Recent research activities at the Institute of Geodesy and Geoinformatics

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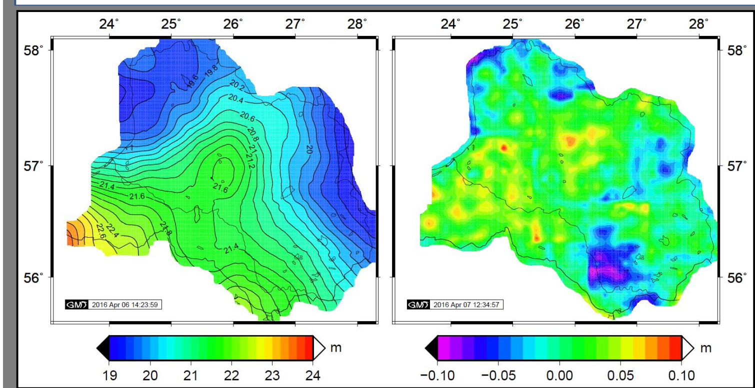
Introduction

This paper discusses the research work done at the Institute of Geodesy and Geoinformatics (GGI) of the University of Latvia, devoted to the geodynamics in Latvia: computation of national geoid model using different data sets, analysis of Latvian GNSS permanent station position time series, development of digital zenith camera for vertical deflection determination, as well as development of new multifunctional optical tracking device for SLR purposes.

Geoid for the eastern part of Latvia

Computation of the geoid model has been completed for the test area of about 45,000 km² in the eastern part of Latvia using the densified GNSS/levelling network data and applying DFHRS software (Digital Finite-element Height Reference Surface), developed at the Karlsruhe University of Applied Sciences, Germany.

The GNSS 4-hour long static measuring sessions were performed by the staff of GGI. Ellipsoidal heights of GNSS/levelling points were computed in ITRF08 frame. The EPN reference station network observation data were used for both the single GNSS/levelling point, as well as for LatPos and EUPOS®-Riga reference station position computation using Bernese GNSS Software version 5.2. All the results were reduced to the epoch of 2015.0 by applying 7 parameter Helmert transformation. The 1st and 2nd order levelling data with LAS14 height values (EVRS2007 realization in Latvia) together with measured ellipsoidal height data of more than 300 points were used for quasigeoid model computation. Two versions of GGI/DFHRS models were computed by applying as initial both the international global gravity model EGG97 and EGM2008 correspondingly. Solutions' standard deviations of residuals are of 1 cm accuracy. Currently geoid model LV14 with 3.2 accuracy is used in Latvia.

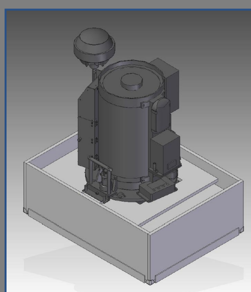


GGI/DFHRS/EGM2008 quasigeoid model (left) and differences between this model and LV14 model.

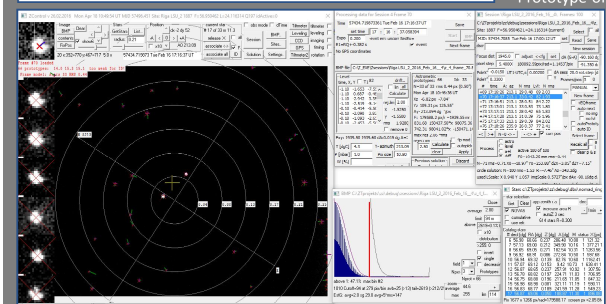
Digital zenith camera

Digital zenith camera is a new kind of astrogeodetic instruments, employing recent advancements in a number of technology areas (GNSS positioning, digital imaging, extensive and accurate astrometric reference star catalogues, high resolution electronic tiltmeter technology) to obtain direct measurements of vertical deflection values.

Over several years GGI is engaged in design of a digital zenith camera. Presently the prototype camera and data acquisition control & processing software are finished and field tests are now proceeding. Our intention is to use vertical deflection measurements along with GNSS/levelling data to improve local quasigeoid model computation.



Prototype of zenith camera.



Screenshot of astrometric processing of frame data.

Multifunctional optical tracking device for SLR purposes

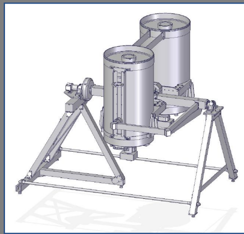
A prototype of new device for both positional and SLR observations of near-Earth objects (satellites, space debris, natural objects) has been designed at the GGI in a joint ESF-funded research project with Institute of Physics of the University of Latvia.

The device uses Alt-Alt mount with twin 16" (41 cm) optical tube assemblies. One of them is used for astrometric image acquisition, the other - as SLR receiver. A separate collimator is used for transmitted laser pulse handling. Computer-controlled stepper motor drive is used for object tracking. Control software relies on mount error model to compensate mount deformations. The intended positioning accuracy is about a few arcseconds; presently 10 arcsecond accuracy level is reached. In order to improve accuracy of transmitted beam pointing, computer-controlled piezoelectric actuators are used for coude path mirrors.

Astrometric subsystem supports system orientation and object coordinate determination in near-real-time. Position determination accuracy is up to a fraction of arcsecond. Objects up to about 15m magnitude can be observed in static mode, up to 18m - in star tracking mode. Astrometric subsystem can be used also for object guiding.

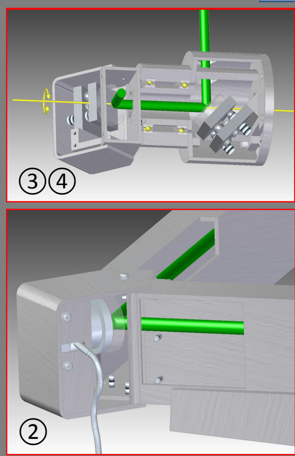
Control software (4 modules, communicating via local network) can run on one or several PCs.

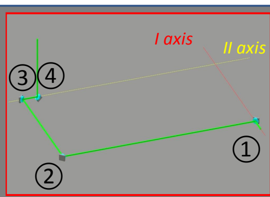
Presently functional tests are completed, the device is being deployed in it's dedicated location.



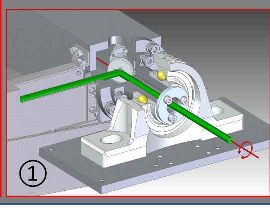
Design of multi-purpose optical tracking device.

Assembly of tracking device.





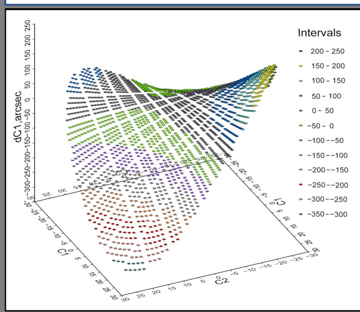
Laser path in beam turning mirrors' assembly (4 mirrors are used).

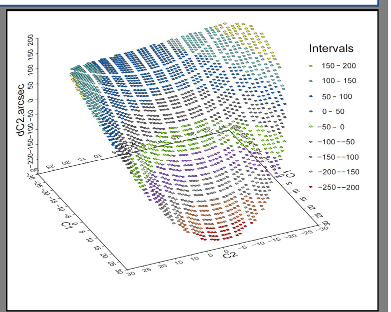


The design of separate optical units.

- Laser beam turns at the mirrors with optimised performances at 532 nm wavelength.
- Each mirror reflects 99,5 % of laser beam light.
- The first two mirrors of laser path are equipped with actuators.
- Laser beam diameter is 6 mm.

Field tests of tracking device's astrometric subsystem have shown imaging and positioning performance close to what was expected for the design. Mount error model parameters were calculated (shown below); resulting positioning accuracy is already adequate for SLR purposes. Magnitude limit for astrometric position determination was found to be about 18m.

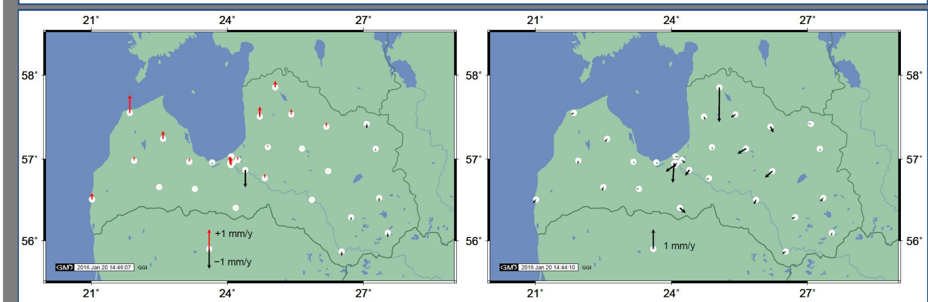




Mount error model: corrections of primary (C1) (left figure) and secondary (C2) (right figure) axis rotation as functions of position.

Latvian GNSS station velocity fields

Time series of GNSS station positions of both EUPOS®-Riga and LatPos networks have been computed applying Bernese GNSS Software version 5.2. DGNSS processing strategy has been implemented using 9 fiducial stations from EPN/IGS networks. Station diurnal coordinates have been obtained for 4-year long observation period - from 2012 to 2015.



More evident outliers in coordinate time series, usually occurred during the winter time, and single (one-day) extremes, which are out of the diapason of ±15 mm in Up component, were excluded. Additionally, time series were aligned from shifts occurred due to GNSS antenna change and introduction of GLONASS observations in 2015.

Obtained results (expressed in ETRF2000) have shown a positive tendency of vertical movements in the western and central parts of Latvia, and negative velocities – in the eastern part. Concerning horizontal movements, velocity field is not homogeneous, showing outstanding movements in the case of some stations. Nevertheless, site velocities are mostly oriented to the South and don't exceed 1 mm/year.

Latvian GNSS station vertical (left) and horizontal (right) velocities obtained from the daily solution (2012-2015) and expressed in ETRF2000.