GLONASS status and development plans

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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**
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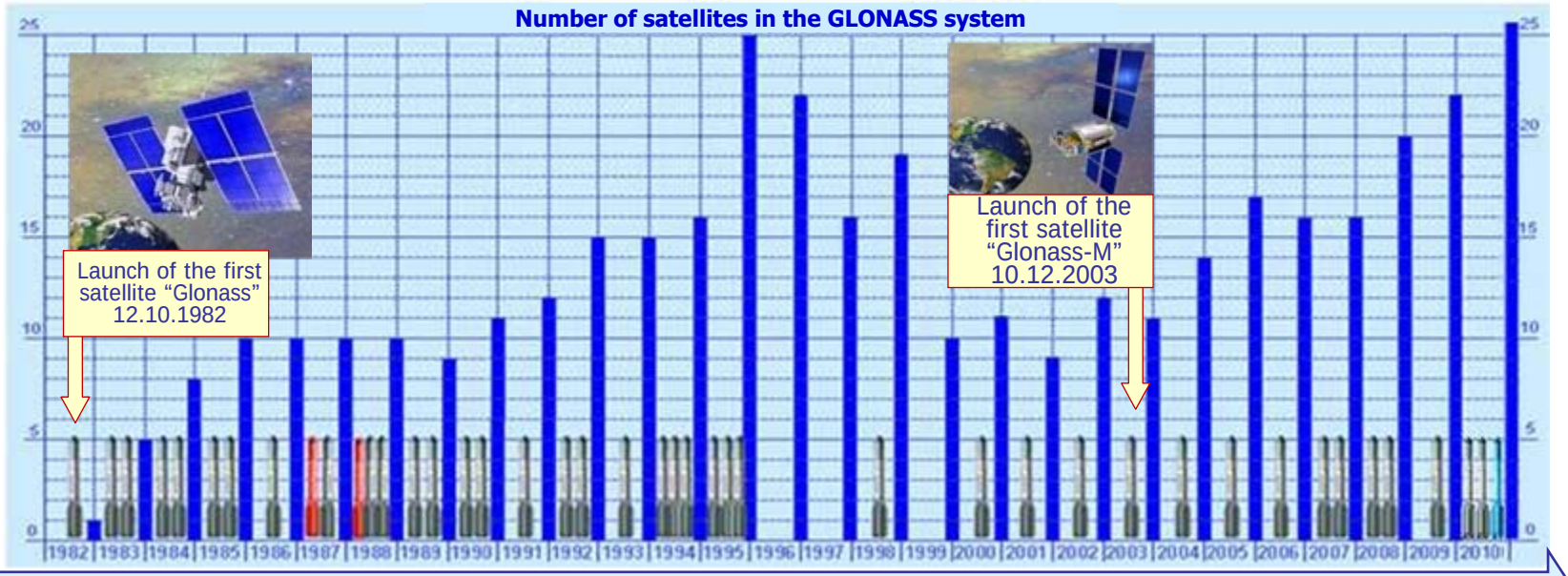
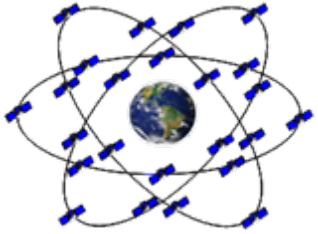
GLONASS Global Navigation System. Dual-use technologies

National government's decision to create GLONASS system



year 1976 — 1982 — 1989 1991 — 1993 1995 — 2007 2009 2011



Military application in the USSR

1993

Military purpose target system

Military application in Russia

Civilian use in Russia

1995

Military application in Russia and military and technical cooperation

Civil application in Russia and in global community

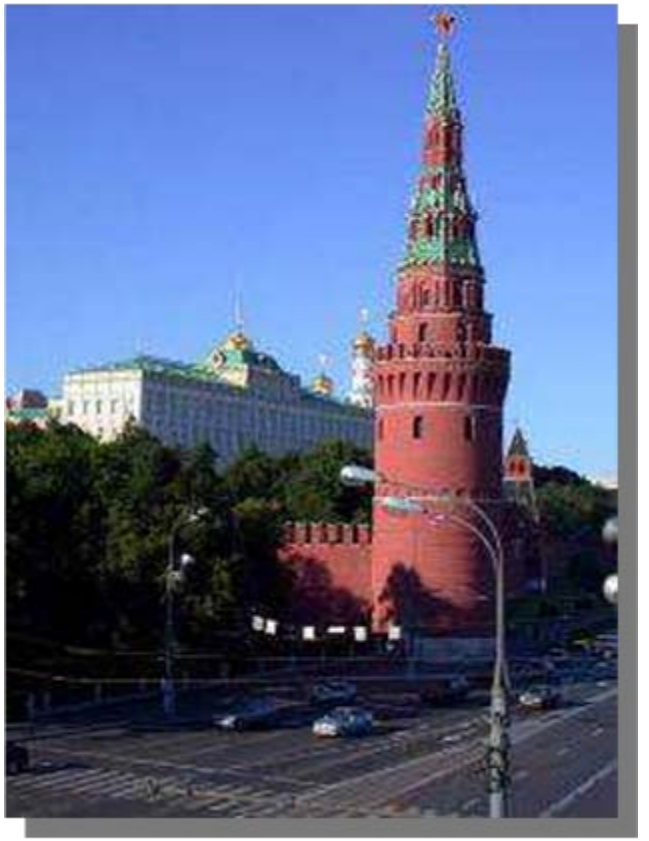
2007

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 economuic 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"

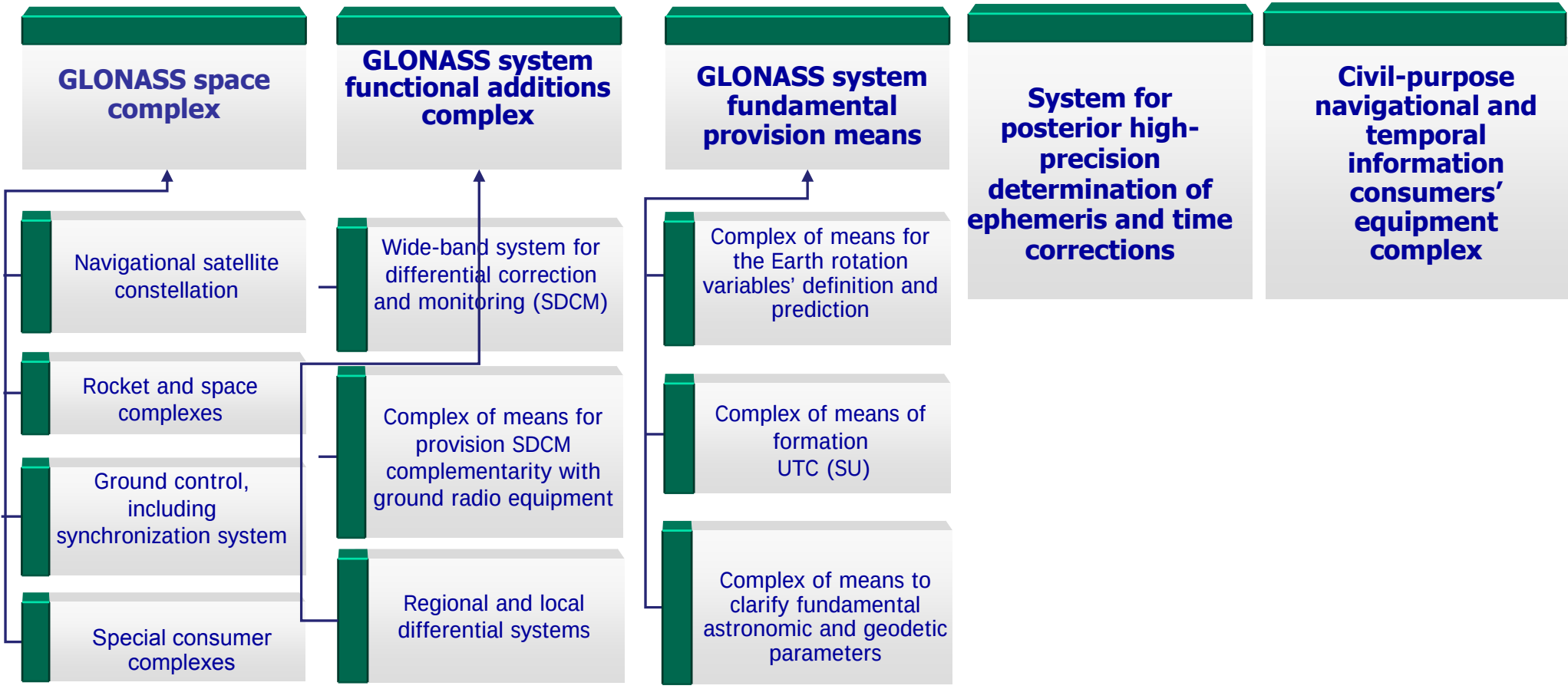
Main task indicators		2008	2009	2010	2011
Navigation field accessibility:	In the territory of the Russian Federation	95 %	98 %	100 %	100 %
	globally	83 %	92 %	100 %	100 %
Number of SVs in the GLONASS system constellation/Number of end-used SVs		18/18	23/22	27/24	29/24
Navigation evaluations' accuracy		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

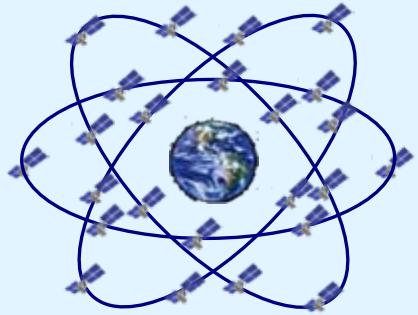
"Proton" booster with the upper stage

"Soyuz-2" booster with the upper stage

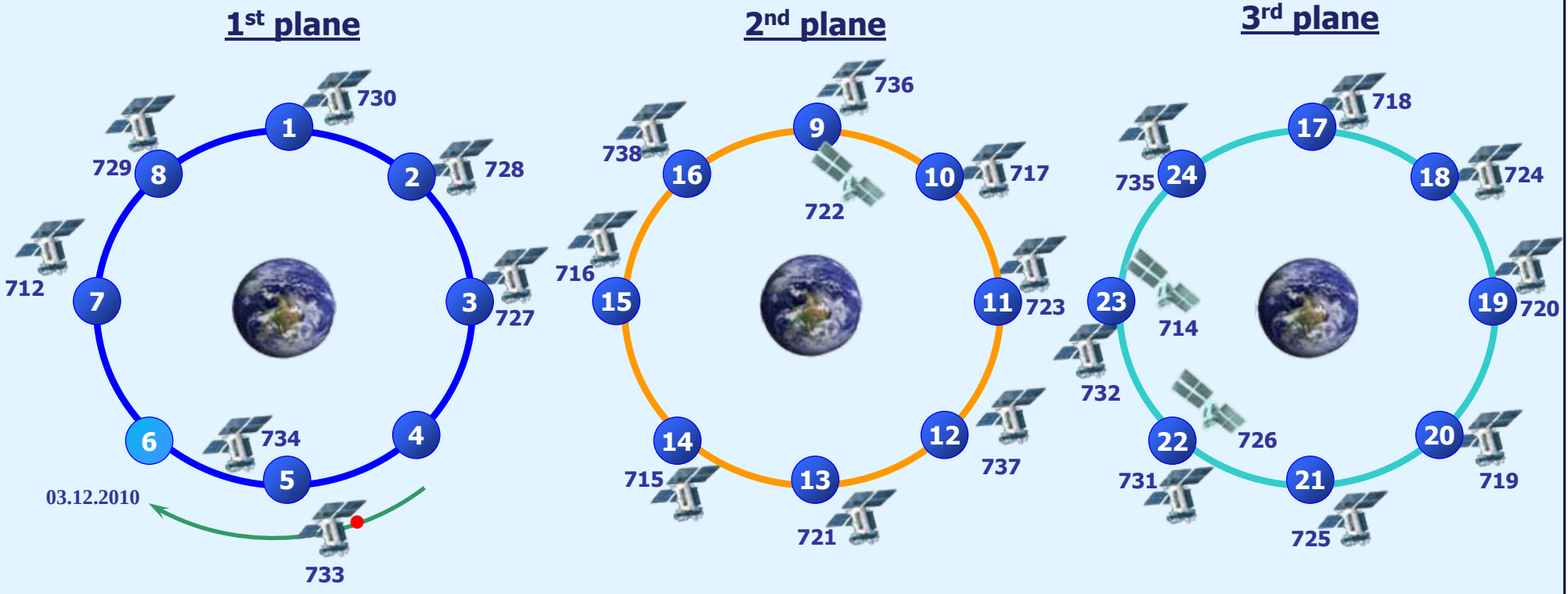
Launch of the unit with 3 “Glonass-M” satellites
September 2, 2010

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

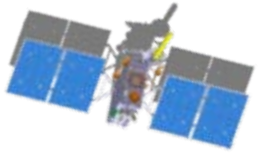


Stages of development of GLONASS system's open access navigation signals

"Glonass" satellite

"Glonass-M" satellite

"Glonass-K1" satellite



"Glonass-K2" satellite

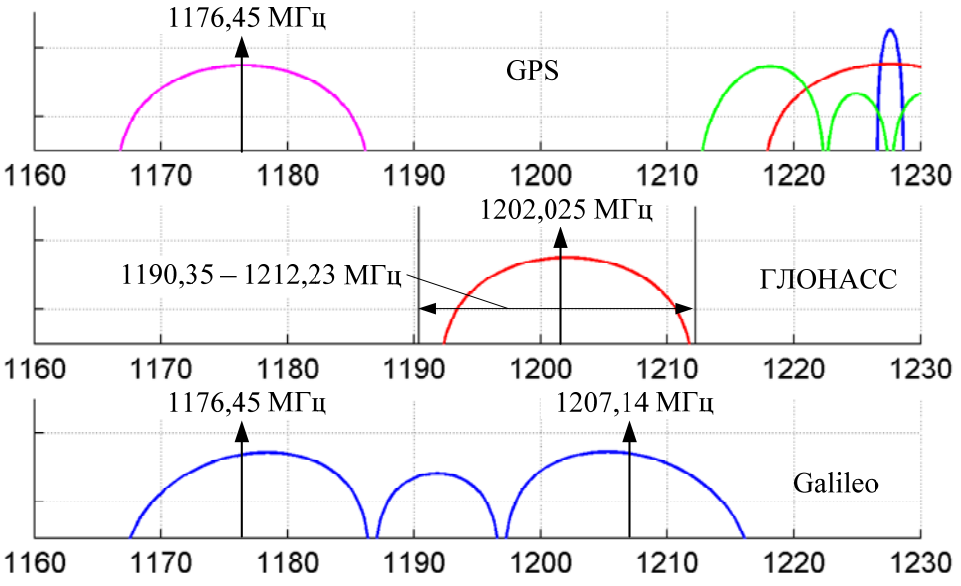
"Glonass-KM" satellite

L1	L2	L3	L1, L2	Future
L1OF	L2OF	-	-	
L1OF	L2OF	-	-	
L1OF	L2OF	L3OC test	-	
L1OF	L2OF	L3OC	L1OC	
L1OF	L2OF	L3OC	L1OC	L1OCM, L2OC, L5OCM

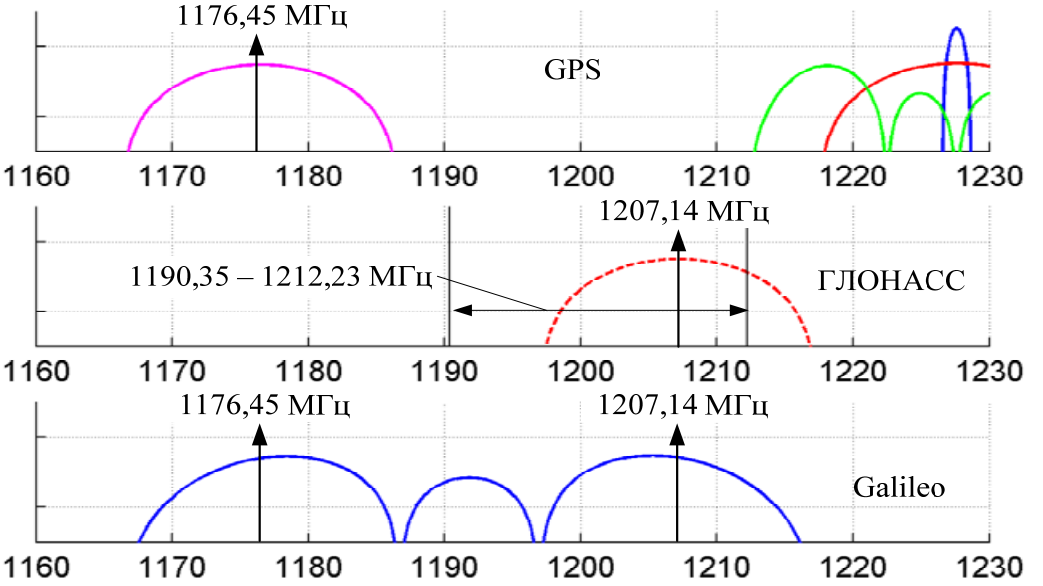
FDMA signal CDMA signal

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 × 1,023 MHz = 1202,025 MHz

- f(L3) = 1180 × 1,023 MHz = 1207,14 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

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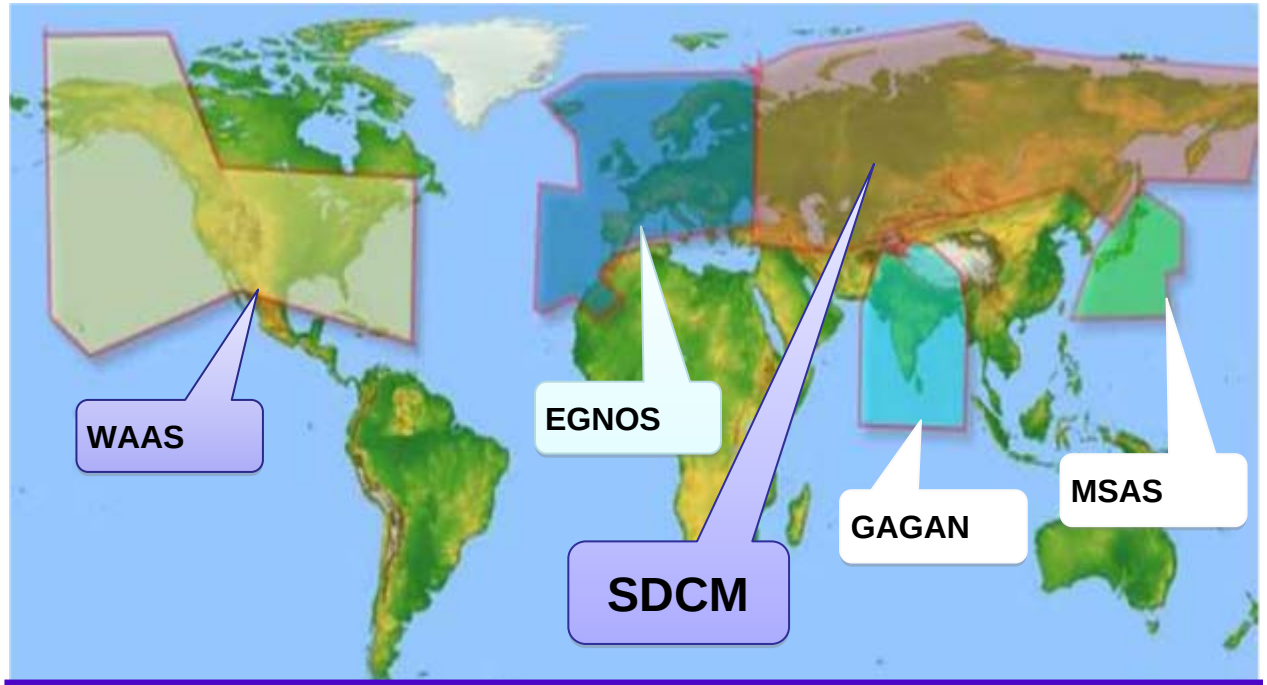
Global Navigation Satellite Systems' functional additions systems

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

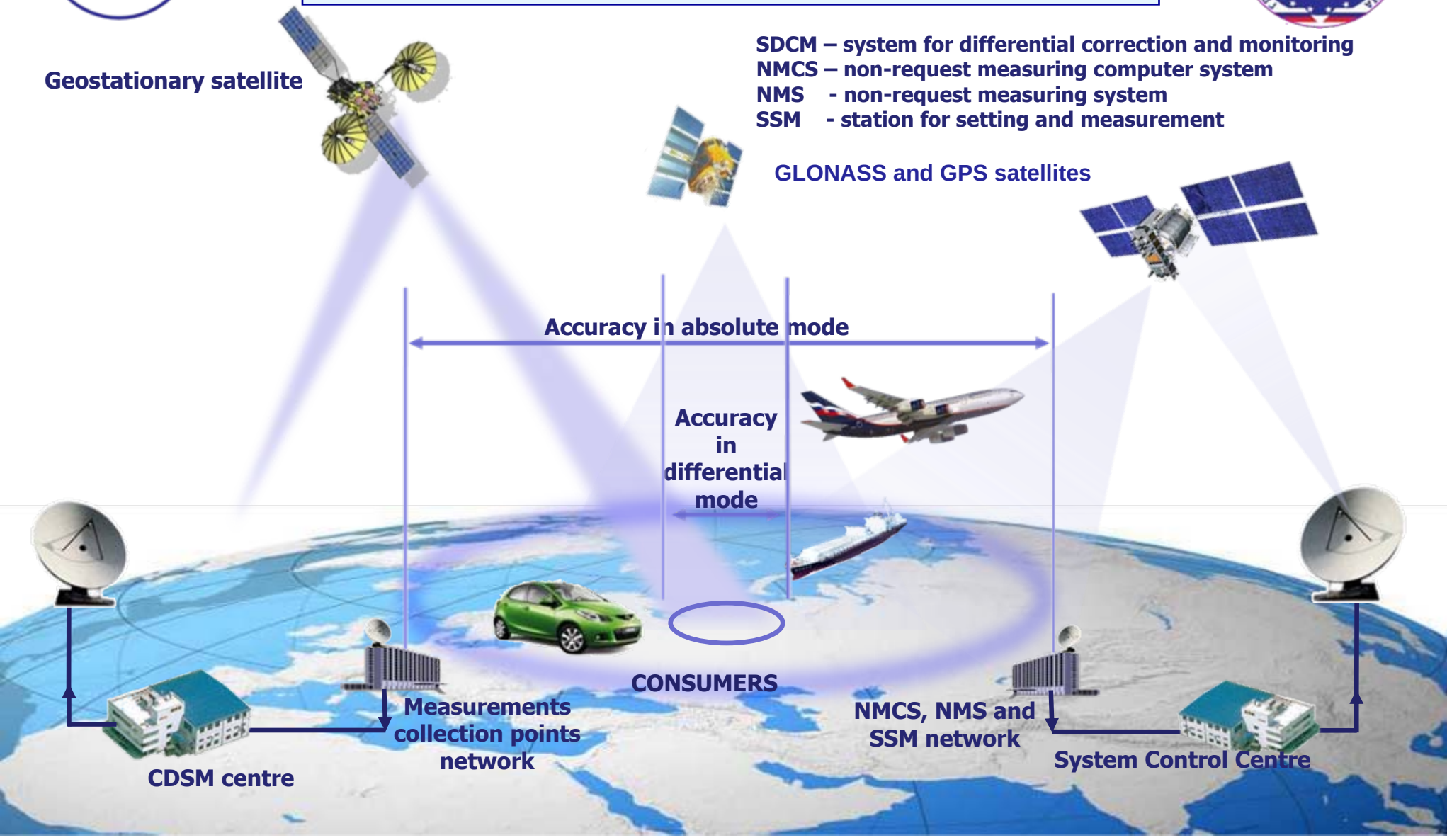
Local (departmental) - 150 km

Regional - 1000 km

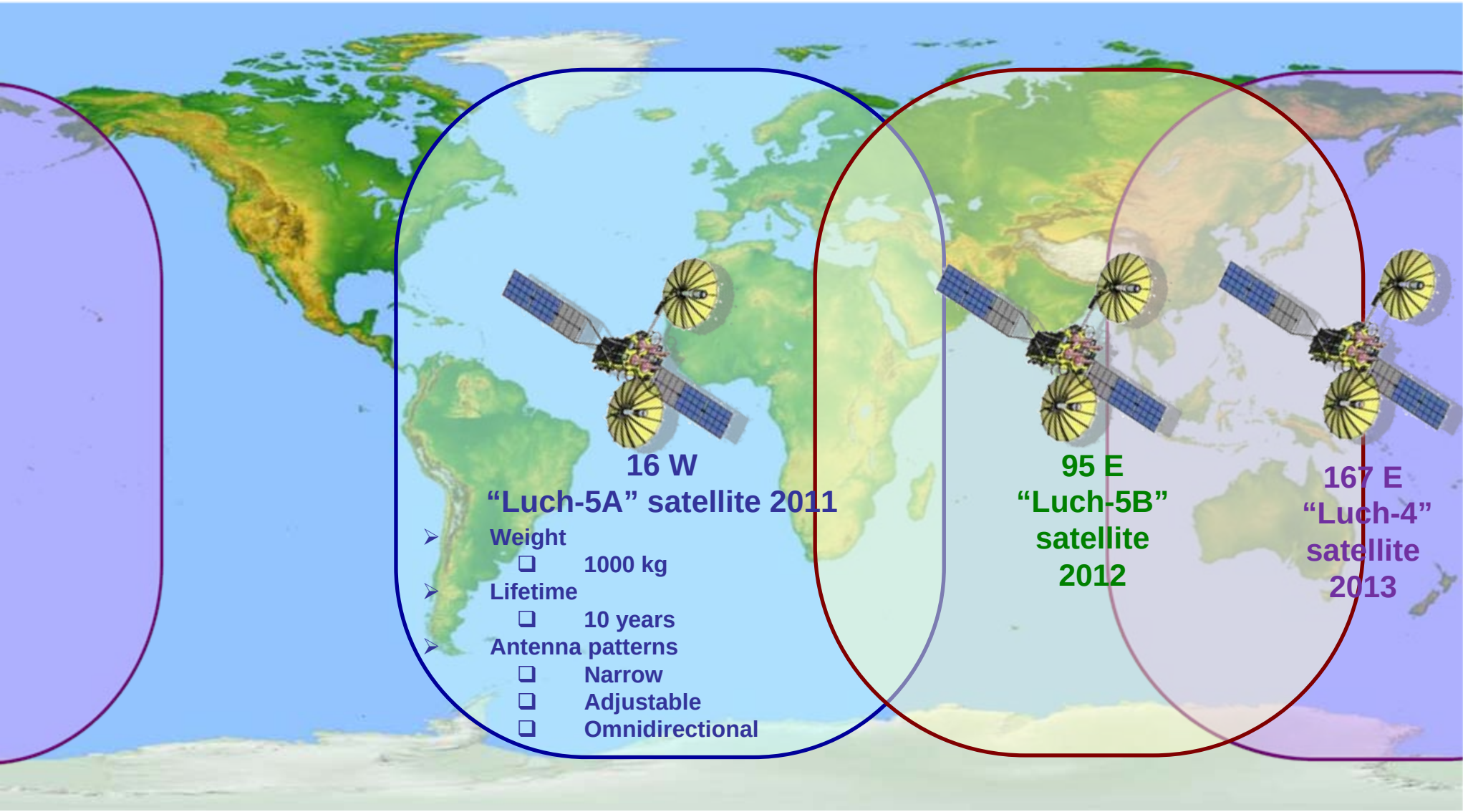
Wide-band (SDCM) – up to 5000 km

System for differential correction and monitoring (SDCM)

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



SDCM Space Segment



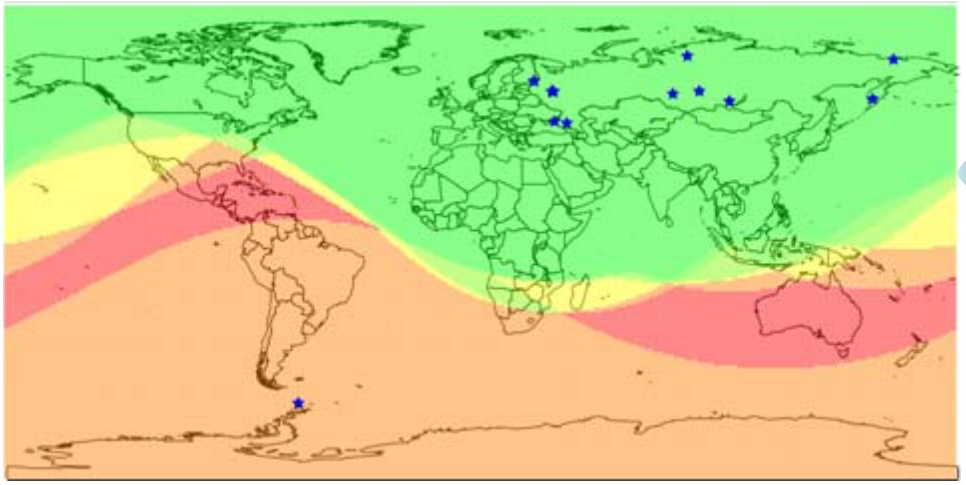
16 W
“Luch-5A” satellite 2011

- Weight
  - 1000 kg
- Lifetime
  - 10 years
- Antenna patterns
  - Narrow
  - Adjustable
  - Omnidirectional

95 E
“Luch-5B”
satellite
2012

167 E
“Luch-4”
satellite
2013

Structure of SDCM measurement collection stations

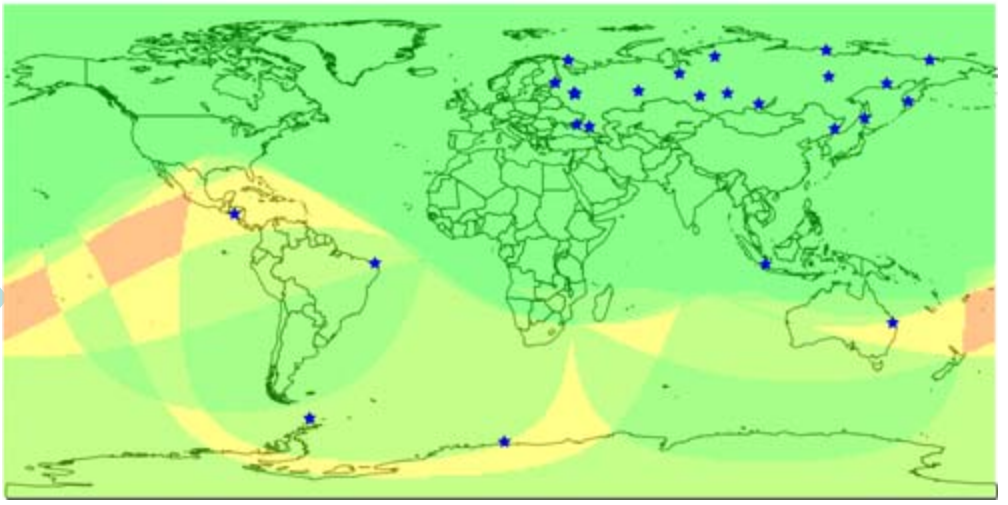


Existing network.

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

>3	2	1	0

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

Satellite navigation payload in geosynchronous orbit

Satellite navigation payload in geosynchronous or highly elliptical orbits

CONSUMERS

Navigation definitions' accuracy in Russia and CIS countries is 3 to 5 cm in real time

Non-request measuring equipment

Means of loading information to satellite

Means of loading information to satellite

Control center

Ability to provide commercial services of high-precision positioning

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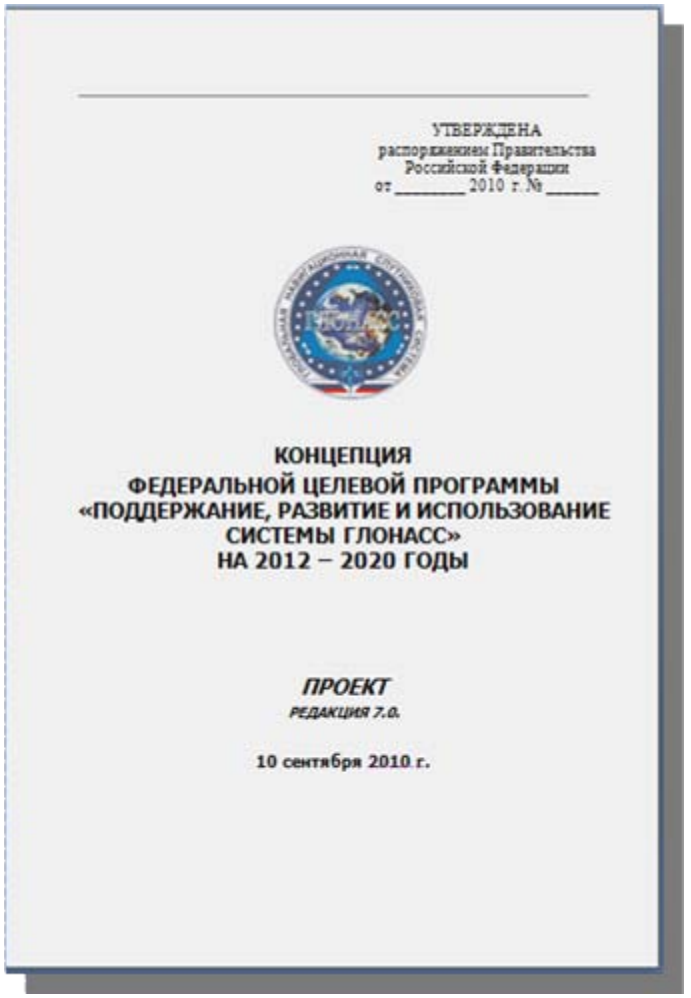
Major principles of the GLONASS-2020 Concept

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


УТВЕРЖДЕНА
распоряжением Правительства
Российской Федерации
от _____ 2010 г. № _____

КОНЦЕПЦИЯ
ФЕДЕРАЛЬНОЙ ЦЕЛЕВОЙ ПРОГРАММЫ
«ПОДДЕРЖАНИЕ, РАЗВИТИЕ И ИСПОЛЬЗОВАНИЕ
СИСТЕМЫ ГЛОНАСС»
НА 2012 – 2020 ГОДЫ

ПРОЕКТ
РЕДАКЦИЯ 7.0.

10 сентября 2010 г.

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

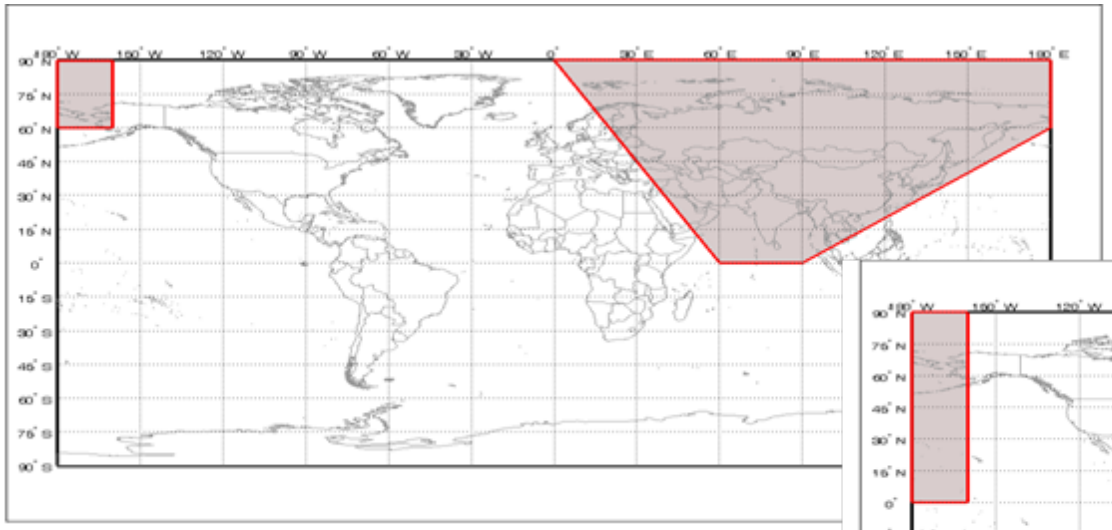
Deployment of regional satellite navigation systems that complement the GLONASS system, providing increased availability of navigation and improved accuracy characteristics based on satellites in high, circular (including geosynchronous) orbits

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

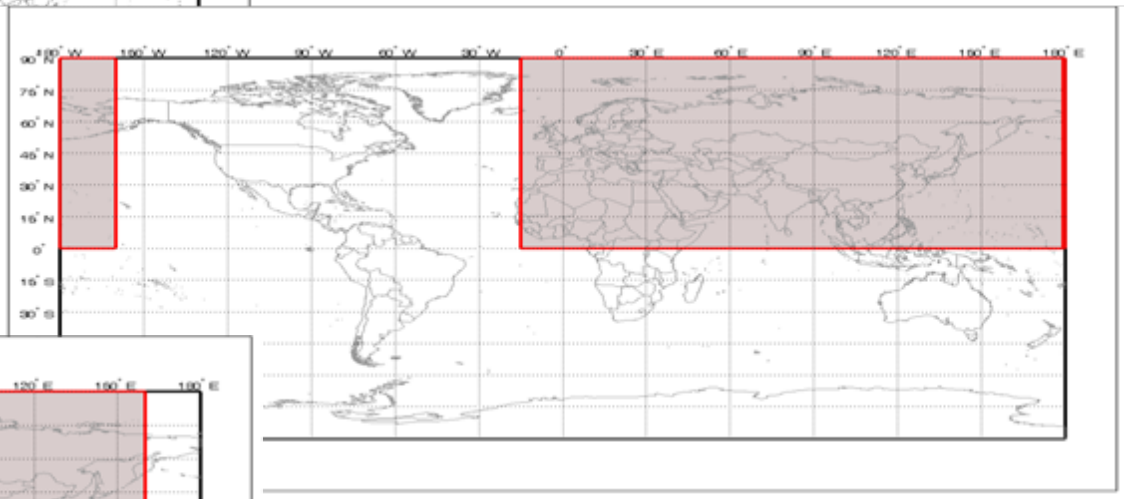
Creating a means of monitoring and verification of GLONASS system navigation fields' performance in order to secure the state's guarantee in respect of the alleged performances

Investigated zones that are serviced by regional navigation satellite systems

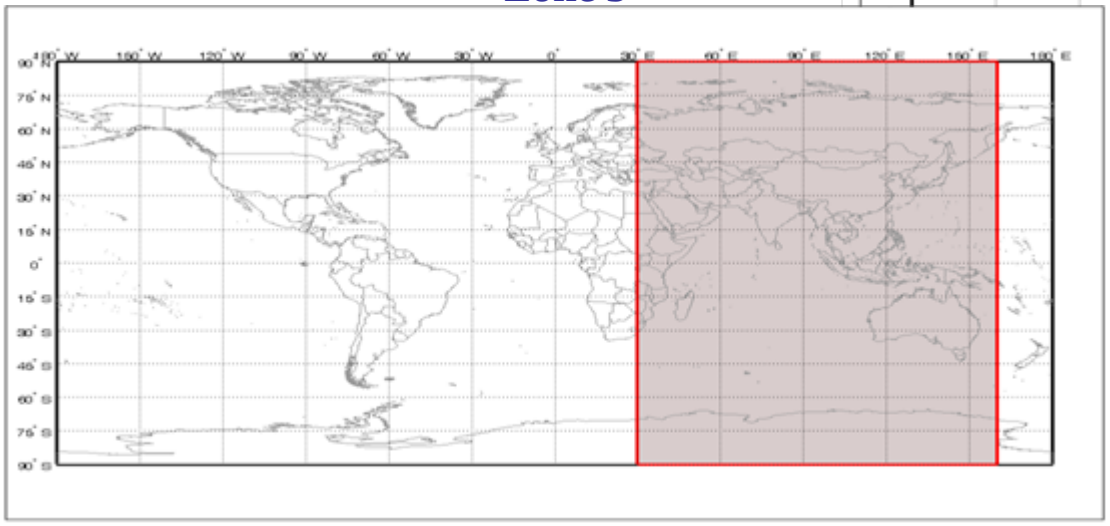
Zone 1



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

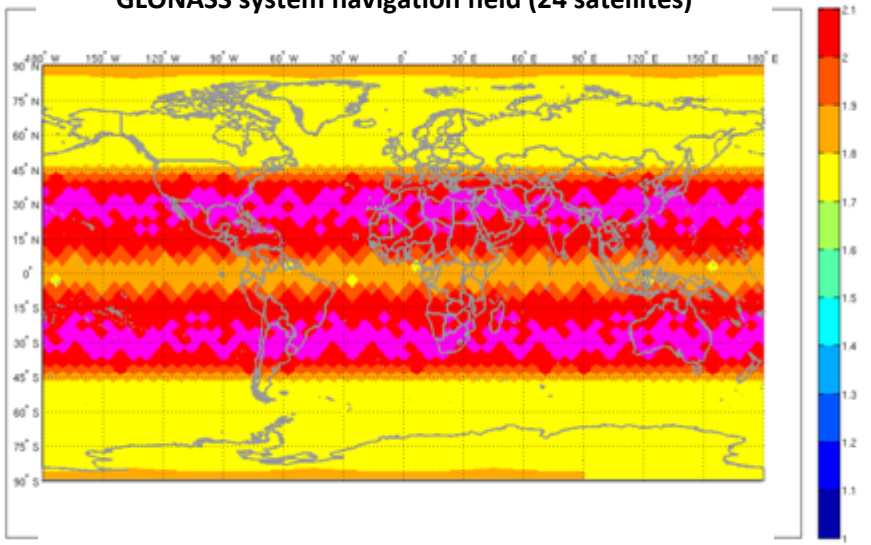
Average PDOP calculation:

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

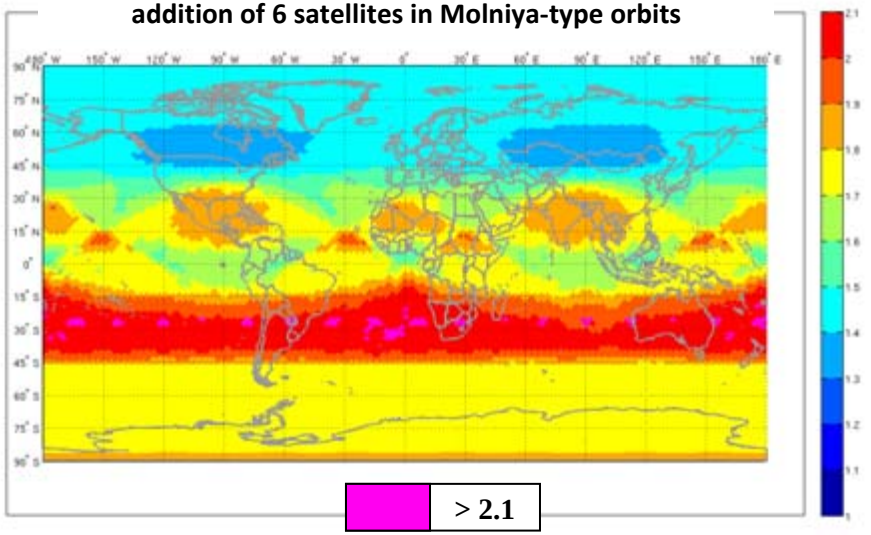
S_i – equal-area plots of the Earth (area of approximately 48,400 sq. km)

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

GLONASS system navigation field (24 satellites)

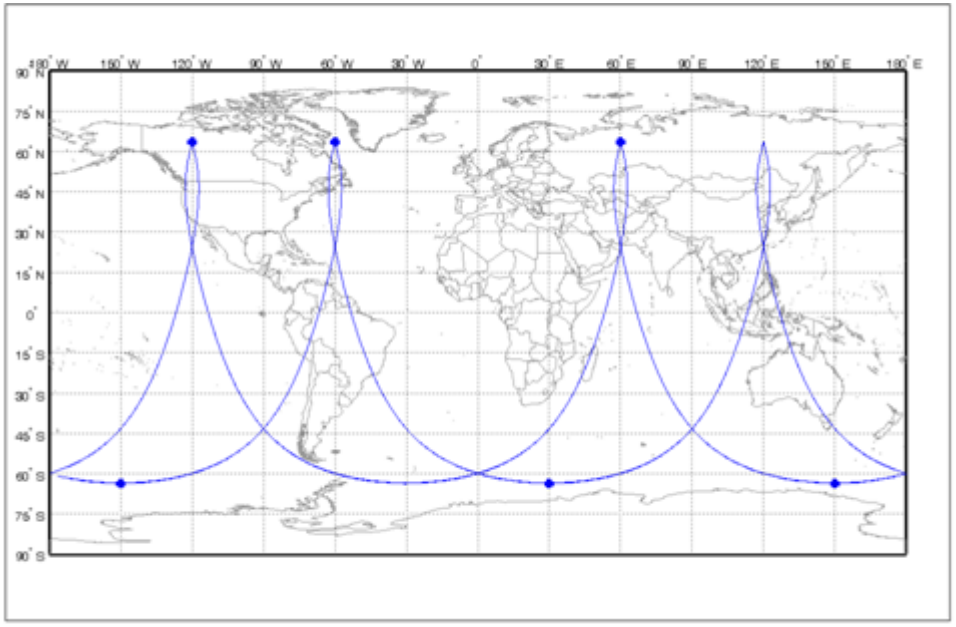


GLONASS system navigation field (24 satellites) with the addition of 6 satellites in Molniya-type orbits



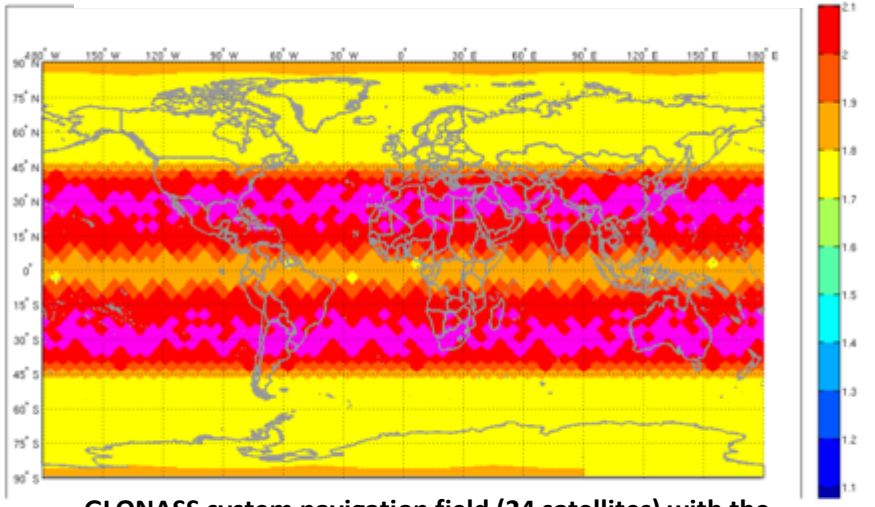
Molniya-type orbit

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

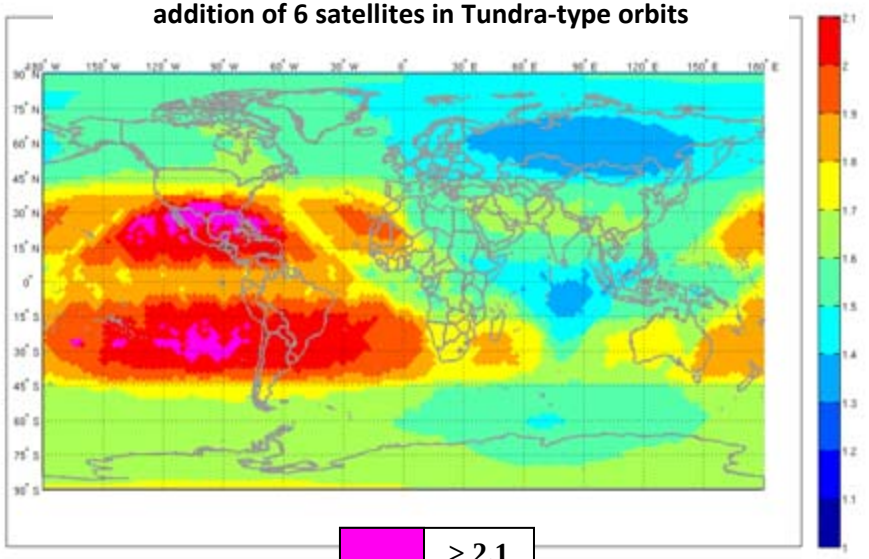


Changes in the GLONASS system navigation field (geometrical factor) with adding satellites in “Tundra-type” orbits

GLONASS system navigation field (24 satellites)



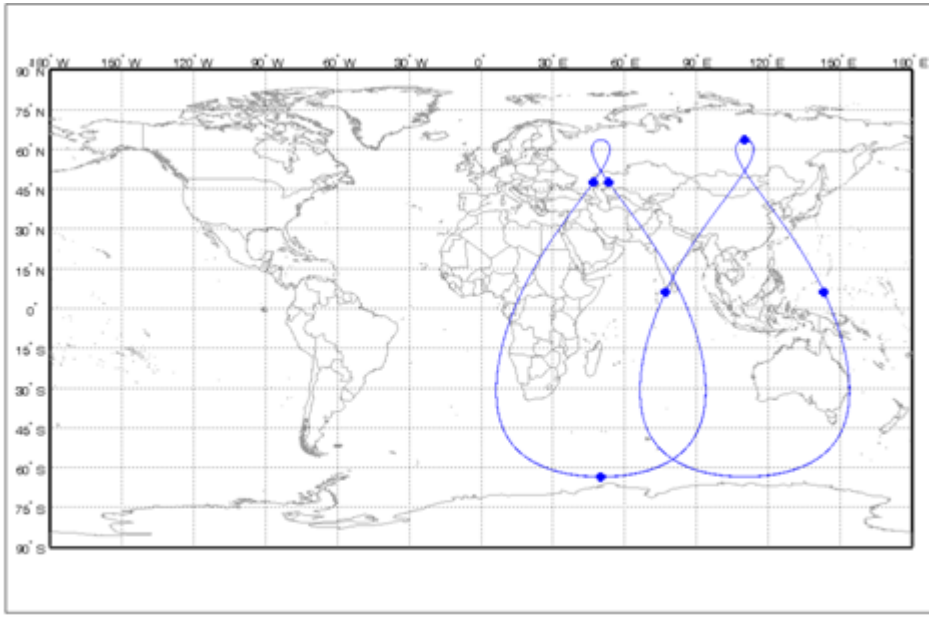
GLONASS system navigation field (24 satellites) with the addition of 6 satellites in Tundra-type orbits



> 2.1

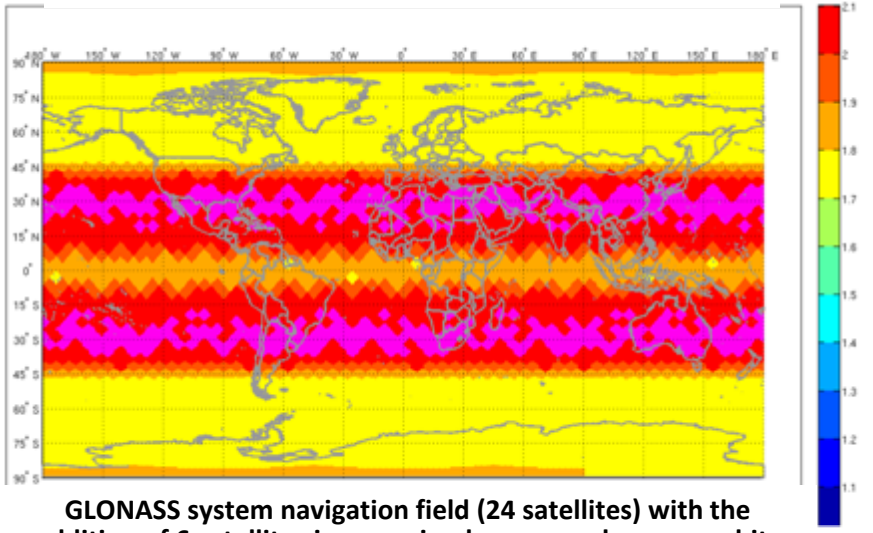
Tundra-type orbit

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

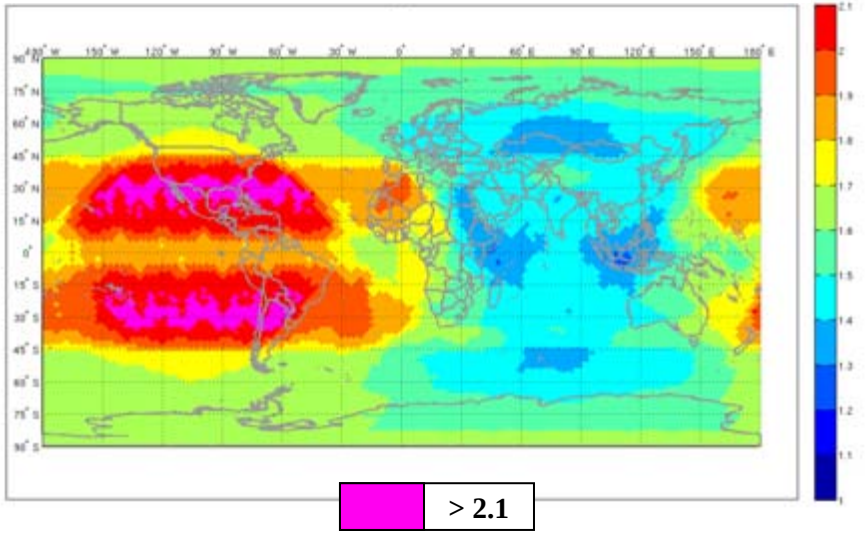


Changes in the GLONASS system navigation field (geometrical factor) with adding satellites in near-circular geosynchronous orbits

GLONASS system navigation field (24 satellites)

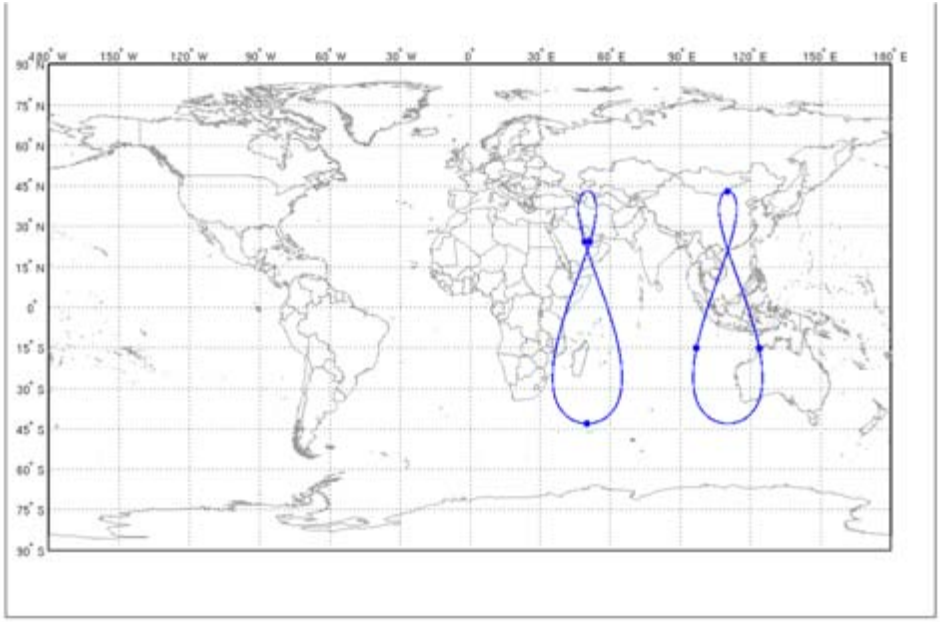


GLONASS system navigation field (24 satellites) with the addition of 6 satellites in near-circular geosynchronous orbits



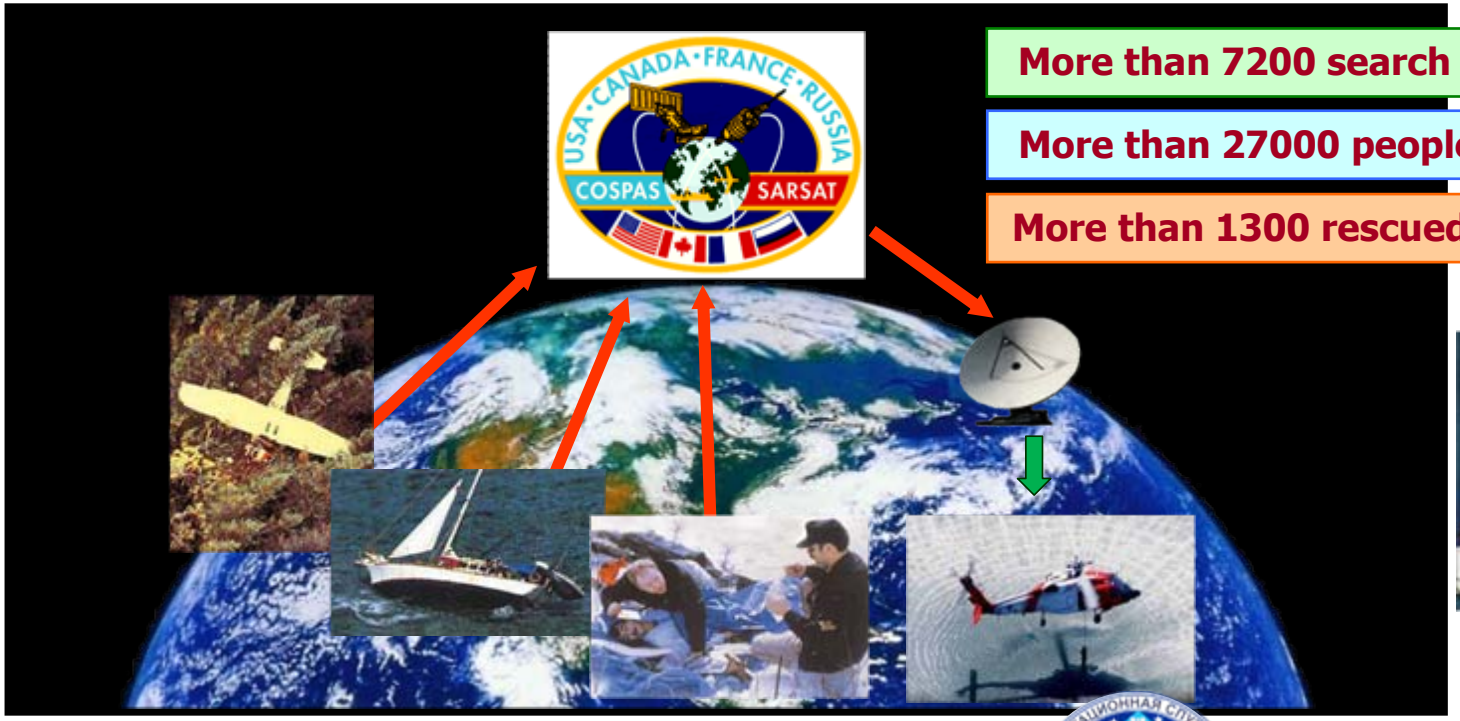
Near-circular geosynchronous orbit

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

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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!

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