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Space Service Volume and Russian GEO satellites PNT

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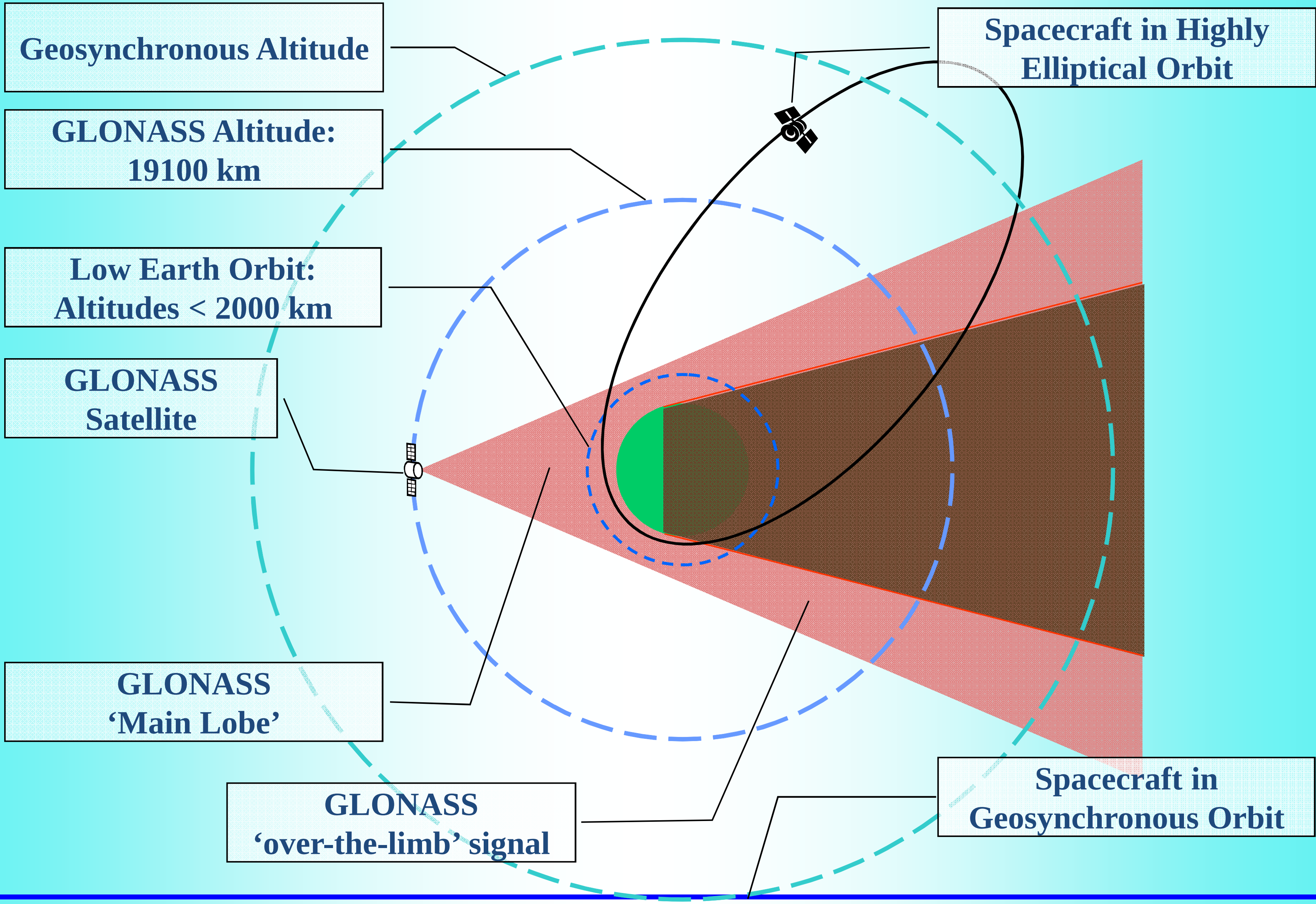
Application objective of using GLONASS/GPS for GEO satellites

- Providing ability to autonomous GEO satellites station keeping within orbital slot (±0,05°) due to ITU requirements
- Increasing reliability and accuracy of the satellite orbit correction operations
- Decreasing influence of “human factor“
- Decreasing operation costs and ground segment costs
- Increasing needs for technology of GEO orbital positioning control without ground control stations
- Opening new opportunities in-clusters navigation and collocation for GEO the satellite constellation

GLONASS use conditions for GEO and HEO satellites



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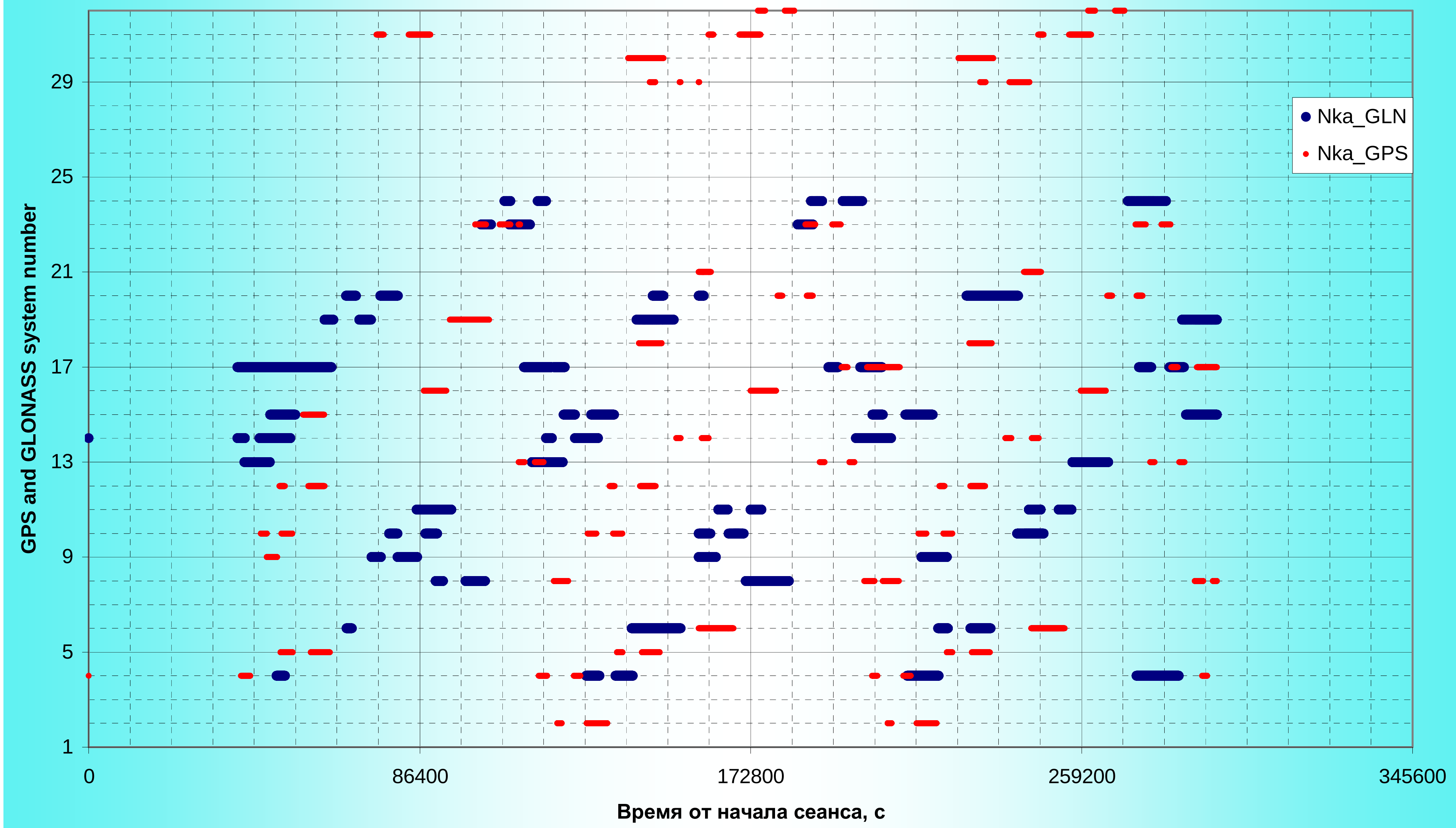
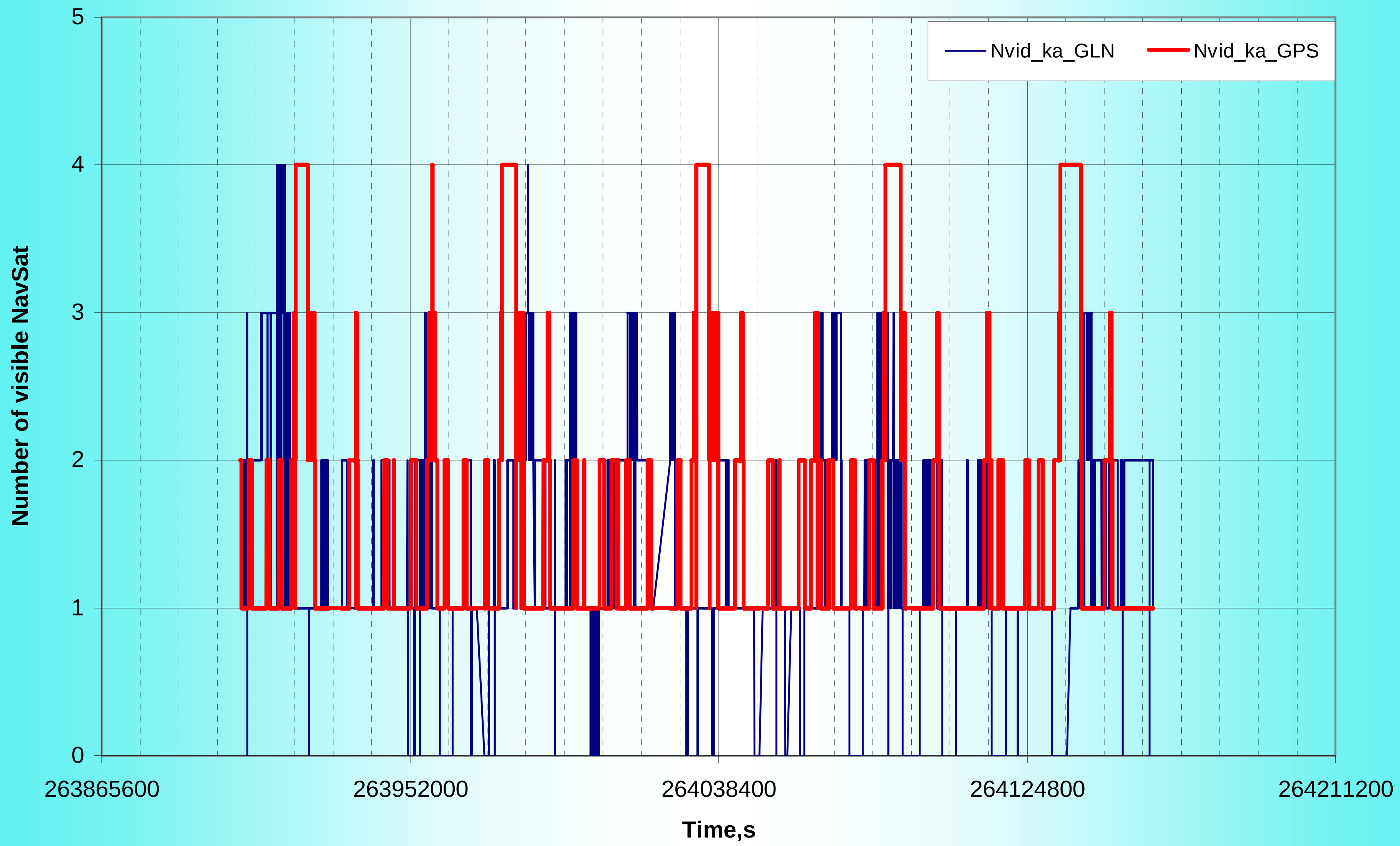
GNSS for GEO satellite PNT

- The active R&D work for GEO satellite autonomous navigation technology on the base of GLONASS and GPS signals had started in Russia at the end of 1990-th.
- The first GEO satellite Raduga-M1 with onboard GNNS GLONASS&GPS receivers and autonomous navigation subsystem Raduga-M1 was launched in 2007
- Successful operation of this satellite confirmed the possibility to perform position and time determination for GEO satellites by GNSS with accuracy at the range 100..300 m (RMS) and 500…1000 ns(RMS)
- More than 6 satellites equipped with onboard GLONASS/GPS navigation receivers are operating on GEO now.
- The Russian meteorological satellite Electro-L N2 is last in line of GEO satellites equipped with the onboard GNSS navigation system Its flight testing was completed in mid-2016

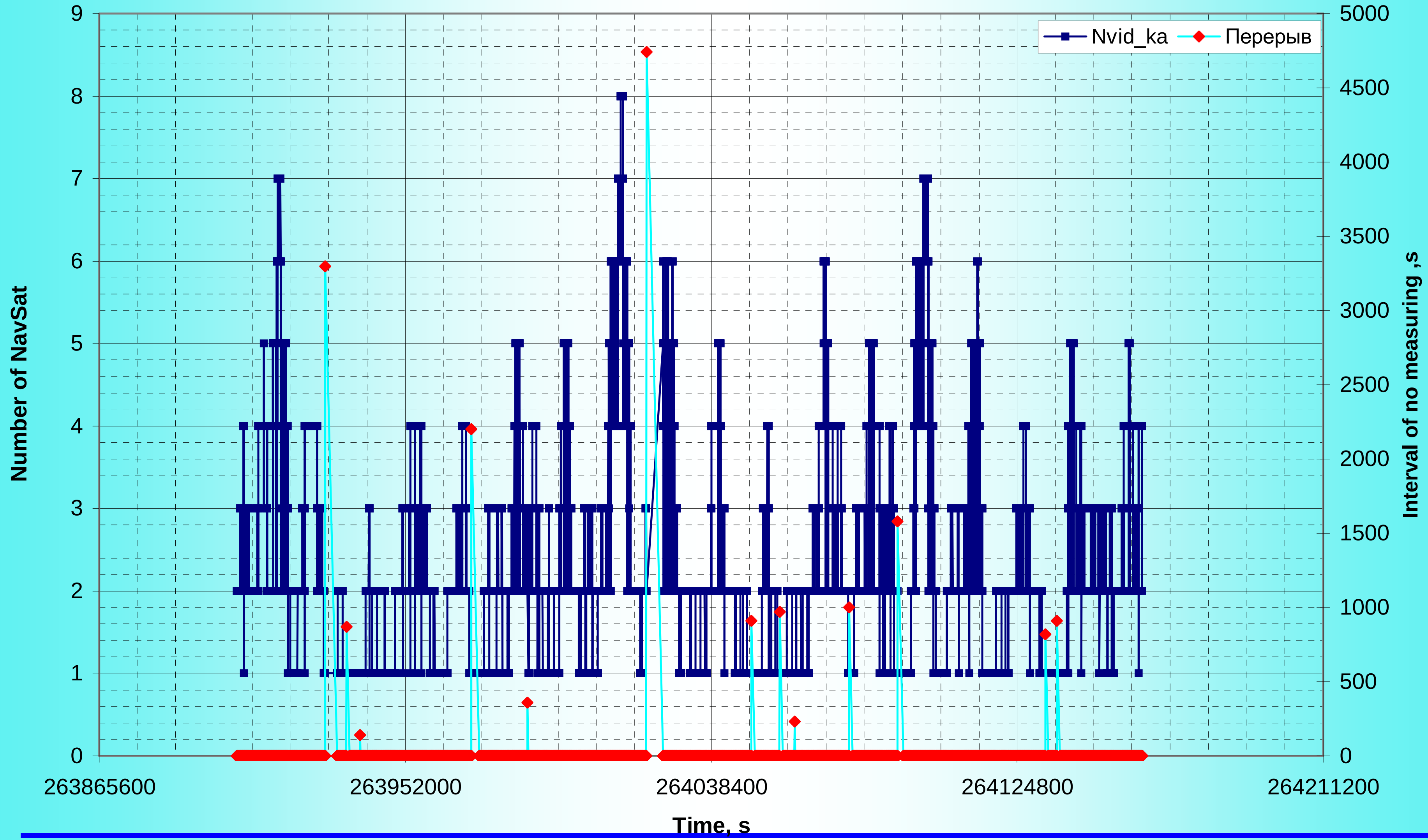
The system numbers GLONASS and GPS NavSat measuring by ARN GEO during 12-15.05.2008



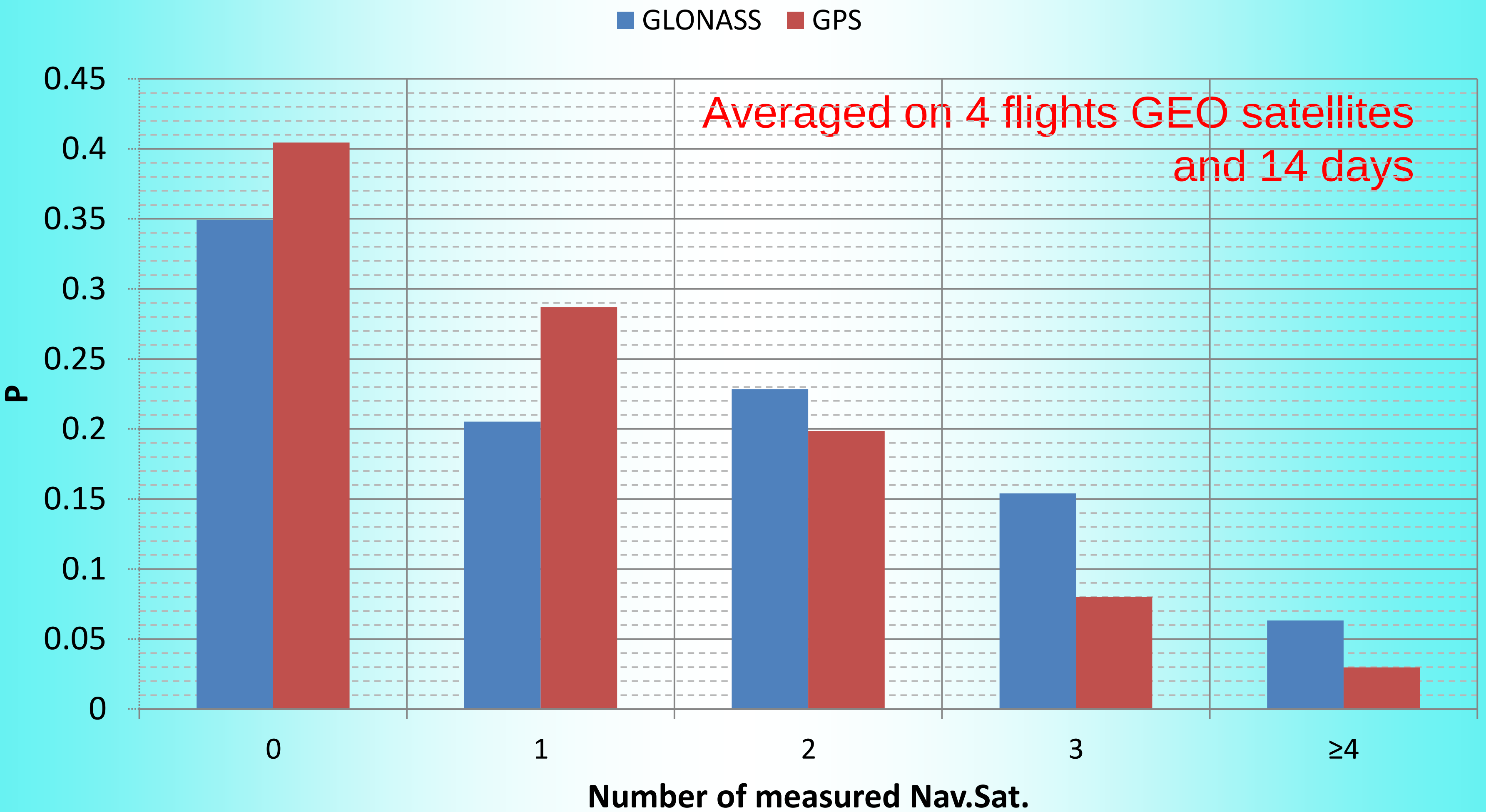
The number of measuring by ARN GEO NavSat GLONASS and GPS during 12-15.05.2008



The sum number of GLONASS and GPS NavSat measuring by ARN GEO during 12-15.05.2008

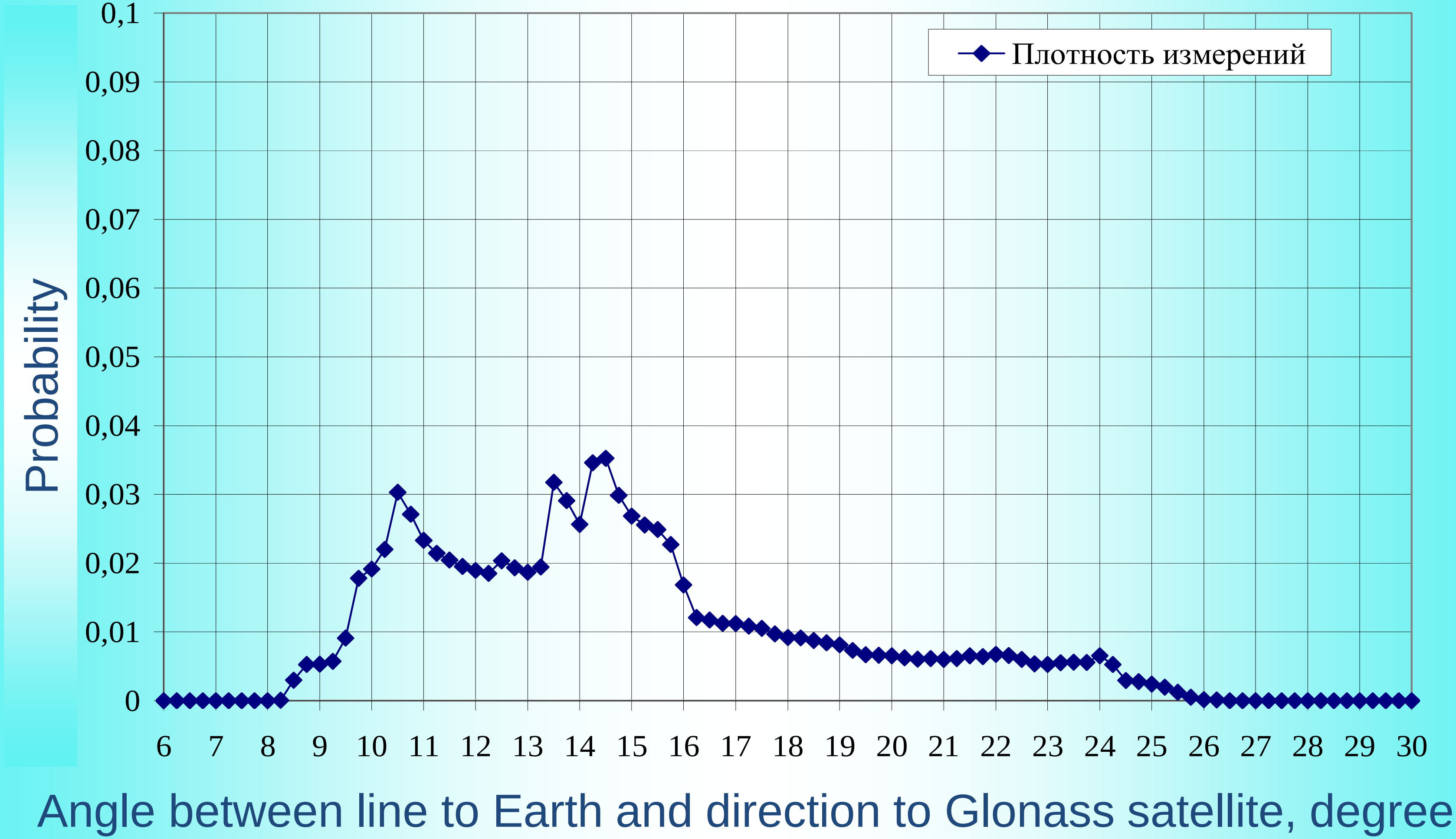


Density of probability of the measurements number of GPS and GLONASS signals in the L1 band by navigation receivers on four GEO satellites at 09-23.09.2016



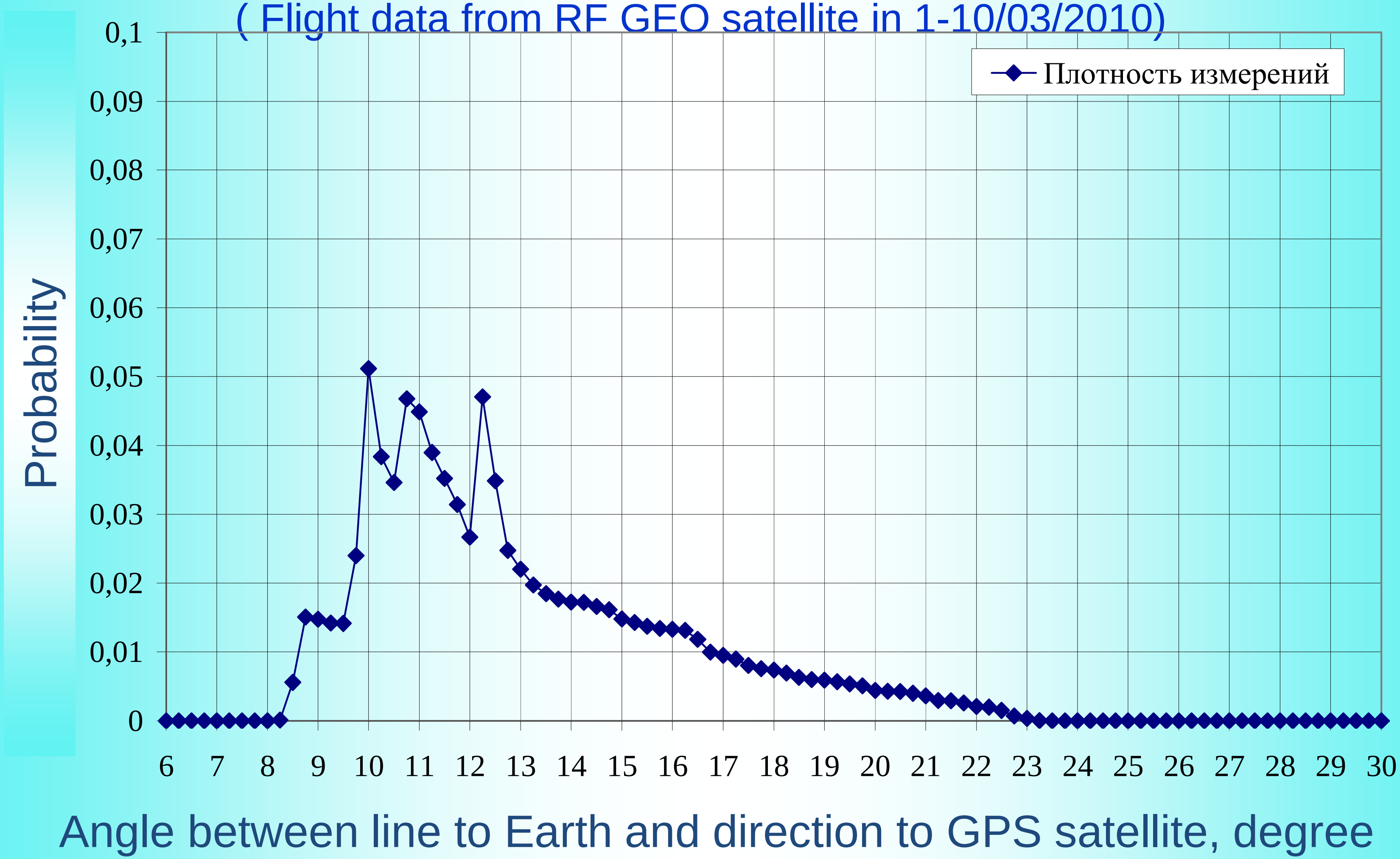
Density of probability of the measurement angle between direction to measuring Glonass satellites and line to Earth for onboard GEO receiver

(Flight data from RF GEO satellite in 1-10/03/2010)



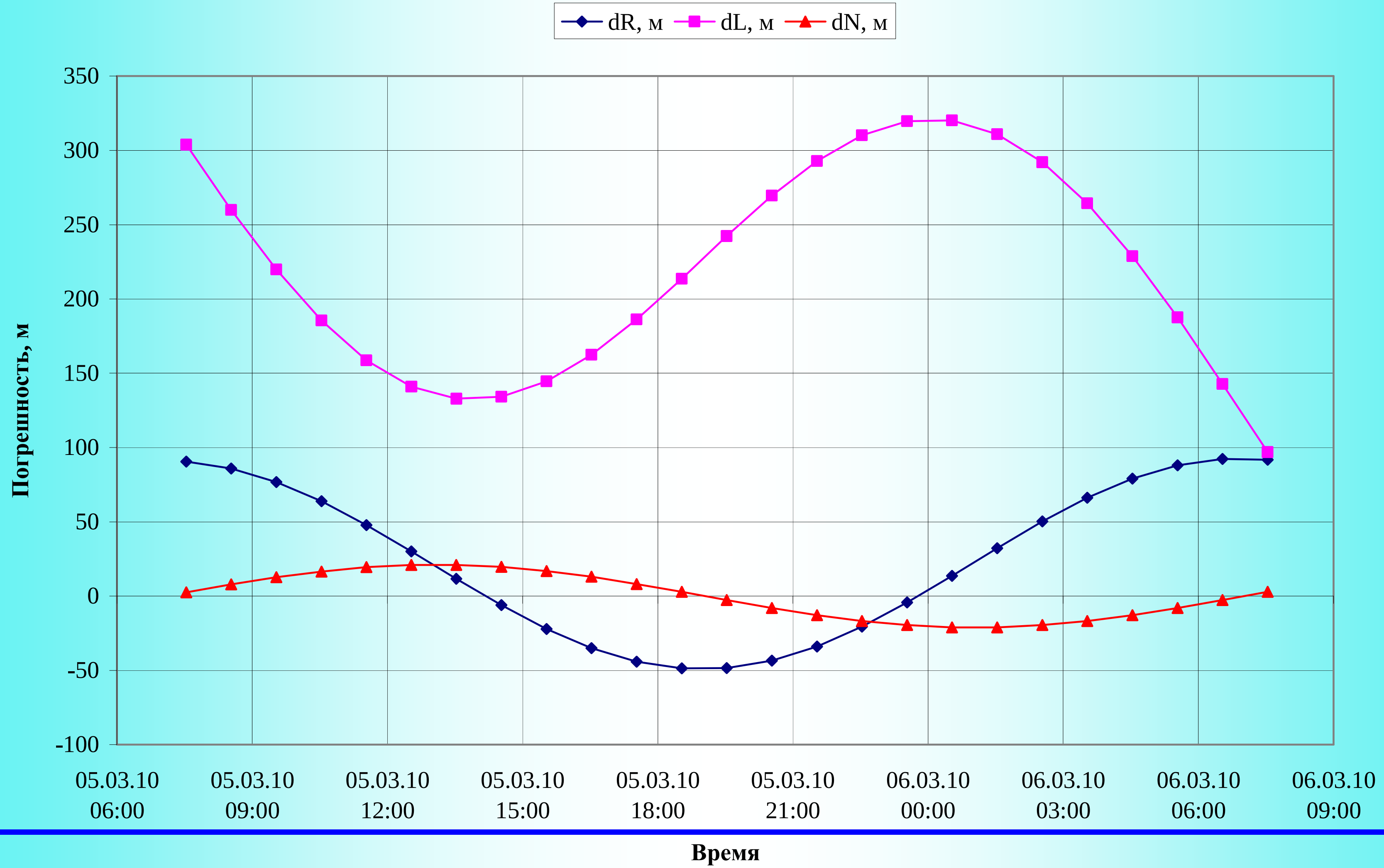
Density of probability of the measurement angle between direction to measuring GPS satellites and line to Earth for onboard GEO receiver

(Flight data from RF GEO satellite in 1-10/03/2010)



GEO satellite positioning error are estimated by onboard GLONASS and GPS measurements

(Flihgt test 05/03/2010)



The GNSS perspective for GEO satellites position and time maintenance

- The accumulated knowledge and experience has shown the prospects and possibilities of the onboard autonomous GNSS navigation technology for GEO satellite and identified new benefits for many high-orbit missions
- Currently, several companies of ROSCOSMOS are developing the next generation of advanced onboard devices and systems for onboard navigation for HEO, GEO and LEO satellites using GNSS GLONASS, GPS, Galileo, Compass signals with better specifications of sensitivity, availability and accuracy

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GNSS is the basis for the development of automation and security for orbital space flight

GNSS can be the basis for development of automation, control and orbital spacecraft operations.

For it could become several condition :

- The widespread using of GNSS for navigation of all types of orbital spacecraft and
- The implementation of the common rules, practices and the exchange of orbital data standards for space navigation, maneuver, collocation

This could be the Basis for the development of automation and the safety of space flights as a response to the challenge of increasing the activity of different countries in outer space

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Thank You for attention

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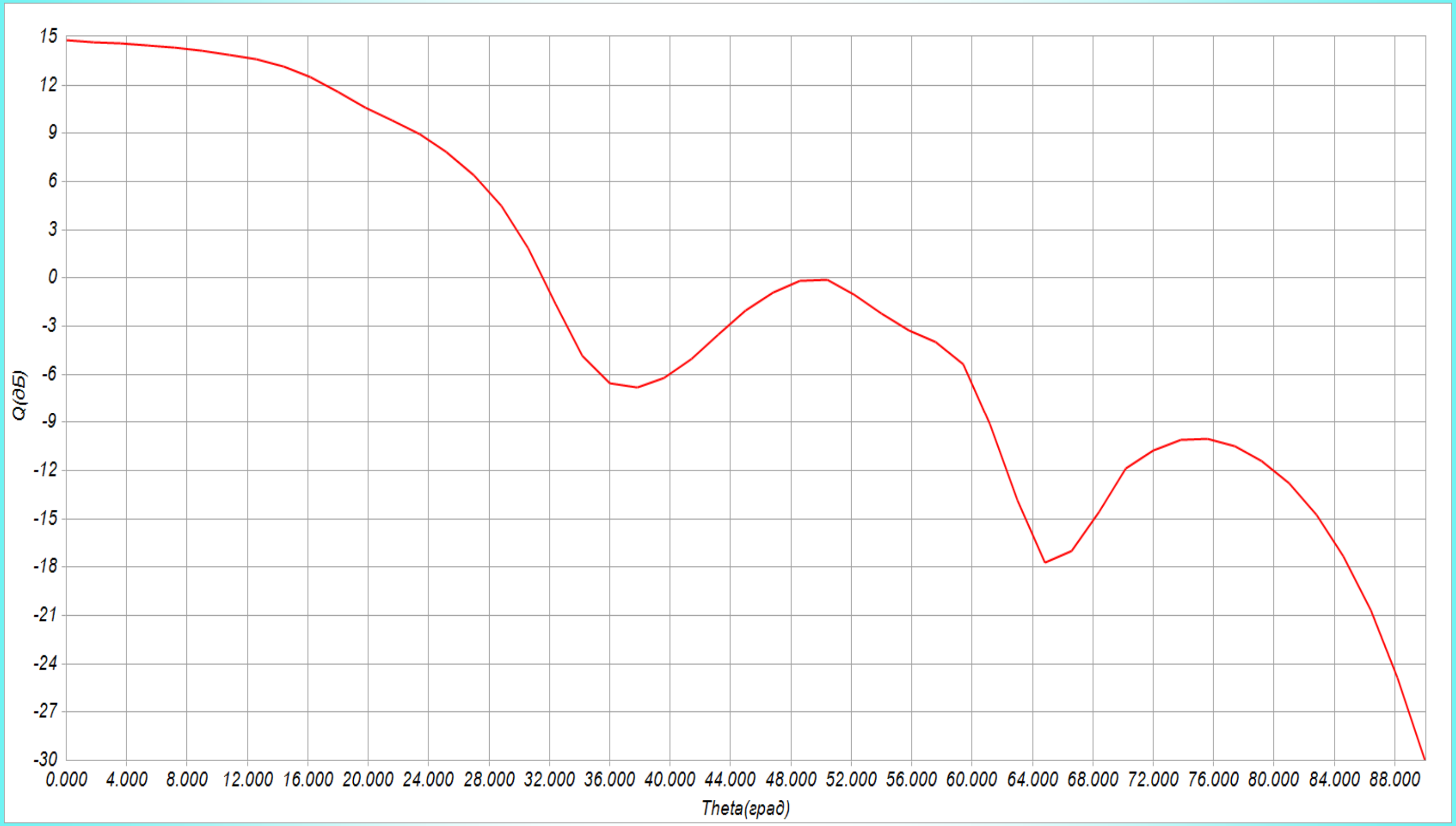
Antenna pattern of onboard navigation receiver on RF GEO satellite



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Definitions	Notes
Lower Space Service Volume (also known as 'MEO altitudes'): 3000 to 8000 km altitude	Four GLONASS signals available simultaneously a majority of the time but GLONASS signals over the limb of the Earth become increasingly important. One-meter orbit accuracies are feasible (post processed).
Upper Space Service Volume (GEO and HEO with the exception of the perigee area): 8000 to 36000 km altitude	Nearly all GLONASS signals received over the limb of the Earth. Accuracies ranging from 20 to 200 meters are feasible (post-processed) depending on receiver sensitivity and local oscillator stability.

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Parameters	Value	
User range error	1.4 meters	
Minimum Received Civilian Signal Power (GEO)	**With account of the GLONASS satellite's transmitter antenna gain pattern**	**Reference Off-Boresite Angle**
L1[1,2]	-180 ÷ -185 dBW	14 – 20 deg
L2	-177 ÷ -184.4 dBW	14 – 28 deg
L3	-176 ÷ -184 dBW	14 – 28 deg
Signal availability[3]		
MEO at 8000 km	**At least 1 signal**	**4 or more signals**
L1	81%	64%
L2, L3	100%	66%
Upper Space Service Volume (HEO/GEO)	**At least 1 signal**	**4 or more signals**
L1	70%	2.7%
L2, L3	100%	29%

Note 1 – FDMA signals in L1 and L2 bands and CDMA signals in L3

Note 2 – L1, L2 signals are transmitted by GLONASS-M and GLONASS-K satellites. At present, the L3 signal is transmitted by the GLONASS-K satellite and by the GLONASS-M No. 55 satellite (flight tests). Furthermore, the final 6 GLONASS-M satellites will also transmit L3 signal.

Note 3 – Assumes that the high-orbit SV has at least one GLONASS satellite in line-of-sight.