

Lantmäteriet's Strategy for Geodesy 2026–2035



LANTMÄTERIET



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Foreword

One of Lantmäteriet's instructions is to meet society's need for a coherent and sustainable geodetic infrastructure and to ensure that it is easily accessible and usable.

But what is geodesy, and why is it important?

Many people are aware that geospatial information is essential in a modern society, for instance in spatial planning, construction, transport, mobile applications, agriculture and forestry, climate research, and total defence. However, it is less well known that society depends on geodesy to produce and make use of geospatial information in efficient and reliable ways.

Geodetic reference systems and frames make it possible to accurately describe positions on the Earth's surface using coordinates and heights above sea level. In addition, geodetic reference networks, with physical markers as well as services, are required to make these reference frames easily accessible to various stakeholders and their needs.

Lantmäteriet ensures that a well-functioning geodetic infrastructure is available at the national

level. In addition to reference networks and reference frames, this includes user support, research, collaboration, standardisation, and technological development that contributes to making the infrastructure user-friendly, efficient, and sustainable over time.

This geodetic strategy provides a comprehensive description of the planned direction for geodesy at Lantmäteriet up to 2035. The strategy presents the role and value of geodesy in society today and highlights the trends and challenges that will likely shape the situation ten years from now.

In particular, the strategy addresses important choices and priorities required for Lantmäteriet's Geodesy Department to continue meeting society's needs in the future. It will guide continued management and development of the national geodetic infrastructure and the provision of geodetic reference frames to society.

Summary

The geodetic infrastructure consists of reference frames, reference networks, and services that make it possible to determine positions on the Earth unambiguously. It enables accurate positioning, navigation, and efficient geospatial information management in areas such as spatial development, climate and environmental work, and total defence. Lantmäteriet holds the national responsibility for providing, managing, and developing this infrastructure.

The Strategy for Geodesy for 2026–2035 describes how Lantmäteriet will meet future needs in the current time of rapid technological development, increased use of GNSS-based positioning, and growing demands for robustness. The starting point is that the current geodetic infrastructure largely fulfils the needs, but management and development is required to ensure long-term reliability.

A central strategic decision is to retain the national reference frames SWEREF 99 and RH 2000 throughout the strategy period. They are considered to be of sufficient quality and are currently used for geospatial information across the whole society. Lantmäteriet will consequently invest resources in improving geoid and land uplift models to ensure the long-term usability of the reference frames. At the same time, it is important to develop high-quality coordinate transformations to international reference frames to meet the needs of users working in global frames.

SWEPOS, the national network of permanent reference stations for GNSS, Global Navigation Satellite Systems, will continue to be a cornerstone of the infrastructure.

Lantmäteriet will continue to operate and develop SWEPOS with a focus on quality, interference monitoring, and support for both professional users and mass-market applications. The demand for GNSS-based positioning services, including safety-critical applications, is expected to increase.

Lantmäteriet will raise its level of ambition in gravity measurement and geoid determination during the period. Improved geoid models will provide better height determination with GNSS and enable a future geoid-based national height frame, which is considered likely to become reality around 2045. This requires more extensive gravity data, methodological development, and long-term competence provision.

A clear societal need concerns robustness and preparedness. Increased dependence on satellite positioning and the changed security situation create vulnerabilities that require cooperation with municipalities and other authorities to raise the awareness of alternative geodetic methods. The development of integrity information – meaning that users receive information about the reliability of services – and monitoring of GNSS data in support of safety-critical applications, are also important components.

Finally, the importance of international cooperation and research is emphasised. The national infrastructure forms part of a global geodetic supply chain that is vulnerable and in need of long-term coordination. Lantmäteriet will continue to contribute actively to international organisations, data exchange, and research cooperation, as well as support capacity building within geodesy.





The Geodetic Infrastructure

The national geodetic infrastructure is essential for efficient surveying, mapping and exchange of geospatial information, for example within spatial planning and development. It also contributes to the global geodetic reference frames that are a prerequisite for, among other things, climate research and accurate measurement of sea level worldwide. The infrastructure must also be capable of evolving in phase with new needs, for example as precise GNSS-based positioning becomes increasingly integrated into vehicles, smart devices, and other technologies.

To define the position of points on the Earth's surface, geodetic reference frames are required. These form the backbone of the geodetic infrastructure. In Sweden, the reference frames SWEREF 99 are used for horizontal and three-dimensional coordinates, RH 2000 for heights, and RG 2000 for gravity. The reference frames are complemented by geoid models to convert heights in SWEREF 99 to "heights above sea level" in RH 2000. Long-term management of the reference frames also requires high-quality land uplift models to handle the effects of postglacial land uplift in the Nordic region. In most cases, users do not need to apply land uplift corrections themselves; these are handled automatically within positioning services where required.

Geodetic reference networks are necessary to make the reference frames usable in practice. These networks may be passive or active and consist of points used as starting points for, for example, surveying and mapping. Passive networks consist of physical markers, such as metal bolts fixed in the ground, with precisely determined coordinates. Users visit these points to connect their own measurements. An active network, by contrast, consists of permanent GNSS reference stations that continuously collect data used for various positioning services.

SWEPOS is the national network of permanent reference stations. It forms the basis of SWEREF 99 and is an important means to provide access to the reference frame. Data from SWEPOS are also used for various GNSS-based services. Lantmäteriet's own service, SWEPOS Network RTK, enables real-time positioning in SWEREF 99 and RH 2000 with an uncertainty of a few centimetres. Users can submit their own GNSS measurements for post-processing, and raw data from SWEPOS are also distributed to other GNSS-based services.

The Swedish reference frames are national realisations of international reference systems and frames, and there are dependencies between them.

The national frames are connected to the international frames, which in turn require observations from national reference networks for their realisation. This strong linkage means that developments in Sweden are influenced by international developments.

For accurate positioning and national reference frame management, the global geodetic infrastructure is essential. Without the collection and analysis of globally distributed data, the national geodetic infrastructure cannot be maintained.

The global geodetic supply chain consists of several components. Geodetic observatories and permanent reference stations worldwide observe the movements of the Earth and satellites. Data are collected and quality-controlled at data centres, which also make them available for computation. Analysis centres then process the raw data, resulting in geodetic products such as global reference frames, Earth orientation parameters, and satellite orbits.

All these components are necessary for accurate and reliable satellite services, for example for GNSS-based positioning, timing, and communication.

Another component of the geodetic infrastructure is the InSAR reflectors installed at selected SWEPOS stations. InSAR is a satellite-based radar technique that enables measurement of very small ground movements. The reflectors provide well-defined measurement points with strong signals, and their known positions at SWEPOS stations make it possible to compare InSAR-based ground motion services with velocities determined from GNSS data.

Lantmäteriet's Responsibility

The primary mission of Lantmäteriet's Geodesy Department is to meet society's need for a geodetic infrastructure.

According to the Government's instruction to Lantmäteriet, the authority shall

- promote a coherent national geodetic infrastructure
- be responsible for the national geodetic reference networks
- promote consistency, coordination, and quality within the field of surveying
- conduct research and development within its area of responsibility.

Within its mandate, Lantmäteriet shall also, among other things

- represent Sweden's interests in international cooperation
- cooperate with authorities and organisations in other countries
- provide advice and support.

Lantmäteriet operates and develops the active reference network SWEPOS, which realises SWEREF 99. The authority also manages the passive reference networks that realise RH 2000 and RG 2000, and develops geoid and land uplift models.

To provide society with a reliable and sustainable geodetic infrastructure in accordance with international practice, Lantmäteriet conducts research in areas relevant to its mission. This is made in close cooperation with universities. Lantmäteriet also collaborates with authorities, municipalities, international organisations, and other actors in the sector. The national infrastructure forms part of the global counterpart, and through international engagement Lantmäteriet monitors any developments in order to meet future needs.

In this strategy, user support and various forms of advisory services are also considered part of the geodetic infrastructure. Lantmäteriet provides advice and support in geodesy, primarily through contributions to conferences and seminars, articles in journals, in-house courses, information on Lantmäteriet's website, and – not least – through HMK, Handbook in Surveying and Mapping.

Lantmäteriet also contributes to Swedish international development cooperation. Together with authorities in recipient countries, geodetic infrastructure is built up and developed in several countries around the world.

Contributions from Other Actors

In addition to Lantmäteriet, other actors contribute to the geodetic infrastructure in various ways.

Universities contribute through both education and research. Master's and doctoral programmes with a focus on geodesy are currently (2026) available at KTH – the Royal Institute of Technology in Stockholm, Chalmers University of Technology in Gothenburg, and the University of Gävle. Three-year bachelor programmes are offered, for example, by Karlstad University and the University of Gävle. Academia also contributes to the geodetic infrastructure through research. Lantmäteriet has an established cooperation primarily with Chalmers, KTH, and the University of Gävle.

Onsala Space Observatory, located outside Gothenburg and operated by Chalmers, is a fundamental station in both the global and national geodetic infrastructures. It hosts, among other things, radio telescopes for VLBI, that is, the observation of signals from astronomical radio sources, a GNSS reference station, gravity measurement instruments, and a tide gauge. VLBI is used, for example, to study crustal dynamics and Earth orientation in space. It is also a crucial component in the realisation of the International Terrestrial Reference Frame, ITRF, and a prerequisite for the functioning of GNSS technology.

At the Research Institutes of Sweden, RISE, research and development are conducted related to geodesy, GNSS with applications, and gravity. RISE is the national metrology institute for calibration of physical quantities such as time, frequency, length, and mass.

The Swedish Maritime Administration holds national responsibility for implementing BSCD2000 as the Swedish nautical chart datum. BSCD2000 is the common reference frame for depths in the Baltic Sea. As a geoid-based height frame, it promotes the use of GNSS for accurate marine navigation and hydrographic surveying. BSCD2000 is identical to the national height frames on land around the Baltic Sea. Along the Swedish coast, RH 2000 and BSCD2000 are the same, but BSCD2000 continues offshore using GNSS and a geoid model.

The Swedish Meteorological and Hydrological Institute, SMHI, and the Swedish Maritime Administration share the responsibility for sea level measurements at tide gauges. Along the Swedish coast there are approximately 60 stations, which are also an important part of the geodetic infrastructure. Swedish time series of sea level observations extend up to 250 years, making them among the longest in the world.

The Geological Survey of Sweden, SGU, conducts gravity measurements primarily for geological mapping, but these observations also constitute a valuable complement to Lantmäteriet's gravity measurements for geoid determination.

Sweden's municipalities complement the geodetic infrastructure with local reference networks – geodetic control networks – that densify the national ones. The Swedish Transport Administration also maintains its own control networks along roads and railways.



Societal Needs

Lantmäteriet assesses that the national geodetic infrastructure and reference frames currently meet the needs of most user groups. Significant investments have been made in the geodetic infrastructure over a long period, but it is also important that management and development continue so that the infrastructure provides maximum benefit in the future as well. As improved measurement technologies become widely available and create new opportunities, the geodetic infrastructure must evolve accordingly.

Most users of the geodetic infrastructure will continue to work within the national reference frames as they do today. These users include, for example, cadastral offices, municipal surveying departments, governmental authorities, and private companies in construction, civil engineering, infrastructure, and consultancy.

However, Lantmäteriet anticipates that certain user groups in the future will have a wish to work in global reference frames, also within Sweden. They must therefore have the possibility to easily transform between national and global reference frames with low uncertainty. This requires Lantmäteriet to continue providing high-quality coordinate transformations so that users can work in both national and international reference frames with approximately the same level of uncertainty – a so-called two-frame approach.

Among the applications where users may want to work in international reference frames are mass-mar-

ket and safety-critical GNSS applications, for instance in autonomous vehicles. Meeting their needs also requires the development and standardisation of integrity information for GNSS data. Data integrity refers to ensuring and communicating the reliability, availability, and continuity of data and services.

A typical trend in many applications is that measurement instruments like total stations and GNSS receivers are becoming increasingly intelligent and user-friendly. The work of surveying engineers is facilitated, and large volumes of data can be collected very rapidly through, for example, laser scanning from both static and mobile platforms, such as drones.

Georeferencing – that is, linking collected data to a reference frame – is carried out using GNSS technology in real time or through post-processing, by measuring supplementary ground control or distinct features within the dataset. From point clouds 3D models and drawings can be created – sometimes with the assistance of AI – and data are efficiently shared among stakeholders via cloud-based services. A well-defined connection to the reference frame also increases opportunities to reuse previously collected data, in line with society's expectations for increased digitalisation.

Applications of this kind do not impose new requirements on the geodetic reference frames themselves but may generate new expectations regarding Lantmäteriet's advisory services.



Strategic Positions

The strategic positions outlined below are intended as a basis for decision-making in a number of particularly important matters for Lantmäteriet's Geodesy Department. They will guide most activities of the division throughout the strategy period.

SWEPOS Positioning Services

We will continue to operate and develop SWEPOS, which will continue to be financed through user fees. The objective is to be able to offer, also in 2035, a national GNSS infrastructure with robust delivery of services and raw data to users and other stakeholders.

Precise GNSS positioning is today an established technique within geodetic surveying, machine control in construction, and automated guidance of agricultural machinery. The establishment and development of SWEPOS have been prerequisites for the introduction of efficient measurement methods in Sweden. SWEPOS is now a highly significant component of the national geodetic infrastructure. In addition to its own services for, among other things, precise real-time GNSS positioning, SWEPOS provides raw data to other service providers, international organisations, and research initiatives.

We consider Lantmäteriet to remain the appropriate authority to take responsibility for GNSS raw data as part of the geodetic infrastructure. Demands for raw data will continue to increase during the coming decade, as will the societal benefits derived from these data. The SWEPOS infrastructure and services are managed in a stable and long-term manner, minimising the risk that access to raw data or system operation falls beyond national control or is governed from abroad. Fee-based financing without profit motives enables us to manage the technical and methodological adaptations that will be required up to 2035.

Extensive quality controls of the SWEPOS data ensure service quality. We monitor and analyse the impact on GNSS data from both interference and ionospheric activity, and SWEPOS already contributes to national security efforts. This work will continue throughout the strategy period.

We must maintain a well-functioning dialogue with the users of our data and services. Continued efforts are required to nurture cooperation

and contacts, and to disseminate experience and results to other authorities and user groups.

During the strategy period, we therefore need to

- continuously work to improve the quality of SWEPOS, for example by preventing and addressing issues at reference stations, further developing quality control of GNSS raw data, and enhancing the monitoring of SWEPOS Network RTK
- conduct a renewed study of the impact of various error sources on real-time GNSS measurement results, to support knowledge-based decisions on the development of SWEPOS, and to provide updated guidance for GNSS measurement
- support high-accuracy GNSS for the mass market by delivering SWEPOS GNSS raw data to providers of mass-market services
- follow developments in GNSS and hybrid positioning technologies, for example low Earth orbit positioning satellites, LEO-PNT, which are expected to have significant impact in the coming years
- continue developing our services to meet the needs of both current and new user groups
- continue international collaboration and commitments in research, development, and standardisation.

National Reference Frames

We will retain the current national reference frames SWEREF 99 and RH 2000 throughout the strategy period 2026–2035.

SWEREF 99 and RH 2000 are essential components of the geodetic infrastructure. They were launched in the early 2000s, and it took approximately another 15 years to implement them throughout society for surveying, mapping, and geospatial information management. In particular, the transition from numerous municipal reference frames required substantial resources. As a result, Sweden now has unified geodetic reference frames that comply with international conventions in the horizontal, 3D, and height components. Coherent and sustainable reference frames are, for example, a critical prerequisite for the possibility to use coordinates to define cadastral property boundaries.

Lantmäteriet assesses that SWEREF 99 and RH 2000 remain very robust and accurate reference frames. Through continuous management, SWEREF 99 is expected to remain fit for purpose throughout the

strategy period. The internal uncertainty of stable height benchmarks in RH 2000 also remains sufficiently low. Both frames continue to follow international conventions, and our intention is therefore to retain them during the strategy period. Since all Swedish geospatial information is now expressed in SWEREF 99 and RH 2000, it is advantageous to wait as long as possible before introducing the next generation of reference frames. A change of national reference frame is a major undertaking, as virtually all coordinates and heights in society would need to be replaced.

To enable continued use of RH 2000, we will improve the gravimetric and national geoid models. This will both enhance GNSS-based height determination in RH 2000 and lay the groundwork for replacing RH 2000 with a new geoid-based national height frame with an updated land uplift epoch in approximately 20 years – around 2045. One important factor supporting such a change then is the development of height determination over long distances using optical atomic clocks. Around 2045, it will likely be possible to determine height differences directly with low uncertainty over very long distances, which will necessitate a modern geoid-based national height frame.

The current gravimetric geoid model is not yet sufficiently accurate, which is another reason to retain the levelling-based RH 2000 during the strategy period rather than introducing a new geoid-based frame immediately. We therefore need to improve the gravimetric geoid model and also enhance its fit to SWEREF 99 and RH 2000 by additional GNSS-levelling observations.

One limitation of continuing to use SWEREF 99 and RH 2000 is that their postglacial land uplift epochs are 1999.5 and 2000.0, respectively. This means that they describe how the country was shaped at those times. To avoid problems in long-distance measurements and when interpreting sea levels and water levels in the large lakes, improved land uplift models will be required.

Staying in SWEREF 99 and RH 2000 also requires high-quality transformation parameters to their international counterparts, ITRF and IHRF. An increasing number of users will measure and work in global frames, for example when global positioning services are used in Baltic Sea navigation. They must be able to transform to and from the national reference frames with minimal uncertainty.

During the strategy period, we therefore need to

- maintain and update the height network that realises RH 2000
- continue determining passive control points with GNSS every six years, the so-called consolidation points
- continue land uplift modelling
- inform affected users about how land uplift corrections must be applied in an increasing number of applications, for example when adjusting levelling measurements over long distances or in sea-level projections
- continue developing and providing the best possible transformations between SWEREF 99 and RH 2000 and their international counterparts, ITRF and IHRF, respectively.

Geoid Determination and Gravity Measurements

We will raise the level of ambition for geoid determination and relative gravity measurement to improve both GNSS-based height determination during the strategy period and the gravimetric foundation for the height frame of the future.

Height determination using GNSS is an efficient method for determining heights in RH 2000, for example by using SWEPOS Network RTK together with the national geoid model. If the geoid model can be improved, this type of height determination can be used for significantly more applications, saving time and costs compared with levelling or other conventional surveying methods. Improving the gravimetric geoid model will also strengthen the basis for the next generation national height frame, which is considered likely to be launched around 2045 and which will, with very high probability, be geoid-based.

Lantmäteriet releases new, improved national geoid models approximately every ten years. These are computed by combining GNSS-levelling observations with a gravimetric geoid model developed in international cooperation within the Nordic Geodetic Commission, NKG, based on data from the NKG gravity database. The next model is planned for 2027. Over a period of approximately 20 years, the objective is for the gravimetric geoid model on land to achieve an uncertainty of 5 mm with high reliability.





The increased level of ambition means that during the strategy period we need to:

- Review, update, and complement the Swedish database of detailed gravity data from approximately 5 km to 3 km spacing, and densify Swedish GNSS-levelling data. We also need to participate in the computation of new Nordic gravimetric geoid models based on data from the NKG gravity database and develop new national geoid models.
- Develop improved methods for gravimetric geoid determination and height system realisation, including validation of the uncertainty using independent data

and methods. We also need to investigate the potential of new techniques, such as optical atomic clocks and determination of deflections of the vertical using star cameras.

- Actively contribute to educating the next generation within the fields of geoid and gravity.
- Continue international cooperation, particularly to ensure that the NKG gravity database is maintained and developed.

A Robust Geodetic Infrastructure

We will work to strengthen the robustness of the national geodetic infrastructure. Our own contribution must be robust, and awareness of alternative methods for accessing the geodetic reference frames must be increased. In cooperation with municipalities and other authorities, we will create the conditions necessary to ensure that reference frames remain accessible even in critical situations.

The changed security situation calls for reinforcement of the geodetic infrastructure from a risk and vulnerability perspective. As an authority with specific responsibility for civil preparedness, Lantmäteriet must review its own operations as well as the services it has developed. Services providing access to the reference frames must remain robust and functional during crises and periods of heightened state of alert.

Positioning services based on SWEPOS have for a long time simplified and streamlined access to the reference frames. Historically, municipalities have been responsible for their own local control networks, as have the infrastructure-building authorities. The local geodetic control networks, which have required maintenance and review, have over time been deprioritised, since georeferenced measurements can be made directly using SWEPOS services, especially Network RTK.

From a national perspective, SWEPOS is the most efficient means of accessing the reference frames, and many stakeholders are now highly dependent on it. Lantmäteriet has over many years been working to enhance the operational reliability of SWEPOS, but certain factors are beyond both technical and organisational control.

The changed security situation is already visible in the form of interference operations, for example disruptions to air and maritime navigation caused by GNSS signal interference. Such external influences can degrade GNSS positioning regardless of whether SWEPOS is used, complicating collection of geospatial information, land-based positioning, and geodetic surveying. If satellite positioning cannot be fully relied upon for collecting essential geospatial information, alternative geodetic methods must be available, and users must have the competence to use them.

As the authority responsible for the national geodetic reference systems and frames, and with a mandate to promote coordination and quality

in surveying, Lantmäteriet must ensure that the reference frames remain accessible even when national services cannot be maintained. Lantmäteriet possesses knowledge and experience from building the current national geodetic infrastructure.

We plan to develop preparedness and contingency plans for crisis situations in dialogue with municipalities and authorities. The geodetic infrastructure must be adapted to societal needs in both normal and crisis conditions. At national and local levels, methodologies, equipment, and maintenance must be ensured to maintain high-quality surveying and geodetic activities in all circumstances.

Municipal geodetic control networks complement national reference networks and positioning services and contribute to robustness. Their design may need to be adapted to the changed security situation.

To enable users to understand how and with what level of reliability positioning data can be used in, for example, autonomous systems and safety-critical applications, the concept of data integrity for satellite data must be further defined. Today, data integrity is a general concept describing limitations related to uncertainty, availability, and credibility. Standardisation is required to clarify how GNSS data integrity should be expressed, and which parameters should be included. Lantmäteriet must continue contributing to this area, both at a strategic level through standardisation work and as a provider of interference monitoring within the GNSS frequency bands.

We monitor GNSS to support our own services and contribute with the SWEPOS infrastructure to the monitoring of GNSS functionality in Sweden in cooperation with other authorities. This work will continue and remain part of national security efforts.

During the strategy period, we will therefore:

- Engage with municipalities, authorities, and stakeholders to identify needs and develop action plans to ensure long-term access to reference frames, also during crises.
- Contribute to the development of a national strategy for Positioning, Navigation, and Timing, PNT.
- Cooperate with other authorities to assess the need for GNSS frequency monitoring and, where necessary, develop action plans. Quality checks of SWEPOS data already contribute to this type of monitoring.
- Conduct strategic analyses of the need for integrity information and what capabilities SWEPOS can offer to different user groups.
- Further develop quality controls and services to meet future requirements for GNSS integrity information.

The Global Geodetic Supply Chain

During the strategy period, we will actively contribute to strengthening the global geodetic supply chain.

Geodetic measurements in Sweden and the national geodetic infrastructure heavily depend on that GNSS is working. We are thus dependent on the global geodetic supply chain. Without continuous updates of data and products, accurate positioning, time synchronisation, and satellite-based mapping would deteriorate or cease to function.

Historically, development of the supply chain has largely been driven by scientific needs and research. Even so, large parts of society now depend on it. The supply chain must therefore transition to a production-oriented phase, where contributions currently based on voluntary efforts are secured through binding agreements and formal arrangements.

The United Nations has identified vulnerabilities and weaknesses in the global geodetic supply chain that require attention and mitigation. This work builds on a UN resolution emphasising the importance of the global geodetic reference frame for sustainable development and has led, among other outcomes, to the establishment of the United Nations Global Geodetic Centre of Excellence, UN-GGCE. The report *Hidden Risks – How weaknesses in the global geodesy supply chain could have catastrophic impacts on critical infrastructure and national economies* highlights the risks.

Decision-makers often lack sufficient understanding of the importance of the geodetic supply chain. Many components lack formal agreements and rely on voluntary contributions, resulting in weaknesses in coordination and governance.

There is also a clear trend of declining educational capacity in geodesy, mainly in the western part of the world, leading to reduced competence availability. In certain technical domains, infrastructure is outdated and analytical capacity insufficient.

To strengthen the global geodetic supply chain, UN-GGCE has begun working on a Joint Development Plan for Global Geodesy. The aim is to translate the needs of member states into concrete strategic goals and activities. Lantmäteriet, and Sweden as a whole, should follow the recommendations provided by UN-GGCE in its *1st Joint Development Plan for Global Geodesy*.

Lantmäteriet is already engaged in several activities that support the global supply chain. We contribute

with data from the permanent reference stations in the SWEPOS network and perform analyses of GNSS data, among other things. We share data and geodetic products with our partners, including cross-border collaborations. Such data exchanges are crucial for the continuous monitoring of crustal deformations, which is necessary to maintain the sustainability of geodetic reference frames over time. It is also essential that we have highly accurate knowledge of the positions of satellites relative to each other and to the Earth. Information about the positions of the Earth and satellite orbits in space is obtained through products and services provided by the global geodetic supply chain.

Through our collaboration with academia, we contribute with our expertise to higher education programmes in geodesy at universities. We also support initiatives aiming at attracting students so that these programmes can continue to meet the future competence needs of the sector. Additionally, by providing doctoral education for our own staff, we contribute to geodetic research itself.

During the strategy period, we therefore need to:

- Work to enable Onsala Space Observatory to take responsibility for a few more steps in the VLBI analysis chain, particularly addressing bottlenecks in correlation processing. By expanding the observatory's mandate, we strengthen the competitiveness and strategic autonomy of Sweden and the EU, and provide a strategically important contribution to the global geodetic supply chain.
- Improve availability of geodetic data and products according to the FAIR principles – Findable, Accessible, Interoperable, Reusable.
- Support international initiatives aimed at securing production chains through formal agreements.
- Inform decision-makers of the need for long-term funding and agreements within the supply chain.





Strategic Direction for Other Key Areas of Activity

In addition to the strategic positions outlined above, we recognise that there are other areas whose direction also needs to be described, particularly where the nature of the work is expected to change compared with today.

Research

Lantmäteriet has a well-established research culture within geodesy, with long-standing academic cooperation and doctoral training of staff. Research strengthens knowledge on building and using geodetic infrastructure.

We intend to continue research in areas relevant to infrastructure development, including

- GNSS for autonomous systems – adaptation of infrastructure and services to future user groups
- error sources in real-time GNSS surveying – as a contribution to the knowledge base for development of SWEPOS and to provide updated guidance for GNSS surveying
- LEO-PNT, positioning using satellites in low Earth orbit
- quantum gravimetry – next generation of gravimeters providing new opportunities
- chronometric levelling – for accurate height determination over long distances
- land uplift modelling – for handling of deformations in the national geodetic reference frames
- geoid modelling – for more accurate GNSS-based height determination and to provide a foundation for a future geoid-based height frame
- VLBI – for improved realisations of global geodetic reference frames and determination of Earth orientation parameters, which together form the foundation of our national geodetic infrastructure.

Since geodesy, by nature, is a global science and not all research can be conducted in Sweden, participation in international research collaborations is important for several reasons, for example to

- understand trends and identify new development potential
- access research that is not conducted in Sweden
- contribute to international research ourselves, thereby strengthening the global geodetic supply chain
- share data that are necessary for understanding and modelling of cross-border phenomena.

Advisory Services and Cooperation

Through advisory services and collaboration, Lantmäteriet ensures that the geodetic infrastructure is used in an appropriate and efficient manner across the areas of activity and sectors of society where geodetic measurement is a routine requirement. We also support the surveying sector by promoting more harmonised working methods and more reliable quality of geospatial information.

At present, Lantmäteriet provides advice and support in geodesy through collaboration with users, training courses, and handbooks, as well as information published on Lantmäteriet's website. The different forms of advisory support address different needs and target groups. The Handbook in Surveying and Mapping, HMK, plays a particularly important role as a sector-neutral source of knowledge and methodological guidance. HMK is used, for example, in higher education and vocational training, in the procurement of geospatial information, and in the development of guidelines and technical specifications.

Lantmäteriet's collaboration with the surveying sector takes place primarily through joint projects and participation in professional and industry associations. In these contexts, we contribute to the long-term supply of skills within the sector. At the same time, Lantmäteriet is better positioned to monitor developments in the sector, both regarding new technologies and evolving user needs.

During the strategy period, the need for precise geodetic measurements using levelling, total stations and GNSS technology is expected to remain broadly at the same level as before. Such measurements play an important role in spatial planning and construction, as well as in Lantmäteriet's own activities,

for instance in cadastral surveying. Maintaining expertise and other prerequisites for continued advisory support within these technical areas is therefore well justified.

The demands for Lantmäteriet's advisory services in geodesy are driven by, among other factors, new technological platforms, the management of large data volumes, and the need to move seamlessly between different levels of detail and reference frames – from national geospatial information in horizontal and vertical reference frames to local or object-specific CAD and BIM data in three dimensions. This is particularly relevant in the spatial planning and construction processes, which are becoming increasingly digitalised.

We assess that advisory services and support from Lantmäteriet in geodetic matters will be particularly required in relation to coordinate transformations, georeferencing and quality control of various types of geospatial information, and to a greater extent than previously.

The existing HMK framework, consisting of handbooks and training courses, provides a logical platform for advisory services and collaboration in the areas described above. To reach new generations of professionals, the formats for advisory services and collaboration will need to be further developed. During the strategy period, the publication of HMK should transition wholly or partly to a digital platform, including machine-readable formats and services that facilitate users' ability to search for and select supporting information based on their specific needs. These needs – and best practice – are most effectively established through dialogue with current and prospective HMK users.

The purpose of developing advisory services and collaboration is to ensure the continued development, dissemination and anchoring of well-functioning working methods – thereby contributing to increased harmonisation, coordination, and quality within the geospatial information domain.

The Need for International Cooperation

Geodesy is inherently global in nature. Geodetic reference systems and frames are specified, as far as possible, in accordance with common international conventions. This enables national frames to align across national borders and that a common reference level can be used to monitor global sea level change.

It is therefore essential that Sweden contributes to international geodesy through active participa-

tion in international cooperation. This enables us to benefit from expertise in other countries and to remain aligned with ongoing developments. International collaboration is a natural and integral part of Lantmäteriet's geodetic activities.

Our closest cooperation takes place within the Nordic and Baltic region, primarily through NKG. NKG facilitates cooperation on geodetic issues and cross-border data exchange, enabling the participating countries to deliver products of high international standard together. This cooperation is particularly important for studies of postglacial land uplift, the collection and analysis of data for crustal deformation modelling, and the computation of geoid models. It has also contributed to improved geoid models over the Baltic Sea. Through this close cooperation, Nordic and Baltic expertise is utilised as efficiently as possible.

At the European level, Lantmäteriet contributes to the work of EUREF by participating in working groups, carrying out regular data analyses, and providing GNSS data from SWEPOS to the European network of permanent reference stations. EUREF is responsible for the European Terrestrial Reference System ETRS89 and the European Vertical Reference System EVRS, of which the Swedish frames SWEREF 99 and RH 2000 are national realisations. EUREF is a sub-commission of the International Association of Geodesy, IAG.

Lantmäteriet also contributes data and analyses to EPOS, a European research infrastructure that coordinates and provides high-quality, multidisciplinary data and tools for researching the physical processes that shape the Earth.

IAG promotes the development of global geodesy through international cooperation and research. Among its responsibilities, IAG oversees the most accurate global geodetic reference frame, ITRF, to which the European ETRS89 realisations are connected. IAG also contributes to the development of the International Height Reference Frame, IHRF, and the International Terrestrial Gravity Reference System, ITRG. In addition, IAG operates global services that collect, make available and analyse observational data from stations worldwide. These services constitute essential components of the global geodetic infrastructure.

Lantmäteriet actively participates in IAG's sub-commissions and services and provides GNSS data from SWEPOS to the international network of permanent reference stations operated by the International GNSS Service, IGS.



Geodetic work is also carried out within the framework of the United Nations, where Sweden is represented by Lantmäteriet. This work is based on the UN resolution on a Global Geodetic Reference Frame for Sustainable Development.

The considerations outlined above demonstrate that Lantmäteriet must continue – and, where necessary, further develop – its international cooperation throughout the strategy period. This is essential to fulfil our mandate.

Artificial Intelligence and Machine Learning

The development of artificial intelligence, AI, continues, and its use is expected to increase significantly during the strategy period. AI and machine learning are already being used to create new opportunities and improve efficiency. In scientific applications, AI has emerged as a global trend. This presents promising opportunities for geodesy, where research and operational applications are often based on long time series and large volumes of data.

Lantmäteriet is closely monitoring developments in AI and envisages targeted investment in skills development to enable the future use of AI in improving internal information flows and optimising information structures. The objective is to make information more searchable, accessible and reusable. Before being implemented in operational environments and used for efficiency gains, AI applications will need to be developed through structured learning processes and pilot activities.

There is also potential for AI to support the long-term maintenance and development of the national geodetic infrastructure. AI may be used to strengthen quality control processes, automate workflows, integrate datasets and support advanced analyses – for example, to identify the impacts of climate change on geodynamic processes.

Scenario 2035 – A Robust and Well- Functioning Geodetic Infrastructure

By 2035, the geodetic infrastructure is a well-functioning, robust and self-evident part of society's fundamental functions. It is used daily by government agencies, municipalities, businesses, and citizens – often without being noticed – yet it is essential for public authorities and private actors who work every day with geospatial information that can easily be combined, reused and shared.

In practice, this means that the management of reference frames takes place in the background, handled by public authorities, system providers and digital services. SWEREF 99 and RH 2000 continue to be widely used and are regarded as stable and reliable. At the same time, it has become more common for certain applications – for example in maritime navigation, autonomous vehicles and international services – to operate directly in global reference frames. For most users, the distinction is rarely apparent in everyday practice, as transformations between national and global systems are performed automatically and with high accuracy.

SWEPOS continues to constitute a backbone of the geodetic infrastructure. For surveying, construction, agriculture and infrastructure development,

access to accurate real-time positioning is taken for granted. Where services are used in safety-critical contexts, clear information is available regarding quality, availability and limitations. Users are accustomed to taking integrity information into account in their systems and decision-making.

Dependence on satellite-based positioning is actively managed. When disruptions occur, there are established procedures, alternatives and the necessary expertise to address the situation. Municipal control networks, traditional surveying methods and national reference networks are used more consciously as complementary resources.

The geodetic infrastructure is recognised as a resource that must remain available even in times of crisis.

Lantmäteriet is regarded as a stable custodian of the geodetic infrastructure. Changes of reference frames have been avoided, and the quality of existing frames has been progressively improved through enhanced geoid models, land uplift models and well-maintained reference networks. For users, this is reflected in improved accuracy – without requiring changes in established working methods. When discussions arise concerning the next generation of the national height frame, they are conducted with foresight and long-term planning.

Together with other public authorities, Lantmäteriet has established structures for cooperation in positioning, navigation and timing, PNT. Monitoring of GNSS signal interference, quality control processes and the provision of integrity information are established components of the infrastructure, providing decision support for both civilian and security-related applications.

Sweden contributes with knowledge, data and analysis to the global geodetic supply chain, and this is regarded as a natural part of safeguarding the national infrastructure. At the same time, decision-makers have a greater awareness that geodesy is neither cost-free nor self-sustaining but requires long-term commitments and sustained expertise.

Geodetic expertise remains strong, despite international challenges in education and skills provision. This has been made possible through long-term research cooperation, international engagement and a clear sense of national responsibility.

In 2035, the geodetic infrastructure is not characterised by major headlines or disruptive technological shifts, but by predictability, trust and room for manoeuvre. It is an infrastructure that is rarely visible – yet immediately noticed the day it ceases to function.

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