National Reference Systems of the RUSSIAN FEDERATION, used in GLONASS. including the user and fundamental segments

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WG D – Reference Frames, Timing and Applications

GLONASS Geodetic Basic

Responsible organization for the GLONASS geodesy:

Ministry of Defense of the Russian Federation

- ✓creating, maintaining and developing the PZ-90 System
- ✓creating and maintaining the GEOIK geodetic systems which are the engineering infrastructure of PZ-90 System
- ✓implementation of the necessary PZ-90 System parameters in Ground Control and GLONASS ballistics
- ✓software: Ministry of Defense

Responsible organization for users of the GLONASS geodesy in the Russian Federation : Rosreestr

- ✓creating, maintaining and developing of the SK-42/SK-95/GRS-2011 Geodetic Reference Systems (GRS)
- ✓providing GLONASS users with GRS parameters and navigation maps
- ✓software: Rosreestr and BERNESE (for GRS-2011)

Three versions of the PZ-90 System

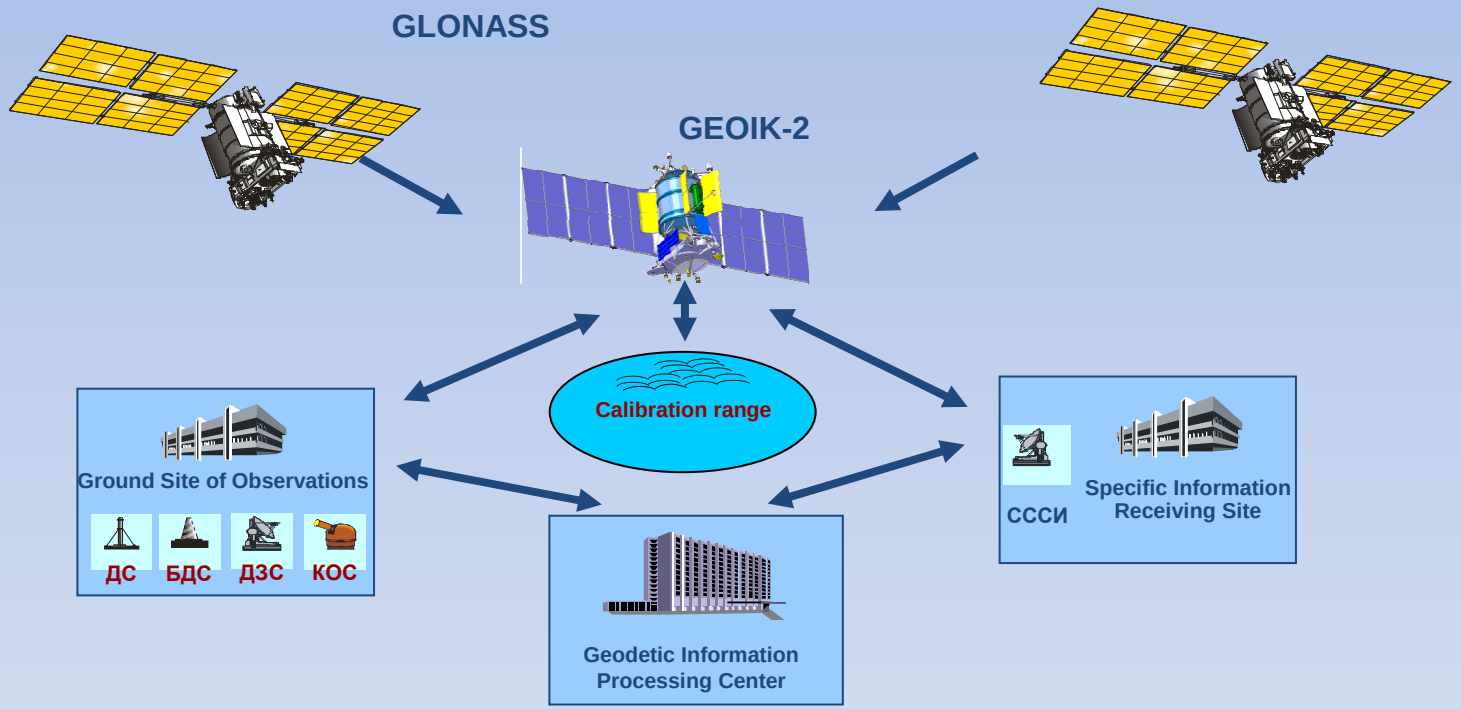
- **PZ-90 - established in 2000**
- **PZ-90.02 - established in 2007**
- **PZ-90.11 - established in 2012**

The basic principles of creating the PZ-90.11

- Satellite dynamic technique
- The generalized least squares
- Common terrestrial reference ellipsoid parameters and Earth's gravity field models remain unchanged
- Consistent with **ITRF** at epoch 2011.0 **at the centimeter level**

Development of GEOIK Space Geodetic Systems

GEOIK-2 (2011 – to the present)
Architecture and Interaction of Elements



GEOIK-2 goals:

- improvement of PZ-90 system and the Earth's gravity field parameters
- determining the ocean plumb line deviation

GEOIK-3 (Perspective)
System Architecture

Ground Control Center


ЦУП СКА

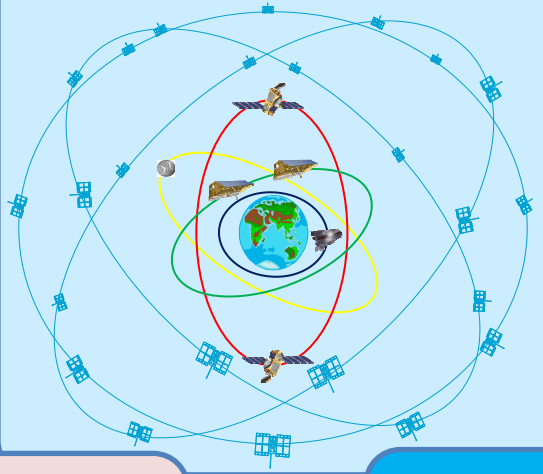

ЦУП НКА1


ЦУП НКА2


TT&C Site


БЦ

Satellite Constellation



Ground Specific Complex


ЦОГИ

ППСИ


НПН


ДС


БДС


КОС


ПК ВРВ


ПК ГГ

Clock System


AFS БСУ СКА

Sat-1 AFS

Sat-2 AFS


АФНВШ


СС МГНС ГЛОНАСС


Synchronization facilities

Rocket – Space Complex

Launch Vehicles

Satellite and Launch Vehicles Technological Complexes

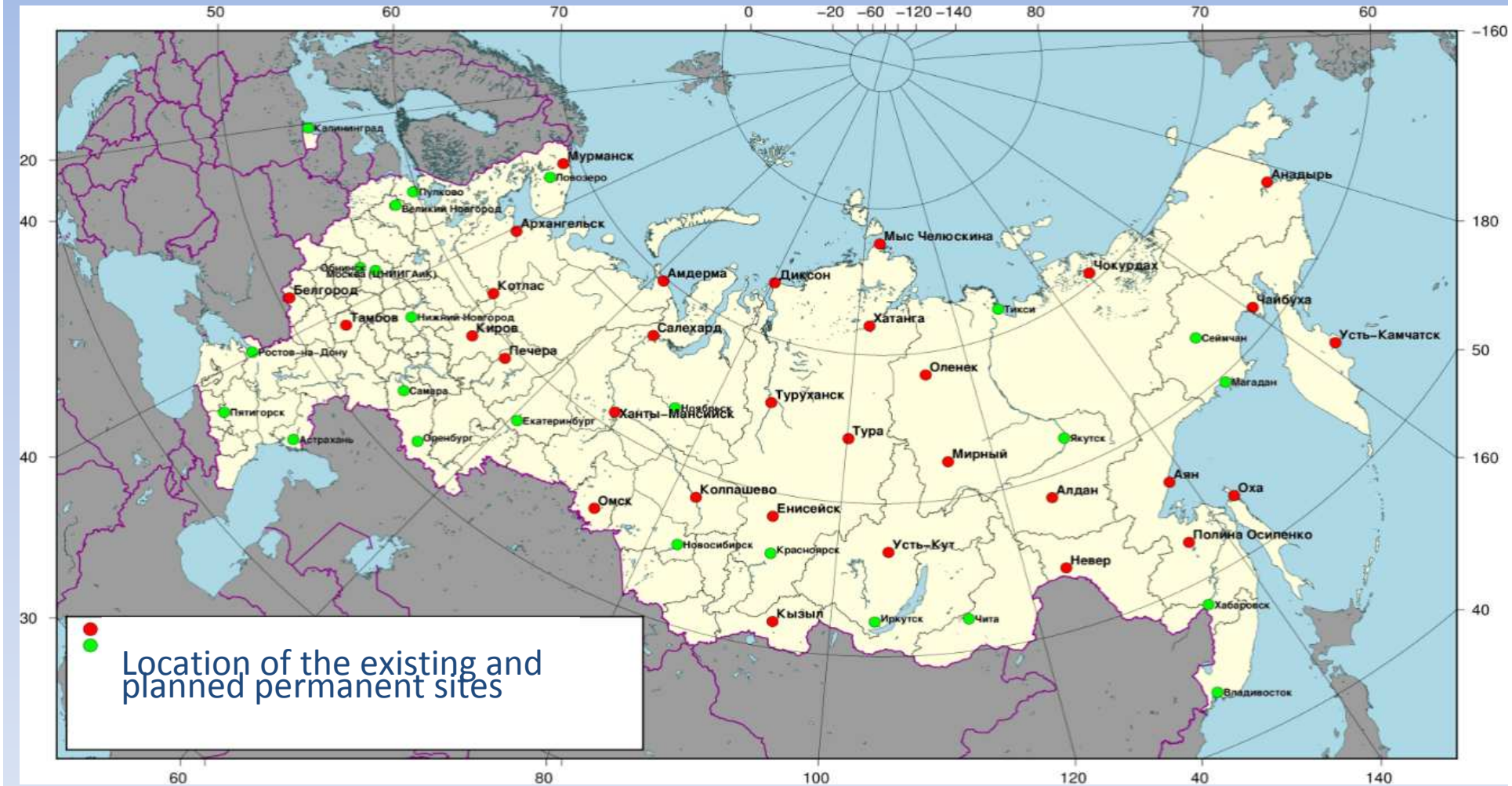
GRS-2011 Reference System

GRS-2011 – new national geodetic reference system (established December, 2012)

- Regional
- Geocentric
- Aligned to ITRF at epoch 2011.0 within few centimeters
- Basic software: BERNESE 5.1
- “Geodetic” - to emphasize its "geodetic" appointment

On basis of GSR-2011 the Russian geodetic infrastructure will be modernized by 2017

GRS-2011 Geodetic Networks



Comparison of PZ-90, GRS-2011 and ITRF

PZ-90.11 and GRS-2011 Fundamental Geodetic Constants

Name	Geocentric gravity constant (including atmosphere)	Angular velocity of Earth rotation
Symbol	*fM*	*ω*
Unit	$km^3/2$	rsd/c
Name	**Value**	
PZ-90.11 (2010.0)	398600,4418	$7{,}292115 \cdot 10^{-5}$
GRS-2011(2011.0)	398600,4415	$7{,}292115 \cdot 10^{-5}$

PZ-90.11, GRS-2011 and ITRS Reference Ellipsoid Parameters

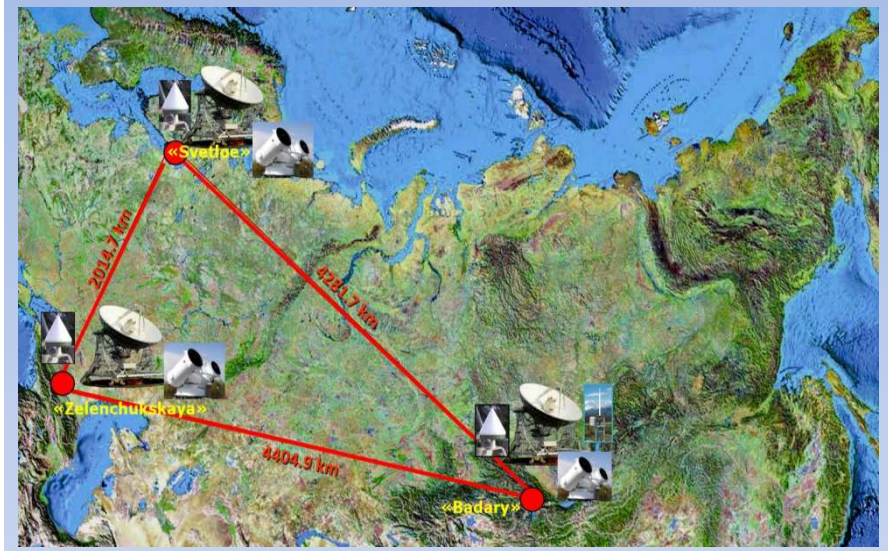
Name	Semi-major axis	Flattening factor
Symbol	a	α (alpha)
Unit	m	-
Name	**Value**	
PZ-90.11	6378136	1/298,25784
GRS-2011	6378136,5	1/298,2564151
ITRS (GRS 80)	6 378 137	1/298,257222101

PZ-90.11 Transformation Parameters

№ п/п	From	ΔX, m	ΔY, m	ΔZ, m	Rx, mas	Ry, mas	Rz, mas	m, 10^{-6}
1	PZ-90	–1,443	+0,156	+0,222	–2,30	+3,54	–134,21	–0,228
2	PZ-90.02	–0,373	+0,186	+0,202	–2,30	+3,54	–4,21	–0,008
3	GRS-2011	–0,000	+0,014	-0,008	–0,562	+0,019	+0,053	–0,0006
4	WGS 84 (G1150)	–0,013	+0,106	+0,022	–2,30	+3,54	–4,21	–0,008
5	ITRF2008	+0,003	+0,001	-0,000	-0,019	+0,042	-0,002	+0,000

Fundamental Base for unified of the Russian PNT

Quasar VLBI Network (IAA RAS)



Status of co-location sites in different networks

Technique	Network	Svetloe	Zelenchukskaya	Badary
VLBI	IVS, EVN station (year)	Sv, 7380 (2003)	Zc, 7381 (2005)	Bd, 7382 (2006)
GNSS	IGS, EPN station (year)	SVTL (2004)	ZECK (1997)	BADG (2011)
SLR	ILRS station (year)	1888 (2012)	1889 (2012)	1890 (2012)
DORIS	IDS station (year)			BADB (1992)

All sites are the core station of the GGOS Network (2012)

Consistency of VLBI-, GPS- and SLR-derived coordinates in ITRF with data obtained in co-location sites of local networks

Co-location site	[RT-32 - GNSS] (Epoch 2005.0)			[SLR-32 - GNSS] (Epoch 2005.0)		
	ΔN, mm	ΔE, mm	ΔH, mm	ΔN, mm	ΔE, mm	ΔH, mm
Svetloe	0	5	4	-3	-5	-17
Zelenchukskaya	-2	-12	-4	-3	11	-17
Badary	2	-15	16	19	19	13

IAA RAS resources for GLONASS fundamental maintenance:

Currently:

- Everyday determinations of UT1 for GLONASS from 1h sessions in e-VLBI mode (with 6 h delay since 2012)

In future

- Global solutions for VLBI observations adjustment with simultaneous ICRF, ITRF and EOP corrections
- Fundamental ephemeris Solar system bodies (EPM)
- Software for VLBI, GNSS and SLR data processing and for combination of SINEX-files

Future Plans

1. In accordance with the Government Decree:
   - PZ-90.11 will be used in GLONASS since January 1, 2014
   - Step-by-step transition of the surveying and mapping from SK-42 / SK-95 systems to GRS-2011 will be implemented before 2017
   - Data on equipment and location of some sites of PZ-90.11 and GRS-2011 networks will be available for users
2. Fundamental base resources will be used for further improvements of PZ-90.11 and GRS-2011 systems
3. Expansion of the PZ-90.11 geodetic network is considered by deploying Roscosmos GLONASS stations in Antarctica and other territories
4. PZ-90.11 and GRS-2011 releases are planned every 3-5 years

Thank you for attention!