



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

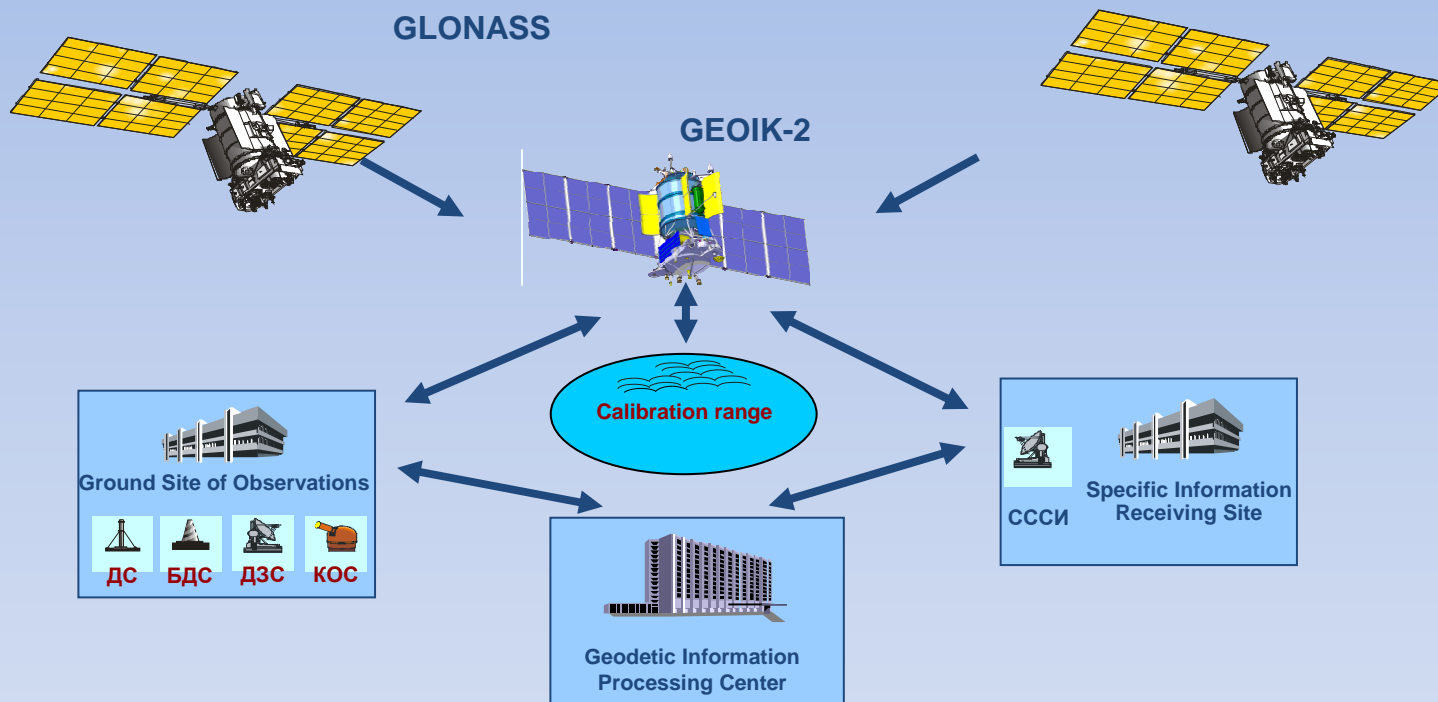
The basic principles of creating the PZ-90.11

- 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

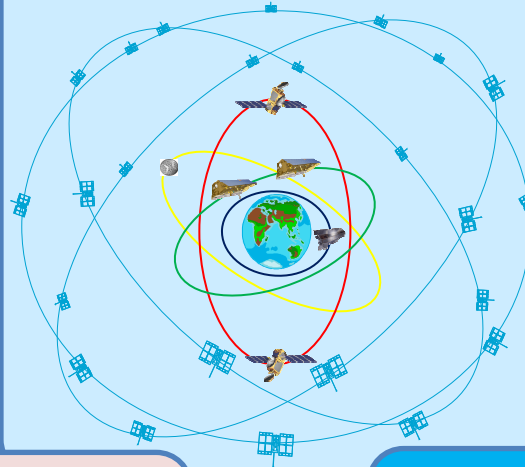


TT&C Site



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/s^2 | rad/s |
| 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

| N_{Π}/Π | From | $\Delta X, \text{m}$ | $\Delta Y, \text{m}$ | $\Delta Z, \text{m}$ | R_x, mas | R_y, mas | R_z, mas | $\text{m}, 10^{-6}$ |
|---------------|----------------|----------------------|----------------------|----------------------|-------------------|-------------------|-------------------|---------------------|
| 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 |

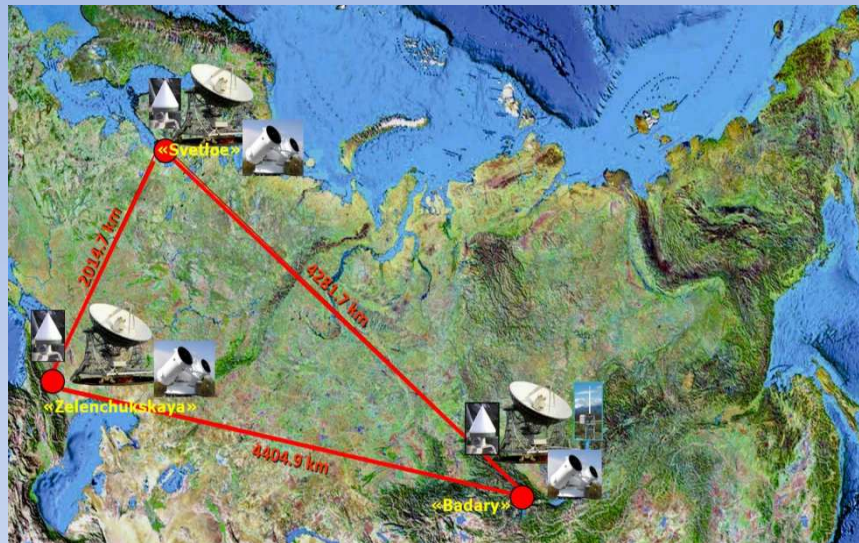


Fundamental Base for unified of the Russian PNT



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!