SWEPOS™ Positioning Services – Status, Applications and Experiences

Bo JONSSON, Gunnar HEDLING, Lars JÄMTNÄS and Peter WIKLUND, Sweden

Key words: GPS, GLONASS, reference stations, Network-RTK, Network-GNSS.

SUMMARY

SWEPOS™, the Swedish network of permanent reference stations, is in IOC operation since 1998 and run by Lantmäteriet, National Land Survey of Sweden. Today (July 2006) the SWEPOS network consists of 120 permanent reference stations for GPS and GLONASS (GNSS). The purpose of SWEPOS is to:

- Provide L1 and L2 raw data to post-processing users.
- Provide DGNSS and RTK corrections to real-time users.
- Act as high-precision control points for Swedish GNSS users.
- Provide data for scientific studies of crustal motion.
- Monitor the integrity of the GPS/GLONASS (GNSS) system.

Today SWEPOS is used as the basis for the Swedish national reference system, SWEREF 99 and beside many surveying and navigation applications also used for meteorology, timing applications and machine guidance.

SWEPOS provides the following Positioning Services:

- Post-processing data through a WWW/FTP service
- SWEPOS Automatic Computation Service on the SWEPOS Web
- The DGPS-service Epos run by the Swedish company Cartesia
- SWEPOS Network-RTK service
- SWEPOS Network-DGNSS service

Experiences from the use and design of the services will be shown in the paper. Financial and organizational issues for the services are also discussed.

Examples of the present applications of the services are cadastral surveying, data capture for data bases with position related information, setting out and machine guidance. Expected future applications are e.g. navigation with high precision.

SWEPOS™ Positioning Services – status, applications and experiences

Bo JONSSON, Gunnar HEDLING, Lars JÄMTNÄS and Peter WIKLUND, Sweden

1. INTRODUCTION

The SWEPOS™ network of GPS/GLONASS reference stations began as a co-operation between the National Land Survey of Sweden and Onsala Space Observatory. The early design phases of SWEPOS were made in 1992. It was then stated that the purposes of the network were to be both scientific and of practical benefit to the professional users and the public. The purposes of SWEPOS are to:

- Provide L1 and L2 raw data to post-processing users.
- Provide DGNSS and RTK corrections to real-time users.
- Act as high-precision control points for Swedish GPS users.
- Provide data for scientific studies of crustal motion.
- Monitor the integrity of the GPS/GLONASS system.

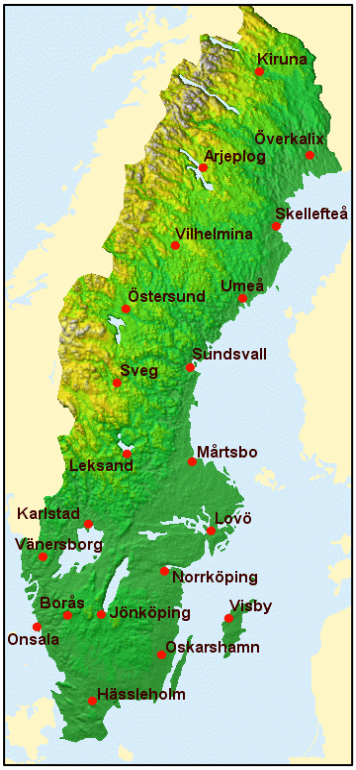

Fig 1. *Design of SWEPOS in 1994*

Today SWEPOS is used as the basis for the Swedish national reference system, SWEREF 99 and besides many surveying and navigation applications SWEPOS is also used for meteorology and timing applications.

At the start in 1994 SWEPOS consisted of 20 stations covering the whole of Sweden with on average 200 km distances between the stations, see figure 1. All the stations were situated on bedrock

The control centre for the SWEPOS network has been located to the National Land Survey of Sweden headquarters in Gävle from the start. In 1996 one more station at the Swedish National Testing and Research Institute in Borås was added. Later several stations, aiming to make the SWEPOS network denser - mostly for Network-RTK applications - have been established. Today (July 2006) SWEPOS consists of 120 stations.

In 1997 the SWEPOS network was updated with 64 kb leased lines to make it possible to collect all GPS data in real-time. In 1998 the SWEPOS network was declared operational for post-processing applications and support for real-time positioning with meter accuracy, IOC-mode.

The development from an experimental network to IOC status was financed by the following governmental agencies: the National Railway Administration, the National Road Administration, the Swedish Civil Aviation Administration, the National Maritime Administration, the Telecommunication Administration, the Swedish State Railways, the Swedish Defence and the National Land Survey. Today the development and operation of SWEPOS are both the responsibility of the National Land Survey.

2. DESIGN OF THE SWEPOS NETWORK AND DATA FLOW

All the SWEPOS stations are connected to a central node, or control centre, using TCP/IP connections. 1 Hz raw observation data and RTCM data (DGPS) are sent via the communication channels to the control centre. The control centre thus has access to all the observations in real time and provides both real time data to distributors and end-users and observation data for post-processing directly to the end user.

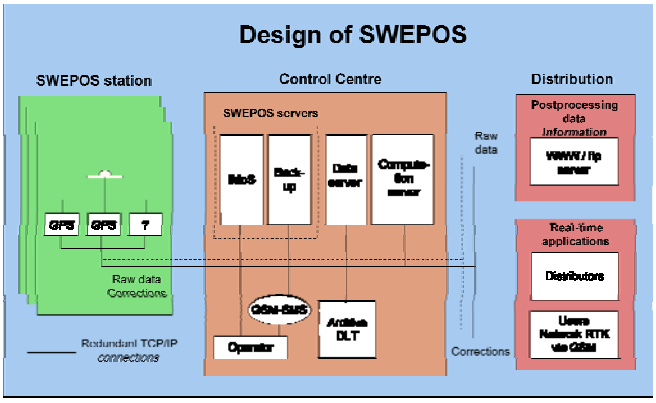

Fig. 2 *Data flow in the SWEPOS network*

Currently GPS/GLONASS measurements in Ashtech or Javad raw data format and RTCM message types 1, 2 and 3 are transferred in real time, via leased 128 kB lines, using the TCP/IP protocol to the control centre at the National Land Survey in Gävle. Data in RINEX format for post-processing can be fetched from the control centre through a WWW/FTP-server. Distributors of real-time DGNSS services can receive SWEPOS real time corrections in the RTCM format from the control centre via a distribution server and a TCP/IP connection. Network-RTK data is distributed via GSM/GPRS from the Network-RTK software, which also is connected to the distribution server.

Today the raw data and the DGPS corrections are quality checked at the control centre. Applying the DGPS corrections to raw data from an adjacent reference station and a subsequent position computation and comparison with the known coordinates performs the quality check of the DGPS corrections. The Teqc software is used for quality checking of the raw data. Network-RTK and Network-DGNSS data is quality checked by the Network-RTK software. The design of the SWEPOS-network data flow can be seen in figure 2.

3. THE SWEPOS STATIONS

In the SWEPOS network the stations are of two types, complete and simplified ones. At the complete stations all equipment is redundant and the antennas are mounted on bedrock, while the simplified ones have only one set of equipment and the antennas are usually mounted on

buildings. Data is collected from all stations every second and a 5 degrees elevation mask is used. A complete network computation of all the SWEPOS stations is done every day with the Bernese GPS software in order to check the stability of antenna mounting of the simplified stations.

3.1 Complete SWEPOS station

Most of the original 21 SWEPOS stations were built in a similar way. A typical complete SWEPOS station can be seen in the picture to the left. In order to find good bedrock and an undisturbed line of sight to the GPS satellites and safe surroundings, most of the original 21 stations are situated in the countryside of Sweden.

Fig. 3 *The complete SWEPOS-station Överkalix*

A three metre high concrete pillar can be seen to the left of figure 3. On the top, a Dorne Margolin antenna is mounted under a radome, made of clear acrylic. Due to the winter conditions in Sweden, the pillar is heated electrically to a constant temperature of about 15^{o} C. To monitor the movements of the pillars, a small precision network is established around the pillar, using steel bolts as markers in the bedrock.

3.2 Simplified SWEPOS station

Fig. 4 *Simplified SWEPOS-station*

Fig. 5 *Instrument rack on the SWEPOS-stations*

In connection with the development of a Network-RTK service, additional stations have been established. Antennas for these new stations are mostly established on the top of buildings, typically belonging to local authorities, see figure 4. Leased lines are also used to connect these stations to the control centre. The positions of the simplified SWEPOS stations are computed

daily in the same way and together with the complete SWEPOS stations. The positions of the simplified SWEPOS stations are checked daily and time series for their positions will be publish on the SWEPOS Web-site along with time series for the complete SWEPOS stations.

4. THE INTERACTION BETWEEN SWEPOS AND EUREF - AND IGS SITES

The National Land Survey and Onsala Space Observatory have been active for a long time in international projects. The European countries have collaborated in building up a network of permanent GPS stations as well as computing national realisations of the adopted European three dimensional reference system ETRS 89. This work is done under the IAG Sub commission for Europe (EUREF). EUREF is also engaged in the establishment of a common vertical reference system based on the national levelling networks and the European GPS campaign EUVN.

The realisation of ETRS 89 in Sweden is called SWEREF 99 and replaces the earlier ETRS 89 realisation SWEREF 93. SWEREF 99 was (certified) accepted by EUREF in June 2000 and is defined by the 21 complete SWEPOS stations.

The SWEPOS stations Visby, Onsala, Borås, Mårtsbo, Vilhelmina, Skellefteå and Kiruna are included in the European network of permanent reference stations, EPN. Data is delivered every hour to the data centre at BKG (Federal Agency for Cartography and Geodesy) in Germany. Data in the EPN network is processed at a number of analysis centres in Europe and the results from these computations are combined to one solution per week, which is available at the EUREF web-site. The data from the Nordic block of EUREF sites is processed at the Nordic Commission of Geodesy (NKG) processing centre at Onsala Space Observatory and National Land Survey. Visby, Onsala, Borås, Mårtsbo and Kiruna are also included in the network for the International GPS Service (IGS).

5. SWEPOS SERVICES

Data from the SWEPOS network is available for the end-user via the following services:

- Post-processing data through a WWW/FTP service
- SWEPOS Automatic Computation Service on the SWEPOS Web
- The DGPS-service Epos run by the Swedish company Cartesia
- SWEPOS Network-RTK service
- SWEPOS Network-DGNSS service

5.1 Data for post-processing

SWEPOS data is available on a WWW/FTP server in RINEX-format. Quality checked data is available for download within one hour after the observation on the SWEPOS station. Data is charged according to a subscription system, see table 1 below.

5.2 SWEPOS Automatic Computation Service on the SWEPOS Web

The National Land Survey has developed an Automated Processing Service in order to facilitate the use of SWEPOS for high-precision static point positioning. The Bernese GPS software and a web application are used for the computations. The use of the Computation Service is charged according to a subscription system, see table 1 below.

The position for any site in Sweden can be computed by submitting an observation file containing dual frequency data in RINEX format to the Automatic Computation Service via the SWEPOS web-site. When the processing is completed (typically after 5-10 minutes) the Web page is updated and a text file with a summary of the processing is sent to the user by e-mail. The final co-ordinates are delivered in the national reference system SWEREF 99, a realisation of the European reference system ETRS 89. The users have to transform the results to the desired local reference system if this is required. From 2-3 hours of observation time a standard deviation of 1 centimetre per planar component and 1.5-2 centimetres in height is obtained.

5.3 The DGPS-service Epos, operated by Cartesia

Epos is a DGPS service operated by the private company Cartesia. Cartesia broadcasts the corrections via the RDS channel on the FM network. An accuracy of 1-2 metres (95%) is achievable over most land and sea areas of Sweden. The fee for subscription of correction data and distribution to one GPS receiver is €650 per year.

5.4 SWEPOS Network-RTK service

During the years 1999-2001 three pre-study Network-RTK projects were carried out, as collaboration projects between Lantmäteriet, local authorities, governmental agencies, universities and private companies, in the region of Gothenburg, Southern Sweden and around Stockholm.

Based on the experiences and the results from the pre-study projects it was decided in late 2001 and early 2002 to establish one-year production Network-RTK projects in the Stockholm area, in the southern Sweden and in the Gothenburg area. The purposes of the projects were to establish networks of Network-RTK stations, to evaluate function and position accuracy and to get experiences of the use of Network-RTK in different production applications. The Production networks were established as collaboration projects with partners from governmental agencies, universities, local authorities and private companies. The existing infra-structure SWEPOS was densified in the project areas.

Based on the production Network-RTK projects SWEPOS Network-RTK service was launched. on January 1, 2004. The coverage area for the service has been extended since 2004 step by step through establishment projects and the present coverage can be found in fig. 6.

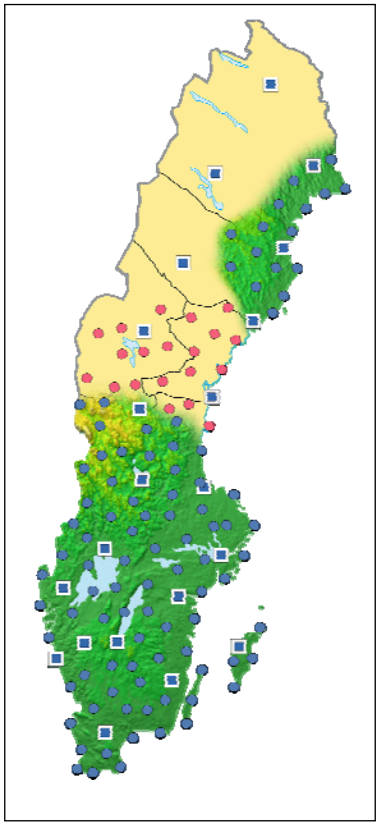

Fig. 6. SWEPOS Network-RTK coverage area in July 2006

SWEPOS Network-RTK service is based on the VRS-concept (Virtual Reference Station) and GSM//GPRS are used as distribution channels for the RTK data. The interstation distances are in average 70 km. Since 1 April, 2006 data for both GPS and GLONASS is provided in the format RTCM ver 3.0. The expected position accuracy is 0.03 m horisontally (95%) and 0.05 m vertically (95%). Data for the SWEPOS Network-RTK service is charged according to a subscription system, see table 2 below, the user pays the distribution costs direct to the GSM/GPRS operator..

5.5 SWEPOS Network-DGNSS service

During 2005 the diploma work "Comparison of Epos and Network-DGPS" was carried out. The Epos service (see above) is based on the single point DGPS concept for the L1-frequency and the goal for the diploma work was to compare the accuracy of Epos with that for a Network-DGPS network with interstation distances of 70 and 200 km. The result indicated an improvement in the positions of 2.5 times horizontally and 1.5 times vertically using Network-DGPS. No major improvements could be found for the denser Network-DGPS network with interstation distances of 70 km. Based on the result of the diploma work SWEPOS single frequency Network-DGNSS service was launched on April 1, 2006. The service uses the VRS-concept and provides differential GPS/GLONASS data in the format RTCM 2.3. The interstation distances are about 200 km. The expected position accuracy is 0.3 m horisontally (95%) and 0.6 m vertically (95%). The data for the SWEPIOS DGNSS service is charged according to a subscription system, see table 2 below, the user pays the distribution costs direct to the GSM/GPRS operator.

6. POLICY FOR SWEPOS AND USER FEES

6.1. Policy

In the report Geodesy 2000 a plan for a national Network-RTK service was presented. The on-going extension of the SWEPOS network is based on this report. SWEPOS is regarded as a national geodetic infra-structure and the investment for the establishment/extension of the SWEPOS network is mainly financed by governmental funds. The users shall contribute to the operation costs of the SWEPOS network, including maintenance and upgrade and shall pay the cost for the distribution of the correction data from the SWEPOS control centre.

6.2. User fees

The main principle for user fees for SWEPOS data is subscription for unlimited access to the required type of SWEPOS data for every-day users. For infrequently SWEPOS users there is a possibility to buy data for a desired time period. In table 1 user fees for post-processing data and the computation service can be found. Fees for the Network RTK and Network DGNSS services are shown in table 2.

Tab. 1 User fees for access to post-processing data and the automated computation service

Service	**Licence agreement**	**One-day agreement**
Five SWEPOS stations		
L1/L2 data from five SWEPOS stations	€1080/year	€55/day
L1/L2 data from five SWEPOS stations + computation service	€1300/year	€65/day
L1 data from five SWEPOS stations	€650/year	€55/year
All SWEPOS stations		
L1/L2 data from all SWEPOS stations	€3250/year	---
L1/L2 data from all SWEPOS stations + computation service	€3900/year	---
L1 data from all SWEPOS stations	€1950 /year	---
One SWEPOS station		
L1 data from one SWEPOS stations	€215/year	---

Tab. 2 User fees for access to the Network-RTK and Network-DGNSS services.

	Fee	**Fee**	**Fee**
Service	***Network-RTK (GPS only)***	***Network-RTK (GPS/GLONASS)***	***Network-DGNSS (GPS/GLONASS)***
Registration	€550/GSM number	€550/GSM number	€550/GSM number
Unlimited data access	€1600/year/GSM	€2150/year/GSM	€975/year/GSMr
Per data access	€550/year/GSM +	€850/year/GSM +	N/A

	€0.55/minute	€0.55/minute	

7. USERS OF THE SWEPOS SERVICES AND APPLICATIONS

Since the start of the establishment of the SWEPOS network of permanent reference stations SWEPOS services have been developed in collaboration with the SWEPOS users. The long term demand from the majority of the users is a positioning service which gives 1 centimetre position accuracy (95 %) in real-time in the whole coverage area of the service. The implementation of the satellite positioning technique has implied that new user groups outside the surveying community has started to determine positions, which means that the user equipment and other ”positioning tools” based on the SWEPOS services must be very user friendly.

7.1. Data for post-processing

Users who download SWEPOS data for post-processing purposes have either high skilled personnel for post processing or tailor-made software for a special application.

Research institutes are using SWEPOS data for studies of crustal motion and estimation of the water vapour content in the atmosphere. Lantmäteriet is using SWEPOS-data for the monitoring of the stability of the Swedish reference systems (e. g. the influence of the land-uplift process). Typical tailor-made applications are airborne data capture systems, e. g. aeral photography and laser scanning, and data capture on the ground for the establishment of databases with information which is related to positions.

During 2005 there were 109 subscriber on post-processing data and 66 single-day users, who together down-loaded 15.954 files with SWEPOS data (one hour observation data or more per file) In addition 482.055 files were down-loaded by the research institutes (120 stations generate 1.051.200 one hour files during one year).

7.2. SWEPOS Automatic Computation Service on the SWEPOS Web

The idea behind SWEPOS computation service is that a user who wants to position a site in the Swedish national reference system shall have a possibility to submit his observation file in the de facto standard format RINEX along with information about the used antenna to the computation service and obtain a position along with quality parameters via e-mail.

During 2005 there were 219 subscribers on the computation service and 230 single day users, who submitted 2.153 observation files to the computation service.

Typical applications for SWEPOS Automatic Computation Service are determination of positions for starting points (base stations) for local RTK or total station measurements e. g. cadastral surveying, data capture for GIS. Another application is connection of local reference systems to the national reference system.

7.3. Epos service run by Cartesia

The Epos service was launched in 1994 when Selective Availability (SA) was activated in the GPS system. Typical applications for the Epos service was farming, forestry, fleet management and data capture for GIS. Today (July 2006) most fleet management applications can be run without DGPS support and the Epos service is used to improve the position reliability and accuracy in farming and GIS applications.

7.4. SWEPOS Network-RTK service

The number of users of SWEPOS Network-RTK service is increasing rapidly. We are approaching 500 users, the goal is to have around 1500 in five years. 43 % of the users are from the local authorities, 36 % from consultancy firms, 17 % from Land Survey and 4 % from other governmental agencies. In fig. 7 the connected time to the Network-RTK service for all users per week is shown

Typical applications for SWEPOS Network-RTK service are cadastral surveying, data capture for GIS, establishment of starting points for total station measurements. Up to now the service has been used very little for machine guidance and precision navigation. In collaboration with the National Road Administration three additional stations has been established in the SWEPOS Network-RTK net for a 20 km road construction project in the Gothenburg area. Radio modems are used for the broadcasting of Network-RTK data. Limitation in the use of SWEPOS Network-RTK service for machine guidance are the availability of standard formats for the digital road model which shall be entered into the machine and the need to upgrade the existing equipment in the construction machines with GPRS modem and RTCM ver 3.0.

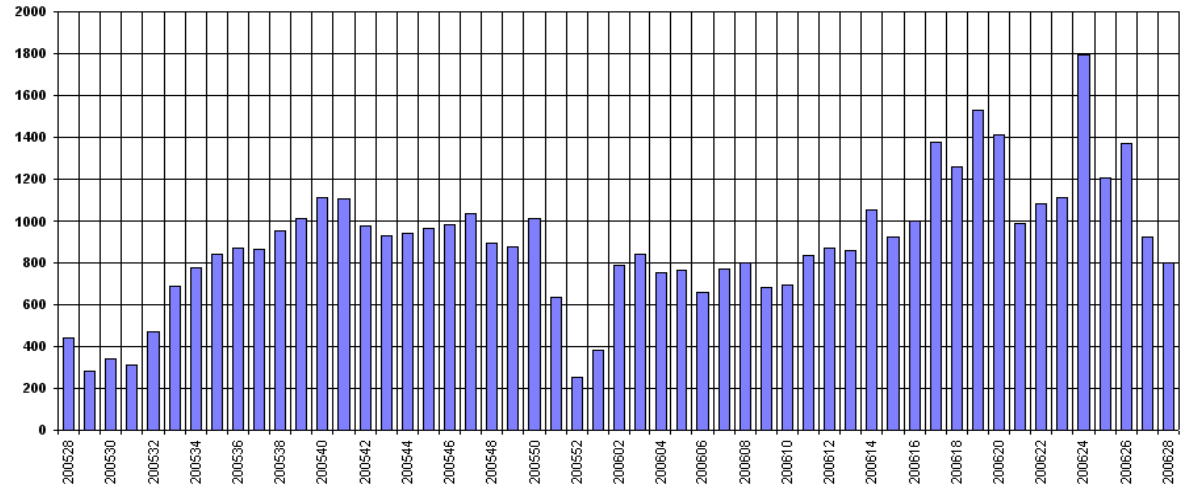

Fig. 7. Total connected time to SWEPOS Network-RTK service during the last 52 weeks

7.5. SWEPOS Network-DGNSS service

SWEPOS Network-DGNSS service is still in the introduction phase. The intention is to offer the service to users, who have single frequency GPS- or GPS/GLONASS receivers and to users who operate in environments which are not convenient for carrier phase measurements.

8. USER EXPERIENCES

The interest for SWEPOS grew very rapidly in the surveying community when we started the pilot projects for Network-RTK. To the three Prototype Production Networks during the time period 2002–2003 there were about 150 connected GSM telephone numbers. The experiences from those users are given below:

- Network-RTK is efficient and easy to use, only one receiver (the rover) is needed for positioning with centimetre accuracy
- It is an advantage to obtain the position directly in a national homogeneous reference system. If the position shall be used in a local reference system, transformation parameters are available.
- The "GPS maturity" of the users is varying, some users have experiences of single station RTK measurements for several years and other users are newcomers and started to use GPS just when the projects were established.
- In each project one start-up day and two user seminars have been arranged for the field surveyors. The steering Committee for each project has had a meeting once every three months. These activities are appreciated as forum for exchange of experiences
- Improved precision (especially in height component) and reliability are required for some applications, e. g. machine guidance and setting out for building elements.
- A high availability of the Network-RTK service is required in order to be attractive for potential users.
- Information about interruptions of the Network-RTK service via sms messages on the cellular phone is appreciated.
- The coverage of suitable distribution channels is a bottleneck in some areas. A service provider, who can offer a combination of cellular phone and the DARC channel on the FM-radio network, could improve the coverage of the distribution of Network-RTK data.
- The existing standard formats (RTCM and NMEA) can be used for the VRS-mode (Virtual Reference Station) but there is still a lack of standard formats for the broadcasting of Network-RTK data. The inclusion of a Network-RTK mode in all brands of GPS receivers is also desirable.
- Many of the users would miss the Network-RTK service if it was terminated.

SWEPOS Automatic Computation Service is very efficient for connection of local surveys to the national reference system and the users can buy a tailor-made process from their GNSS dealer, which is very easy to handle.

Many of the users of SWEPOS Network-RTK service do not belong to the conventional surveying community and this has resulted in the development of a field manual for Network-RTK measurements. The GPS dealers provide also tailor-made packages for SWEPOS Network-RTK service for different applications.

9. NORDIC POSITIONING SERVICE

A task was given to the Nordic Geodetic Commission by the Directors General of the Nordic Mapping Authorities in January 1999. The task was to establish a Nordic project for the development, establishment and operation of a service for positioning and navigation in the Nordic area. In January, 2000 a proposal for a two years development project on a Nordic Positioning Service was presented for the Directors General. The proposal was approved and the Directors General signed an agreement in the fall 2000, which included external funds.

External funds have not been obtained and therefore a reduced project is going on. Up to now the collaboration work between Denmark, Norway and Sweden has been focused on exchange of knowledge and development of an agreement on exchange of data between the existing networks of permanent reference stations. A Nordic Web-portal for post-processing data has been developed and a computer network between the control centres of the Nordic networks of permanent reference stations has been established. A Network-DGPS service with decimetre accuracy, covering Denmark, Norway and Sweden is under development.

10. FUTURE PLANS

The remaining extension of the SWEPOS network of reference stations is planned to be carried out during 2007, if the on-going financing process is successful, as a collaboration project between Lantmäteriet, local authorities, governmental agencies and private consultancy companies, in order to create a base of users for future contributions to the operation costs.

Special attention will be paid to the use of SWEPOS Network-RTK service for machine guidance in the near future. There are demands on an improvement in the accuracy in the height and the possibility to use surface meteorological information will be investigated

We will also pay attention to the introduction of the L3- and L5-frequencies in GPS and the development of the Galileo.

Local SWEPOS seminars will regularly be arranged in order to inform about the potential of the SWEPOS services and to get a feedback from the present SWEPOS users. A reference group consisting of about twenty representatives from the SWEPOS user community gives regularly feedback on the performance of SWEPOS and future developments. The group has a meeting once or twice a year.

11. CONCLUSIONS

A multi-purpose network of permanent stations is beneficial both for the users and for the providers of national infrastructure for positioning and non-safety-of-life navigation. The long-term plan for SWEPOS, which was developed in the early nineties, will be completed in a few years. The professional use of the GNSS techniques for positioning is increasing very rapidly outside the conventional surveying community, which implies more user friendly equipment and positioning concepts.

REFERENCES

Geodesi 2000 – svensk geodesiverksamhet under kommande tioårsperiod, LMV-rapport 2001:1, Gävle 2001

Hedling et al. (2001): SWEPOS™ - the Swedish network of permanent GPS reference station (status February 2001), Presented at FIG Working Week, 6-11 May 2001, Seoul, Korea

Jonsson B. et al. (2002): Nordic Geodetic Commission - a successful collaboration between the Nordic countries in the field of geodesy, FIG XXII International Congress, Washington, D.C. USA, April 19-26 2002

Jonsson B. et al. (2002): Some experiences of Network-RTK in the SWEPOS™ network, Proceedings of the 14th General Meeting of the Nordic Geodetic Commission, Helsinki

Jonsson B. et al (2003) SWEPOS™ Network-RTK Services – status, applications and experiences, ION GPS/GNSS 2003, 9-12 September, 2003, Portland, Oregon, U.S

Norin D. et al (2006): Kortmanual för mätning med SWEPOS Nätverks-RTK-tjänst, LMV-rapport 2006:2

Raquet J.F. (1998): Development of a Method for Kinematic GPS Carrier-Phase Ambiguity Resolution Using Multiple Reference Receivers, University of Calgary, Calgary.

Samsioe J. & B. Öhman (2000): Testplattform för nätverks-RTK i syfte att ge en rikstäckande GPS-tjänst med centimeternoggrannhet. Institutionen för väg- och trafikplanering, Chalmers Tekniska Högskola, Göteborg.

Wahlund S. (2002): Production measurements with Network RTK – Tests and analyses, LMV-rapport 2002:2, Gävle

Wiklund P. (2002): Slutrapport för projekt “Position Stockholm-Mälaren –1”, LMV-rapport 2002:1, Gävle

Vollath U., A. Buecherl, H. Landau, C. Pagels, B. Wagner (2000): Multi-Base RTK Positioning Using Virtual Reference Stations. Proceedings of ION GPS 2000, Nashville, 2000.

von Malmborg H. (2006): Jämförelse av Epos och nätverks-DGPS, LMV-rapport 2006:5

Wübbena G. et al. (1996): Reducing distance dependant errors for real-time precise DGPS. Proceedings of .ION GPS-96, Kansas City.

BIOGRAPHICAL NOTES

Mr Jonsson is graduated with a B. Sc. in mathematics, physics and astronomy from University of Lund in 1969 and courses in Geodesy at the University of Uppsala in 1974. He is working as GPS Program Manager and Deputy Head of the Geodetic Research Division of National Land Survey since 1996. Mr Jonsson is secretary in the Presidium of the Nordic Geodetic Commission.

Mr. Hedling is a Senior Research Geodesist at the Geodetic Research Division of the National Land Survey of Sweden. He received a M Sc. in applied physics from Lund University in 1986. He has worked with different GPS applications during the last 15 years.

Mr. Jämtnäs was graduated as M. Sc. in Physical Geography at the University of Uppsala in 1999 and as diploma engineer in Geomatics at the University of Gävle 2005. He is working with at the National Land Survey since 2005 with the development and operation of the SWEPOS network.

Mr. Wiklund is Project Manager at National Land Survey for the Network-RTK Service. He was graduated as diploma engineer in mapping and surveying at the University of Gävle in 1996.

CONTACTS

Senior Research Geodesist Bo Jonsson
Lantmäteriet, National Land Survey
Lantmäterigatan 2
S-801 82 Gävle
SWEDEN
Tel.: + 46 26 633738
Fax: +46 26 610676
e-mail: bo.jonsson@lm.se
www.swepos.com