JOINT-STOCK COMPANY
INSTITUTE OF SPACE DEVICE ENGINEERING

Signal Quality Monitoring

Authors: Yury Yaskin, General Director, Chief designer.
Valeriy Tyubalin, Deputy Chief designer

ICG-7 Meeting, Beijing, China , 4-9 November 2012

Avnues of development:

1. Controlling ephemeris information through monitoring station network of differential correction and monitoring system (SDCM).

2. Mobile equipment serves to control the GLONASS and GPS navigation signals. It is used for testing vehicles equipped with satellite navigation equipment.

3. Fixed equipment serves to control navigation signals in time and spectral domains, and power characteristics of navigation signals.

Mobile equipment to control the GLONASS and GPS navigation signals (MECNS). The hardware composition.

Mobile MECNS . Software. Constellation characteristics forecasting .

Forecasting is based on the GLONASS and GPS almanacs.

Any point can be defined on the world map – performance forecasting will be provided for it exactly.

Forecasting is made for various antenna "masks" taking into consideration possible shady sectors.

Height of users may be up to 7000 km.

Possible mutual conversion of different coordinate systems.

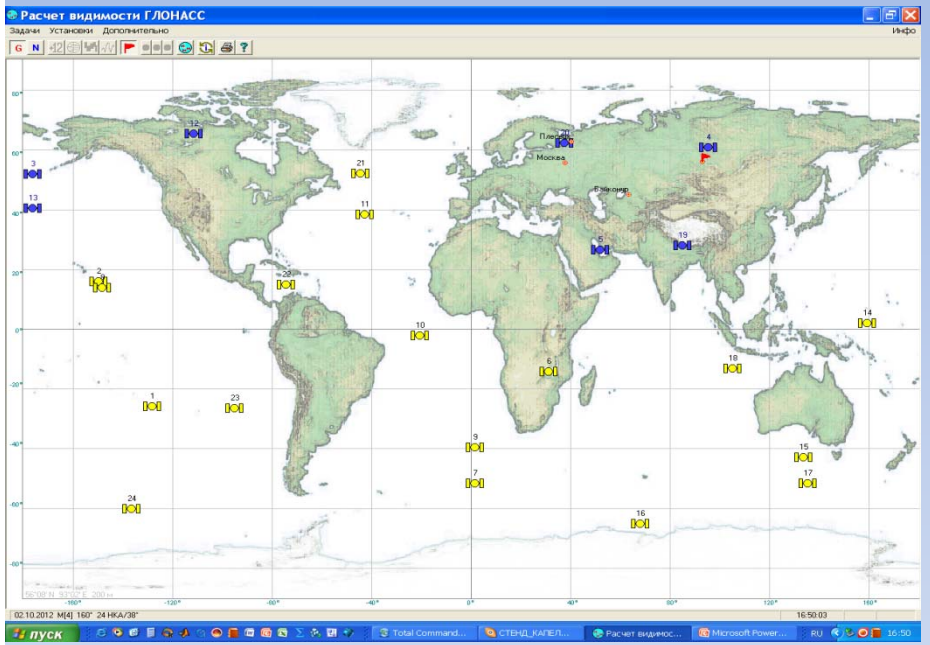
The following characteristics are predicted :

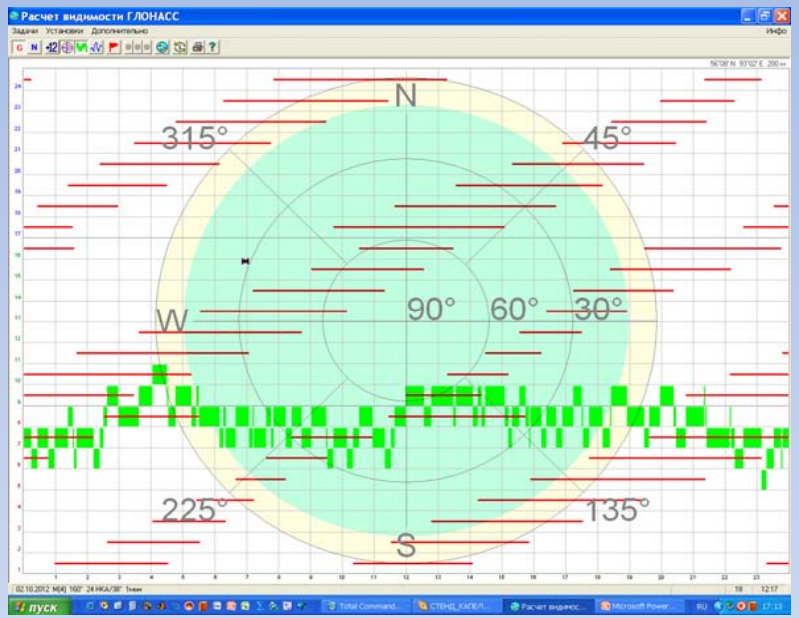
- Visibility zone of each satellite in a constellation at a given point;
- Satellite position on the celestial sphere, the angle of elevation, azimuth.
- The coefficients of the geometry: HDOP, VDOP, PDOP, TDOP, GDOP
- Availability over a time period on the basis of two criteria: guaranteed number of visible satellites and guaranteed geometry coefficient .
- Integral characteristics of positioning global accuracy.
- Integral characteristics of satellite global coverage.

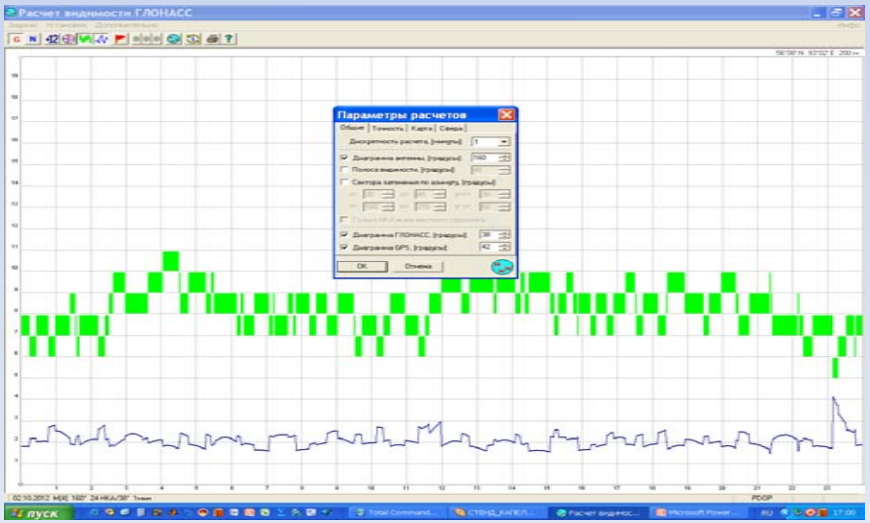
Recording all major parameters.

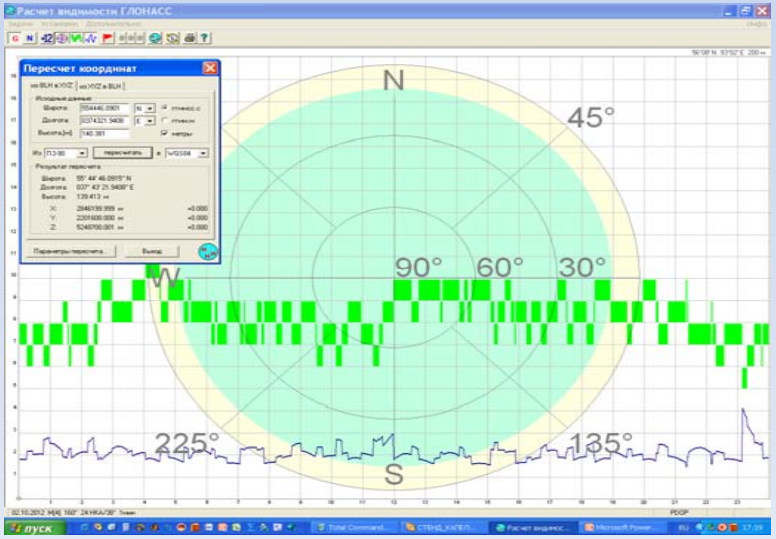
JOINT-STOCK COMPANY
INSTITUTE OF SPACE DEVICE ENGINEERING

Constellation characteristics forecasting. Selection of a point. Geometry factors, availability, position in the celestial sphere.



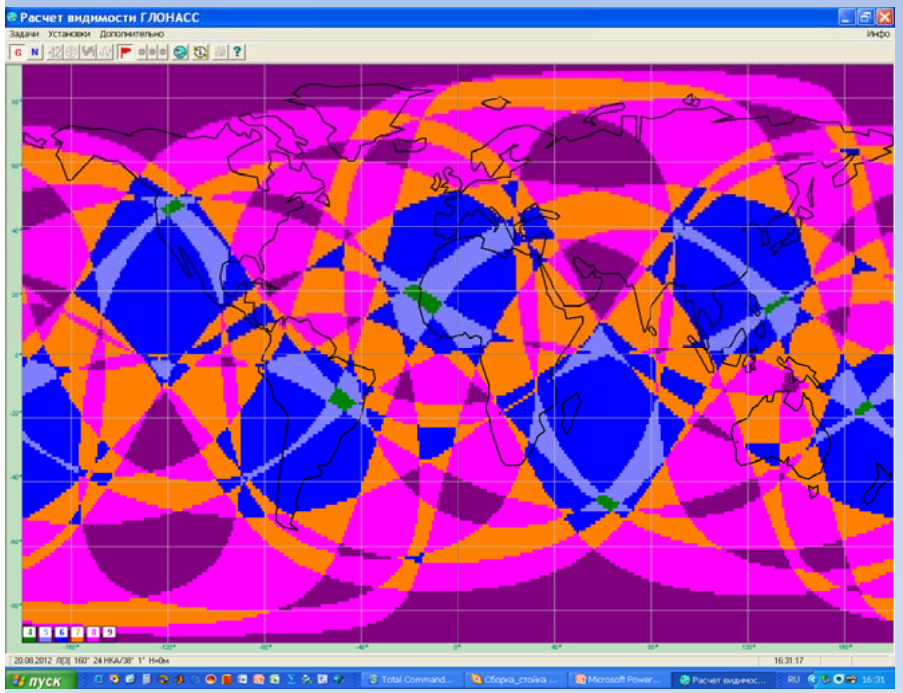


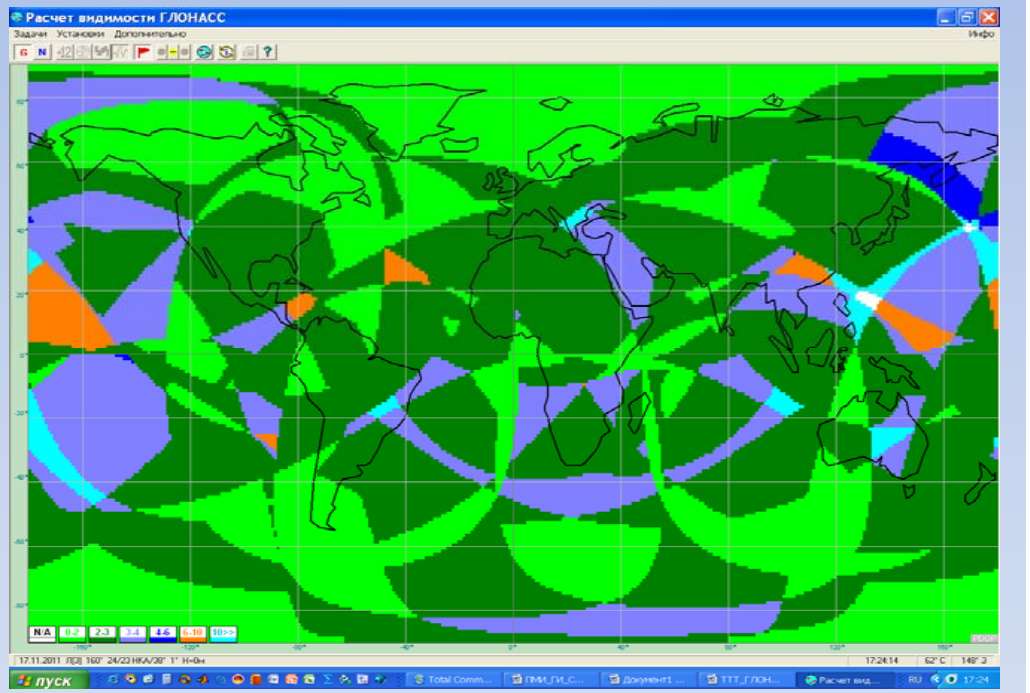




JOINT-STOCK COMPANY
INSTITUTE OF SPACE DEVICE ENGINEERING

Constellation characteristics forecasting. Number of visible satellites. Accuracy characteristics.





Real time software.

There are the following operation modes in real time: "Movement", "Stop", "Control of the field."

In all modes, equipment can work with the following GLONASS and GPS signals:
GLONASS (C/A, L1, L2) + GPS (C / A L1, L2C); GLONASS (C/A L1, L2); GPS (C / A L1, L2C).

In all modes the following parameters are displayed:
receiver channels monitoring (L1/L2 channels energy budget, search / tracking)
position (current time, coordinates in a given system, satellite's number in the solution, estimation of coordinates and velocities accuracy (planned and altitude), altitude, course;
satellite location in the celestial sphere (azimuth and elevation);
continuous measurement on L1 and L2;
messages on received information.

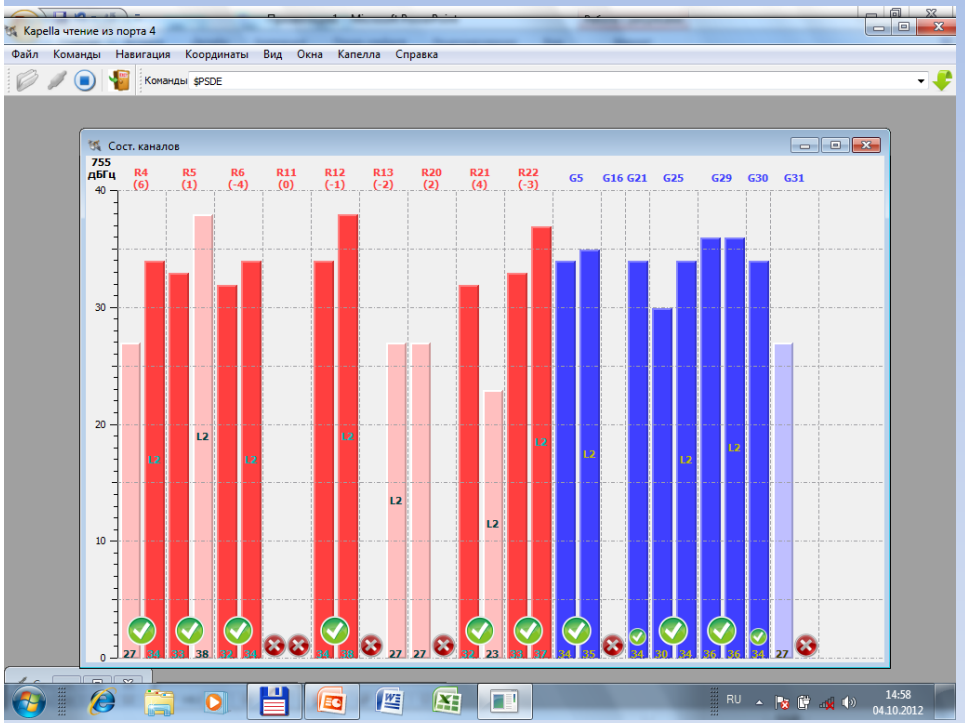
"Stop" and "Control field" modes display additional information
accuracy "Target" for plane coordinates;
differential operation modes (correction data / receiving and processing correction data according to the RTCM 104 standard).

"Control field" mode displays additional information:
Screening GLONASS and GPS satellites using RAIM algorithms ;
RAIM thresholds can be set by the operator either using SBAS data or without it.

All digital information is recorded in decimal and binary form. A communication session can be stored and replayed later. Archive time - 30 days.

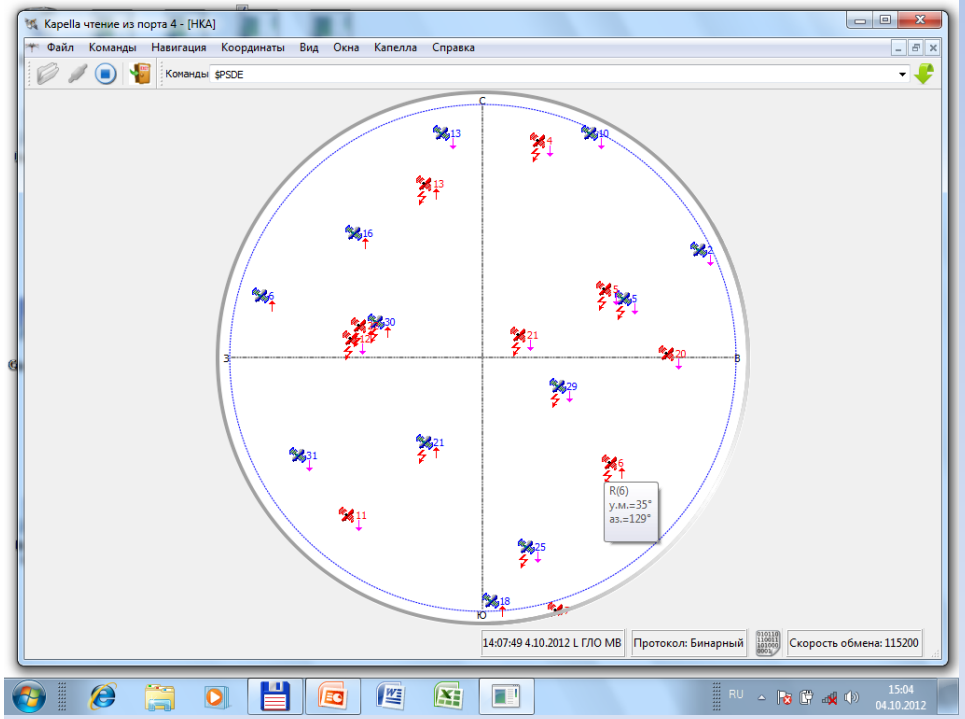
JOINT-STOCK COMPANY
INSTITUTE OF SPACE DEVICE ENGINEERING

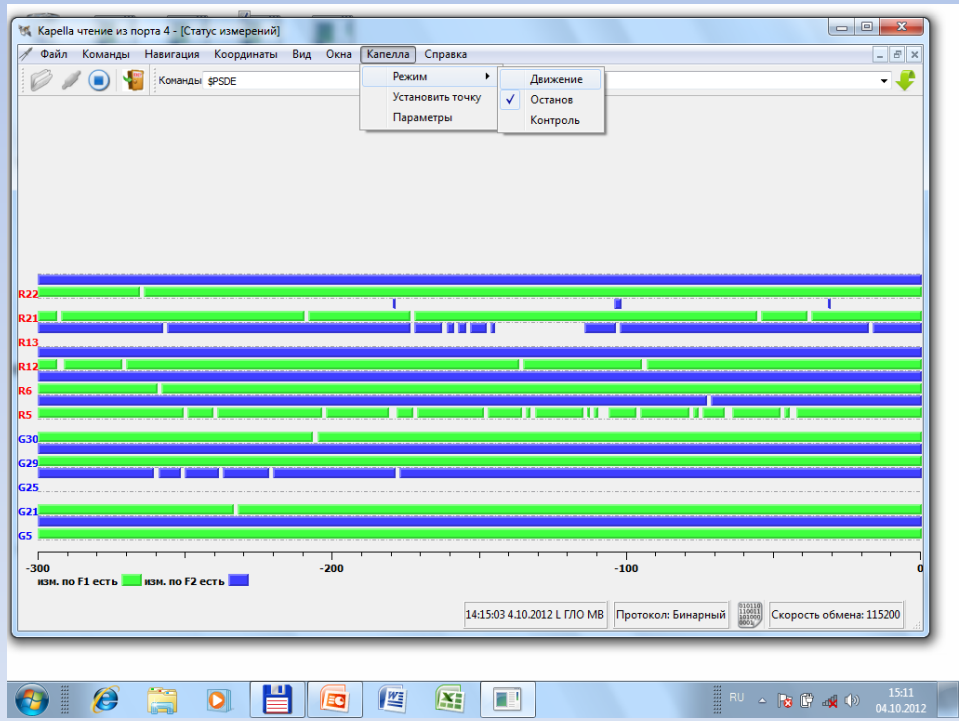
Status and power budget of receiving channels. Position.



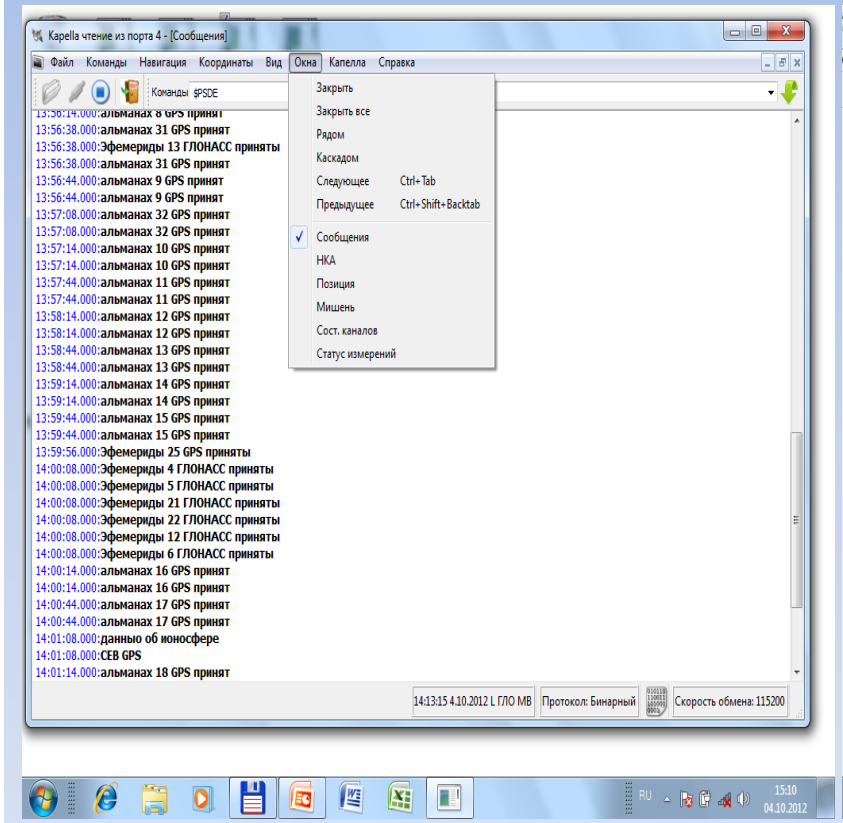
JOINT-STOCK COMPANY
INSTITUTE OF SPACE DEVICE ENGINEERING

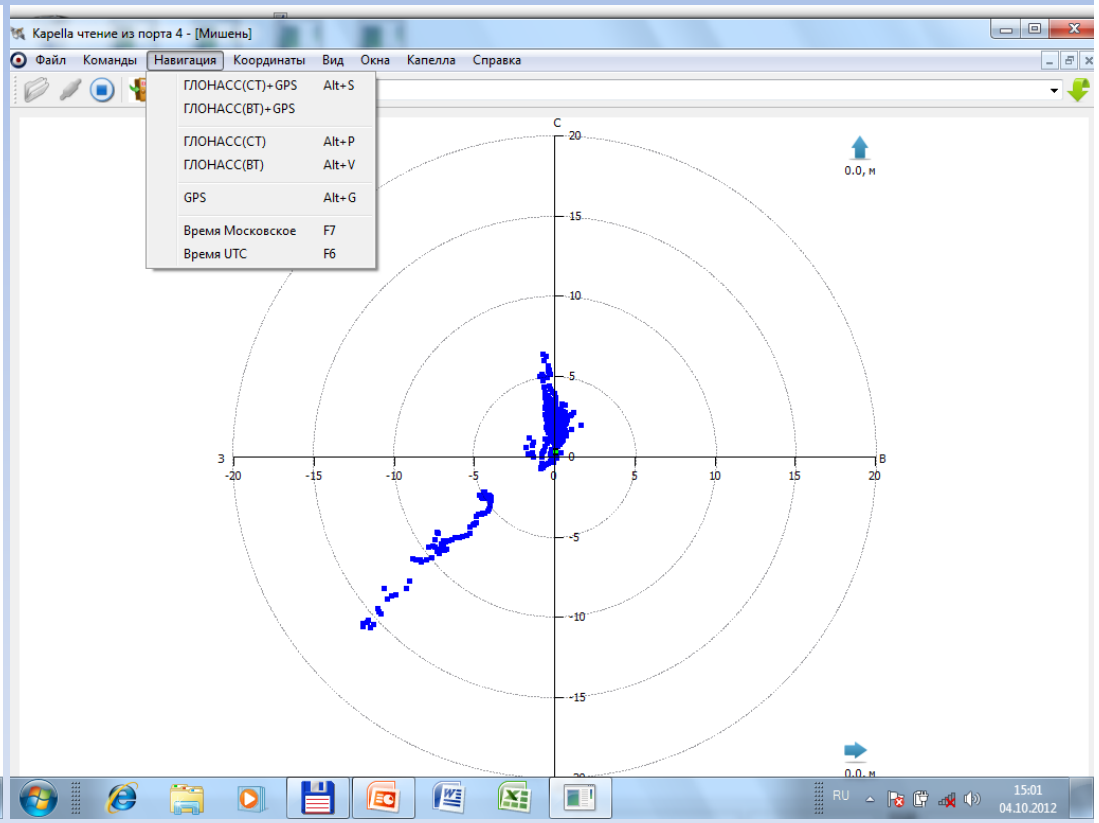
Satellites position in the celestial sphere. Continuous measurement on L1/L2.



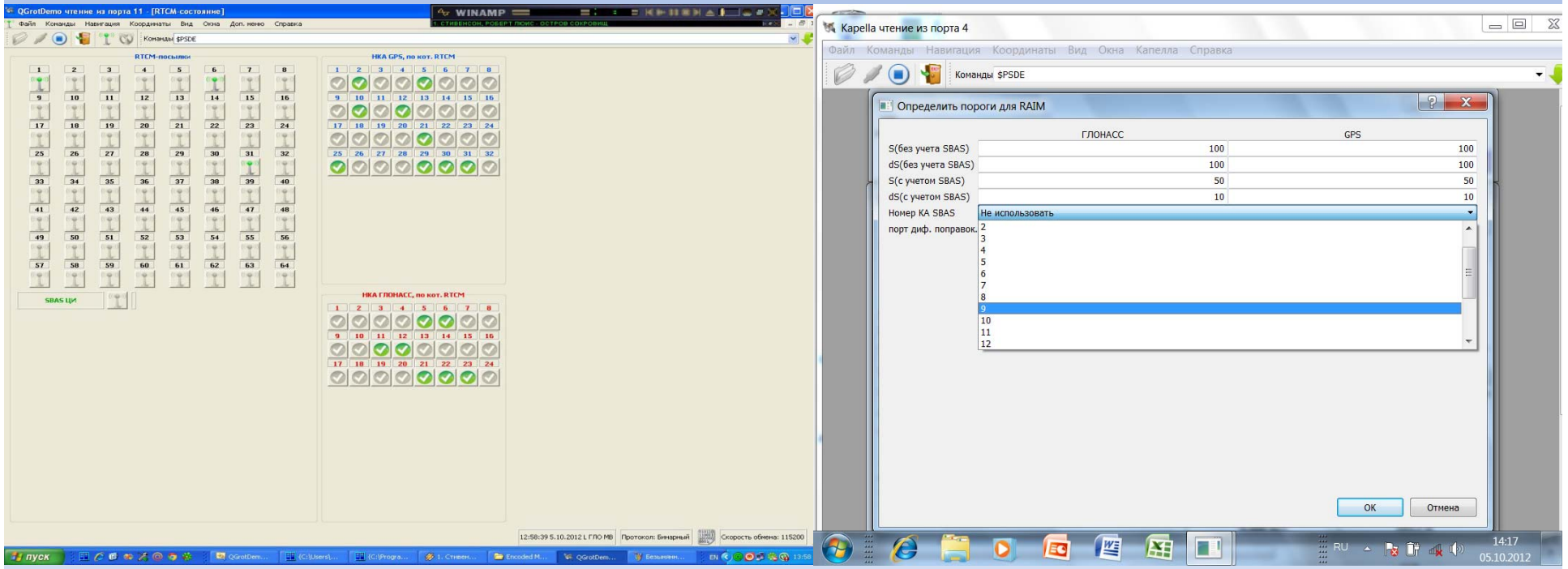


Message, the target





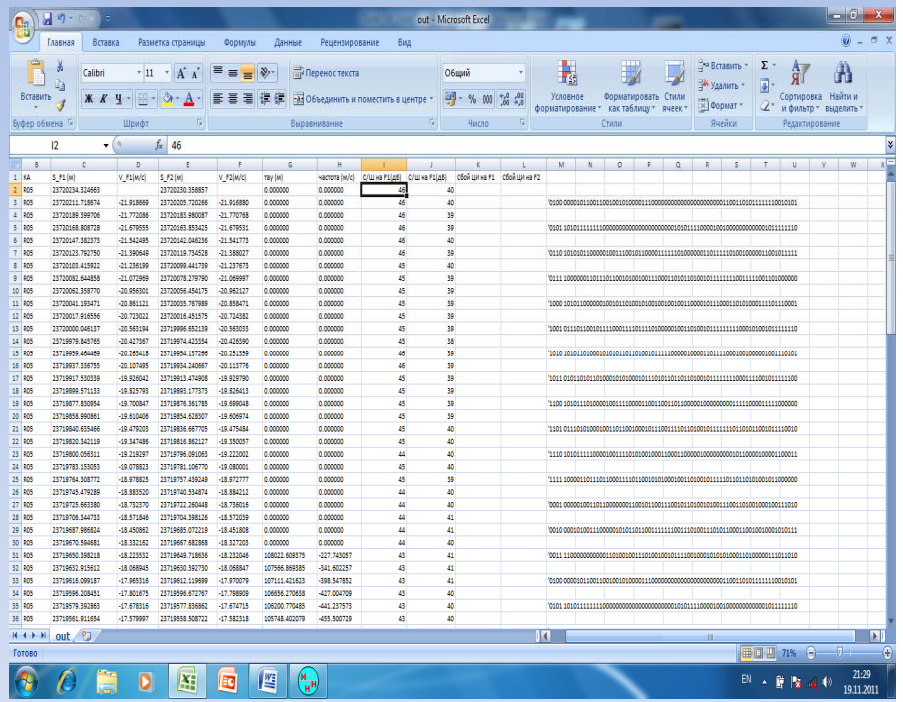
Differential mode. RAIM thresholds.



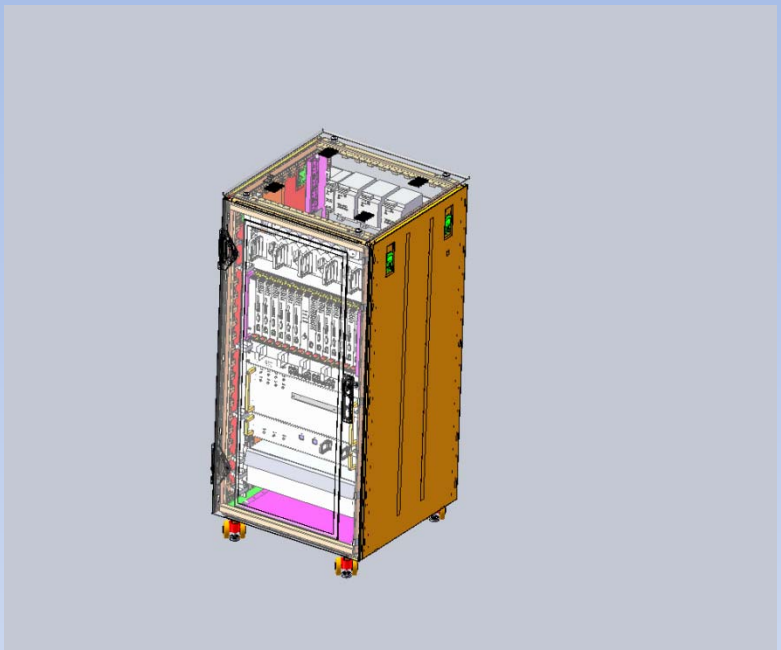
Example of recording digital information. Measurements. Recorded binary frame.

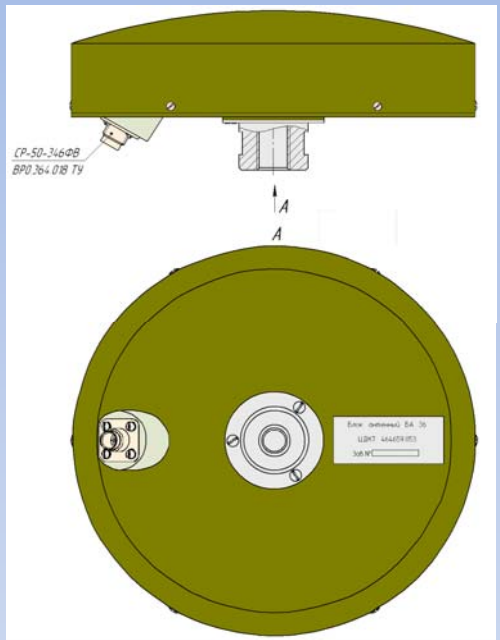
09:07:38.000
эфемериды приняты для НКА ГЛОНАСС 15
t_b = 3.330000000e+04
SV_Helth =0x 0
IODC =0x 25
X = 1.944899170e+04
Y = 1.642590918e+04
Z = 2.288999512e+03
Vx = 3.958740234e-01
Vy = 2.909755707e-02
Vz = -3.581364632e+00
Ax = 1.862645149e-09
Ay = -9.313225746e-10
Az = 0.000000000e+00
gamma = 1.818989404e-12
tau = -7.383152843e-05
dtau = 3.725290298e-09
en = 0

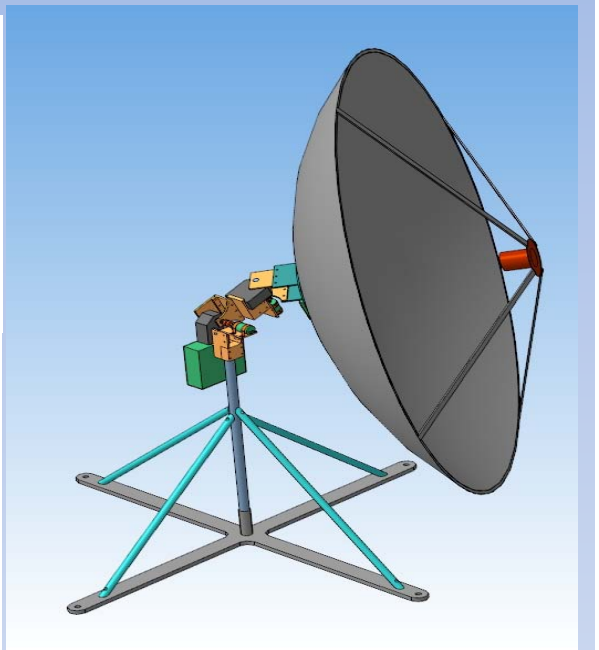
09:07:33.000
эфемериды приняты для НКА GPS 10
Code_on_L2 =0x0000000000000001
L2_P_flag =0x0000000000000000
SV_accuracy =0x0000000000000000
SV_Health =0x0000000000000000
IODC =0x0000000000000016
fit_interval_flag =0x0000000000000000
Tgd = -2.793968e-09
Toc = 4.608000e+05
Af0 = -1.940737e-05
Af1 = -1.136868e-12
Af2 = 0.000000e+00
e = 1.07813964132e-02
dn = 5.008066e-09
M0 = 8.20028294339e-01
SqrtA = 5.15364611053e+03
Toe = 4.608000e+05
Omega0 =-2.93632310873e+00
I0 = 9.47870835676e-01
W = 7.16680260838e-01
OmegaDot = -8.509640e-09
IDOT = -2.189377e-10
Cuc = 1.139939e-06
Cus = 6.193295e-06
Cic = -8.381903e-08
Cis = 9.685755e-08
Crc = 2.538750e+02
Crs = 2.093750e+01



Fixed equipment. Composition.







12 identical reconfigurable for different GNSS receivers in the eurorack :
GLONASS (L1, L2, L3/L5, C/A, P, FDMA, CDMA);
GPS (L1 C / A, L1C, L2C, L5);
GALILEO (L1 E1, E5a, E5b);
COMPASS (L1 BOC 1,1);
QZSS (L1 BOC 1,1; L5 BPSK 10);
SBAS (L1, L5).

Antenna (omnidirectional, directional), a set of cables, laptop, Power Supplies.

Software of the fixed equipment .

Software of fixed equipment includes:

**Software to predict orbital GNSS performances and their augmentations. Fixed equipment software structure is similar to the software for mobile GLONASS/GPS equipment.
Also for other GNSS**

**Real-time software is similar to the software for mobile GLONASS/GPS equipment.
Also for other GNSS**

Development of software for different GNSS signals depends on the interface control documents for these signals .

Status of development.

Eurorack is designed and manufactured.

Receivers are designed and manufactured.

Software is developed and aligned for GLONASS (L1, L2, C/A) and GPS (L1 C / A, L2C).

SQM monitoring of the GNSS navigation signals.

Monitoring the quality of GNSS navigation signals performs the following functions:

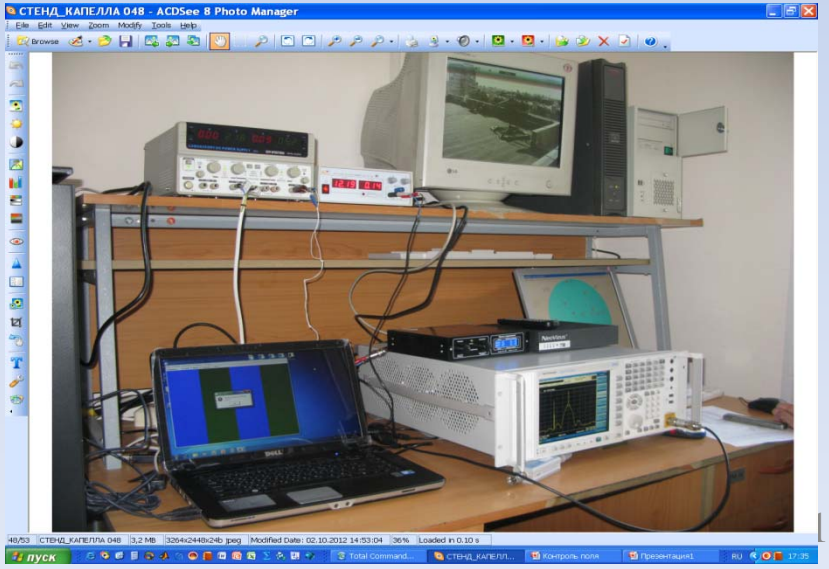
- estimates spectral characteristics of the navigation signals;
- estimates spectral and energy characteristics of the interference;
- displays and estimates the time characteristics of the navigation signals;
- estimates the energy characteristics of navigation signals.

Composition of the equipment to control quality of GNSS navigation signals.

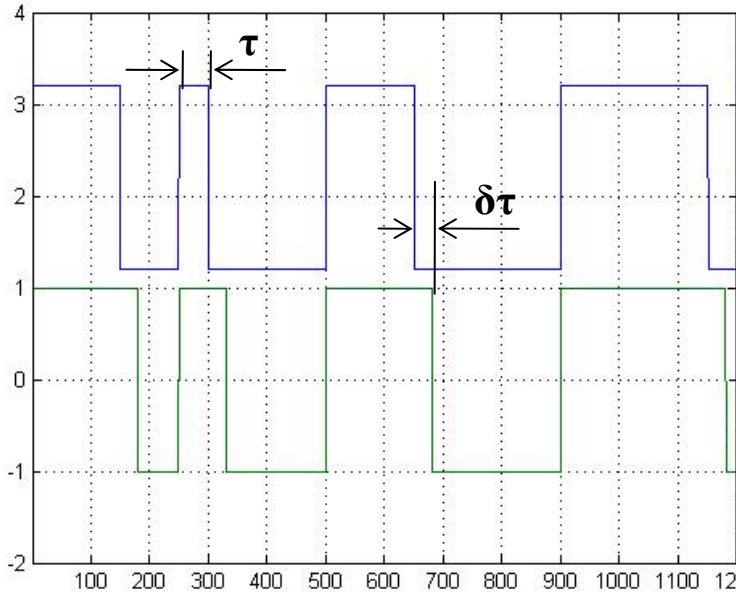
- Beam antenna diameter, d = 3.7 m, gain, K = 33 dB. Antenna control system, monitoring antenna orientation system.
- Dedicated receiver.
- A high-quality spectrum analyzer.
- Dedicated software .
- Laptop.

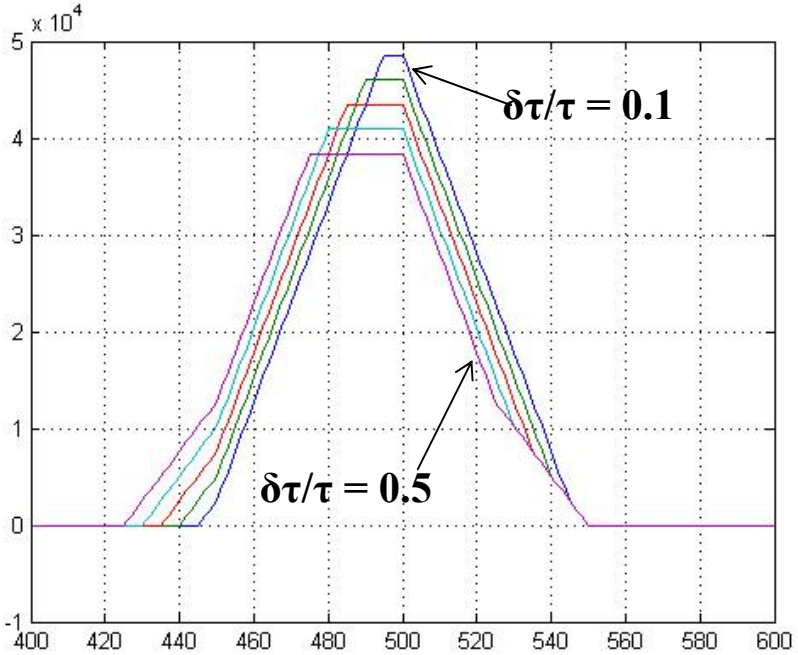
JOINT-STOCK COMPANY
INSTITUTE OF SPACE DEVICE ENGINEERING

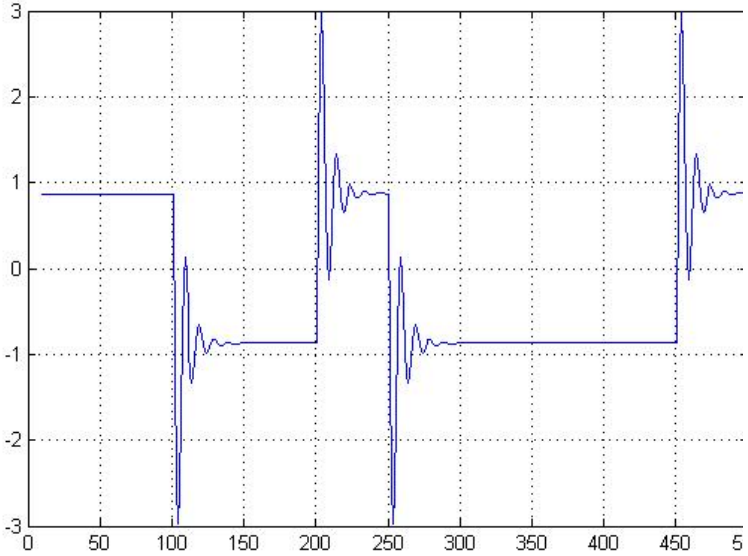
SQM. Fixed equipment

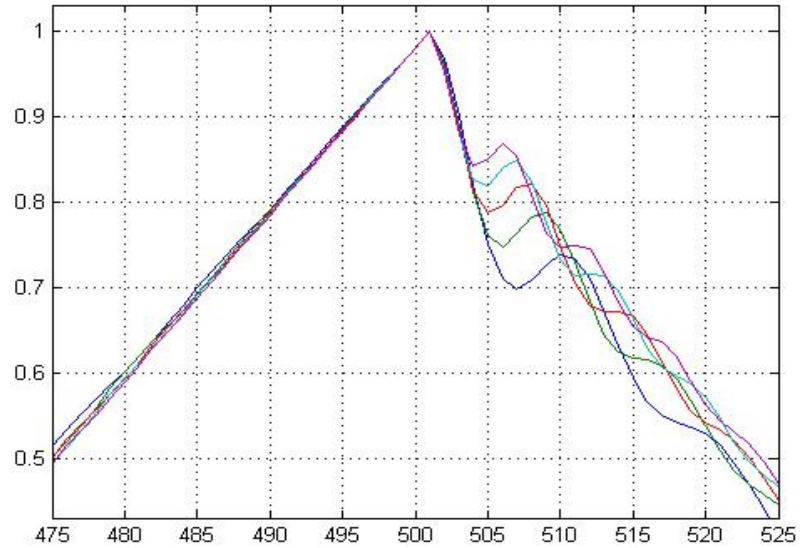


Distortion (1-st and 2-nd type) of a signal in time domain.

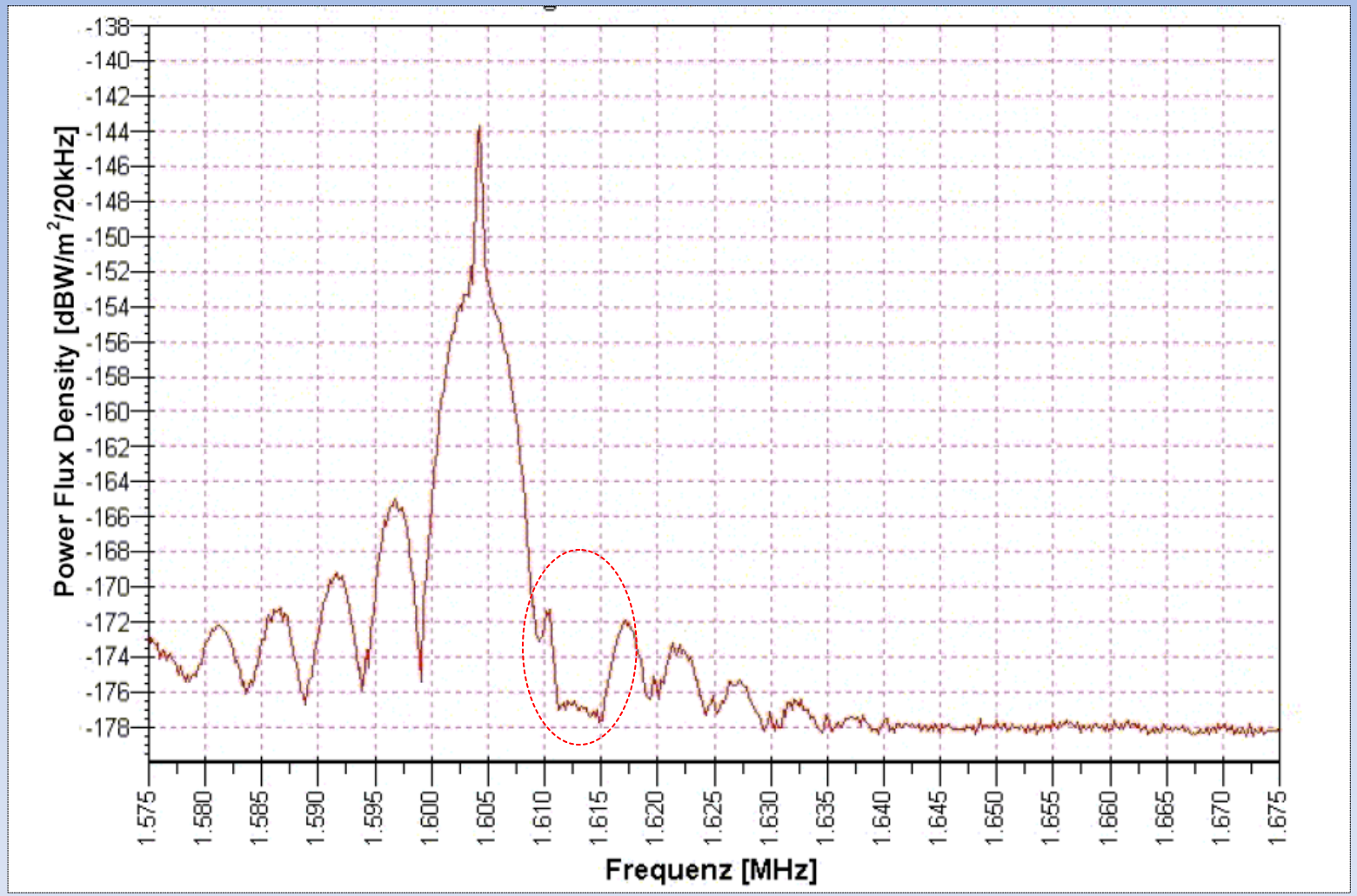








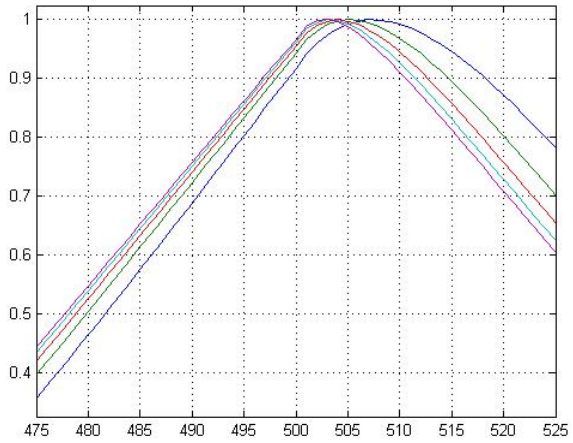
Spectrum distortion of GLONASS navigation signals on the L1 band



Modeling of navigation signal distortion.

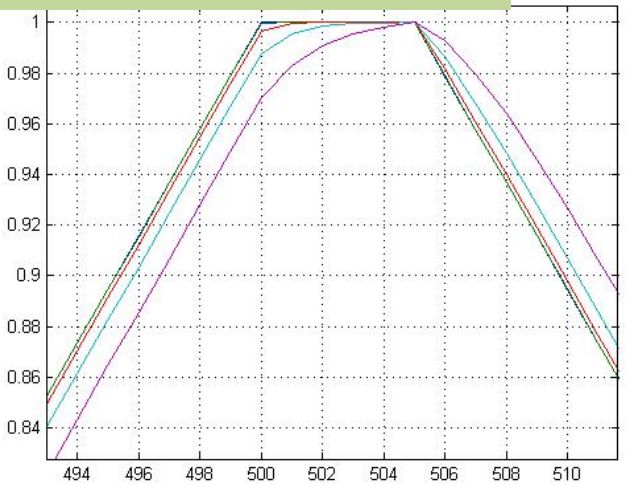
Simulation served to define basic parameters of a dedicated receiver.

ADC.



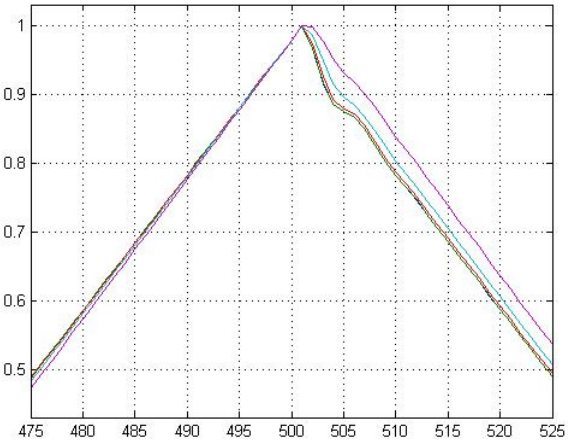
ACF in the finite duration of the transition process.

Δf in L1 band.



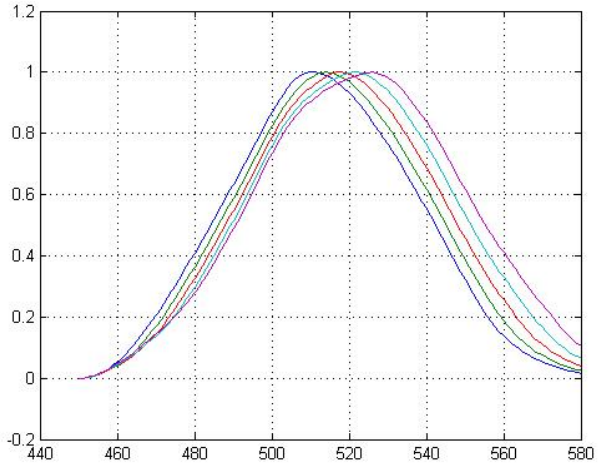
ACF at distortions of the 1st kind and band-limited input signal.

Δf in L5-L2 band.



ACF view the perversions of the 1st kind and band-limited input signal.

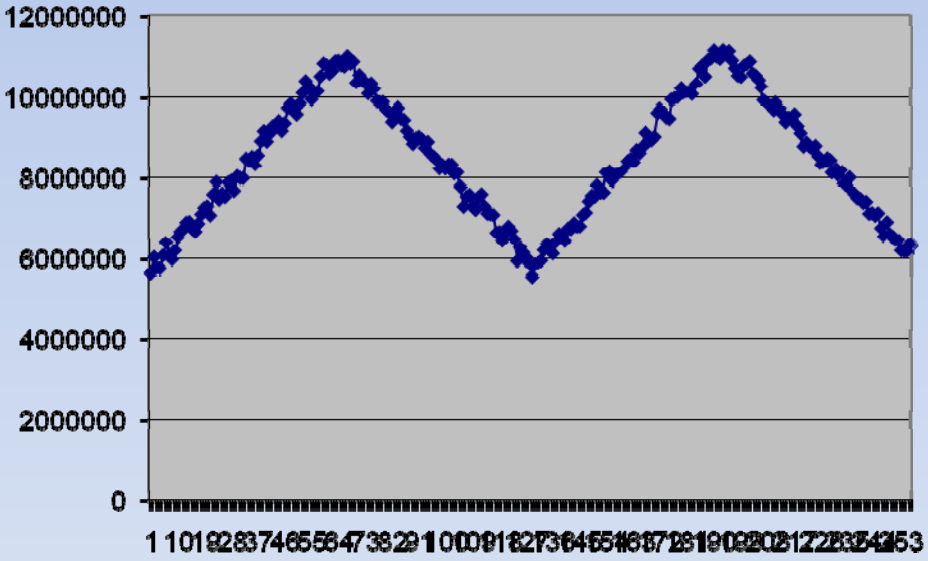
Number of points of the ACF.



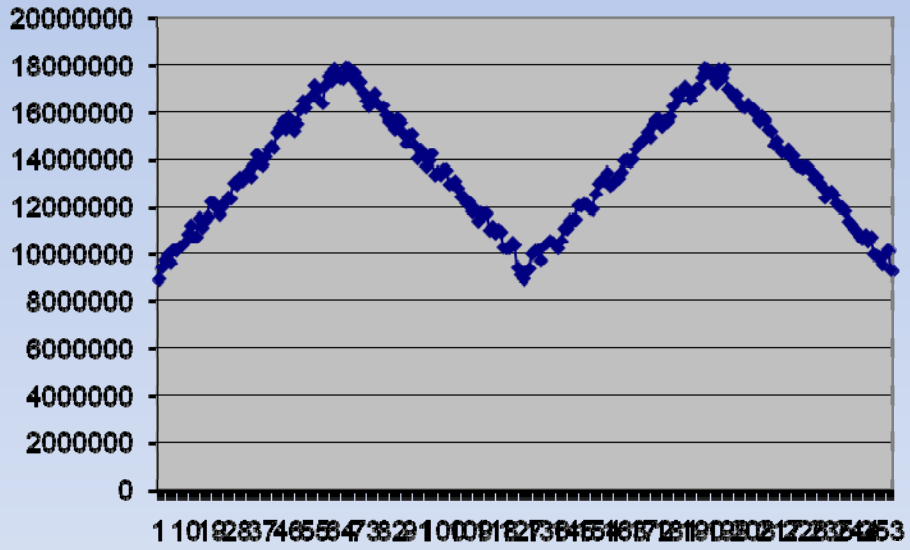
View of ACF in the band 2 and a different change of duty cycle.

Experimental studies of navigation signals.

Glonass-M; № 13, (f. = -2, ACF - 128, date: 30 August 2012, L1 band. Point coordinates: 55 ° 34 'N, 37 ° 38' I (Moscow).



GPS; № 4, (ACF - 128, date: 30 August 2012, L1 band. Point coordinates: 55 ° 34 'N, 37 ° 38' I (Moscow).

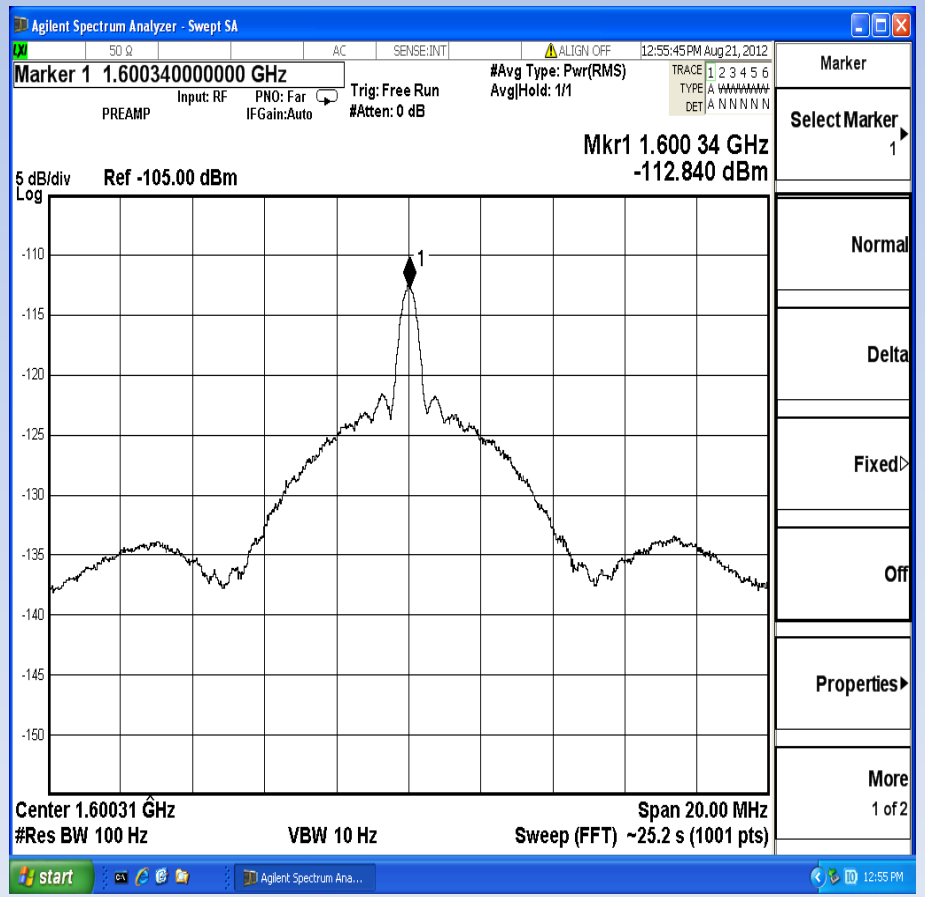


JOINT-STOCK COMPANY
INSTITUTE OF SPACE DEVICE ENGINEERING

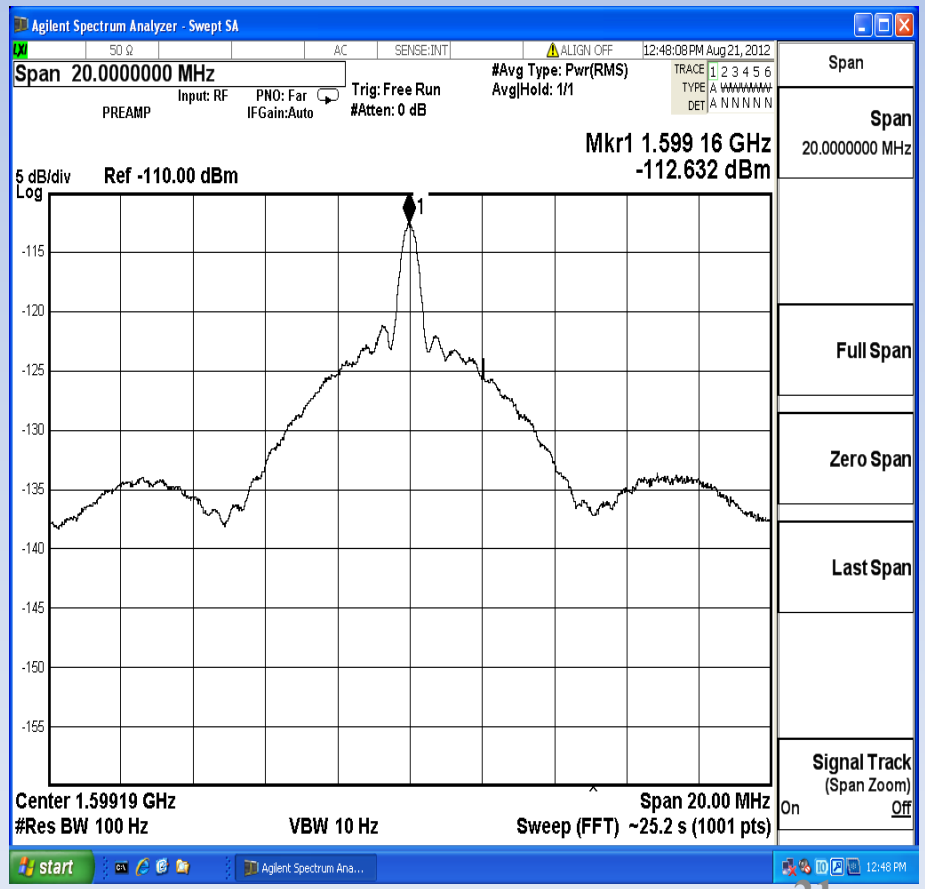
Experimental studies of navigation signals spectrum.

Band L1

Glonass-M № 22



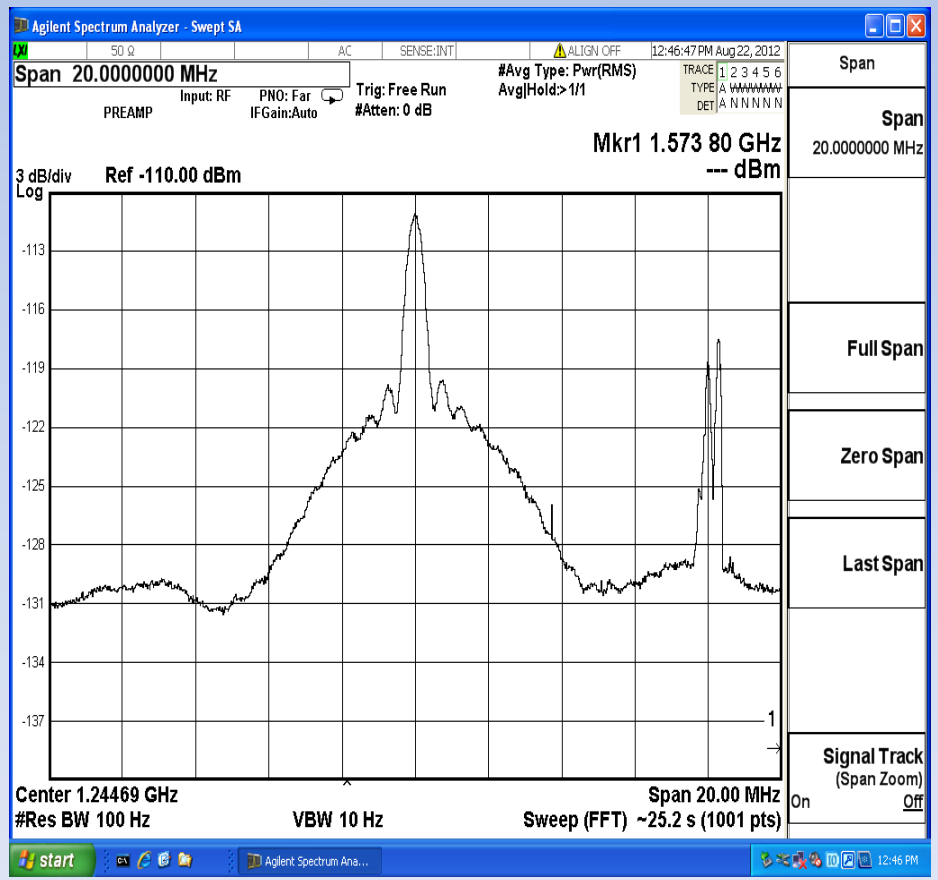
Glonass -K;



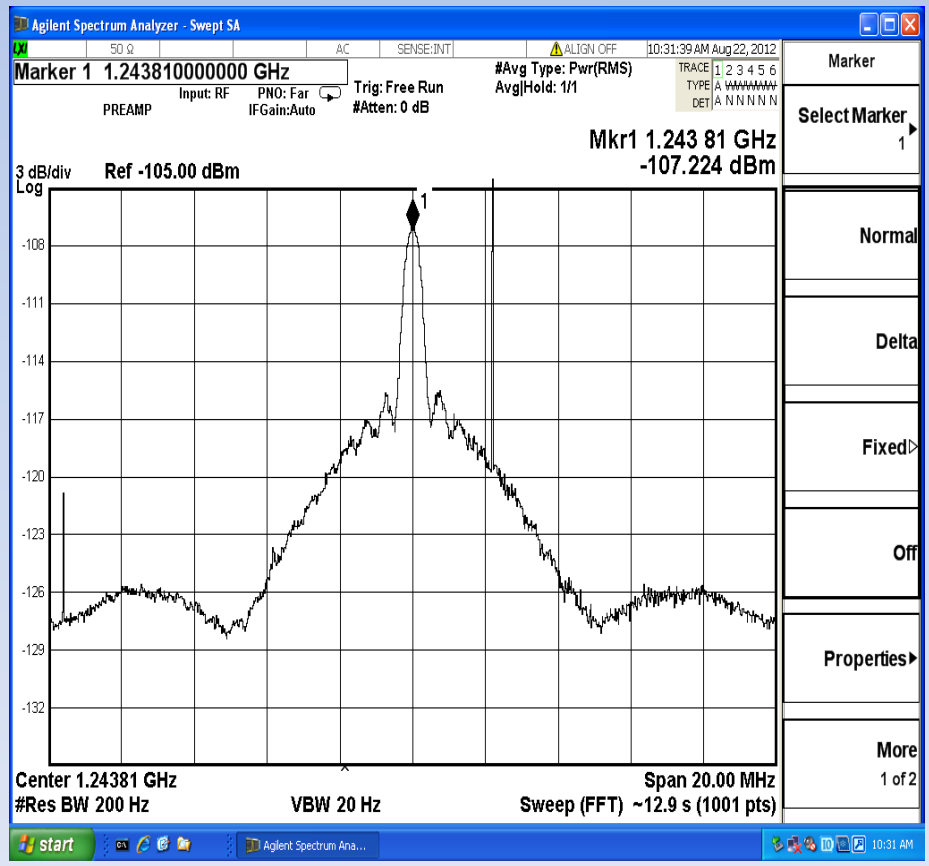
Experimental studies of navigation signals spectrum.

Band L2

Glonass-M № 22



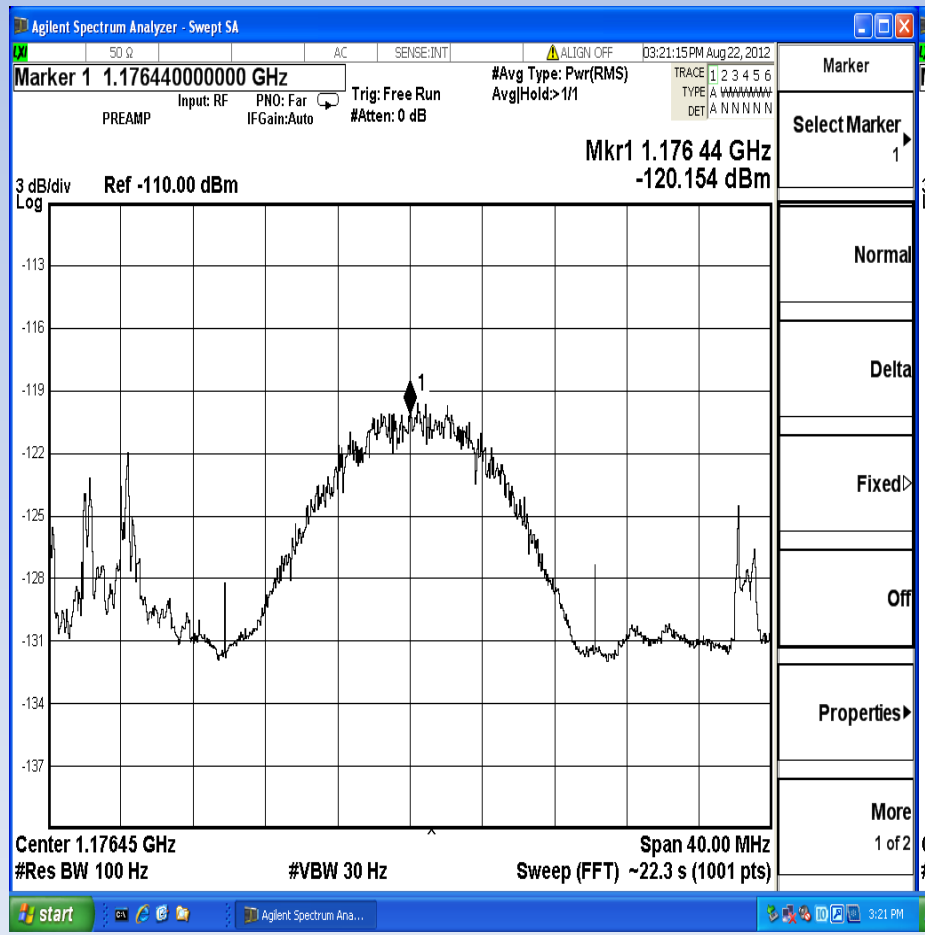
Glonass -K



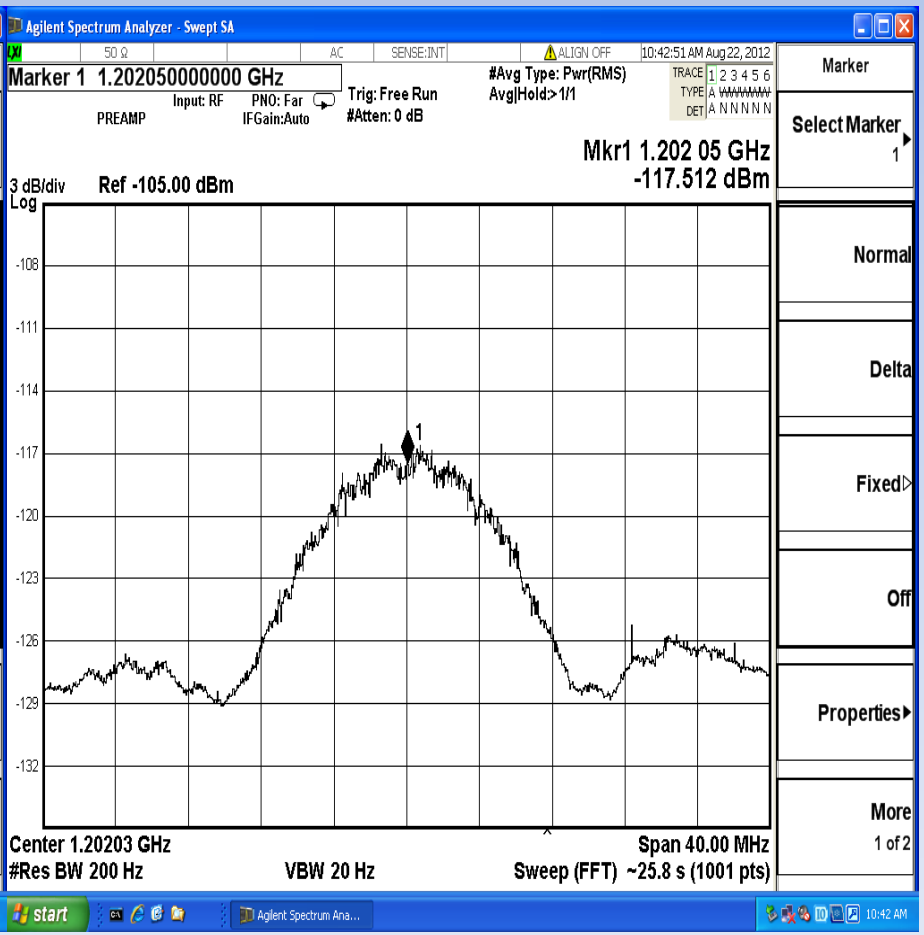
Experimental studies of navigation signals spectrum.

Band L3/L5

GPS № 25



Glonass -K



Conclusions (1).

1. Compact (mobile) 64 - channel equipment to control GLONASS/ GPS navigation signals on L1/L2 bands are designed, manufactured and operate.

2. Such equipment is especially useful in areas of testing mobile technique using the GLONASS/GPS satellite navigation device. It allows you optimally plan the tests and serve as a "referee" in conflict situations .

3. Fixed multi-system navigation signals monitoring equipment can receive and process open signals of all (now known) GNSS and their augmentations. This allows you to compare and evaluate different GNSS options. The equipment is designed so that if any GNSS signal structure is modified, then it will be sufficient to reprogram the settings without changing the hardware. The equipment is manufactured. Currently, this equipment and software are being tested.

Conclusions (2).

4. Developed quality control system for GNSS navigation signals on the band of L1, L2 and L3/L5 allows:

- estimate modulating wave distortions : changing pulse bandwidth, presence of the transient process in the pulse bandwidth formation;
- estimate the level of the navigation signal near the ground;
- estimate the spectral characteristics of the signals;
- estimate interference conditions at the receiving point .

5. The state of SQM development: the equipment is manufactured; currently this equipment and software are being tested; calibration equipment for directional antenna is mounted.

Thank you for your attention