National Report of Sweden to the EUREF 2005 Symposium

– geodetic activities at Lantmäteriet, the National Land Survey of Sweden

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1. Introduction

At Lantmäteriet (the National Land Survey of Sweden) the activities in the fields of geodetic reference frames and geodetic reference networks are focused on introducing the ETRS 89[1] realisation SWEREF 99, introducing the new national height system RH 2000 and the ongoing project RIX 95. Large efforts are also carried out concerning the operation and expansion of the Swedish network of permanent reference stations SWEPOS™. Some of the activities are done within the framework of NKG[2].

2. Contributions from Lantmäteriet to EPN[3] and ECGN[4]

Seven SWEPOS stations are included in EPN. The stations are Onsala, Mårtsbo, Visby, Borås, Skellefteå, Vilhelmina and Kiruna (ONSA, MAR6, VIS0, SPT0, SKE0, VIL0 and KIR0). Both daily and hourly data are delivered.

Furthermore Onsala, Mårtsbo, Visby, Borås and Kiruna are also included in the IGS[5] network. Skellefteå (SKE0) is proposed to be a new IGS station. All the Swedish EPN/IGS stations are equipped with dual-frequency GPS[6]/ GLONASS[7] receivers and Dorne Margolin antennas.

Lantmäteriet operates the NKG EPN Analysis Centre in co-operation with Onsala Space Observatory.

Sweden has, according to a co-ordination done within the framework of NKG, offered all seven Swedish EPN stations except Vilhelmina for ECGN. NKG has also created a Nordic

[1] ETRS 89 = European Terrestrial Reference System 89

[2] NKG = Nordic Geodetic Commission

[3] EPN = EUREF Permanent Network

[4] ECGN = European Combined Geodetic Network

[5] IGS = International GPS Service

[6] GPS = Global Positioning System

[7] GLONASS = Globalnaya Navigatsionnaya Sputnikovaya Sistema

densification called NGOS[8] (Poutanen et al, 2005).

3. ETRS 89 realisations in Sweden

SWEREF 99 was adopted by EUREF as the Swedish ETRS 89 realisation at the EUREF 2000 symposium in Tromsö (Jivall & Lidberg 2000).

Work is going on for a common Nordic reference frame within the framework of NKG. It will not replace the national ETRS 89 realisations, but it will give the possibility to verify differences between them. The frame will be used for development of transformation strategies between ITRF[9] and the national ETRS 89 realisations; see further Knudsen et al. (2005) and Jivall et al. (2005).

The introduction of SWEREF 99 is dealt with in section 6.

4. Network of permanent reference stations (SWEPOS™)

Since July 1st 1998 the Swedish network of permanent reference stations (SWEPOS), see figure 1, is operational in IOC[10] mode, i.e. for positioning in real-time on the metre level and by post-processing on the centimetre level (Kempe et al. 2004). Positioning in real-time on the centimetre level is possible in regional parts of Sweden. SWEPOS also offers an automated post-processing service, based on the Bernese software (Kempe & Jivall 2002), see www.swepos.com.

The purposes of SWEPOS are to:

- provide single- and dual-frequency data for relative GPS measurements.
- provide DGPS[11] corrections and RTK[12] data for distribution to real-time users.
- act as the continuously monitored foundation of the Swedish geodetic reference frame (SWEREF 99).
- provide data for geophysical research.
- monitor the integrity of the GPS system.

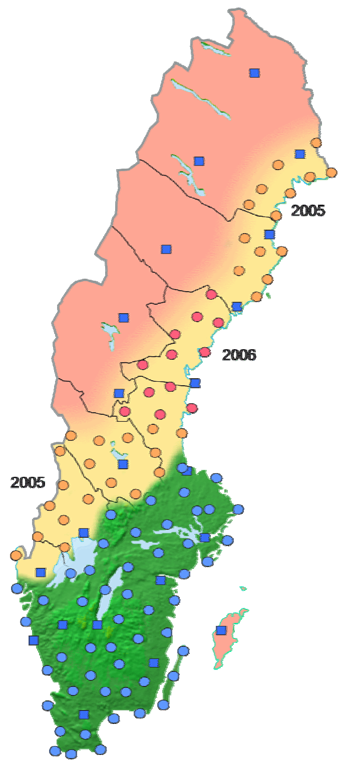


***Figure 1**: The SWEPOS network (squares are complete stations and dots are simplified ones). Blue stations are in operation (June 2005) and orange and red stations are planned. The green marked area (south) shows the coverage of SWEPOS*

[8] NGOS = Nordic Geodetic Observing System

[9] ITRF = International Terrestrial Reference Frame

[10] IOC = Initial Operational Capability

[11] DGPS = Differential GPS

[12] RTK = Real Time Kinematic

Network RTK Service today and the yellow part will be covered 2005-2006.

The same 21 stations that SWEPOS consisted of when it became operational in IOC mode are still in operation. These stations are complete stations, i.e. they are monumented on crystalline bedrock and have redundant equipment for GNSS[13] observations, real-time communications, power supply etc.

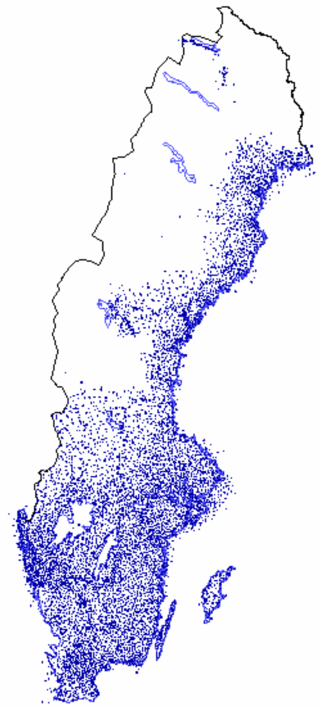
A number of simplified stations have been added during the last seven years. Today (in June 2005) SWEPOS also includes 53 simplified stations, which mainly are located on top of buildings and with less redundant equipment than the complete ones. The simplified SWEPOS stations are mainly used for network RTK (Jonsson et al. 2003) and for on-going research projects for the use of GPS in meteorological applications.

A regional network RTK service was launched on January 1st 2004. This service (SWEPOS Network RTK Service) covers the most populated areas of Sweden, see figure 1, and there is today (June 2005) approximately 320 subscriptions. There are also preparations for establishment projects in the rest of the country, except for the mountainous north-west part. As distribution channel for network RTK, GSM[14] is used, but tests with distribution via mobile Internet have also been performed (Peterzon 2004). In order to verify the performance of network RTK, a lot of test measurements have been performed, where some test measurements also included different network RTK software (Engfeldt et al. 2003).

The establishment of a Nordic Positioning Service based on network DGPS is in progress within the framework of NKG. Actions that have been carried out are the establishment of a computer network between the nationnal control centres, the development of a Nordic web-portal for post-processing data and test measurements with network DGPS.

5. RIX 95

Since 1995, a project involving GPS measurements on triangulation stations and selected local control points called RIX 95 has been in operation. The work is financed by a group of national agencies. The principal aims are to connect local co-ordinate systems to the national reference frames (SWEREF 99 and RT 90) and to establish new points easily accessible for local GPS measurements.



[13] GNSS = Global Navigation Satellite Systems

[14] GSM = Global System for Mobile communication

Figure 2: Completed areas in RIX 95 (June 2005).

The project is planned to be completed in 2006. Each year about 450 triangulation stations and 450 new points (mainly existing local control points) are measured. The present situation for the measurements is shown in figure 2. Transformation parameters are now (June 2005) available for 182 of the 290 Swedish municipalities.

6. Introduction of the ETRS 89 realisation SWEREF 99

SWEREF 99, the national realisation of ETRS 89, is used as the national geodetic reference frame for GPS since 2001.

Lantmäteriet has decided that SWEREF 99 shall also be our official reference frame and replace RT 90 for surveying and mapping.

A formal decision regarding map projections for national mapping purposes as well as for local surveying was taken in 2003 (Lantmäteriet 2003). All the projections are of Transverse Mercator type and the chosen values for the defining parameters are shown in table 1.

The timetable for the introduction in databases and in product lines at Lantmäteriet will be decided later.

System	Projection parameters			
	central meridian, λ_0	scale reduction factor, k_0	false northing (m)	false easting (m)
SWEREF 99 TM	15° E	0,9996	0	500 000
SWEREF 99 12 00	12° 00' E	1	0	150 000
SWEREF 99 13 30	13° 30' E	1	0	150 000
SWEREF 99 15 00	15° 00' E	1	0	150 000
SWEREF 99 16 30	16° 30' E	1	0	150 000
SWEREF 99 18 00	18° 00' E	1	0	150 000
SWEREF 99 14 15	14° 15' E	1	0	150 000
SWEREF 99 15 45	15° 45' E	1	0	150 000
SWEREF 99 17 15	17° 15' E	1	0	150 000
SWEREF 99 18 45	18° 45' E	1	0	150 000
SWEREF 99 20 15	20° 15' E	1	0	150 000
SWEREF 99 21 45	21° 45' E	1	0	150 000
SWEREF 99 23 15	23° 15' E	1	0	150 000

***Table 1**: Defining parameters for SWEREF 99 map projections.*

A proposal for a new map sheet division and index system has been developed.

The work with the introduction of SWEREF 99 among other authorities in Sweden such as local authorities are in progress. Approximately 60 of the 290 Swedish municipalities have started the process to replace their old system with SWEREF 99.

7. Introduction of the new national height system RH 2000

Sweden has a new national height system. The final adjustment was done in the beginning of 2005. RH 2000, as it is called, is based on the third national precise levelling of Sweden and has 2000.0 as epoch of validity (in the perspective of the Fennoscandian glacial isostatic adjustment). The definition of RH 2000 is done according to EVRS 2000[15] and in co-operation with the other Nordic countries. The network consists of about 50 000 bench marks, representing roughly 50 000 km double run precise levelling measured by motorised levelling technique.

The final computation has used a land uplift model based on a combination and modification of models developed by Olav Vestöl (Statens Kartverk, Norway) and Kurt Lambeck (Ågren et al. 2005).

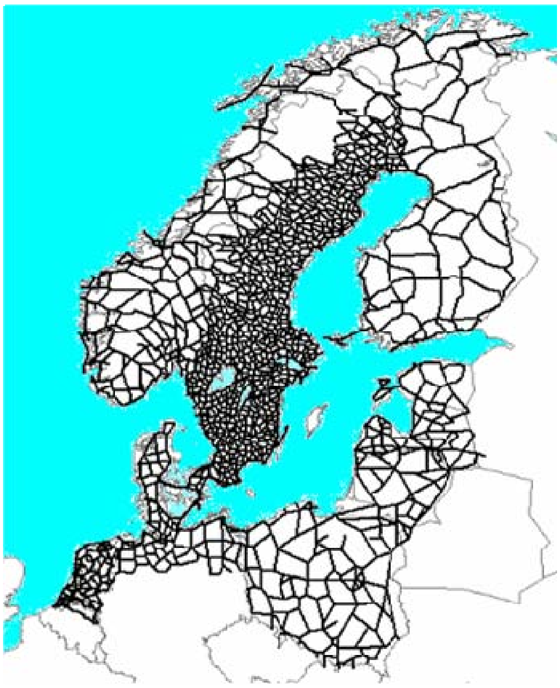


***Figure 3**: Nordic Height Block*

The adjustment is done in a common adjustment of a Nordic height block, based on data from mainly the Nordic states and the states around the Baltic Sea. The latter data has been provided by UELN[16]-database, see figure 3. The work is done within the framework of NKG and will also give information about the closing error around the Baltic Sea.

The work with the introduction of RH 2000 among other authorities in Sweden such as local authorities are in progress. Approximately 40 of the 290 Swedish municipalities have started the process to replace their old height system with RH 2000.

8. Height correction model

A new height correction model for Sweden is under development and will be called SWEN 05LR. The model is based on the geoid NKG 2004, calculated by the working group on geoid determination within the Nordic Commission on Geodesy. The model is then fitted on SWEREF 99 and RH 2000 using almost 1100 levelled points that has also been measured with GPS. Information about the residuals are also included in the model so that the users will receive heights as close as possible to RH 2000. The expected rms for a user is 1,5-2 cm.

9. Gravity activities

Absolute gravity measurements in Sweden have been carried out at eleven locations (Onsala, Göteborg, Borås, Mårtsbo, Kramfors, Östersund, Arjeplog, Skellefteå (also known as Furuögrund), Kiruna (KIR0, also known as Esrange), Visby and Smögen) by BKG[17], IfE[18] and UMB[19] in

[15] EVRS 2000 = European Vertical Reference System 2000

[16] UELN = United European Levelling Network

[17] Bundesamt für Kartographie und Geodäsie, Germany

[18] Institut für Erdmessung, Universität Hannover, Germany

co-operation with Lantmäteriet. All points are co-located with permanent reference stations for GPS in the SWEPOS network except Göteborg and Kramfors. Onsala is also co-located with VLBI[20]. Visby and Smögen are co-located with tide gauges.

In 2005 absolute gravity measurements will be carried out on Onsala, Mårtsbo, Kramfors, Östersund, Arjeplog, Skellefteå, Kiruna, Visby and Smögen (same stations that were measured in 2004) by IfE, UMB and Lantmäteriet.

10. Station velocities

Together with Onsala Space observatory at Chalmers University of technology, a new tree dimensional velocity field for the Fennoscandian land uplift area has been computed (Lidberg 2004 and Lidberg et al 2005). It is derived from more than 3000 days of continuous observations at 53 permanent GPS stations. The results show a maximum vertical rate of 10.6 mm/yr at Umeå, which is somewhat south of current estimated location of the land uplift maximum. From internal and external accuracy assessment, the rate uncertainty for stations with the longest observation records is estimated to the 0.2 mm/yr level in horizontal components and 0.5 mm/yr for the vertical component (1σ level).

11.References

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[20] VLBI = Very Long Baseline Interferometry

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