Quality Assessment of Network-RTK in the SWEPOS™ Network of Permanent GNSS Stations

Lars JÄMTNÄS, Johan SUNNA, Ragne EMARDSSON & Bo JONSSON, Sweden

Key words: GNSS, Network-RTK, SWEPOS

SUMMARY

SWEPOS® is a multi-purpose network of permanent GNSS reference stations. Since the late 1990s, SWEPOS has been used to define the Swedish national reference frame and continuously monitor land uplift and crustal movements. Network-RTK technique was introduced regionally in 2002 and has expanded nation-wide through successive establishment projects, with co-operative efforts by Lantmäteriet (the National Land Survey of Sweden) and the SWEPOS user community. Today (Jan. 2010) SWEPOS consists of 185 permanent stations, and the network-RTK service has 1500+ registered users.

The network-RTK establishment projects included a large volume of test measurements in order to verify the technique and quantify some measures of accuracy for the user community. More recently the project "Close-RTK" was initiated by Lantmäteriet, SP Technical Research Institute of Sweden and Chalmers University of Technology in a more rigorous effort to assess the quality of the present network-RTK technique - as well as future development scenarios of space (GNSS) and ground (SWEPOS) infrastructure. Different error sources affecting measurements with network-RTK technique (e.g. atmospheric and local effects) were studied and quantified within the project. This resulted in an error budget for different cases, initially based on the current satellite constellation and a nominal network density of 70km between the reference stations.

Given the inclusion of future satellite systems, such as Galileo and Compass, and a densified SWEPOS network (with 35km between the reference stations), Close-RTK predicts that rover horizontal and vertical position uncertainties will decrease by a factor 2. In addition, the study gives recommendations for an optimal choice of elevation cut-off angle for this scenario and demonstrates that the use of ionosphere-free linear combination may be beneficial for RTK positioning during periods of increased ionospheric activity.

Quality Assessment of Network-RTK in the SWEPOS™ Network of Permanent GNSS Stations

Lars JÄMTNÄS, Johan SUNNA, Ragne EMARDSSON & Bo JONSSON, Sweden

1. INTRODUCTION

SWEPOS® is a network of permanent GPS/GLONASS reference stations which began as a co-operation between Lantmäteriet (the Swedish mapping, cadastral and land registration authority) and Onsala Space Observatory in the early 1990s. The purposes of SWEPOS are mainly to (Jonsson et al., 2006):

- Provide GNSS data for real-time and post-processing applications
- Act as high-precision control points for GNSS users
- Provide data for scientific studies (e.g. climatology and tectonics)
- Monitor the integrity of the GNSS systems
- Act as basis for the Swedish national reference frame, SWEREF 99 (a certified ETRS89 realization)

Positioning with GNSS techniques is used by a variety of Swedish organizations to increase productivity and efficiency in their respective fields. The largest volume of production measurements are today carried out with network-RTK. Typical applications are detail and cadastral surveying, and recent years also within building and construction (e.g. machine guidance). Growing demands for around-the-clock availability and reliability of high-precision positioning presents a challenge to Lantmäteriet as a service provider. We therefore have to address the following questions:

- What quality - primarily defined as “accuracy” or “uncertainty” (see GUM, 2008) - can be expected from the SWEPOS positioning services?
- How can this information be comprehensibly presented to the SWEPOS user community, both for production planning and verification/quality check?

This paper presents some of the ongoing efforts to assess the present state and quality of network-RTK in Sweden. We will primarily focus on the Close-RTK project (Emardson et al., 2009a), initiated by Lantmäteriet, Chalmers University of Technology, and SP Technical Research Institute of Sweden (“Close” being a colloquial acronym of these participating institutions).

2. NETWORK-RTK IN SWEDEN

2.1 Present SWEPOS infrastructure

The current 10-year plan for geodetic activities at Lantmäteriet (Engberg, 2001), which was created nearly a decade ago, projected a national network-RTK service. The ongoing extension of the SWEPOS network is based on this plan, and has so far been achieved through collaborative establishment projects with participants from state and municipal authorities, private companies, academic institutes and GNSS equipment vendors. Starting from the original 21 SWEPOS stations – which comprise the physical backbone for the Swedish national reference frame – a step-by-step regional densification has led to the 185 permanent GNSS reference stations we have today, January 2010 (figure 1). All SWEPOS stations are equipped with multi-frequency GNSS receivers and choke-ring antennas of Dorne Margolin design. Data from all stations is collected every second at the SWEPOS control centre (located at the headquarters of Lantmäteriet in Gävle, Sweden) via leased TCP/IP connections, which are monitored at all times. The average in-between-station distances are about 70km, following recommended praxis and conclusions from previous studies (Jonsson et al., 2006).

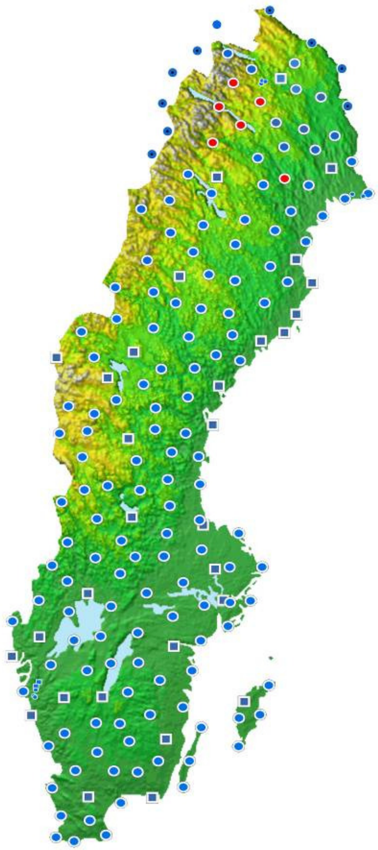
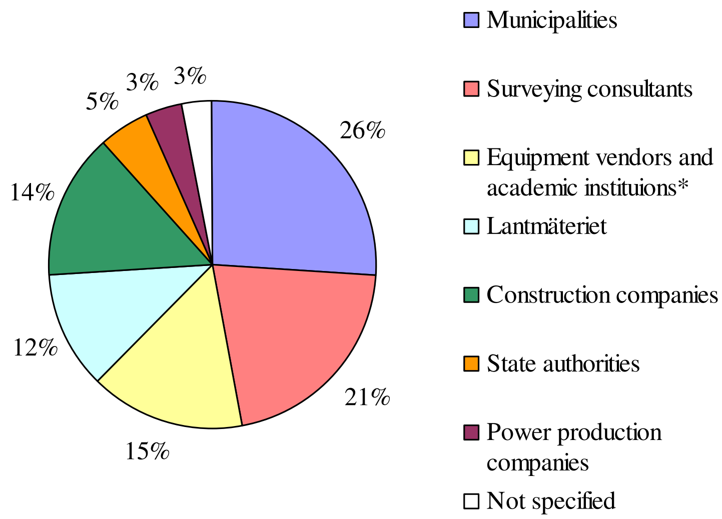


Figure 1: Left: Current SWEPOS network and a number of bordering Norwegian and Finnish stations that are used in SWEPOS Network-RTK Service. Blue squares are stations of Class A type. Blue dots are stations of Class B type, established step-by-step for network-RTK purposes. Red dots are Class B stations which are planned in the near future.
Top right: A SWEPOS "Class A" station with the concrete antenna monument directly on bedrock and with redundant equipment in specially designed cabins. All the original 21 stations are of this type.
Bottom right: A SWEPOS "Class B" station with a roof-mounted antenna, typically with the equipment located inside a public building.



* Free of charge if for demo or scientific purposes

Figure 2: SWEPOS Network-RTK users, per organization category (January 2010).

2.2 SWEPOS Network-RTK Service

The SWEPOS Network-RTK Service was launched in 2004, following the successful completion of the first pre-study and establishment projects. It has now, 2010, extended nation-wide, with close to 1600 registered users that span a wide range of fields (figure 2). The total production volume carried out with network-RTK continues to increase (figure 3).

SWEPOS is regarded as a critical component of the national geodetic infrastructure, which guarantees that further investment and extension of the network will be financed by governmental funds (Engberg, 2001). But the everyday maintenance of the SWEPOS network and services has mainly been financed by user fees, in part due to the viable user communities that quickly were established regionally during the extension projects.

The present SWEPOS Network-RTK Service is based on the Virtual Reference Station concept, with two-way GSM or GPRS communication between the control centre in Gävle and the RTK users. Real-time GNSS data is delivered to rover receivers in the RTCM standard, with an expected rover horizontal position uncertainty of 0.03m (95%) and vertical position uncertainty of 0.05m (95%). How this translates to an actual positioning error on the user side is not trivial, given the influence from factors that are very hard to either predict or to estimate: weather, local environment, rover antenna characteristics, mobile coverage (read: data loss), user experience and so forth.

On this note, many of the users of SWEPOS Network-RTK Service do not belong to the conventional surveying community. This prompted the development of a short-hand manual for the service (Norin et al., 2007), which is now distributed to all new users. However, the users still need tools to assess the quality of their measurements, given that they follow recommended praxis. Specification of tolerance levels for revisits with Network-RTK (Odolinski & Sunna, 2009) and the plan to present information about ionosphere error estimates on the SWEPOS web page (Lidberg, 2009) are steps in this direction.

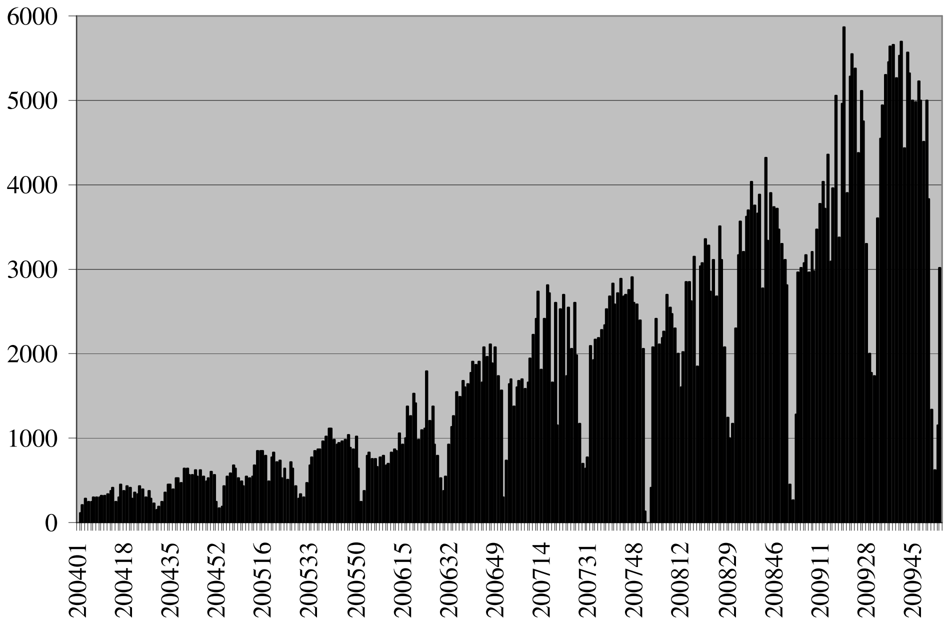


Figure 3: Total user connection time (in hours) per week for the SWEPOS Network-RTK Service, from the launch in January 2004 to late 2009.

2.3 Project adaptation and user demand

A recent trend in SWEPOS development is the increasing demand for flexible and tailor-made positioning solutions, mainly aimed at large-scale construction projects. One example of this concept is the project services set up for the construction of new parallel-running double track railway and four-lane highway north of Gothenburg, which is the largest ongoing construction project above ground in Sweden. Lantmäteriet has, in collaboration with the National Road and National Rail Administrations, established nine SWEPOS reference stations with redundant equipment and communication links along the 75km long project area - in other words: a local densification of the national SWEPOS network. Radio modems are used for one-way distribution of network-RTK correction data in the project area. The short in-between-station distances make it possible to reach expected position uncertainties of less than 0.02m horizontally (95%) and 0.03m vertically (95%) for real-time applications, for example machine guidance - and possibly even less with the automated post-processing service adapted for the project.

Because of complex geological conditions in the project area, the geodetic networks used for production work has to be closely monitored over extended periods of time. The project setup therefore includes real-time monitoring of the local reference stations (zero-baseline) and two additional RTK-monitoring stations that continuously receive the radio distributed correction data. This makes it possible to instantly detect deviations or interruptions in positioning services, for example through web applications and alarm messaging. This concept has proven to bring advantages in terms of productivity, allowing up to 95% of all surveying and production measurements to be carried out with GNSS equipment.

Monitored 1Hz RTK data is routinely saved to a database for monthly presentation within the project, but this information can be made arbitrarily detailed (depending on request). Coming efforts will be made to present RTK monitor data quality in a way that meets user demand - i.e. not just through real-time web applications, but accessible and searchable via web portal for post-production verification of GNSS measurements.

The overall picture from project adaptation has been further corroborated by a survey carried out by questionnaire in early 2008. We received approximately 400 answers from the 900 organizations that subscribes to the Network-RTK Service. A majority of the users were satisfied with the general performance of the service, and close to 50% of the organizations could perform all their positioning with network-RTK. They were questioning the current vertical position uncertainties; more than 40% of the users requested improvements in order to benefit from the use of network-RTK, notably for machine guidance and for staking out building elements. The SWEPOS users also rely on high availability and performance and expect to be notified immediately in case of operation failures. An SMS message service is today included in the network-RTK service, but real-time status maps have occasionally been requested. Additional monitoring stations for the nation-wide service are planned for late 2010, which will aid and improve status information to users.

3. ASSESSING THE QUALITY OF NETWORK-RTK

3.1 The picture from previous studies

Field studies with network-RTK have previously been conducted as part of the SWEPOS establishment projects and diploma works, primarily to verify various aspects of the network-RTK technique. Theses studies have included controlled test measurements in order to verify the technique and to quantify some measures of accuracy for the user community (see table 1). The measurement strategy has in these cases generally been to keep the rover centred over a number of geodetic points with well determined coordinates in SWEREF 99, using a tripod, and to perform repeated initialisations. This has been done with different brands of RTK equipment and under varying conditions (considering the large total number of network-RTK measurements).

A tendency towards decreasing rover positioning uncertainty with network-RTK can be seen over this period; from 15-20mm (1σ) horizontally and 25-30mm (1σ) vertically in the early studies, to corresponding numbers of 10-15mm and 20-25mm at present. These numbers have been confirmed through other studies over these years, and is most likely explained by a combination of factors: modernization of equipment on both the service provider and the end-user sides (e.g. GNSS antennas with better multipath reduction), better modelling of atmospheric errors in the network-RTK software, and steadily decreasing ionosphere disturbances as we have moved further away from the latest sun spot maximum.

Field period for Establishment project/ Diploma work	Horizontal error @ 68% (mm)	Horizontal error @ 95% (mm)	Vertical error @ 68% (mm)	Vertical error @ 95% (mm)	# of meas. (# of control points)	GNSS obser-vations & corrections
1 Feb 2001 – 31 Mar 2001	16	37	32	91	-- (--)	GPS
4 Apr 2003 – 3 Jun 2003	13	29	22	46	>1500 (7)	GPS
9 Apr 2002 – 31Dec 2003	15	34	29	69	>4200 (--)	GPS
14 Mar 2002 – 31 Dec 2003	19	35	25	51	780 (--)	GPS
2 Feb 2002 – 31 Dec 2003	18	39	27	68	>6100 (89)	GPS
28 Jun 2004 – 23 Jul 2004	15	32	24	51	600 (7)	GPS
Apr 2005	16	32	27	57	640 (4)	GPS
Jun 2005	12	24	25	52	360 (6)	GPS/GLO.
Sep 2006 – Oct 2006	14	25	17	41	221 (9)	GPS/GLO.
Aug 2006 – Mar 2007	10	22	18	43	180 (11)	GPS, GPS/GLO.
31 Jan 2007 – 16 Feb 2007	15	30	23	46	632 (6)	GPS/GLO.
Apr 2008	13	23	21	40	300 (3)	GPS

Table 1: Error percentiles based on the empirical distributions from a number of field studies conducted with network-RTK. The vertical error is based on ellipsoidal heights.

The combined end-result from these studies gives a good idea of "nominal" position uncertainties for the network-RTK service in general. However, this does not really help us to estimate the expected uncertainty in a given situation. One reason for this is the short time window for each point occupation (even with repeated initialisations) in these studies - possibly with high autocorrelation in measured rover coordinates, making quality estimates difficult or even pointless. This problem has been discussed by Jämtnäs & Ahlm (2005) following Kjørsvik (2002), and recently in Odolinski (2009) where tools to analyze such data has been developed for SWEPOS monitoring.

3.2 Current Network-RTK with SWEPOS

"Close-RTK" is arguably the broadest and theoretically most ambitious attempt to evaluate network-RTK in Sweden so far. All results presented from the Close project (in sections 3.2 and 3.3) are from Emardson et al. (2009a) unless otherwise specified.

The main objectives for this project were to:
(1) investigate the achievable levels of accuracy or uncertainty with the present network-RTK technique, based on a detailed study of contributing error sources and their effect on rover positioning, and to
(2) evaluate the expected quality of network-RTK positioning in the future, given possible changes in the infrastructure of space and ground segments (e.g. the inclusion of the Galileo satellite system and a densified SWEPOS network). Measures to improve the vertical component were considered a priority, mainly for the reasons described in the previous sections.

Different error sources that are affecting measurements with network-RTK were thoroughly studied and quantified, namely:

- Rover and satellite clock errors
- Satellite orbit error
- Ionosphere signal delay
- Troposphere signal delay
- Multipath and receiver noise for the rover and the reference stations (local effects)

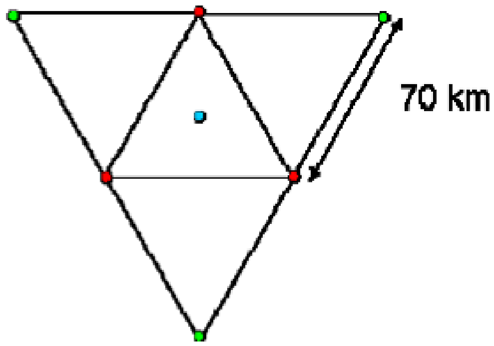


Figure 4 (from Emardson et al., 2009a): Network configuration is assumed as outlined in the figure. The central blue dot is the rover. The red and green dots are reference stations with different weights in the interpolation.

Since clock and orbit errors either cancel out in processing or have minimal effect on network-RTK measurements, focus was mainly placed on the ionosphere, troposphere and local effects and how they "translate" into an estimated rover position error from surrounding reference stations (figure 4). These studies resulted in an "error budget" for different cases (nominal/small contribution (5%)/large contribution (95%), based on an assumed network density of 70km between reference stations. Table 2 lists the different error sources and how they would contribute to errors in the measured phase in the zenith direction.

Error Source		**Error Nominal (mm)**	**Error 5% (mm)**	**Error 95% (mm)**
Satellite clocks		0	0	0
Satellite orbits		0	0	0
Ionosphere		7.2	2.0	16.3
Troposphere		6.2	2.1	10.3
Local effects	Rover	2.0	1.2	4.0
	Reference	1.2	1.2	1.2

Table 2: Summary of contribution from the different error sources, given as interpolated phase errors for zenith direction.

The errors in horizontal and vertical rover position estimates were then statistically modelled (via error propagation analyzes), based on this error budget and the GPS and GLONASS satellite constellation of August 2008. Standard-weighted L1 observations were used for this basic scenario, with a 13 degree elevation cut-off angle. The contribution from each error source on the position estimate errors are listed in table 3.

Error Source		**Horizontal error for nominal situation (mm)**	**Vertical error for nominal situation (mm)**
Satellite clocks		0	0
Satellite orbits		0	0
Ionosphere		10.7	16.6
Troposphere		3.9	20.9
Local effects	Rover	3.5	5.6
	Reference	0.9	1.4
Total (RMS):		**12.0**	**27.3**

Table 3: Summary of expected rover position errors with network-RTK, and the contributions from the different error sources.

To evaluate these results, a comparison was made with actual real-time measurements using the SWEPOS Network-RTK Service. Rover data was collected during a time period of 24 hours, with coordinate estimates every 15 seconds. The RTK equipment was configured with an elevation cut-off angel of 13 degrees and both GPS and GLONASS observation were processed. This was performed at two different locations with well determined positions in SWEREF 99:

- Site 1, located near the centre of a station network triangle with mean distances between reference stations of approximately 43km
- Site, 2 located nearby a reference station in a network triangle with mean distances between reference stations of approximately 73km.

Error Source		**Modelled horizontal error (mm)**	**Modelled vertical error (mm)**
Satellite clocks		0	0
Satellite orbits		0	0
Ionosphere		3.4	5.3
Troposphere		4.2	15.9
Local effects	Rover	3.5	5.6
	Reference	1.2	1.4
	Total (RMS):	**6.6** (vs.8.6)	**17.8** (vs.19.3)

Table 4: Modelled positioning errors for site 1, with contributions from the different error sources. Actual measurement errors are in parenthesis.

Error Source		**Modelled horizontal error (mm)**	**Modelled vertical error (mm)**
Satellite clocks		0	0
Satellite orbits		0	0
Ionosphere		3.1	4.8
Troposphere		1.3	5.9
Local effects	Rover	3.5	5.6
	Reference	1.1	1.7
	Total (RMS):	**5.0** (vs.7.6)	**9.6** (vs.14.3)

Table 5: Modelled positioning errors for site 2, with contributions from the different error sources. Actual measurement errors are in parenthesis.

The measurement errors were calculated as the difference between the estimated and known position. Tables 4 and 5 list modelled and measured horizontal and vertical errors for site 1 and site 2 respectively. The measured vertical error is clearly higher than the modelled for site 2, which could be explained by a higher degree of variability in the troposphere during the 24 hours than the value chosen for the model. Otherwise these results seem to confirm that the simulated rover position errors from the error budget of Close-RTK come reasonably close to actual network-RTK measurements.

Expanding the basic scenario from L1 observations to consider other linear combinations, Emardson et al. (2009b) summarizes the contributions to the vertical error from the major error sources as seen in figure 5. L3 is the widely used ionosphere-free linear combination and L_0 is a linear combination of L1 and L2 which minimizes the combined effect of ionosphere and local errors. Since the contribution from the ionosphere is expected to increase as we approach the next solar spot maximum of 2012, alternative linear combinations for RTK processing could be worth considering. It should however be noticed that reduction of ionosphere through such methods comes at the expense of increased local effects.

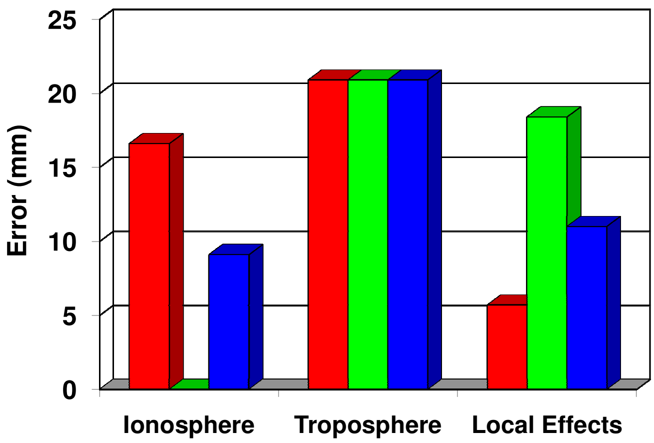


Figure 5 (Emardson et al., 2009b): Vertical error contribution from the three major error sources, for L1 (red), L3 (green) and L_0 (blue).

3.3 Future Network-RTK with SWEPOS

Emardson et al. (2009a) also investigated the potential quality of network-RTK in Sweden, considering different development scenarios of space and ground infrastructure, i.e. the future satellite systems and the future SWEPOS network. With a fully developed GNSS constellation – including GPS, GLONASS, Galileo and Compass – we would typically have 25-35 satellites available for observation at any given time, using a standard 13 degree cut-off angle. With such a large number of potential satellite observations, we can assume that there are other possibilities for RTK processing, including choice of elevation cut-off angle. This can be seen clearly in figure 6, where horizontal and vertical position errors are plotted as function of elevation angle. The minimum vertical error occurs at a cut-off angle of over 20 degrees for a future GNSS constellation. Figure 7 then demonstrates the horizontal and vertical errors for three different situations: (1) The "nominal" situation with the current GNSS constellation, (2) a future full GNSS constellation with a 13 degree cut-off angle - and finally (3) a future full GNSS constellation, but with a 24 degree cut-off angle.

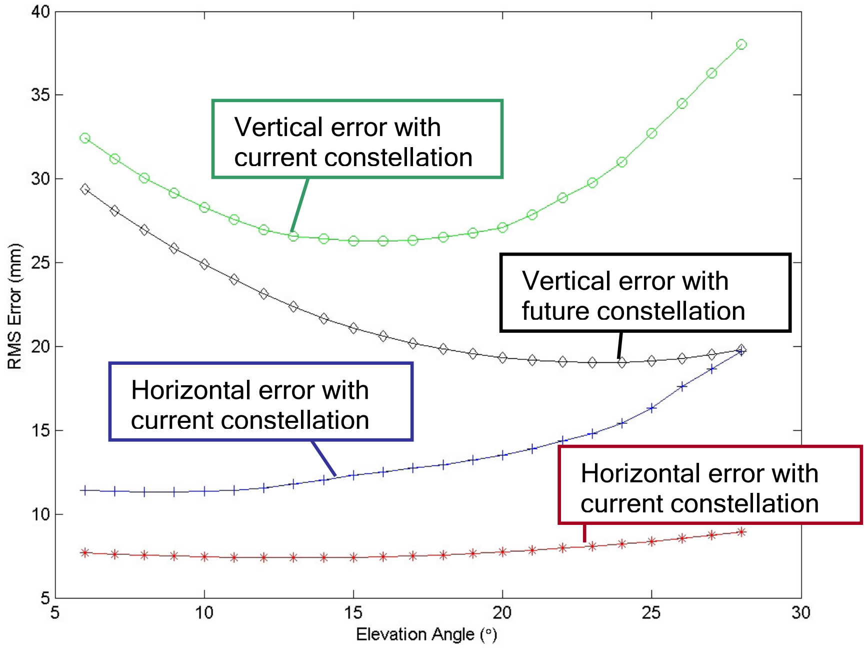


Figure 6 (adapted from Emardson et al., 2009a): RMS error as a function of elevation angle for the horizontal and vertical components.

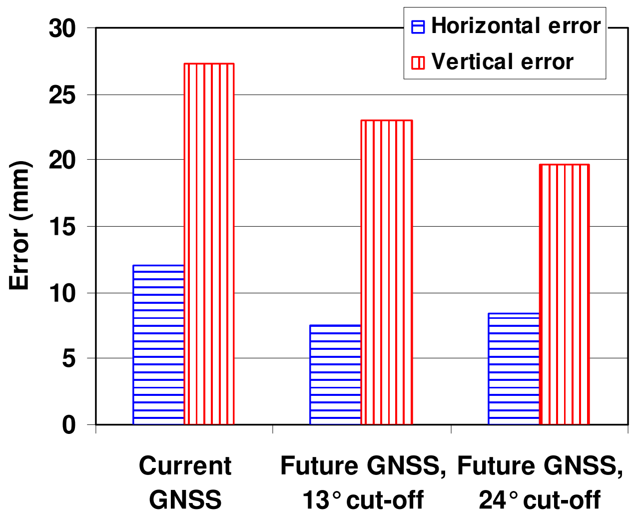


Figure 7: Horizontal and vertical positioning errors, with current and future GNSS constellations.

The effect of a future development of SWEPOS infrastructure was also investigated. The error models for the nominal case were based on the assumption of in-between reference station distances of 70km. Given a densified network with 35km distances the vertical error budget changes as seen in figure 8, where the contribution from three major error sources are plotted for three different cases: (1) The "nominal" situation with current GNSS constellation and SWEPOS, (2) a situation with a future full GNSS constellation, and a 24 degree cut-off angle, and (3) a future SWEPOS network with in-between station distances of 35km. It can here be seen that the densification would lead to an equal improvement on vertical position error as a fully developed GNSS constellation, mainly due to improved interpolation of the ionosphere signal delays.

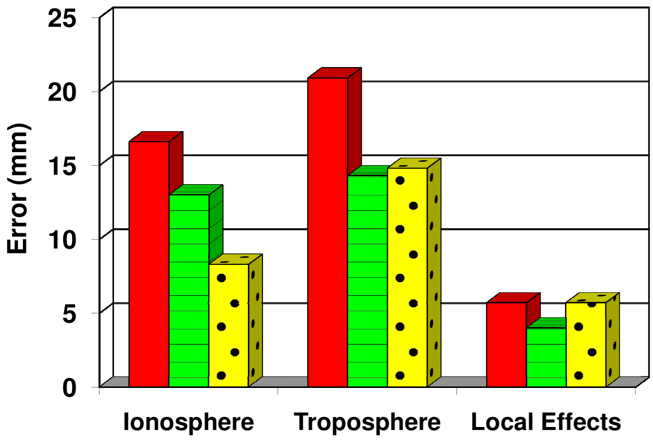


Figure 8 (Emardson et al., 2009b): Vertical error contribution from the three major error sources, for nominal (red), new GNSS (green striped) and network densified (yellow dotted) cases respectively.

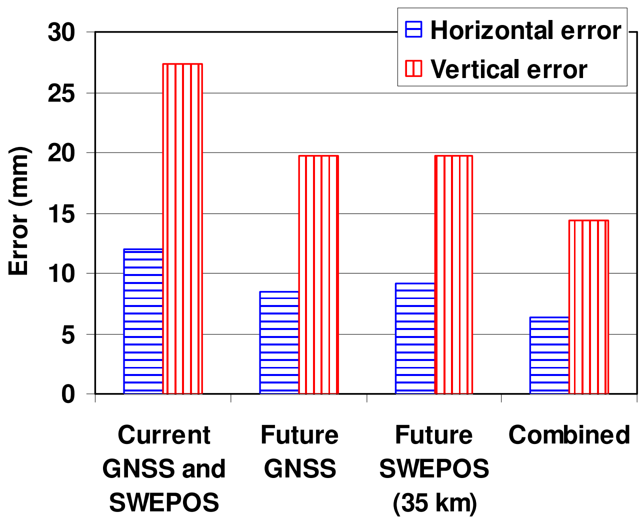


Figure 9: Horizontal and vertical positioning errors, with current and future GNSS constellations.

Finally, we can see the effects of a "combined" situation in figure 9, where we have the expected horizontal and vertical position errors when using network-RTK with *both* a fully developed GNSS constellation and a densified SWEPOS network. This is based on standard L1 processing, but other possibilities (corresponding to the linear combinations in figure 5) were examined as well. In conclusion, rover position uncertainties can be expected to decrease by a factor 2, both for the horizontal and the vertical component, given the proposed changes in GNSS constellation and SWEPOS infrastructure.

4. CONCLUDING REMARKS

The ongoing quality assessment of network-RTK provides valuable information about the error sources and how they affect rover positioning. Results from Close-RTK and similar projects will continue to guide the development of SWEPOS to meet the demands of the user community. This includes optimization of a future reference station infrastructure, but also the development of assessment tools for real-time users, such as ionosphere monitoring via the SWEPOS web page.

REFERENCES

Jämtnäs L and Ahlm L, 2005: Field study of Internet distributed network-RTK (in Swedish). Reports in Geodesy and Geographic Information Systems, no. 2007:1, Lantmäteriet, Gävle.

Emardson T, Jarlemark P, Bergstrand S, Nilsson T, and Johansson J, 2009a: Measurement Accuracy in Network-RTK. SP report 2009:23, ISBN 978-91-86319-10-6, SP Technical Research Institute of Sweden, Borås.

Emardson R, Jarlemark P, Johansson J, Bergstrand S, Lidberg M, and Jonsson B, 2009b: Measurement Accuracy in Network-RTK. Submitted to: Bulletin of Geodesy and Geomatics, Special issue from the EUREF Symposiun in Florence, May 2009.

Engberg L E, 2001: Geodesy 2000 – Swedish geodetic activities for the upcoming ten year period (in Swedish). Reports in Geodesy and Geographic Information Systems, no. 2001:1, Lantmäteriet, Gävle.

GUM, 2008: Evaluation of measurement data - Guide to the Expression of Uncertainty in Measurement. JCGM 100:2008, Working Group 1 of the Joint Committee for Guides in Metrology (JCGM/WG 1). *http://www.bipm.org/en/publications/guides/gum.html* (accessed 2010-01-12).

Jonsson B, Heding G, Jämtnäs L and Wiklund P, 2006: SWEPOS Positioning Services – Status, Applications and Experiences. XXIII FIG International Congress, Oct. 8-13 2006, Proceedings, TS3.1 (14 pp), FIG, München.

Kjørsvik N, 2002: Assessing the Multi-Base Station GPS Solutions. XXII FIG International Congress, 19-26 April 2002. Proceedings, TS5.6, FIG, Washington D.C.

Lidberg M, 2009: Project definition for Close-RTK II (in Swedish), dated 28 Aug. 2009, Lantmäteriet, Gävle.

Odolinski R, 2009: Evaluation of SWEPOS RTK-service based on data from the monitoring stations (in Swedish). Intern PM, dated 9 Sep. 2009, Geodetic Research Department, Lantmäteriet, Gävle.

Odolinski R & Sunna J, 2009: Detail surveying with network RTK – an accuracy research (in Swedish). Reports in Geodesy and Geographic Information Systems, no. 2009:2, Lantmäteriet, Gävle.

BIOGRAPHICAL NOTES

Mr. Lars Jämtnäs has a M.Sc. degree in physical geography from the University of Uppsala and a diploma engineer degree in geomatics from the University of Gävle. Since 2005, he is working with the development and operation of the SWEPOS network at the Geodetic Research Department of Lantmäteriet.

Mr. Johan Sunna has studied to M.Sc. with emphasis on Geodesy and Geoinformatics at The Royal Institute of Technology, KTH. Since 2009, he has been working as a Land Surveyor at the Geodetic Research Department of Lantmäteriet**.**

Dr. Ragne Emardson has a M.Sc. degree in computer science and engineering and a Ph.D. degree in electrical engineering from Chalmers University of Technology in Gothenburg. From 1998 to 2000, he was a postdoctoral researcher with the Jet Propulsion Laboratory, California Institute of Technology, Pasadena. He has also held positions with Ericsson Mobile Data Design and SAAB Ericsson Space. Since 2003, he is with SP Technical Research Institute of Sweden.

Mr. Bo Jonsson has a B.Sc. degree in mathematics, physics and astronomy from University of Lund in 1969 and courses in Geodesy at the University of Uppsala in 1974. He has been the GPS Program Manager and Deputy Head of the Geodetic Research Department of Lantmäteriet since 1996. Mr. Jonsson was secretary in the Presidium of the Nordic Geodetic Commission during the time period 1998-2006.

CONTACTS

Mr. Lars Jämtnäs
Lantmäteriet
801 82 Gävle
SWEDEN
Tel. +4626633845
Email: lars.jamtnas@lm.se
Web site: www.swepos.com