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 activity in the field of reference frames and reference networks is focused on introducing the new ETRS 89 realisation SWEREF 99, the ongoing projects RIX 95, SWEPOS including developments towards network RTK services and the finalisation of the third precise levelling.

2. Lantmäteriet and EUREF Permanent Network (EPN)

Five stations in SWEPOS, the Swedish network of permanent reference stations (see section 6) are included in EUREF Permant Network (EPN). The stations are ONSA, MAR6, VIS0, VIL0 and KIR0. Both daily and hourly data are delivered. When IGLOSS will become active (June 11) the SWEPOS/IGS/IGLOSS-station SPT0 will also be included in EPN.

ONSA, SPT0, MR6G (identical to MAR6), VS0G (identical to VIS0) and KR0G (identical to KIR0) are also included in the IGS network.

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

3. SWEREF 99

SWEREF 99 was adopted by EUREF as an ETRS 89 realisation in Tromsö 2000. SWEREF 99 was introduced as the national reference system for GPS during 2001.

Lantmäteriet has recommended in a report to our government during the autumn 2001 that SWEREF 99 shall be our official reference system and replace RT 90 for surveying and mapping. A decision will likely come during 2002.

Before SWEREF 99 can replace the national reference system RT 90 and the local reference systems used in the municipalities, an official map projection has to be defined to SWEREF 99. In the report to the government Lantmäteriet recommended the following:

- For national map projection a Transverse Mercator with central meridian, λ_0=15°, and scale reduction factor, k_0 = 0.9996
- For local surveying, a system of zones with 1° 30' between central meridians and k_0 = 1 is recommended

4. RIX 95

Since 1995, a project involving GPS measurements on triangulation stations and selected local control points (RIX 95) has been in operation. This is supported by a group of national agencies. The principal aims are to establish transformation formulas between local coordinate systems and the national reference systems (SWEREF 99 and RT 90), and to establish new points easily accessible for local GPS measurements. The project is to go on for 10 years; each year about 400 triangulation stations and 550 new points are measured.

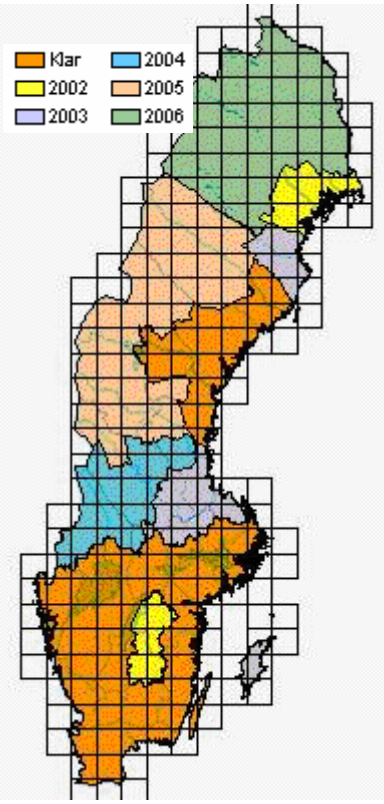

Figure 1: Plan for RIX 95.

5. GPS occupation at points in the Swedish Precise Levelling Network

GPS observations on points in the precise levelling network exist with a known and high quality from SWEPOS ,the EUVN-project and the RIX 95 project. The points are determined both in SWEREF 99 and the present national height system RH 70.

The 21 primary SWEPOS stations has been connected by precise levelling to the national precise levelling network. The SWEREF coordinates on the SWEPOS stations originate from 6 weeks observations. All stations are equipped with Dorne Margolin T/B-type antennas. The Bernese Software has been used for the processing. The ellipsoidal heights in SWEREF 99 have the estimated accuracy of 1 cm 1 sigma.

In the EUVN-project four Swedish tide gauges and seven SWEPOS-stations participated. The observation time was 7x24 hours. The tide gauges were equipped with Dorne Margolin T-type antennas. The Bernese Software has been used for the determination in SWEREF 99. The ellipsoidal heights in SWEREF 99 have the estimated accuracy of 1 cm 1 sigma.

In the RIX 95 project two type of GPS-observations are performed. The so called SWEREF points are observed for 2x24 hours with a new setup between the sessions. Dorne Margolin T-type antennas are used and the Bernese Software is used for the processing. The ellipsoidal heights in SWEREF 99 have the estimated accuracy of 1 cm 1 sigma. The approximate distance between the SWEREF points are 50 km, but all points are not connected to the national levelling network by precise levelling. Until now we have 41 levelled SWEREF points in the areas that have been finally computed. (Another c. 100 SWEREF points have been connected to the national height system by GPS-levelling with an estimated accuracy of 1-3 cm 1 sigma.)

The densified stations of RIX 95 are called RIX 95 points. The inter-station distance is approximately 5 km. The points are measured in a network with baselines of 5-20 km. Single frequency receivers with standard geodetic antennas of Ashtech and Geotracer are used. The processing is performed in GeoGenius The ellipsoidal heights in SWEREF 99 have the estimated accuracy of 1-2 cm 1 sigma. Until now we have 651 levelled RIX 95 points in the areas that have been finally computed. Another c. 60 unmarked points are determined in the same way as the RIX 95 points (i.e. fictive points with heights both in the national height system and SWEREF 99.

The distribution of the points from above mentioned projects are shown in figure 2. (The unmarked points and the points that have been connected by GPS levelling are not included in the figure.)

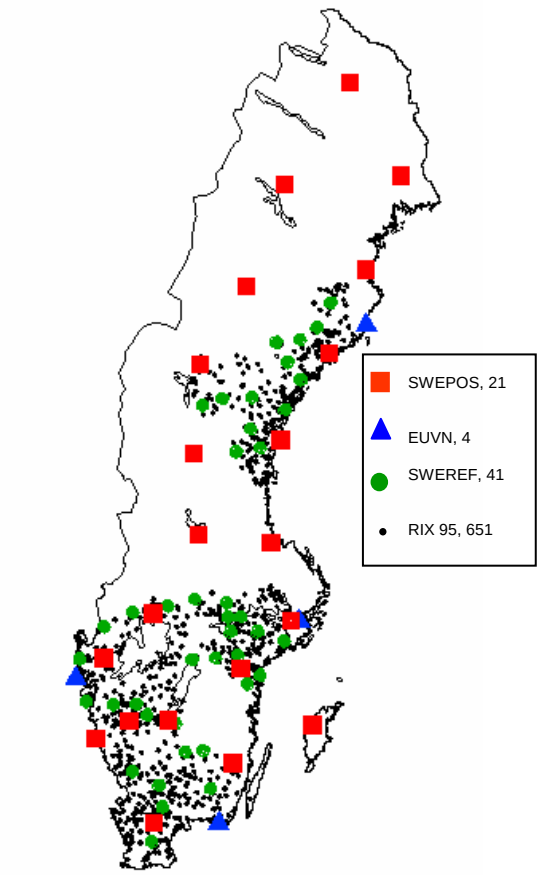

Figure 2: GPS occupations at points in (or connected by precise levelling to) the national precise levelling network.

More SWEREF points and RIX 95 points will be observed with the same density according to the plan of the RIX 95 project – se section 4.

The levelled heights in the present height system RH 70 has the estimated accuracy of 1.4 mm/√km. The points included in EUVN have geopotential numbers in UELN 73 but just a minor part of the points in SWEPOS and RIX 95 have geopotential numbers.

Early 2004 results from the third precise levelling will be available – see section 7. This includes both heights in a new national height system and geopotential numbers. The accuracy in the new height system is expected to be 1.15 mm/ √km.

There are no restrictions of data availability of final results, i.e. today heights in SWEREF 99 and RH 70 are available on above mentioned points. The information does today not exist in compiled form, but could be put together when needed for the points that so far has been finally computed. Early 2004 heights in the new Swedish height system and SWEREF 99 as well as geopotential numbers will be available for all points. At this time a larger part of Sweden will be covered according to the plan of RIX 95.

For August 20-23 2002 a GPS-campaign is planned to connect the Swedish and Finnish levelling networks over Åland Sea. Four points (between Stockholm and Gävle) in the Swedish precise levelling network will be observed for 3x24 hours. Dorne Margolin T-type antennas will be used for the whole campaign and the Bernese Software will be used for the processing. The project is a co-operation within the Nordic Geodetic Commission (NKG) between Lantmäteriet and the Finnish Geodetic Institute (FGI).

6. SWEPOS

Since 1 July 1998 the Swedish network of permanent reference stations, SWEPOS, see figure 3, is operational in IOC mode, i.e. positioning in real time on the meter level and by post-processing on the centimetre level. Positioning in real-time on the centimetre level is possible in regional parts of Sweden.

The purpose of SWEPOS is to:

- provide single- and dual-frequency data for relative GPS measurements.
- provide DGPS corrections and RTK data for broadcasting to real-time users.
- act as the continously monitored foundation of the Swedish geodetic reference frame (SWEREF 99).
- provide data for geophysical research.

- monitor the integrity of the GPS system.

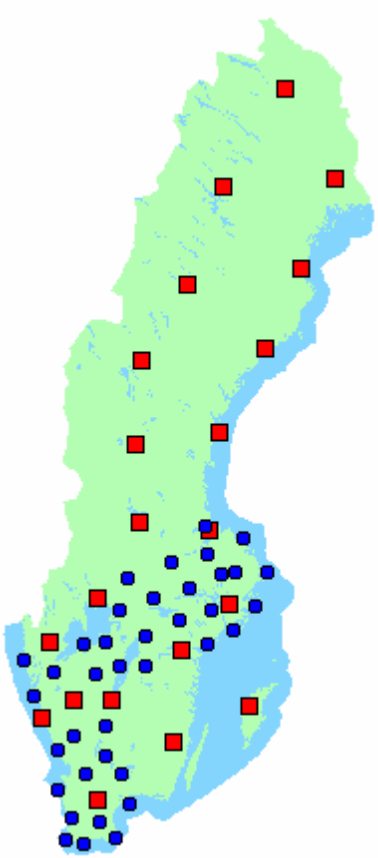

Figure 3: The SWEPOS network September 2002.

Twenty-one of the SWEPOS stations are complete stations i.e. they are monumented on bedrock and have redundant equipment for GNSS-observations, communications, power supply etc. In the middle of September 2002 SWEPOS also compromises thirty-six simplified stations i.e. stations mainly located on the top of buildings and with less redundant equipment than the complete stations. The simplified SWEPOS stations are used for regional Netwrk-RTK services

All the SWEPOS stations have real time connections to the control centre at Lantmäteriet in Gävle via leased TCP/IP connections.

To investigate the conditions for regional services for real-time positioning on the centimetre level several projects have been carried out. During 2000 and 2001 two pre-study projects were carried out with National Land Survey, Onsala Space Observatory, local authorities and government agencies as partners. In the autumn 2000 network RTK tests were carried out by the project SKAN-RTK in a network of 5 reference stations in southern Sweden, the distances between the stations in this test were between 40 km and 82 km. In the spring 2001 the project - Position Stockholm-Mälaren – carried out RTK tests in a larger network with 8 SWEPOS stations around Stockholm. The inter-station distances in this network were between 49 km and 107 km. In both these projects GPS-Net from Trimble was used as Network-RTK software and GSM as distribution. channel. The results in these projects were encouraging .

Based on the pre-studies shown above, three prototype regional Positioning services will be in operation in the middle of September 2002. These services are carried out as one-year projects with partners from governmental agencies, local authorities and consultancy companies. The aim of these services is to evaluate and improve the Network-RTK techniques and production work. The intention is to provide regional services on regular basis after this first year.

A regional Positioning service in the Stockholm area was in operation on 7 February, 2002, a service in southern Sweden is planned to be operational during June 2002 and in the western part of Sweden in the middle of September 2002

In a Nordic co-operation, steps towards a Nordic positioning service have been taken.

SWEPOS DGPS correction data is distributed by the following companies: Cartesia, Generic Mobile and Fugro-Omnistar.

In October 2000 an automated post processing service, based on the Bernese

software, was introduced at the SWEPOS web page (www.swepos.com).

7. Third Precise Levelling of Sweden

The third precise levelling of Sweden is progressing according to plan which means that the new national height network should be calculated in the winter 2003/4.

The final network will consist of about 50 000 bench marks representing roughly 50 000 km double run precise levelling measured using motorised levelling technique.

Preparation for the computation of a new height system has started. This work is currently divided into two different projects aiming at preparing data for the final calculation as well as investigating how the new height network should be implemented.

The work with this preparation includes building up more knowledge on the more theoretical aspects of a new height system.

Within the working group on height determination under the Nordic Geodetic Commission (NKG) work is focused on calculating a Nordic Height block including the height networks from Denmark, Finland, Norway and Sweden. Within the work a lot of effort is put towards creating a model of the land uplift over Scandinavia.

8. Gravity Network

Absolute gravity measurements in Sweden has been done at five locations (Onsala, Göteborg, Mårtsbo, Furuögrund (also known as Skellefteå) and Esrange (also known as Kiruna)). Onsala, Mårtsbo, Furuögrund and Esrange are co-located with GPS. Onsala is also co-located with VLBI. None of these stations are located nearer a mareograph than approximately 15 km.

This year we expect to complete the measurements of our First Order Gravity Network. This mean that some 70 stations are to be observed using relative observations with two LaCoste&Romberg instruments.

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