



**FEDERAL SPACE AGENCY**



# **GLObal Navigation Satellite System (GLONASS)**

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**4-th meeting of International Committee on GNSS**

**13-18 September, 2009, St-Petersburg, The Russian Federation**

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# Content



- **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**

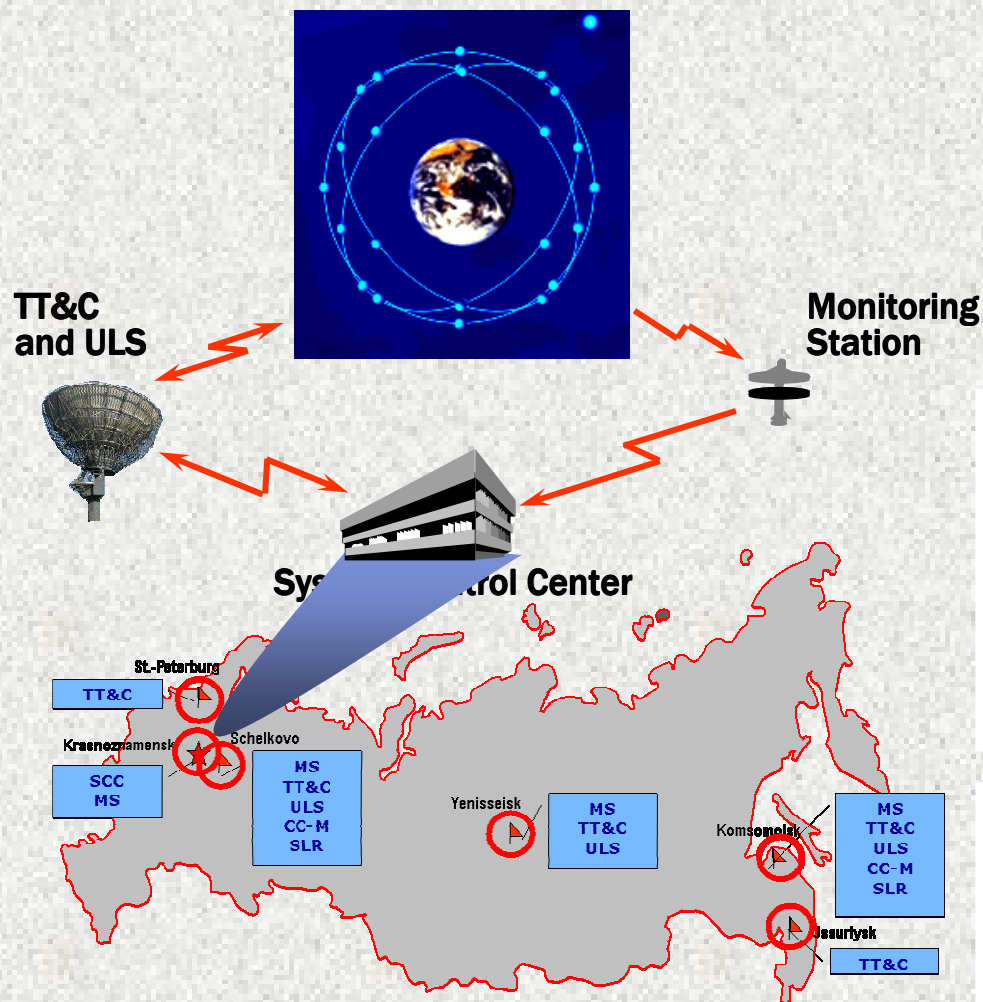


# Content



## ➤ **System description**

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  - Ground segment**
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### ➤ 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

### ➤ Two types of signal:

- ❑ Standard (open)
- ❑ Special (authorized)

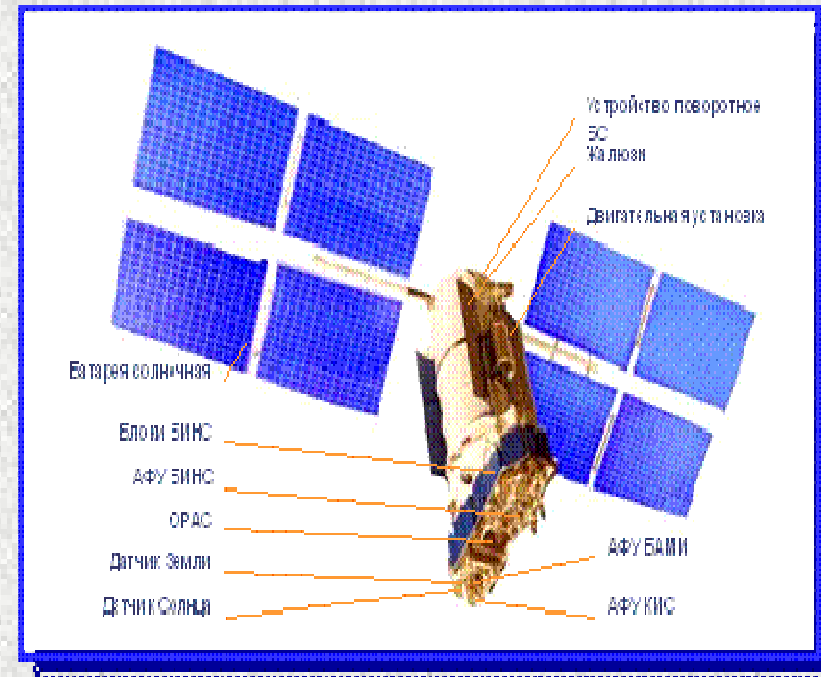
## Navigation satellite "Glonass-M"

### Main features

- **Guaranteed life time** 7 years;
- **Mass** 1415 kg;
- **Clock stability** 1e-13;
- **Attitude control accuracy** 0,5 deg;
- **Level of unpredictable acirs** 5e-11 m/c<sup>2</sup>
- **Navigations signals:**  
4 signals in L1 and L2 bands with FDMA

### Main features

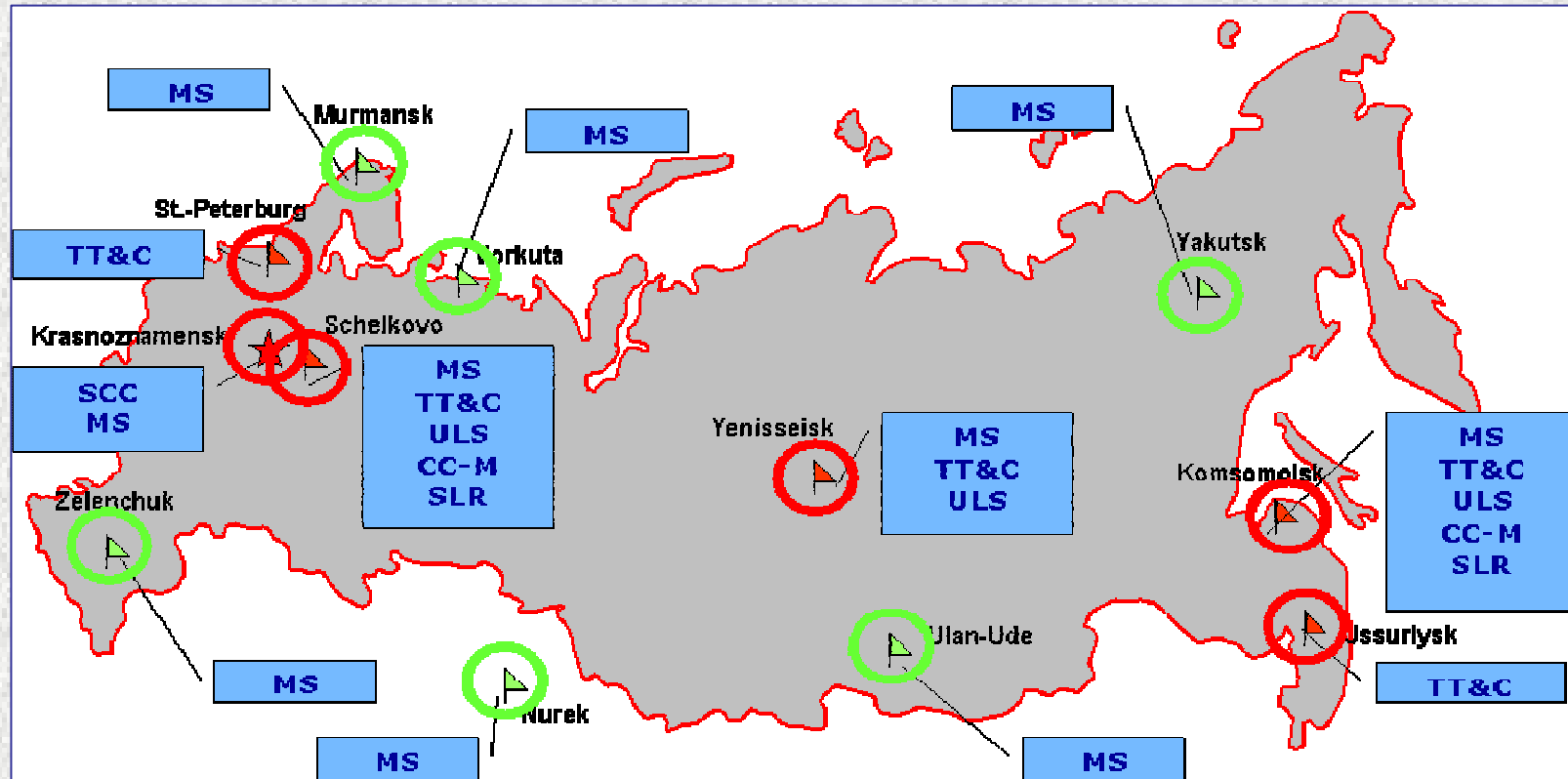
- **Extended life time**
- **Second civil signal L2**
- **Increased board clock stability**
- **Improved attitude and the solar panel pointing accuracy**
- **Improved dynamic model**
- **Using Inter Satellite Link (ISL) measurements for improvement ephemeris and clock navigation data (test mode)**





# System Description.

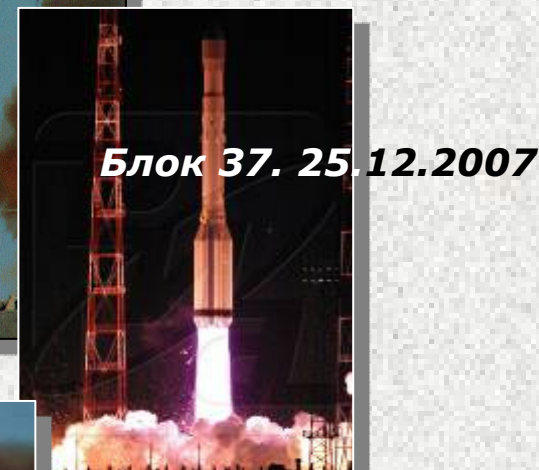
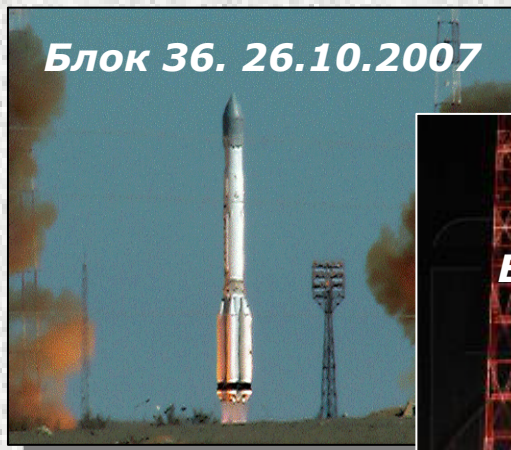
## Ground Control Segment



- SCC – system control center
- TT&C – telemetry, tracking, commanding station
- ULS – upload station
- New stations after 2010

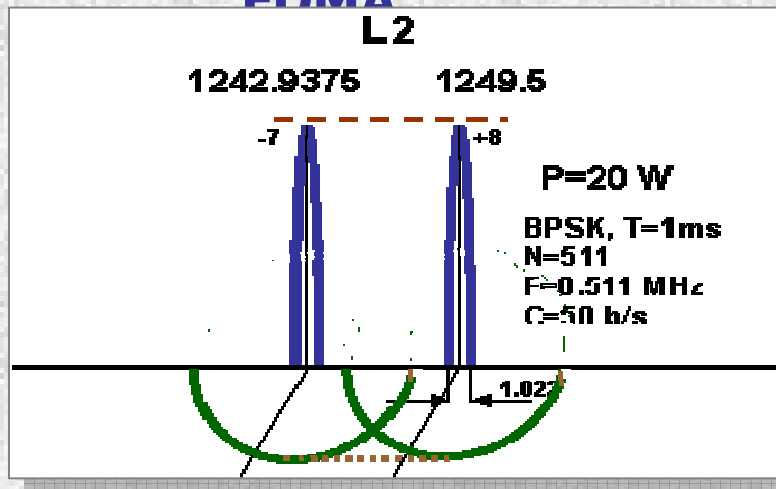
- MS – monitoring and measuring station
- CC – central clock
- SLR – laser tracking station
- Operational stations

- **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**



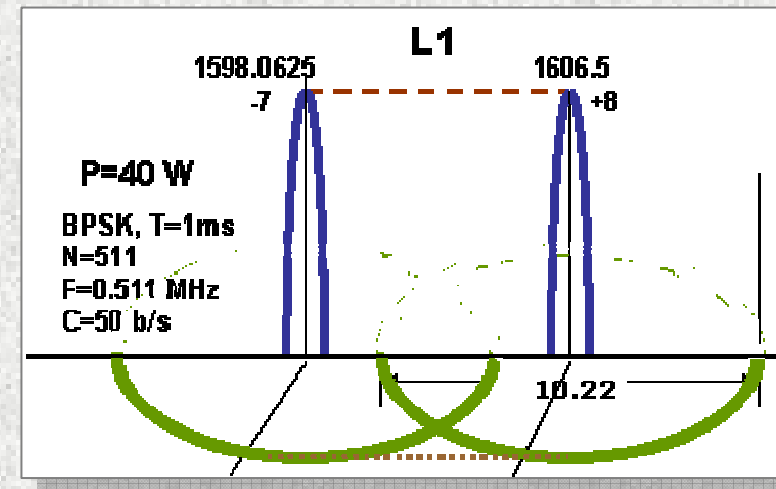
## ➤ L2

- L2 open FDMA
- L2 authorized FDMA



## ➤ L1

- L1 open FDMA
- L1 authorized FDMA

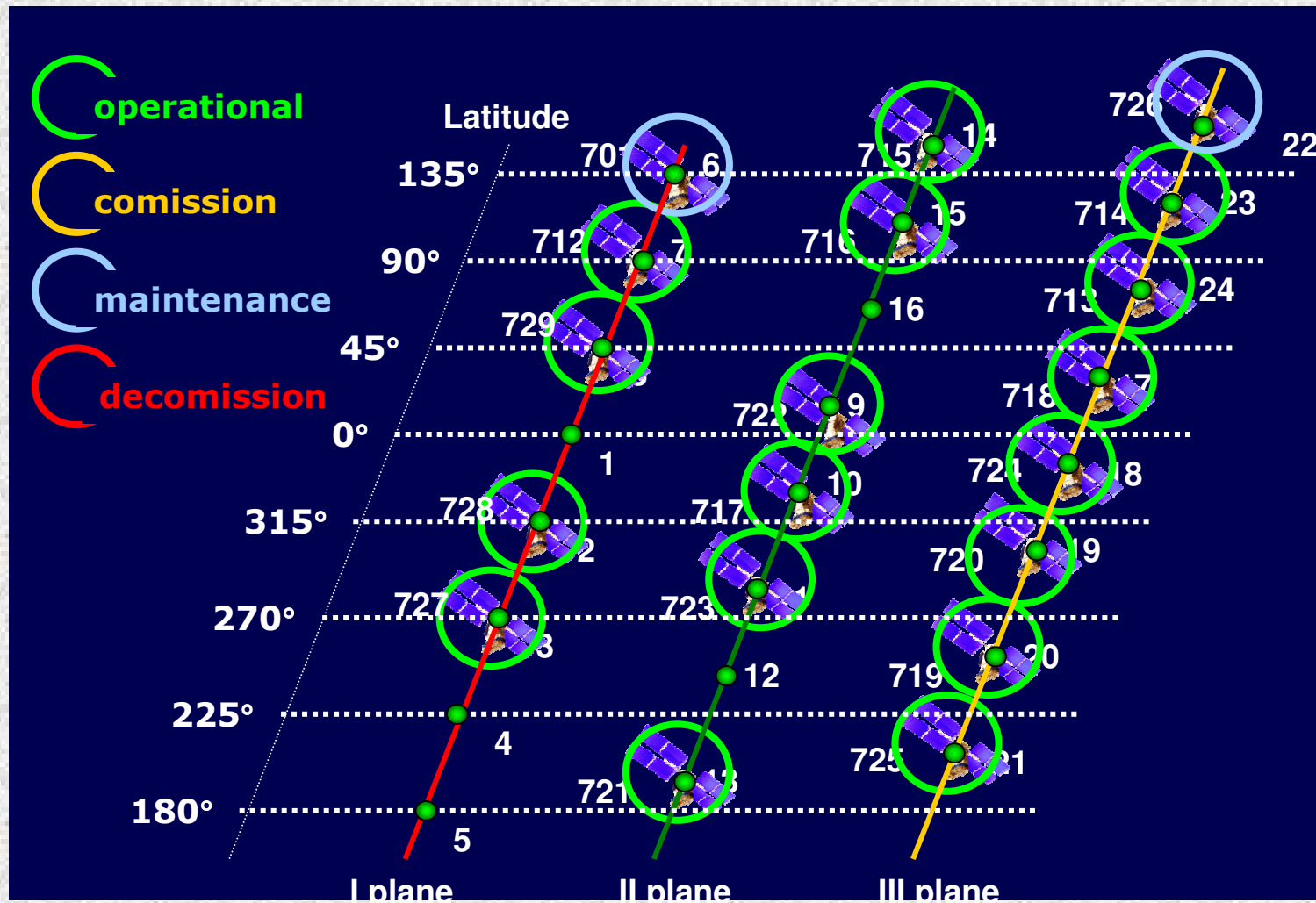


**GLONASS will continue transmitting existing FDMA signals for the future**





# GLONASS Constellation Status (14.09.2009)



**17 satellites operational**

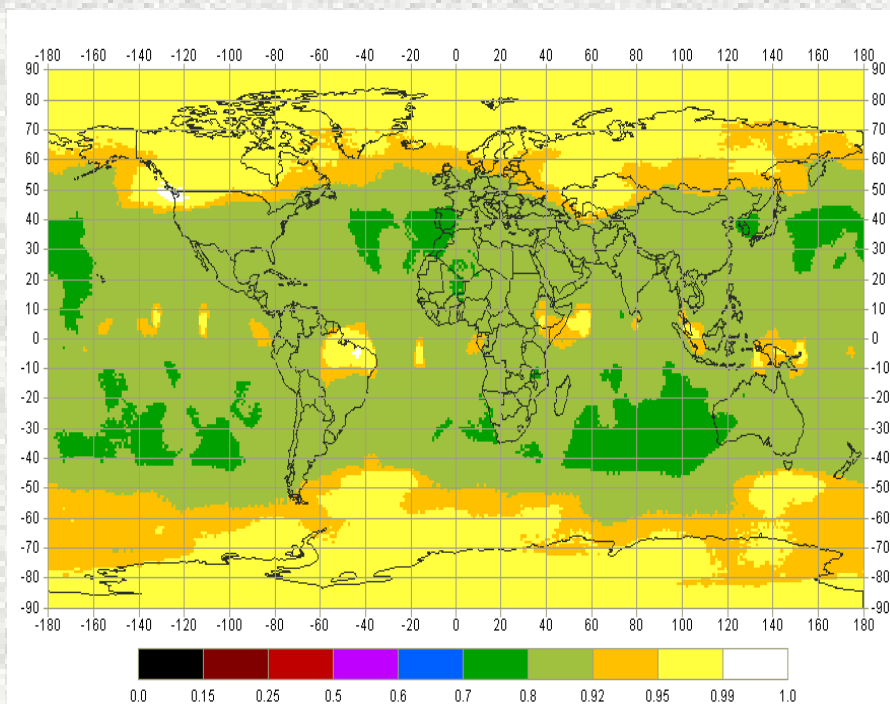


# GLONASS Availability

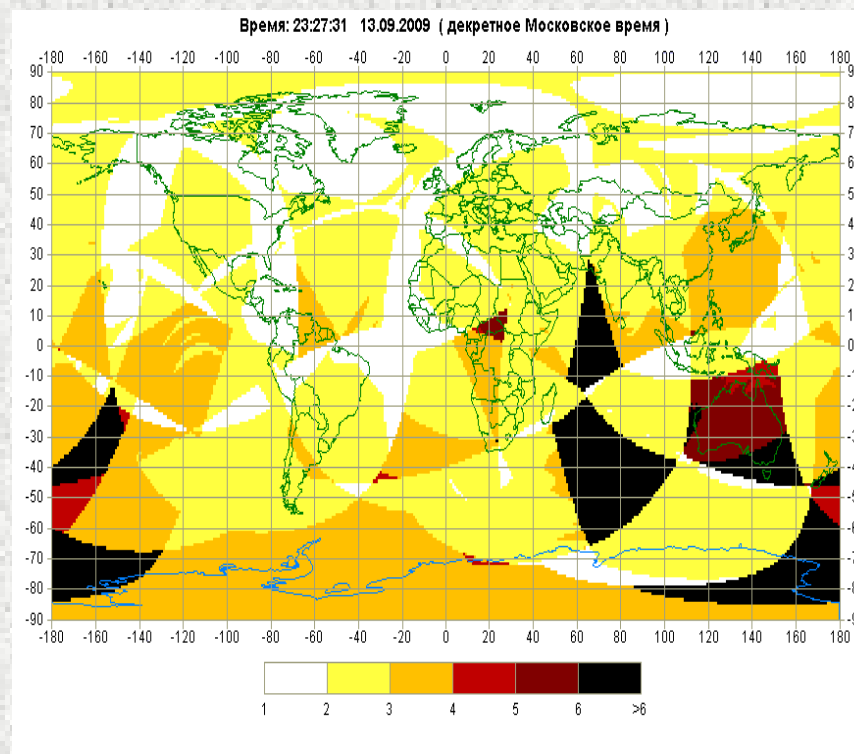
(14.09.2009, 0:27 a.m. )



**Global availability is 87-95% (PDOP<6,  $\gamma$ >5°)**



**Mean availability for a day**



**Instant availability**

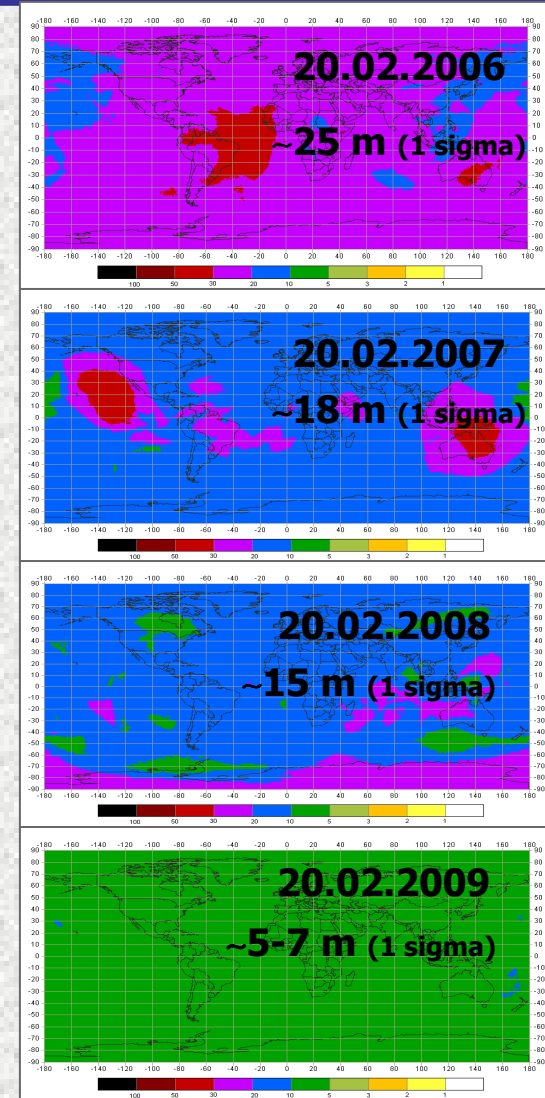
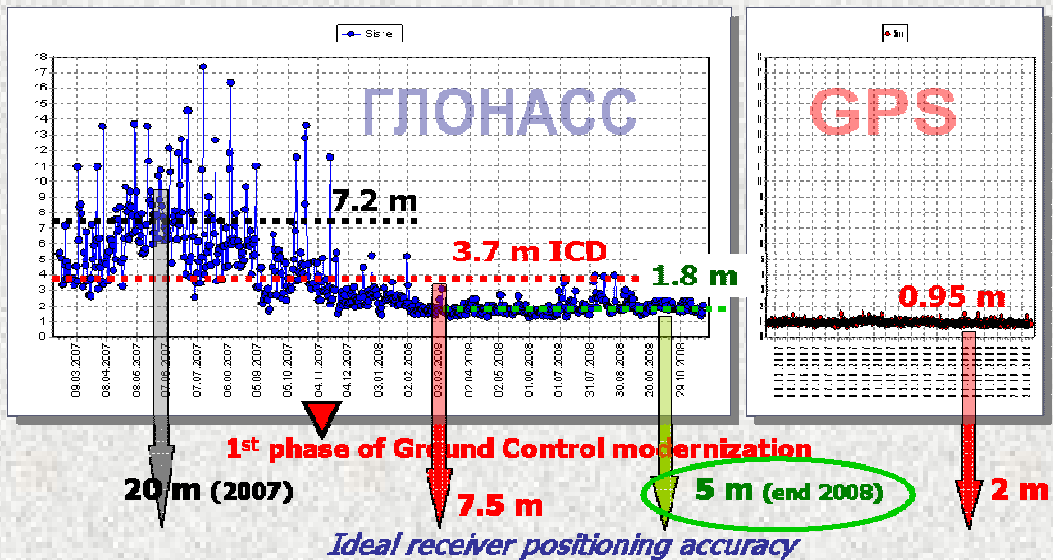


# GLONASS Accuracy

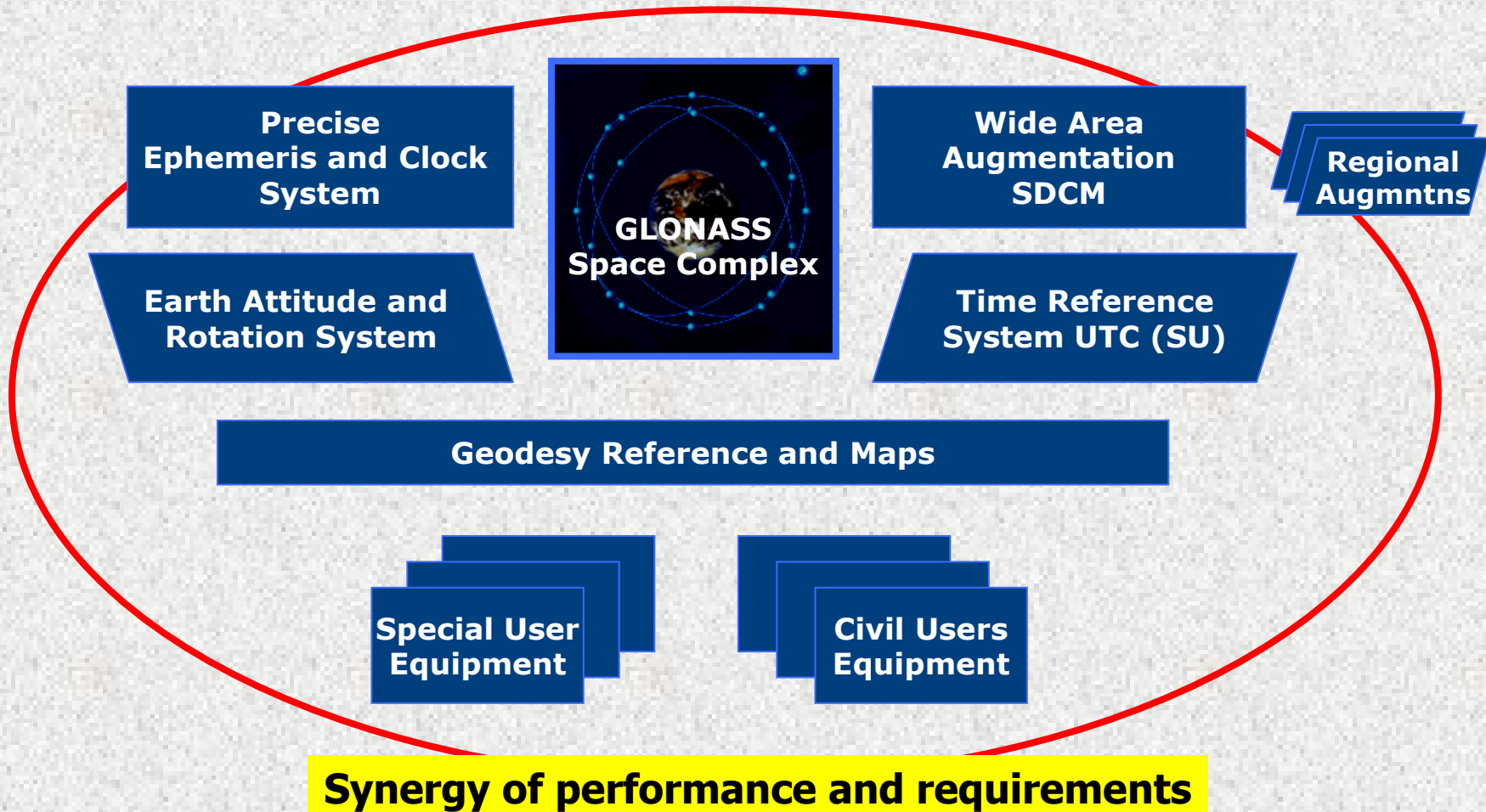


- **GLONASS accuracy has 5 time improved for last three years**
- **Now it is the same order of GPS**
- **Next improvement phase is expected by 2011**

SISRE (1 sigma)



## New GLONASS Technical Requirements

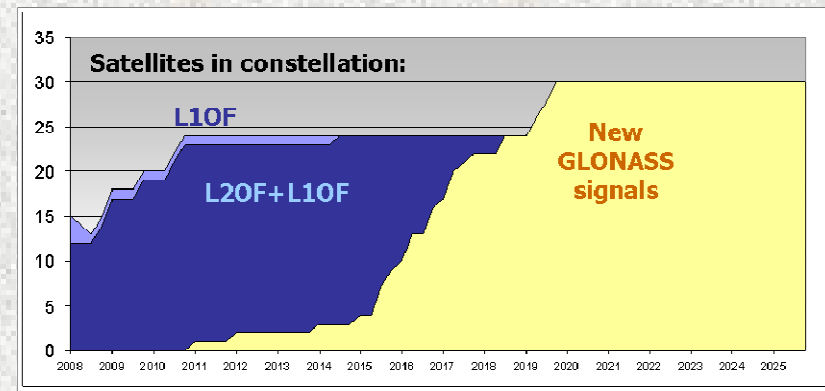
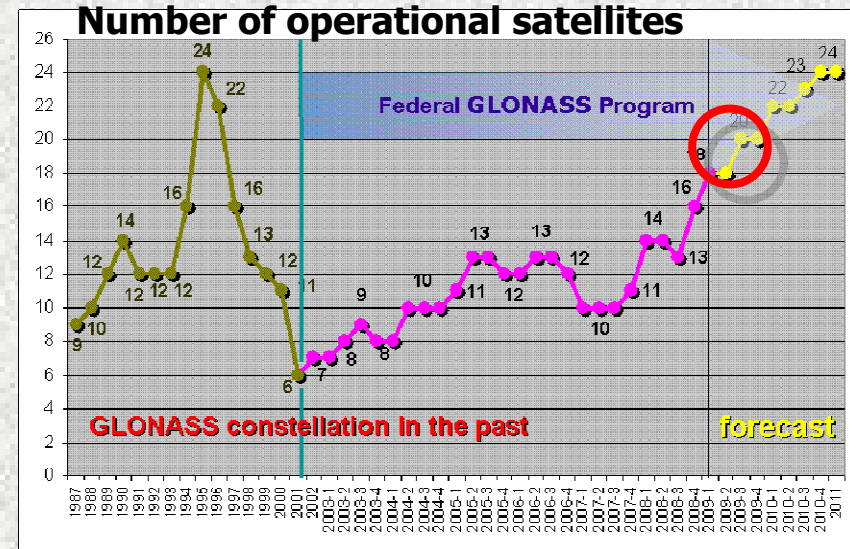




# GLONASS Strategy Planning



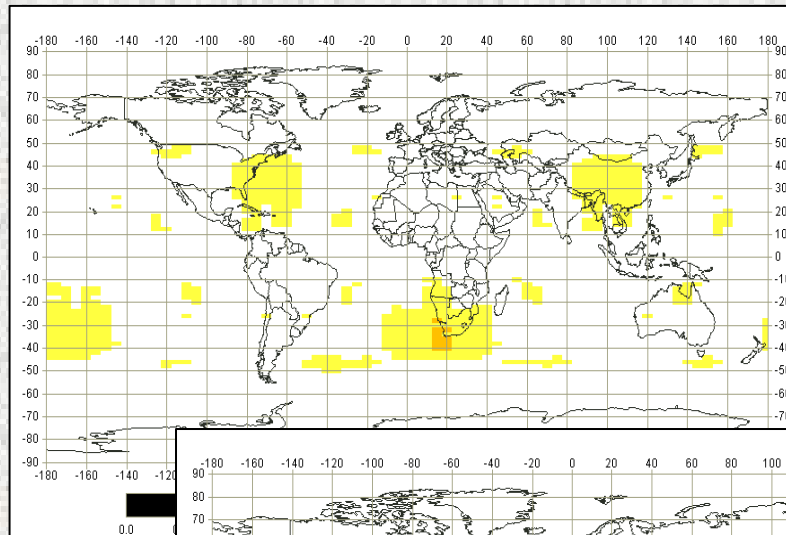
- Full constellation deployment in 2010
- Ground Control Segment modernization
- New GLONASS-K satellite (with improved performance) IOV start by 2010
- GLONASS will continue transmitting existing FDMA signals
- Additional new CDMA signals since GLONASS-K deployment
- GLONASS performance competitive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



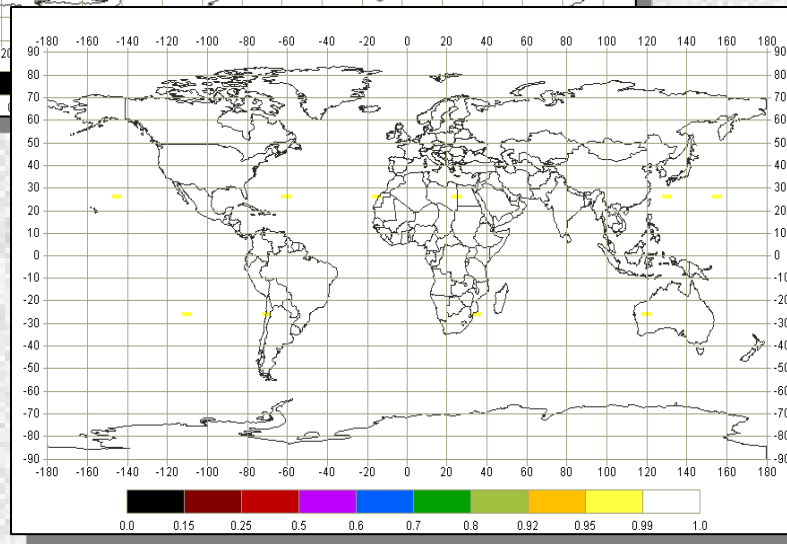
Constellation Update based on GLONASS-K  
 GLONASS-K Flight Tests



# GLONASS Deployment Program



**December, 2009**  
**22 satellites.**  
**99.7% global availability**



**December, 2010**  
**24 satellites.**  
**99.99% global availability**



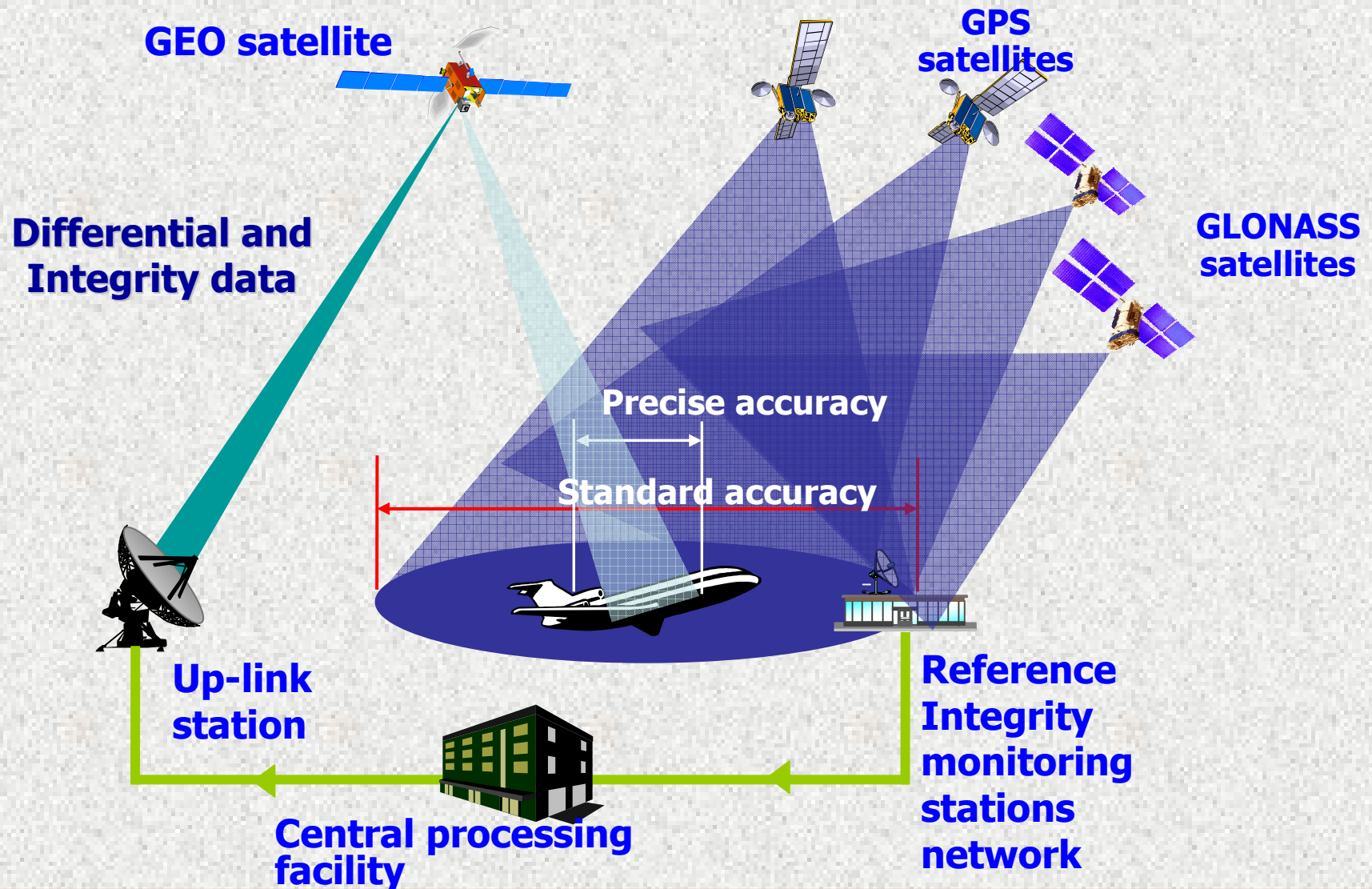
# The direction of GLONASS navigation signals modernization



- 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







# SDCM Objectives



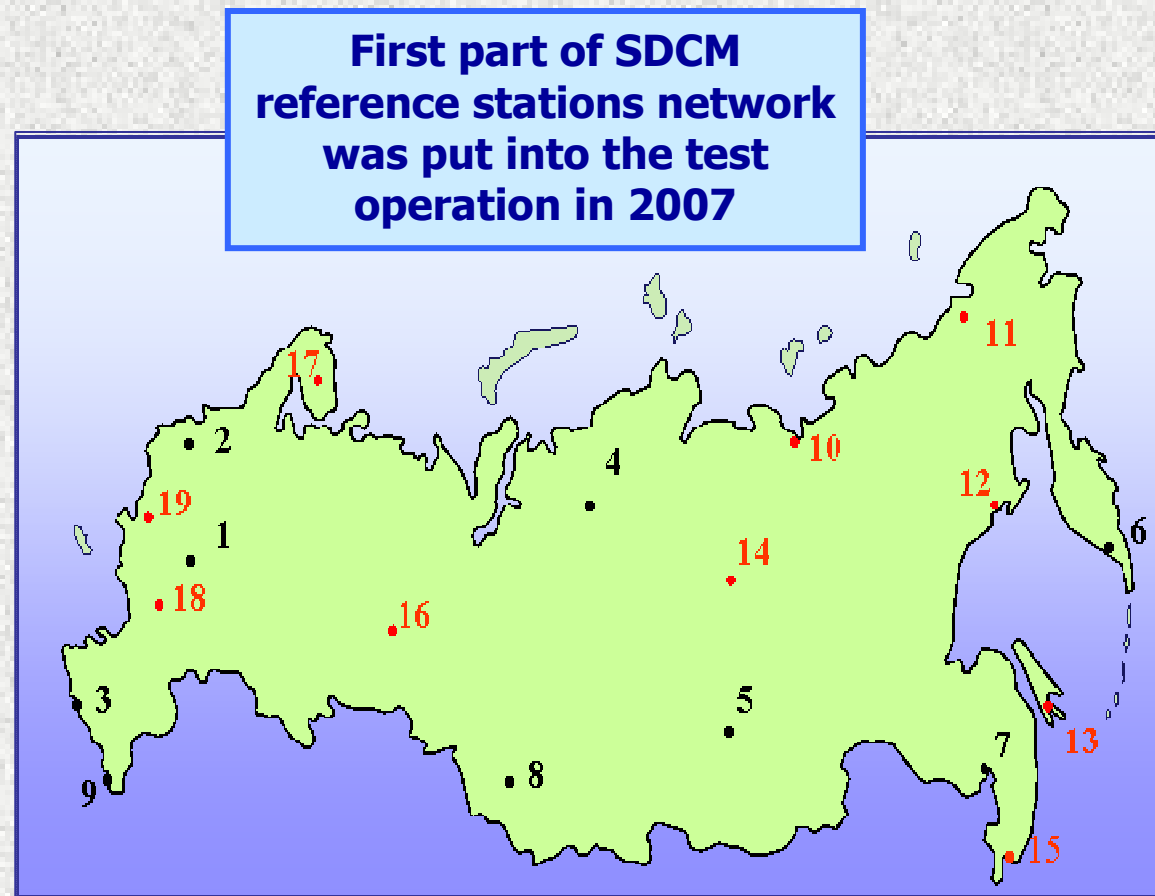
- **GNSS Monitoring**
  - ❑ Integrity monitoring
  - ❑ A posteriori detail analysis of system performance
- **Differential corrections**
- **Service area – the Russian Federation**

➤ **Reference stations (2008):**

1. Moscow (Mendeleevo)
2. Pulkovo
3. Kislovodsk
4. Norilsk
5. Irkutsk
6. Petropavlovsk-Kamchatka
7. Khabarovsk
8. Novosibirsk
9. Gelnzhik

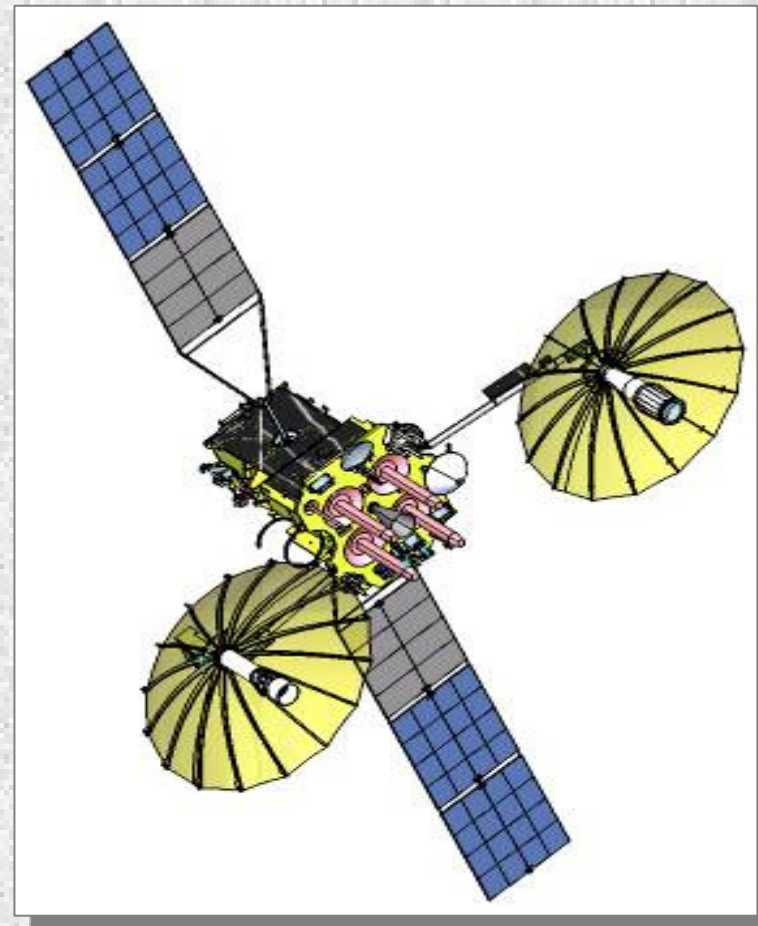
➤ **Reference stations (further development):**

10. Tiksi
11. Bilibino
12. Magadan
13. Yuzhno-Sakhalinsk
14. Yakutsk
15. Vladivostok
16. Sverdlovsk
17. Lovozero
18. Voronezh
19. Pechery



- **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





# Content



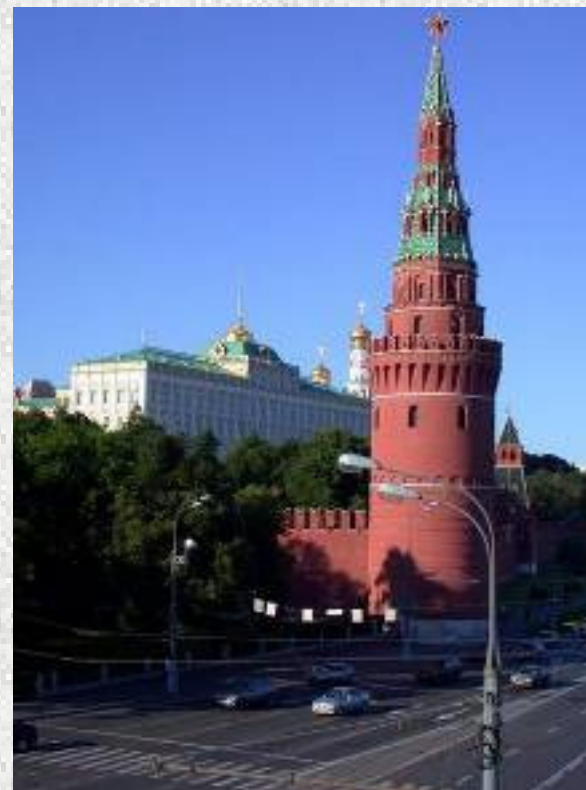
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# State Policy Basic Principles



- **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**



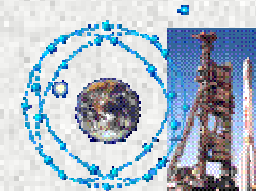
**Federal GLONASS Program is a basis for GLONASS sustainment, development and use**

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

**Update of  
September 12,  
2008**

## 1 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

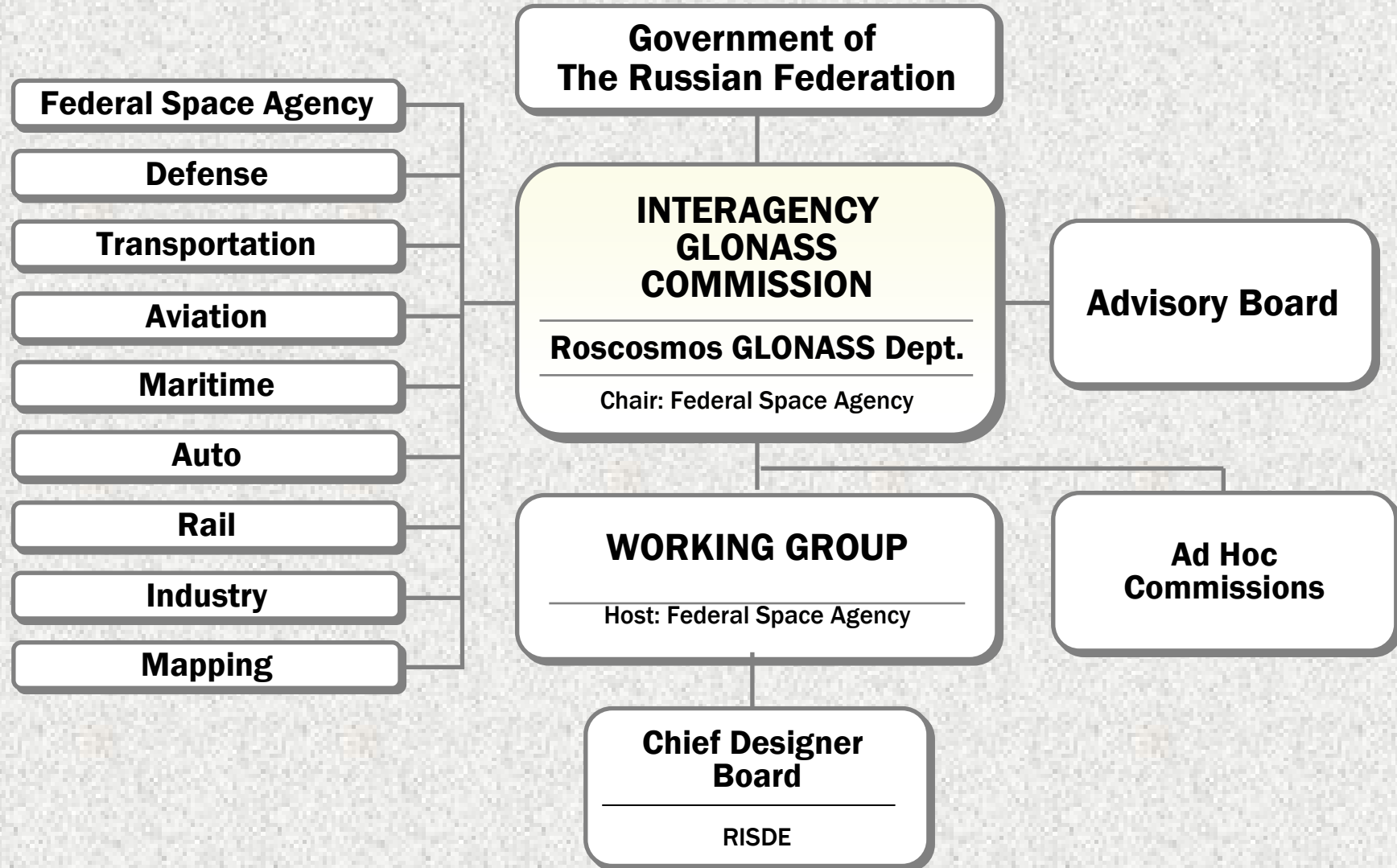


**5** User equipment development for authorized users





# GLONASS Management





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# View on Compatibility



- **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**



# View on Interoperability



- **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**



# FEDERAL SPACE AGENCY



**Thank you!**

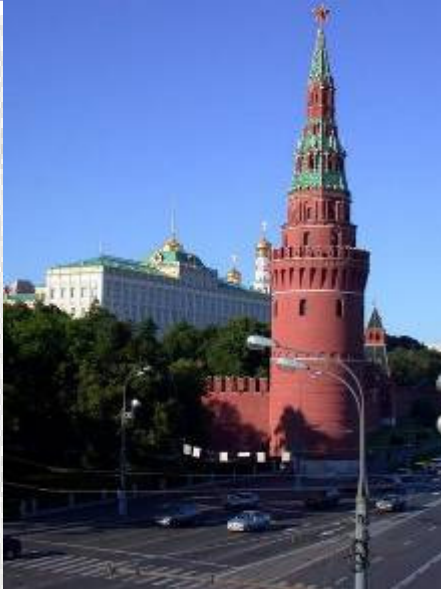
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# History of the GLONASS Policy



- **1976: Decree of the Soviet Union Communist Party Central Committee and Council of Ministers of the USSR №1043-361 from 16.12.1976 on the creation of Global Navigation Satellite System system**
- **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**

GLONASS constellation status, 08.11.2008r.

| Total satellites in constellation |  | 17 SC |
|-----------------------------------|--|-------|
| Operational                       |  | 16 SC |
| In commissioning phase            |  | 1 SC  |
| In maintenance                    |  | -     |
| In decommissioning phase          |  | -     |

GLONASS Constellation Status at 08.11.2008 based on both the almanac analysis and navigation messages received at 11:00 08.11.08 (UTC) in IAC PNT TsNImash

| Orb. # | Orb. slot | RF chnl | # SC | Launched | Operation begins | Operation ends | Life-time (years) | Satellite health status |                    | Comments               |
|--------|-----------|---------|------|----------|------------------|----------------|-------------------|-------------------------|--------------------|------------------------|
|        |           |         |      |          |                  |                |                   | In almanac              | In ephemeris (UTC) |                        |
| I      | 4         | 06      | T95  | 10.12.03 | 29.01.04         |                | 58.0              | +                       | +08.41.08.11.08    | In operation           |
|        | 6         | 01      | T01  | 10.12.03 | 08.12.04         |                | 58.0              | +                       | +11.11.08.11.08    | In operation           |
|        | 7         | 05      | T12  | 26.12.04 | 07.10.05         |                | 46.5              | +                       | +11.11.08.11.08    | In operation           |
| II     | 8         | -2      | T22  | 25.12.07 | 25.01.08         |                | 18.5              | +                       | +05.06.08.11.08    | In operation (L1 only) |
|        | 10        | 04      | T17  | 25.12.06 | 03.04.07         |                | 22.5              | +                       | +07.05.08.11.08    | In operation           |
|        | 11        | 00      | T23  | 25.12.07 | 22.01.08         |                | 18.5              | +                       | +10.00.08.11.08    | In operation           |
| III    | 13        | -2      | T21  | 25.12.07 | 08.02.08         |                | 18.5              | +                       | +11.11.08.11.08    | In operation           |
|        | 14        | 04      | T15  | 25.12.06 | 03.04.07         |                | 22.5              | +                       | +11.11.08.11.08    | In operation           |
|        | 15        | 00      | T16  | 25.12.06 | 12.10.07         |                | 22.5              | +                       | +11.30.08.11.08    | In operation           |
| IV     | 17        | -1      | T18  | 26.10.07 | 04.12.07         |                | 12.5              | +                       | +04.02.08.11.08    | In operation           |
|        | 18        | -3      | T24  | 25.09.08 | 26.10.08         |                | 1.4               | +                       | +05.23.08.11.08    | In operation           |
|        | 19        | 03      | T20  | 26.10.07 | 25.11.07         |                | 12.5              | +                       | +08.08.08.11.08    | In operation           |
| V      | 20        | 02      | T19  | 26.10.07 | 27.11.07         |                | 12.5              | +                       | +08.41.08.11.08    | In operation           |
|        | 21        | -1      | T25  | 25.09.08 | 05.11.08         |                | 1.4               | +                       | +10.25.08.11.08    | In operation           |

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