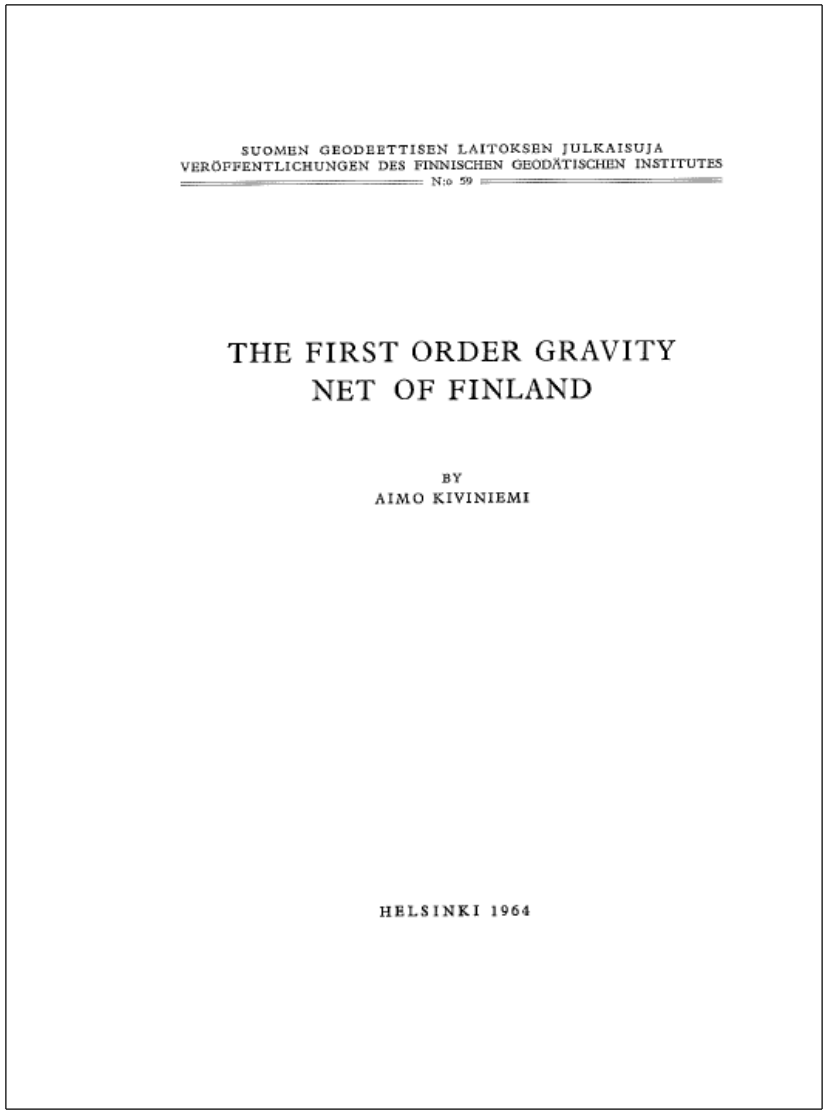
Remeasurement of the Finnish First Order Gravity Net FOGN started in 2009 Revision of the Finnish National Gravity Net

Jaakko Mäkinen (1), Marcin Sekowski (2), Jan Krynski (2), Hannu Ruotsalainen (1), Mirjam Bilker-Koivula (1)

(1) FGI
(2) IGiK Warsaw



Publ. Finn. Geod Inst. 59 (1964)

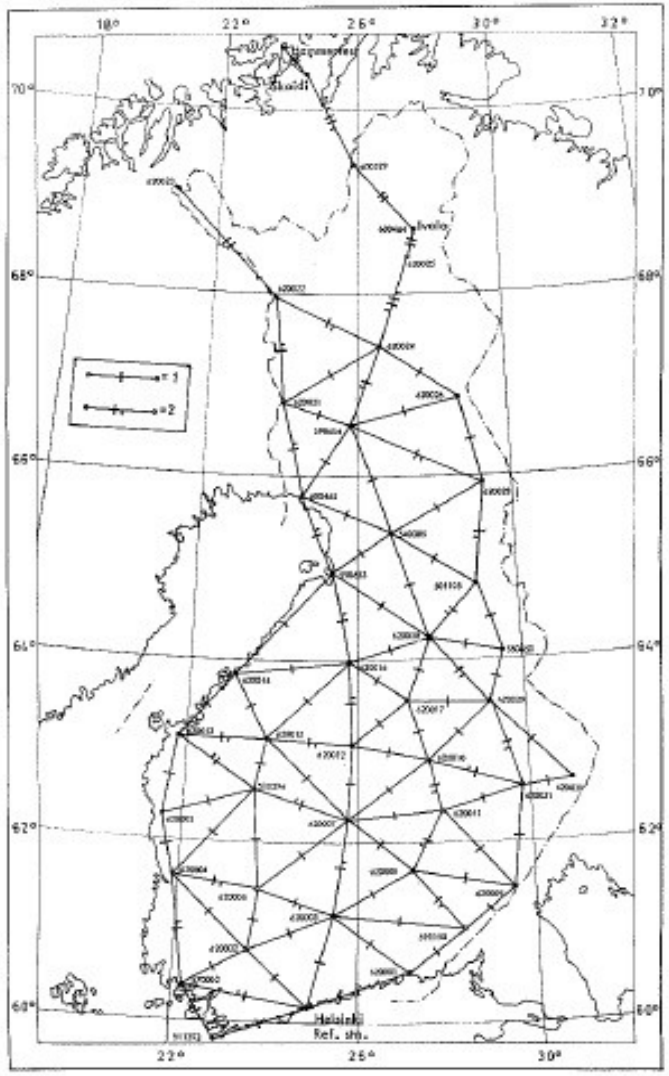


Fig. 1. The first order gravity net of Finland. 1 = double measurement, 2 = triple measurement

Publ. Finn. Geod Inst. 59 (1964)

Use of the FOGN

- reference sites for gravity mapping by the FGI and others (mostly by geologists)
- outdoors, accessible at any time without prior arrangements
- easy to find even in winter with plenty of snow
- reasonably permanent stations in monumental buildings, mostly on church stairs; bedrock is rare
- changes come mostly from reconstruction of steps e.g. to allow wheelchair access
- otherwise the stability of the gravity values (about 0.01 mgal) is sufficient for the purposes of the FOGN
- note: no geodynamical ambitions

Forssa church
control measurement in 1988

FOGN present status I

- measured 1962-63 by Aimo Kiviniemi, Worden Master 227
- present zero and scale derived from a readjustment into IGSN71 by T. Honkasalo in 1971
- epoch 1963.0, mean tide system (from IGSN71)
- original estimate for accuracy of gravity differences 0.03...0.06 mgal (one-sigma)
- control measurement in 1988 by Kiviniemi
- performed in large loops, 2xLCR-G (G-55, G-600)
- rms for discrepancies (1988-1963) of gravity differences without correction for land uplift was 0.035 mgal (JM)

FOGN present status II

- values of some rebuilt sites was corrected on the basis of measurements 1988, otherwise the 1971 values retained
- current values published in PFGI 125 (1998),
- some more recent patches are unpublished
- comparisons with absolute-gravity measurements (PFGI 125 and after) show values are consistent with AG within estimated accuracy after system differences (permanent tide and epoch) are accounted for
- new values for rebuilt sites have been deduced from ties within the FOGN, not from absolute-gravity measurements
- FOGN consistent reference for Finnish gravity mapping 1963-
- original recalculation of data previous to FOGN will be discussed later

Future uses of the FOGN

- shall be the same as the old uses: reference for gravity survey
- in other words, no geodynamical task added
- new improved values required in order to :
- improve the referencing of gravity for geoid calculation
- obtain basis for re-calculation of older gravity surveys tied to FOGN
- internal accuracy should be compatible with the modern relative gravimeters of the users
- achieving 0.02 mgal (2-sigma) for the new values is enough
- A10 specs in other words

Consequences for planning I

- A10 is the instrument of choice
- instead of time-consuming looping with 2-4 relative gravimeters between FOGN and absolute-gravity sites
- a single occupation with the A10 fulfills the goals
- primarily measurement on the old site
- for technical reasons it is occasionally necessary to do the measurement at an excenter (which could be just decimeters from the old site) + a relative tie
- even in the case of an excentric absolute measurement, the old site is retained as the FOGN station
- IGiK A10-020 was available and an agreement was signed between IGiK and FGI, measurement in 2009 and 2010
- 2009 expedition Marcin Sekowski and Jaakko Mäkinen

Geodynamics application backwards in time

- time difference is 47 years, assume accuracy in 1963 was 0.03 mgal 1-sigma
- even if the new measurements were errorless, the accuracy of the gravity change is 0.6 ugal/yr 1-sigma which corresponds to 4 mm/yr in land uplift
- and note that because the old measurements were relative, the signal are the land uplift differences, not the land uplift
- 1988 control measurements will help some
- conclusion: uplift will be seen but not very well, doubtful whether new insights can be gained
- note that the error statistics imply that maximizing the accuracy of the new measurements does not pay off

Consequences for planning II

- with the A10, ”high-speed production” mode is sufficient: 8x120 drops, drop interval 1 second, total time 24 min
- we decided to do two independent setups, rotating the gravimeter 180° in between
- with 150 km between stations, we assumed that 2-4 stations per day could be measured (2 turned out to be right)
- unlike with typical FG5-measurements, there is practically no time when the gravimeter runs and the team is free to do supporting measurements
- the supporting measurements are: levelling, vertical gradient , eventually a relative tie from an excenter, documentation (photos, sketches), GPS (RTK or static)
- vertical gradient at 3 levels: the stations will have published $g(z)=g_0+az+bz^2$

Consequences for planning III

- absolute team should not be delayed by the time-consuming (1 day +) supporting measurements
- solution: absolute team + supporting team
- supporting team comes afterwards, starting (and ending) this season
- no (third) reconnaisance team: the absolute team mostly does its own reconnaissance
- telephone and internet reconnaissance where problems known in advance, visits in connection with other projects
- e.g., risky sites in some city centers will have an excenter measured in the suburbs

FG5 control

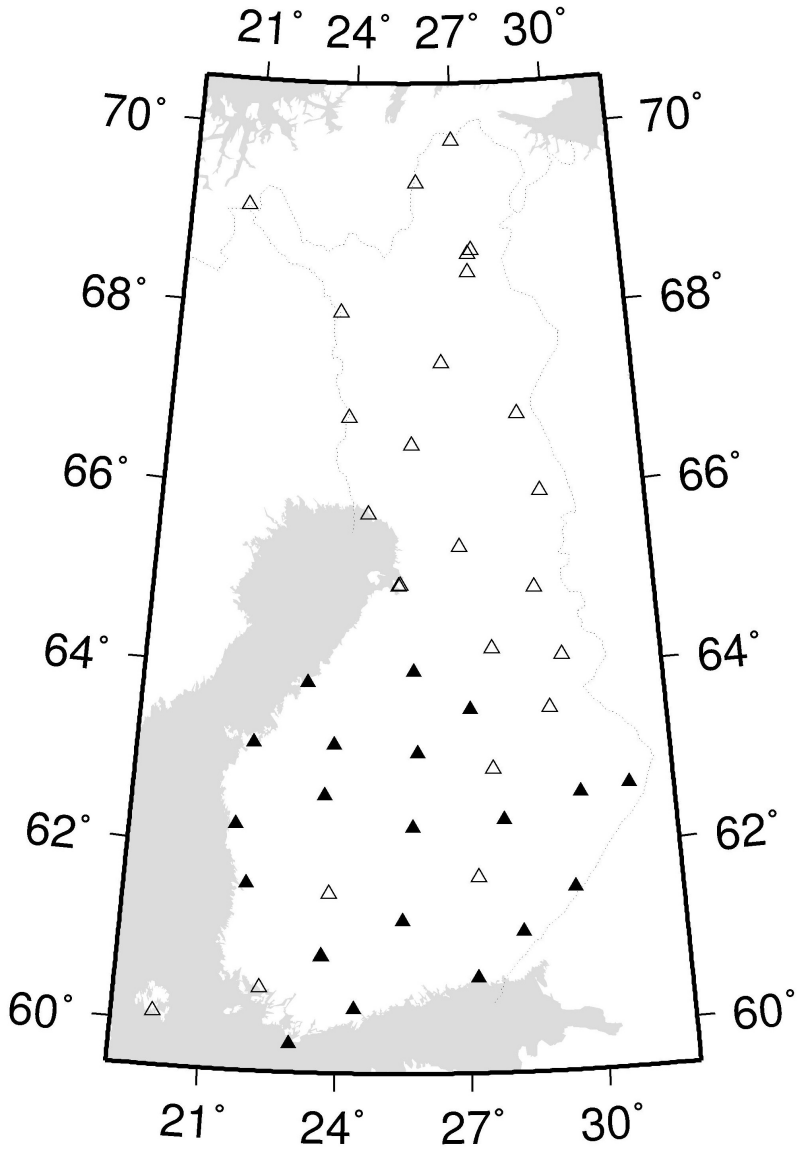
- visits at FG5 sites 1-2 per week
- no science need for concurrent FG5 measurements
- but would be aesthetically desirable
- not possible in 2009 due to problems with the FG5-221 of the FGI

A10 operation

- was possible from car at all sites
- Polish “fisherman's tent” for protection agains wind and sun
- wooden benches to make platform for tent on stairs
- sleeves sewn on tent, weights on sleeves to keep tent in place

Forssa 2009

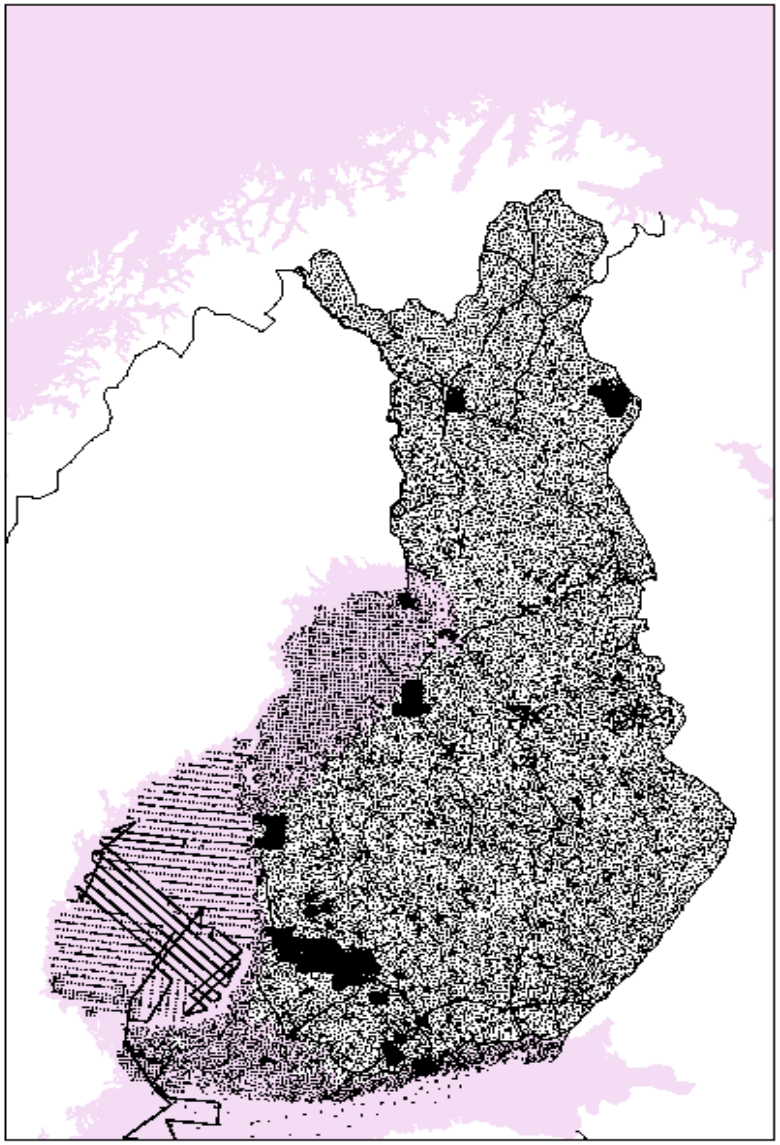
Forssa 2009



Solid 2009, 19 sites
Open 2010, 29 sites

Experiences 2009

- A10-020 was 29 days away from Warsaw
- Operating part of time out of Metsähovi
- Travel, test campaign in Metsähovi, understanding the vacuum pump, calibration of two-mode laser and rubidium oscillator at MIKES (National Metrology Institute in Finland)
- 15 “field days” , 19 FOGN sites occupied
- rms of all setup differences (I-II) 5 ugal
- 10 comparisons to FG5 values, mean diff 1 ugal, stdev 4 ugal
- 15 points had the original FOGN or the 1988 replacement preserved
- abs. measurement on 10 points was within 0.3 m of 1962 point position



National gravity net FGI

35000 stations

Using the results

- New values for FOGN g=g(z)
- Epoch: taking 2000.0 consistent with N2000
- Recalculate all surveys connected to FOGN since 1962
- For FOGN stations lost before present, find proxy stations and connect with relative measurements
- additional spot checks
- performed by the support team to minimize driving around Finland
- Pre-1962 surveys used “Fundamental gravity network” with distortions of up to 1 mgal in some parts
- Fundamental gravity network shares some stations with FOGN and the rest were connected in the 1960s
- however, correction was not performed nodal point to nodal point but by areal interpolation
- will be redone now