Geodetic activities at the National Land Survey of Sweden

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Presented at the EUREF meeting in Dubrovnik, Croatia, 2001-05-16--18.

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 third precise levelling.

Geodesy 2000, a program for geodetic activities in Sweden for the first decade of the 21st century has recently been published (in Swedish). The main issues of this investigation is replacement of the national horizontal reference system RT 90 and local reference systems in use with SWEREF 99, the establishment of a new height system based on the third precise levelling, and establishment of a nation wide (or Nordic) RTK service.

2. SWEREF 99

SWEREF 99 was adopted by EUREF as an ETRS 89 realisation in Tromsö 2000. SWEREF 99 is based on ITRF 97 epoch 1999.5. The conversion to ETRS 89 was performed according to the EUREF guidelines by C.Boucher and Z. Altamimi. The last step, which is to take the velocities within the European plate into account, has not been performed since we lack a good model for the movements within the European plate. This means that SWEREF 99 externally (with respect to the plate motions) referes to epoch 1989.0 and internally (with respect to the land-up-lift) to epoch 1999.5.

SWEREF 99 is defined by 21 of the SWEPOS-stations. A densification is carried out in the project RIX 95 –see below.

The first step to introduce SWEREF 99 will be to replace the former EUREF realisation SWEREF 93. This will be done for the SWEPOS network on May 26 2001. The difference between SWEREF 93 and SWEREF 99 is c. 5 cm in east-west component.

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 appointed to SWEREF 99. An investigation on map projection to SWEREF 99 has started this year and the goal is to have a decision before the end of the year.

A pre study has been carried out at Lantmäteriet, including both technical discussions of suitable map projections and an inventory on coordinate and map projection dependent activities at Lantmäteriet. The outcome from the technical discussions was that the Transverse Mercator projection should be used and that several zones are needed for local surveying. Different alternatives discussed for the national projection (small scale maps) are

- UTM (3 zones according to the standard)
- UTM zone 33 in the whole country
- Transverse Mercator with $\lambda_0=15\,^\circ$ and $k_0 = 1$
- Transverse Mercator with parameters such that the coordinate values will be very close to RT 90 (Reit 1997).

The last alternative is very popular among the departments involved in the map production, since the production process to a lot is dependent on the map sheet index.

The next step is to make a cost/benefit analysis of the two alternatives UTM zon 33 and the last alternative where the coordinates will be close to RT 90.

In parallel with this, discussions on alternative map projections will be undertaken with users outside Lantmäteriet. e.g. the municipalities, the Swedish Defence, the Civil Aviation Administration, the national rail and road administrations e.t.c.

Transformation parameters have been calculated for the transformation between SWEREF 99 and RT 90. The transformation model is a three dimensional Helmert-transformation with fixed scale factor. The 2D RMS of the fit on 20 SWEPOS-stations is 5.1 cm. Maximum 2D residual is 9.2 cm. For the conversion between ellipsoidal heights in SWEREF 99 and normal heights in RH 70, a height corrections model – SWEN01L- based on the NKG 96 geoid has been established.

3. RIX 95

Since 1995, a project involving GPS measurements on triangulation stations (RIX 95) has been in operation. This is supported by a group of authorities as the National Railway Administration, the National Road Administration, the National Maritime Administration, the Telecommunications Administration, the Swedish Defence and the Association of Local Authorities. 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.

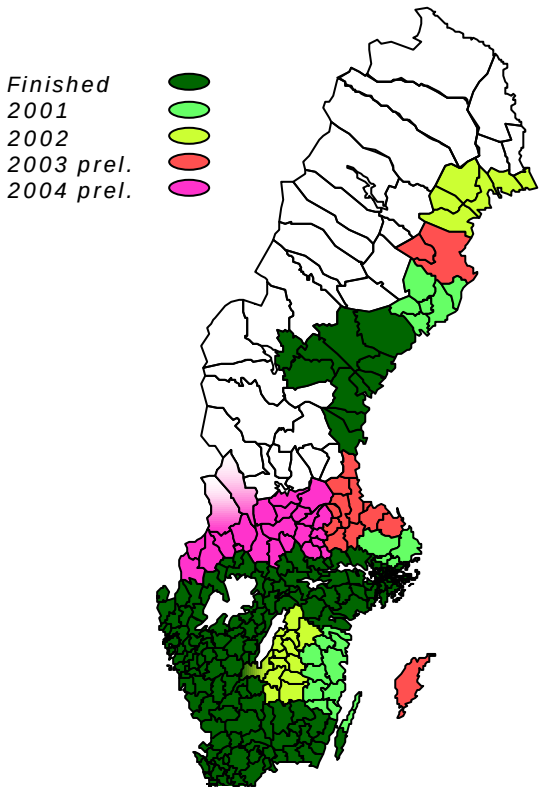


Figure 1: Plan for RIX 95.

4. SWEPOS

Since 1 July 1998 the Swedish network of permanent reference stations, SWEPOS, is operational in IOC mode, i.e. positioning in real time on the meter level and by post-processing on the centimetre level. Future plans are for positioning in real-time on the centimetre/decimetre level.

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.

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. Currently SWEPOS also compromises fourteen simplified stations i.e. the are located on the top of buildings and has less redundant equipment than the complete stations. The simplified SWEPOS stations are mainly aimed to improve RTK services.

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

To investigate the conditions for a national service for real-time positioning on the centimetre/decimetre level several projects have been carried out. The National Land Survey, Onsala Space Observatory and Teracom have co-operated in a project called NeW-RTK (NetWork RTK). The gaols are to study conditions for such a service especially with respect to the modelling of atmospheric effects. The DARC channel on the FM-Radio network has been used for the distribution of corrections in this project. In spring 2000 a test of the Geo++ network RTK program was made in a network around Gothenburg with DARC as distribution channel.

The Terrasat Network RTK program GPSnet has been tested in two projects with National Land Survey, local authorities and government agencies as partners. In autumn 2000 network RTK tests were carried out by the project SCAN-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 a project - Position Stockholm-Mälaren – has carried out RTK tests in a larger network with 8 SWEPOS stations around Stockholm. The inter-station distances in this network are between 49 km and 107 km. The results in these projects have been encouraging.

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

SWEPOS real-time correction data are distributed by the following companies: Teracom, Generic Mobile, 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).

The SWEPOS-stations Onsala, Visby, Mårtsbo, Vilhelmina and Kiruna are included in the permanent EUREF network. Onsala, Borås and Kiruna are also included in the IGS network.

5. Third Precise Levelling of Sweden

The third precise levelling of Sweden is progressing according to plan. The project started in 1979 and is planned to be finished in the few coming years. We only have a few connections to Norway left to level (215 km double run), which will be levelled this year.

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

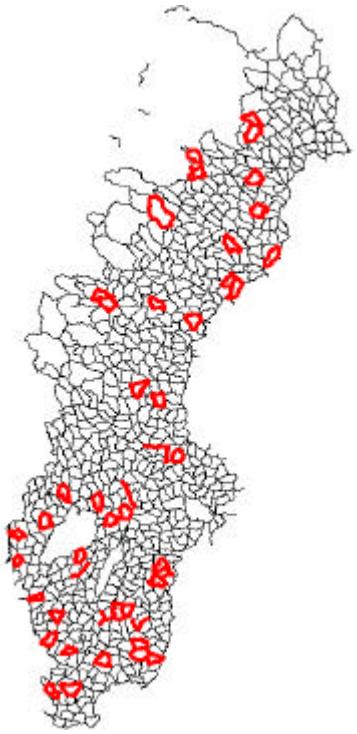
The motorised levelling technique is used for the project.

The main production work during the season 2000 and the next few years is to remeasure those loops in the network that have unacceptable big closing errors – see figure 2. Last year 1 700 km double run was relevelled and this season 1 200 km is planned to be relevelled. The total amount of relevelling is planned to be around 5 000 km double run. The result from the first year of relevelling shows that desirable improvements were achieved.

Figure 2: Planned relevelling.

Preparation for the computation of a new height system has started. This work is divided in five parts.

- Finding gross errors in the dataset.
- Inventory of available software for adjustment.
- Study of possible systematic errors, i.e. settings of rod and instrument on different types of roads and under different weather conditions.



- Study of how to deal with land uplift and observations made in different epochs.
- Preliminary adjustment including only data from the third precise levelling. The purpose of this adjustment is to learn about the adjustment process and to make sure that data from the third precise levelling is suitable for this process. This adjustment will later be followed by a "final" adjustment including more data.

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

6. Gravity Network

This year we have the goal to complete the measurements of our Second Order Gravity Network, which means that we have to measure over 2000 new points. To fulfil this we also need to measure some 30 points in our First Order Gravity Network. This means that after this summer 40-45 % of our First Order Gravity Network will be completed.

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