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NATIONAL REPORT

National Report of Sweden to the EUREF 2022 Symposium

– Geodetic Activities at Lantmäteriet

1. Introduction

Lantmäteriet, the Swedish mapping, cadastral and land registration authority, is responsible for the national geodetic infrastructure. The geodetic work is based on the geodetic strategic plan (Lantmäteriet, 2018) and some of the main activities in the field of geodetic reference frames are

- the operation, development and services of SWEPOS™, the Swedish national network of permanent reference stations for GNSS
- contributions of SWEPOS data to international initiatives such as EPN, EPOS and IGS as well as international analyses of GNSS data
- the implementation and sustainability of the Swedish national reference frame SWEREF 99 and the national height system RH 2000 (ETRS89 and EVRS realisations respectively)
- improvements of Swedish geoid models.

2. Contributions from Lantmäteriet to EPN

The number of SWEPOS stations included in EPN is 27. Seven of the original SWEPOS stations have been included since the very beginning of EPN. These stations are Onsala, Mårtsbo, Visby, Borås, Skellefteå, Vilhelmina and Kiruna (ONSA, MAR6, VIS0, SPT0, SKE0, VIL0 and KIR0). The other 20 stations are represented by an additional monument located at the original SWEPOS stations. Daily and hourly data are delivered for all stations, while real-time data are delivered from nine stations. One additional station – the additional monument at the SWEPOS station in Borås – has recently been proposed to the EPN but is not yet included.

Lantmäteriet operates the NKG EPN AC on behalf of the Nordic Geodetic Commission (NKG). The NKG AC contributes with weekly and daily solutions, since November 2019 based on CODE rapid products, using the Bernese GNSS Software. The EPN sub-network processed by the NKG AC consists of 105 reference stations (May 2022) concentrated to northern Europe.

3. EPN Related GNSS Analysis

The NKG GNSS AC is chaired by Lantmäteriet (Lahtinen et al., 2018). The project aims at a dense velocity field in the Nordic and Baltic area. Consistent and combined solutions are produced based on national processing using the Bernese GNSS Software version 5.2, following the EPN analysis guidelines. A second reprocessing of the full NKG network including all Nordic and Baltic countries is under planning and will be consistent with EPN Repro3. The weekly solutions from the earlier reprocessing (Lahtinen et al., 2019) and the continued operational solutions contribute to the EPN densification project on a regular basis.

Lantmäteriet is one of the analysis centres in E-GVAP, as the Nordic GNSS Analysis Centre (NGAA), and undertook the data processing for approximately 750 GNSS stations mainly in Sweden, Finland, Norway, Denmark (Lindskog et al., 2017). Two near real-time (NRT) ZTD products, i.e. NGA1 and NGA2, are currently provided. Both products are obtained from the Bernese GNSS Software ver. 5.2 using a network solution. The NGA1 product is updated every hour while the NGA2 product is updated every 15 minutes. Due to the limited access to real-time data, the NGA2 product is currently only provided for all Swedish stations. We are planning to add some Norwegian and Finnish stations to the NGA2 product using real-time GNSS data streams from the EPN.

4. SWEPOS – the National Network of Permanent Reference Stations for GNSS

SWEPOS is the Swedish national network of permanent GNSS stations operated by Lantmäteriet; see the SWEPOS website, https://www.swepos.se.

The purposes of SWEPOS are

- providing single- and dual-frequency data for relative GNSS measurements
- providing DGNSS corrections and RTK data for distribution to real-time users
- acting as the continuously monitored foundation of SWEREF 99
- providing data for geophysical research and for meteorological applications
- monitoring the integrity of the GNSS systems.

By May 2022 SWEPOS consisted of totally 459 stations, of which 53 are of a higher class, the so-called class A, and the remaining 406 stations are of class B, see Figure 1. This means that one class A station has been decommissioned and one class B station has been established since the EUREF Symposium in 2021.

Figure 1: Sveg is one of the SWEPOS class A stations. It has an old monument (established in 1993) as well as an additional monument (2011). Right: Gustavsberg is a SWEPOS class B station with a roof mounted GNSS antenna established mainly for network RTK purposes.

The class A stations are monumented on bedrock and have redundant equipment for GNSS observations, communications, power supply etc. Class B stations are mainly established on top of buildings for network RTK purposes. They have the same instrumentation as the class A stations (dual-frequency multi-GNSS receivers with choke ring antennas), but with somewhat less redundancy.

Five of the original 21 SWEPOS stations (Onsala, Mårtsbo, Visby, Borås and Kiruna) are included in the IGS network, as well as three of the additional monuments with newer steel grid masts (ONS1, MAR7 and KIR8).

5. SWEPOS Services

SWEPOS provides real-time services of metre level uncertainty (DGNSS) and centimetre level uncertainty (Network RTK), as well as data for post-processing in RINEX format. An automated post-processing service, based on the Bernese GNSS Software, is also available.

Good coverage of the Network RTK service has been obtained in border areas and along the coasts through exchange of data from permanent GNSS stations between the Nordic countries. Several stations from SATREF in Norway and the Danish Agency for Data Supply and Efficiency are included in the service together with stations from private operators in Norway, Denmark, and Finland as well as Sweden.

The Network RTK service has, in May 2022, approximately 8100 subscriptions, which means some 800 additional users since the EUREF Symposium in 2021. Lantmäteriet also has cooperation agreements with seven international GNSS service providers using data from SWEPOS stations for their services. This is done to increase the use of SWEPOS data as well as optimising the benefits of the geodetic infrastructure.

The real-time services utilise Trimble Pivot Platform GNSS Infrastructure Software and are operating in virtual reference station mode. The Network RTK service distributes data for GPS, Glonass and Galileo as well as GPS

L5 and L2C signals using RTCM MSM. The plan is to include BeiDou during 2022.

To meet the demands for uninterrupted availability of the real-time services, from current as well as future user groups, a redundant server infrastructure in a separate physical location – a so-called High Availability solution – was established in late 2020. This solution will protect against e.g. loss of electricity or Internet connectivity. It will also facilitate system maintenance since all traffic can be redirected to the other location while e.g. updating is done.

5.1 Near Real-Time Data Processing

In December 2021, Lantmäteriet started to produce a new coordinate solution for the SWEPOS stations, given by a Near Real-Time (NRT) GNSS data processing. The main objective of the NRT data processing is to obtain hourly coordinates for all SWEPOS stations. The coordinates are used as an independent data set for the monitoring of the quality of the reference stations used for e.g. the Network RTK service.

The Bernese GNSS Software version 5.2 is used to acquire ionospheric free linear combination measurements and analyse these in a network solution. We use the ultra-rapid GNSS orbit products provided by CODE. For each hourly data processing, besides the data for the last hour, four more hours' of data are added to the session in order to stabilise the estimation of ambiguity parameters. After the ambiguity resolution step and in the final solution step only the data for the last hour were used.

In the end of each NRT data processing, all estimated hourly coordinates are connected to SWEREF 99. The displacements of the hourly coordinates with respect to the "official" coordinates of the stations are calculated in east, north, and up directions. The displacement information is further distributed to the interface of the SWEPOS monitoring system.

Since the NRT data processing produces solutions for every hour, large variations of the stations can therefore be detected faster than daily and weekly solutions. In addition, the hourly coordinates are also useful to detect and study the variations due to short-lived interferences, e.g., sudden large ionospheric variations, which otherwise will be averaged out by the daily and/or weekly solution.

6. Reference Frame Management – SWEREF 99

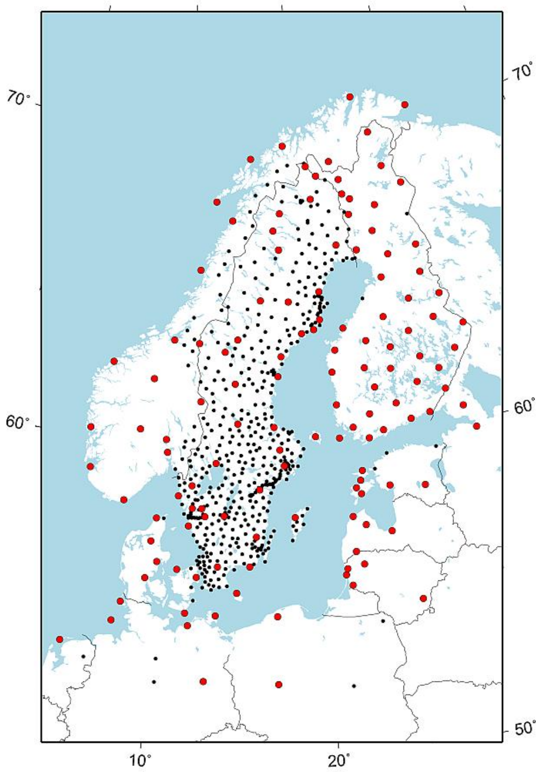
SWEREF 99 was adopted by EUREF as the Swedish realisation of ETRS89 in 2000 (Jivall & Lidberg, 2000) and is used as the national geodetic reference frame since 2007. SWEREF 99 is defined on SWEPOS class A stations (see chapter 4) and equivalent stations in our neighbouring countries.

The coordinates of the SWEPOS stations are regularly updated when necessary, e.g. when GNSS antennas were exchanged and when new antenna models and computation strategies have been introduced.

In addition to this, a review of the frame was undertaken during 2020 and updated coordinates were implemented in the SWEPOS services in the beginning of 2021. The new coordinates are based on GNSS data from the autumn 2019 and the NKG_RF17vel land uplift model.

There are about thirty reference frame defining stations in Sweden and, in addition, approximately 100 stations in our neighbouring countries (Jivall & Lilje, 2021), see Figure 2. The number of foreign defining stations will however decrease with time, since there is no ambition to determine all foreign stations anew when they are altered.

Figure 2: Red dots show the defining stations of the SWEREF 99 update 2021. The other stations in the campaign are shown in black.



By defining SWEREF 99 as an active reference frame we are exposed to rely on the positioning services of SWEPOS, like the Network RTK service. All alterations of equipment and software as well as movements at the reference stations will in the end affect the coordinates. To be able to check all these alterations, approximately 300 nationally distributed passive so-called consolidation points are used. Each year, 50 of them are remeasured with static GNSS following a yearly programme.

A set of transformation parameters between ITRF2014 and SWEREF 99 is available at Lantmäteriet's web site and in the PROJ transformation library, starting from version 7.2.1.

7. Maintenance of the National Levelling Network

The third precise levelling of the mainland of Sweden lasted 1979–2003, resulting in the new national height system RH 2000 in 2005 (Ågren et al., 2007).

Our assessment is that RH 2000 will be the national height system for many years to come and that it will be based on levelling. The reason is that the precision of height determination with GNSS (height above the ellipsoid) is not as accurate as the levelling technique. Therefore, the maintenance of the height control network needs to be continued for the foreseeable future.

Since the beginning of the 1990s, a systematic inventory and updating of the network is performed continuously. All benchmarks are visited but since benchmarks founded in bedrock and nodal points are more valuable for the perseverance of the network, destroyed points are replaced according to specific criteria. This approach ensures that a sufficient number of destroyed benchmarks are replaced, securing the sustainability of the network and at the same time keeping costs down.

When new height benchmarks are demarcated to replace destroyed bench-marks, the levelling of them is done through procurement procedures, which is also the situation for the re-measurements of the 300 consolidation points described in chapter 6.

8. Geoid Determination

According to Lantmäteriet's strategic plan (Lantmäteriet, 2018), an important goal is to compute a seamless geoid model of high accuracy that fulfils the needs of users both on land and at sea. The current Swedish national geoid model is SWEN17_RH2000, which has been computed by combining the Nordic NKG2015 gravimetric model with Swedish GNSS/levelling data. Many activities are going on to realise improve the Swedish geoid model. A new gravity reference system/frame RG 2000 was finalised in 2019 (see chapter 9). New Swedish detail gravity observations are continuously being collected using Scintrex CG5 with the purpose to fill gaps or replace old data of lower quality.

At the same time, much work is spent on the common BSCD2000 (Baltic Sea Chart Datum 2000) in the Baltic Sea (Schwabe et al., 2020). This will improve navigation and hydrographic surveying with GNSS-based methods and geoid model in the Baltic Sea. A crucial activity to reach this goal has been to improve the gravity data in the Baltic Sea, which has been done in the FAMOS project. The FAMOS geoid will realise BSCD2000 in the Baltic Sea and connect to the national EVRS realisations on land. The FAMOS (finalisation) work is made under the umbrella of the Chart Datum Working Group of the Baltic Sea Hydrographic Commission.

During 2019–2020, eight large dedicated marine campaigns were observed with Lantmäteriet's ZLS marine gravimeter. Gravity data were then delivered to the FAMOS database together with all data collected by the other participating countries/organizations around the Baltic Sea. During 2021, Lantmäteriet computed a so-called FAMOS interim geoid model based on the latest version of the FAMOS gravity database, which was then submitted to the project. The final FAMOS geoid model is expected to be finalised and released during 2023.

In the last years, much work has been spent on improving and densifying the Swedish national GNSS/levelling dataset. The number of stations will increase from 185 to around 300 in 2023. The core of the new, updated dataset is the so-called SWEREF GNSS stations for which accurate levelled heights are available in RH 2000. A majority of these SWEREF points are consolidation points that are redetermined every six years (see chapter 6). This makes it possible to detect and remove unstable points. Since 2019, the levelled normal heights of the GNSS/levelling points are also checked by re-levelling relative to benchmarks in the national precise levelling network. During 2021, 24 points were checked.

The Swedish national GNSS/levelling dataset consisting of 185 stations were delivered in 2022 to the EUREF working group "European Unified Height Reference" and the ongoing work with the European Height Reference Surface, EHRS.

In 2020, an industrial PhD student was initiated at the University of Gävle in cooperation with Lantmäteriet. The main aim of this PhD project is to develop and investigate different methods for regional realisation of the International Height Reference System (IHRS) in Sweden and the Nordic/ Baltic countries.

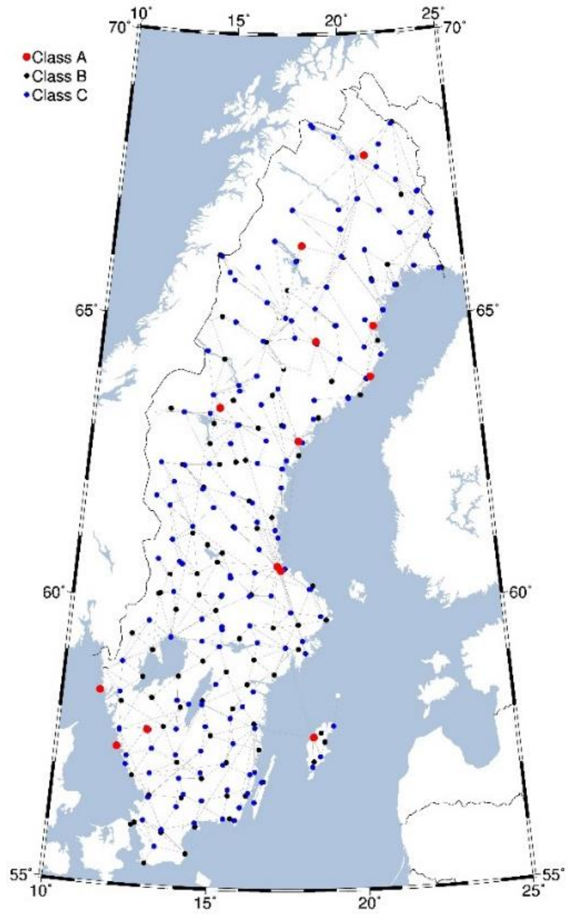
9. Gravity Activities

In Sweden 13 stations are revisited with Lantmäteriet's absolute gravimeter, FG5X-233, with an interval of approximately one to three years. Since 2007, FGX-233 also regularly participates in local, regional and international AG intercomparisons in order to keep track of possible systematic biases. This year, Lantmäteriet together with Onsala Space Observatory and the Finnish Geospatial Institute are arranging an AG intercomparison at Onsala Space Observatory as a mission from the NKG. The intercomparison goes on between May and July and will gather 16 different instruments.

All Swedish absolute gravity stations for FG5 (also known as Class A points in the Swedish gravity reference frame RG 2000) are co-located with SWEPOS stations. Ratan, Skellefteå, Smögen, Visby and Onsala are co-located with tide gauges. Onsala is also co-located with VLBI telescopes and a superconducting gravimeter, which is annually calibrated with FG5X-233 AG observations.

In the beginning of 2018 the new Swedish gravity reference frame, RG 2000, became official (Engfeldt et al., 2019) and in 2019 another realisation was accomplished (Engfeldt, 2019). The reference level is as obtained by absolute gravity observations according to international standards and conventions. It is a zero permanent tide system in post glacial rebound epoch 2000. RG 2000 is realised by totally 343 points of three different classes; see Figure 3.

Figure 3: Reference points in RG 2000 (class A, B, C).



Since 2021, all Lantmäteriet's detail gravity observations have got a gravity value in RG 2000, no matter of which origin the observations were. The quality of the older detail gravity observations is under investigation and more detail gravity observations will be performed during this year and the upcoming years where it is needed.

10. Geodynamics

Studies of crustal deformation in Fennoscandia by means of continuous GNSS observations have been carried out within the BIFROST effort since more than three decades (Kierulf et al. 2021). The next reprocessing of GNSS data, BIFROST2022, has been initiated which will largely extend the number of stations (500+) and observation time span. This effort is a cooperation of NKG members with Poland. First tentative results are anticipated in 2022. The results will help in the generation of revised land uplift and deformation models for northern and central Europe.

Lantmäteriet is involved in the EUREF effort on obtaining a high-resolution velocity model for Europe and adjacent areas. The first EUREF velocity model was presented at the EUREF Symposium in 2021 (Steffen et al., 2021a) based on a new least-squares collocation method with moving variance and taking plate boundaries into account (Steffen et al. 2022). The densified EPND2150 velocity field (https://epnd.sgo-penc.hu/) will be used now to provide the first official EUREF velocity model EuVeM2022. The corresponding publication is in progress.

The generation of the strain-rate product has become Lantmäteriet's responsibility within EPOS. This project is currently in the sustainability phase (EPOS-SP). The Swedish consortium EPOS-Sweden has now been officially formed and is supported as an infrastructure project by the Swedish Research Council. Lantmäteriet has produced the first strain-rate grid for Europe (Lantmäteriet, 2021) which can be downloaded from the product portal at https://gnssproducts.epos.ubi.pt. An update is planned for this year.

Lantmäteriet further contributes with GIA modelling studies and data in different fields. Latest studies include the potential of relative sea-level data in GIA model improvement (Rosentau et al., 2021), sea-level investigations along German coasts (Dangendorf et al., 2022; Kelln et al., 2022) and synthetic results on GIA-induced stress evolution and its impact on fault reactivation (Steffen and Steffen, 2021). GIA model data are available as velocity fields and geoid change from spherical, radially homogenous, compressible earth model with commonly used ice models (Steffen, 2021) and the uplift and geoid change from a spherical, radially homogeneous, material-compressible earth model with a new global ice model assembled from regional ice models (Steffen et al., 2021b).

11. Geodetic SAR and InSAR

During 2019–2021 Lantmäteriet participated in the ESA founded project Geodetic SAR for Baltic Height System Unification, led by the Technical University of Munich (Gruber et al., 2020). The main goal of the project was to investigate the possibility to connect tide gauges and national height systems around the Baltic Sea by means of absolute positioning by SAR, using active transponders. Three active transponders were installed in Sweden at the SWEPOS stations Mårtsbo, Kobben and Vinberget and they are now fully operational. Lantmäteriet also contributed to the project with high resolution geoid modelling at tide gauges and also contributed to the final report of the project, which is available from the project website https://eo4society.esa.int/projects/sar-hsu, and also contributed to a journal article which includes the results of the project (Gruber et al., 2022).

Another InSAR related project is the introduction of a nationwide ground motion service (GMS) for Sweden (2020–2022). This project is coordinated by the Swedish National Space Agency and the first product which is the result of processing of 6 years Sentinel-1 data (2015–2021) over Sweden and is now publicly available via the web-based service at https://insar.rymdstyrelsen.se. The nation-wide GMS visualises the localisation of deformation in different parts of Sweden and includes the time series of displacements for ~1.5 billion measurement points. Within this project as well as afterwards, the geodetic infrastructure in Sweden will be complemented with at least 20 passive corner reflectors, co-located with SWEPOS stations. So far, four passive corner reflectors have been installed in Onsala space observatory, Mårtsbo observatory and Norrköping airport (see Figure 4) and some field tests have been carried out in these locations and in Visby (where we set up two corner reflectors which will be installed after multipath analysis). Lantmäteriet will also participate in an activity related to atmospheric corrections of the signals from the satellites.

Figure 4: Left: The approximate locations of the electronic corner reflectors (ECR) and passive reflectors (CR) which are co-located with permanent GNSS stations (solid red circles). Right: Trihedral triangular passive corner reflector installed in Mårtsbo.

12. Other Activities

12.1 Guidelines for Mapping and Surveying

The regulatory documents for Lantmäteriet states that one of its responsibilities is to contribute to efficient and standardised surveying and mapping in Sweden. One of the means to accomplish this is through a series of best-practice guidelines called HMK (a Swedish acronym roughly translated as "Guidelines for mapping and surveying").

HMK covers a wide variety of methods for geodata capture (e.g. laser scanning, aerial photography, geodetic surveying), and includes recommendations for professional surveyors as well as potential clients that need to specify such services.

The HMK guidelines are reviewed by a stakeholder reference group on an annual basis and are published as new versions in case of major revisions. New guidelines published during 2021 included

- geodetic infrastructure in Sweden
- control surveying
- terrestrial detail surveying
- GNSS/RTK detail surveying.

The HMK guidelines are published online at https://www.lantmateriet.se/hmk, free of charge. The guidelines are also supplemented by online self-study courses and technical literature that cover topics related to HMK more in-depth.

12.2 Review of the National Boundary with Norway

The national boundaries with Finland and Norway are reviewed approximately every 25 years, as bilateral cooperation. During 2020–2024, the boundary with Norway will be reviewed. The Swedish Government has appointed a so-called border commission at Lantmäteriet for the review, and the task is performed in cooperation with Kartverket, the Norwegian Mapping Agency. During this review, Sweden is responsible for the northern part of the border and Norway is responsible for the southern part.

The purpose is to get an updated documentation of the boundary and its demarcation. Border markers will be restored, their positions determined with high quality, and the border line will be cleared from trees and shrubs.

The result after successful field work in 2021 is 200 completed and restored border markers with high-quality coordinates, as well as 60 km of marked and cleared border line. This corresponds to approximately 45 % of the total amount of field work.

During 2022, 25 persons will be involved in the field work along the border; 10 of them full time from May to September. The plan is to complete another 40-45 % of the restoration and coordinate determination work, so that 2023-2024 primarily can be devoted to completion and documentation. However, since the field work is carried out in demanding mountain terrain far from civilisation, planning is always dependent on the constantly changing weather.

12.3 “Reference Network in the Air”

The project “Reference Network in the Air” (in Swedish: Stomnät i luften 2.0) is a research and innovation project initiated by the Swedish Transport Administration and is based on earlier research concerning positioning systems for large-scale construction projects (Trafikverket, 2011). The aim of this project is, through 13 sub-activities, to secure that the Swedish Transport Administration uses a modern, robust and future-proof geodetic infrastructure for positioning based on GNSS technique.

Lantmäteriet is, together with the KTH Royal Institute of Technology and RISE Research Institutes of Sweden, a major partner of this project and involved in most of the activities. The Swedish Transport Administration is also contributing.

The project started in 2019 and runs until the end of this year.

12.4 Monitoring of EGNOS

Lantmäteriet is one of the partners in the EGNOS Service Performance Monitoring Support (SPMS) project and participates in the work package of local position performance assessment. Lantmäteriet's objective is to monitor the position obtained by SWEPOS class A stations in Överkalix and Visby using EGNOS corrections. The safety of life analysis of the data is done by Lantmäteriet. At the end of each quarter, we perform the following tasks:

- Daily monitoring and assessment of the availability of the data and the processing.
- Quality check and analysis of the results.
- Prepare quarterly reports.

12.5 The PNK4TUM Project

PNK4UTM – Positioning, Navigation, and Communication for Unmanned Aerial Traffic Management – project is an R&D project funded by the Swedish Transport Administration. The project started in April 2020 and runs until November 2024. The purpose of this project is to analyse, plan and implement the required infrastructure to prepare technology, processes and business development in the field of UAVs (Unmanned Aerial Vehicles).

The long-term purpose is to significantly improve the functionality of the cellphone network and positioning services (as the SWEPOS services) to perform the long-term implementation of unmanned aerial traffic management.

Lantmäteriet/SWEPOS intends, together with Ericsson, to develop and provide network RTK corrections to drones in an efficient manner via the 3GPP format. There is also an interest in looking at alternative positioning methods such as PPP or PPP-RTK.

The main partners in the project are RISE, Ericsson, Lantmäteriet, Telia, T2data, UMS Skeldar, Västervik municipality and Linköping University.

12.6 Prepare Ships

Prepare Ships is a Horizon 2020 project funded by the European Union with participating partnership organizations from Sweden, Germany, and Norway. The aim of the project is to develop a decision support system for secure ship navigation by dynamic prediction of ship movements and sharing of such information ship-to-ship and ship-to-shore. This kind of system has several benefits including provision of secure navigation in form of fairway navigation and collision avoidance decision support, together with reduced emissions into the environment. The proposed system design incorporates several different techniques, like machine learning for dynamic predictions, resilient and precise EGNSS positioning with sensor fusion, and additionally employs a variety of transmission techniques and protocols.

Lantmäteriet's part in the project is to provide GNSS positioning support in form of network RTK corrections for precise centimetre-level positioning and resilient positioning by providing additional integrity information together with the correction data. Corrections will be provided from fixed VRS points along the coastline to ensure scalability with a potentially large number of future users. On Lantmäteriet's part, the main challenges lie in establishment of new GNSS reference stations, adaptation of correction data to comply with bandwidth limitations related to the dissemination channels unique to maritime applications, and development of integrity estimation and integrity messages for dissemination to the end-user.

Some initial testing of the developed system was performed in September 2021 in the Gothenburg archipelago. The final test and demonstration of the complete system took place in the Gothenburg archipelago in March 2022.

The Prepare Ships project started in December 2020 and ended with the final seminar in May 2022.

12.7 DINPAS

DINPAS – Digital Infrastructure Enabling Accurate Positioning for Autonomous Systems – is an R&D project funded by Vinnova, Sweden's innovation agency. The aim of the DINPAS project is to evaluate the requirements of future autonomous airports in terms of reliable, precise positioning as well as scalability to large numbers of devices, to benefit the next generation of industrial digital solutions. The targeted implementation, including software for generating corrections, 3GPP-based delivery, and navigation device, will be used for evaluating relevant performance.

Lantmäteriet's contribution to the project comprises implementing a new software for generation of GNSS corrections based on the State Space Representation (SSR) technique. The SSR corrections will be based on data from the SWEPOS stations, and different configurations of reference stations as input for generation of corrections will be evaluated during the project. GNSS positioning based on SSR corrections will then be compared to positioning using corrections based on Observation Space Representation (OSR) technique which are used in the ordinary SWEPOS network RTK service.

The project started in October 2021 and will run until September 2023. Involved partners are RISE, AstaZero, Combitech, Ericsson, IBG, Katla Aero, Lantmäteriet, Telia and u-blox.

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Acronyms and Abbreviations

Table 1: Explanations of acronyms and abbreviations used in the report, in alphabetical order.

Acronym or abbreviation	Explanation
3GPP	3rd Generation Partnership Project
AC	Analysis Centre
AG	Absolute Gravity
BIFROST	Baseline Inferences for Fennoscandian Rebound Observations Sea level and Tectonics
BSCD	Baltic Sea Chart Datum
CODE	Centre for Orbit Determination in Europe
CR	Corner Reflector
DGNSS	Differential GNSS
ECR	Electronic Corner Reflector
E-GVAP	The EUMETNET GNSS water vapour programme
EGNOS	European Geostationary Navigation Overlay Service
EGNSS	European GNSS
EHRS	European Height Reference Surface
EPN	EUREF Permanent GNSS Network
EPOS	European Plate Observing System
ETRS	European Terrestrial Reference System
EU	European Union
EVRS	European Vertical Reference System
FAMOS	Finalising Surveys for the Baltic Motorways of the Sea
GIA	Glacial Isostatic Adjustment
GMS	Ground Motion Service
GNSS	Global Navigation Satellite Systems
HMK	Guidelines for mapping and surveying (Handbok i mät- och kartfrågor).
IGS	International GNSS Service

Acronym or abbreviation	Explanation
IHRS	International Height Reference System
InSAR	Interferometric Synthetic Aperture Radar
ITRF	International Terrestrial Reference Frame
MSM	Multiple Signal Message
NKG	Nordic Geodetic Commission (Nordiska kommissionen för geodesi)
NRT	Near Real-Time
OSR	Observation State Representation
PNK4UTM	Positioning, Navigation, and Communication for Unmanned aerial Traffic Management
PPP	Precise Point Positioning
R&D	Research and Development
RINEX	Receiver Independent Exchange format
RISE	Research Institutes of Sweden
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-Time Kinematic
SAR	Synthetic Aperture Radar
SPMS	Service Performance Monitoring Support
SSR	State Space Representation
UAV	Unmanned Aerial Vehicle
VLBI	Very Long Baseline Interferometry
VRS	Virtual Reference Station
ZTD	Zenith Total Delay