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SWEPOS - A Swedish Network of Reference Stations for GPS

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SWEPOS - A SWEDISH NETWORK OF REFERENCE STATIONS FOR GPS

by Gunnar Hedling and Bo Jonsson

Huvudinnehåll

This paper shows the status of SWEPOS - A Swedish network of reference stations for GPS - in spring 1995. Applications using data from the SWEPOS network are also presented. The paper was presented at the 4th International Conference on Differential Satellite Navigation Systems (DSNS 95) in Bergen, April 1995.

LDOK KG Satellitgeodesi

ABSTRACT

A Swedish experimental network of permanent reference stations for GPS, SWEPOS has been established by the National Land Survey of Sweden, Onsala Space Observatory and the project "GPS Resources in Northern Sweden".
The purpose of the network is to

- provide single- and dual-frequency data for relative GPS measurements.
- provide differential corrections for broadcasting to real-time users
- provide data for studies of crustal dynamics
- act as high-precision control points for Swedish GPS users
- monitor the integrity of the GPS system.

The network consists of twenty-one stations and today (spring 1995) there are 33 GPS receivers installed at the stations.

For real-time users DGPS data from the SWEPOS network is broadcasted via the FM-network by the company TERACOM Svensk Rundradio, this service is called EPOS .

Data from the reference stations for post-processing purposes is at present available at no cost for Swedish users via Internet or Bulletin Board Service (LMV-BBS). For scientific purposes, the data is also available from Onsala Space Observatory.

In this paper the configuration and status of the SWEPOS network is described. Some future developments and applications using data from the SWEPOS network are also presented.

CONTENTS

1. INTRODUCTION

The concept of a national system of GPS reference stations was originally presented in the report "Geodesi 90" (1990), which was prepared by the National Land Survey (NLS), together with the Swedish geodesy community. In parallel with the development of this report a Swedish Satellite Navigation project: IT4-GPS ran between 1989 and 1992. In this project several Swedish companies, military agencies and government agencies worked together in the field of GPS, for navigation in the air, on land and on sea. Among other things, concepts for GPS reference networks were investigated, see Hedling & Jonsson (1991).

In 1991 Onsala Space Observatory (OSO) and the Smithsonian Astrophysical Observatory proposed a network of Swedish stations for monitoring vertical and horizontal crustal movements associated with post glacial rebound in Fennos-candia.

These proposals resulted in the SWEPOS network which was designed and built by the National Land Survey of Sweden, Onsala Space Observatory and the project "GPS Resources in Northern Sweden", see Hedling & Jonsson (1993).

During 1991 and 1992 locations for the 20 stations were reconnoitred and 6 stations became operational. The remaining 14 stations became operational in the summer 1993. A 21st station has been located to Borås and is planned to be operational before this summer.

Current status of the SWEPOS network is summarised in figure 1.

2. SWEPOS

2.1 The stations

The SWEPOS GPS antennas are placed on top of three meter high concrete pillars. The pillars are on bedrock and the line of sight from the top to the GPS satellites is undisturbed at elevation angles larger than 10 degrees over the horizon. The pillars are heated electrically to a constant temperature of about 15 degrees Celsius, this is to avoid deformation of the pillars because of differences in temperature. Every pillar is surrounded by a small precision network marked with steel bolts in the bedrock. These are used to monitor movements of the pillars.

Normally data is collected with 15 sec epoch intervals and 10 degrees as elevation mask. For special applications epoch intervals down to 1 second are possible.

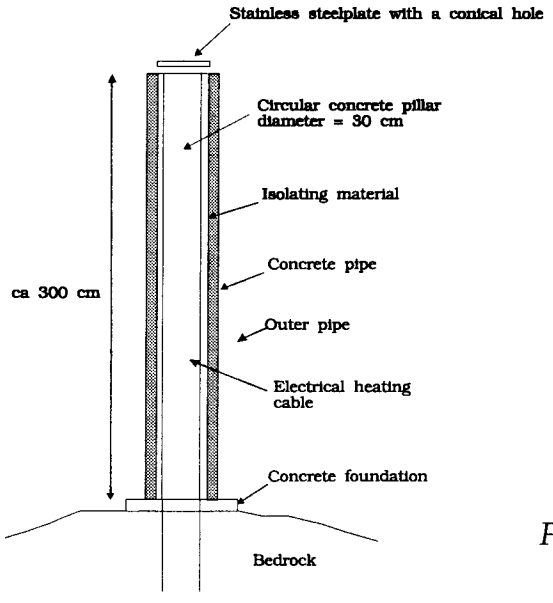

Figure 2. The construction of the pillar .

Figure 3. The SWEPOS station in Vilhelmina.

Extra backup batteries have been installed at the twelve stations acting as reference stations for the Epos service, see below. These will maintain operation of the stations for 48 hours.

The differential corrections for the Epos service are computed for satellites at elevation angles larger than 5 degrees. The station building and the pillar of the SWEPOS station in Vilhelmina are shown in figure 3.

2.2 Control Center

All of the stations are controlled from a control center at the National Land Survey in Gävle. Raw data - dual frequency code and carrier phase observations - from the stations is transferred via ordinary dial-up telephone lines, modem and remote control software to the control center.

At the control center the data is translated to Rinex and stored on a server. Here the data - Rinexed or raw - can be accessed via Novell Netware, TCP/IP and a BBS. A diagram of the SWEPOS computer network is shown in figure 4.

Today most of the data is transferred during the night, so the delay between actual measurement and the time the data is accessible on the server is usually from 0 hours up to 24 hours. For 4 stations the raw data is transferred 5 times per day, this means that during daytime the delay between the time of the measurement and the

time when the data is accessible is within 3 hours. With faster communication links to the stations it can be expected that all the data from the SWEPOS network will be accessible within a couple of hours from the time when the measurement is made.

All data from the SWEPOS network is at present available at no cost for Swedish users. Users have to be registered though.

3. THE EPOS SERVICE

During 1993 primary investigations were made by TERACOM and NLS to use RDS for the distribution of real-time corrections in a DGPS system, see Weber & Tiwari (1993) and Sjöberg et al. (1994). Finally 12 of the SWEPOS stations (see figure 1) were chosen to act as DGPS references stations.

This commercial DGPS service is called EPOS and it is managed by Teracom. It is covering the whole of Sweden and it became operational on the 5th December 1994. The Epos service offers two levels of accuracy; one basic level which gives a position accuracy below 10 m (2drms) and one premium level which gives an accuracy below 2 m (2drms). To obtain the premium level of accuracy the user have to use a GPS receiver with low-noise C/A-code measurements.

4. APPLICATIONS

Figure 5. Staking out the borderline for

Important applications for the SWEPOS stations have been to act as high-precision control points for a new geodetic reference system, SWEREF 93 (Reit, 1994) . SWEPOS data is also routinely used for positioning projects and photo-grammetric production.

In the future post-processing or real-time DGPS techniques is thought to be the most cost-effective way of cadastral surveying in less densely populated areas. DGPS is already successful in Sweden for the staking out of long property borderlines, see figure 5.

The new Epos DGPS service has already proved to be a powerful tool for the integration of GPS and GIS

a national park.

that takes place in modern field computers and pen computers (Johansson, 1994).

4.1 Studies of crustal movements

Daily estimates of the coordinates for all the SWEPOS stations have been done by Onsala Space Observatory, for almost two years now . The repeatability of all the baselines is estimated to be about 1mm+ 1 ppb. This high level of precision is needed for the geophysical and meteorological studies going on at OSO, see Johansson et al., 1994.

5. FUTURE DEVELOPMENTS

The integrity monitoring of the SWEPOS network and data has been falling behind somewhat, during the rapid design and construction of the SWEPOS network. Integrity monitors will be installed in the near future.

Plans to upgrade current dial-up telephone lines to faster and more reliable communications methods have already been mentioned.

A customised database system for the SWEPOS data is also planned.

Tests will be done to distribute corrections for real-time kinematic (RTK) surveying from the SWEPOS stations.

NLS will collaborate with Teracom to investigate the possibilities to use the DARC channel for the distribution of RTK corrections.

6. CONCLUSIONS

The planning of the Swedish SWEPOS network began in 1991. In 1995 21 stations are in operation with 33 GPS receivers (12 TurboRogue's and 20 Ashtech Z-12's).

The distribution of pseudo-range corrections from the SWEPOS network is operating in full scale since December 1994 .Data for post-processing is available via Internet or a BBS. The conditions for routine use of SWEPOS data for production work are good.

Our goal is to have the SWEPOS operational for distribution of real-time kinematic corrections at the latest in 1999.

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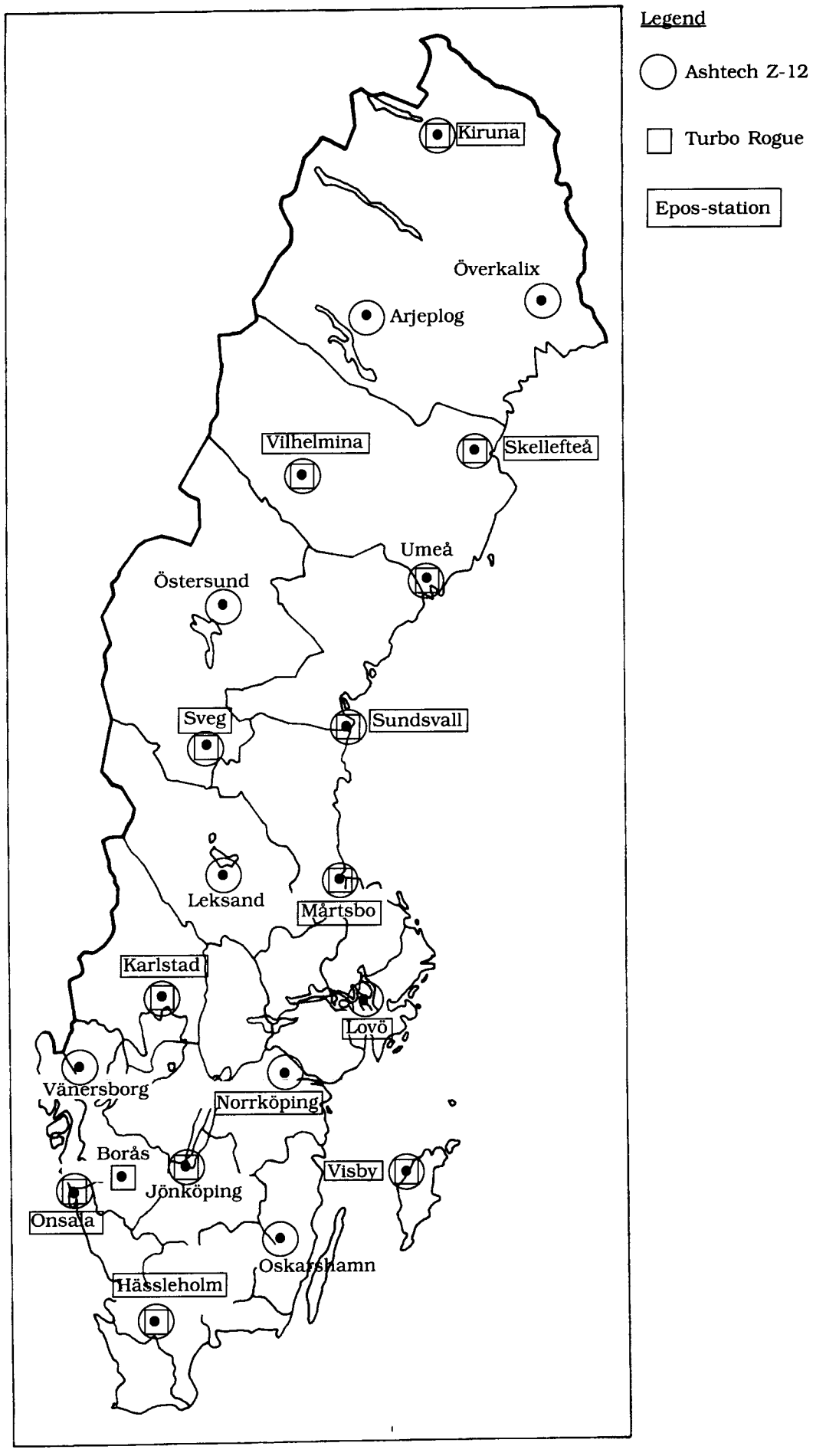

Figure 1. SWEPOS-status spring 1995

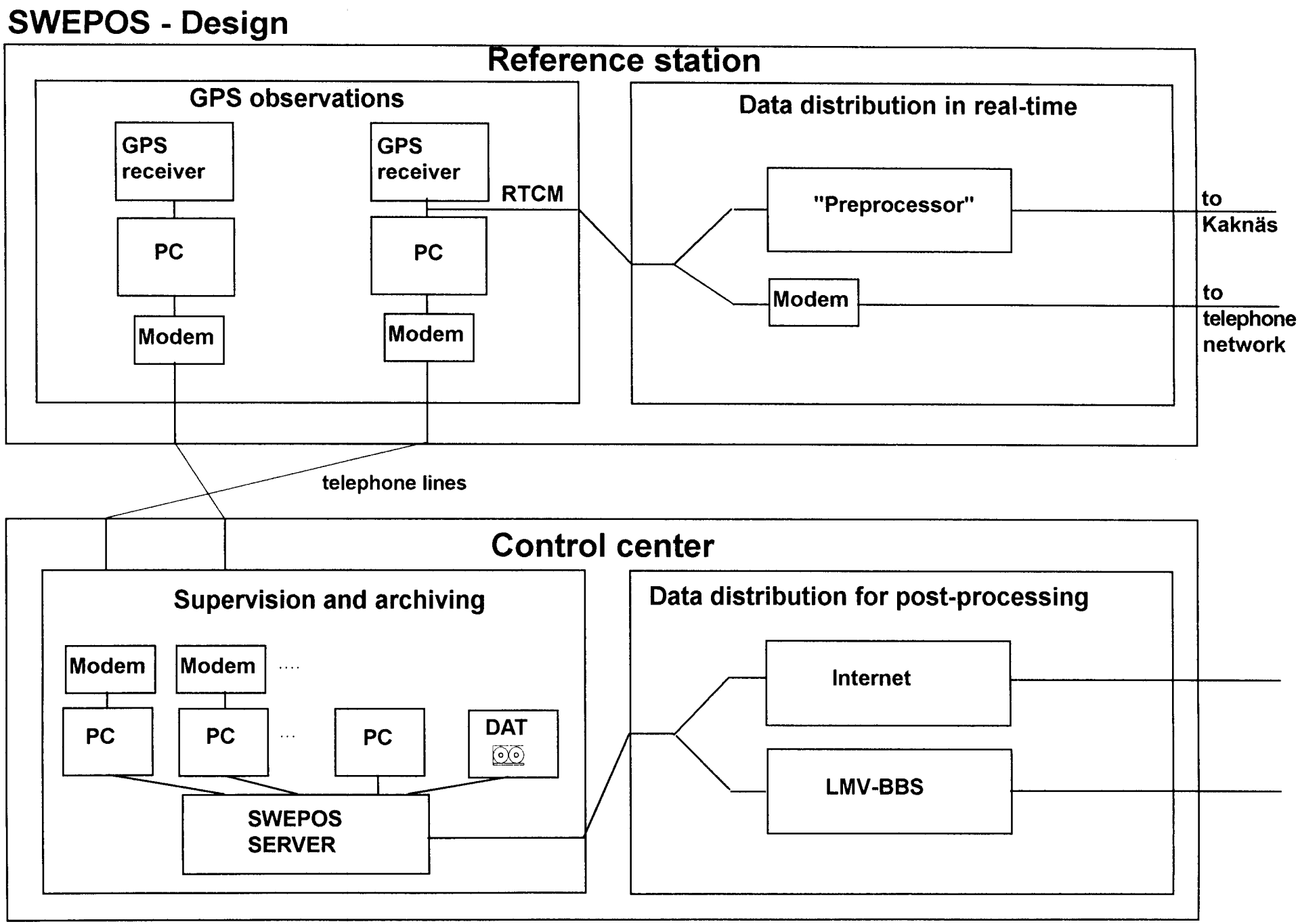

Figure 4. SWEPOS Design in spring 1995.