On the development of the Geodetic Reference Frame in Russia

Tatevian S.K., Kuzin S.P.

Institute of astronomy RAS, Moscow, R.F.

Demianov G.V.

Central Research Institute of Geodesy and Cartography, Moscow, RF.

Satellites methods of positioning in modern geodesy and navigation.

SPACE RESEARCH CENTER, PAS

2012-09-13-15. WARSAW, Poland.

- The importance of Space Geodetic measurements to global change monitoring, studies of the climate related geodetic contributions to the Earth's parameters variations and to geo-hazards researches cannot be overstated.

- To meet the stringent requirements of the future ITRF: <1mm at epoch position
- <0.1mm/y in secular change
- The IAG project Global Geodetic Observation System (GGOS) aimed to develop well-distributed, co-located network with accurate ties among the different instruments.

- **With the purpose of improving the National geodetic reference frame in Russia and with the intention to integrate this frame with the ITRF a development of the precise fundamental geodetic network, based on the combined use of GNSS, SLR, VLBI and gravity measurements, is now carried out.**
- **This network will fix the national geocentric reference system all over the country with mean square errors at the level of 2-3 cm for absolute coordinates and for relative positioning within errors of 1 cm and less.**

The National Geodetic Reference Frame.

- At present this new regional reference network consists of 33 permanent (50 in future) fundamental stations and about 300 geodetic points of the first class.

All core sites are equipped with dual GPS/GLONASS receivers, and several fundamental stations are collocated with the existing on the Russian territory sites of the international IGS network, satellite Laser ranging stations and VLBI observatories (QUASAR" network) All collocated sites will provide connection of the regional reference frame to the global ITRF.

Vertical datum

- For monitoring of the vertical components of the reference system the normal heights, determined by precise leveling and gravimetric data at the core sites, are used. According to the M. Molodensky theory the values of geodetic heights above the general Earth ellipsoid, estimated by GNSS measurements, should be strictly coincided with the sum of the normal height and quasi-geoid height. These data provide an independent control of the geocentric reference system.

- The ellipsoid, determined by altimetric measurements, with the semimajor axis, equal to 6 378 136.5±2-3 m, is adopted as a reading one for the reference system.
- The quasi geoid heights are estimated with the use of the global gravity field model. The last version of the global model has been developed at the Central research institute of geodesy and cartography (Moscow) in 2008. Now the new version, estimated with use of GOCE data, is in preparation.

RUSSIAN GNSS (GPS/GLONASS) NETWORK

Geodetic VLBI-Network «Quasar», collocation with other techniques.

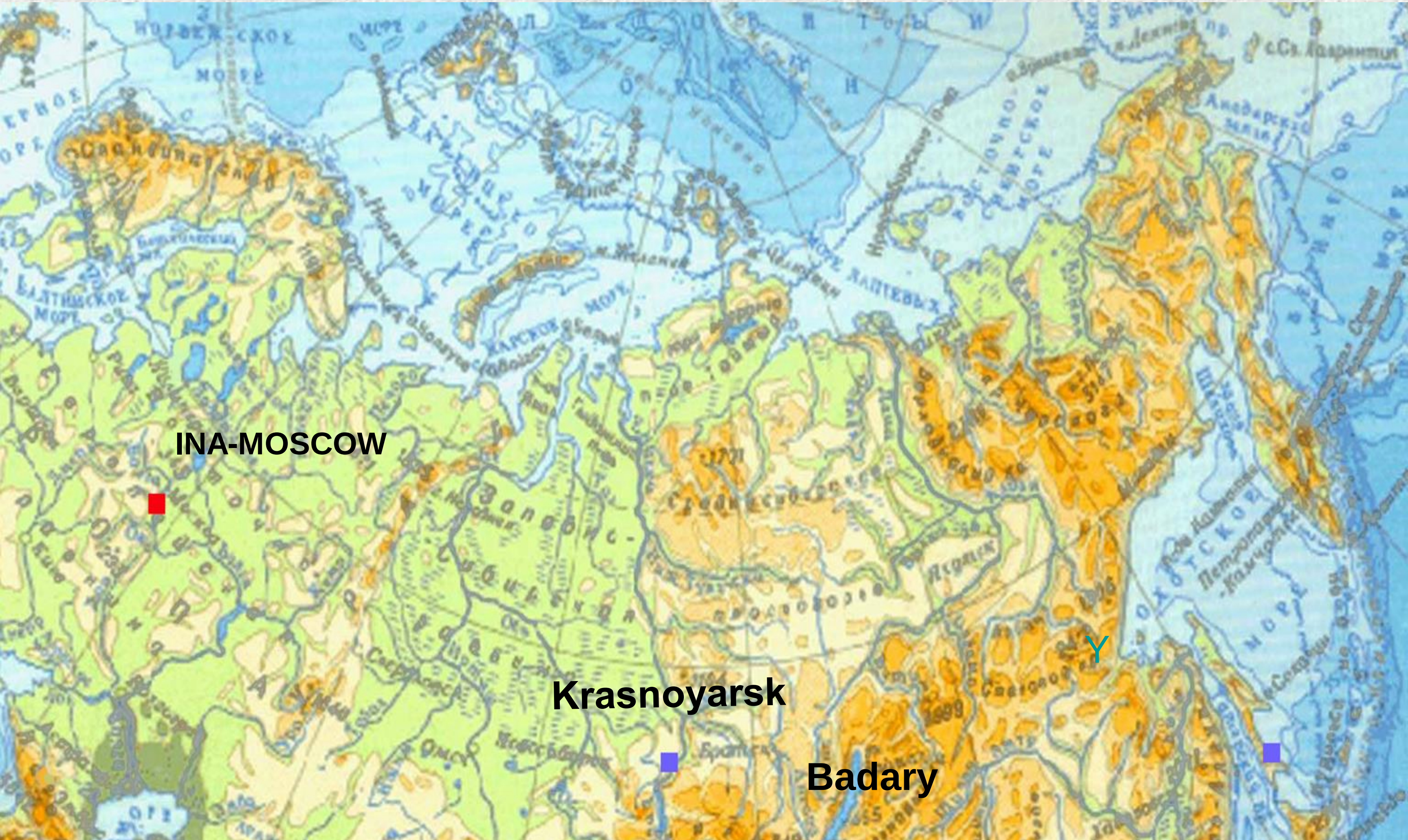
Russian VLBI NETWORK-QUASAR

QUASAR-VLBI network consists of three newly constructed 32 m radio telescopes located in Svetloe, Zelenchukskaya, and Badary.

The main problems dedicated to the QUASAR network:

- **Establishing and maintenance of the International Celestial Reference Frame (ICRF) and its realization in the form of a catalogue of extragalactic radio sources.**
- **Establishing and maintenance of the International Terrestrial Reference Frame (ITRF) and its realization in the form of a catalogue of coordinates and velocities of reference stations.**
- **Determination and monitoring of the parameters of mutual orientation of ICRF and ITRF – Earth Orientation Parameters. Constructing a national scale of Coordinated time UTC(SU).**

2 Doris beacons in Russia, and DORIS analyses center at the Institute of Astronomy, RAS



Doris Beacon at the ”Quasar” Geodetic VLBI Observatory “Badary

Frequency – 2036,25, Power in Pulse – 40 W
Frequency – 401,25, Power in Pulse – 20 W
Azimuth angle – 0-360°, Elevation angle – 0-70

Russian SLR-Network

- Current
- 2011
- 2012

Satellite Laser Ranging Systems (made by the RSA enterprises), which are installed at three QUASAR observatories and at the several GNSS sites for geodynamic studies.

Satellite heights 400 - 23 000 km
Normal points precision 0,5-1 cm
Angular measurements precision 1-2″

Optical system diameter 25 cm
Laser pulse frequency 300 Hz
Pulse energy 2.5 mJ
Mass 120 kg

GLONASS Constellation Specification

- Satellite in constellation:
  - 24 satellites
- Three orbital planes:
  - 8 satellites in each
- Inclination:
  - 64.8º
- Orbit height:
  - 19 100 km
- Orbit revolution time:
  - 11h 15m

GLONASS data analyses

Now the constellation of the GLONASS consists of 24 satellites at three orbital planes, 8 satellites in each. Inclination of the orbit is 64.80, height 19100 km and revolution time 11h 15min.

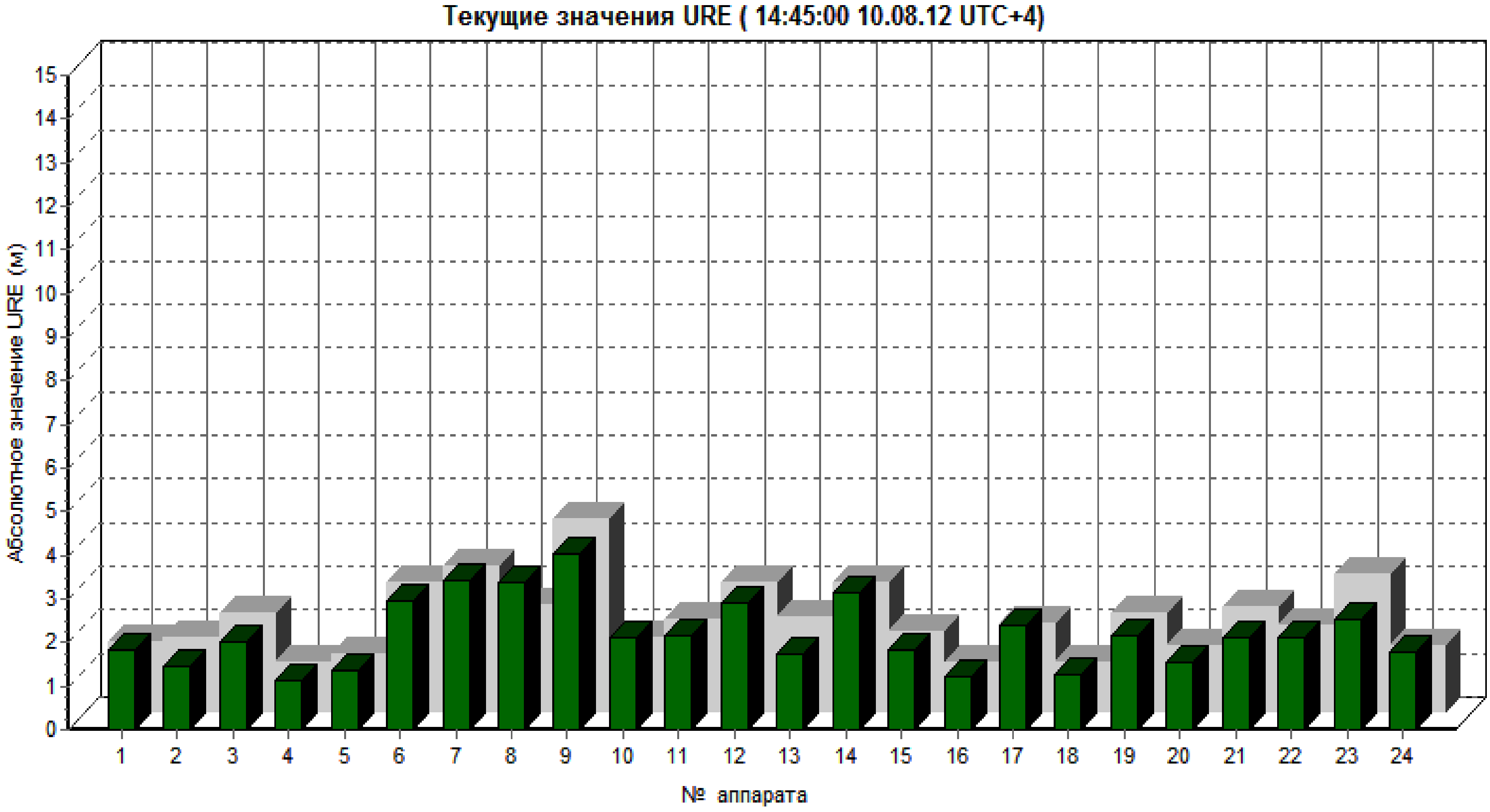
GPS/GLONASS data storage and analyses are performing at the analyses centers of the Institute of Astronomy (with GIPSY/OASIS II software, assignable by the JPL/ NASA) and at the Central Geodetic Research Institute with use of BERNESSE software.

GLONASS constellation status, 10. 08.2012

• **Total satellites in constellation**	**31SC**
Operational	24 SC
• In commissioning phase	-
• In maintenance	2SC
• Spares	4 SC
• In flight tests phase	1 SC

CURRENT URE VALUES in meters

Green- current URE values, **Grey -** average URE values for the last 5 min.



GLONASS/GPS data analysis.

- **38 IGS (GLONASS+GPS)** sites and **15 Russian (GLONASS+GPS)** sites were used for computation:
- **Processing period:** IGS sites – 1year (2011)
- Russian sites 0.5 year (the second half 2011, days 182-365)
- **Hardware used** **-** different receivers at the GLONASS SITES:
- **Software used:** Gipsy-Oasis II software, developed at the JPL.
- Utility gd2p.pl (GPS data to position) from Gipsy-Oasis II used as for GLONASS and GPS data.
- GLONASS – IGS (GFZ AC) precise orbits and clocks
- Strategy was the same for both systems with the exception of :

  -Ambiguity resolution applied only for GPS measurements

  -Satellite antenna phase center variations were used for GPS only

GLO-GPS station coordinates differences

Site	Mean coordinate differences (mm)		
	X-component	Y-component	Z-component
BADG	-7.20 ± 1.39	60.32 ± 2.13	51.82 ± 2.48
METZ	73.91 ± 2.93	27.12 ± 2.39	102.84 ± 4.21
NKLG	132.40 ± 3.72	21.40 ± 2.13	2.37 ± 0.91
NRMD	-94.63 ± 3.56	21.47 ± 2.66	-43.50 ± 1.79
PDEL	92.61 ± 2.75	-43.24 ± 1.90	72.19 ± 2.15
REUN	63.98 ± 2.72	86.25 ± 3.35	-43.74 ± 1.73
REYK	63.35 ± 1.74	-16.36 ± 1.40	95.29 ± 3.02
STHL	125.77 ± 3.53	-10.34 ± 1.60	-55.25 ± 1.33
STR1	-76.75 ± 2.75	51.02 ± 2.11	-70.40 ± 2.07
THTI	-106.30 ± 4.25	-66.22 ± 3.31	-84.38 ± 1.82
THU2	11.70 ± 2.58	1.88 ± 2.70	85.52 ± 4.73
TLSE	103.38 ± 2.53	2.34 ± 1.41	94.20 ± 2.20
WUHN	-21.48 ± 2.60	92.36 ± 4.62	57.35 ± 2.82
YAR3	-38.69 ± 1.99	88.69 ± 2.96	-57.53 ± 1.80

Для обеспечения эффективного развития и применения системы ГЛОНАСС в целях создания высокоэффективной системы геодезического и навигационного обеспечения Российской Федерации необходимо построение национальной высокоточной геоцентрической системы координат. Только в этом случае возможно достижение паритета с системой GPS и обеспечение конкурентно способности системы ГЛОНАСС, в том числе и на международном уровне

TRANSFORMATION PARAMETERS
From PZ90.02 to PZ-90.11 and ITRF

ΔX	ΔY	ΔZ	σ_x	σ_y	σ_z	m
mm			$sec \cdot 10^{-3}$			
PZ90.02 – PZ90.11 (GLONASS)						
-9,7	-8,6	-191,5	0,295	-0,046	18,0	$-1{,}7e^{-11}$
PZ 90.02 – ITRF						
3,3	22,4	-194,1	0,564	0,137	17,3	$-3{,}4e^{-11}$
PZ 90.11 – ITRF						
9,7	8,9	21,2	0,068	0,156	0,212	$7{,}6e^{-11}$

SUMMARY

- **ITRF includes 6 regional reference networks, which are embedded in the Sub Commission SC1.3 of the IAG. There is no corresponding infrastructure of the ITRF in the European part of Russia, Northern and Central Asia. From this point of view a development of the separate block with the precise realization of the Global terrestrial reference frame, covered this vast terrain, is difficult to overvalue.**