Transportа elektronikas un telemātikas katedra

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Precision Estimation of GPS Devices in Static and Dynamic Modes

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United Nations/Latvia Workshop on the Applications of Global Navigation Satellite Systems May 14-18, 2012

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Riga Technical University

Department of Transport Electronics and Telematics

Profesor Ansis Kluga

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Precision estimation with Re-reference system

Receiving antenna of Re-reference system and indoor antenna of Re-reference system

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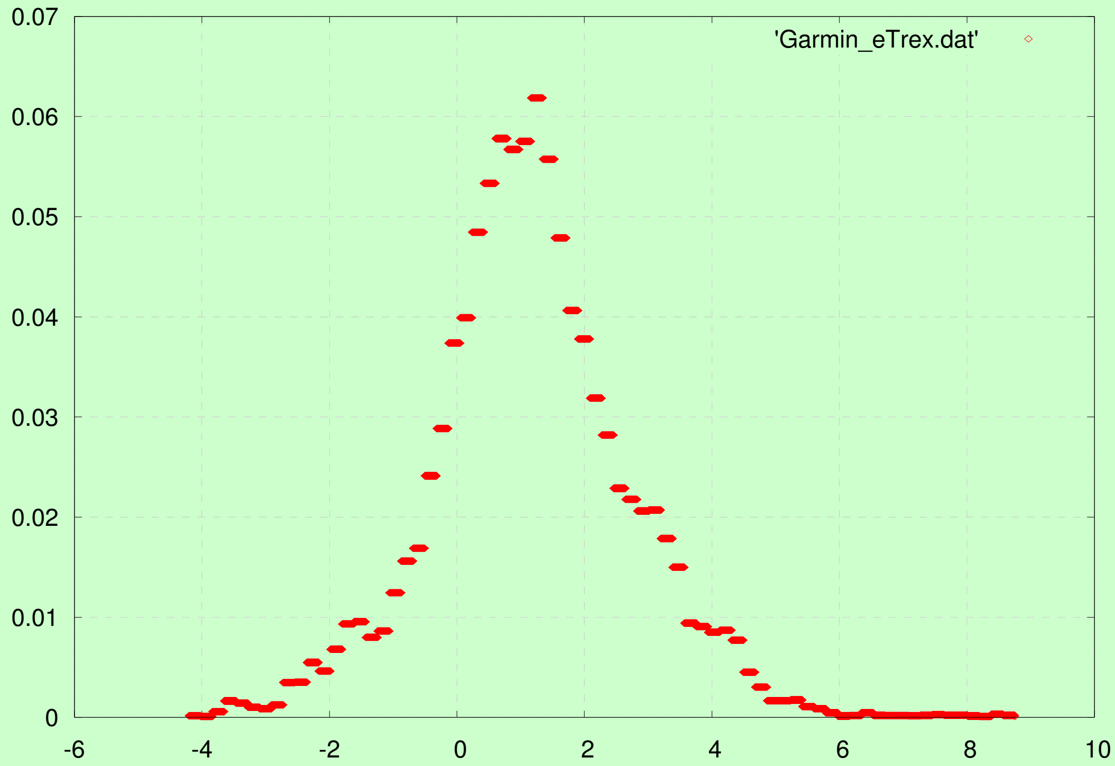
Precision estimation with Re-reference system

Δ=1/10000



m

Histogram of Latitude Horizontal Errors

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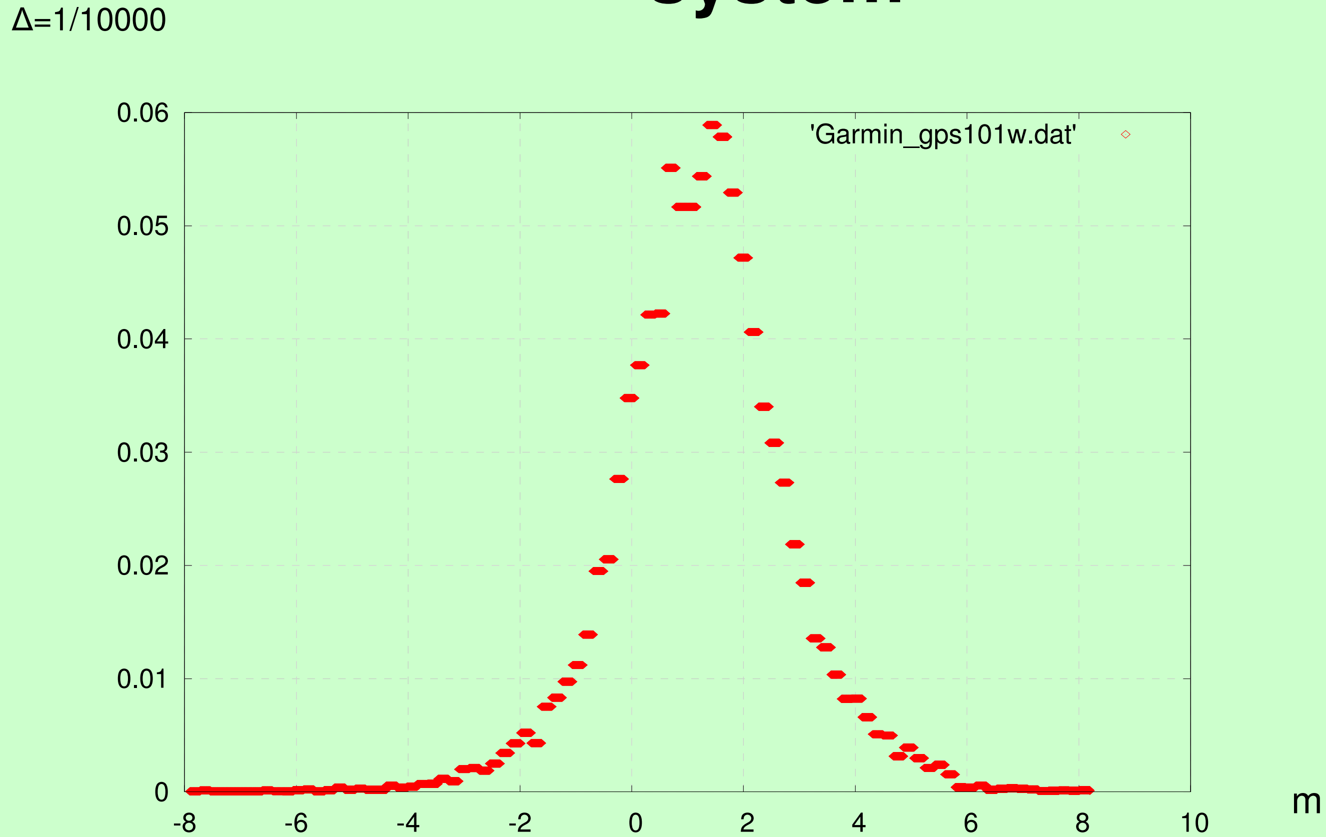
Precision estimation with Re-reference system



Histogram of Latitude Horizontal Errors

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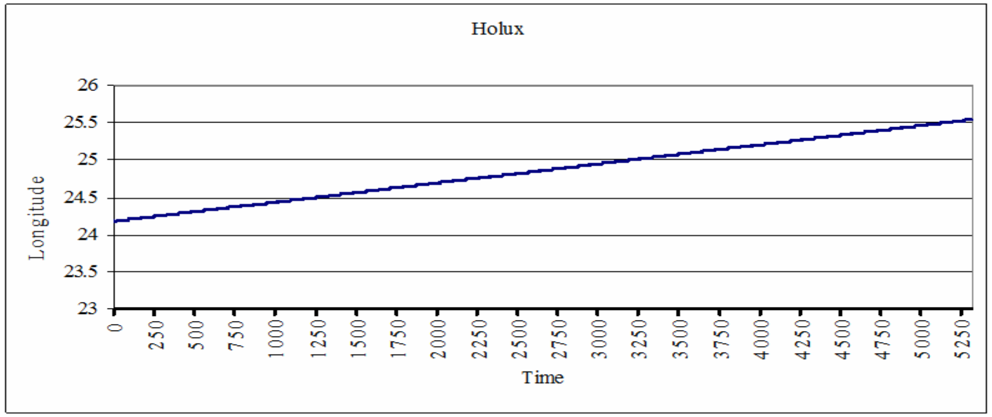
Accuracy Estimation of GPS Receiver Parameters with Simulator in Dynamic Mode

- Spirent STR-4500 GPS satellite signal simulator was used for all experiments

Position fix when satellite signals are lost

1. By using Spirent STR-4500 GPS satellite signal simulator, we modeled uniform motion (i.e. no acceleration).
2. The trajectory of motion is linear, and velocity is approx. 60 km/h.
3. In the middle of the experiment transmitting antenna has been disengaged for 10 minutes


Holux
Longitude
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25
24.5
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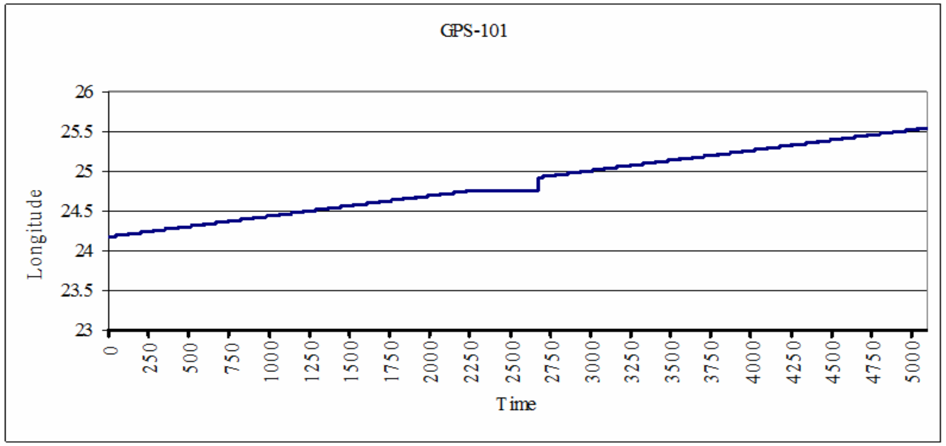
Time


GPS-101
Longitude
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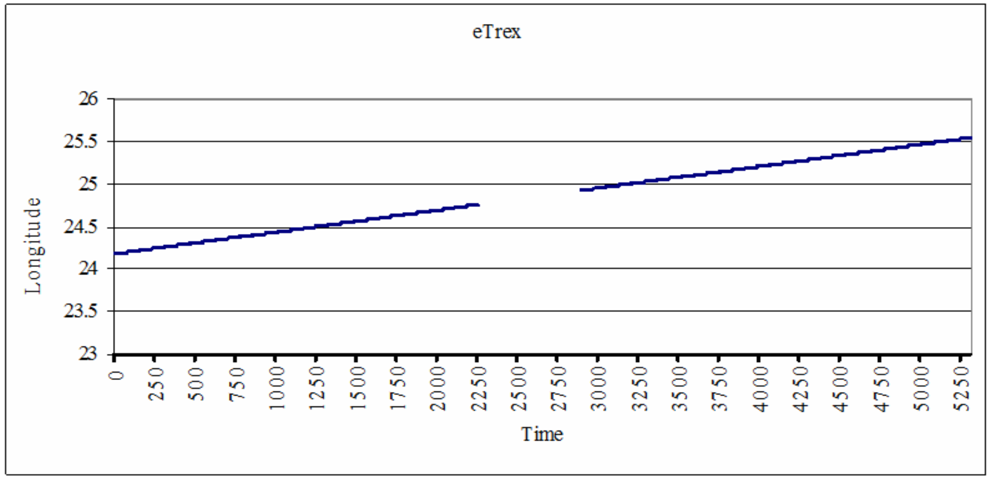
Time


eTrex
Longitude
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3000
3250
3500
3750
4000
4250
4500
4750
5000
5250
Time

Position fix and velocity errors in simple vehicle dynamics

For these experiments we have requested from Spirent 4 scenarios:

- Variable latitude, constant longitude, velocity range 0 – 180 km/h
- Variable longitude, constant latitude, velocity range 0 – 180 km/h
- Variable latitude, constant longitude, velocity range 0 – 800 km/h
- Variable longitude, constant latitude, velocity range 0 – 800 km/h

Position fix and velocity errors in simple vehicle dynamics

For various our GPS receivers we have estimated the following values:

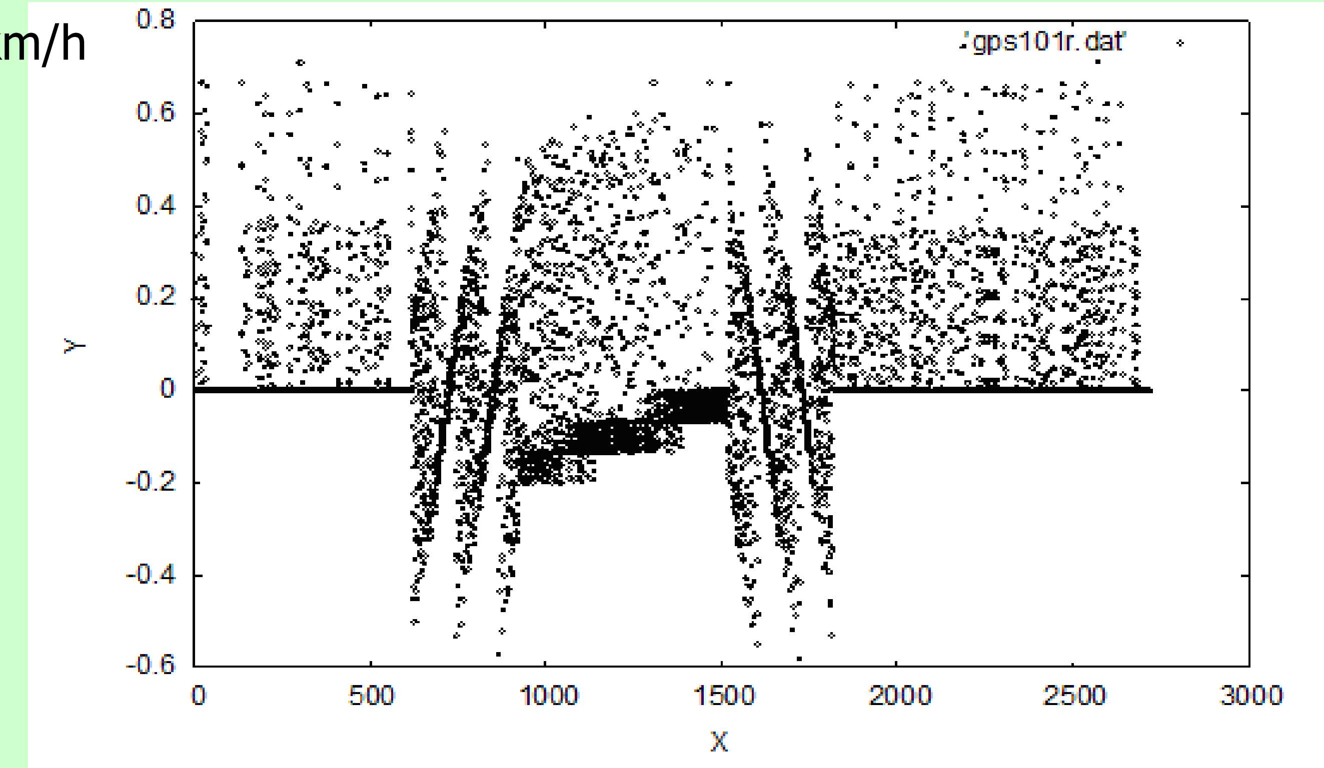
- Velocity error;
- Position fix radial error.

We have estimated mean values and RMS of these two errors as well.

Position fix and velocity errors in simple vehicle dynamics

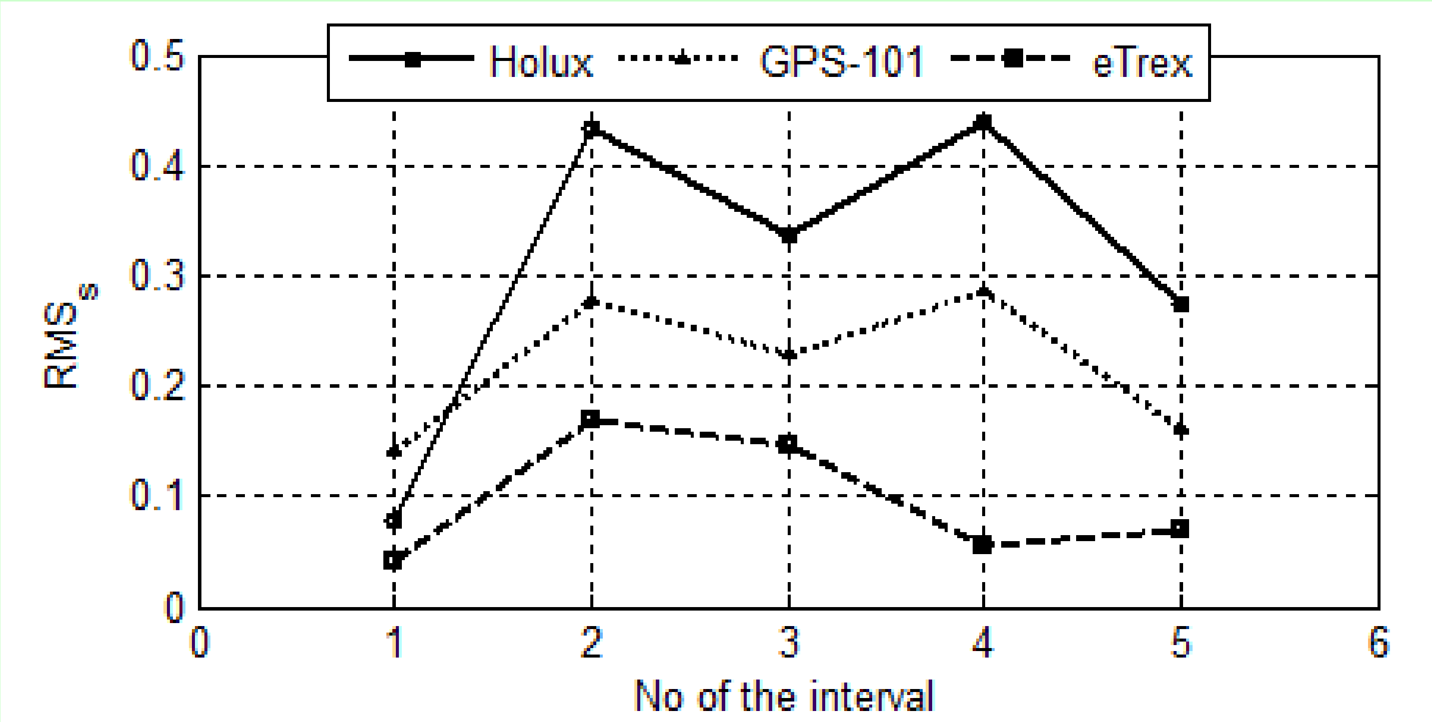
Example: Velocity error for Graymark GPS-101, 800 km/h velocity profile

ε_s, km/h



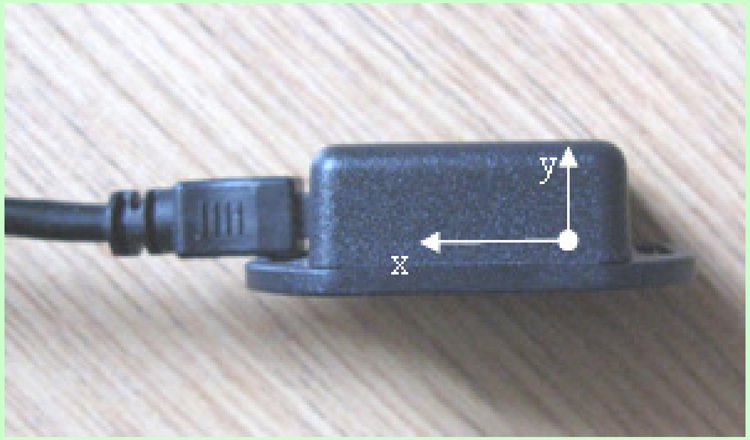
Position fix and velocity errors in simple vehicle dynamics

Example: Velocity error RMS for all GPS receivers over time intervals



Combined Information Processing from GPS and IMU using Kalman Filtering Algorithm

Current research and study have emphasized on using low cost IMU and GPS integration by the benefit of computing power and low price of IMU. The vehicle kinematics is obtained by a Holux GPS and a Motion Node IMU sensor.



Kinematics test results

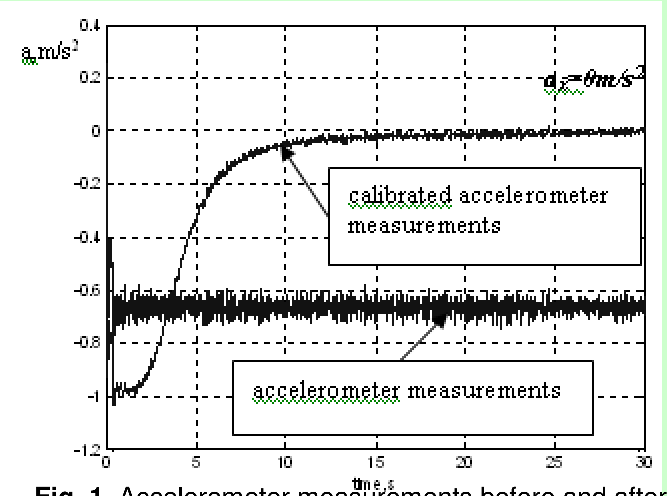


Fig. 1. Accelerometer measurements before and after postcalibration process

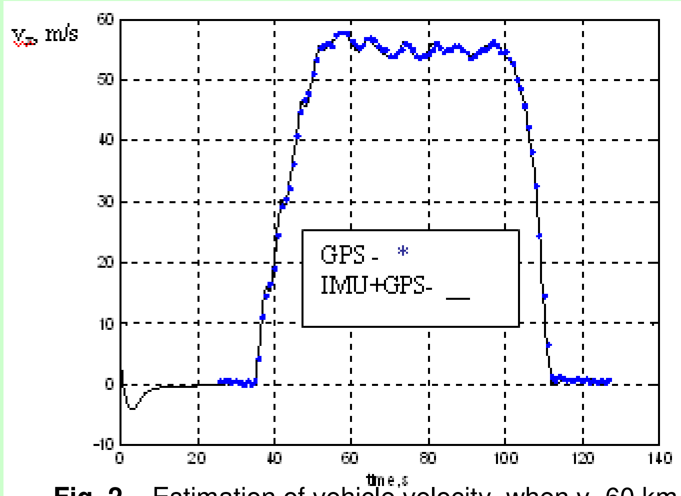


Fig. 2. Estimation of vehicle velocity, when v=60 km/h

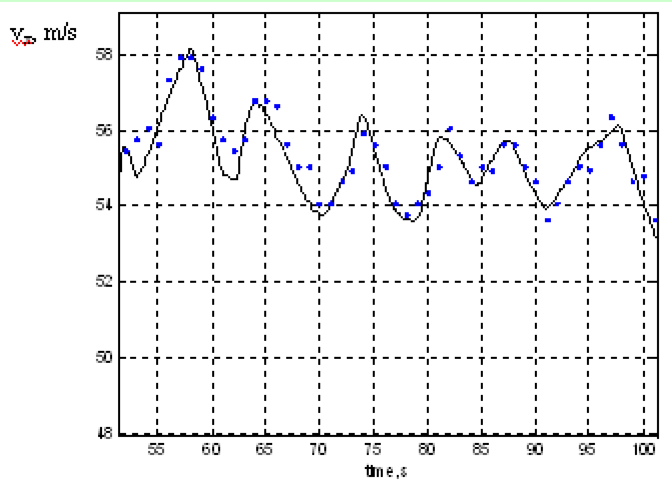


Fig. 3. Estimation of vehicle velocity, when v=60 km/h (zooming in of the Fig.2 at time interval from t= 50s till t=100 s)

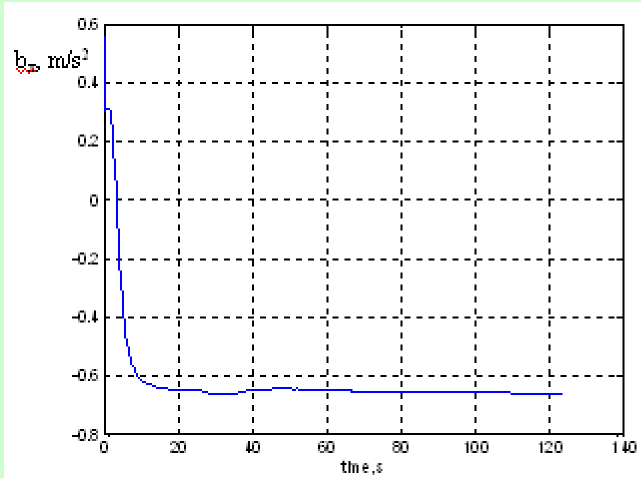


Fig. 4. Estimation of accelerometer bias, when v=60 km/h

GPS and IMU Complex System Experimental Research

These studies used the company Xsens a complex system of MTI-G, which consists of 12 channel GPS receiver and the inertial sensor with barometric altitude meter and magnetometers. To convert data from Xsens file format NMEA compatible format, suitable for data processing with GPS-oriented programs, we developed a conversion program.

Measurements on the bridge:

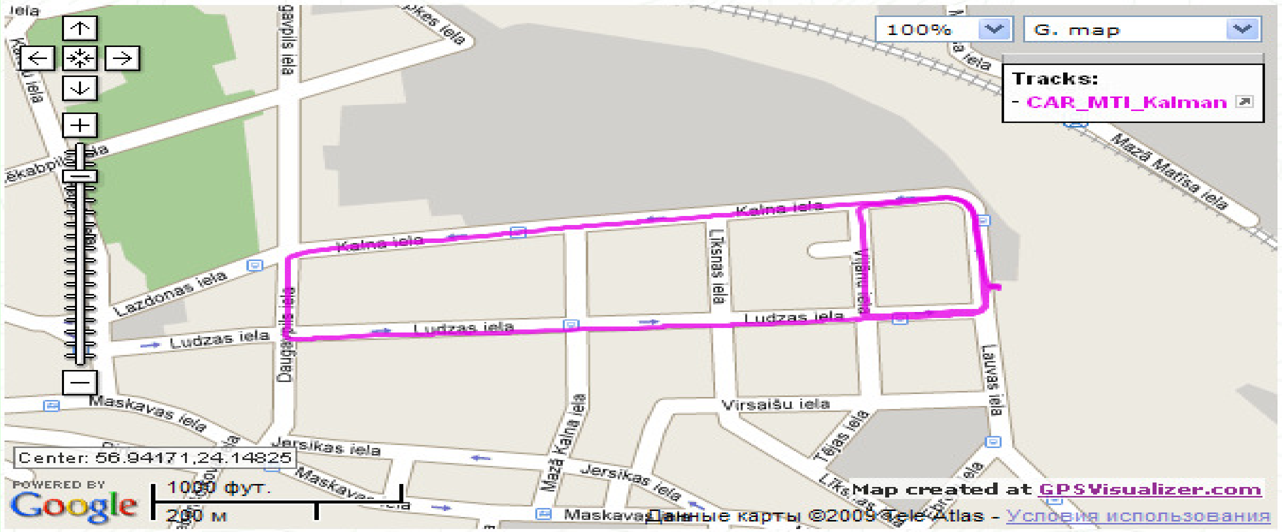
a) with GPS,

b) using GPS and IMU date complex processing

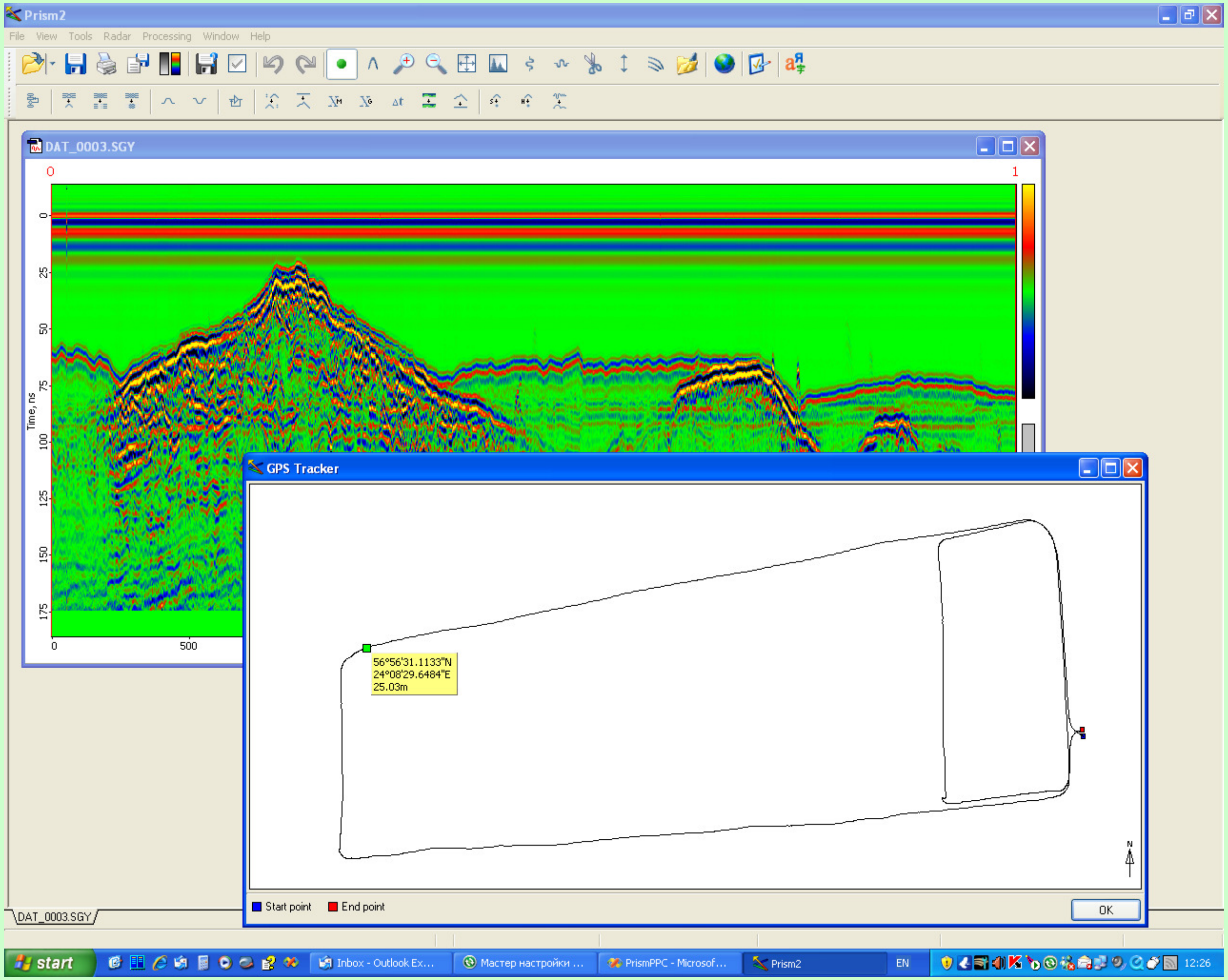
As seen from the maps shown the complex information-processing improves the measurement accuracy.

After treatment using Least-Squares Fitting (LSF) these data can provide highly accurate results

Very widespread is the applications of complex system (GPS and IMU) in transport systems. Our studies have dealt with the possibility of using this system for underground radar



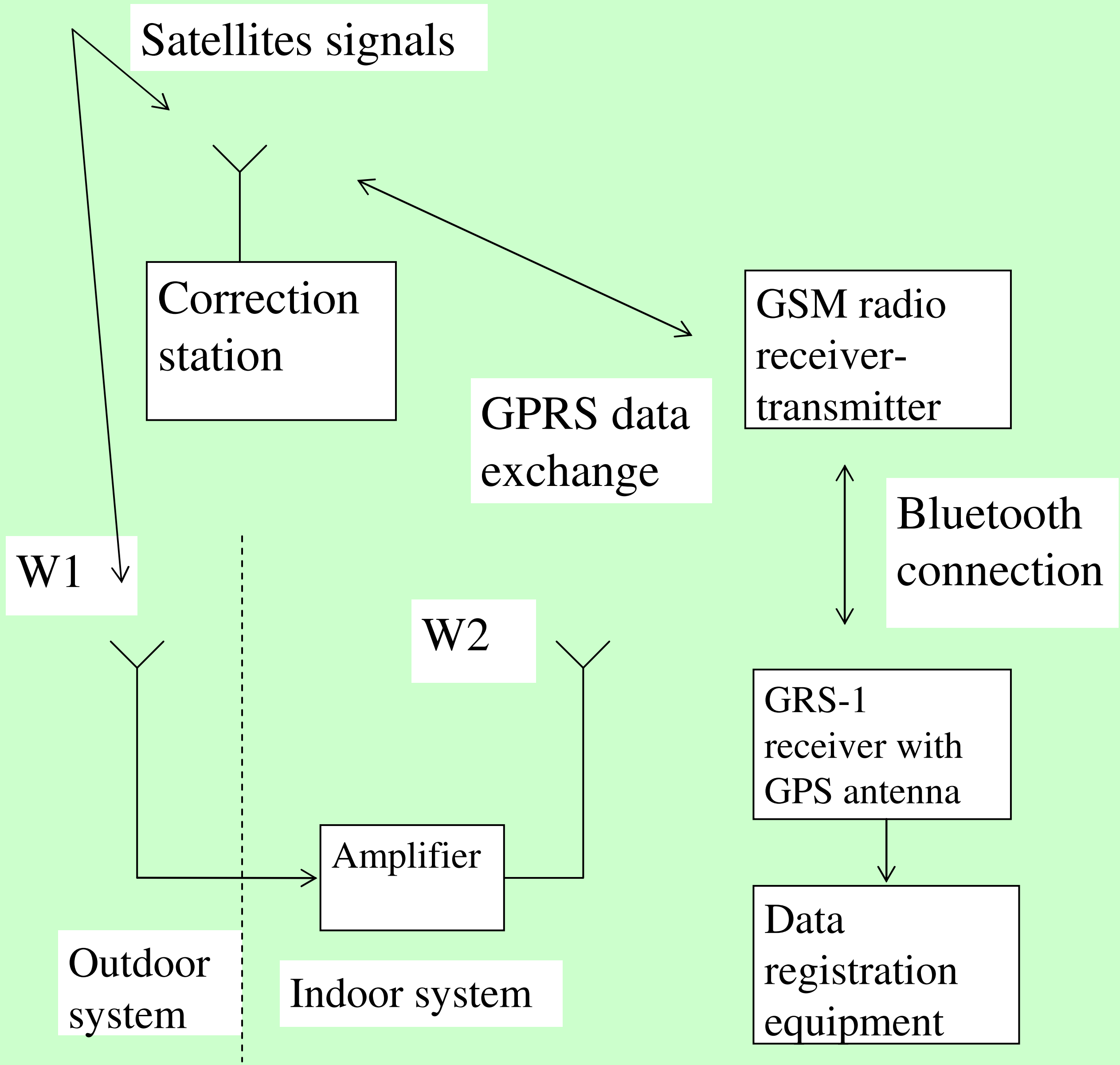
Trajectory measurements reflecting on the map in underground radar

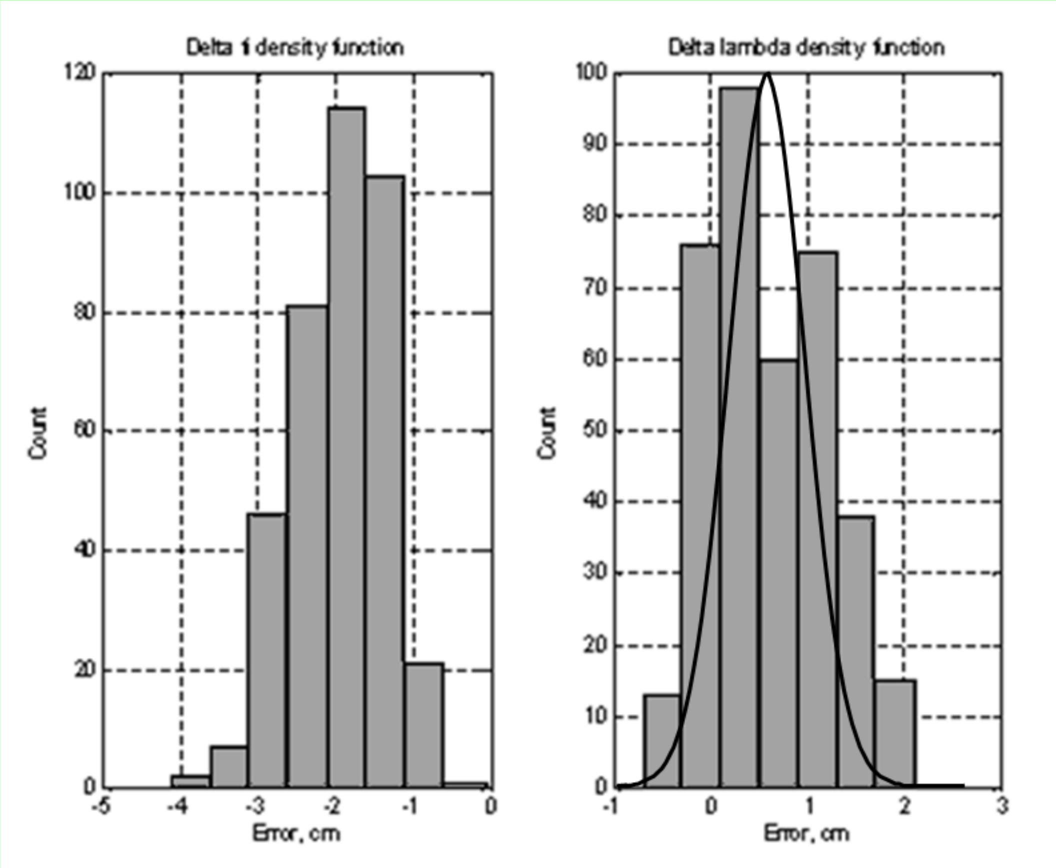


Trajectory measurements in underground radar

Real-time kinematic

RTK makes use of carrier-phase and pseudorange measurements recorded at a (usually) fixed reference location with known coordinates and transmitted in real time to a user's rover receiver using a radio link of some kind.


Satellites signals
Correction station
GPRS data exchange
GSM radio receiver-transmitter
Bluetooth connection
W1
W2
GRS-1 receiver with GPS antenna
Amplifier
Data registration equipment
Outdoor system
Indoor system

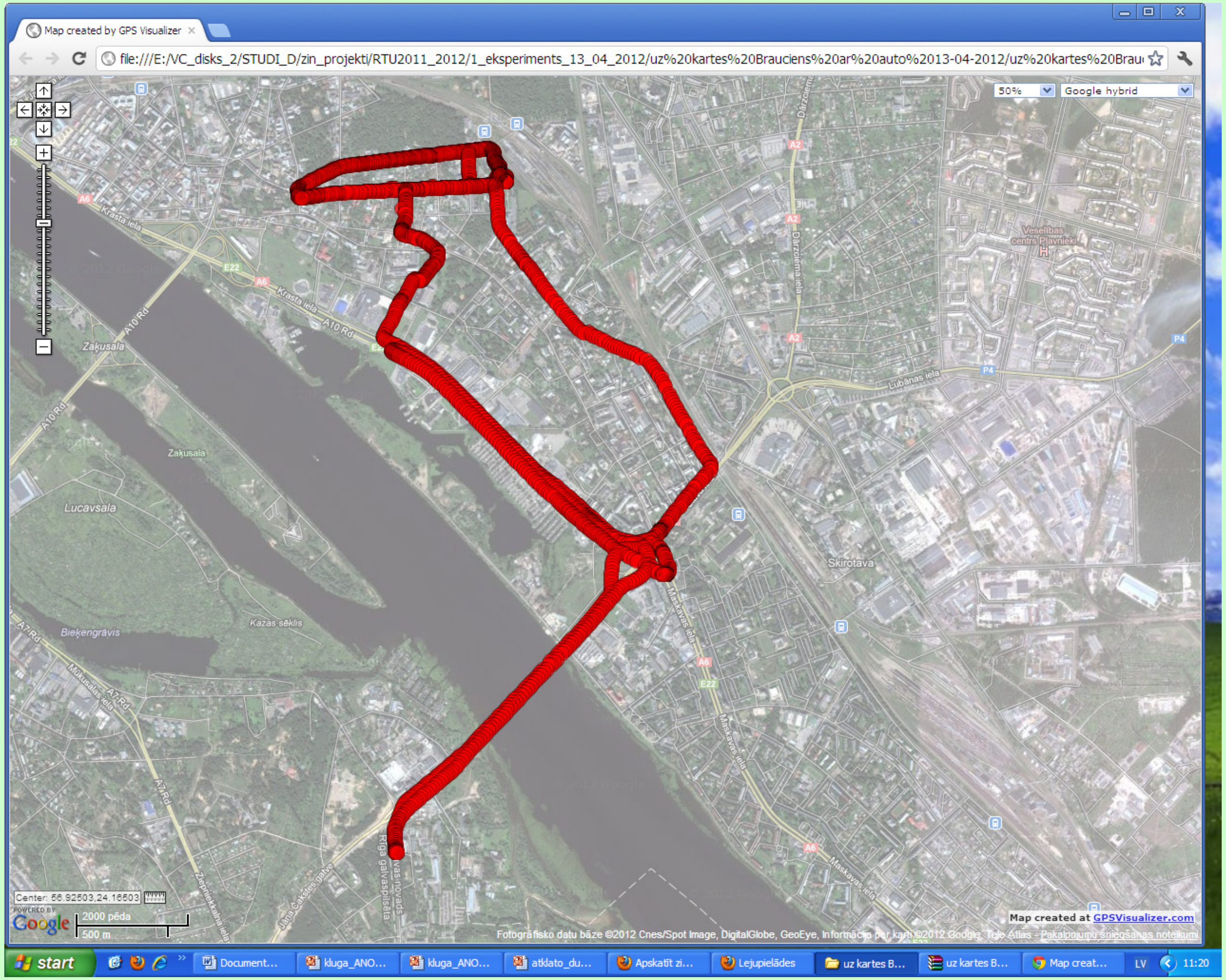


Delta fi density function
Count
Error, cm
Delta lambda density function
Count
Error, cm

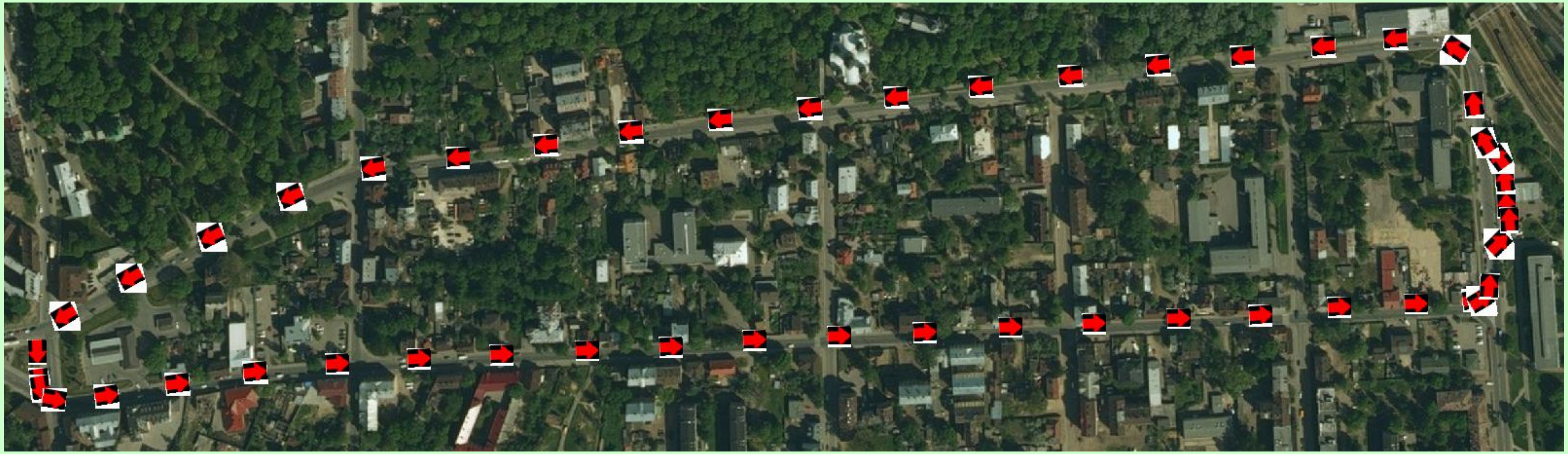
We use GPS device Topkons Hiper+ Measurements on the bridge

After treatment using Least-Squares Fitting (LSF) these data can provide highly accurate results

Mobil system Topcon for RTK measurements



Results of measurements



Results of velocity measurements

Publications

1. Bistrovs V.,Kluga A. MEMS INS/GPS Data Fusion using Particle Filter//Electronics and Electrical Engineering. - 6. (2011)77.-80.lpp.
2. Bistrov V. Study of the Characteristics of Random Errors in Measurements by MEMS Inertial Sensors//Journal Automatic Control and Computer Sciences. - 5. (2011) 284.-292. lpp.
3. Klūga A., Klūga J. Dynamic Data Processing with Kalman Filter // Electronics and Electrical Engineering. - 5. (2011) 33.-36. lpp.
4. Kluga A., Grabs E., Zelenkovs A., Belinska V. Accuracy estimation of GPS receiver parameters with simulator in dynamic mode // Electronics and Electrical Engineering. – 6 (94). (2009) pp. 9-14
5. Bistrovs V., Klūga A. Combined information processing from GPS and IMU using Kalman filtering algorithm // Electronics and Electrical Engineering. - 5(93). (2009) pp. 15-20
6. Beļinska V., Grabs E., Klūga J., Klūga A. Estimation of GPS Receiver Parameters with Re-reference System and Signal Simulator // Electronics and Electrical Engineering. – No.5(85) (2008), 69.-72. lpp.

Publications Feedback

Hello,

My name is Haiyu Lan, I am a student from Haerbin Engineering University, China.

I have just begun my PhD study this year, so I am looking for an academic research direction now.

Recently, I have read one of your articles, *MEMS INS GPS Data Fusion using Particle Filter* and deeply attracted by your inventions and ideas…

These days I have read many articles related to the MEMS-IMU Navigation System, your technics is absolutely good in my opinion. These articles and your explain will give me a clear academic research direction.

I think your approach is really novel and attractive, and also I really like to study your theories by practice, also luckily, there is a MEMS-IMU in my lab. Now I am trying!!!

My email address is lanhaiyu@126.com

Finally, thank you for your patience again!

Best regards

Haiyu Lan

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Thank you for attention!

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