

# Geodetic activities at the National Land Survey of Sweden

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## 1. Introduction

At the National Land Survey of Sweden the activity in the field of reference frames and reference networks is focused on the national project RIX 95 (which principle aim is to establish transformation formulas between SWEREF 93 (EUREF 89) and national and local reference systems), the SWEPOS network, the third precise levelling of Sweden, and, in collaboration with Onsala Space Observatory, studies of Post Glacial Rebound.

## 2. 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 the national reference systems SWEREF 93 / RT 90 and local coordinate systems, 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.

RIX 95 is described in more detail in a related report presented at the EUREF-symposia in Prague.

## 3. SWEPOS

### The SWEPOS network

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 centimeter level. Future plans are positioning in real-time on the centimeter/decimeter 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 high precision control points for Swedish GPS users.
- provide data for geophysical research.
- monitor the integrity of the GPS system.

Twenty-one of the SWEPOS-stations are full stations i. e. they are monumented on bedrock and have redundant equipment for GNSS-observations, communications, power supply etc. and four stations are "simple" i. e. they are located on top of buildings and there is not so much redundancy at these stations. All the SWEPOS stations are connected to a central node, or control centre, using TCP/IP connections. 1 Hz raw observation data and RTCM correction data (DGPS and RTK) are sent via the

communication channels to the control centre. The control centre thus has access to all the observations in real time and provide both real-time data to distributors and observation data for postprocessing direct to the end user.

To investigate the conditions for a national service for real-time positioning on the centimeter/decimeter level, National Land Survey, Onsala Space Observatory and Teracom have decided to cooperate in a project called NeW-RTK (NetWork RTK). The plans are to study the conditions for such a service during 1997 - 1999 with respect to the modelling of atmospheric effects and multipath errors, predicted orbit information, the DARC channel on the FM-Radio network and the SWEPOS network.

Currently single station RTK-data is distributed on DARC channel on the FM-radio network from seven SWEPOS-stations.

The compatibility of SWEPOS data with available GPS equipment on the market has been studied both for postprocessing and real-time applications in two diploma works. In another diploma work the accuracy and the length of the observation time have been studied for different methods and equipment when determining new points relative to the SWEPOS stations. The SWEPOS network makes it possible to determine the position anywhere in Sweden in the SWEREF 93 system with cm accuracy, today by postprocessing and tomorrow maybe in real time.

Combined GPS/GLONASS equipment is installed on four SWEPOS stations for a joint Swedish participation by Onsala Space Observatory and National Land Survey in the IGEX experiment.

### Contribution from SWEPOS to the IGS and the permanent EUREF network

Data from SWEPOS-stations Onsala, Visby, Mårtsbo, Vilhelmina and Kiruna are transferred daily to the NKG local computing centre at Onsala Space Observatory. Onsala and Kiruna are also included in the IGS network

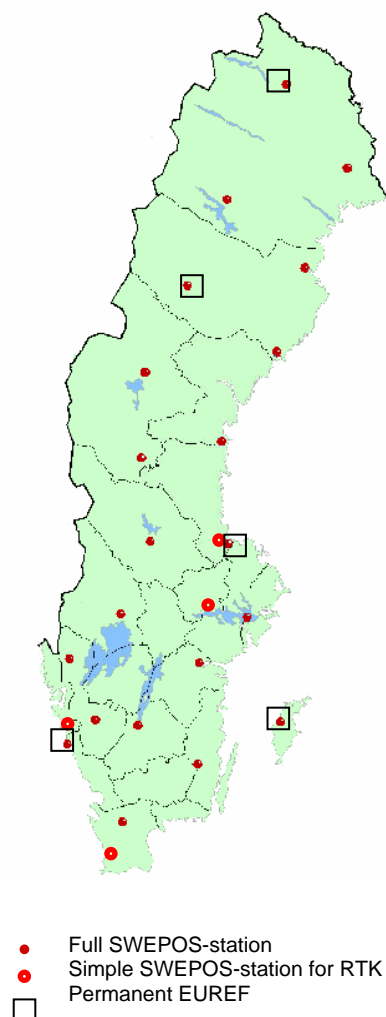


Figure 1. Map of SWEPOS 1999

#### 4. Third Precise Levelling of Sweden



*Fig. 1: The net configuration of the third precise levelling.*

The third precise levelling of Sweden is progressing according to plan. It started in 1979 and the levellings are planned to be finished in the few coming years. The final network will consist of about 50 000 bench marks representing roughly 50 000 km double run precise levelling. The levellings have now reached the most northern parts of Sweden, see figure 1. Due to weather conditions the levelling season is limited from the end of May to the beginning of October.

The technique used is motorised levelling which involves three cars and four people in a levelling team. Three teams are used

in Sweden. A team levels about 11 km every day excluding relevelings, which are done when tolerance limits between forward and backward levellings are exceeded.

In 1998 about 3400 km was levelled including a releveling percentage of about 8%. The number of relevelings has been high since 1994 and investigations are done to try to decrease it.

Maintenance of the primary height network is done in southern Sweden during the spring time. The reason for this is the fact that  $\frac{1}{2}$  - 1 % of the bench marks are destroyed every year.

#### 5. Other topics

In cooperation with Onsala Space Observatory continuous GPS observations are performed, since 1993, on the permanent reference stations in the SWEPOS network. The purpose is to monitor crustal motion, especially postglacial rebound, in three dimensions, i.e. both vertical uplift and horizontal strain.

A series of studies have been made on the postglacial rebound of Fennoscandia using long-term mareograph data and gravity data. This has led to, among other things, a set of absolute uplift rates possible to use for the reduction of GPS-measured heights of the permanent reference stations.

The Refstrat project is a work to develop a scenario for future reference networks and reference frames as well as strategies to realise the scenario.

It should also be mentioned that a Swedish geoid height system connected to SWEREF 93 and RH 70, and based on the Nordic geoid NKG

96, has been developed. The geoid model has been merged together with postglacial land uplift values from 1970 to 1993 into the correction model SWEN98(L).

Sweden participate in the NKG Baltic 99 airborne gravity project, where the goal is to do airborne gravimetry for the Baltic Sea, which will improve the geoid determination in the region.

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