Accuracy Positioning with GNSS technology of Topcon

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TOPCON POSITIONING SYSTEMS

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ION-Alberta

It's time.

Multi-system GNSS receivers

- - Navigation application;
- - GIS application;
- - Survey application;
- - Machine control application;
- - Agricultural application.

Past and present line of TOPCON GNSS receivers

Survey GNSS receivers of Topcon

G3 technology: tracking of GPS/GLONASS (C/A, P L1, P L2, L2C) + GPS L5 + Galileo

GMS-2: L1 GPS/GLONASS receiver for GIS with camera and compass.

Classical HiPer receivers is very popular receivers.

GNSS antennas of Topcon


Legant


CR3

PG-A1/2/3


MG-A1/2

OEM-boards

- Euro 112T, 40 channel, GPS/GLONASS L1/L2, 112mm*100mm, 2.7W

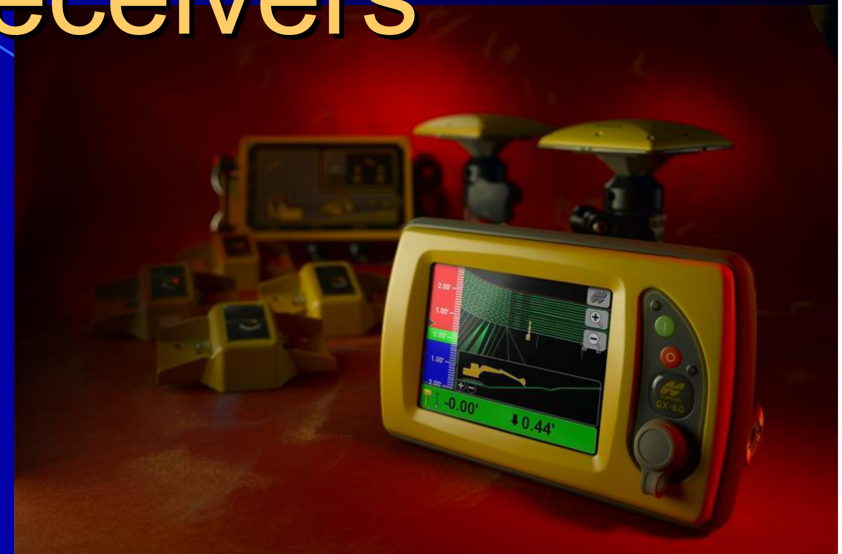
- Euro 160T, 40 channel, GPS/GLONASS L1/L2, 112mm*100mm, 3.5W, narrow “in-band" interference suppression, input/output frequency, 20nsec PPS, Co-Op tracking

- TG-3, 50 channel, GPS/GLONASS L1, 1.2W, 72mm*62mm, 100Hz measurements output

- Euro G3 160T, 72 Universal channel, GPS L1/L2/L2C/L5 , GLONASS L1/L2, GALILEO, 160mm*100mm, input/output frequency, 5nsec PPS

Machine Control of dozers/graders with GNSS receivers

Machine Control of excavators with GNSS receivers



Agriculture with GNSS receivers

- New SGR-1 receiver

Accuracy Positioning

- \- Multi-System navigation receiver;
- \- Advanced Design of navigation receiver;
- \- Advanced Multipath mitigation;
- \- Differential positioning;
- \- Common tracking loops (Co-Op tracking);

Software for Receivers Design (1)

The input data are as follows:

1) Parameters of the received signal

a. carrier frequency of the signal;

b. signal code (GPS or GLONASS; C/A or P-code);

c. carrier-to-noise power density ratio C/N_0;

e. power of the reflected signal (its relative amplitude) if multipath present.

2) RF-part parameters

a. quartz oscillator frequency;

b. local oscillator frequencies.

3) QADC parameters

a. sampling rate $f_s = 1 / T_s$;

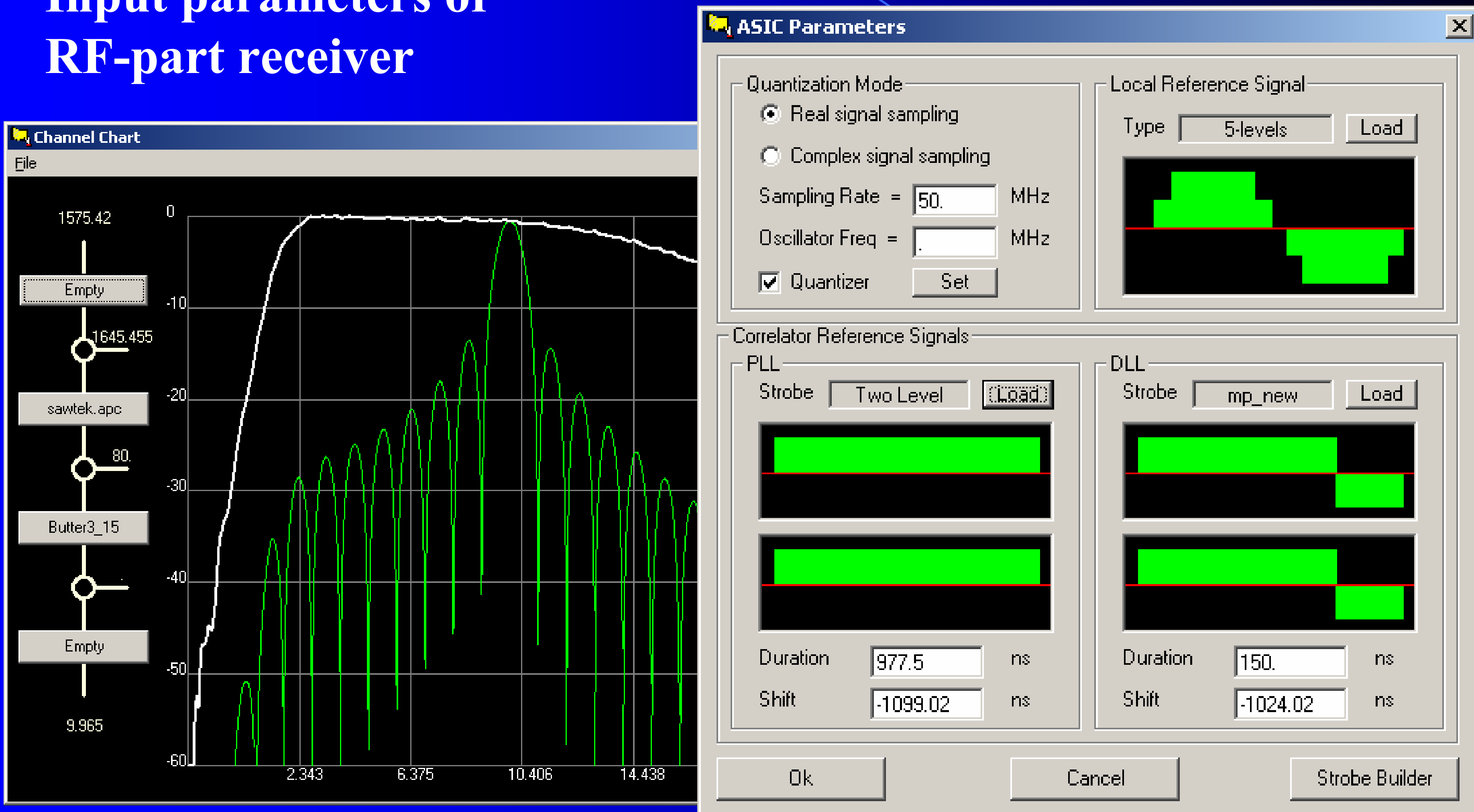
b. variant of signal quantization.

1. Vorobiev M., Zhdanov A., Zhodzishsky M., Ashjaee J. Automated Design of Navigation Receivers Multipath. Proc. of ION GPS-99, Nashville, Tennessee.

Software for Receivers Design (2)

CAD-package for the navigation receivers design

Input parameters of RF-part receiver



Software for Receivers Design (3)

Output parameters:

1) Statistical characteristics of correlation signals I, Q, dI, dQ

The computation of these parameters is carried out with the help of numerical methods rather than simulating approach, that is not so time-consuming.

2) phase and code noise errors

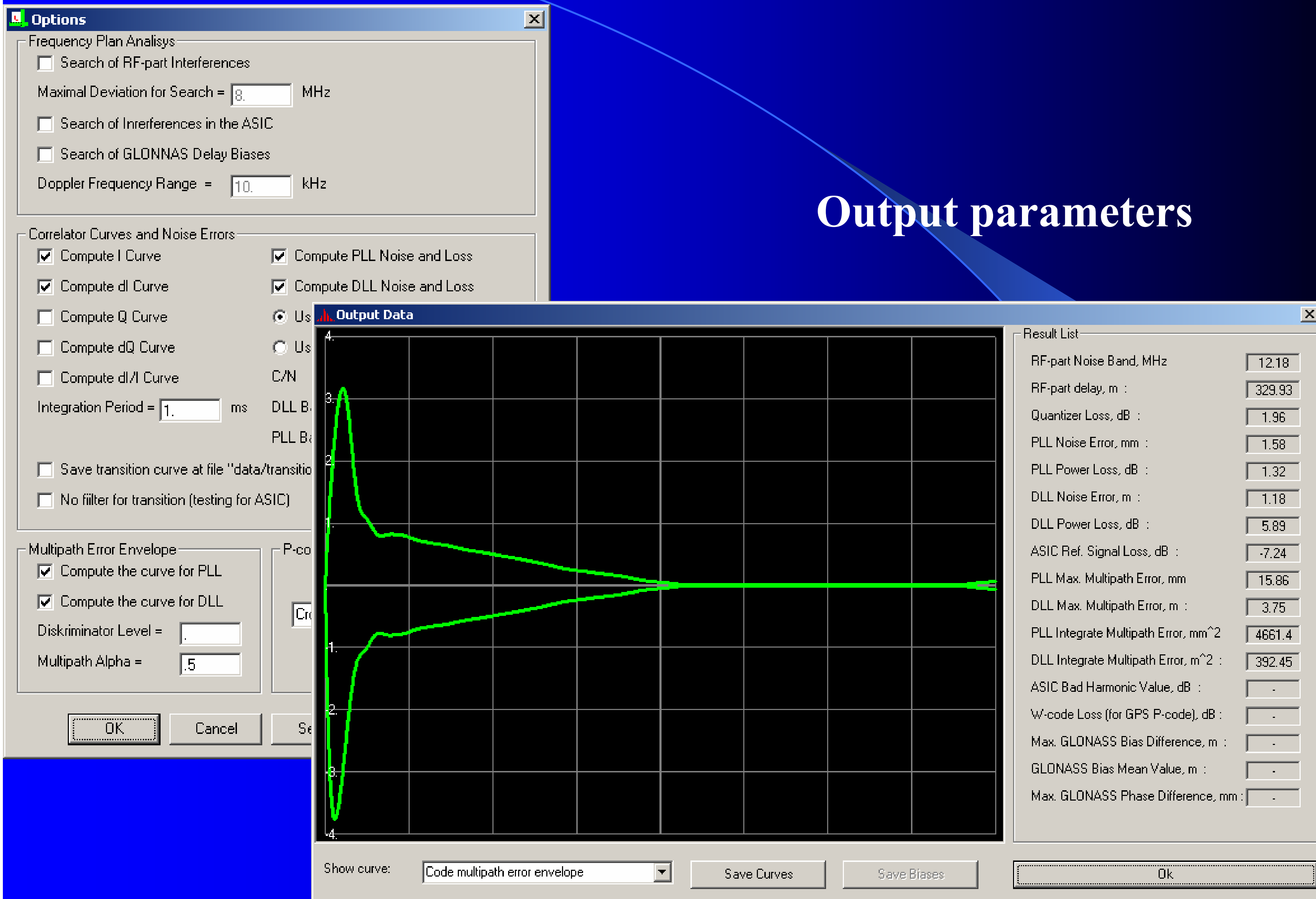
3) spurious harmonics due to low-level approximation of reference oscillations in ASIC.

4) interpath and interchannel biases

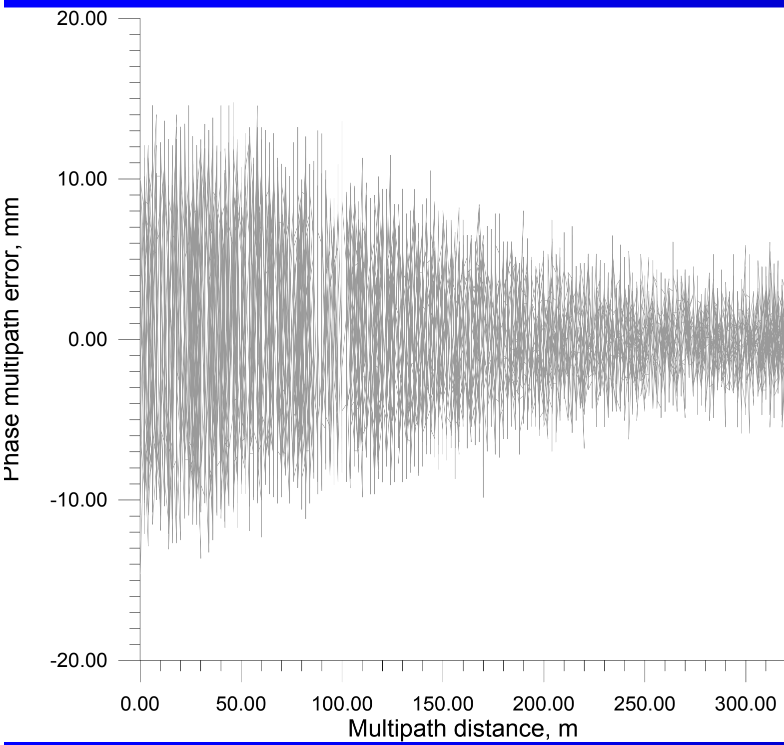
5) phase and code multipath errors

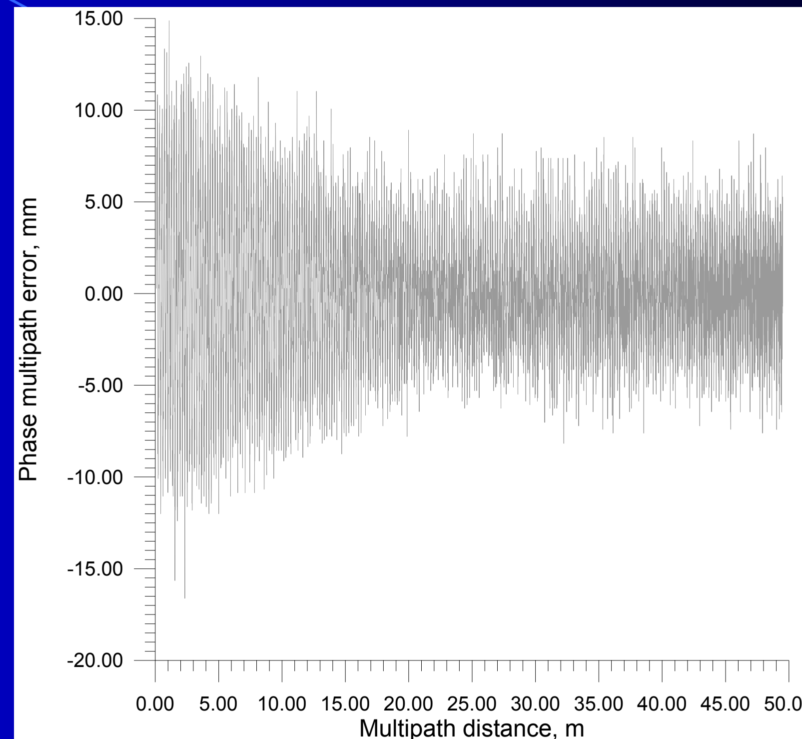
Software for Receivers Design (4)

Output parameters



Multipath mitigation with multipath strobe signals in receiver correlators (1)

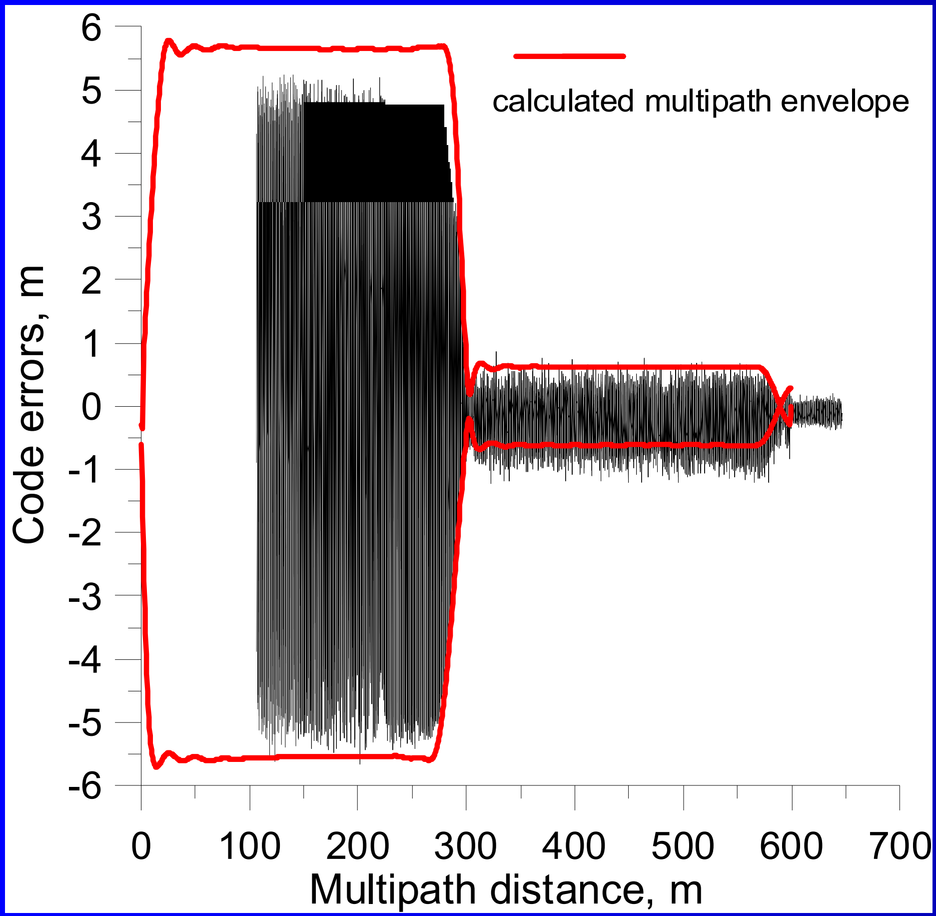


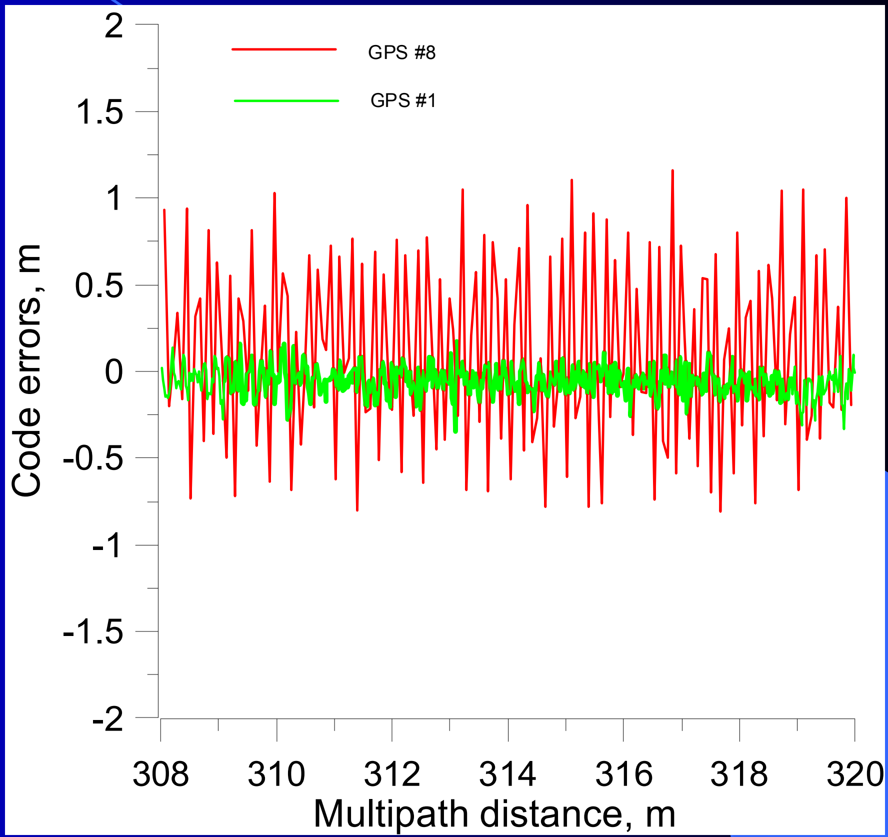


1. US6493378 Methods and apparatuses for reducing multipath errors in the demodulation of pseudo-random coded signals Zhodzishsky M. et al., Dec. 2002

2. Veitsel V., Zhdanov A., Zhodzishsky M. The mitigation of multipath errors by strobe correlators in GPS/GLONASS receivers. GPS Solutions, Volume 2, Number 2, Fall 1998

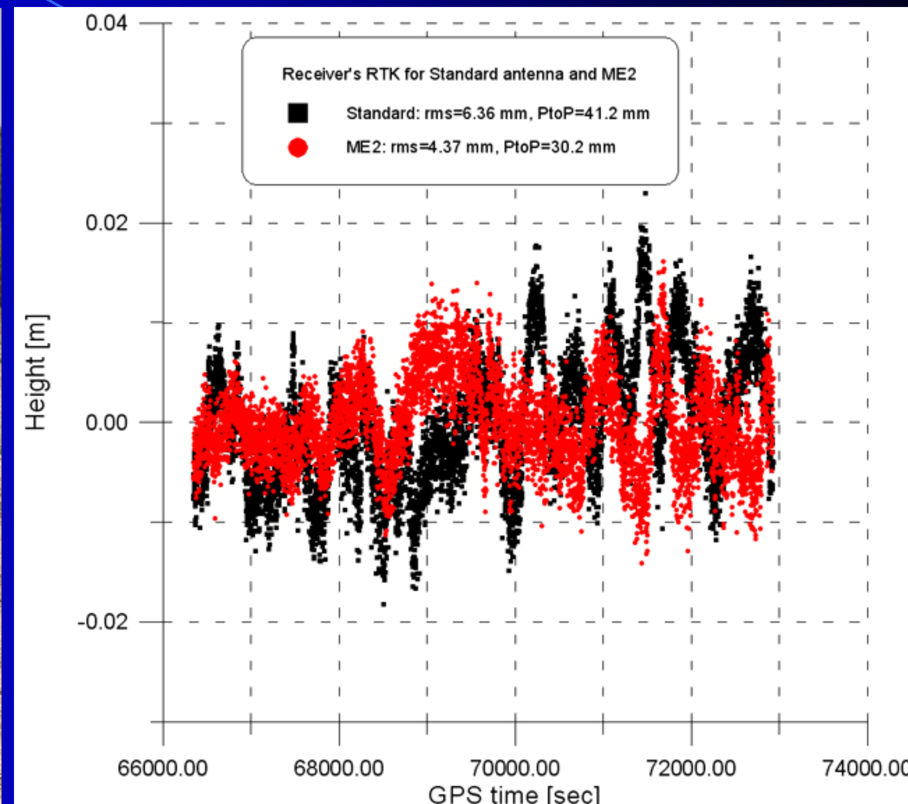
Problem of Multipath mitigation for some GPS Gold codes





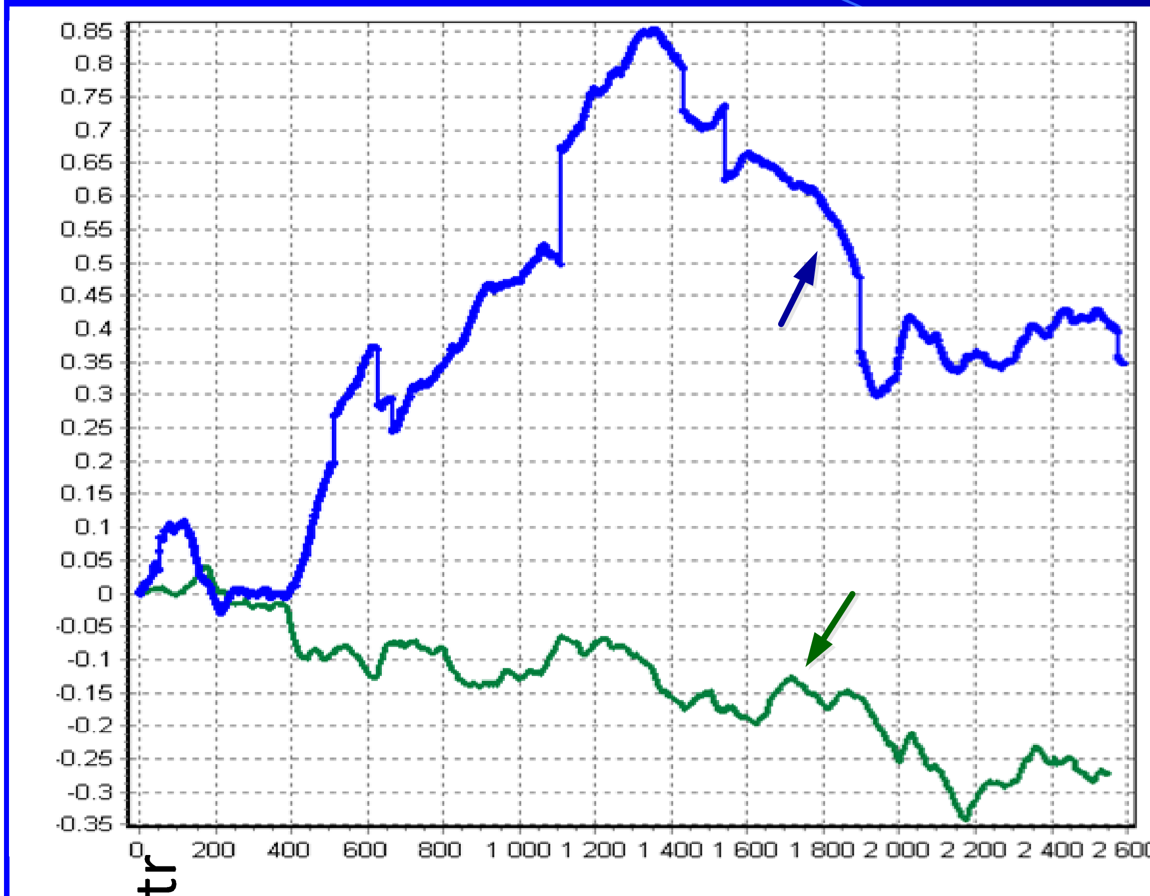
1. Veitsel V., Zhodzishsky M., Vorobiev M., Milyutin D. Impact of Pseudorandom Noise Codes on Multipath Mitigation, Proc. ION GPS 2005.

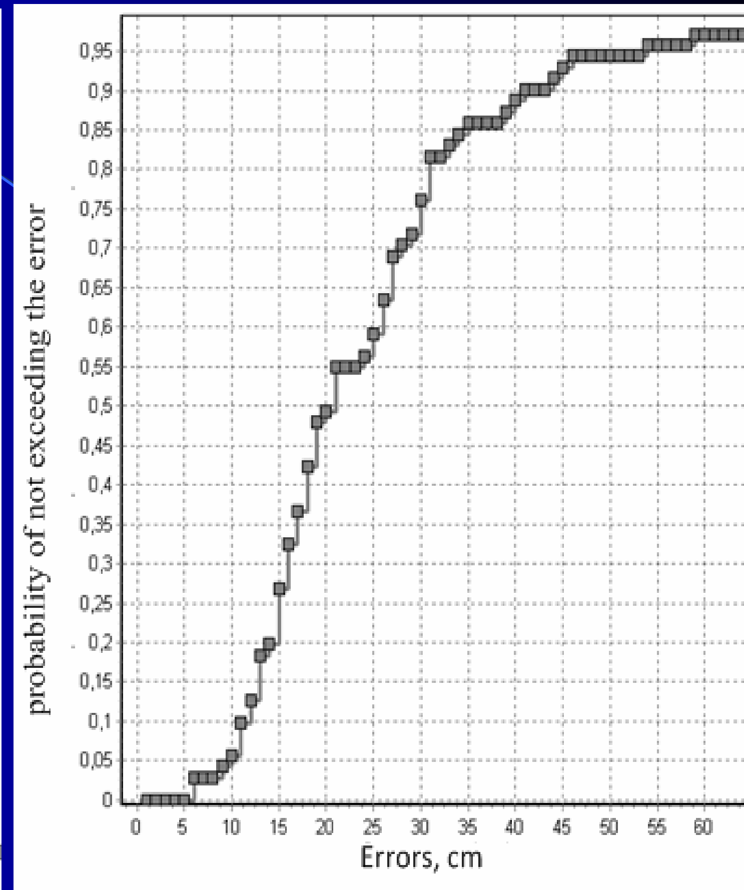
Multipath mitigation with two-element vertical antenna



1. US 6,882,312 , Method and apparatus for multipath mitigation using antenna array, Apr.19, 2005
2. Vorobiev M., Veitsel A., Pushkarev S. Two-element Vertical Antenna for Multipath Mitigation in Field Conditions, ION GPS-2006

Local positioning for accuracy pass-to-pass

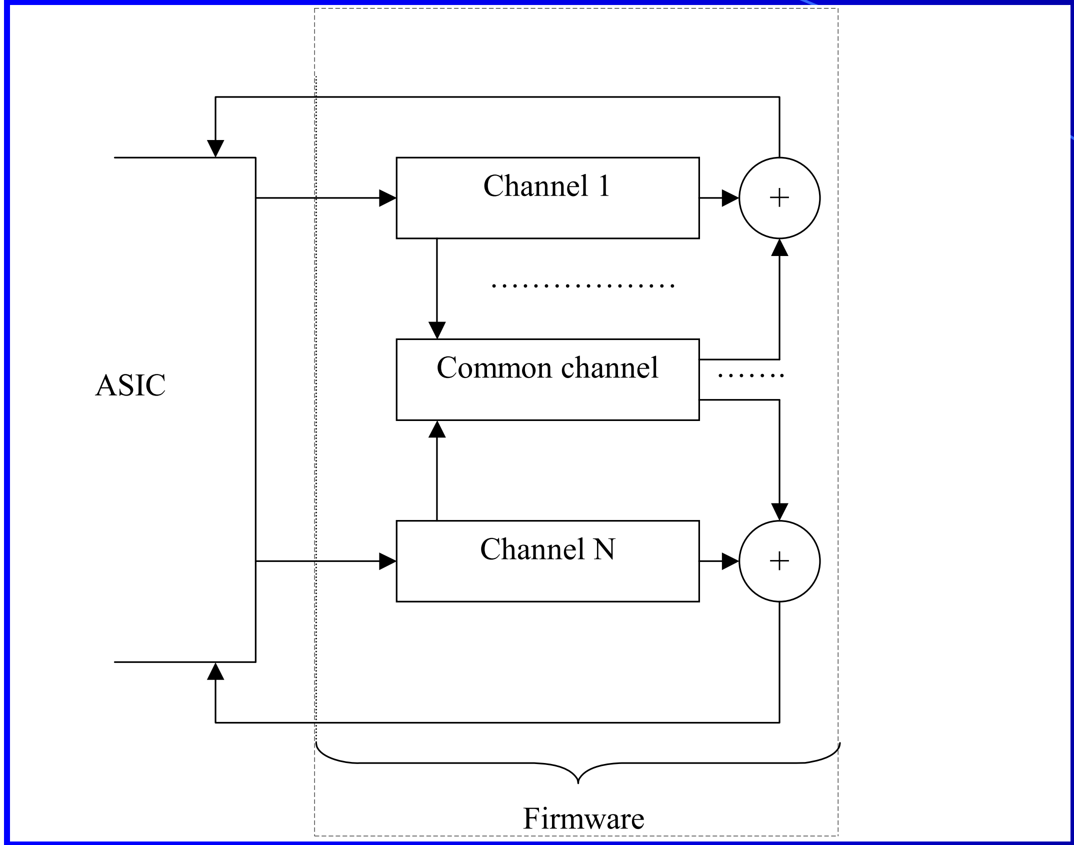




1. US7522099 Position determination using carrier phase measurements of satellite signals, Zhodzishsky M., Veitsel V., Zinoviev A., April 2090

2. US7710316 Method and apparatus for determining smoothed code coordinates of a mobile rover, Zhodzishsky M., Veitsel V., Zinoviev A. , May 2010

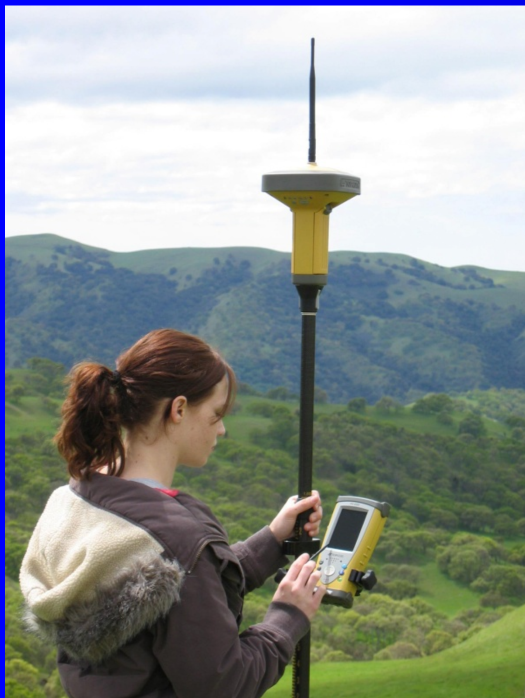
Common tracking loop (Co-Op)



1. Tracking satellite with low SNR (high satellites help low satellites)
2. Fast acquisition and reacquisition
3. Minimize noise errors
4. Fast search
5. Stabilization oscillator offset

1. US6313789 Joint tracking of the carrier phases of the signals received from different satellites Zhodzishsky M et al., June 2001
2. Zhodzishsky M., Yudanov S., Veitsel V., Ashjaee J. , Co-Op Tracking for Carrier Phase, ION GPS 1998
3. US7495607 Method and apparatus for adaptive processing of signals received from satellite navigation systems Zhodzishsky M., Veitsel V. et al. , Feb 2009

Benefits from GPS/GLONASS



"I've made three big mistakes in my surveying life. The first was getting into a business partnership. The second was not getting 4WD on my truck. The third was not getting GLONASS. If you were in Southern California, I wouldn't be telling you this. Learn from my mistakes... "

From POB message boards

"I have two Legacy receivers and one Hiper, all full GLONASS capable. I can honestly say I can remember only two times in the last 3 years that we had to sit and wait for constellation geometry to come around to get PDOP in the helm of what we demand.

I can also honestly say I've watched two [GPS-only] crews sit on their @$$ for roughly 30-45 minutes at a time, At least once or twice a week. The rodman is pounding on the dirt with his hammer, the crew chief is pounding on the data collector and antenna trying to 'wake it up'. All the while our crews are quietly working away. Some simple math,,,, one hour a week, 52 weeks a year, three years,,, that down time just cost as much as the whole GLONASS capable rover".

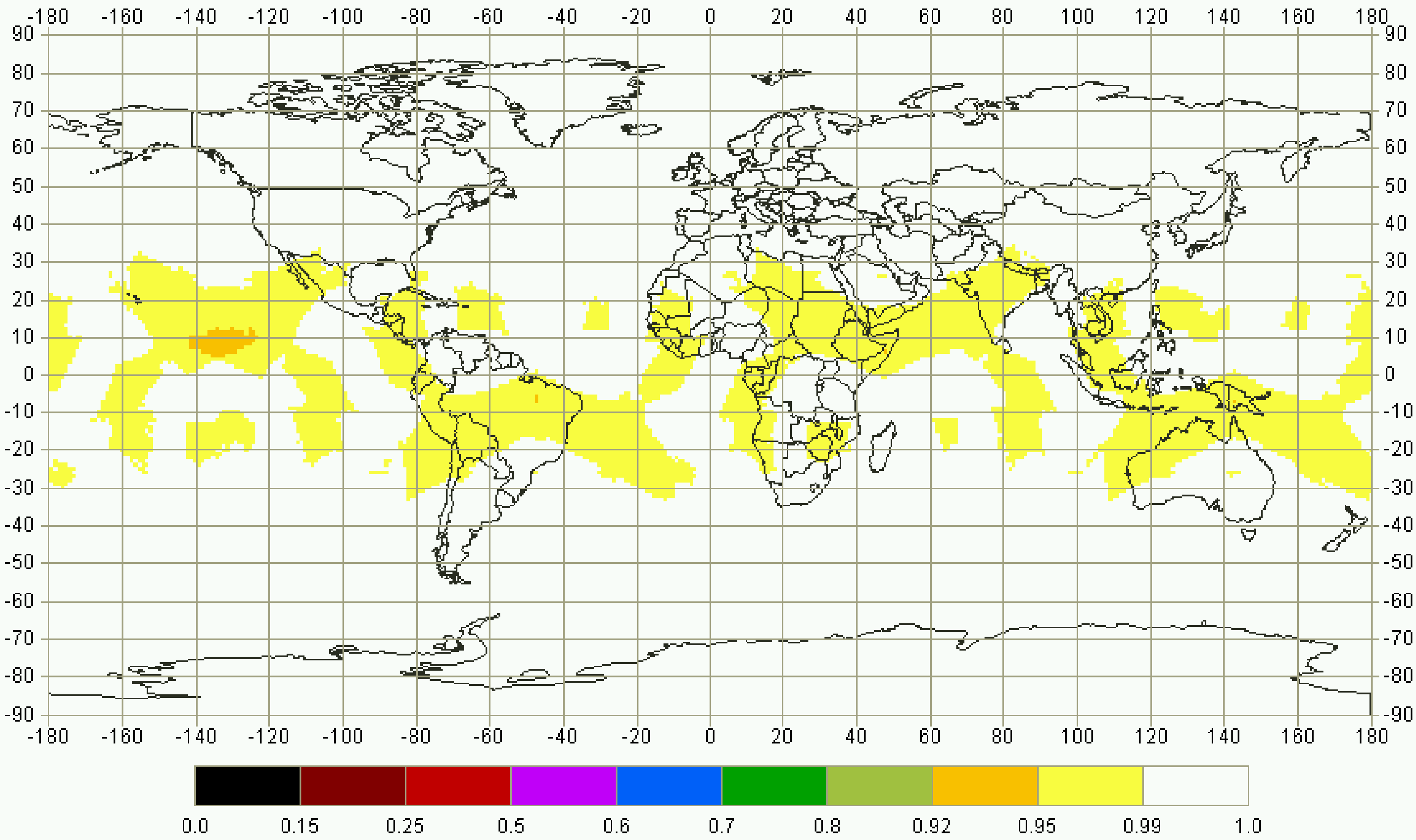
From POB message boards

Current status of GLONASS (1)

- As it was predicted in 2005, GLONASS has achieved a great progress over last four years. Federal GLONASS program (2002-2011) remains the program having high priority.
- There are 22 GLONASS-M satellites orbiting. There are no first generation GLONASS satellites working.
- The launches are expected in this year can increase total number of GLONASS SVs to up to 24 (full constellation). In the February 2010 next generation GLONASS-K is expected to be launched. It will broadcast new civil L3 CDMA signal.
- GLONASS has become a must in order to overcome the problem associated with not enough number of GPS satellites when working at sites having obstructed view or even under open sky at certain periods of time (Topcon supports GLONASS starting at 2000).
- At present, GLONASS may not be considered just as a GPS augmentation system but rather as a solo global navigation system that provides 24/7 service.

Current status of GLONASS (2)

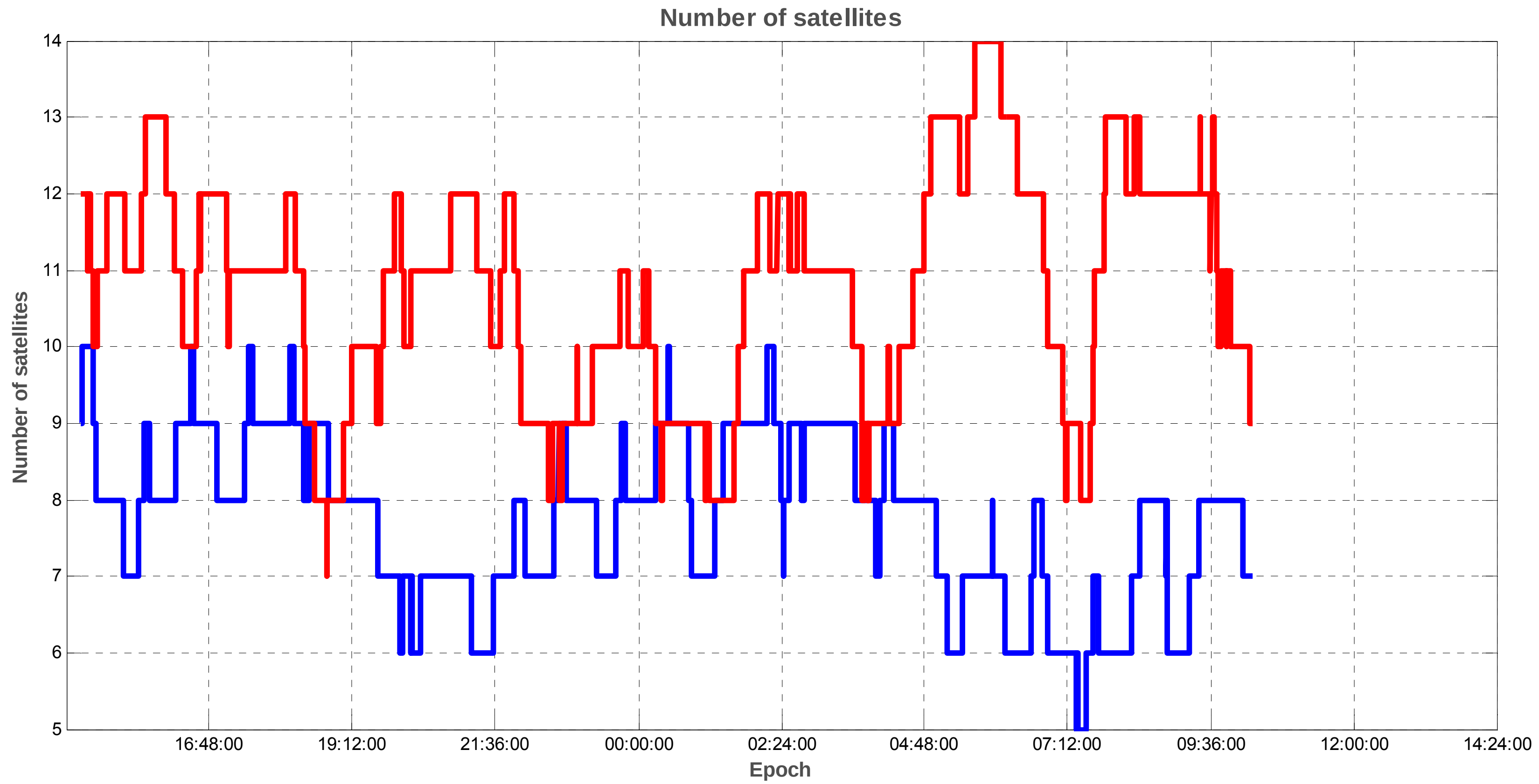
Integral availability of GLONASS navigation (PDOP≤6) during the 24 hours period (mask angle ≥5°)
Date: 24.02.2011
Current constellation: 22 SC in operation (1,2,..5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24)



Note: availability is calculated using a current almanac for the 24 hours period as percentage of time during which the condition PDOP≤6 is valid at mask angles ≥5°, where PDOP is a position (three-dimensional) dilution of precision. Step of calculation: 4 minutes in duration and 1 degree over the surface

Ref.: http://www.glonass-ianc.rsa.ru

GLONASS: 24/7 global service?



<u>All-in-view mode, 0 elevation mask, test site: Moscow:</u>

- Up to 22 GPS+GLONASS satellites can be tracked
- Up to 10 GLONASS satellites can be visible simultaneously.

GLONASS - 24/7 global service.

When working with GLONASS-only satellites over the period of about 2.5 days under the following receiver settings: 5° elevation mask, PDOP < 30.

02% - no position (three or less number of satellites above 5 degree elevation mask or PDOP > 30).

20% - stand-alone positioning;

05% - RTK float solution;

73% - RTK fixed solution;

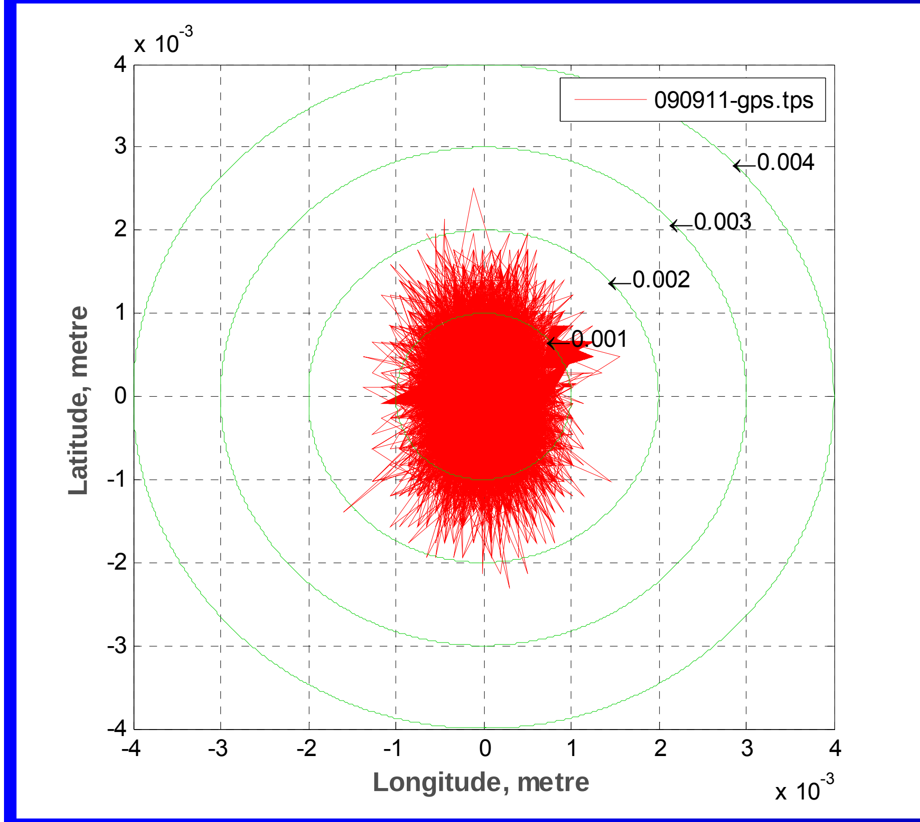
GLONASS is approaching to GNSS that provides global 24/7 service.

Topcon receivers support stand-alone, DGNSS and RTK positioning with any constellation: GPS-only, GLONASS-only, GPS+GLONASS

GLONASS RTK positioning performances (1)

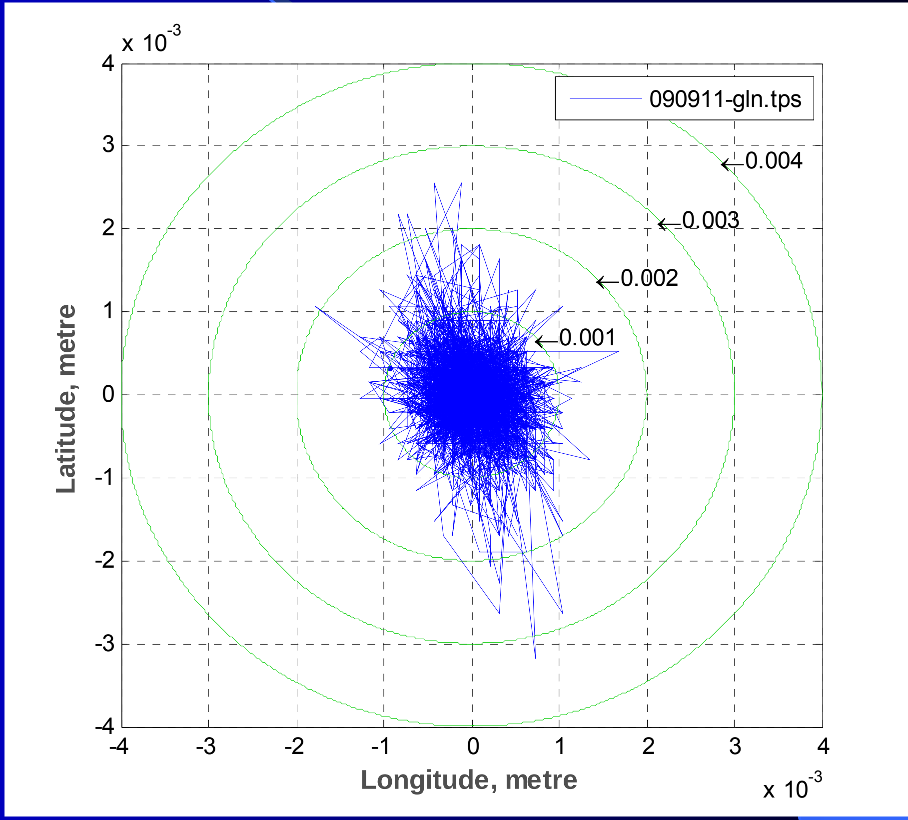
RTK GPS-only solution:

At all epochs (GPS SVs: $6 \leq SV \leq 12$)



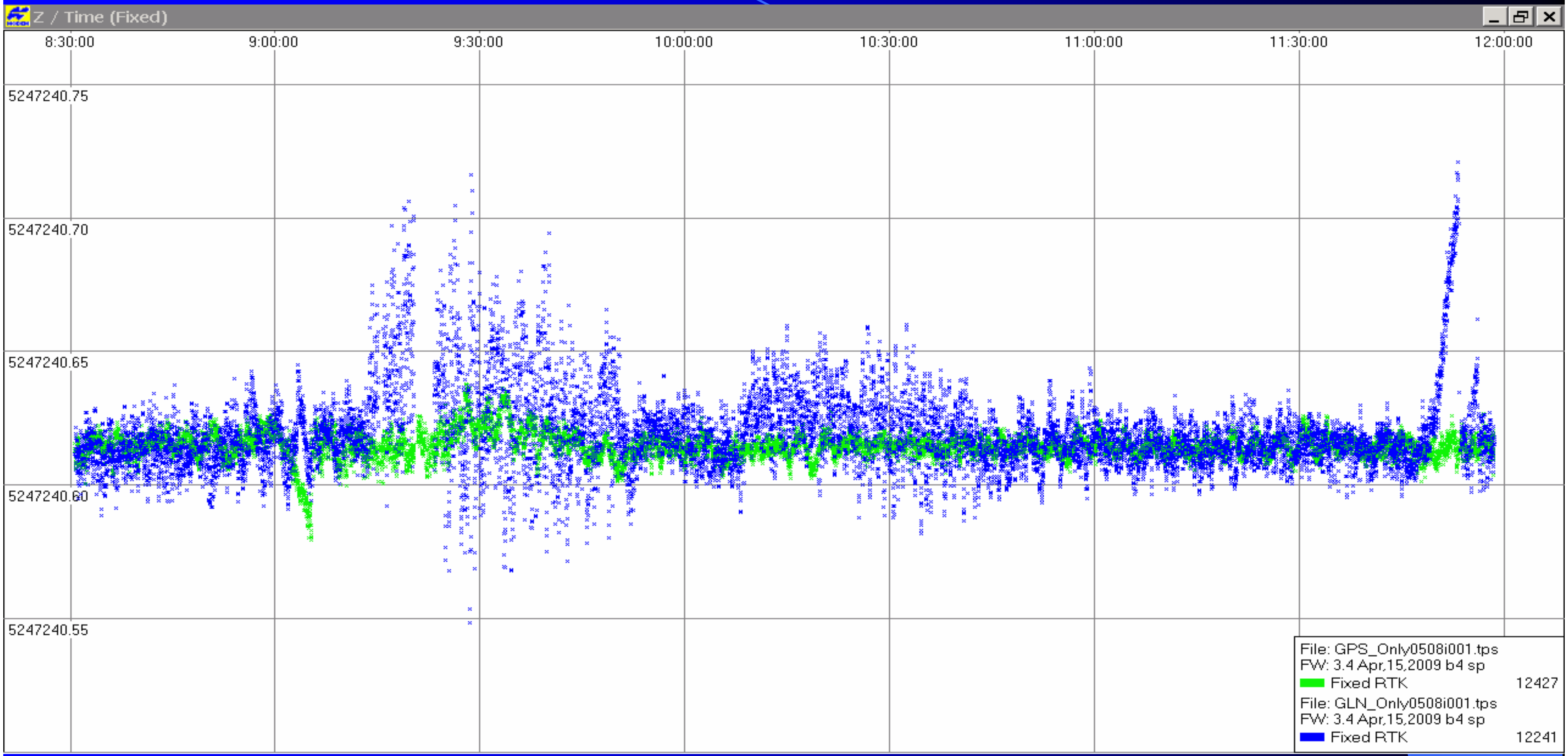
RTK GLONASS-only solution:

At a subset of all epochs when total number of GLONASS SVs ≥ 7



Accuracy of GLONASS RTK positioning is the same as GPS RTK accuracy provided enough number of GLONASS satellites are available for positioning

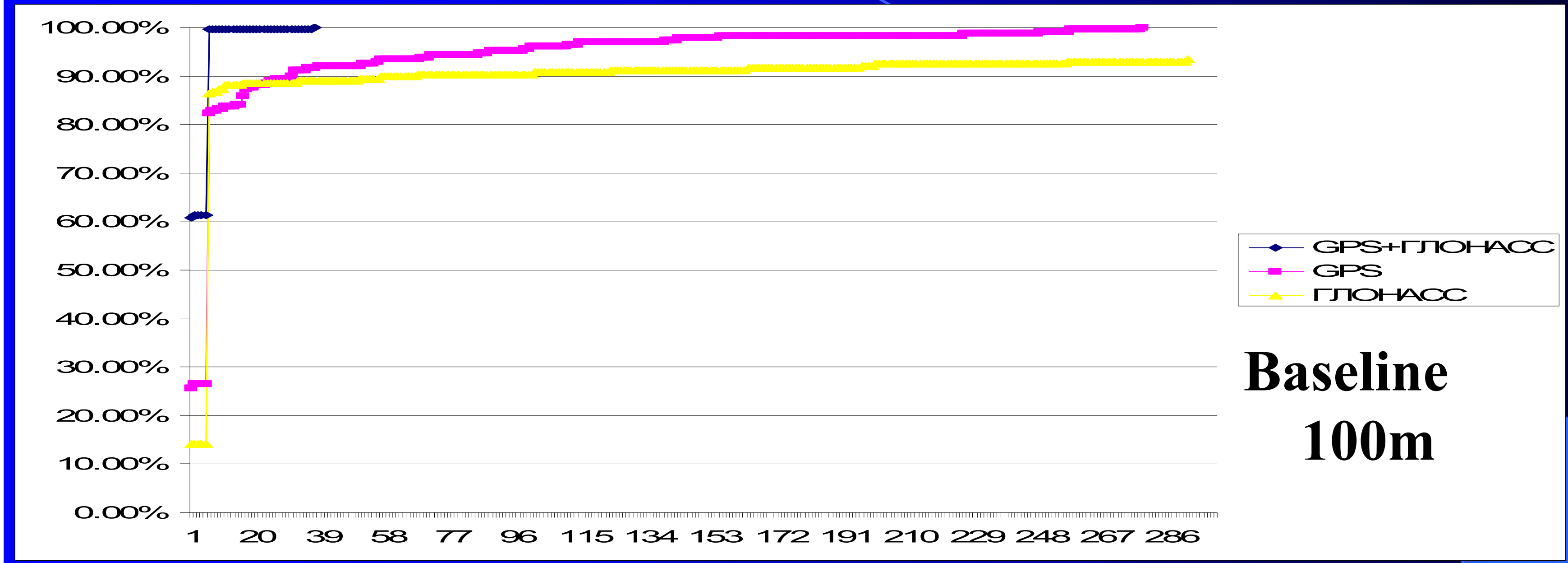
GLONASS RTK positioning performances (2)

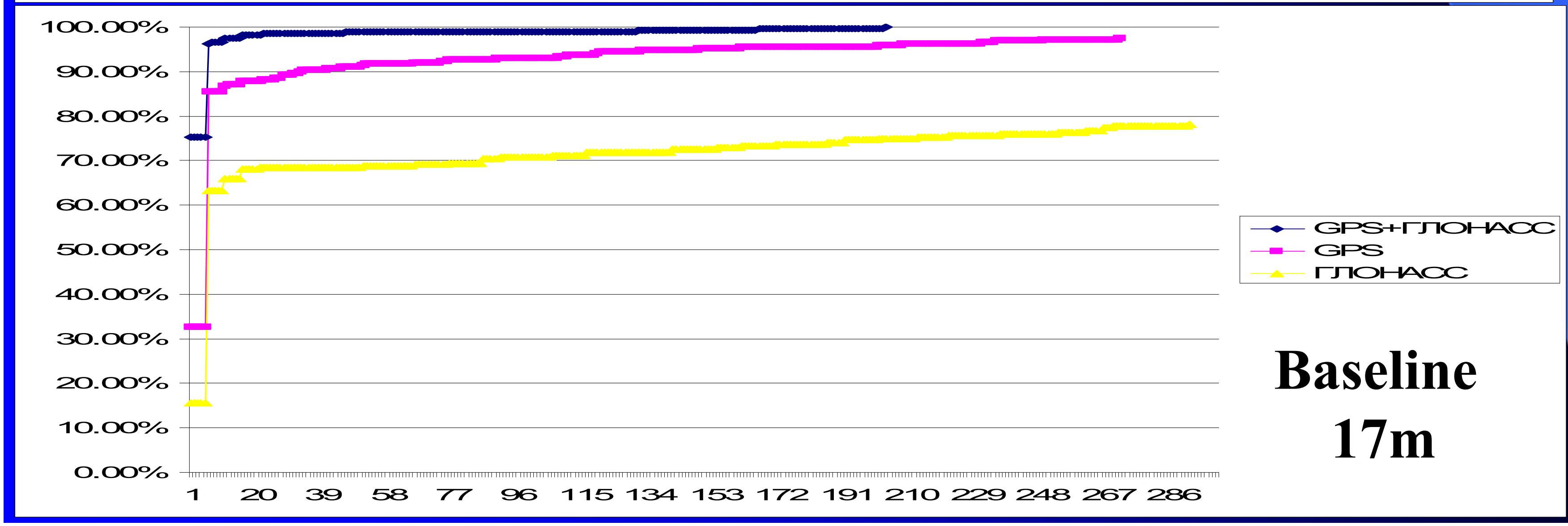


Green point – RTK with GPS measurement only

Blue point – RTK with GLONASS measurement only

Time-to-fix of ambiguities for RTK with GPS and GLONASS





Biases in GLONASS carrier phase double differences interoperability problem

• GLONASS double differences depend on both carrier phases and pseudoranges (via receiver clock offsets) because of FDMA.

• Before 2006, all combined GPS+GLONASS receivers were calibrated in such a way that GLONASS double differences, which were plotted at zero baseline, were equal to integer numbers at a few millimeters level (generation of GNSS receivers from Ashtech to Topcon Positioning Systems).

• Since 2006, GPS+GLONASS receivers started to be produced by other manufacturers.

• No attention was given to keeping GLONASS double differences at integer level when working with other GNSS receivers that already existed on the market.

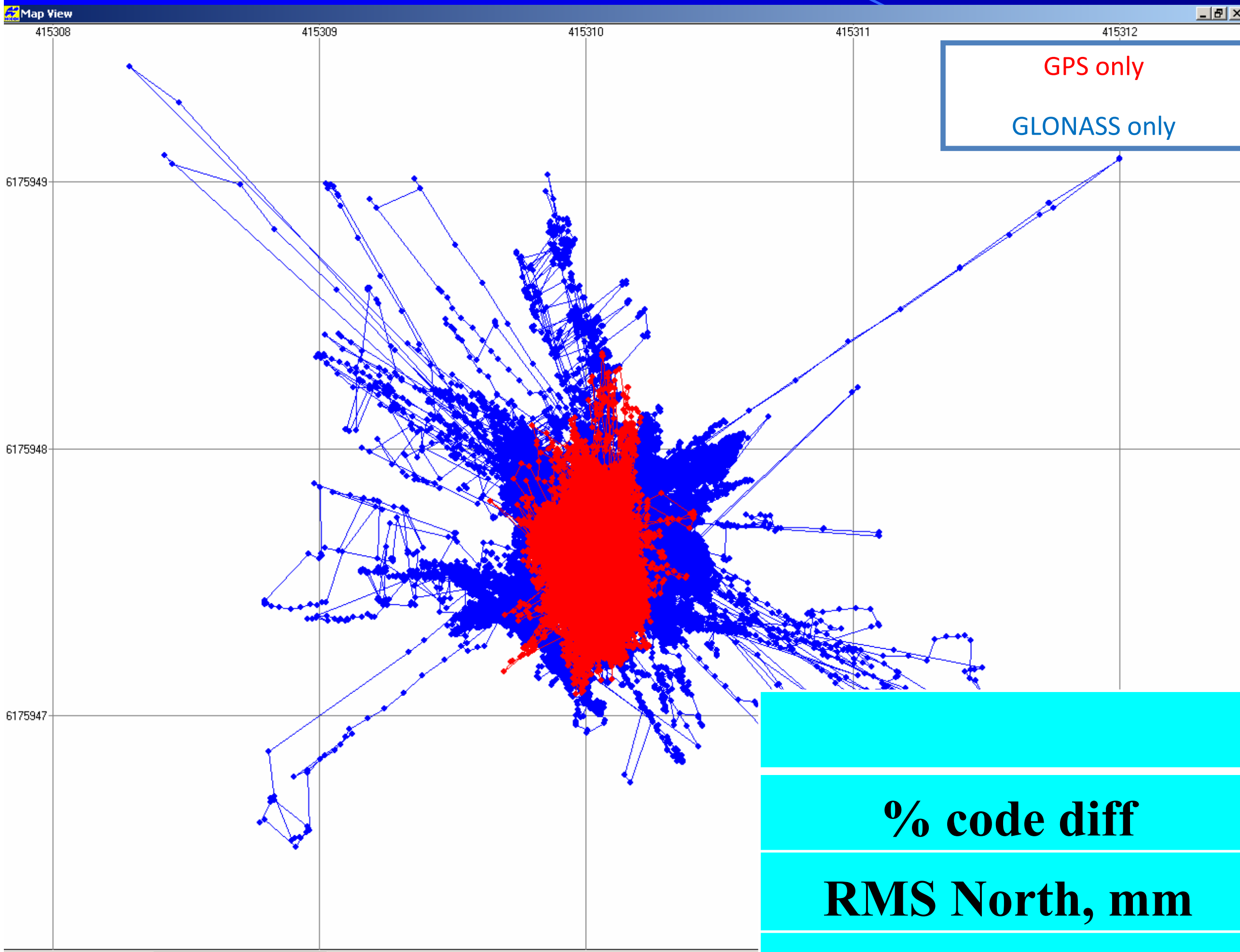
• All that led to the problem of so-called "GLONASS biases" in carrier phase differences.

• RTCM SC-104 has taken a leading role in resolving this problem for more optimum processing of GLONASS carrier phase observables.

Receiver Biases for GLONASS RTK measurements

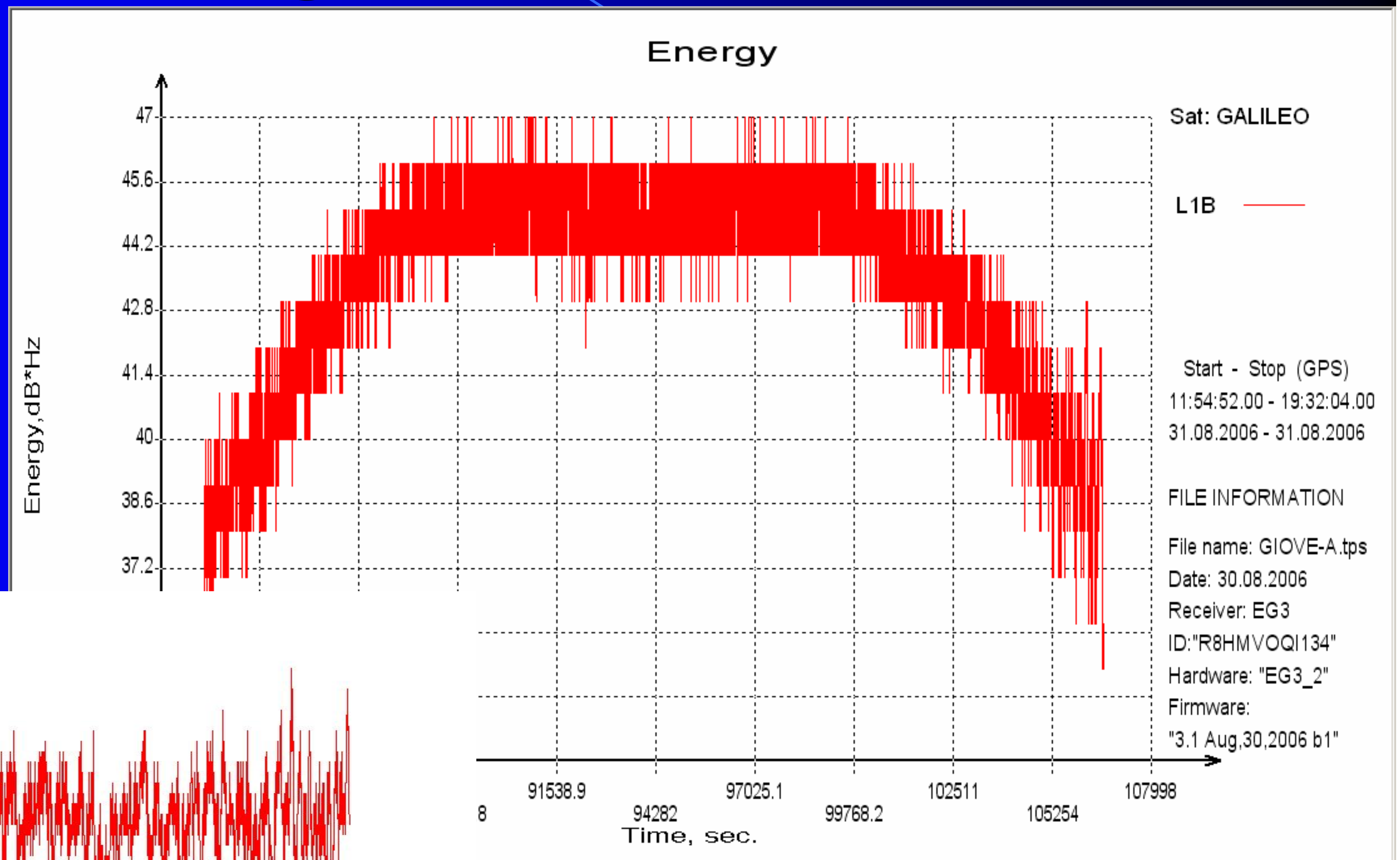
RECEIVERS	MIN. biases (nearest frequency)	MAX. biases (last frequency)
Ashtech,Javad,Topcon	~ 0	~ 0
Company A	24 mm	144 mm
Company B	7 mm	42 mm

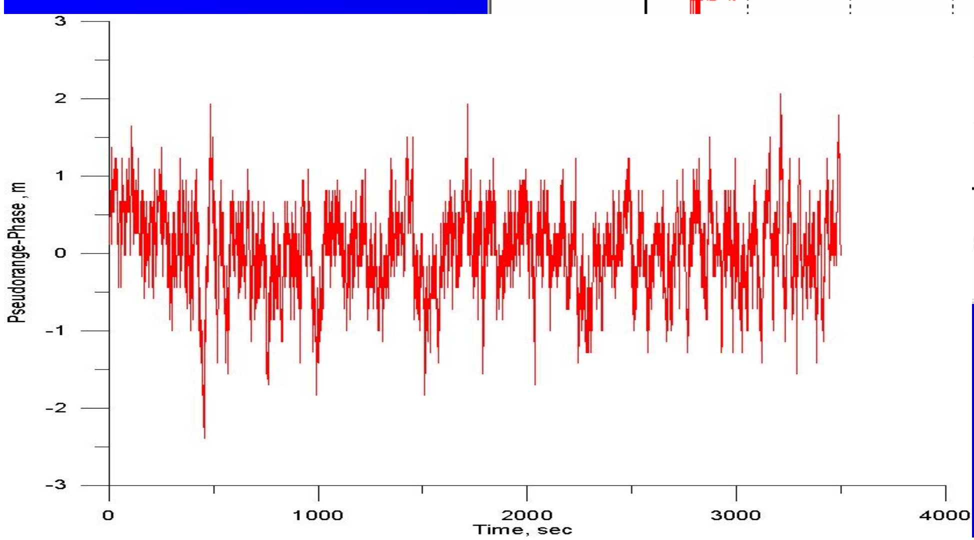
GLONASS DGNSS positioning performances



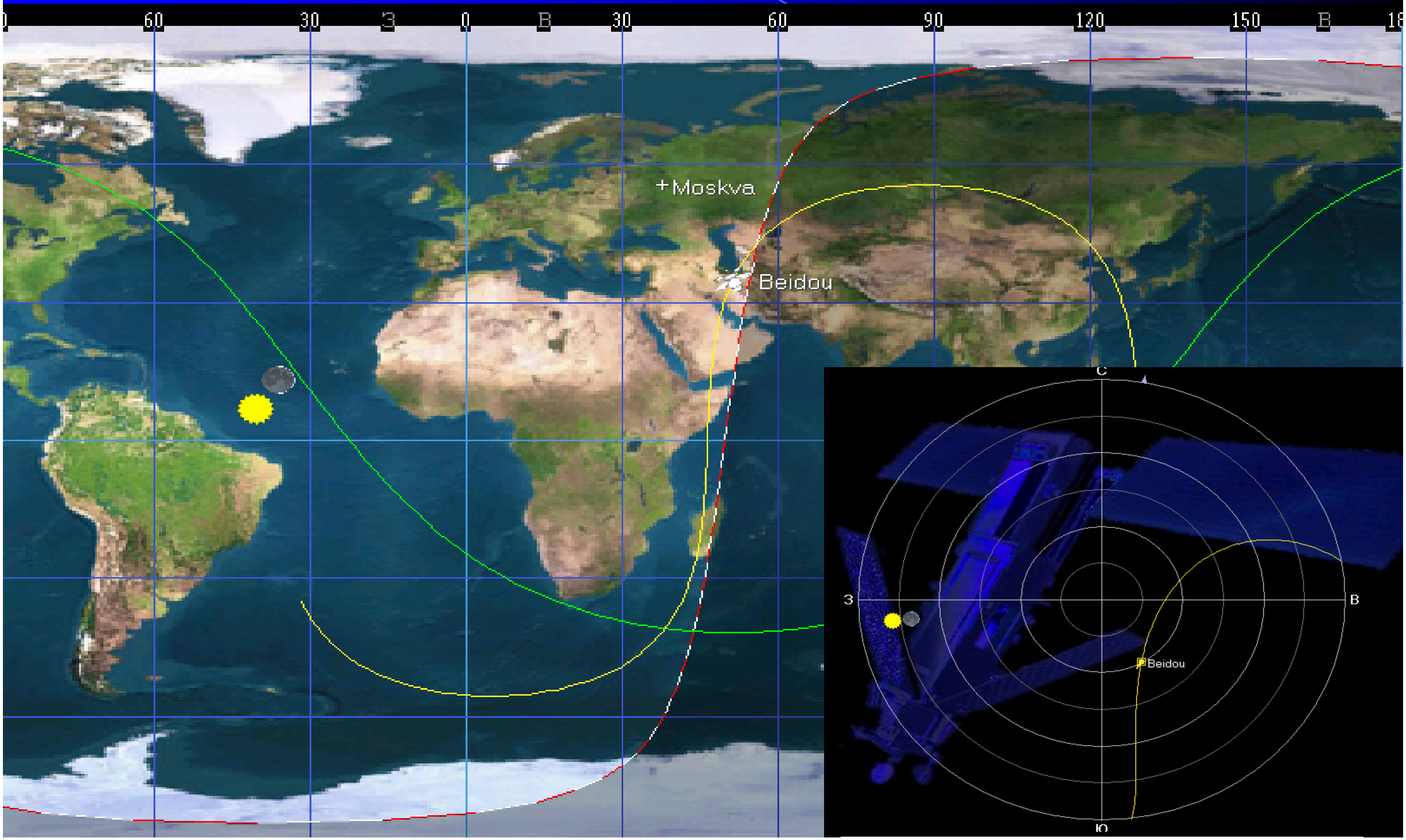
	GPS	GLONASS
% code diff	100.0	100.0
RMS North, mm	0.118	0.219
RMS East, mm	0.077	0.230
RMS Height, mm	0.258	0.590
Mean num. of sat’s	11	8

Tracking of GALILEO GIOVE signals





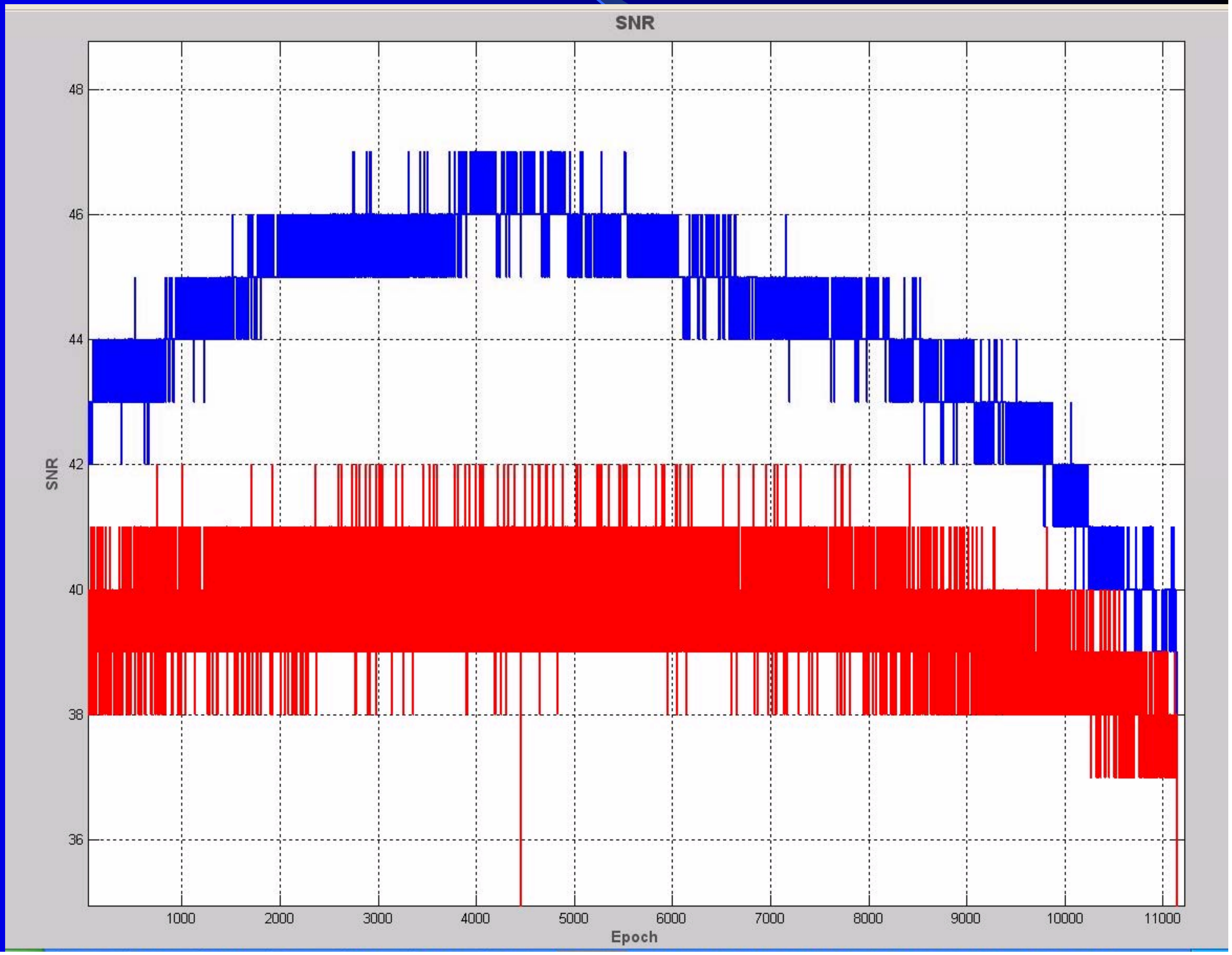
The track of Beidou satellite



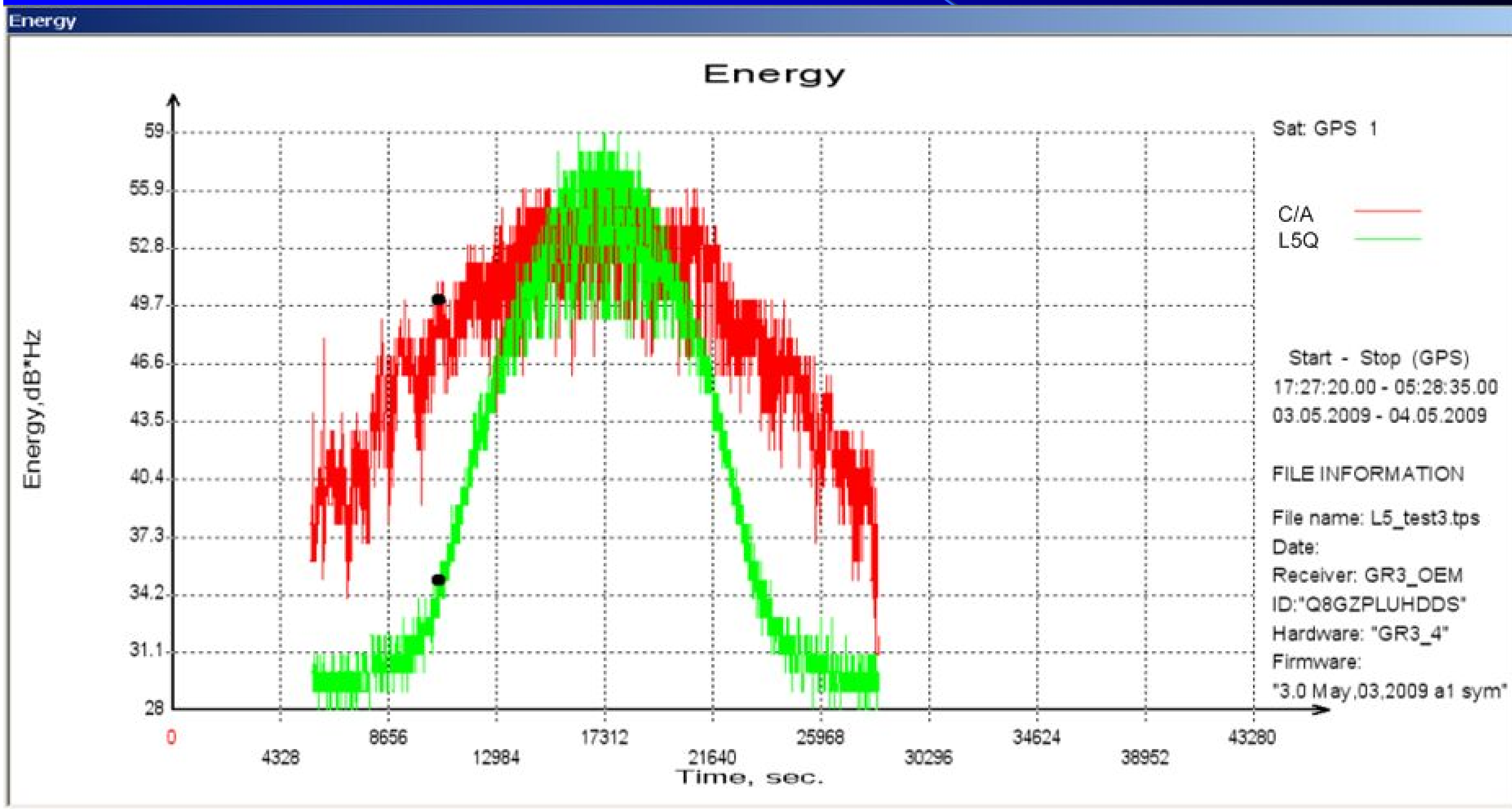
Tracking of signals from Beidou satellite

Blue – energy for B1 signal

Red – energy for B2 signal



Tracking of L5 signal from GPS satellite



TOPCON TECHNOLOGY CENTER

G3 Technology

The next generation in satellite positioning technology

Thank you for you attention!

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Another WORLD'S FIRST from Topcon