Joint-stock company
«RESEARCH-AND-PRODUCTION CORPORATION
«PRECISION SYSTEMS AND INSTRUMENTS»

Results of the PZ-90.11 reference frame implementation to GLONASS

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PZ-90.11 introduction topicality

Geodetic parameters	PZ-90	PZ-90.02	ITRF
Geopotential	5.0	0.05-0.10	0.05-0.10
Tie to the Earth's center of mass	1.2-1.5	0.4-0.5	0.05-0.10
Relative turn	5.0	0	0
Absolute tie of coordinates	2.0-3.0	0.3-0.5	0.2-0.4
Relative tie of coordinates	0.5	0.02-0.03	0.02-0.03

By the Russian Government Executive Order №797-r of June 20th 2007, the PZ-90.02 system of the Earth's geodetic parameters was introduced and it was enacted to keep on working on further improvement of the State geocentric reference frame called «The Earth's Parameters of 1990»

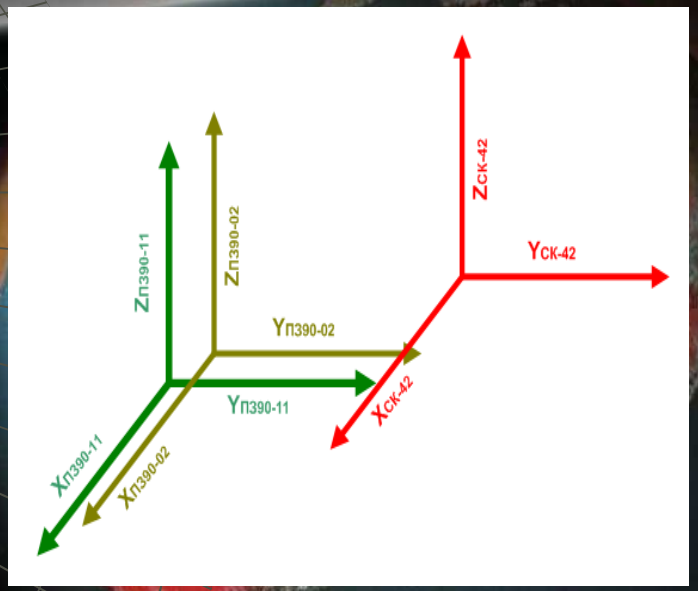
Governing documents

By the Russian Government Order №1463 of 28.12.2012, the new highly accurate edition PZ-90.11 (error of tie to the Earth's center of mass does not exceed 5 cm) was introduced, thus replacing PZ-90.02 (error of tie to the Earth's center of mass is at the level of 40-50 cm). Regarding the GLONASS system operation, the Russian Ministry of Defense and Federal Space Agency were ordered to upgrade to PZ-90.11 until January 1st 2014.

Decision on the procedure of initial geodetic data introduction to GLONASS

Accuracy of the used initial geodetic data:

- **PZ-90.02 of SC-42 ---- ± 3 m**
- **PZ-90.02 ---- 0.5 m**
- **PZ-90.11 ---- 0.005 m**



Broadcast ephemeris prediction comparison between PZ-90.02 and PZ-90.11

Estimation interval: from 17.09.11 to 18.10.11

NSC	$Re^{0.95}$ PZ-90.02	$Re^{0.95}$ PZ-90.11	Relative difference, %	OSD instability, $\cdot 10^{-13}$
712*	3,10	2,99	3,5	>2
719*	1,16	1,00	13,8	>1
724*	1,43	1,26	11,9	>1
716*	1,74	1,69	3	>1
715*	1,33	1,20	10	>1
735	0.71	0.62	15	<0,5
725	0,72	0,47	34,7	<0,5
728	0,63	0,52	17,5	<0,4
729	1,00	0,72	28,0	<0,6
730	0,74	0,48	35,1	<0,4
731	0,70	0,51	27,1	<0,4
732	1,10	0,73	33,6	<0,9
733	0,99	0,82	17,2	<0,6
734	0,72	0,48	33,3	<0,5
Mean			27	
721**	1,11	1,07	4	<0,7
717**	1,58	1,42	11	<0,6
723**	1,03	0,86	16,5	<0,4
736**	0,74	0,64	13,5	<0,6
737**	0,65	0,66	0	<0,5
738**	0,79	0,58	26,6	<0,5
Overall			17,9	

* - NSC OSD instability does not meet the AC requirements

**- NSC on-board dynamic operations on the measurement processing interval.

Results of the PZ-90.11 introduction to GLONASS

The Russian Government Order №1463 has been fully implemented

Since January 1st 2014, PZ-90.11 has been successfully introduced to the GLONASS system

1. **Initial geodetic data on all the stations of the GLONASS system in PZ-90.11 have been calculated**
2. **Ephemeris for the GLONASS system has been experimentally exercised using PZ-90.11**
3. **Parameters for upgrading from PZ-90.02 to PZ-90.11 have been calculated**
4. **GLONASS ephemeris and frequency-time support loops have been switched to use PZ-90.11**

By the PZ-90.11 introduction to the GLONASS system, the ephemeris support accuracy has been increased by nearly 30%

Problems experienced by the PZ-90.11 users

Errors of conversion of geocentric coordinates taken from SC-42 (Russian national reference frame) in PZ-90.11 in accordance with the document called «The Earth's Parameters of 1990 (PZ-90.11)»

ΔX, м	ΔY, м	ΔZ, м	10^{-3} ω_X, arcsec	10^{-3} ω_Y, arcsec	10^{-3} ω_Z, arcsec	m, 10^{-6}
+23,557 (± 2)	–140,844 (±2)	–79,778 (± 3)	–2,30 (±100)	–346,46 (± 100)	–794,21 (±100)	–0,228 (±0,250)

Site work execution procedure and schedule (2013)

Work execution by the procedure (2014-2015)

Site differential correction calculation sequence

Site geodetic point (GP) catalogue creation

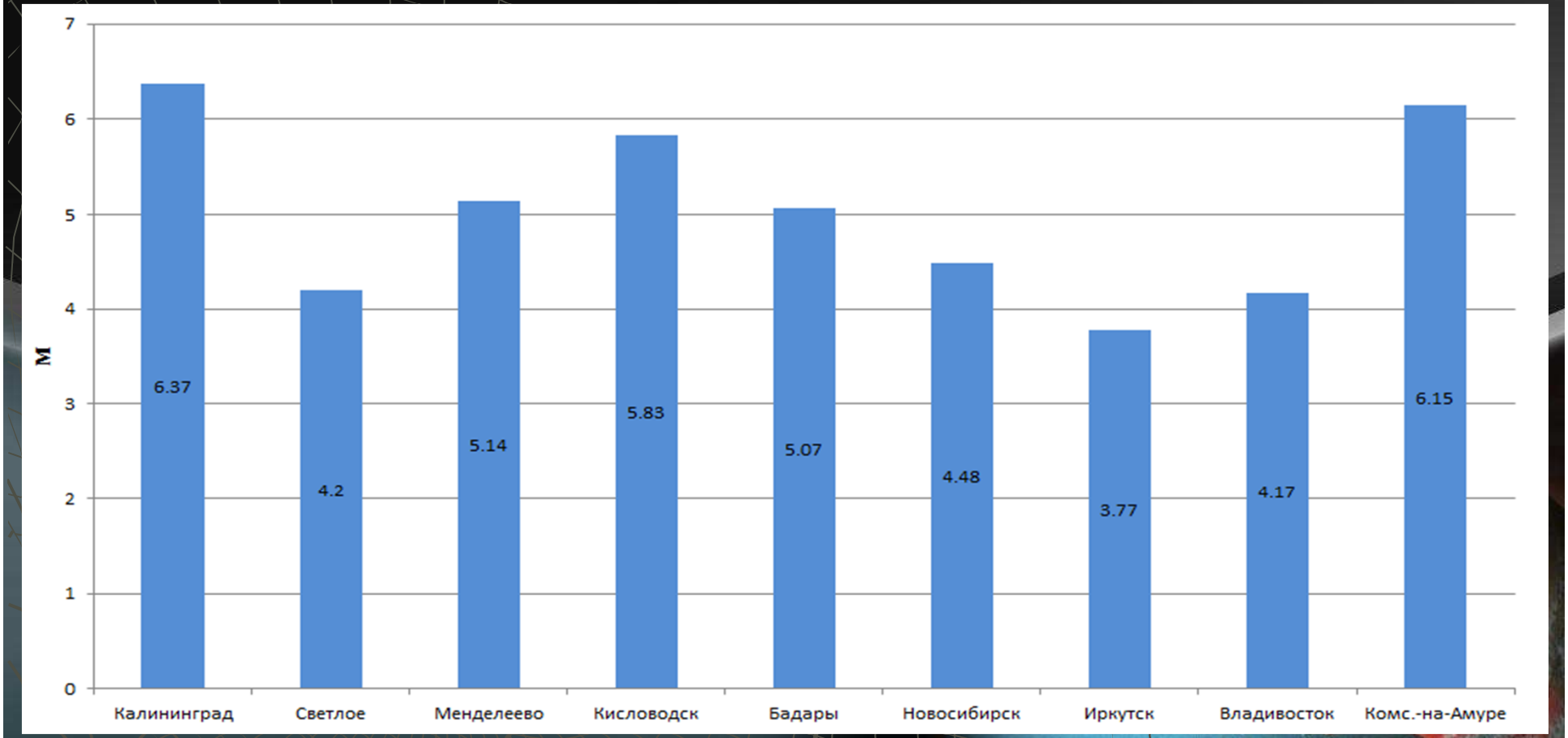
SC-42 site GP coordinate catalogue extract generation

Taking site GP measurements through user navigation equipment and then submitting them to the Russian system of high precision determination of ephemeris-time corrections (SVOEVP)

Highly accurate geodetic tie of the site GP in PZ-90.11 and differential correction calculation

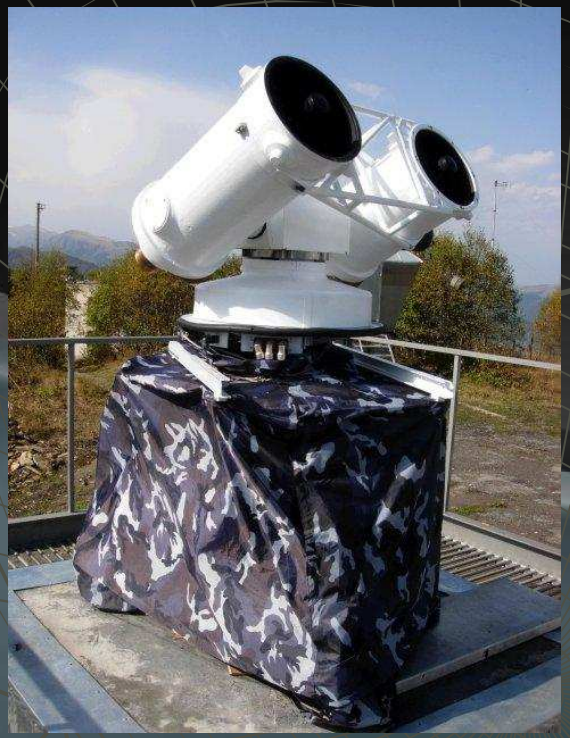
$$\Delta П^{ГТ}_{ПЗ-90.11,j} = П^{ГТ}_{ПЗ-90.11,j} - П^{ГТ}_{СК42->ПЗ-90.11,j}$$

Work execution results, 1st stage



Differential corrections for standard parameters of upgrading from SC-42 to PZ-90.11 for different sites vary in the range of up to 6-7 m

Checking the accuracy of the PZ-90.11 transfer performed by the GLONASS navigation signals



Initial data:

1. Measurements collected by both the Russian and ILRS quantum optical systems (QOS)
2. QOS initial geodetic data in PZ-90.11

Task completion procedure

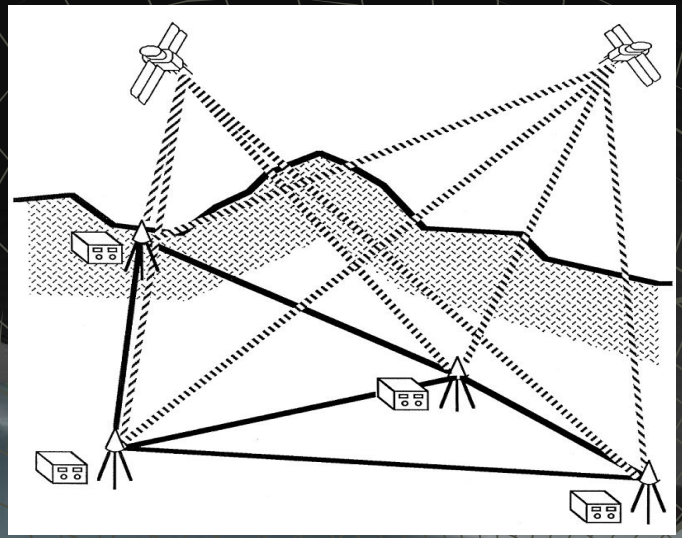
Improvement of the QOS coordinates through laser ranging and their further comparison with the standard coordinate values given in PZ-90.11

Host site

System of high precision determination of ephemeris-time corrections

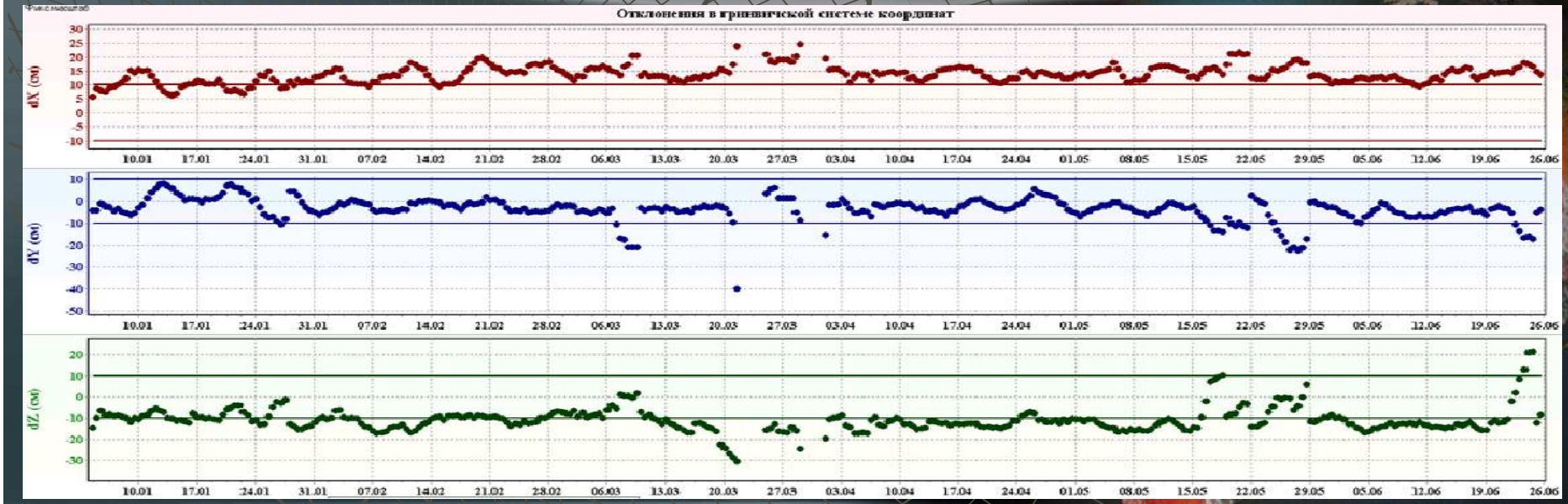
Accuracy of the PZ-90.11 transfer through the GLONASS navigation signals is 15...30 cm

Initial geodetic data monitoring system in SVOEVP



Task completion procedure:

Determination in post-processing mode using a posteriori ephemeris data



SGP parameter estimation through the GLONASS navigation signals in SVOEVP

Estimation of the accuracy of the national reference frame transfer through the GLONASS navigation signals

QOS			Closing errors, M		
International identifier	Longitude	Latitude	ΔX	ΔY	ΔZ
Barnaul	82.2	51.3	0.0	0.1	0.1
Mendeleevo	37.2	56.0	-0.1	-0.3	-0.2
Komsomolsk-on-Amur	136.7	50.7	-0.3	0.1	0.0

Estimation of parameters of transition between the national reference frame and ITRF

Type	Transition parameters						
	Mass center offset, m			Turns, 10^{-3} arcsec			Scale
	ΔX	ΔY	ΔZ	ωx	ωy	ωz	$m*10^{8}$
Transition elements calculated through the GLONASS navigation frame data	0.000	0.000	0.000	0.3	0.5	0.6	-1.21
Transition elements in accordance with «The Earth's Parameters of 1990 (PZ-90.11)»	-0.003	-0.001	0.000	0.019	-0.042	0.002	0.00

Key results of the PZ-90.11 reference frame introduction to GLONASS

1. **The Russian Government Order №1463 was fully implemented and since January 1st 2014 PZ-90.11 has been successfully introduced to the GLONASS system.**
2. **By the PZ-90.11 introduction to the GLONASS system, the ephemeris support accuracy has been increased by nearly 30%**
3. **1st stage of works on the PZ-90.11 introduction to the sites has been completed**
4. **Upon transition from SK-42 to PZ-90.11, the coordinate conversion accuracy has been increased from ± 3 m to ~30 cm**


Thank you for your
attention!