



GLONASS status and development plans

Prof. Dr. Grigory Stupak

5th Meeting of the International Committee
on GNSS, Turin, Italy, 2010



Content



- GLONASS Policy, Architecture and Status
- SDCM
- Development Plans
- Summary



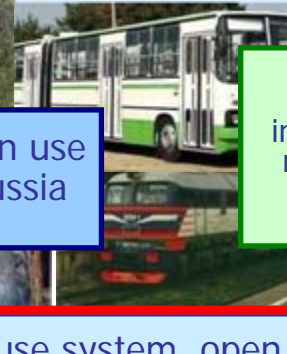
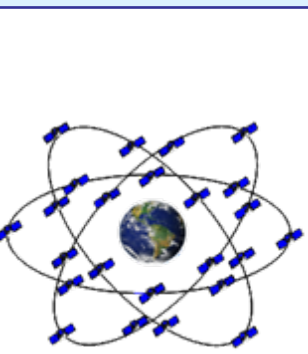
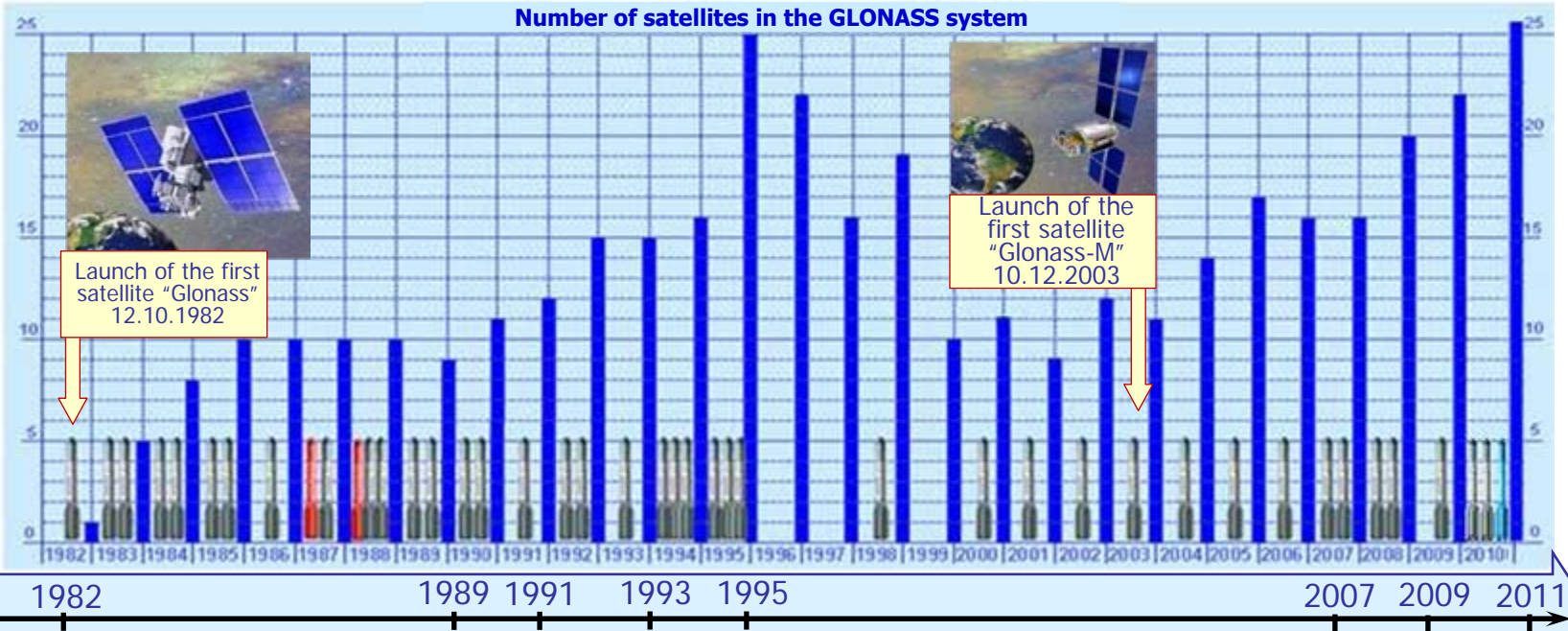
- **GLONASS Policy, Architecture and Status**
- SDCM
- Development Plans
- Summary



GLONASS Global Navigation System. Dual-use technologies



National government's decision to create GLONASS system



Military application in the USSR

Military application in Russia

Civilian use in Russia

Military application in Russia and military and technical cooperation

Civil application in Russia and in global community

1993

1995

2007

Military purpose target system

Dual-use system, open for international use

GLONASS as a dual-use technology is a resource for innovative breakthrough



Government policy philosophy



- **GLONASS is an important part of national infrastructure that ensures national security and economic development**
- **Navigation provision means' creation, development and maintenance are national function and responsibility**
- **Consumers are provided with GLONASS civil navigation services free of charge**
- **Easy and free access to GLONASS information is necessary for consumer equipment creation and development**
- **Rendering GLONASS services together with services of other GNSS to ground beaconry and other consumers in order to improve reliability**
- **International cooperation on GNSS compatibility and interoperability**



The federal task program “Global navigation system” is the basis for GLONASS system maintenance, development and effective use



Federal task program for GLONASS system maintenance, development and effective use



Main task indicators of the federal task program “Global navigation system”

Main task indicators		2008	2009	2010	2011
Navigation field accessibility:	In the territory of the Russian Federation	95 %	98 %	100 %	100 %
	globally	83 %	92 %	100 %	100 %
Number of SVs in the GLONASS system constellation/Number of end-used SVs		18/18	23/22	27/24	29/24
Navigation evaluations' accuracy		12,4 m	7,0 m	5,5 m	2,8 m
Navigation field integrity within SDCM operation zone		-	-	-	10 c

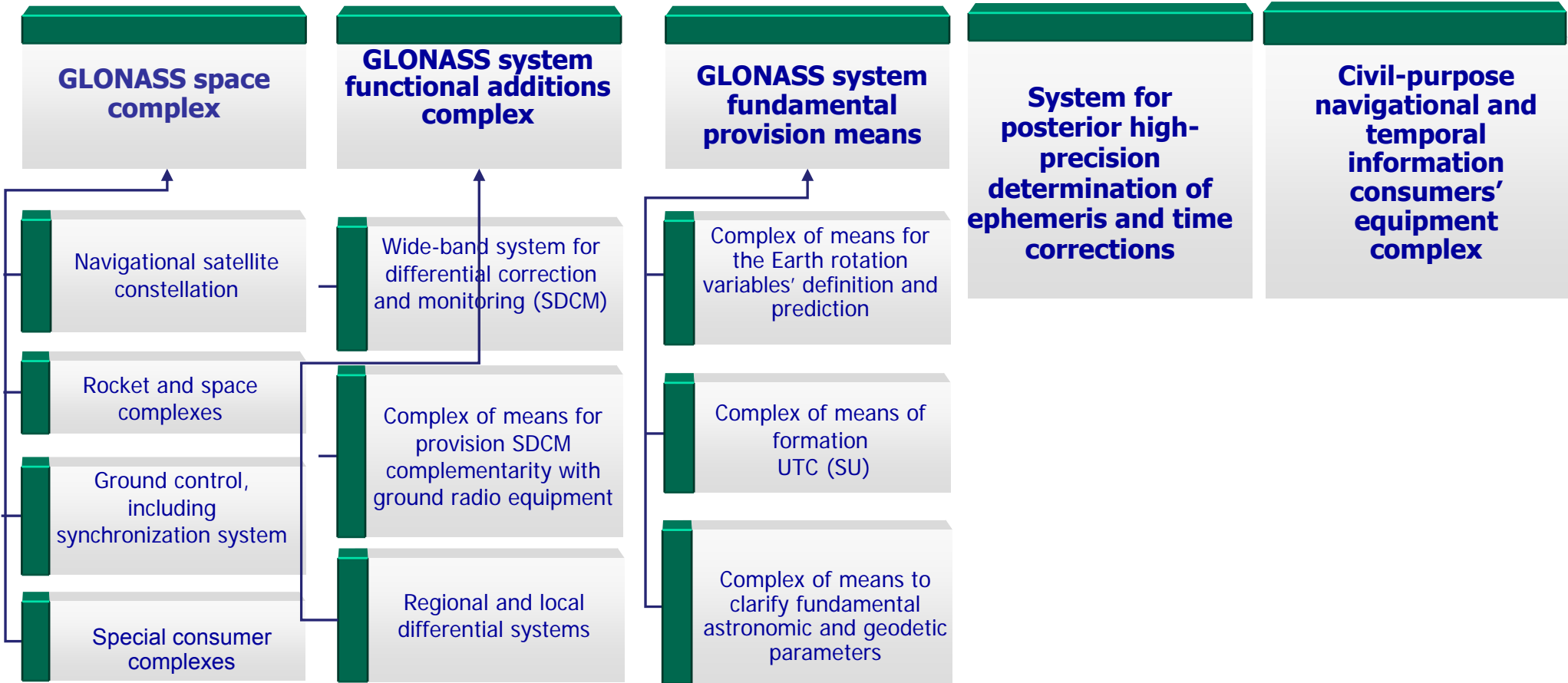
The concept project of the federal task program for GLONASS system maintenance, development and use is developed for the years 2012 - 2020

The Program objectives are as follows:

- **mass introduction of domestic navigation technologies** in domestic and foreign navigation service markets for all categories of consumers;
- guaranteed provision of all categories of consumers with navigation services taking into account continuously increasing demand for them in the interests of national security and social and economic development of the Russian Federation;
- strengthening the leadership of the Russian Federation in the field of global satellite navigation through maintenance and development of the GLONASS system, improving its performance, enhancing its functionality, use conditions and areas, for the balanced development of the constituent parts



GLONASS system structure





GLONASS system satellites' launch vehicles



"Proton" booster with the upper stage



"Soyuz-2" booster with the upper stage





Launch of the unit with 3 “Glonass-M” satellites
September 2, 2010

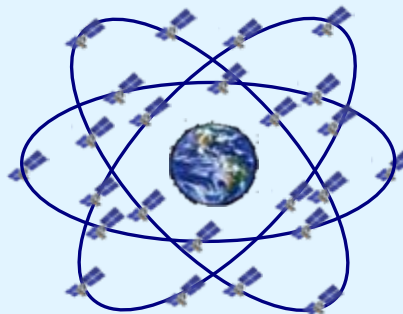




GLONASS system satellite constellation's composition, condition and structure

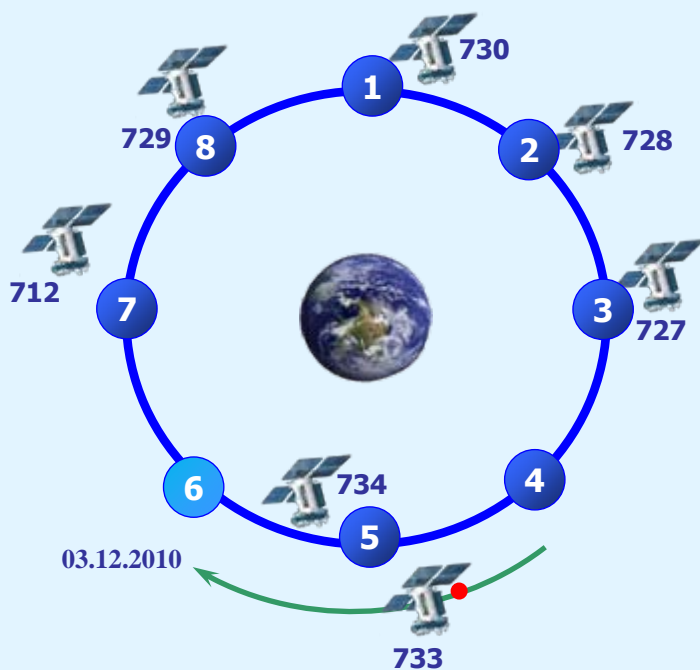


Satellite constellation's composition (as of 17.10.2010)
The constellation contains 26 satellites, 3 of them are in the orbital reserve

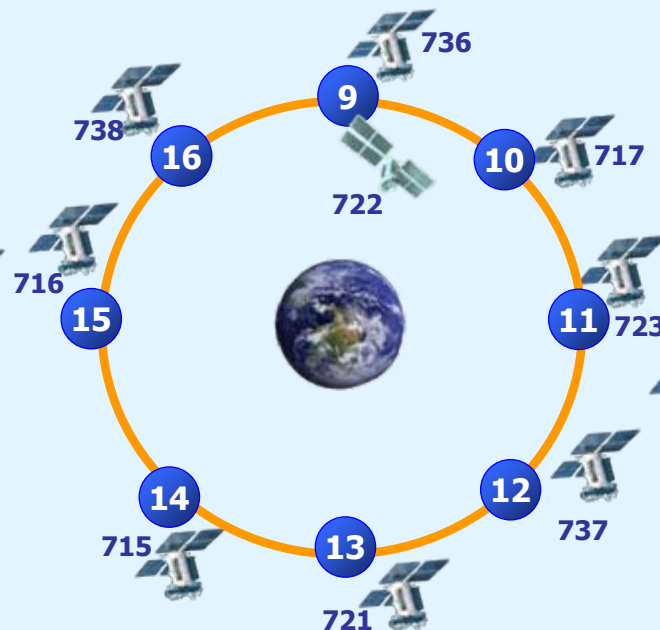


3 "Glonass-M" satellites' launch and the beginning of new generation "Glonass-K" satellites' flight test are scheduled in 2010

1st plane



2nd plane



3rd plane





Stages of development of GLONASS system's open access navigation signals



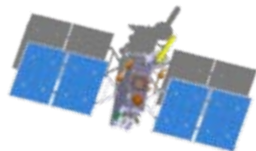
"Glonass" satellite



"Glonass-M" satellite



"Glonass-K1" satellite



"Glonass-K2" satellite



"Glonass-KM" satellite

	L1	L2	L3	L1, L2	Future
"Glonass" satellite	L10F	L20F	-	-	
"Glonass-M" satellite	L10F	L20F	-	-	
"Glonass-K1" satellite	L10F	L20F	L30C test	-	
"Glonass-K2" satellite	L10F	L20F	L30C	L10C	
"Glonass-KM" satellite	L10F	L20F	L30C	L10C	L10CM, L20C, L50CM



FDMA signal



CDMA signal

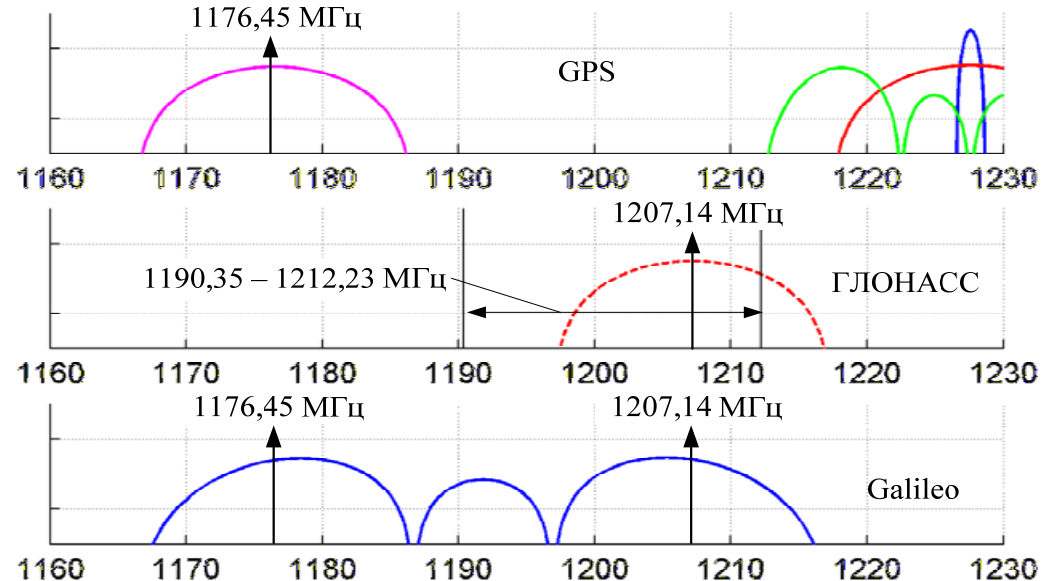
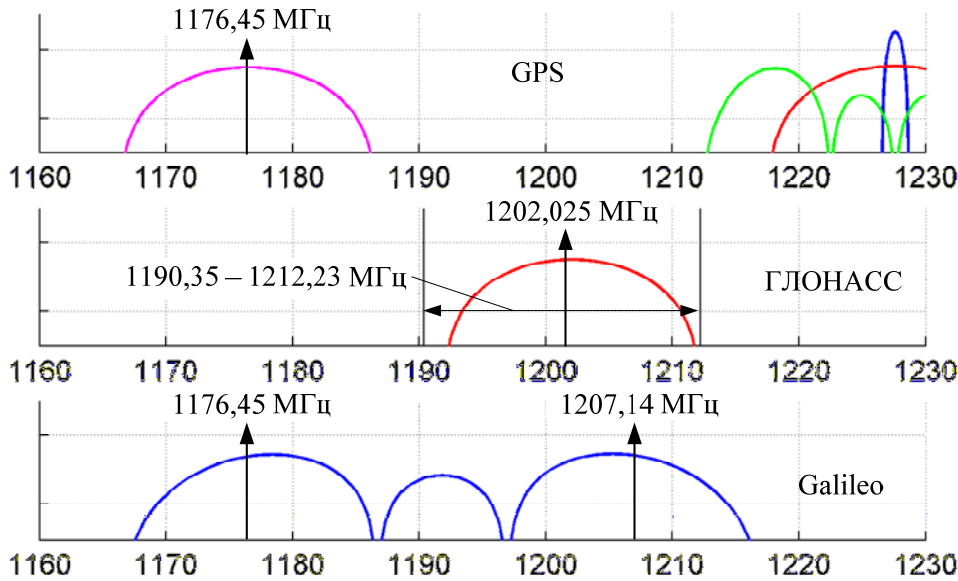


GLONASS navigation signal LOC3 with open access and code division in L3 band



Current status (satellite “Glonass-K” No 1, 2)

Planned status (satellite “Glonass-K” No 3, 4, ...)



- $f(L3) = 1175 \times 1,023 \text{ MHz} = 1202,025 \text{ MHz}$

- $f(L3) = 1180 \times 1,023 \text{ MHz} = 1207,14 \text{ MHz}$

- Modulation: QPSK(10)
- Radio signal has information L3I and pilot L3P components of equal power that are transmitted at the quadratures of carrying oscillation
- The signal power at the Earth's surface is at least – 158 dBW



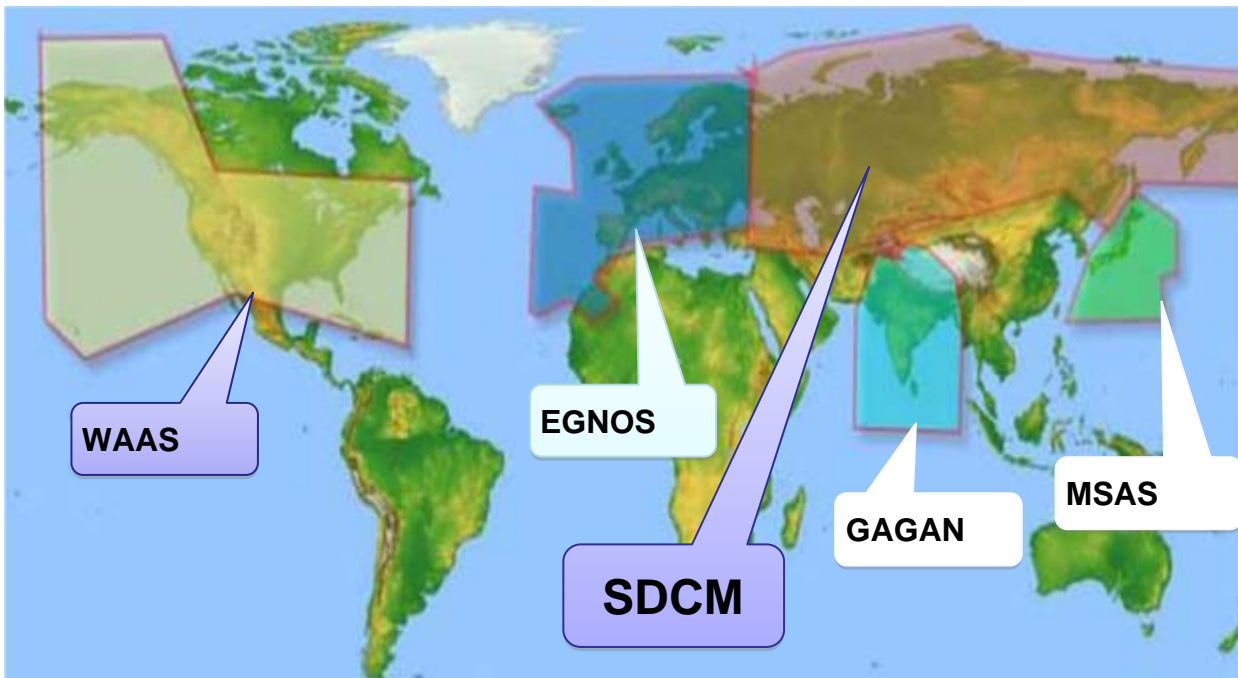
- GLONASS Policy, Architecture and Status
- SDCM
- Development Plans
- Summary



Global Navigation Satellite Systems' functional additions systems



The Russian system for differential correction and monitoring of radio navigation fields (SDCM) is a functional addition to satellite navigation systems GLONASS and GPS and provides improved performance of these systems for applications requiring **high accuracy and reliability**



Consumers are provided with:

- Information about the navigation field's integrity;
- Refined information on time and ephemeris;
- Correcting information for the measurements;
- Information on GLONASS and GPS (and Galileo in the long term) satellite navigation systems' functioning quality

The Russian system for differential correction and monitoring of radio navigation fields is a new level of navigational support for consumers

Local (departmental) - 150 km
Regional - 1000 km
Wide-band (SDCM) – up to 5000 km



System for differential correction and monitoring (SDCM)

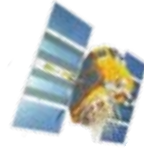


Geostationary satellite



SDCM – system for differential correction and monitoring
NMCS – non-request measuring computer system
NMS - non-request measuring system
SSM - station for setting and measurement

GLONASS and GPS satellites



Accuracy in absolute mode

Accuracy in differential mode



CONSUMERS



CDSM centre



Measurements collection points network



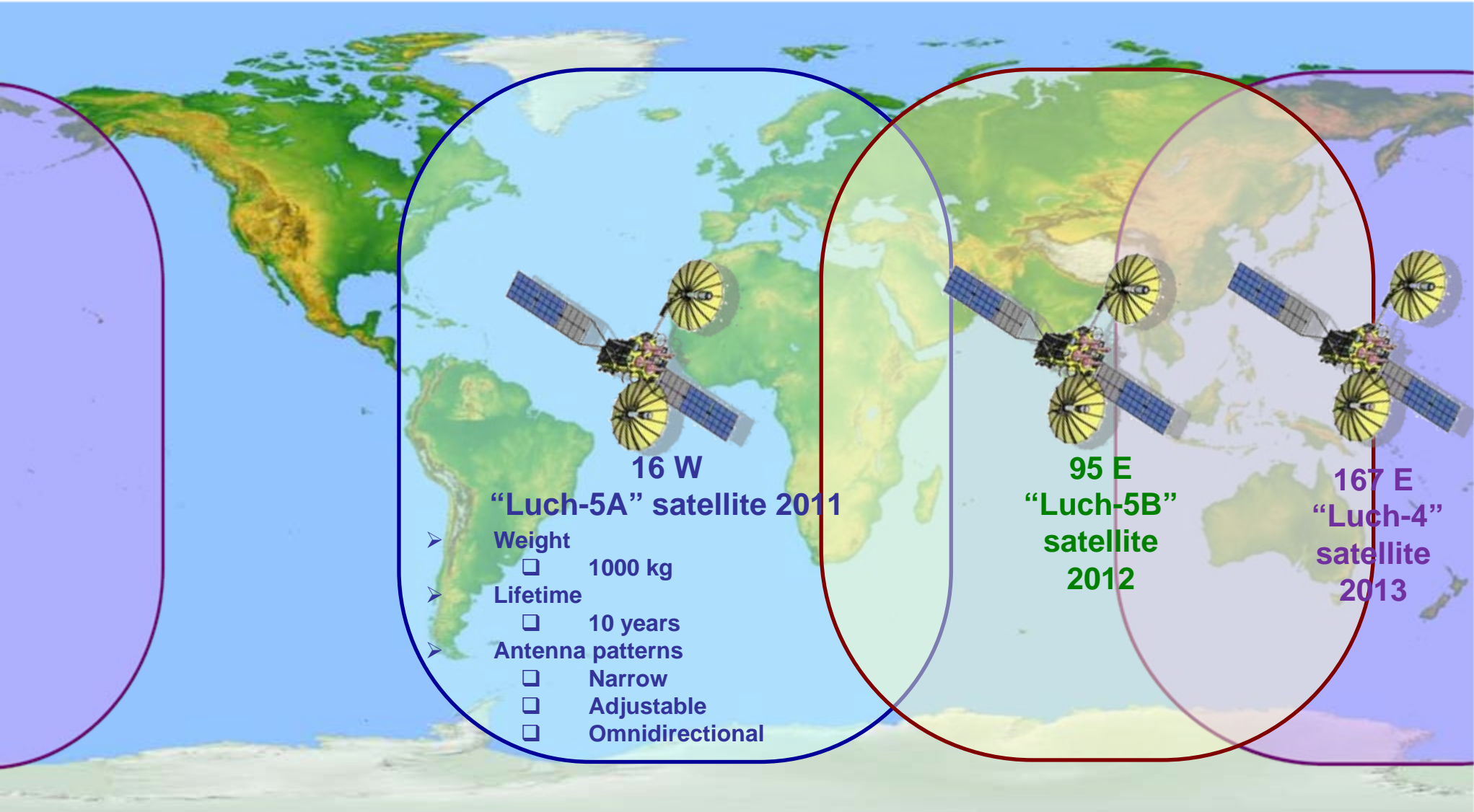
NMCS, NMS and SSM network



System Control Centre



SDCM Space Segment





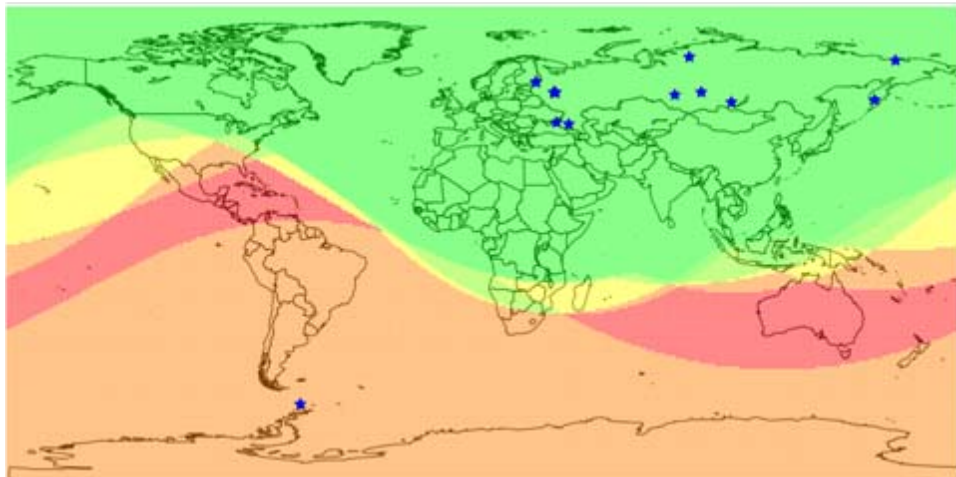
Structure of SDCM measurement collection stations



Existing network.

14 stations:

Leningrad Oblast. (Pulkovo and Svetloye), Moscow (CDCM, Mendeleyevo, 32 GNII), Krasnodar Territory (Gelendzhik), Stavropol Territory (Kislovodsk), Krasnoyarsk Territory (Krasnoyarsk and Noril'sk), Novosibirsk, Irkutsk, Petropavlovsk- Kamchatskiy, in the Chukotka Autonomous District (Bilibino), Antarctic (Bellingshausen station)

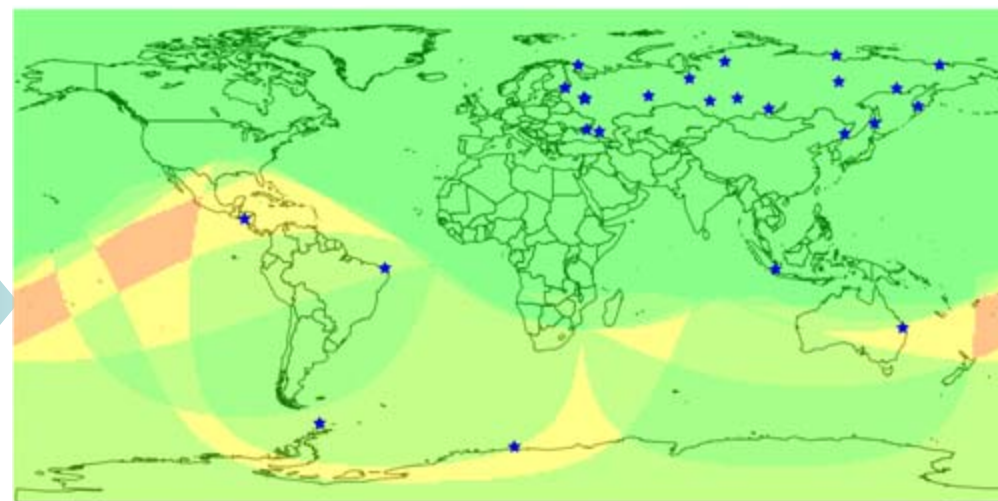


Prospective network.

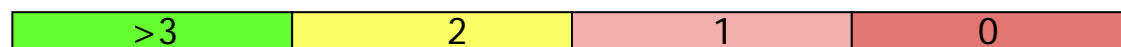
8 stations in the territory of the Russian Federation:
Murmansk region. (Lovozero), Ekaterinburg, Tyumen' region. (Noyabr'sk), Republic of Sakha (Yakutsk and Tiksi), Magadan, Vladivostok, Yuzhno-Sakhalinsk

5 stations abroad:

Antarctica (Novolazarevskaya), Australia (Brisbane), Nicaragua (Managua), Brazil (Natal) and Indonesia (Jakarta)



Simultaneous satellite tracking from multiple stations





SSI-01 monitoring station installation and commissioning (Bellingshausen, Antarctica, 2010)



Main view of the SSI-01



Off-site equipment



**GLONASS/GPS antenna +
Vaisala weather station**

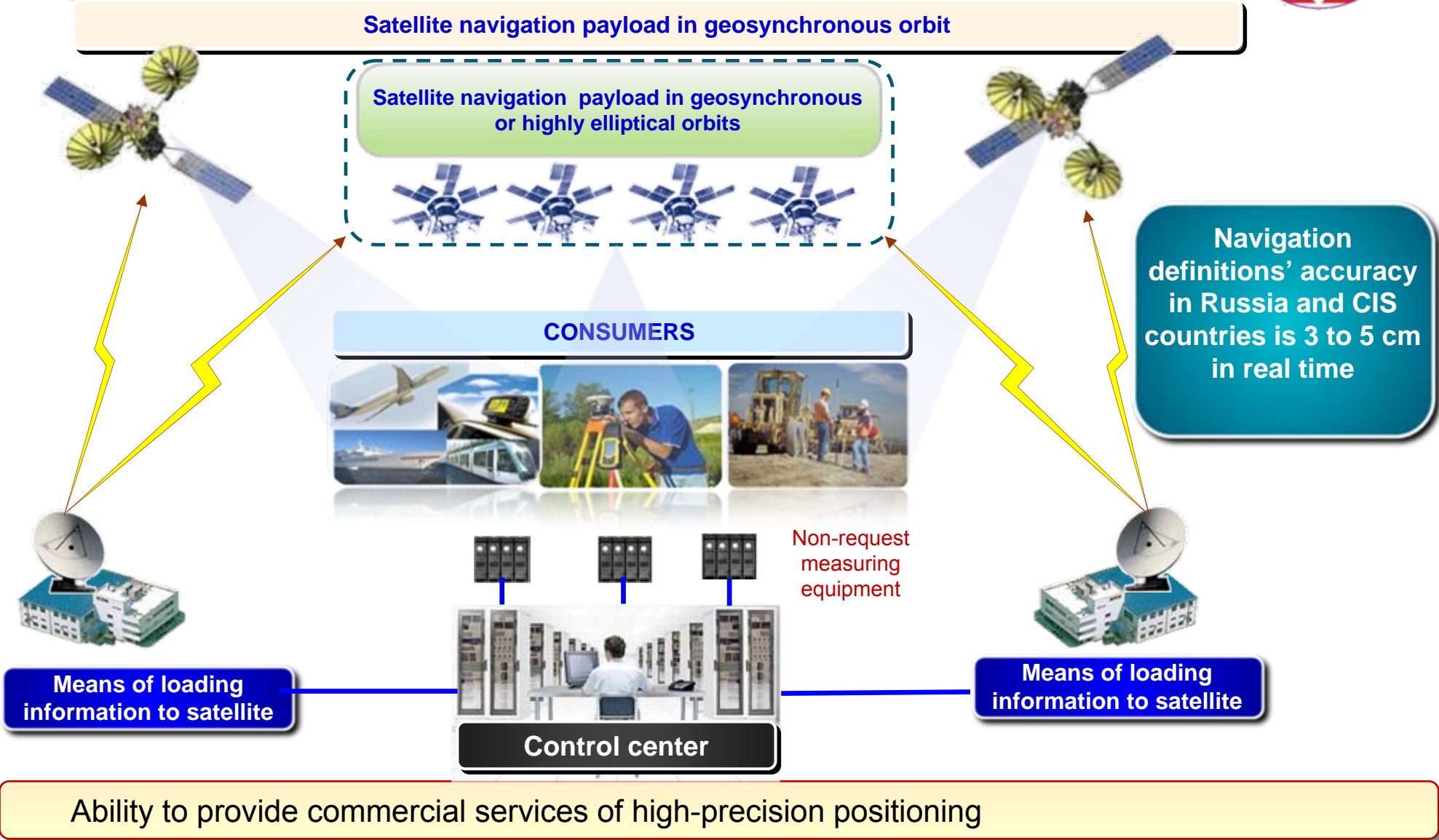


**Satellite
communication**





Regional system of high-precision positioning based on SDCM





- GLONASS Policy, Architecture and Status
- SDCM
- Development Plans
- Summary

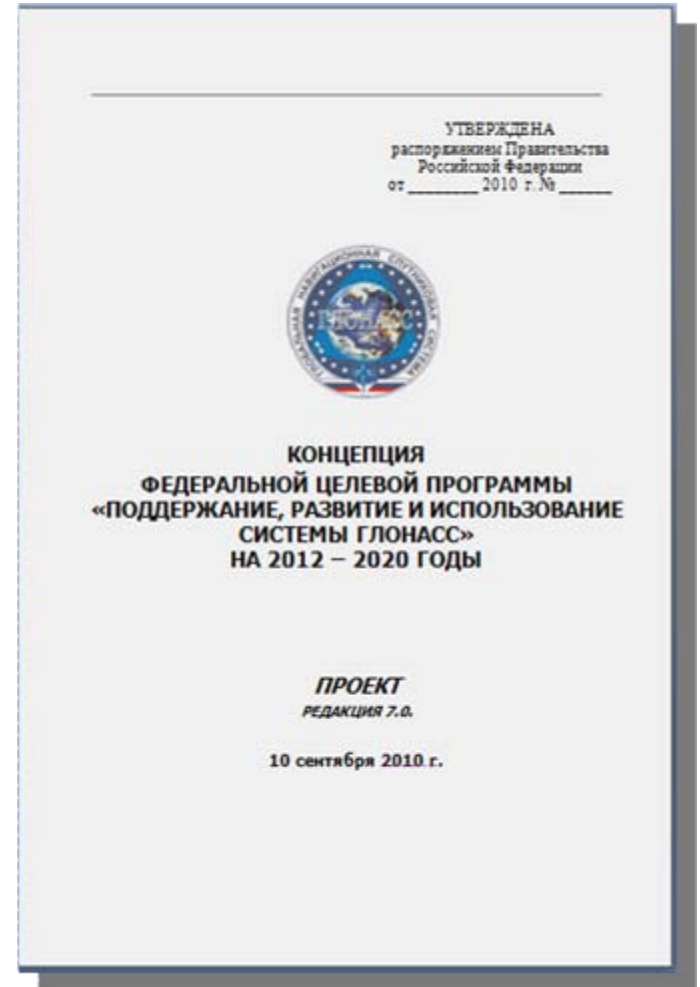


Major principles of the GLONASS-2020 Concept



Sustainment, Development, Use

- **Sustainment**
 - **State commitments** on performance (constellation, availability, accuracy, reliability)
 - Launch program until 2020 with spares on-orbit and on the ground
- **Development**
 - Constellation improvement
 - New signals implementation
 - Accuracy and availability improvement
 - Interference protection improvement
 - New capabilities implementation
 - Service area widening
- **Use**
 - Governmental use support
 - Private activity encouraging
 - Make GLONASS a worldwide utility





GLONASS system's main development directions for the period up to 2020



Formation of the GLONASS system satellite constellation based on the "Glonass-K" satellite with improved tactical performance and advanced features. Development of prospective satellite "Glonass-KM" on the basis of new technologies and with higher accuracy and performance

Deployment of the GLONASS system ground segment new tools, including augmentations, new assisting systems to expand the scope of the system's use

Creating a new generation of consumer navigation means and systems on their basis, introduction of navigation technologies on basis of GLONASS system in order to modernize Russian economy and for special consumers

Deployment of regional satellite navigation systems that complement the GLONASS system, providing increased availability of navigation and improved accuracy characteristics based on satellites in high, circular (including geosynchronous) orbits

Creating a wide-band augmentation that provides solution of problems of integrity and high-precision regional navigation

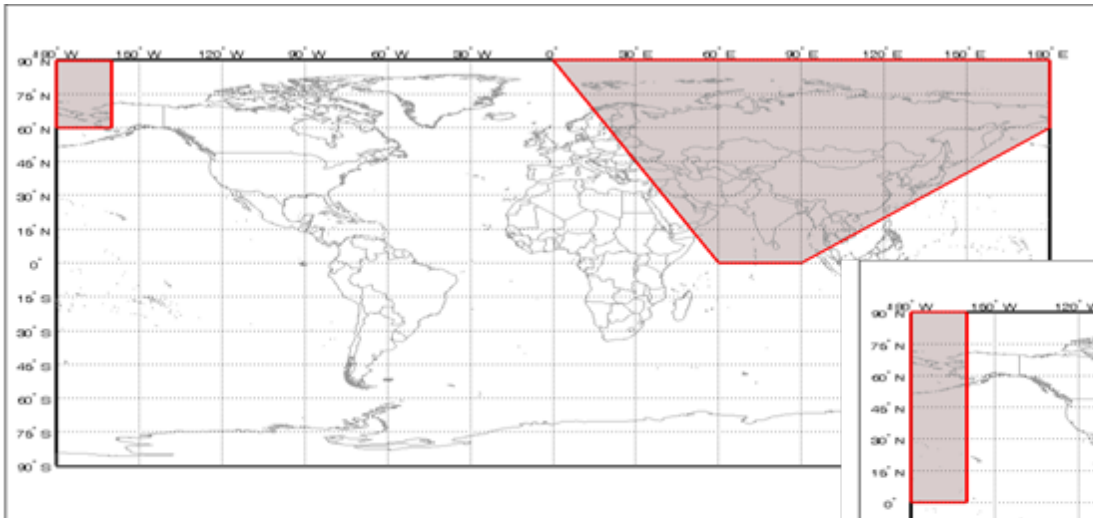
Creating a means of monitoring and verification of GLONASS system navigation fields' performance in order to secure the state's guarantee in respect of the alleged performances



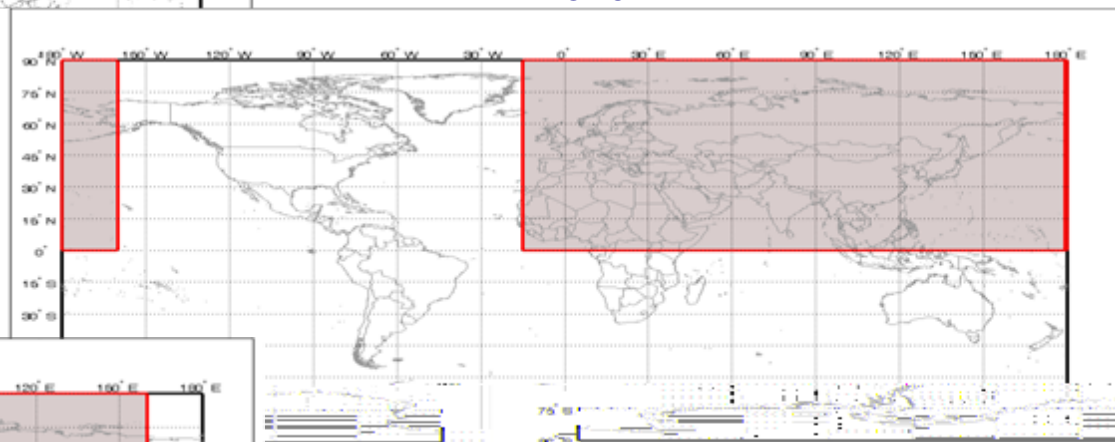
Investigated zones that are serviced by regional navigation satellite systems



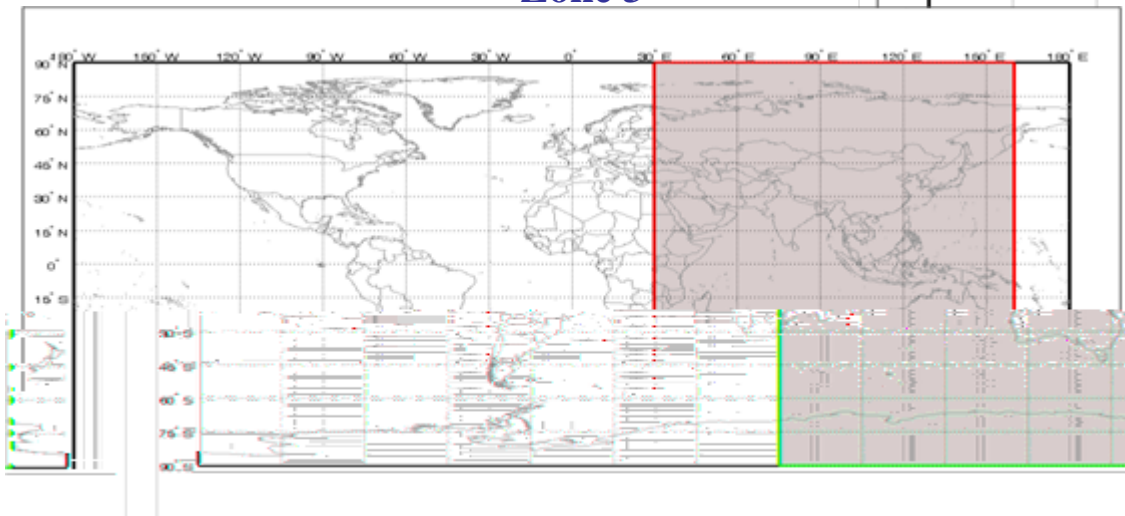
Zone 1



Zone 2



Zone 3



PDOP calculation was carried out for the centers of equal-area plots of the Earth S_i that are separated by approximately 220 km

Average PDOP calculation:

$$PDOP = \frac{1}{N} \sum_{i=1}^N PDOP(S_i)$$

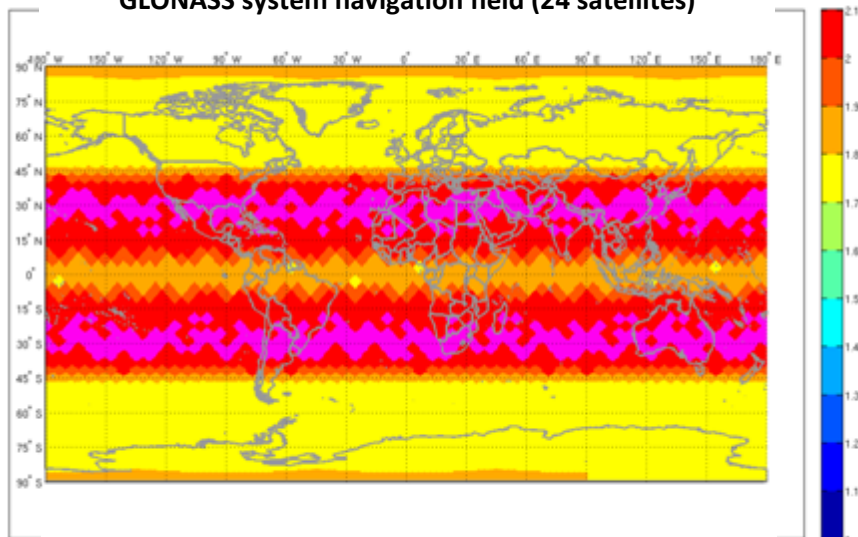
S_i – equal-area plots of the Earth (area of approximately 48,400 sq. km)



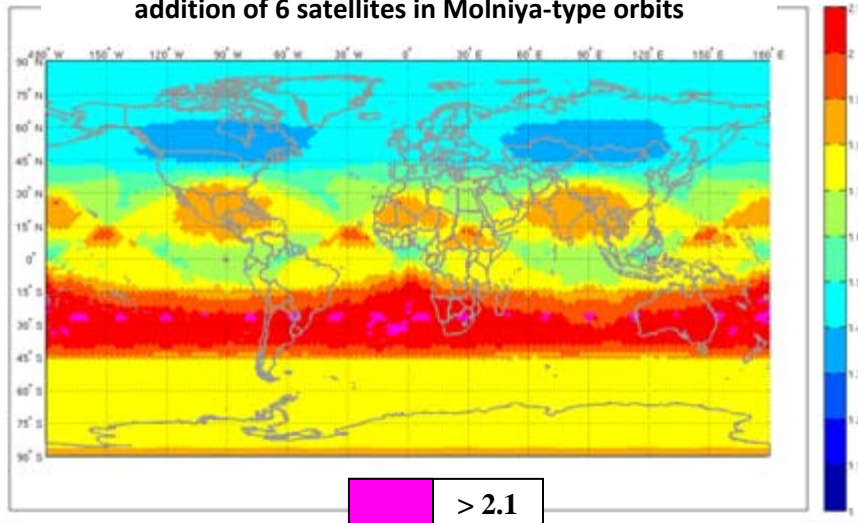
Changes in the GLONASS system navigation field (geometrical factor) with adding satellites in “Molniya-type” orbits



GLONASS system navigation field (24 satellites)

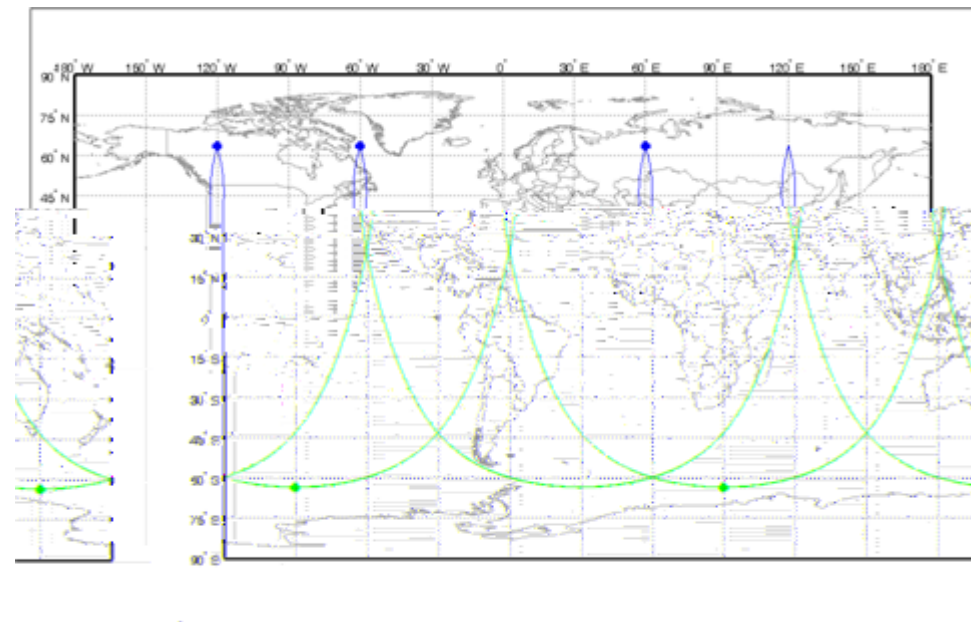


GLONASS system navigation field (24 satellites) with the addition of 6 satellites in Molniya-type orbits



Molniya-type orbit

- | | |
|----------------------|-----------------|
| Number of satellites | – 6; |
| Major axis | – 26561745 m; |
| Orbital period | – 43082 s; |
| Orbits inclination | – 63,5 degrees; |
| Perigee argument | – 270 degrees; |
| Perigee altitude | – 39846000 m; |
| Apogee altitude | – 535050 m; |
| Misalignment | – 0,74 |

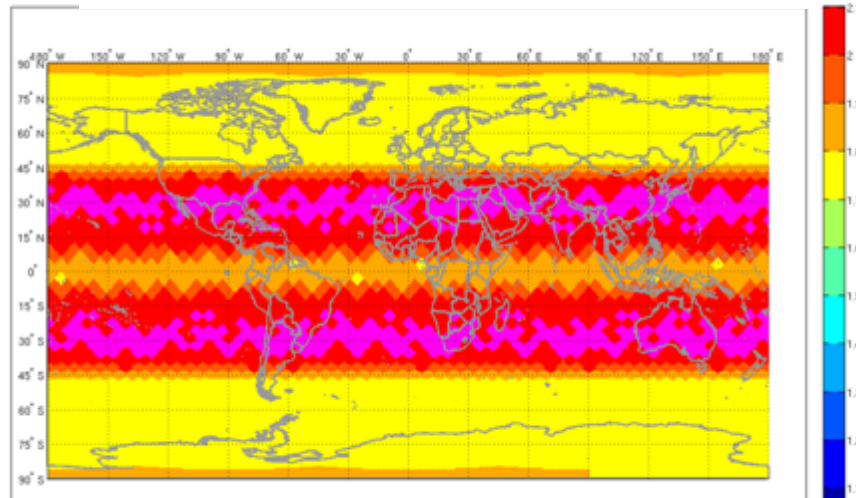




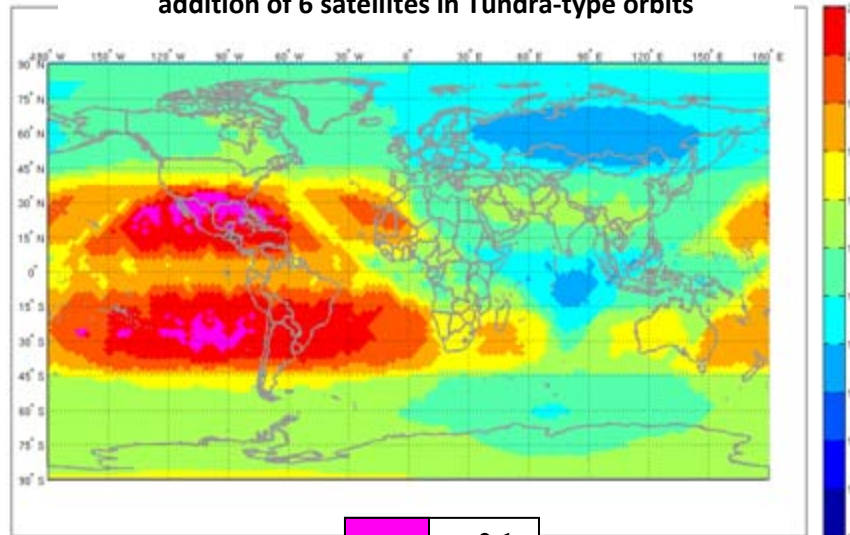
Changes in the GLONASS system navigation field (geometrical factor) with adding satellites in “Tundra-type” orbits



GLONASS system navigation field (24 satellites)

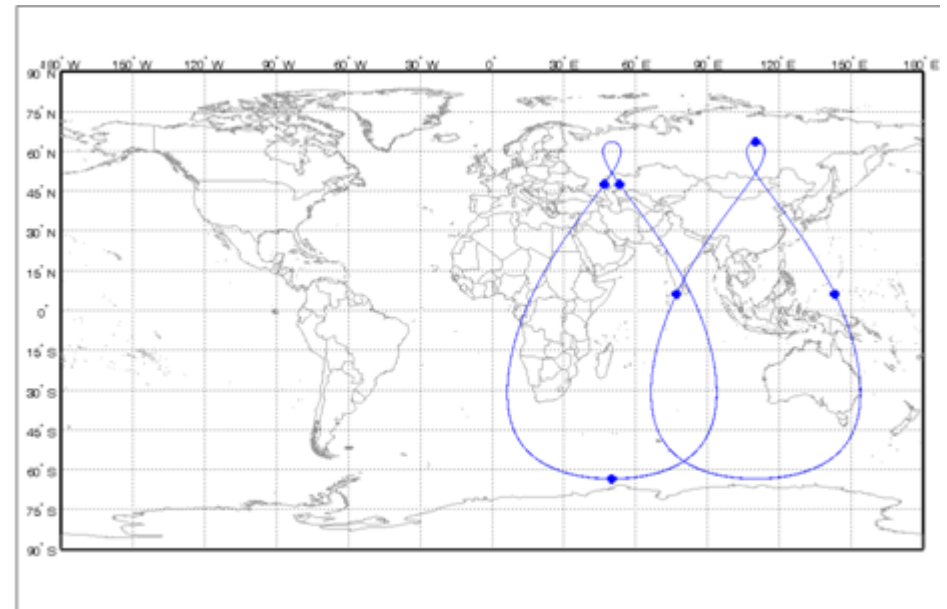


GLONASS system navigation field (24 satellites) with the addition of 6 satellites in Tundra-type orbits



Tundra-type orbit

- Number of satellites – 6;
- Major axis – 42164142 m;
- Orbital period – 86164 s;
- Orbits inclination – 63,5 degrees;
- Perigee argument – 270 degrees;
- Perigee altitude – 49286000 m;
- Apogee altitude – 22301000 m;
- Misalignment – 0,32

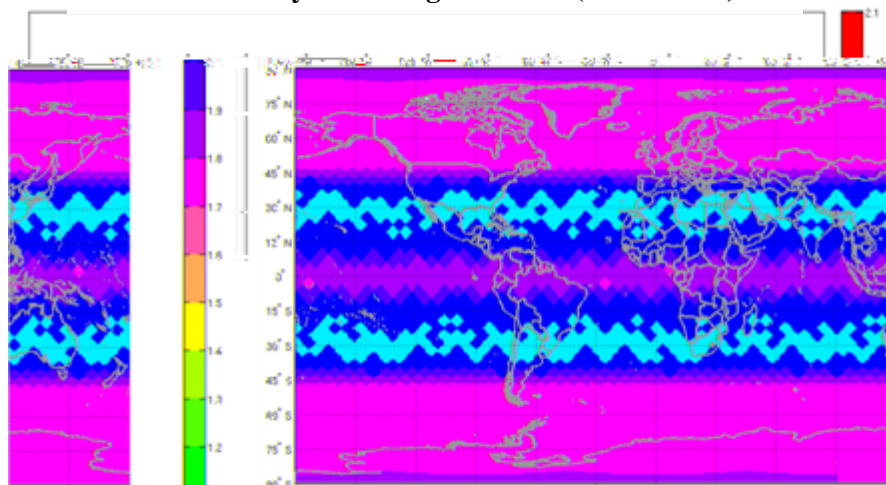




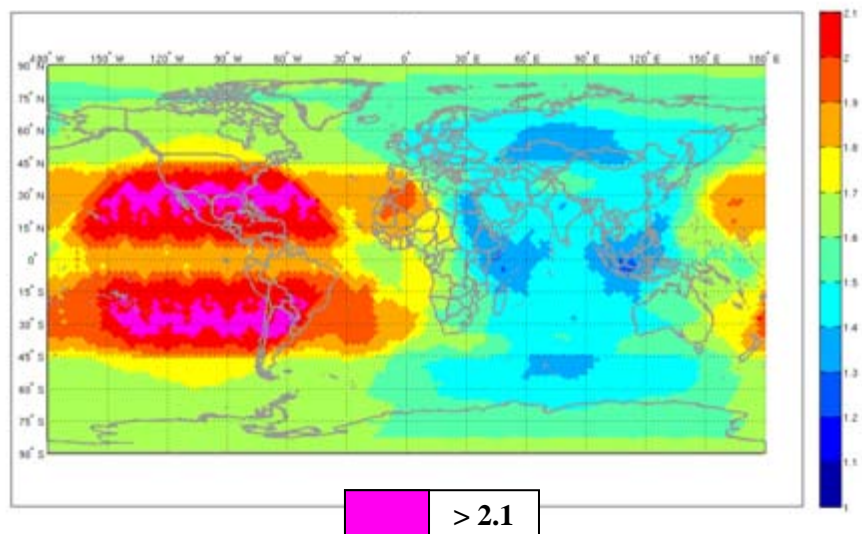
Changes in the GLONASS system navigation field (geometrical factor) with adding satellites in near-circular geosynchronous orbits



GLONASS system navigation field (24 satellites)

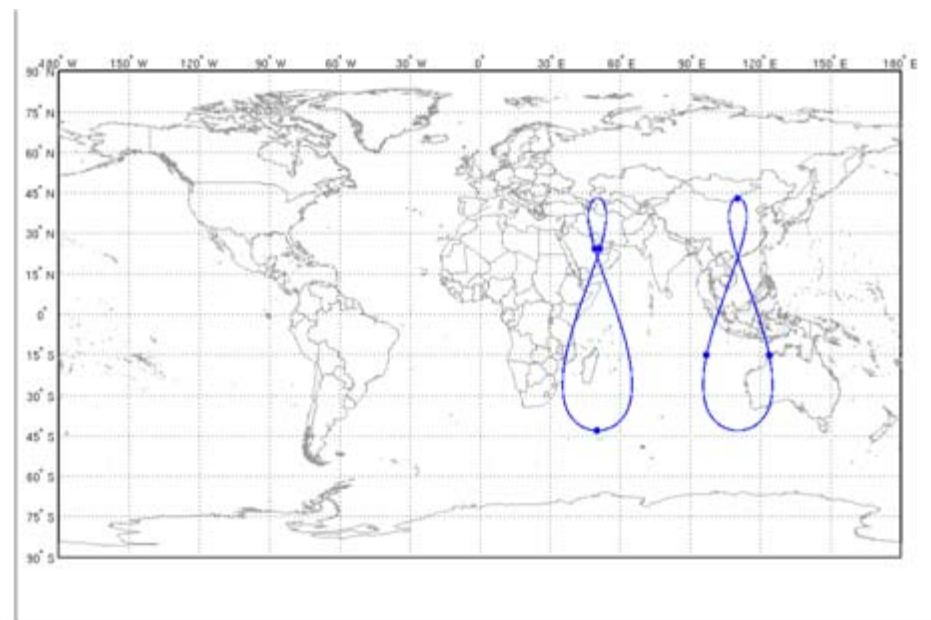


GLONASS system navigation field (24 satellites) with the addition of 6 satellites in near-circular geosynchronous orbits



Near-circular geosynchronous orbit

- Number of satellites – 6;
- Major axis – 42164142 m;
- Orbital period – 86164 s;
- Orbits inclination – 43 degrees;
- Perigee argument – 270 degrees;
- Misalignment – 0,075





COSPAS-SARSAT international search and rescue system



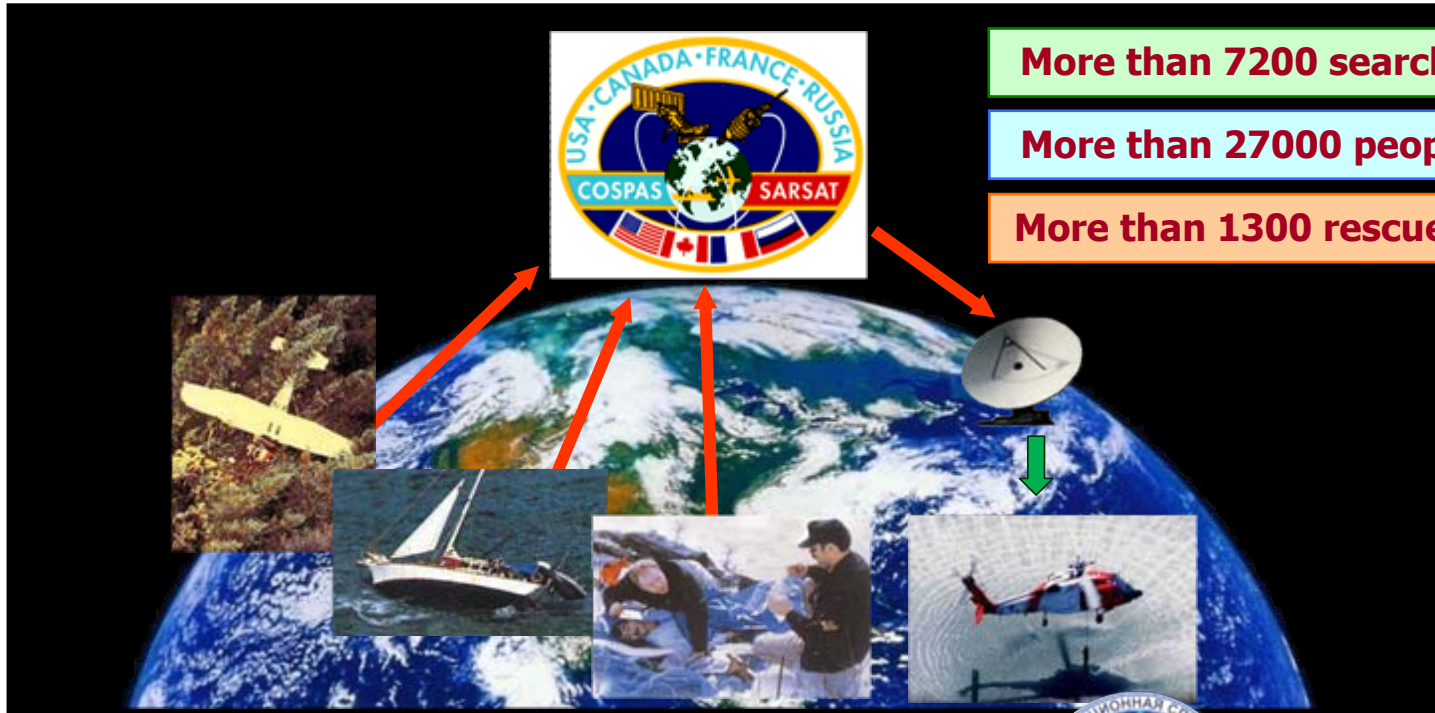
COSPAS-SARSAT system (1982-2010)



More than 7200 search and rescue operations

More than 27000 people rescued in the world

More than 1300 rescued in the Russian Federation





- GLONASS Policy, Architecture and Status
- SDCM
- Development Plans
- **Summary**



Summary



- GLONASS Program is the high priority of the Russian Government policy
- GLONASS open service is free for all users
- GLONASS Program is in a progress, objective to be achieved by 2011
- 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
- GLONASS will continue
 - Keep the GLONASS traditional frequency bands
 - Transmit existing FDMA signals
 - Introduce new CDMA signals
- New GLONASS Program is under development
 - State commitments for major performance
 - GLONASS sustainment, development, use
- International cooperation – make GLONASS as one of key elements of the international GNSS for worldwide use

**Thank you
for your attention!**

**Prof. Dr. Grigory Stupak
Deputy Designer General on
GLONASS**

mail: stupak_gg@rniikp.ru