Test of SWEPOS® network RTK service in the Baltic Sea

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Some first initial theoretical and practical studies of using GNSS for high precision navigation of vessels in the Baltic Sea has been performed. Theoretical simulations has shown possibilities to achieve vertical RMS of approximately 30 mm (68 %) based on network RTK in a reference network that covers the area of the Baltic Sea, provided that fixed ambiguity resolution could be solved. Such network will have maximum baselines of approximately 250 km. During a test campaign in the southern Baltic Sea, with baselines of approximately 75 km between the reference stations, fixed solutions was achieved in all parts of the area. The critical issue at sea for network RTK is the need of two way communication with the reference network in order to get RTK corrections. Using Swedish mobile network works for areas close to the coast but not further away from the coastline. RTK corrections through a VSAT satellite link worked well over the entire area for the test campaign but need special antennas installed at the vessel in order to receive the satellite link signal.

Introduction

The use of GNSS for high precision navigation of vessels is under development. A quality of +/-10 cm is necessary in the height component in order to be useful for effective route planning.

Close to the coast, the dense SWEPOS network and SWEPOS network RTK service with the virtual reference station (VRS) concept should be possible for navigation with required quality. Further away from the coastline the distance to the reference stations will increase and the quality of the SWEPOS network RTK solution will decrease, or possibly not give a fixed solution at all due to the extrapolation of the VRS. Extrapolation could be avoided if reference stations from other countries are included in a common reference network for the Baltic Sea.

Another problem with the VRS concept of network RTK is the need of a two way data communication for the RTK corrections. The mobile network communication that is normally used at land has limited reach from the base stations and will not cover areas further away from the coast.

Figure 1: The German vessel DENEB was used for, among others, practical test of SWEPOS in the southern Baltic Sea. Photo: Kent Ohlsson

Theoretical simulations

During winter and spring 2015 Lantmäteriet, in collaboration with Onsala Space Observatory at Chalmers University of Technology and SP Swedish Technical Research Institute, was running a project called CLOSE III (Johansson, et al., 2016). One part of the project was a theoretical study of how a high performance GNSS service for the Baltic Sea could be designed for navigation of a moving vessel. Vertical RMS for network RTK measurements was simulated for distances from 20-2000 km between reference stations (Figure 4). A vertical RMS of approximately 30 mm at 68 % confidence level for an ionospheric free L3 combination is expected at the approximately 250 km baselines which could occur in the Baltic Sea. But this is under the circumstances that the ambiguity fixing is solved correctly which could be difficult for a moving vessel and such long baselines.

Test of SWEPOS during DENEB cruise

Within the FAMOS project a cruise with the German Vessel DENEB was performed on the south Baltic Sea in May 2016 (Figure 1). Lantmäteriet participated during two days with a goal, among others, to investigate SWEPOS network RTK service in this area of the Baltic Sea. To avoid extrapolation also some Danish reference stations as well as the German station Arkona was included in the SWEPOS service (Figure 5 & 6). It creates a network with baselines of approximately 75 km between the reference stations.

Two GNSS equipment was used for the test of SWEPOS. One RTK rover connected to the Swedish mobile network making measurements every second in order to study how far from the coast it is possible to achieved fixed solution through similar RTK technique GNSS that are used on land (Figure 2).

The other test was done with a GNSS receiver connected to an external antenna at the mast of the vessel (Figure 2). The same antenna signal was used of BKG to test a PPP solution and their network RTK service SAPOS. The communication for the RTK corrections was solved with a VSAT satellite internet link (Figure 3). RTK positions was stored every second together with necessary information as for example solution type. A new VRS was calculated every 5 km in order to not get corrections to far away from the VRS.

Figure 2: The RTK rover mounted on the stern deck of the vessel. The external GNSS antenna for the other test is mounted on the mast of the vessel. Photo Kent Ohlsson.

Figure 3: One of the two antennas used for the communication with the reference network through a VSAT satellite link. Photo: Kent Ohlsson.

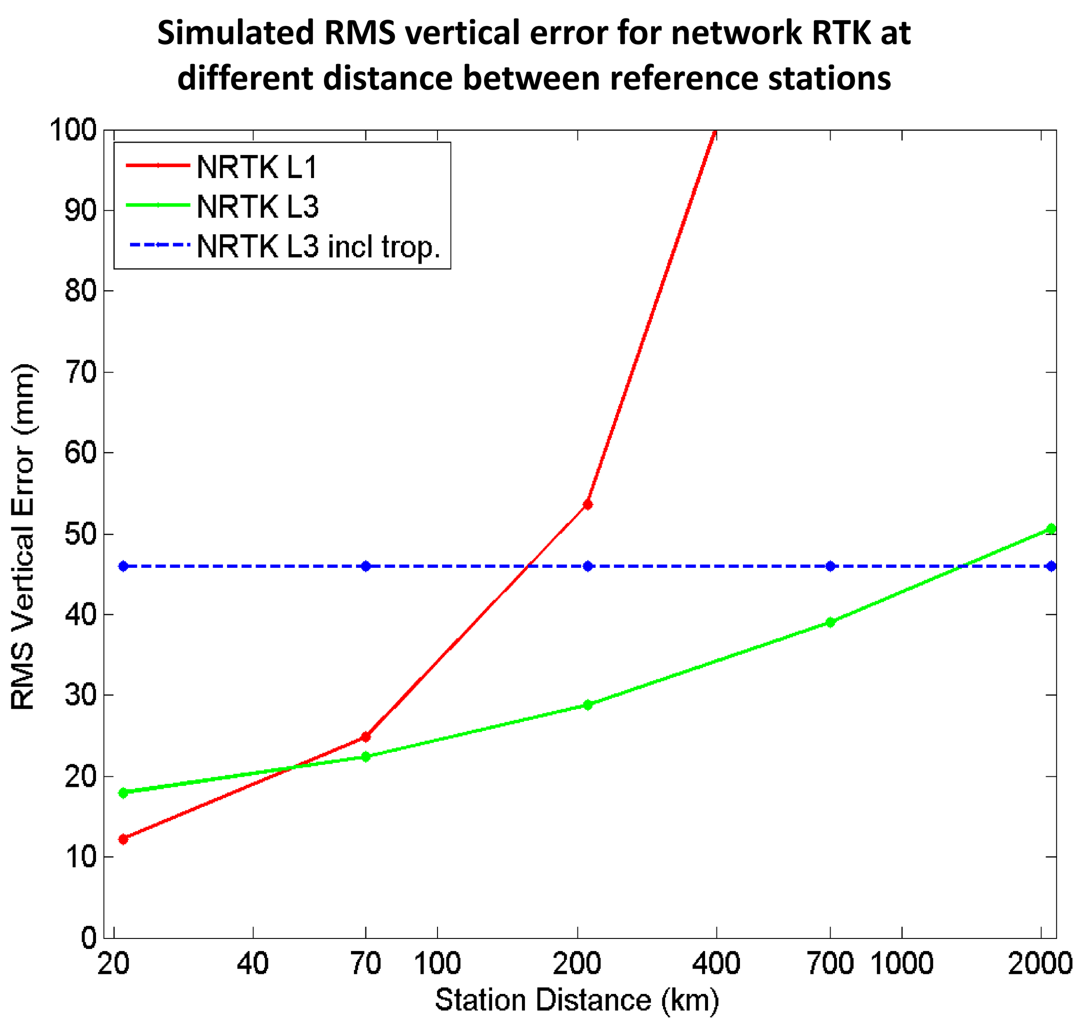

Figure 4: Vertical RMS (68 %) from simulations of network RTK with distance between stations in the reference network of up to 2000 km. Three different observing methods was simulated (L1, L3 with and without Zenith Tropospheric Delay estimation). From (Johansson, et al., 2016)

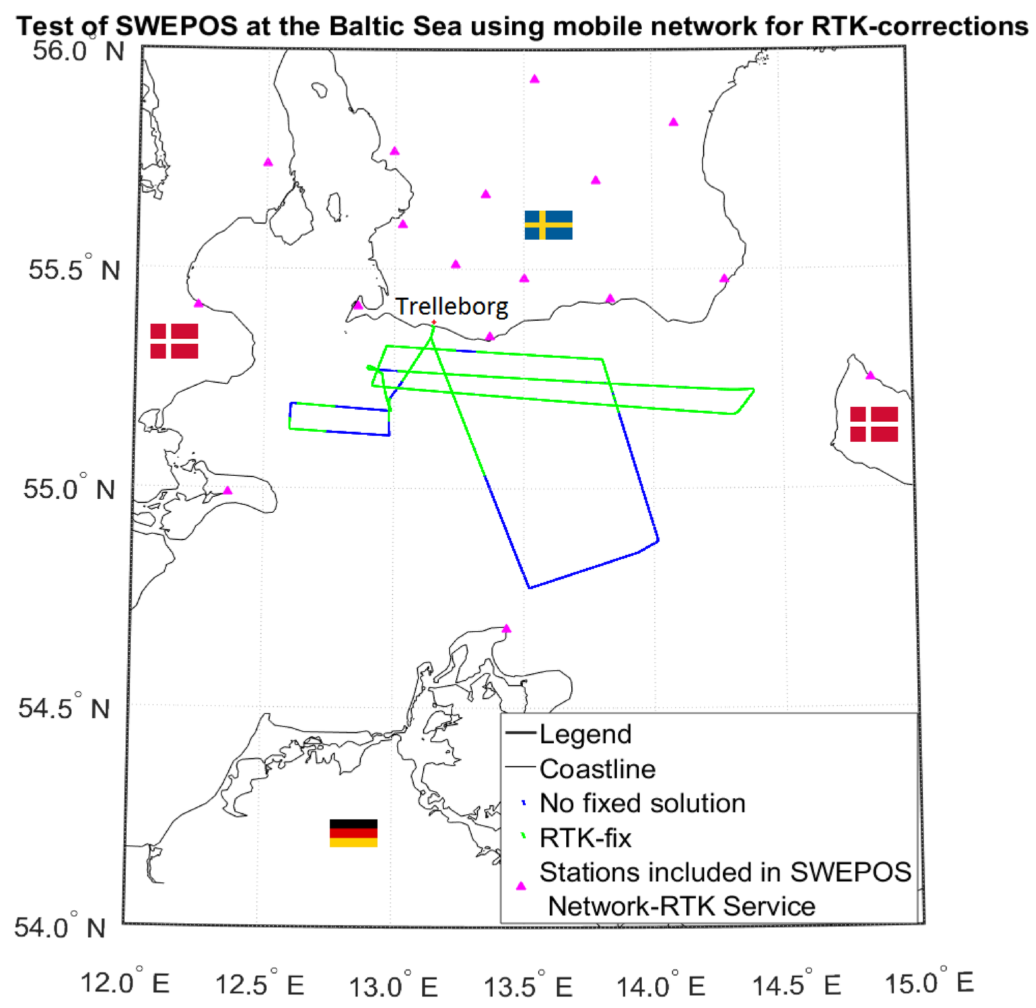

Figure 5: The trajectory of the cruise, with RTK fixed solutions in green, for RTK corrections via Swedish mobile network.

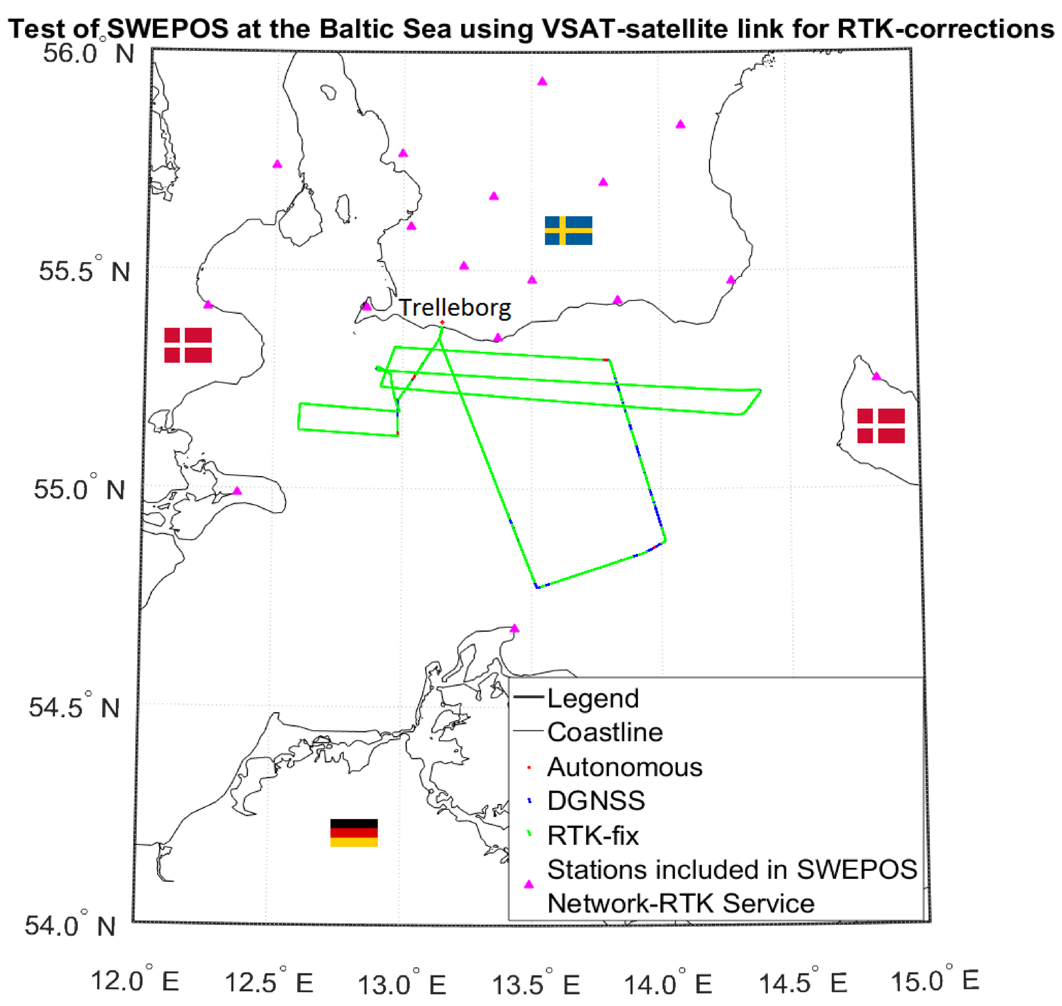

Figure 6: The trajectory of the cruise, with RTK fixed solutions in green, for RTK corrections via VSAT satellite link.

Conclusions and future work

As long as the Internet connection for distribution of the RTK corrections works, navigation with SWEPOS network RTK service should be possible in the southern part of the Baltic Sea where the field experiments was done. Communication with the Swedish mobile network worked most of the time within approximately 30 km from the Swedish coast but lost the connection further away (Figure 5). Communication with the VSAT satellite link worked most of the time in the entire area except for periods when heading north (Figure 6). There was some technical problems with the antenna that receive the VSAT satellite link when heading north. That caused the problems to receive the necessary RTK corrections to get fixed RTK solution. For other parts of the Baltic Sea where the distances between the reference stations will be longer, other campaigns has to be done in order to test if network RTK is a possible solution or if PPP is a more reliable navigation tool in such areas of the Baltic Sea. Evaluation of the quality of the fixed solutions could be done through comparisons of the real time coordinates with post processed ones. Also comparisons with BKG:s PPP and SAPOS solutions is planned within the project.

References

Johansson, J., et al., 2016, CLOSE-RTK 3b, WP3 – New Services,
From the Draft, Report not published yet.

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