



Developments of the GLONASS system and GLONASS Service

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GLONASS State Policy



- ❑ **GLONASS is a dual use system (Presidential Decision, March 1999)**
 - Free use of the civil signal
 - Signal specification available to users and industry (Interface Control Document)
 - No selective availability of the civil signal
- ❑ **GLONASS is opened for international cooperation (Gov. dec. 1999) :**
 - Presented as a basis to implement the international navigation satellite system
 - Negotiations on cooperation with EU, US, China and others
- ❑ **Federal GLONASS Mission Oriented Program (2002-2011) approved by the Government in August 2001.**
 - State Customers of GLONASS are Roskosmos and Ministry Of Defense
 - Roskosmos is a coordinator of the Federal GLONASS Program.
 - The Coordination Council of the Federal GLONASS Program has been established in 2002 including State Customers of the Program: Roskosmos, MOD, MOT, Federal Agency of Industry, Russian Mapping Agency.
- ❑ **Governmental decision on the combine GLONASS/GPS receivers use**
- ❑ **Concept of the National Navigation and Time Provision approved by the President in 2004**
 - GLONASS is a key element of the Concept.



Federal GLONASS Program



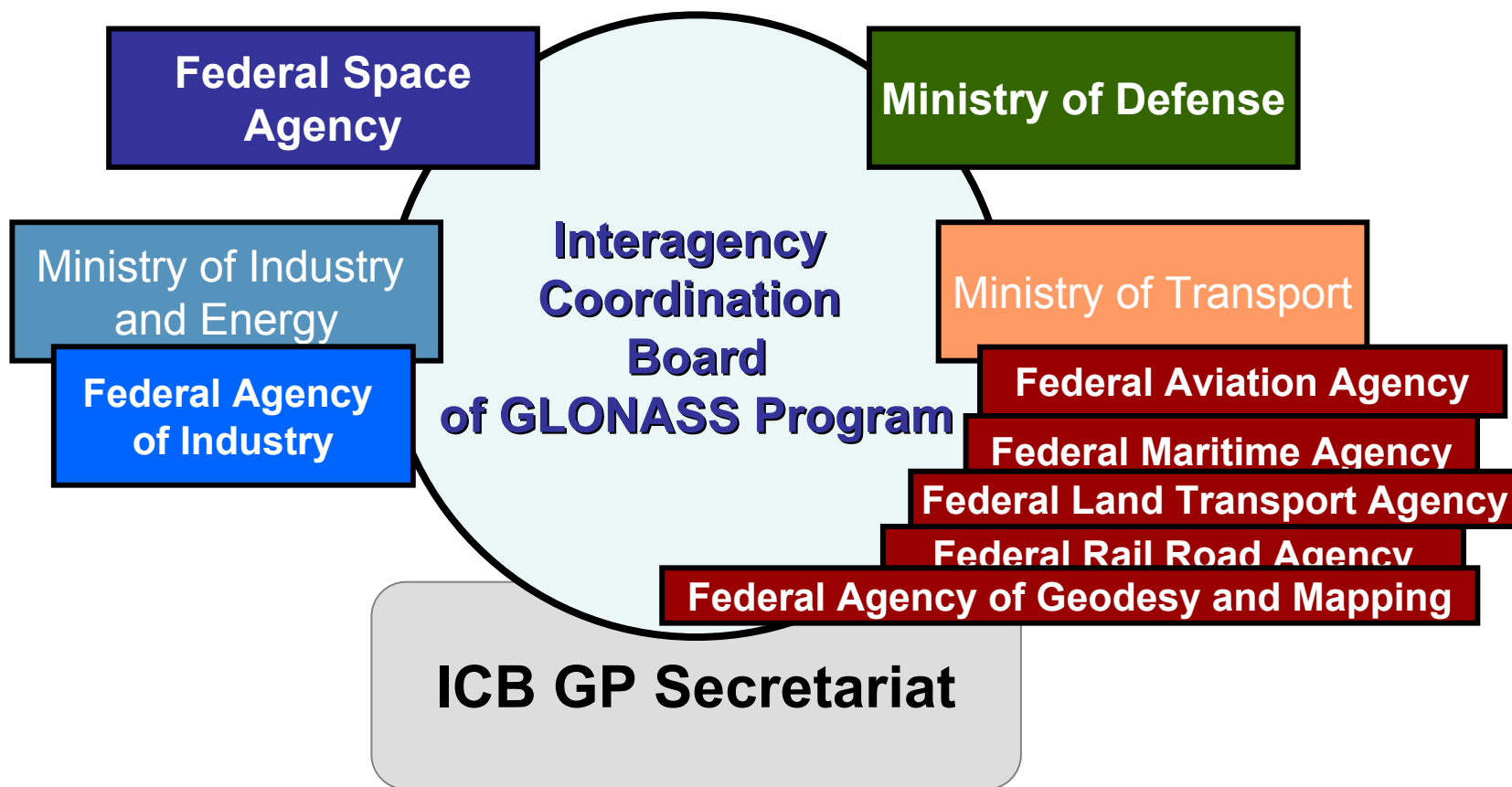
**Approved by the Russian Government in August, 2001 for 10 years.
Coordinated by Russian Aviation and Space Agency**

Program Directions:

- ↪ **Sustainment and development of GLONASS system:**
 - Minimal operation capability (18 satellites) by 2008
 - Full operation capability (24 satellites) by 2010
- ↪ **Development and production preparation of the GNSS user equipment for civil and special users**
 - Combined GNSS receivers
 - Integrated systems based on SatNav techniques
 - Components manufacture
- ↪ **Navigation technology introduction in the transport infrastructure**
- ↪ **Geodesy system modernization**



GLONASS Program Management Structure





GLONASS Architecture



Orbital constellation:

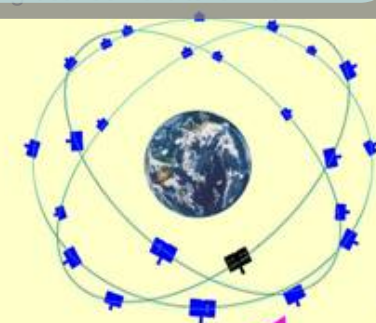
24 satellites (8 satellites in each of 3 planes)

Orbit type:

circular, $H = 19\,100\text{ km}$, $i = 64.8^\circ$

Orbit period: 11 hours 15 minutes

Angular spacing between orbits is 120°



Data for position determination and time synchronization

Satellite control. Status monitoring

Orbital constellation deployment and maintenance

ROCKET-SPACE COMPLEX

"PROTON-K" Launcher ("PROTON-M")
"BREEZE-M" Booster



Technical facilities for:
- satellite
- launcher
- booster

BAIKONUR cosmodrome

"SOYUZ-2" Launcher
"FREGAT" Booster



Technical facilities for:
- satellite
- launcher
- booster

PLESETSK cosmodrome

USERS

Position determination
Definition of velocity correction
Definition of time correction

ground



air



nautical



space



GROUND SEGMENT FOR SATELLITE CONTROL AND ORBIT DETERMINATION & TIME SYNCHRONIZATION



SCC - System Control Center

TT&C - Telemetry, Tracking & Control



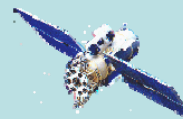
GLONASS Status



Guarantied lifetime - 36 month

Mean actual lifetime 54.7 months

Block 33. Launch in 26 December 2004



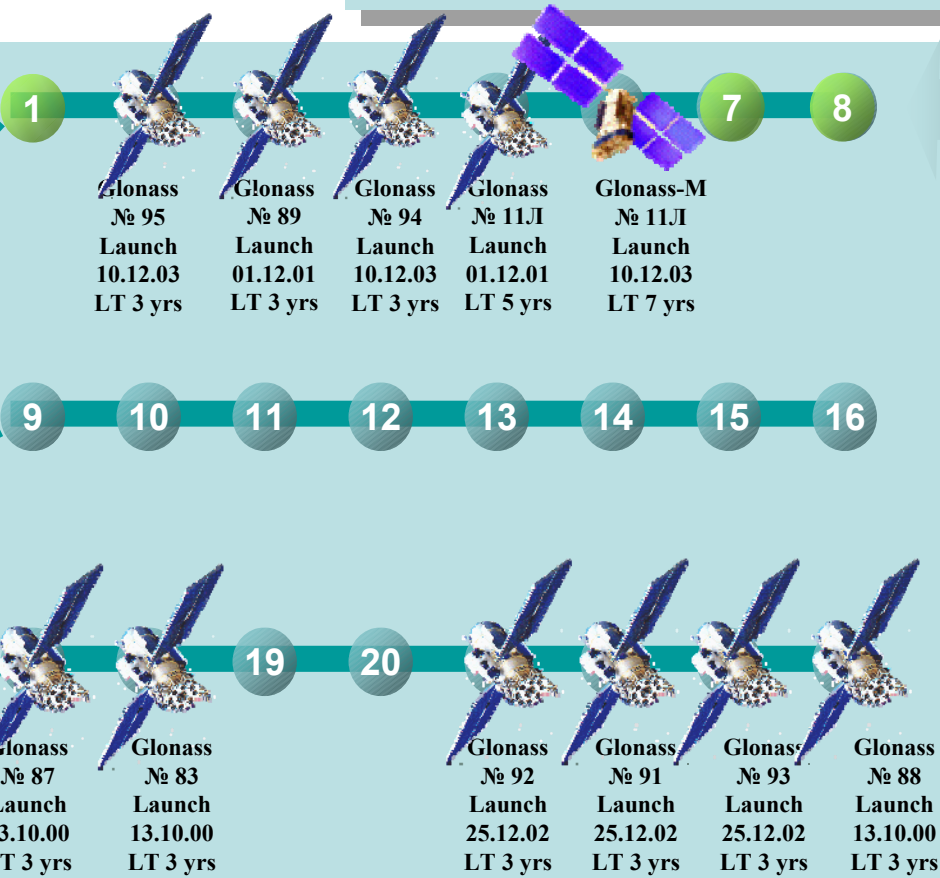
Glonass № 96
Life-time 3 years



Glonass № 97
Life-time 3 years



Glonass-M № 11J
Life-time 7 years





GLONASS Modernization



GLONASS 1982-2007



Developer NPO PM
Producer PO "Polyot"
Total launched 79 SV
Ordered 3 SV
In orbit 10 SV
Life-time 3 years

GLONASS-M 2003-2015



Developer NPO PM
Producer NPO PM
Ordered 9 SV
In orbit 1 SV
To be ordered 6
Life-time 7 years
2nd civil signal

GLONASS-K 2008-2025



Developer NPO PM
D&D phase
To be ordered up to 27 SV
Life-time 10 years
3rd civil signal

GLONASS-KM 2015-.....



Requirement definition
since 2002 r.

Ground control segment modernization
Navigation (OD\$TS) system modernization
GLONASS augmentation system implementation
System certification for safety of life applications

Navigation service market development

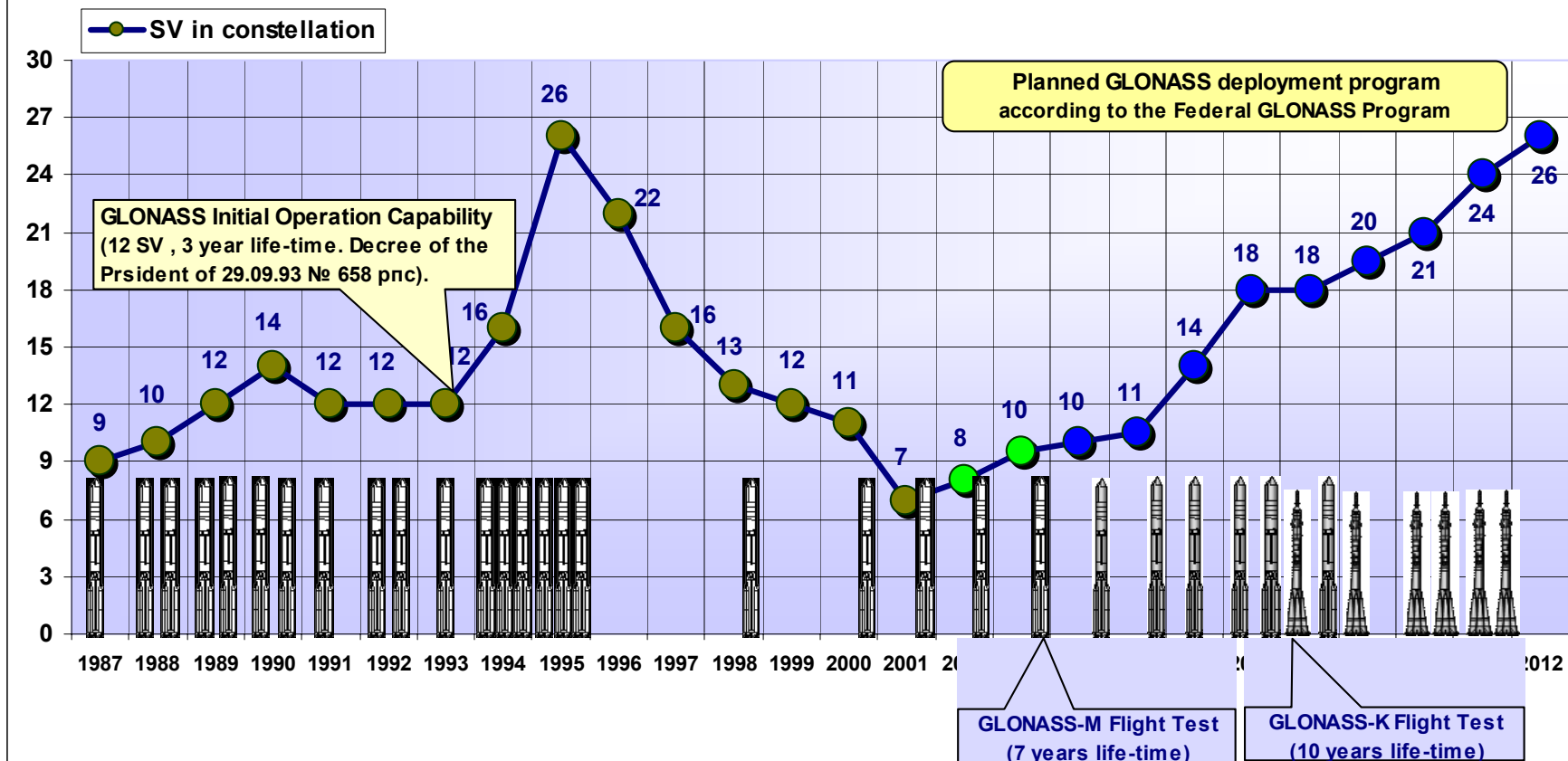
Search and Rescue service implementation
Supplementary functions (TBD)



GLONASS Launch Program



GLONASS Deployment Program. History and Progress.





GLONASS Performance

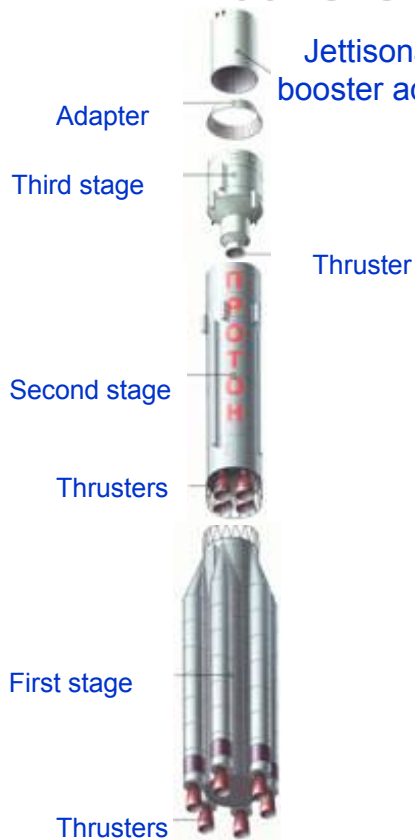


	GLONASS	GLONASS-M	GLONASS-K
First Flight Test Launch	1982	2003	2008
Life-Time	3 years	7 years	10—12 years
Mass	1400 kg	1400 kg	800 kg
SV Number in a group launch:			
- PROTON	3	3	6
- SOYUZ	-	-	2
Power	1000 W	1000 W	1000 W (TBC)
User positioning accuracy (vertical, real-time), 95%	60 m	30 m	5-8 m (<1 m with global differential data)
Number of Civil Signals	1	2 (since G-M#1)	3
Number of Control Access Signals	2	2	3
Additional functions	-	-	Integrity signal (TBC) Differential corrections (TBC) SAR (TBC)

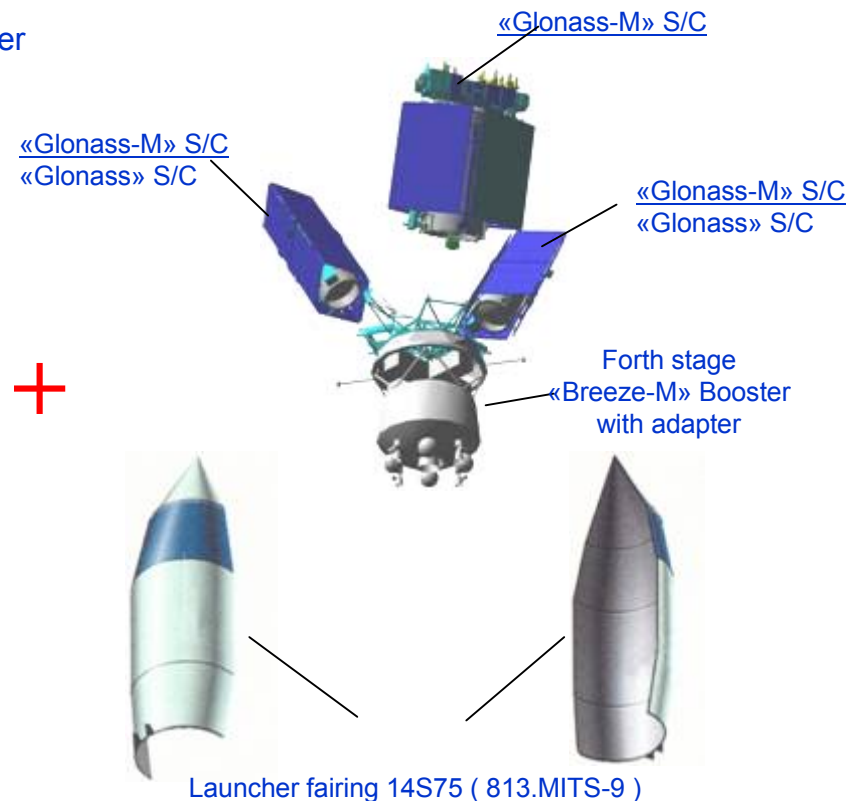
Group Launch of «Glonass»/«Glonass-M» satellites



«PROTON»/«PROTON-M» Launcher

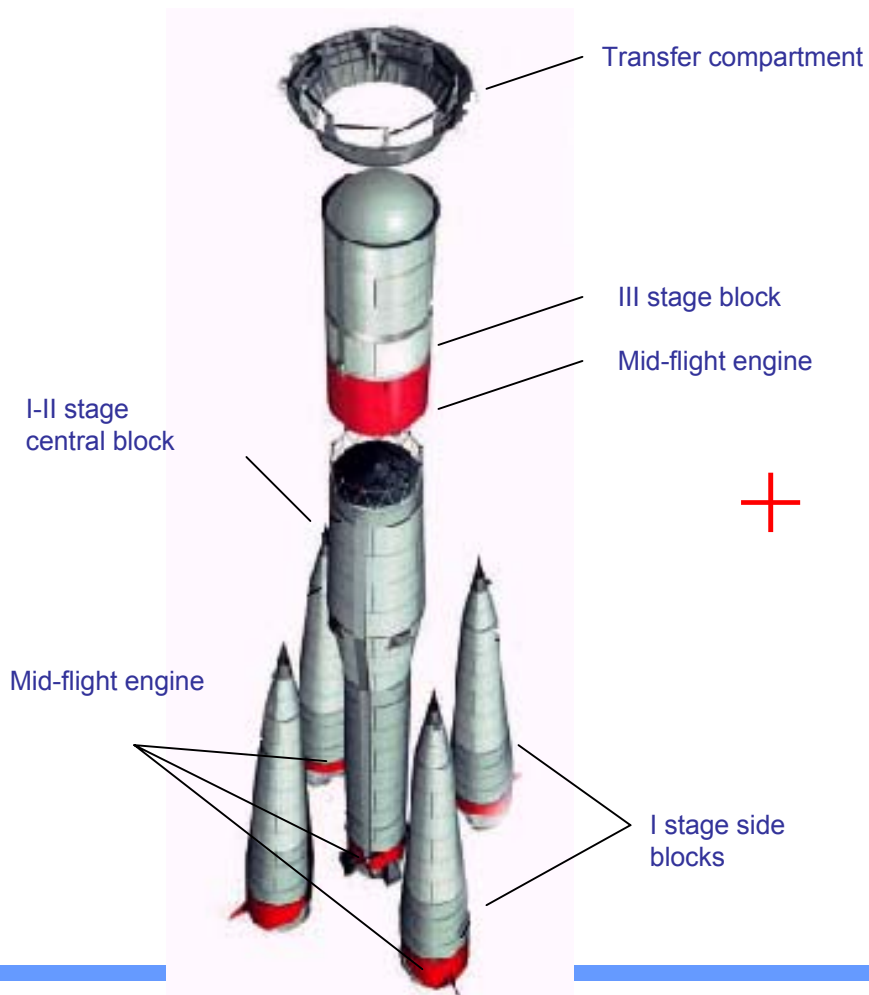


«Breeze-M» Booster

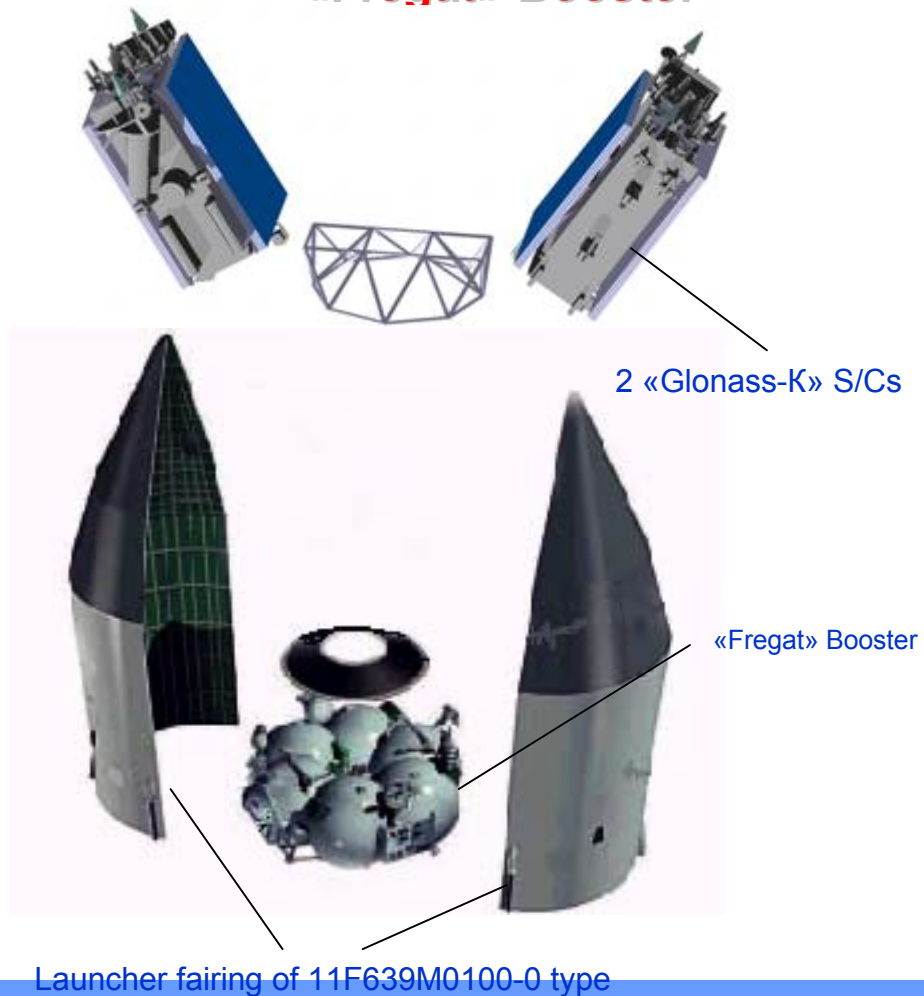


Group Launch of «Glonass-K» satellites

«Soyuz-2» Launcher



«Fregat» Booster





GLONASS Frequency Plan



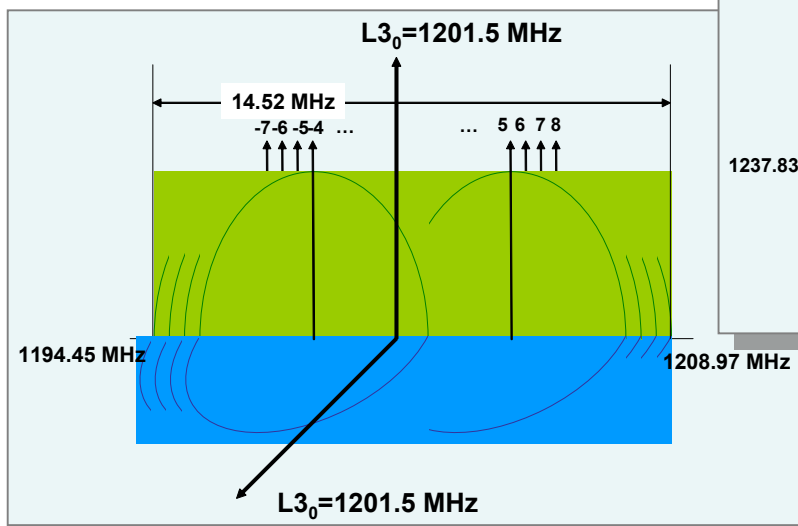
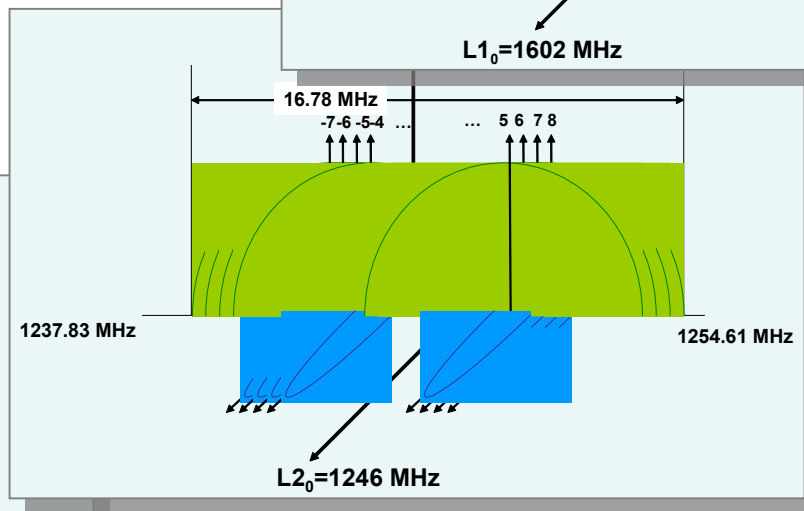
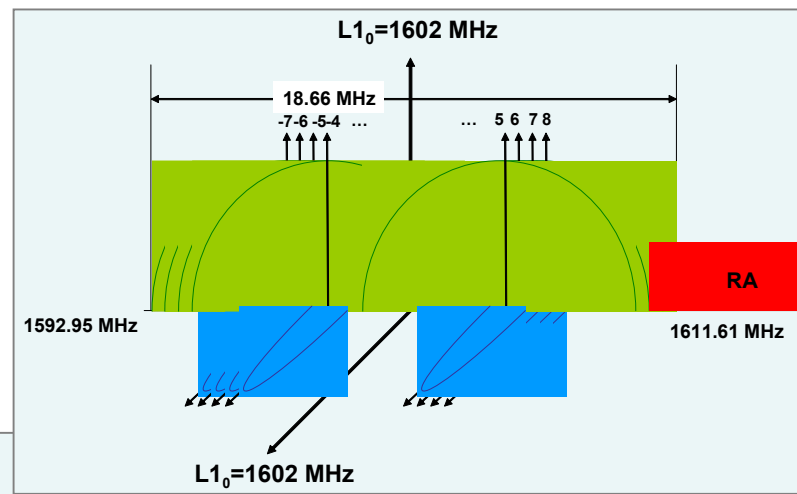
$$f_{k1} = f_{01} + k \cdot \Delta f_1$$

$$f_{k2} = f_{02} + k \cdot \Delta f_2$$

$$f_{k3} = f_{k1} \cdot 3/4$$

$$f_{01} = 1602 \text{ MHz}; \Delta f_1 = 562,5 \text{ kHz}$$

$$f_{02} = 1246 \text{ MHz}; \Delta f_2 = 437,5 \text{ kHz}$$





Russian GNSS Augmentation (1/2)



↪ Architecture

- Global (all Russia) segment (SBAS+)
- Regional subsystems

↪ Objective

- GNSS integrity monitoring, orbit and time correction determination, data broadcasting to users

↪ Basic specification

- Service area – the Russian Federation
- Accuracy of positioning in real time for mobile users applying the global corrections to GNSS SVs orbit and time is below 1 m
- Accuracy of positioning at the regional subsystem coverage is below 5 cm in real time

↪ Data delivery options

- L3 civil signal since GLONASS-K
- Navigation transponder in GEO satellite of EXPRESS-AM type
- SISNET technique, TV, FM, GSM...



Russian GNSS Augmentation (2/2)

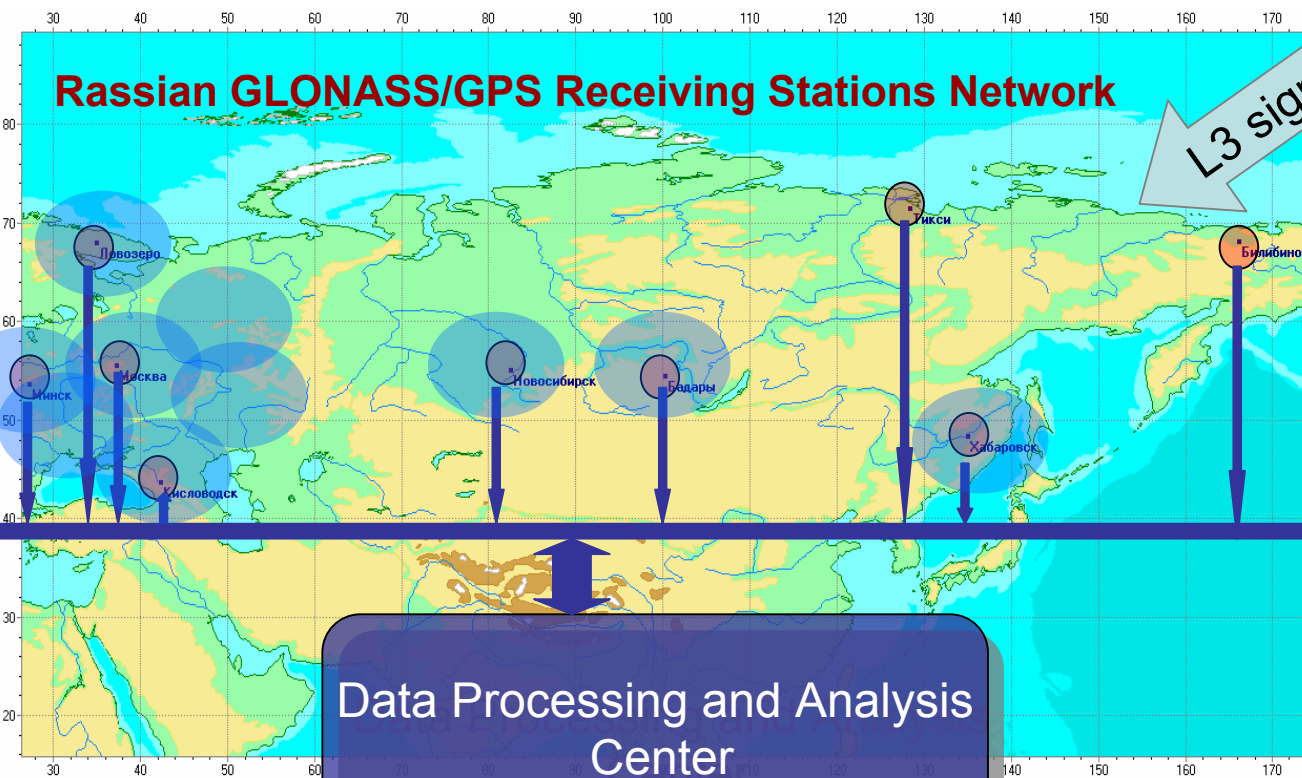


Operation: 2008-2010

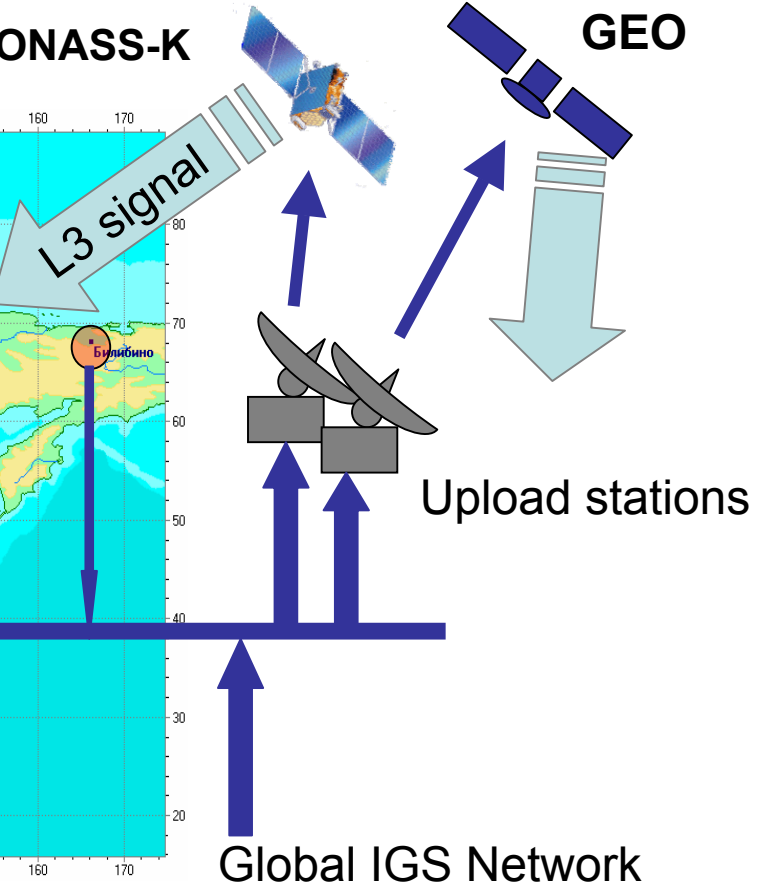
GLONASS-K

GEO

Russian GLONASS/GPS Receiving Stations Network



Data Processing and Analysis Center



- Integrity information
- Global Orbit and Time Corrections

Positioning in real time:
Global <1 m
Regional <5 cm



New GLONASS Services for Civil Users



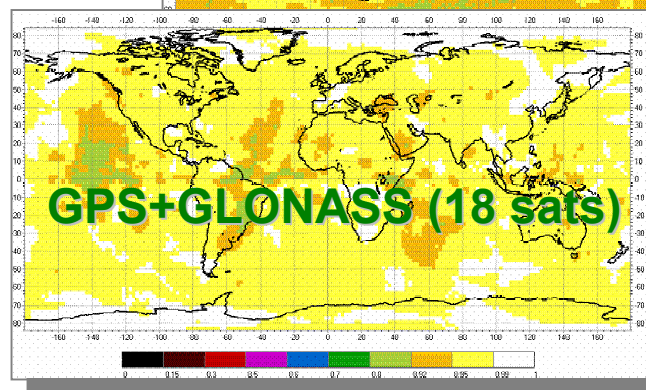
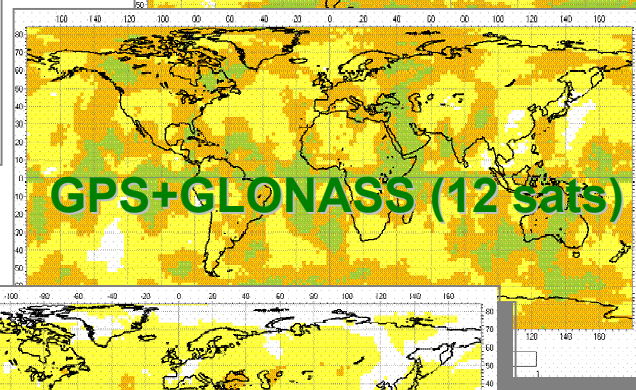
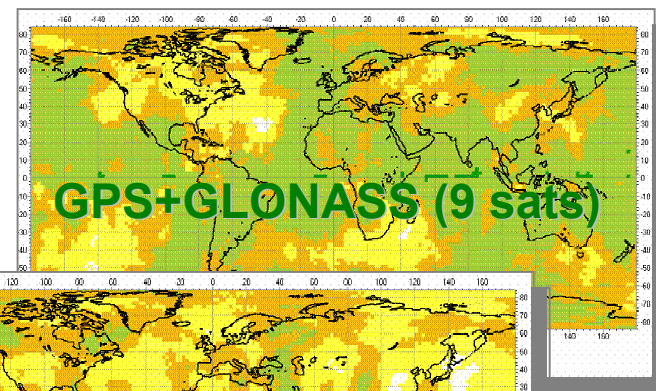
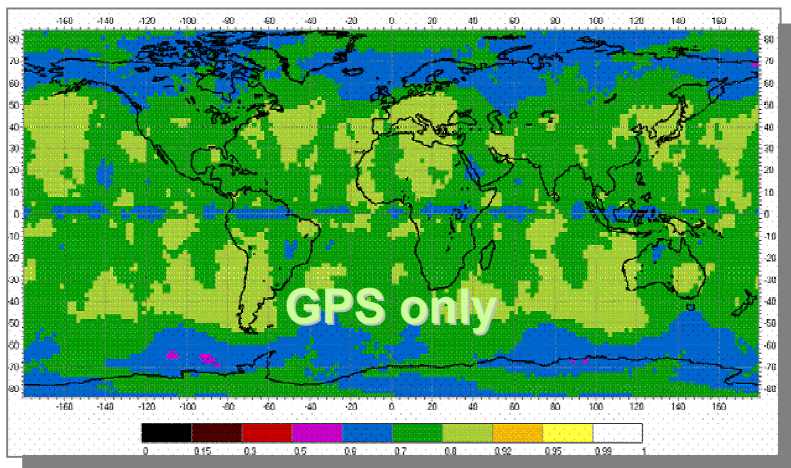
- ↪ Second civil signal at L2 frequency band **since GLONASS-M in 2003** for higher accuracy
- ↪ Third civil signal at L3(L5) frequency band since GLONASS-K in 2008 for higher reliability and accuracy, especially for safety-of-life applications
- ↪ GNSS Integrity information in the third civil signal (GLONASS-K) – **reliability of navigation service**
- ↪ Global differential ephemeris and time corrections in the third civil signal (GLONASS-K) – **sub meter real time accuracy for mobile users**
- ↪ Search and Rescue service (extension of COSPAS/SARSAT service) – **shortening time of precise positioning and rescue for people in distress**



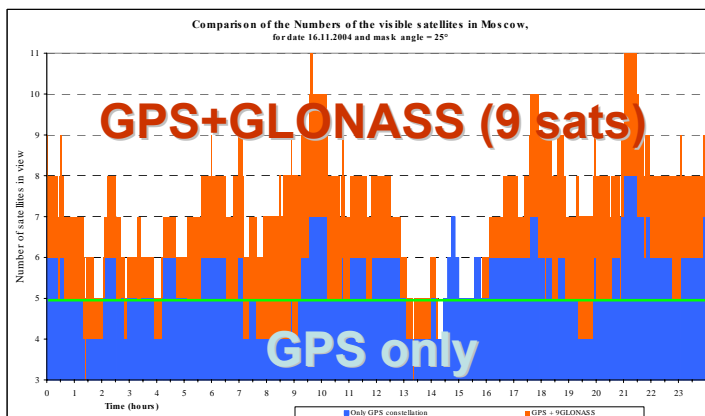
GPS/GLONASS Combine Use



Advantage of Positioning Availability for Urban and Canyon Conditions
(GDOP<5, mask angle 25°)



Number of satellites in view for
Moscow region





Activity in ITU



L3 GLONASS signals

- Application for preliminary publication submitted one year ago
- Application for L3 GLONASS registration has been prepared to be submitted to ITU this year

L2 GLONASS Civil Signal

- Application for L2 GLONASS Civil signal submitted



Activity in ICAO



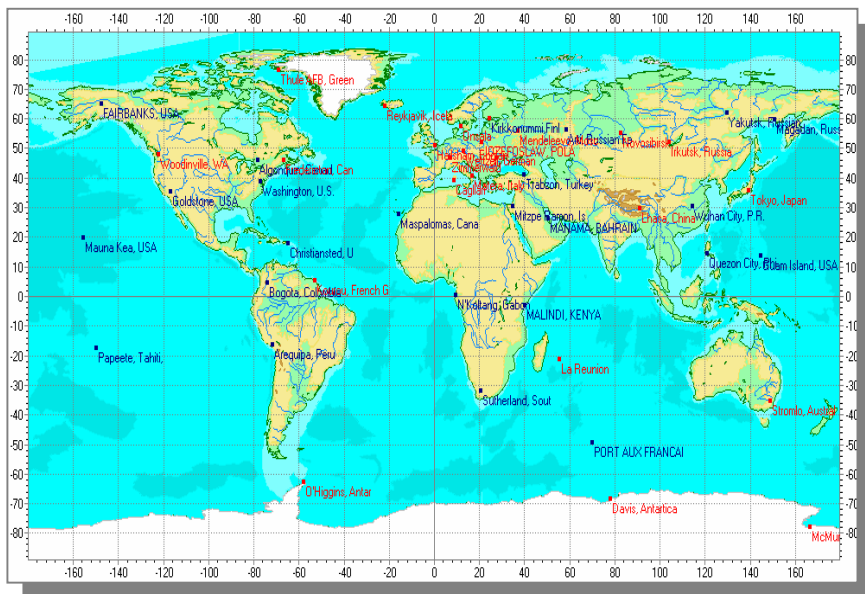
- ↪ **SVs “Glonass” and “Glonass-M” introduced into the SARPs draft**
- ↪ **SV “Glonass-K” to be presented in the SARPs**
- ↪ **SARPs to be approved**



Cooperation with IGS

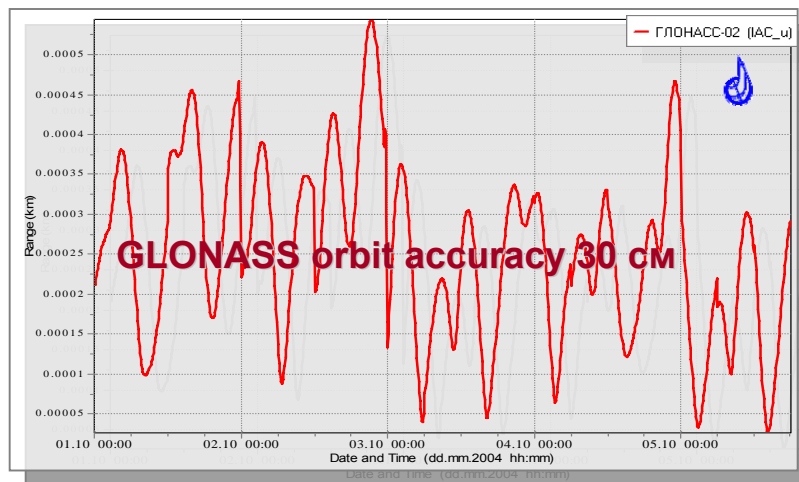
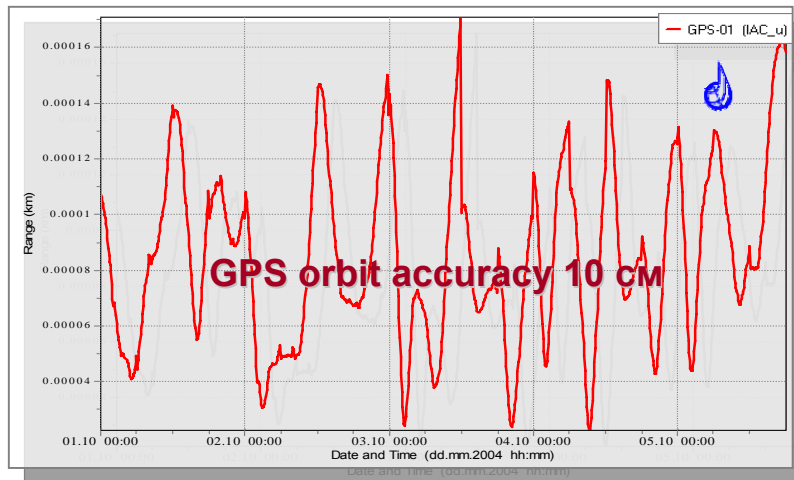


GPS/GLONASS IGS Network



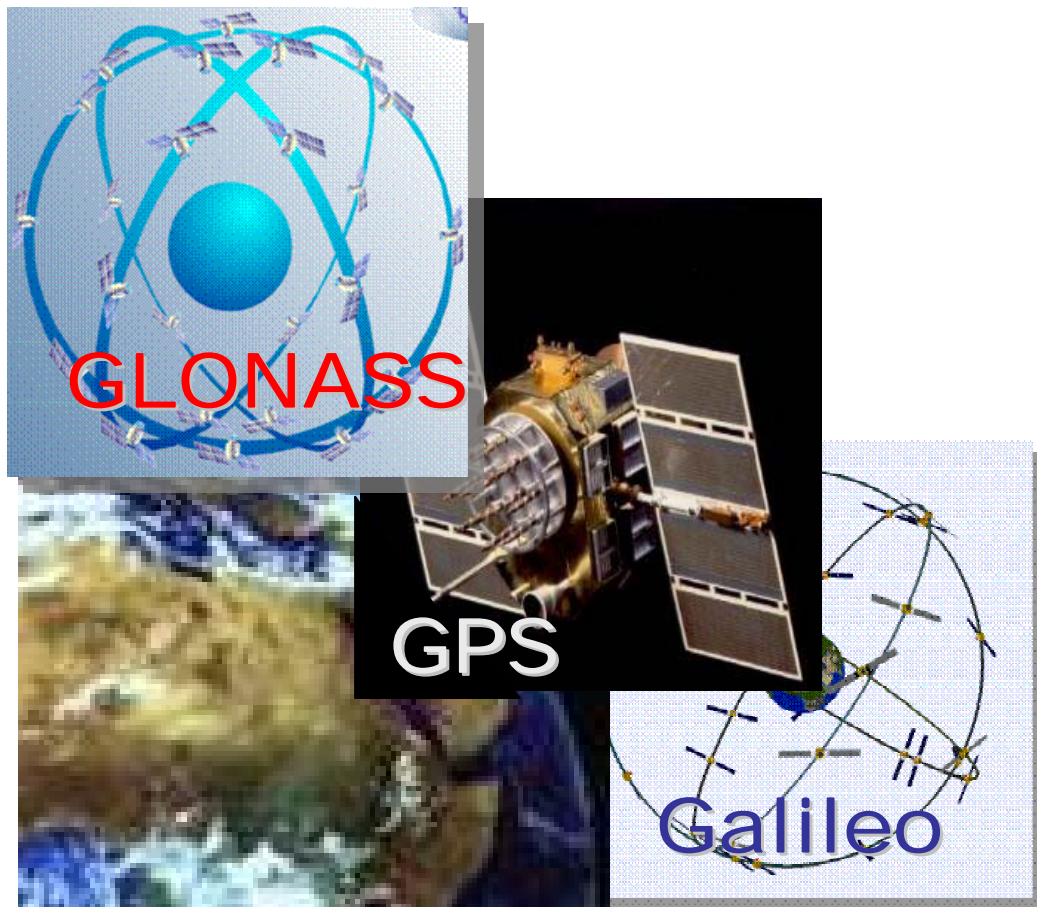
Accuracy of orbit prediction for 24 hours is < 80 cm

Comparison of MCC and CODE final orbits





Objectives of International Cooperation



- ❑ Developing GLONASS, GPS and GALILEO to provide better compatibility and interoperability
- ❑ Benefit users by reliable, accurate and with high availability the navigation service
- ❑ Beneficial use of SatNav service world market



Cooperation with the US



Joint Statement of the US and the Russian Federation signed at 10.12.2004

- ↪ **United States and the Russian Federation intend to continue to provide the GPS and GLONASS civil signals appropriate for commercial, scientific and safety of life use on a continuous, worldwide basis, free of direct user fees**
- ↪ **The United States and the Russian Federation intend to cooperate, as appropriate, on matters of mutual interest related to civil satellite-based navigation and timing signals and systems, value-added services, and global navigation and timing goods in relevant international organizations and fora**
- ↪ **In particular, both sides intend to work together to the maximum extent practicable to maintain radio frequency compatibility in spectrum use between each other's satellite-based navigation and timing signals**
- ↪ **Both sides will work together to the maximum extent practicable to maintain compatibility and promote interoperability of GPS and GLONASS for civil user benefits worldwide**



↪ **GPS/GLONASS Time scale shift**

↪ **WGS-84-GPS and PZ-90-GLONASS
transformation parameters
definition**



Cooperation with the EU



Agreement between EU and Russia is close to be completed

- ↔ **Signal compatibility**
- ↔ **System interoperability in sense of geodesy and time reference**
- ↔ **Common standards**
- ↔ **Industry cooperation**

- **GSTB-V2A and GSTB-V2B satellites will be launched by SOYUZ Russian launchers**

- **GSTB-V2A and GSTB-V2B are equipped by the laser reflectors manufactured in Russian Research Institute of Precise Device Engineering**



Cooperation with India



- ↪ **Agreement on the Cooperation in Space Activity for Peaceful Use has been signed in December 2004**
- ↪ **The section of the Agreement has been dedicated for GLONASS cooperation**
 - Both sides agreed to cooperate in order to restore jointly the GLONASS constellation (in 2007 18 satellites) and develop further based on GLONASS-M and GLONASS-K satellites assuming both Russian and Indian launch service
 - The respective ground infrastructure has to be established to provide the joint satellite navigation activity



Summary



- ❑ **GLONASS modernization will benefit to the civil users:**
 - More robust navigation against interference, compensation for ionosphere delays due to new signals
 - Higher accuracy, availability, integrity, reliability
- ❑ **In combination with GPS the GLONASS use is improving the navigation service quality**
- ❑ **GLONASS is opened for international cooperation to provide system compatibility, interoperability, to make systems really complementary giving the users better reliability of navigation service.**



Thank you!

