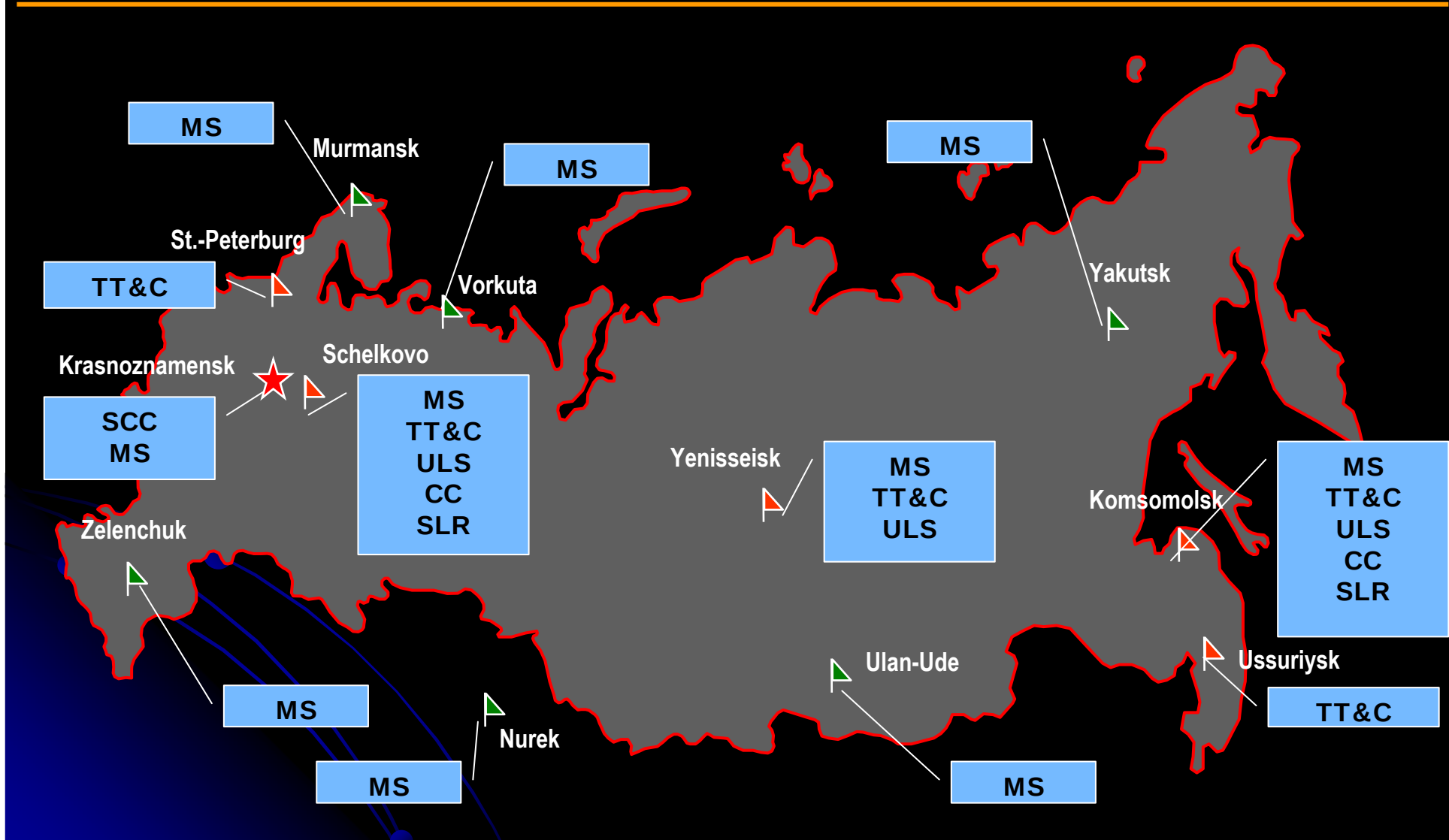
Three atomic frequency generators  
Synchronization unit

Stability:  $1 \cdot 10^{-13}$





# 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:

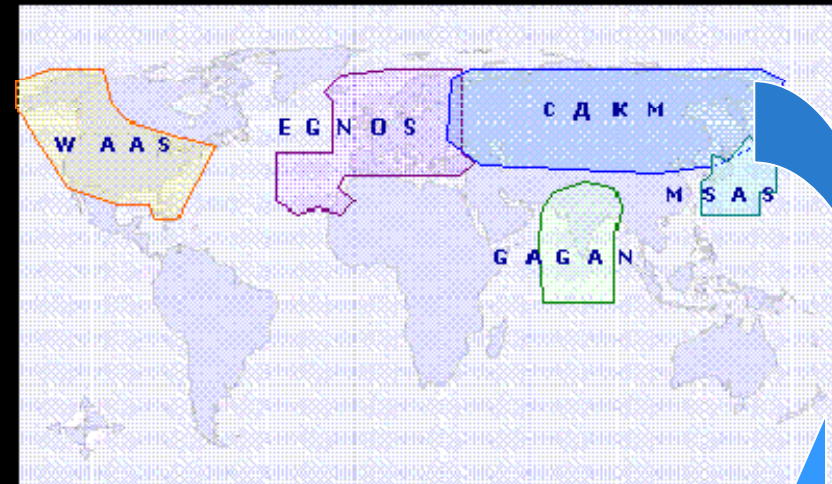
- ✦ Orbit and clock correction transmission to users
- ✦ Integrity provision

## □ Status:

- ✦ Limited monitoring network deployed
- ✦ Operation tests

## □ Validation

- ✦ 2010



Пункты сбора измерений на территории РФ:  
1 – Москва; 2 – Пулково; 3 – Космодром; 4 – Норильск; 5 – Иркутск; 6 – Петропавловск-Камчатский; 7 – Хабаровск; 8 – Новосибирск.





# User Equipment



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



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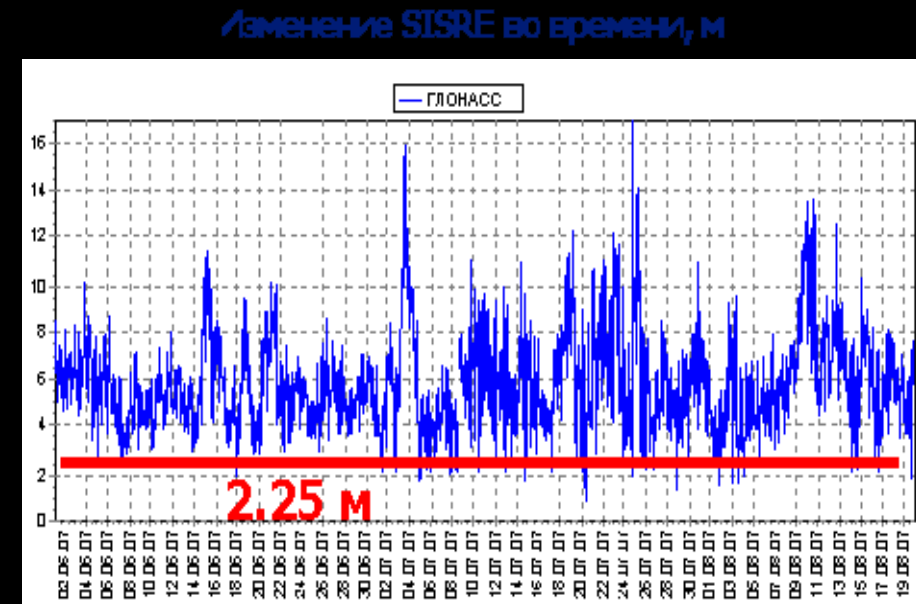
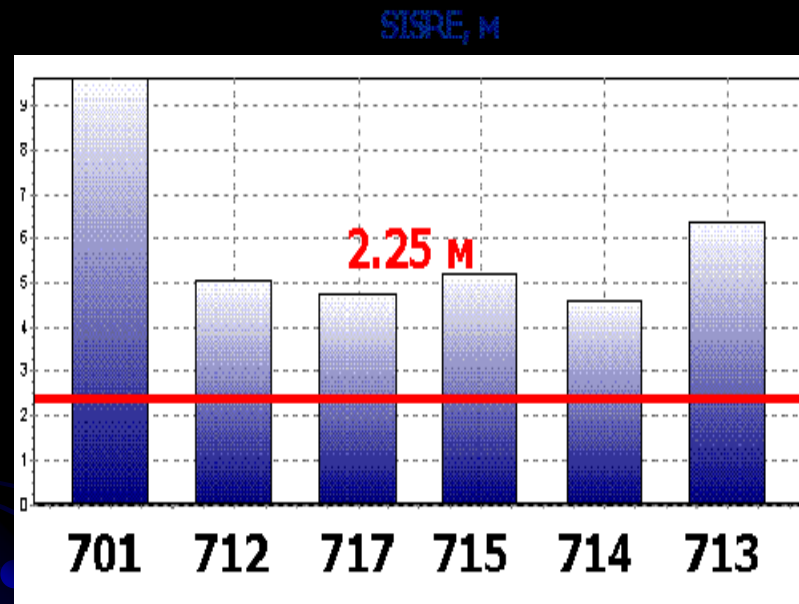
# GLONASS-M Flight Test (not yet completed)



# GLONASS-M SISRE (today status)



## Flight test results



**Main problem – clock synchronization**



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# On-board clock stability (observed)



## Requirement:

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

## Achieved results:

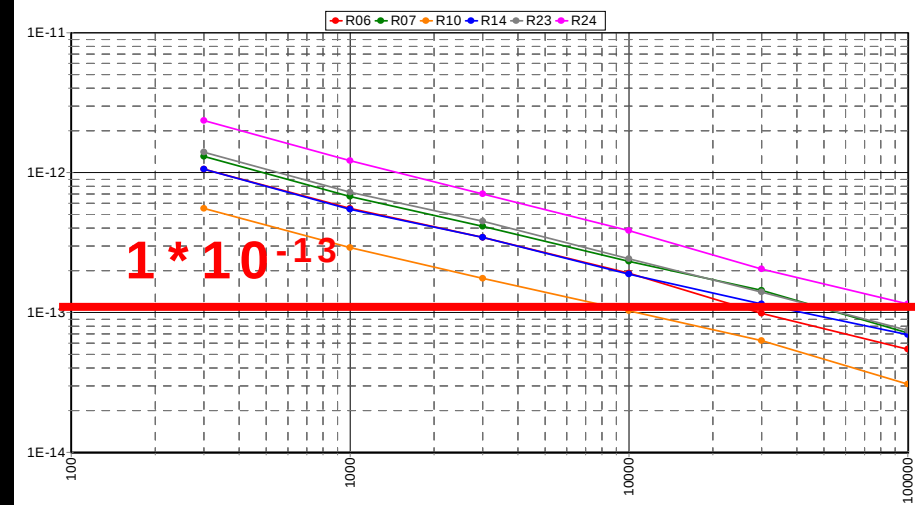
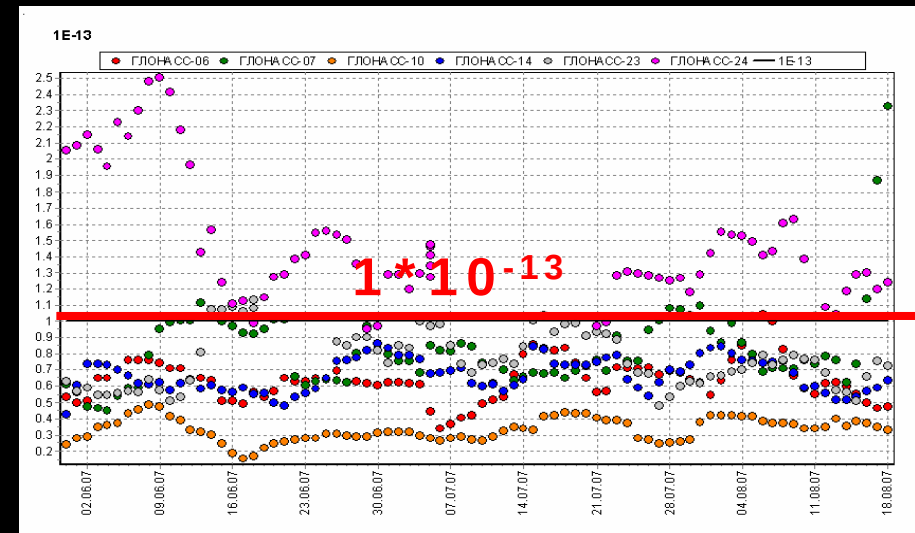
↙ For all GLONASS-M  
(without GL-M # 13)

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

↙ 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

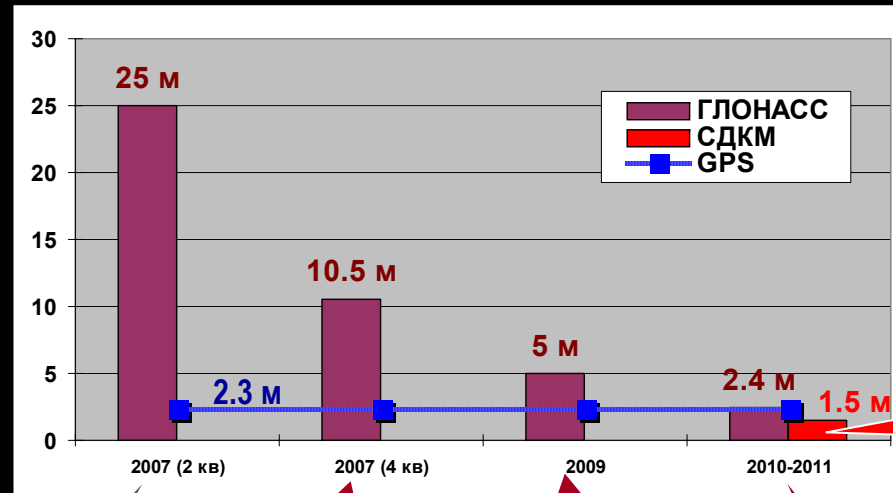




# GLONASS Accuracy Improvement Program



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



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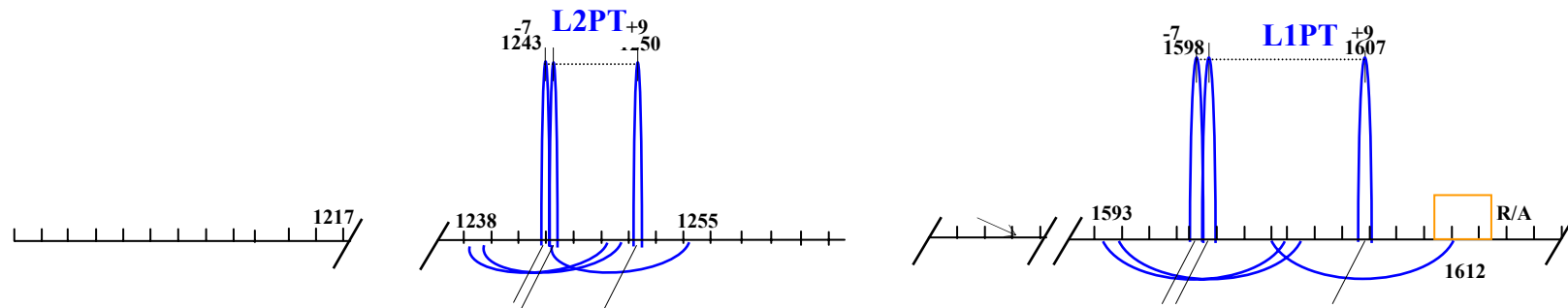
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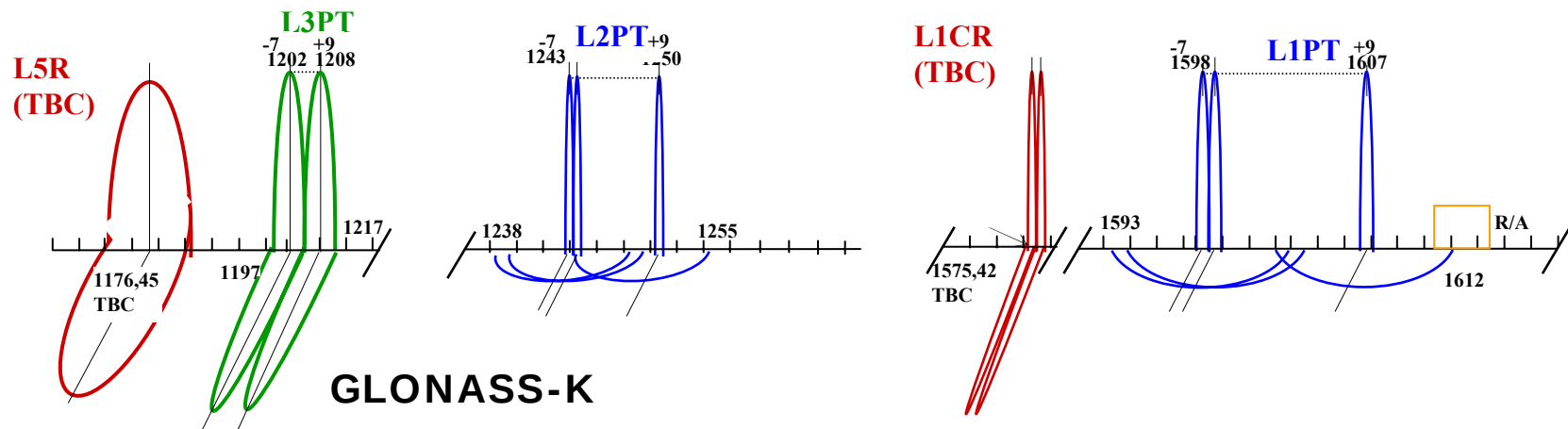
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# Signal Modernization



GLONASS existing signals



GLONASS-K

**L1CR, L5R: pending final decision**



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# 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

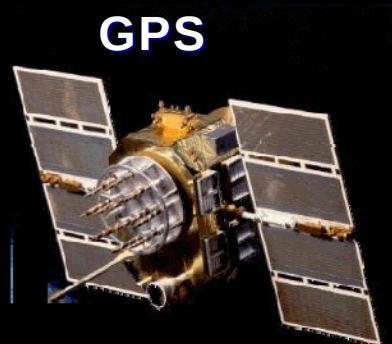


- **Continuous global navigation by 2010**
  - ✦ 24 satellites in constellation
- **GLONASS performance to be comparable with GPS (2010)**
- **Ground control segment modernization**
  - ✦ Monitoring station network extension (Russia)
  - ✦ System time scale improvement
  - ✦ Monitoring network outside 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**

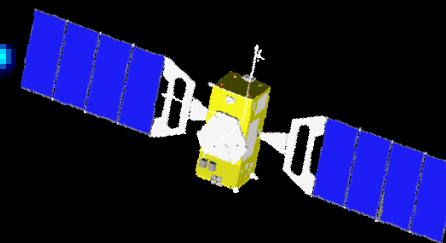




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GPS



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



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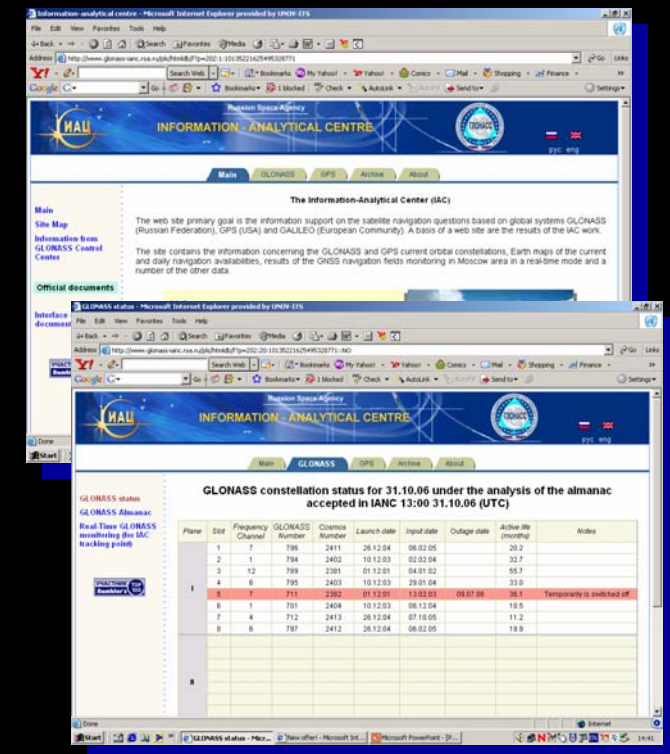
# User Interface



[www.glonass-ianc.rsa.ru](http://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



- ❑ **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 !**