# Russian Federation view on further stages of SSV simulation

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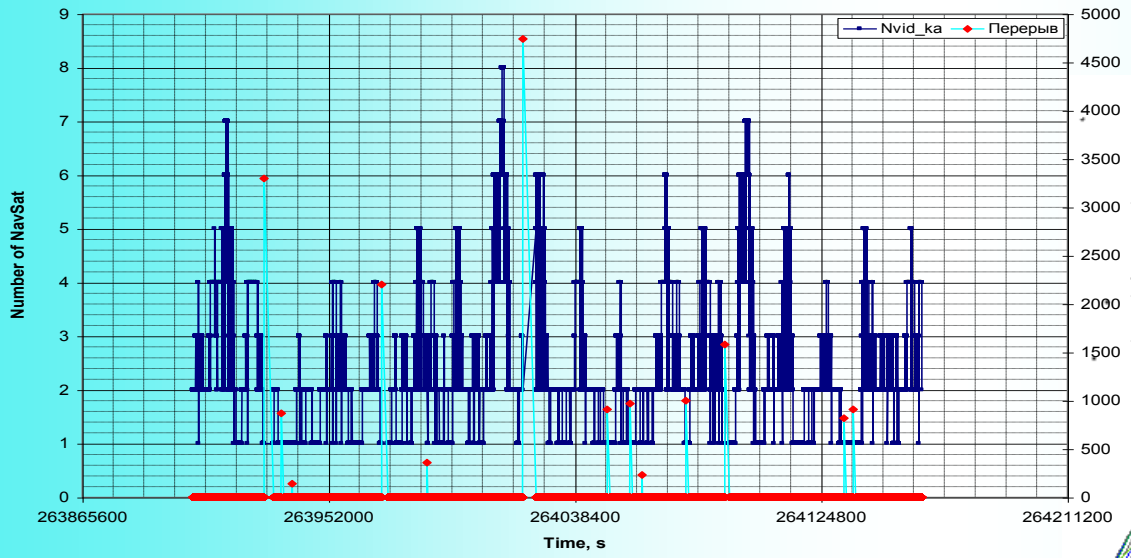
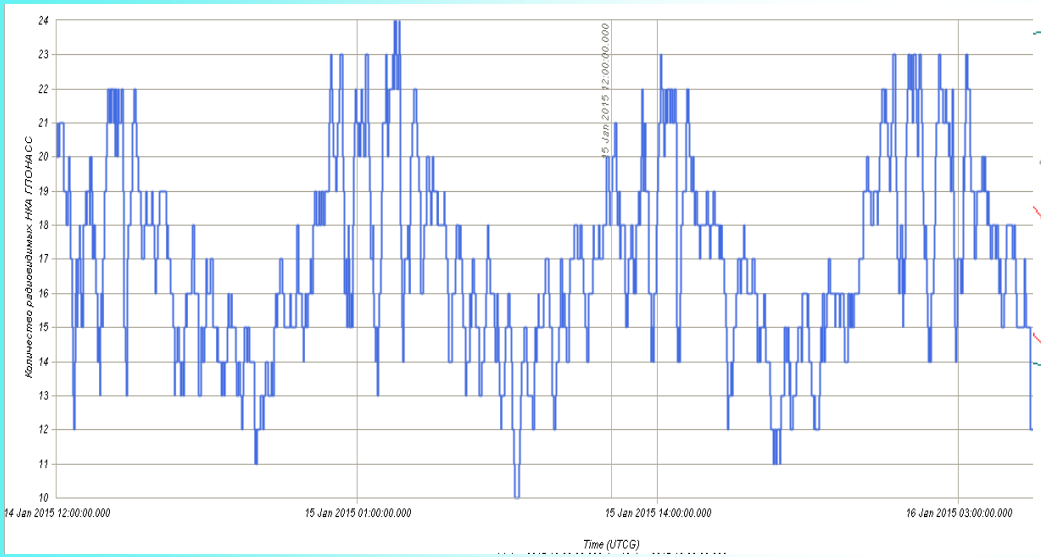
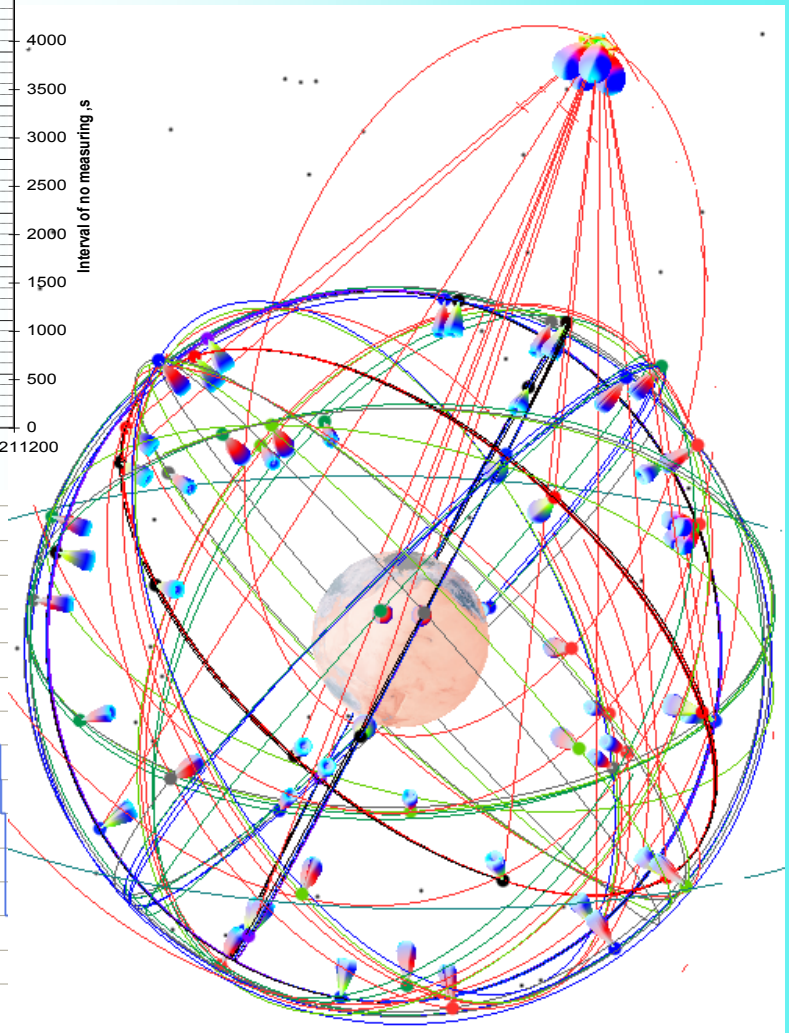
# Practical experience in the development and use of GNSS for navigation for GEO and HEO satellite

- With the end of 2007 on board of JSC ISS GEO satellites the GNSS recievers are used for orbit positioning
- Currently in Russia there are more than 6 GEO and HEO satellites using signals of GLONASS and GPS for coordinate and time maintenance
- Over the long development period of the onboard autonomous GNNS navigation receivers and system the special approaches for modeling these systems and assess the potential availability and accuracy was developed
- Verification of the approaches and models was held according to the data obtained during flight test and operation of GEO satellites with special GNSS navigation system onboard

# GNSS SSA availability depend of type orbit and the antenna systems complexity



# Features of availability evaluation of GNSS SSA for GEO and HEO users

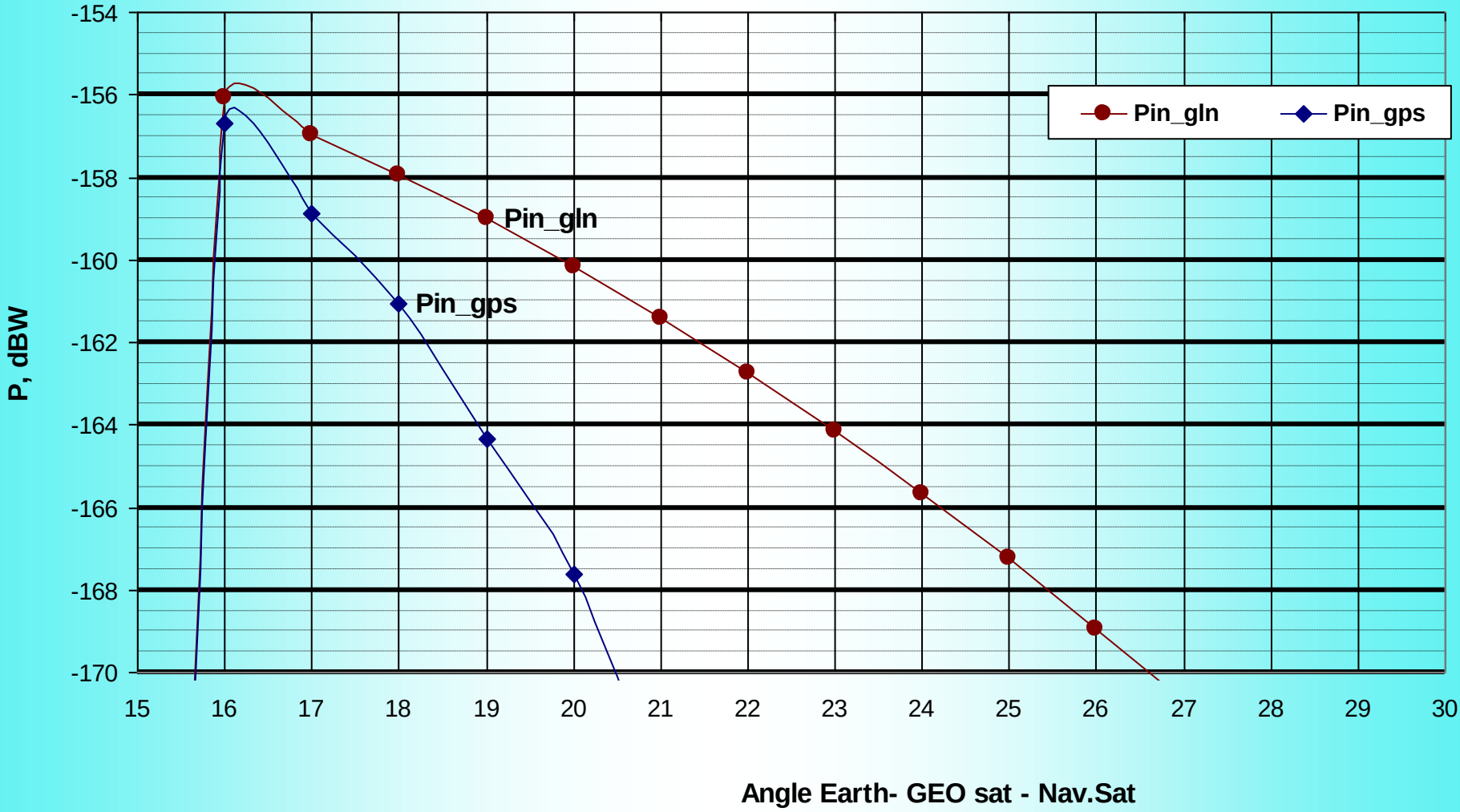
According to the results of the research, simulation and operation of onboard GNSS navigation systems, we can draw an important conclusion:

- The availability and the geometric factor and therefore the positioning and timing accuracy of high-orbit satellites is greatly influenced by the antenna structure and user antenna gain pattern and the receiver sensitivity
- The significant influence on the reliability and accuracy of availability modeling is having the precision of simulation models for GNSS satellites transmitted antenna pattern and level of transmitted power

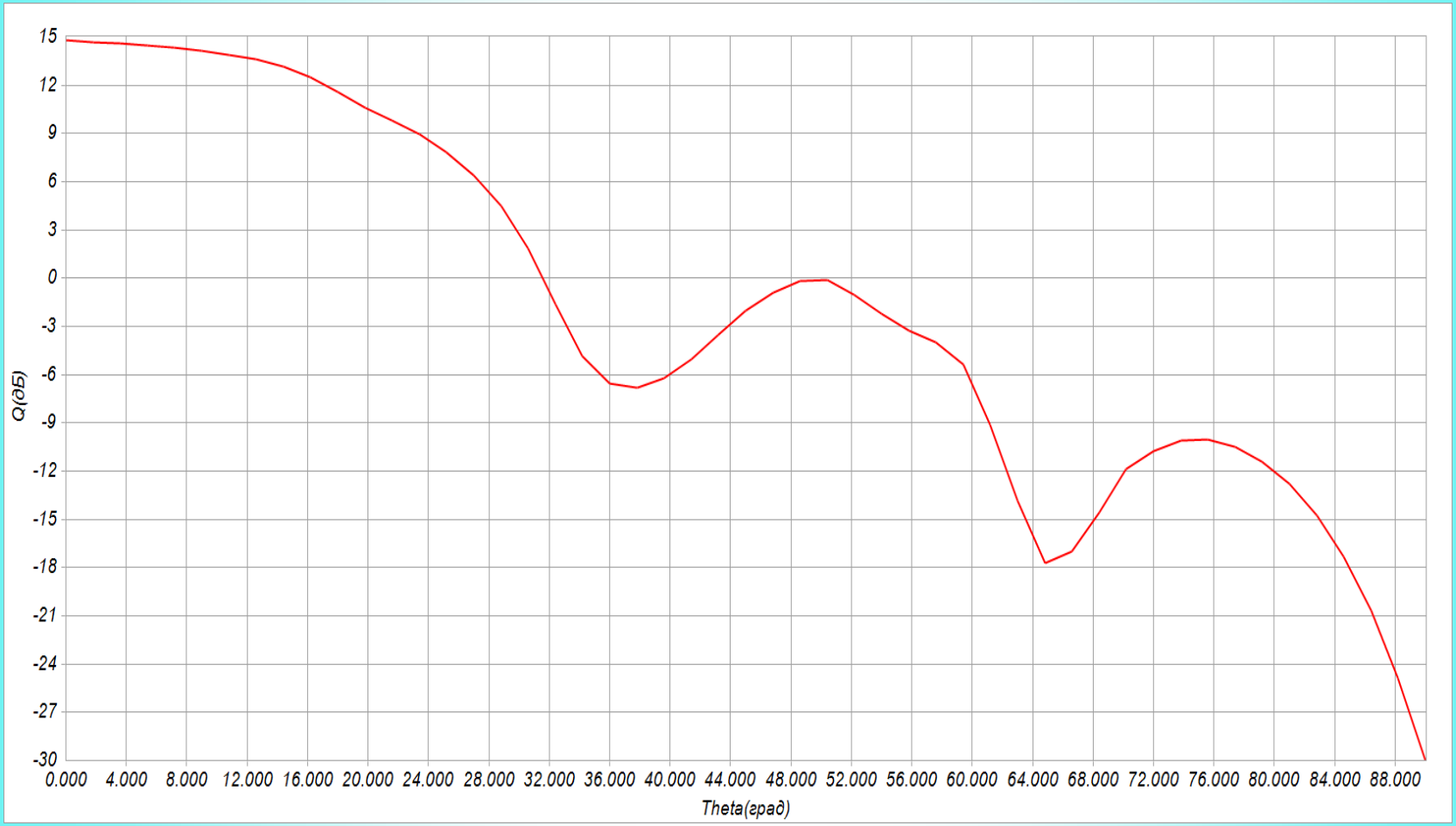
# Features of availability evaluation for GEO and HEO users

- All GNSS was developed mainly for maintenance of ground and near-ground user
- Navigation link and transmitted antenna patterns have been optimized for these tasks
- High-orbit space users mainly uses the signals emitted from the slope of transmitted antenna pattern
- The transmitters antenna pattern working areas is the side of main lobe with a significant slope and, in some cases, first side lobe
- Since the significant slope lobe a significant and a small change in angle cause significant changes on the gain level.
- A method of evaluating of navigation service availability and the potential system accuracy used to ground applications is not suitable for SSA.

# GLONASS and GPS power signal on input of GEO onboard receiver with a single 15 dB receiving antenna 15 dB



# Antenna pattern of RF GEO onboard receivers



# Practical experience of using GLONASS and GPS navigation in GEO satellites

The accuracy and availability of navigation measurements high orbit users affected by the following factors:

- Number of received measures
- The features of the distribution of measurements session in the orbit position estimation interval
- DOP factor
- SISRE
- Source of noise (Earth,Moon, Sun, space noise)
- User range error of navigation receiver

That factor could significantly change across orbit position and vary for different orbit type

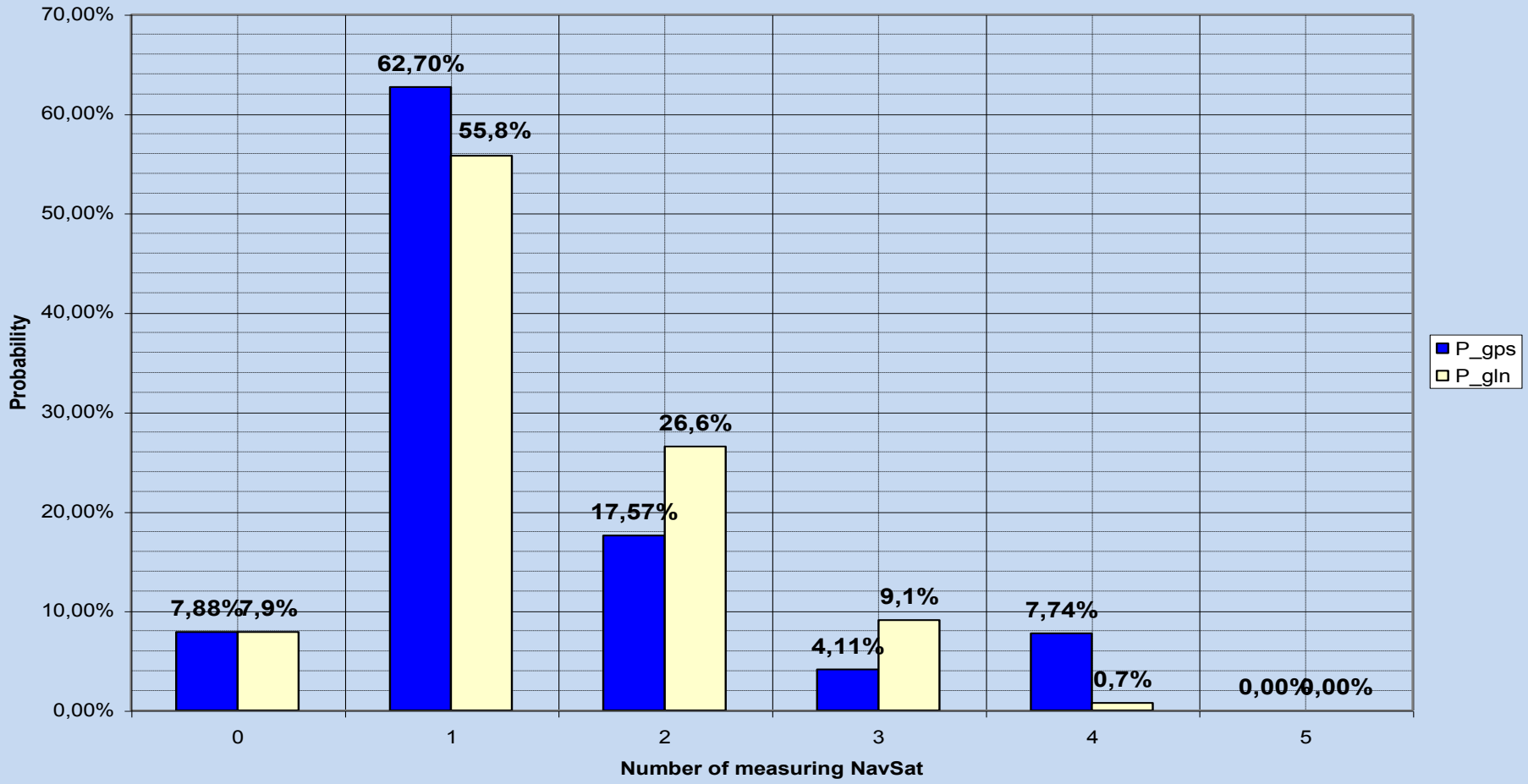
# The characteristics for GNSS SSA

Currently in the works of ICG WG-B on the modeling of the GNSS SSA to assess the availability of navigation services are used following parameters: .

- the minimum received power,
- the probability of a measurement of one satellite,
- the probability of measuring 4 or more satellites.

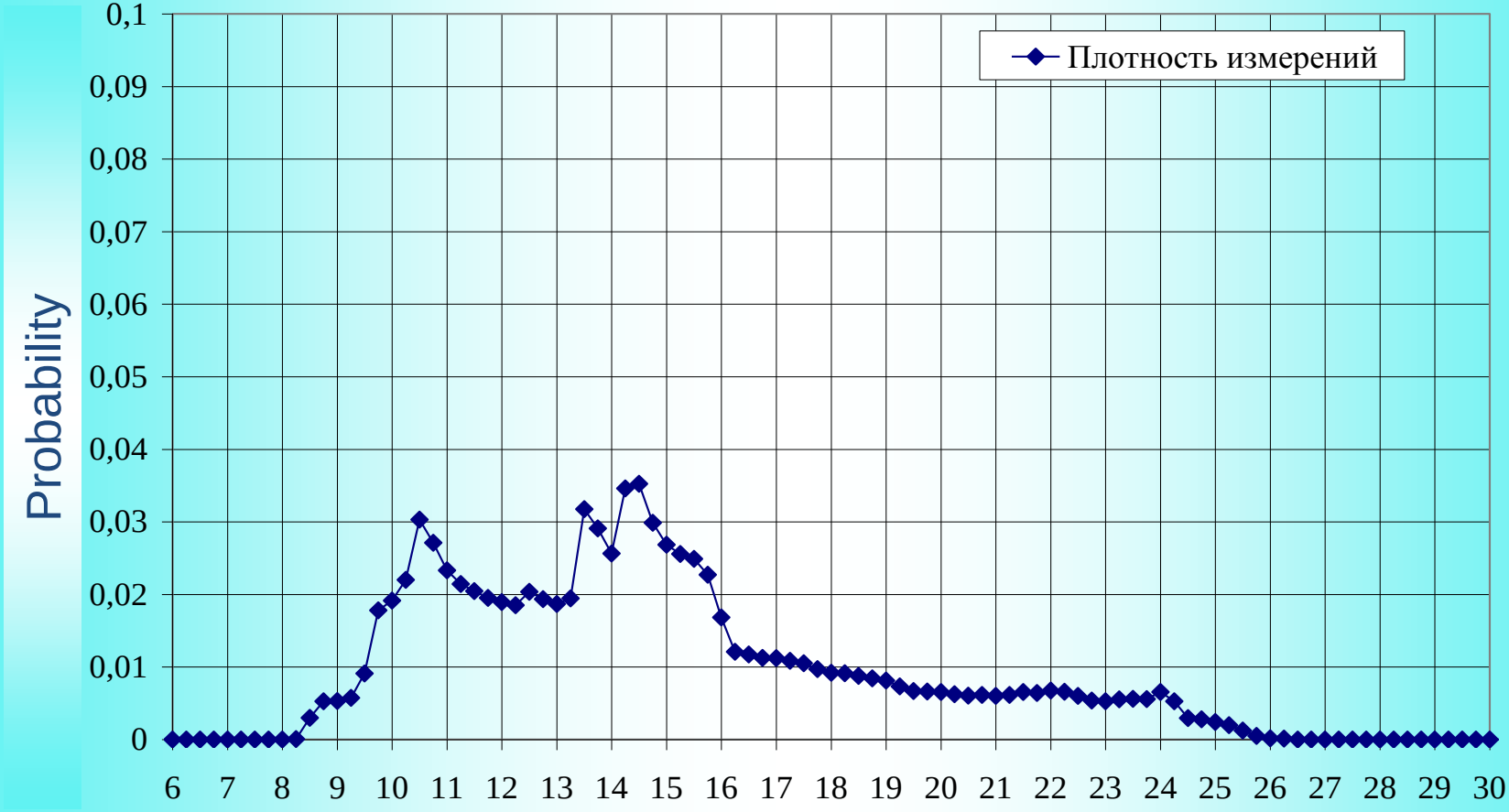
For adequate and representative estimates of system availability and potential accuracy and comparison of different of GNSS it is not enough

# Probability distribution of the number of simultaneously measurable satellites GLONASS and GPS



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

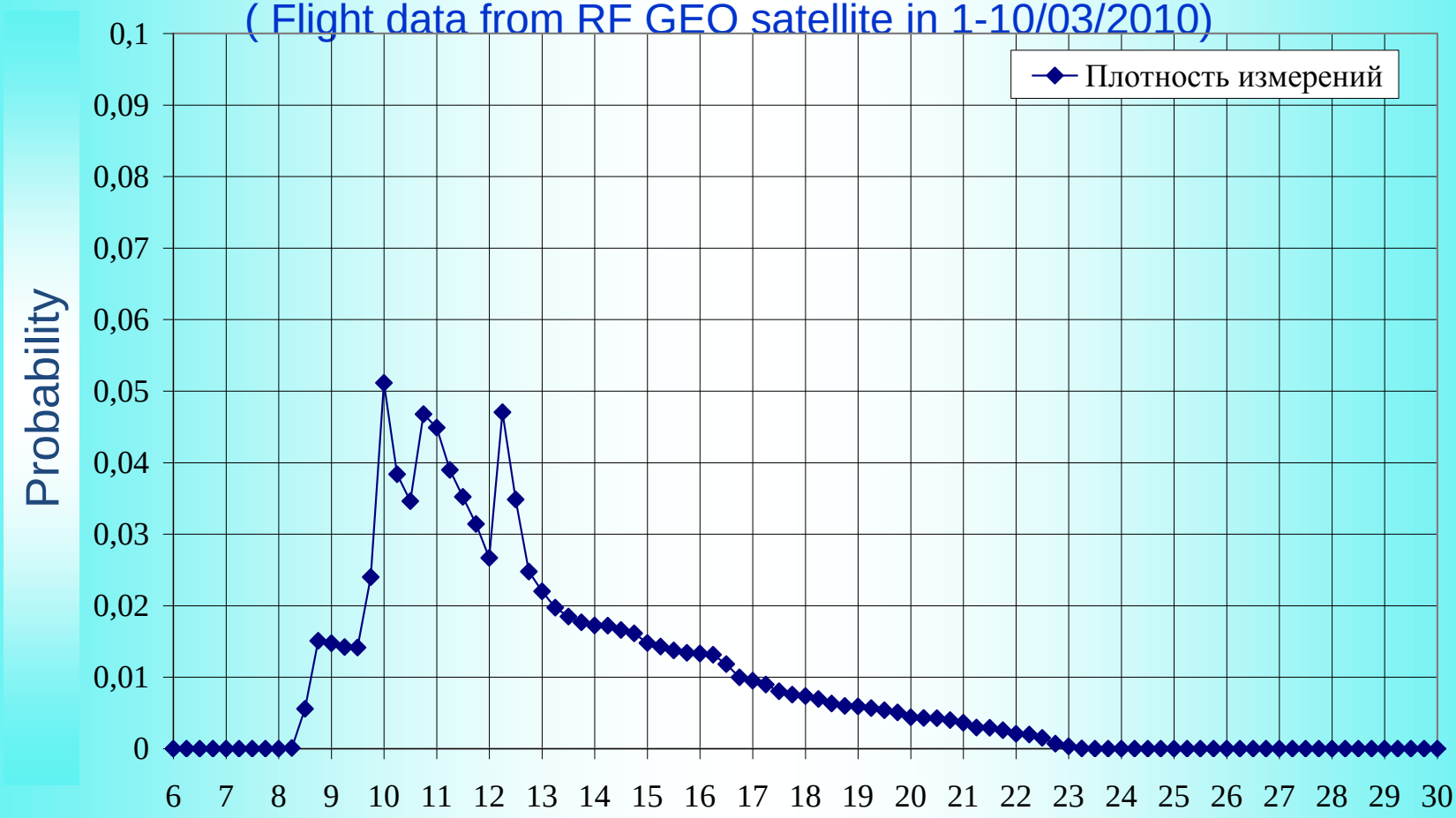
( Flight data from RF GEO satellite in 1-10/03/2010)




Angle between line to Earth and direction to Glonass satellite, degree

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

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



# Proposals for the approach to evaluate the service availability for GNSS SSA

- The specifications of the antenna system of the user and the sensitivity of the receiving equipment has a significant impact on the parameters of accessibility and accuracy
- Due to the different conditions for different missions and types of satellites and orbits listed above the list of parameters is not fully reflects the conditions of navigation services in the GNSS SSA and do not allow to adequately compare services in the space area for various GNSS and missions
- To describe SSA availability the family of graphs of probability distribution functions of measurements in the parameters C/N at receive point and visible angle are proposed to use

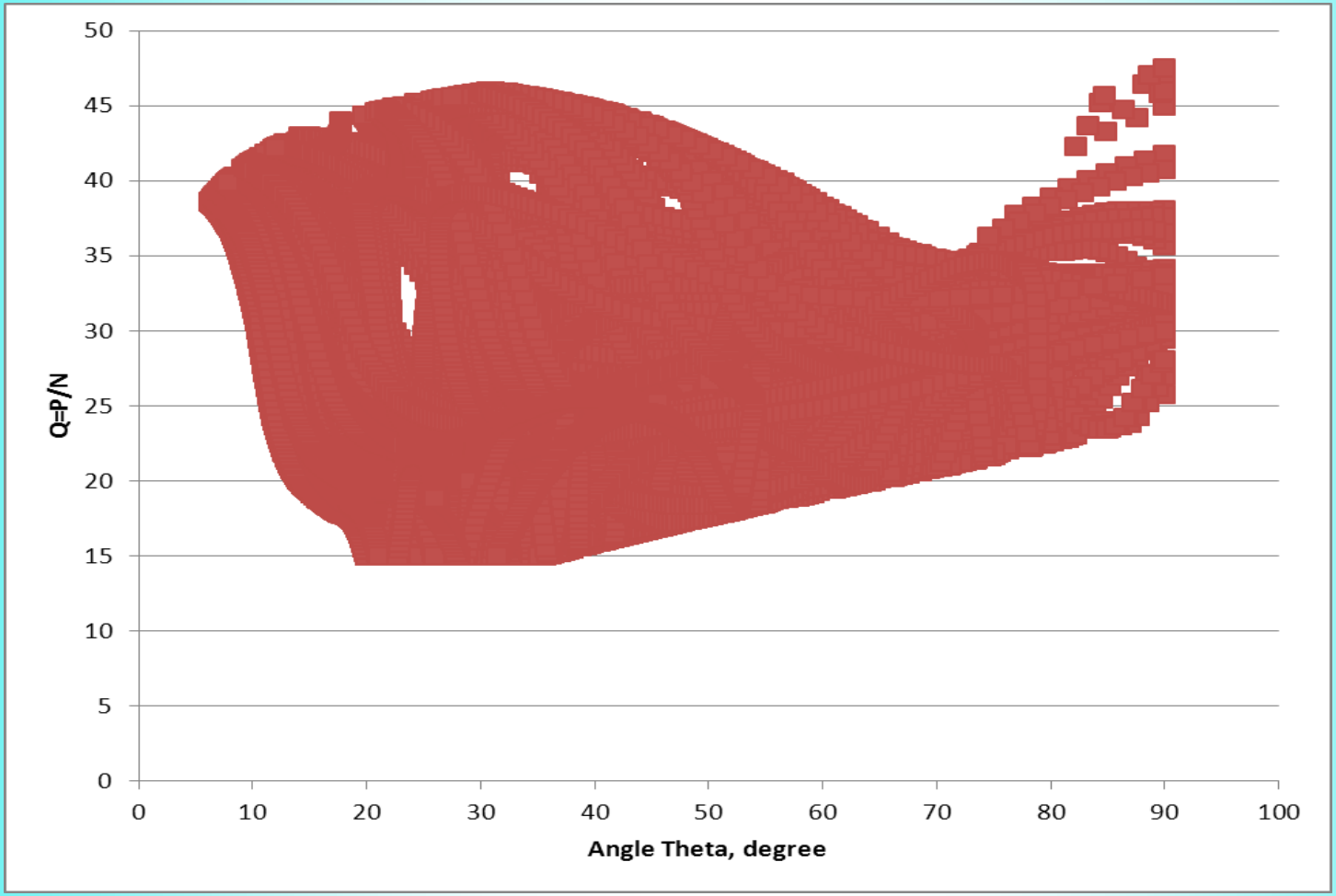
# Proposals for the approach to evaluate the service availability for GNSS SSA

- For evaluation and comparison of navigation conditions in the space area is proposed to conduct analysis for each type of orbit separately
- It is proposed to determine the density distribution of available Qsys=P/N in the reception point
- On the basis of the accumulated data to calculate the theoretically optimal profiles for the required antenna gain user for specified sensitivity threshold (35, 30, 25 dBHz)
- In the simulation of measurements should take into account that often for receivers  the acquisition and signal detection threshold and tracking of the signal threshold are different. Tracking signal and measurement of parameters may continue at lower levels of signal power.

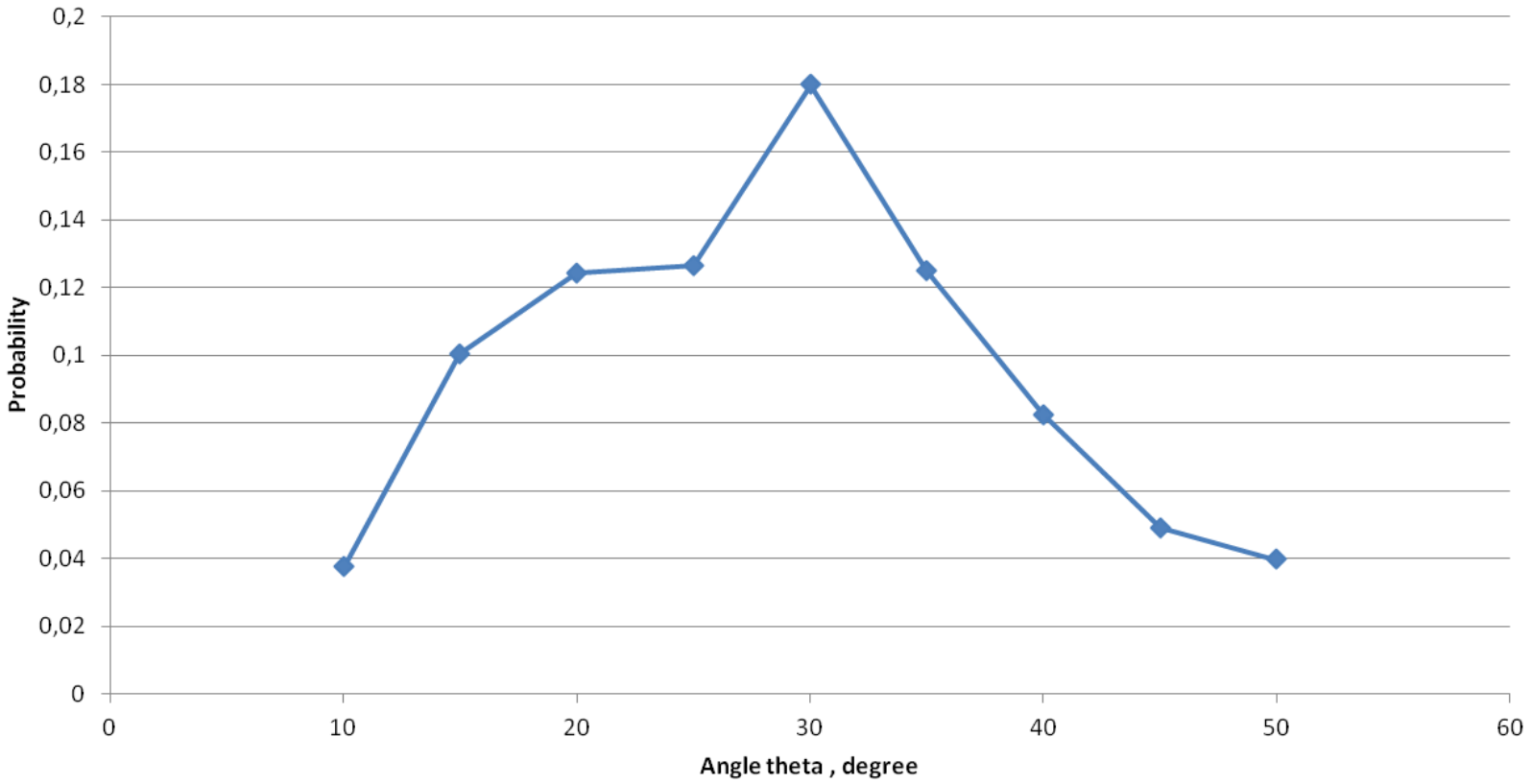
# Proposals for the approach to evaluate the service availability for GNSS SSA

- As the main parameter to calculate availability is Q=P/N [dBHz] excluding the receiver antenna gain
- To simulate motion and alignment geometry to use a consistent nominal or real data models of the motion of the satellite, power levels and antenna patterns of GNSS transmitters
- When calculating the power of signal and noise at the receiving point to consider the loss of signal propagation in space, polarization loss, the cosmic noise of the Earth, the sun, the moon, the thermal noise of the receiver
- The difference between the obtained Q-value and threshold sensitivity indicates the required gain of the receiving antenna. The distribution of this quantity by the angle-and time-distribution of the number of available sessions displays the quality and accessibility of navigation service.

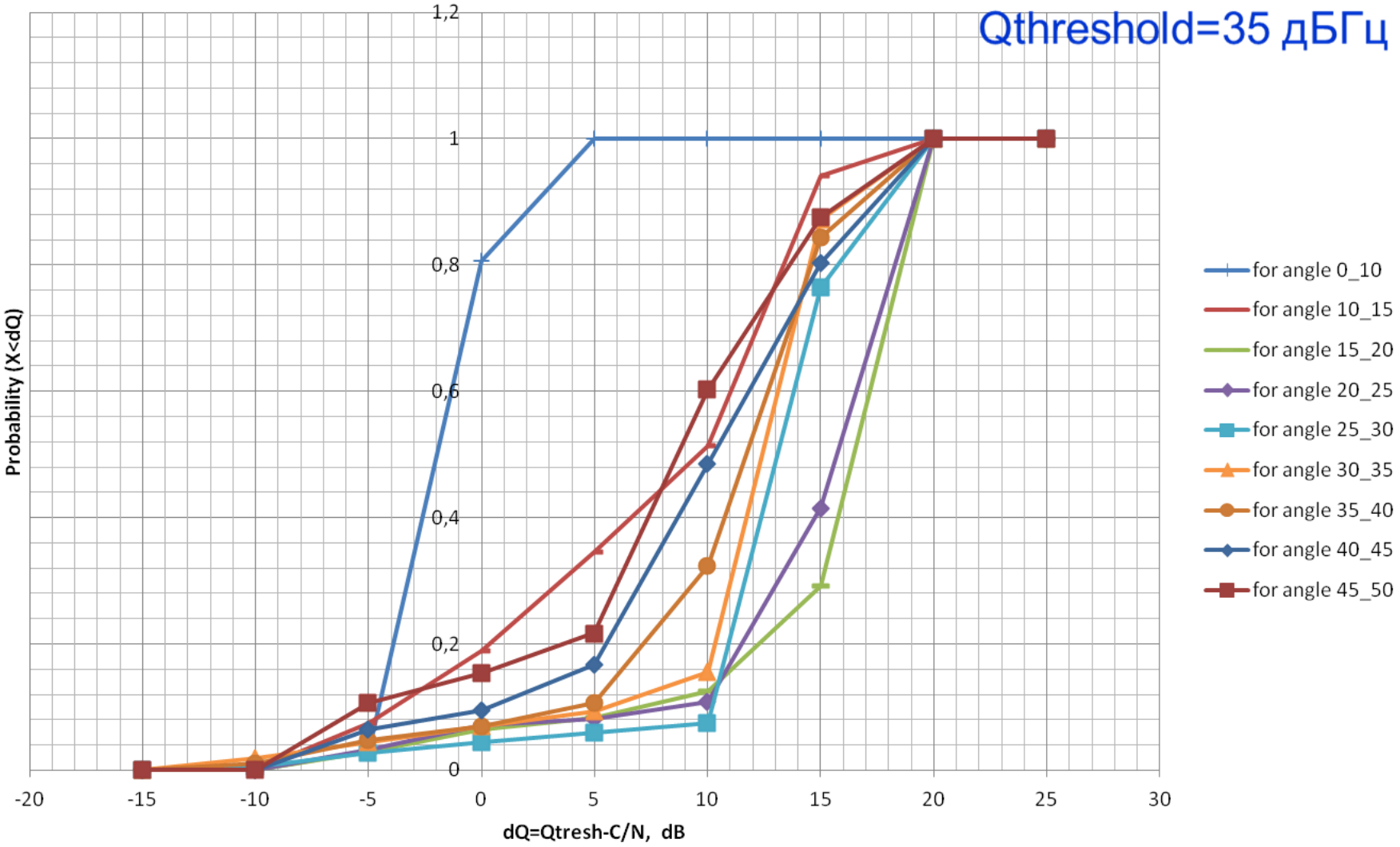
# Q factor for GLONASS satellite signals at receive point at HEO (Tundra) satellite



# An example of the density distribution for the angle of vision of GLONASS satellites from HEO (Tundra) satellite

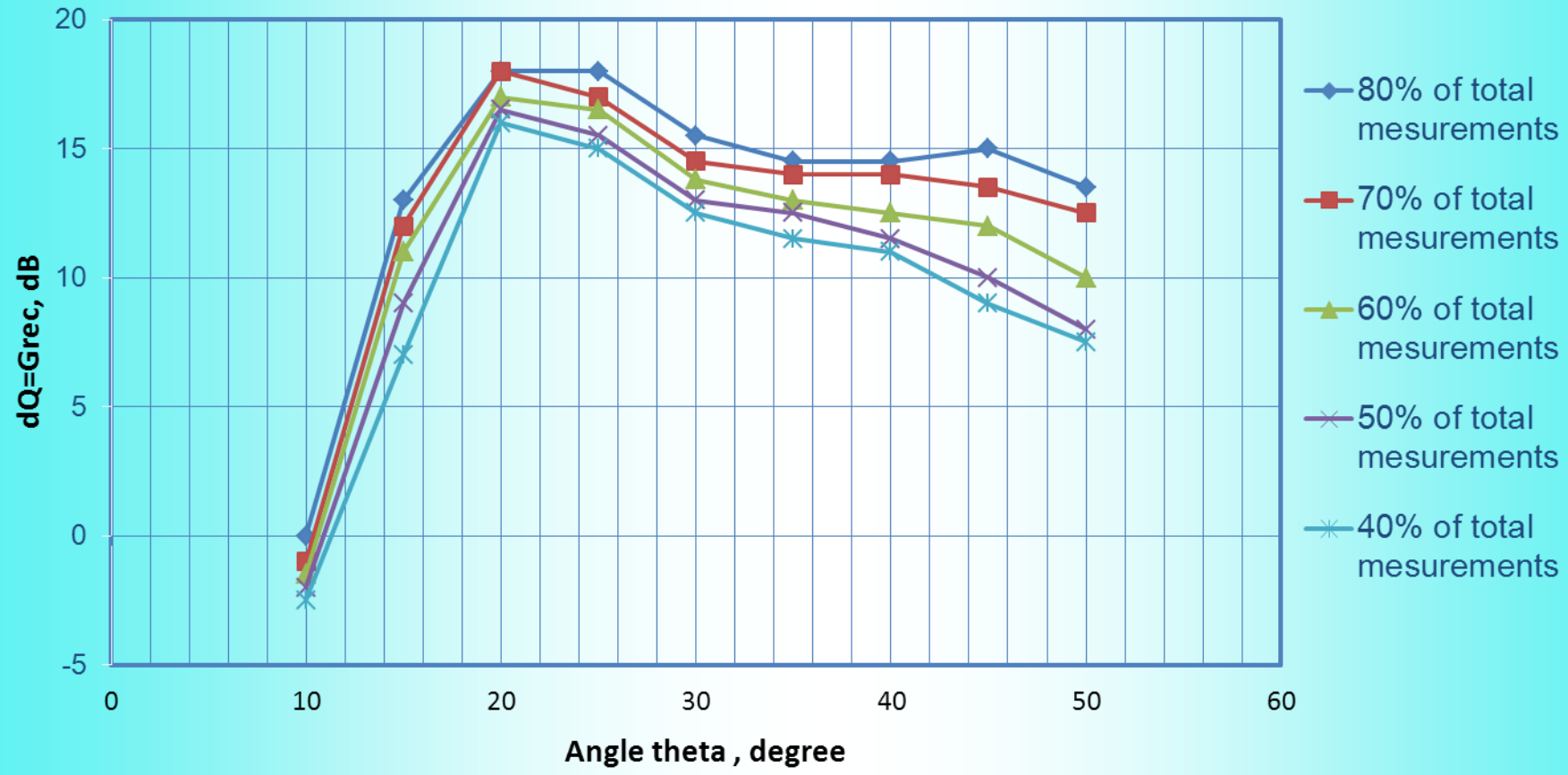


# The group of graphs of the distribution function of the dQ - required addition receiver antenna gain



# The optimal receiver antenna pattern for HEO(Tundra) satellite

**For receiver signal accusation threshold Qthres =35dB/Hz and for range of shares of volume covered measurements from 40% до 80%**



# Proposals for the approach to evaluate the service availability for GNSS SSA

- Since the theoretically optimal antenna profile that would receive 100% of the potential measurements is quite hard to realize, it is proposed to calculate and present the theoretical profiles for a range of percentage of available measurements, 50%, 60%, 70%, depending on the angle of observation satellites.
- Another measure of evaluating the potential quality of service of GNSS in the space area is DOP factor. However, to normalize by this parameter is difficult, since its value strongly depends on the type and the position in orbit and used antenna system. Graphs are shown for the case of omnidirectional antenna will not show the potential for the user.

# Conclusion

- The approach proposed and designed for this methodology data and charts for all GNSS and the main types of orbits will enable potential users depending on the mission type and requirements for accuracy and availability of navigation sessions to choose the type and complexity of the antenna system and receiving equipment
- This approach allows potential users to more accurately estimate what contribution to the availability and accuracy of GNSS service to space zones resulting from the geometry and parameters of GNSS, and what part depends on the receiver and its antenna system
- It is invited to consider the presented approach and it development for use in later stages

# Thank You for attention

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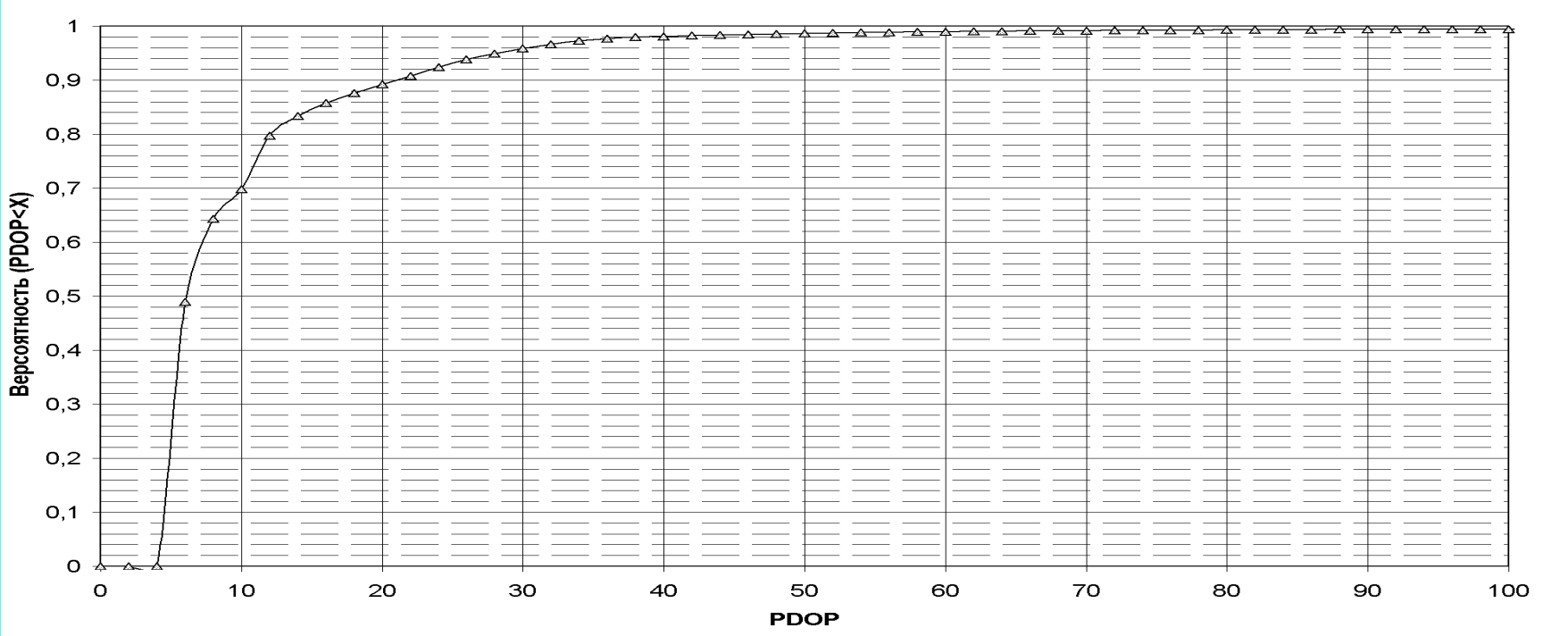
- A radical way to increase the availability of GNSS coordinate and time service for space users

# Way to increase the availability of GNSS for space users

- Set on the GNSS satellites extension transmitter transmitting signal in the direction from Earth to space
- Transmit one standard open signal in L1 bend
- Use the 3 dB not directive antenna
- Set the ttransmitter power on the level 35-40 W
- This will significantly expand the space navigation area up to Moon orbit

# Modeling PDOP for GEO user for GLONASS with additional space directed transmiter antenna



# PDOP on the trace Earth-Moon-Earth