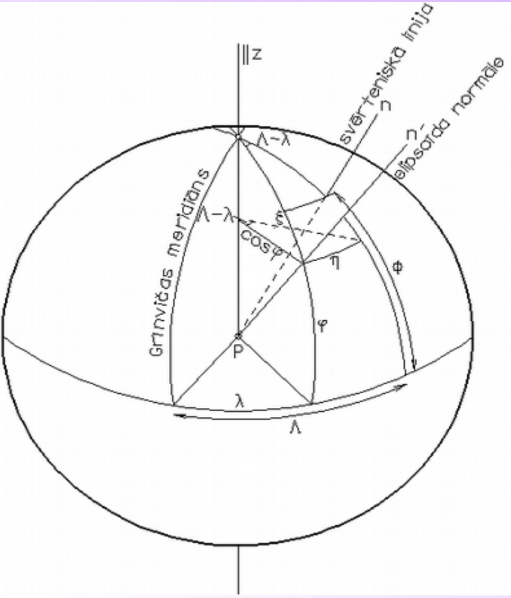
Digital Zenith Camera for Geodetic Purposes in Latvia



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Presented by Jānis Kaminskis

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Development of a digital zenith telescope optical system and telescope prototype and analysis of experimental vertical deflection measurements for applications in Latvian geodetic network has been performed at the **Institute of Geodesy and Geoinformation (GGI),** University of Latvia.

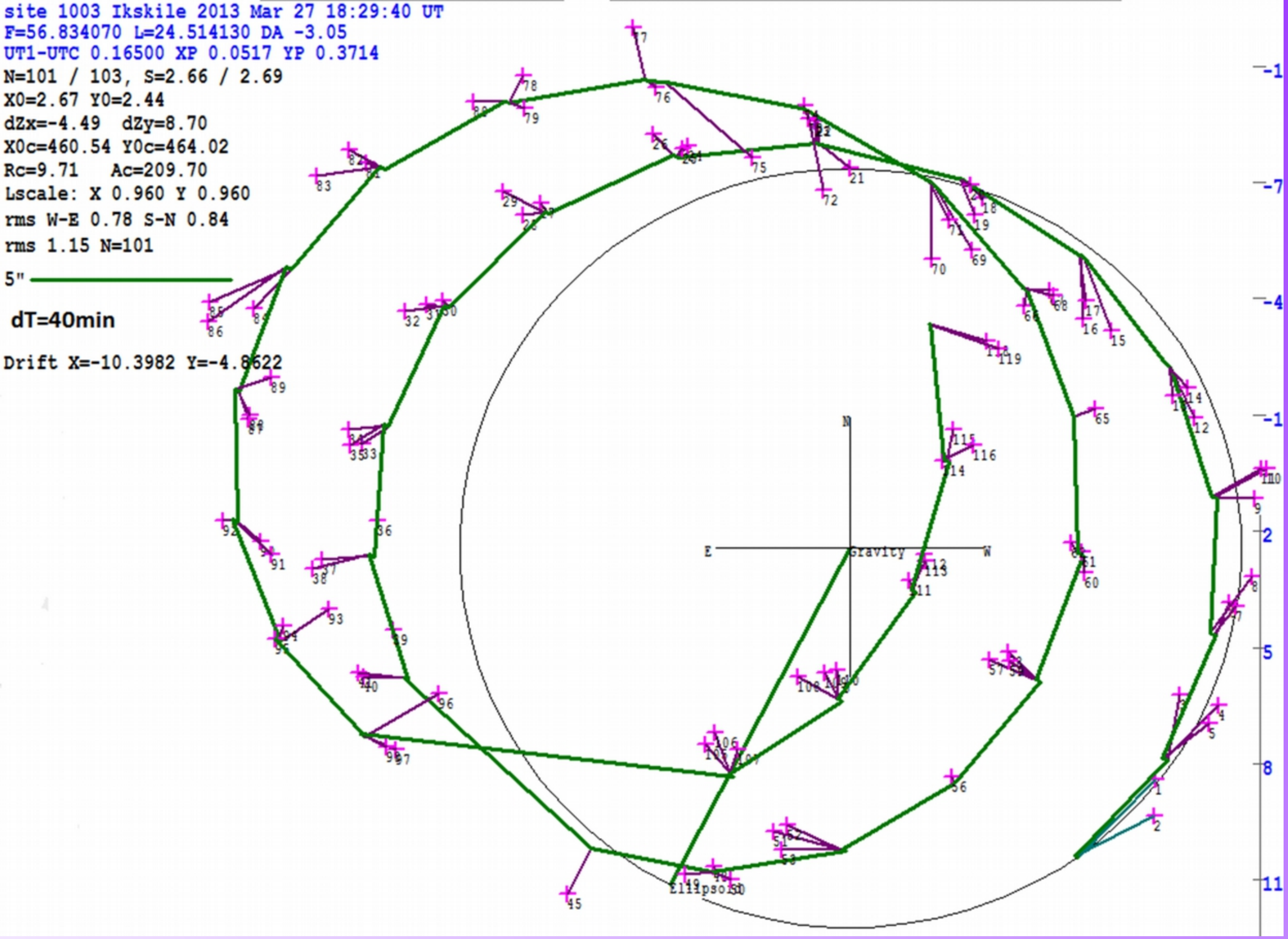
An **original optical system** for a digital zenith telescope was computed and a **patent application** has been submitted.

The astro-geodetic method is known since mid-20th century, however with little recognition, since the acquisition and processing of high quality data was time and labor consuming process. During the recent decades due to the emergence of site geocentric coordinate acquisition using GNSS, charge-coupled device (CCD) imaging technologies, high resolution electronic tiltmeter technologies and extensive, high accuracy reference star catalogues, this method has become increasingly popular. The research has yielded that astro-geodetic methods provide a faster result with a smaller number of measurements than in the case of gravimetric methods. In order to apply and expand the astro-geodetic method in Latvia and improve precision of local geoid model, vertical deflection measurements will be performed in Latvia.

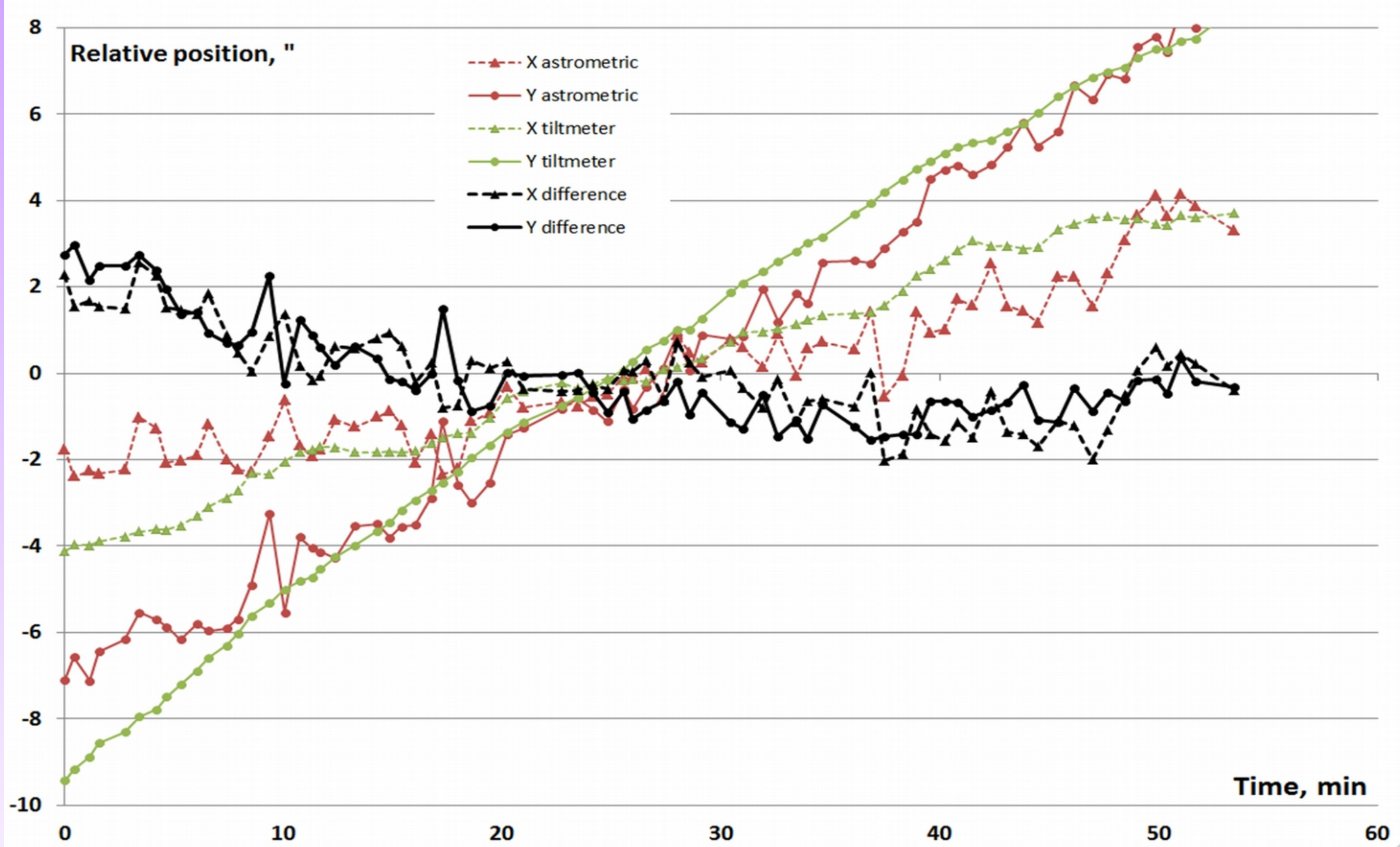
Astrometric and gravimetric subsystems:

- 20 cm catadioptric telescope, F=1373 mm
- Field of view 0.35 x 0.27 dg, 1360 x 1024 pixels (~1”)
- Reference star catalogue: subset of NOMAD (*Naval Observatory Merged Astrometric Dataset*) up to 15m
- Reference stars per frame: 4 .. 23, average 12
- Star magnitude: 6m ..13m with 0.1-0.3 sec. expousure
- Source of apparent places: NOVAS (*Naval Observatory Vector Astrometry Software*)
- RMS of star image position: 0.3” .. 1.5”, average 0.5”
- Zenith position accuracy for frame: 0.1” .. 0.2”
- Precision tiltmeter HRTM with 50 prad (~1e-5") resolution in +-2' range

Development of a zenith telescope was commenced in 2011 in the Institute of Geodesy and Geoinformatics <*GGI*> at the University of Latvia



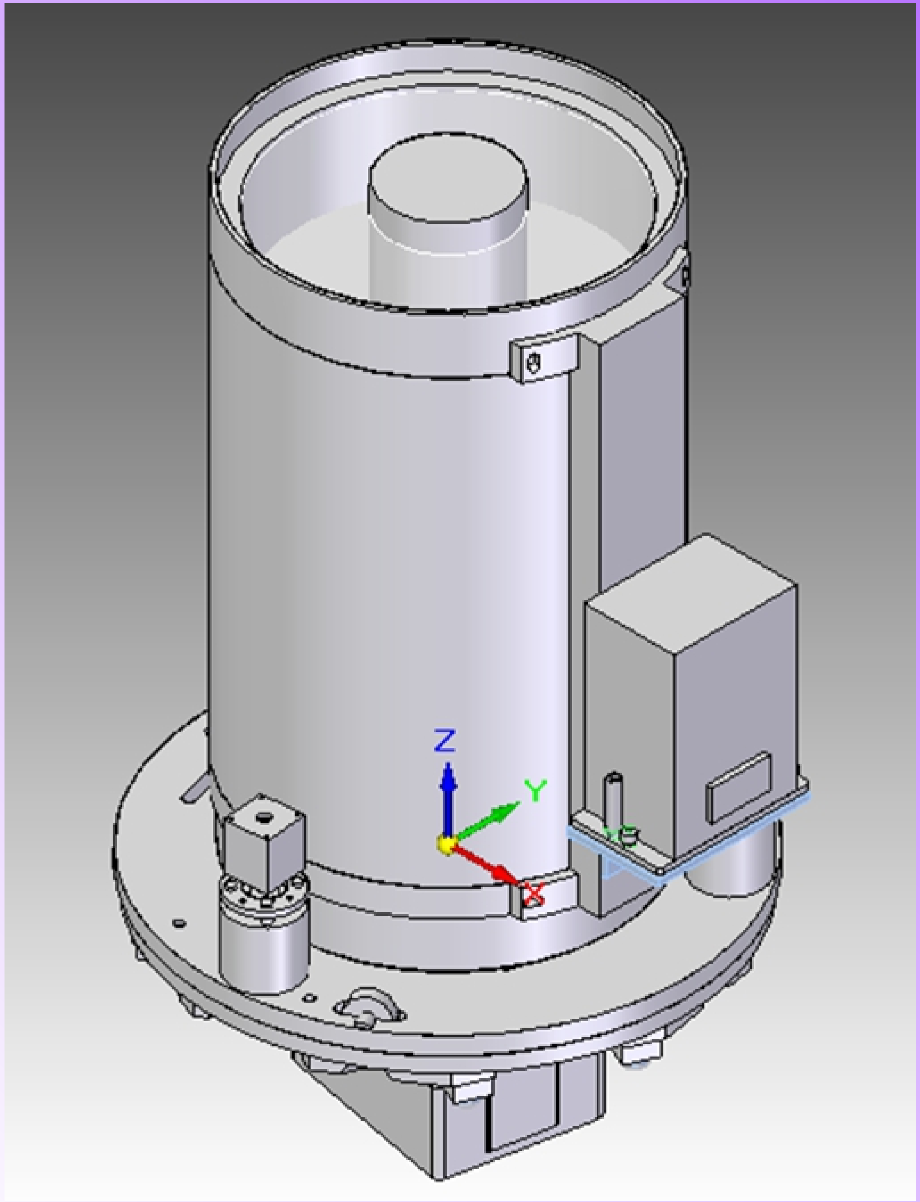
Difference between directions to reference ellipsoid normal and tiltmeter axis in rotating coordinate system. In ideal circumstances it should make circle with radius of plumb line deflection value (shown by thin black line). In reality, thermal deformations changes tiltmeter axis direction relative to optical system, resulting in spiraling trajectory. If dependence of deformations on time is close to linear, evaluation of compensating drift model is possible.



Drift of plumb line and ellipsoidal zenith positions and difference of them in instrument coordinate system. Drift of plumb line and ellipsoidal zenith positions and difference of them when instrument is in stationary position. Some bending of instrument assembly has occurred besides tilting of support surface, resulting in decidedly non-linear drift of tiltmeter and imager relative orientation. Observation sessions must be short (a few minutes) to avoid most of effects of this bending or include them in linear drift model.

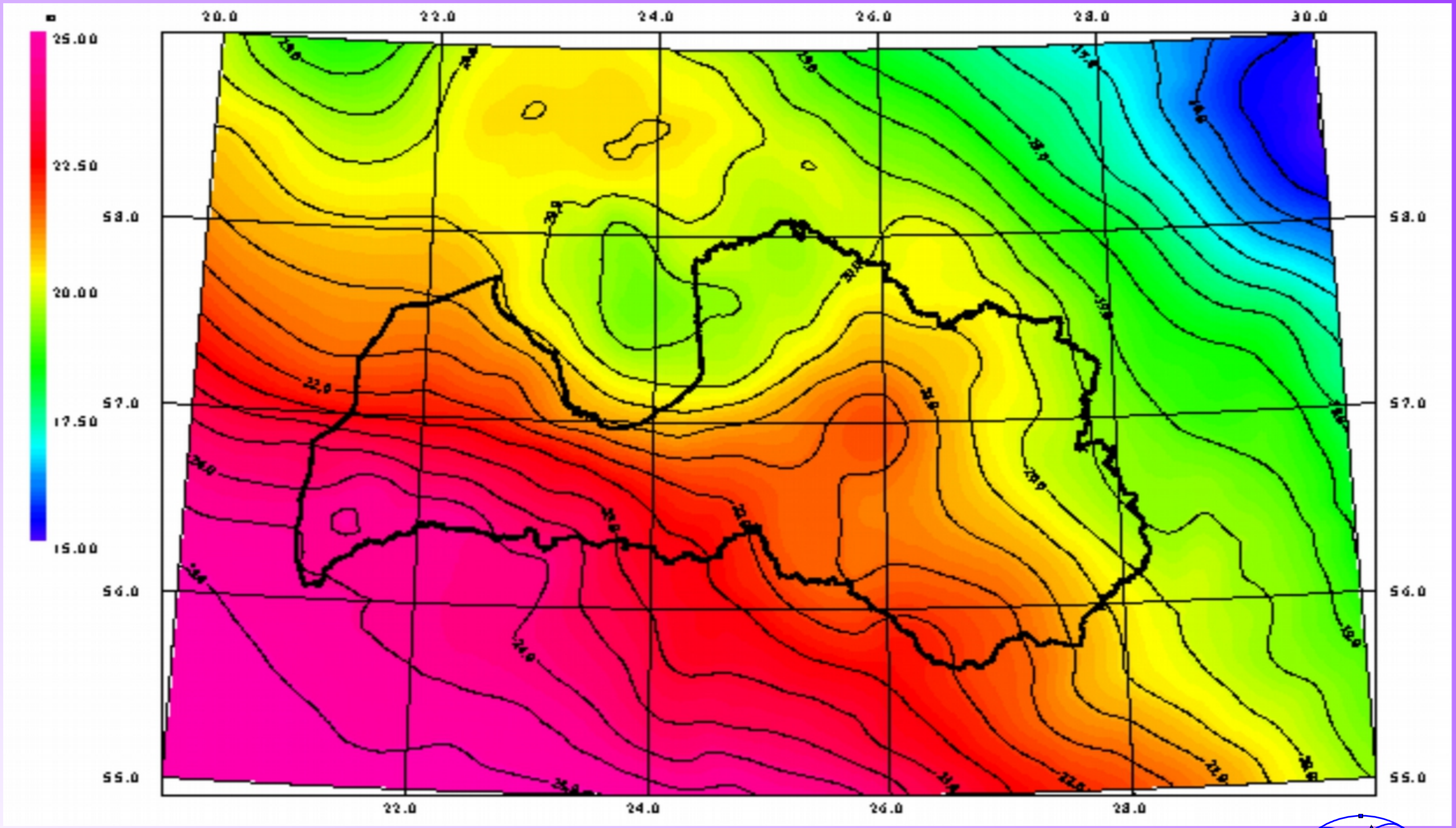
Digital zenith camera

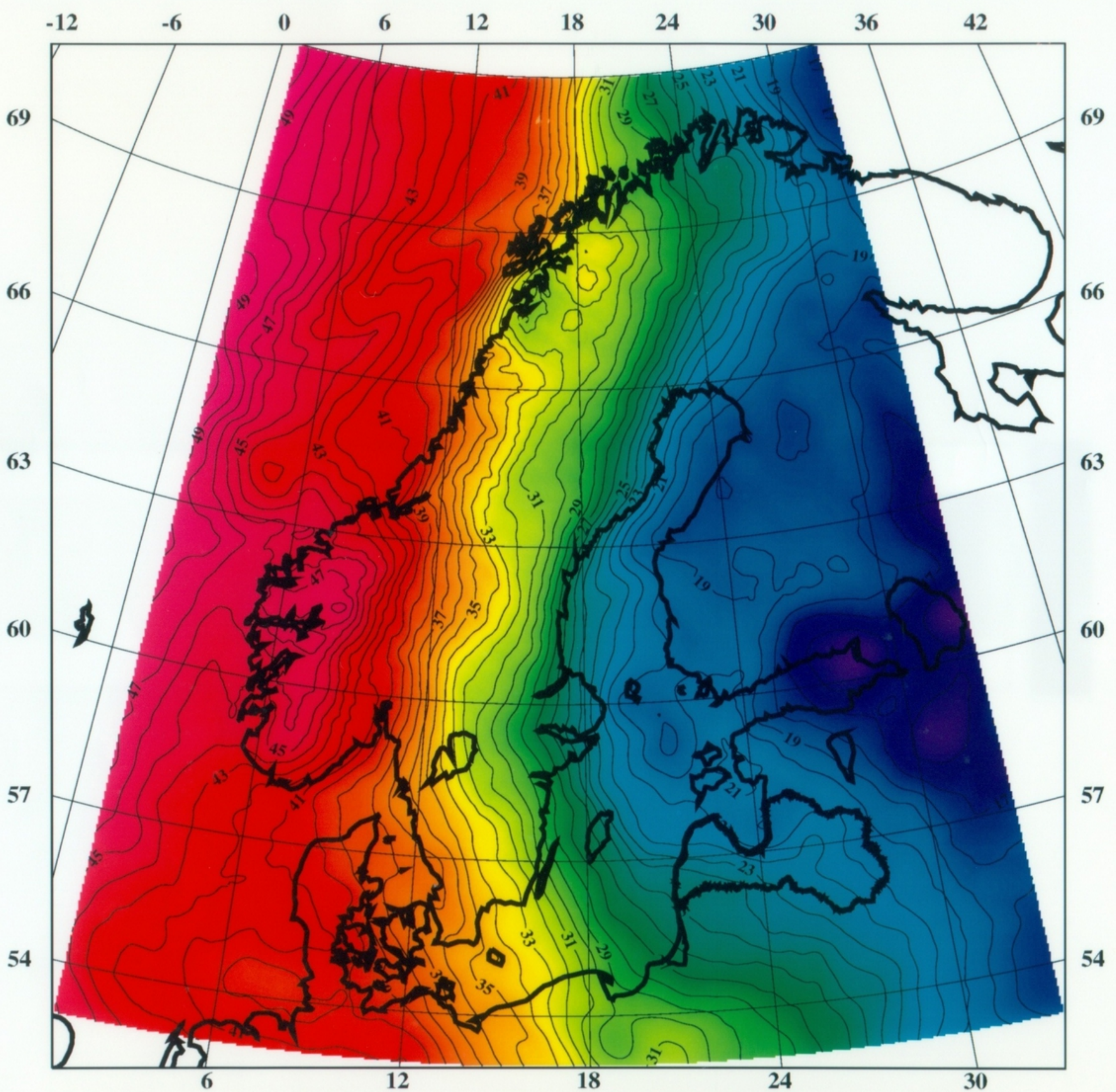
Continuing digital zenith camera project, a prototype camera has been built and an extensive test research carried out, looking for solutions and design elements which might present problems and should be improved [1]. In general, camera properties were found close to expected. The most problematic aspect of prototype camera was mechanical stability of camera assembly. Effects of thermal deformations during observation sessions were found to be a serious disturbing factor. Also, necessity to improve extent of automation was obvious. As a result, an improved camera design was made. It uses different approach to observation process – motorized leveling will be performed in each camera position before measurements, ensuring, that tiltmeter readings are always small and minimizing problems rising from tiltmeter scale and orientation uncertainty.



New camera design

Latvia geoid (LV'98) from gravimetry and ERS-1 data





NKG
from
15m
till
50m
c.i.1m

Possible combination with other geodetic techniques:
GNSS & VLBI

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RTU

IRBENE

Typical view of antenna,
Place in a quite place without radio noise

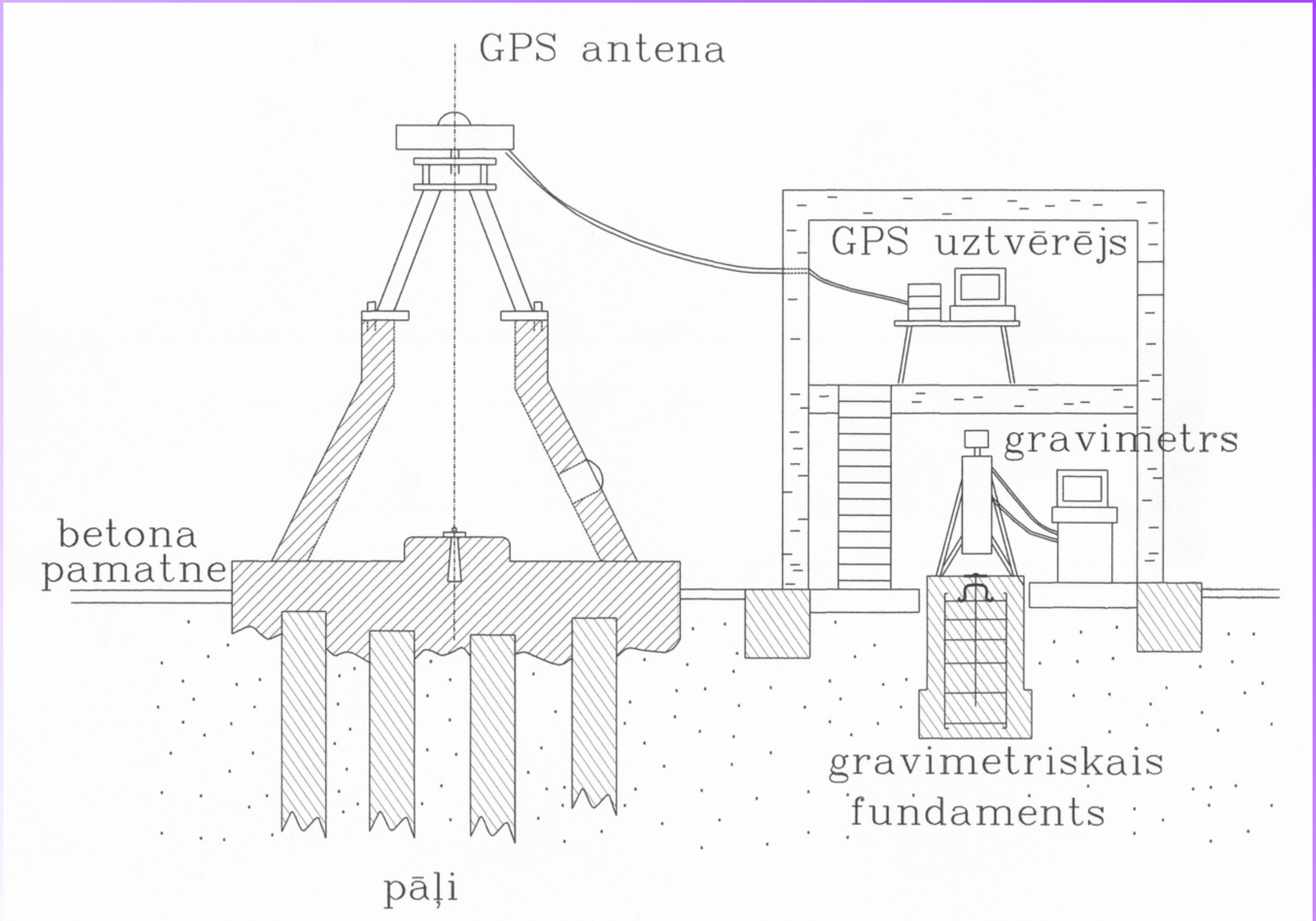
RT-32 max angular speed around the altitude and the azimuth axis (2 direct-current, 60kw motors): **2°/sec**

Possible use in geo-VLBI

IRBENE


VIRAC
Ventspils International Radio Astronomy Center
Lielirbe
Miķeļtornis
Lūžņa
Oviši
Irbe
Irbene
Jaunupe
P 124
Rinda
Ance
Jom
Liepene
Vēde
Akmeņdziras
Muižarāji
Klāņezers
Virpe
Būšnieku ez.
STALDZENE
VENTSPILS
Pope
Jaunāmuiža
St.Ventspils II
A 10
Nīcnieki
Krievlauki
Dokupe
Elkšķenes st.
Dandzītes
Blāzma
Amele
Tārgale
Elkšķene
Puzes ez.
Puzenieki
Kamārce
Puzesmuiža
Stikli
Vārve
Ventspils rajons
Liezde
Ūdrande
Engure
Leči
Ugāle
Zūras
Landze
Usmas st.
Dzirnavas
Māteri
Tirukša ez.
Ventava
PILTENE
Usma
Spāre
P 123
Ziras
Venta
Laidzes ciems
Cirkale
Bērtmejciems
Tingere
Īve
Anuži
Valpene
Gibzde
Dumciems
Ciruļi
Pobuži
Pūņas
Valgale
Ciemklabji
TALSI
P 129
Pastende
A 10
Aizupes
Dižstende
Norway
Sweden
Finland
Estonia
Irbene
Rīga
Latvia
Rusia
Denmark
Lithuania
Germany
Poland
Belorusia

IRBENE


GPS antena
GPS uztvērējs
gravimetrs
betona pamatne
gravimetriskais fundaments
pāļi

IRBENE

Computations with GRAVSOFT

C:\Users\Janisk\Desktop\GEOID_~1\GEOID_O.EXE

```
  *************************************************************
  *                                                           *
  *   GEOID - GRAVSOFT geoid interpolation and transformation *
  *                                                           *
  *   vers. MAR95 (c) RF, Kort- og Matrikelstyrelsen, Denmark *
  *************************************************************

Enter task: 1 = interpolate geoid heights
            2 = ellipsoidal to orthometric heights using geoid
            3 = orthometric heights to ellipsoidal    -     -
            4 = geoid heights in different datum ...
            5 = deflections of the vertical ...
-> 5

 --- deflections of the vertical wanted, unit: arcsec ---
Enter binary geoid file name: CR=\geoide\geoid94a.bin
-> geoid94a.BIN

Geoid grid limits and spacing in degrees:
   55.00000    59.00000  20.00000    30.00000     0.02500   0.05000
Do you wish to input data points from a file? (Y/N or CR=N)
-> N

Enter file name for output: (CR=geoid.out)
-> deflection_vertical.out

Type of input: 1 = lat, lon (degrees)
               2 = lat, lon (deg,min,sec)
               3 = X, Y, Z (meter)
               4 = N, E (UTM, meter)
-> 1

- output coordinates are geographic degrees -
Enter: rfi, rla (x=exit)
-> 57.553  21.855

       1   57.55300000  21.85500000     2.961     0.268
Enter: rfi, rla (x=exit)
-> _
```

Results from GRAFSOFT at IRBENE and around

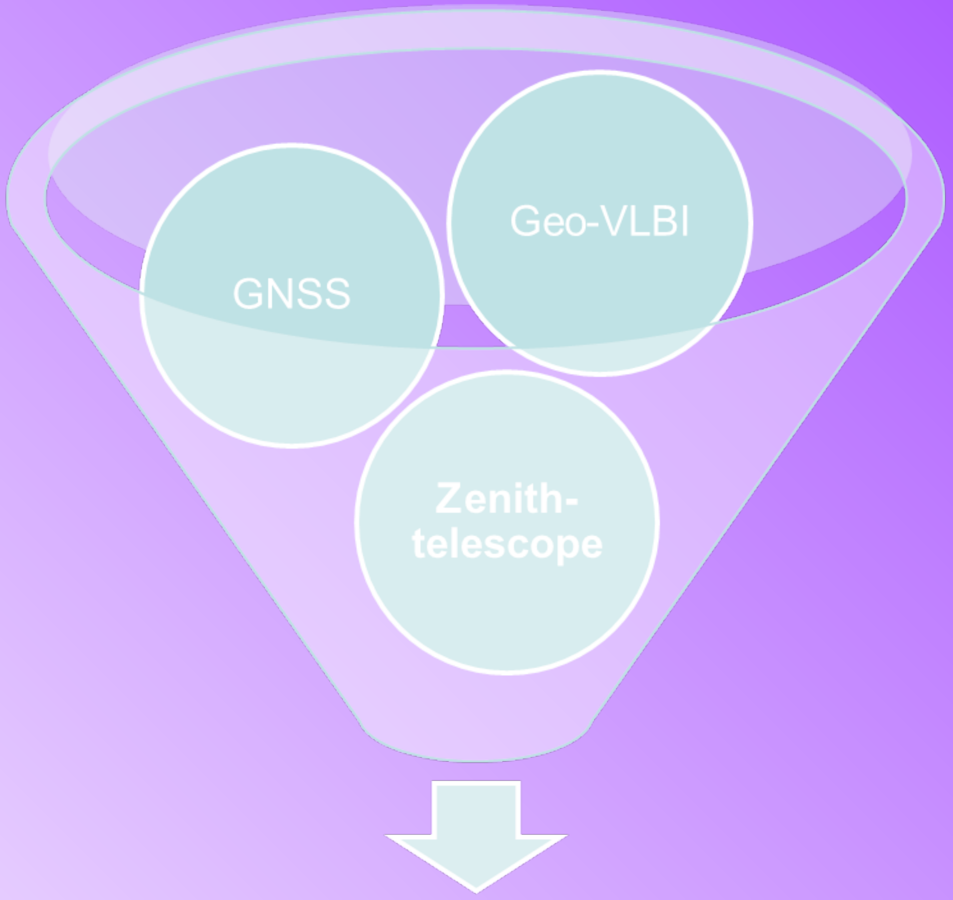
DEFLECTI.OUT - Notepad

File Edit Format View Help

No	LATITUDE	LONGITUDE	DEFLECTIONS IN ARCSEC		
1	57.55300000	21.85500000	2.961	0.268	VLBI IRBENE
2	57.65300000	21.85500000	2.070	0.616	TO NORTH
3	57.45300000	21.85500000	3.131	-0.397	TO SOUTH
4	57.55300000	21.95500000	3.131	0.293	TO EAST
5	57.55300000	21.75500000	2.538	-0.053	TO WEST

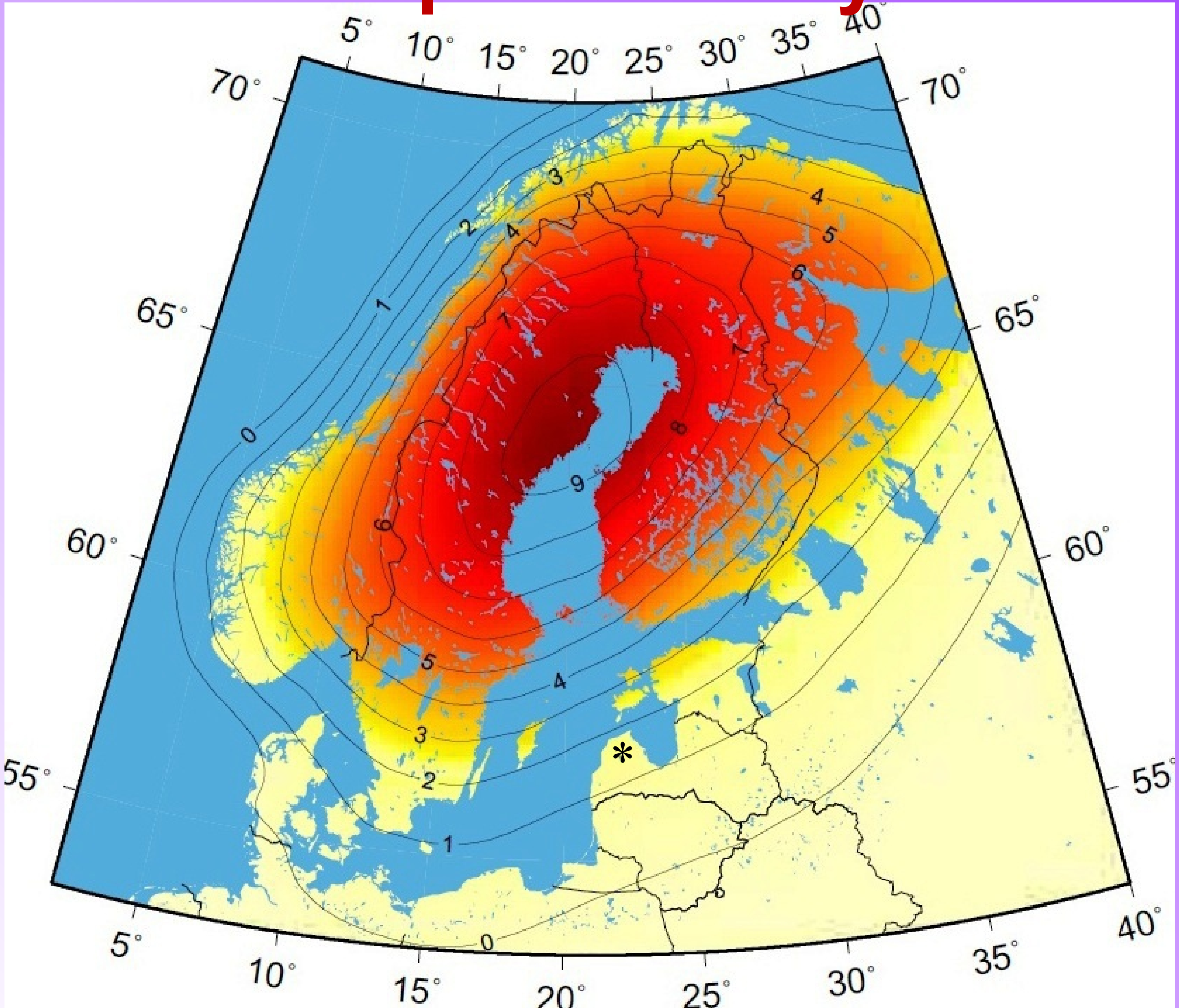
Typically Deflections of Vertical <DoV> in the Baltic region fluctuate from **- 2** to **+ 5** arc seconds; locally more

Combinations for development or future / together different techniques



Improvements in accuracy

IRBENE located in Fenno-Scandinavian uplift territory



FOTONIKA-LV

GGI ASI

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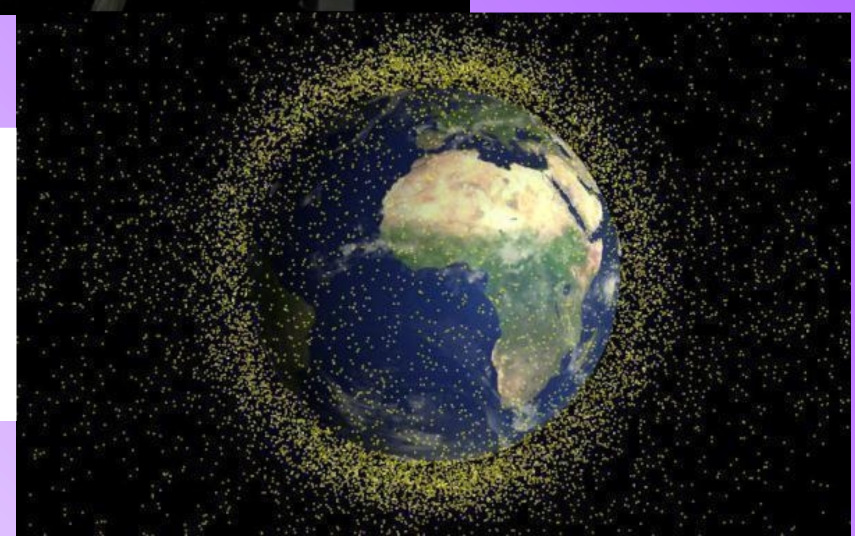
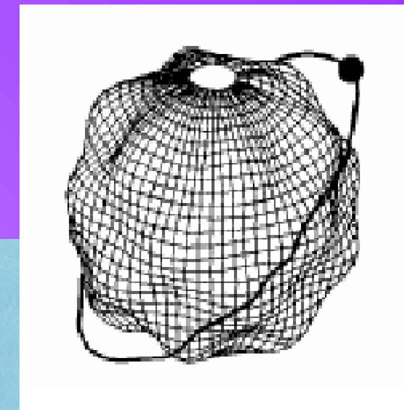
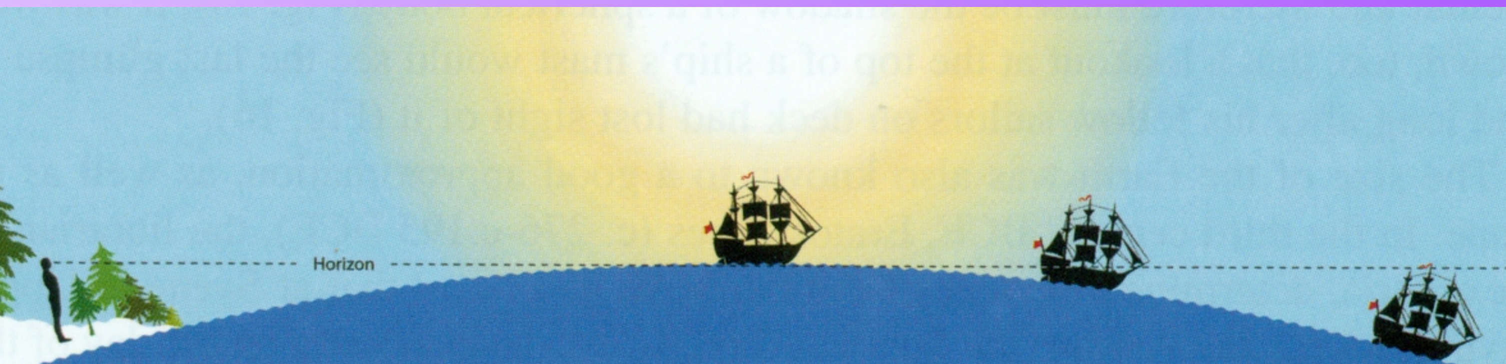


Questions?





Thank You for attention!

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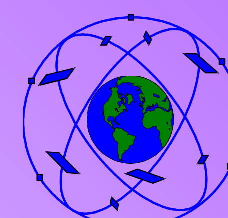

http://www.lu.lv/ggi/eng/