NLS
FINNISH GEOSPATIAL
RESEARCH INSTITUTE
FGI

Research Strategy for the Finnish Geospatial Research Institute 2018–2023

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1 NATIONAL LAND SURVEY OF FINLAND

The over 200-year old national Land Survey of Finland does various kinds of land surveying like parcelling and reallocations of pieces of land, produces map data material and promotes the joint use thereof.

The National Land Survey of Finland safeguards the land ownership and credit system by maintaining information about mortgages and registrations of title to property as well as other property information in its registers. Other central tasks are spatial data research and application as well as data and information system development.

The National Land Survey of Finland has offices in 37 localities across Finland, from Mariehamn to Ivalo. The number of employees totals approximately 1,800. The organisation consists of a central administration and four operations units, which are Production, General Administration, Centre for ICT Services and Finnish Geospatial Research Institute (FGI).

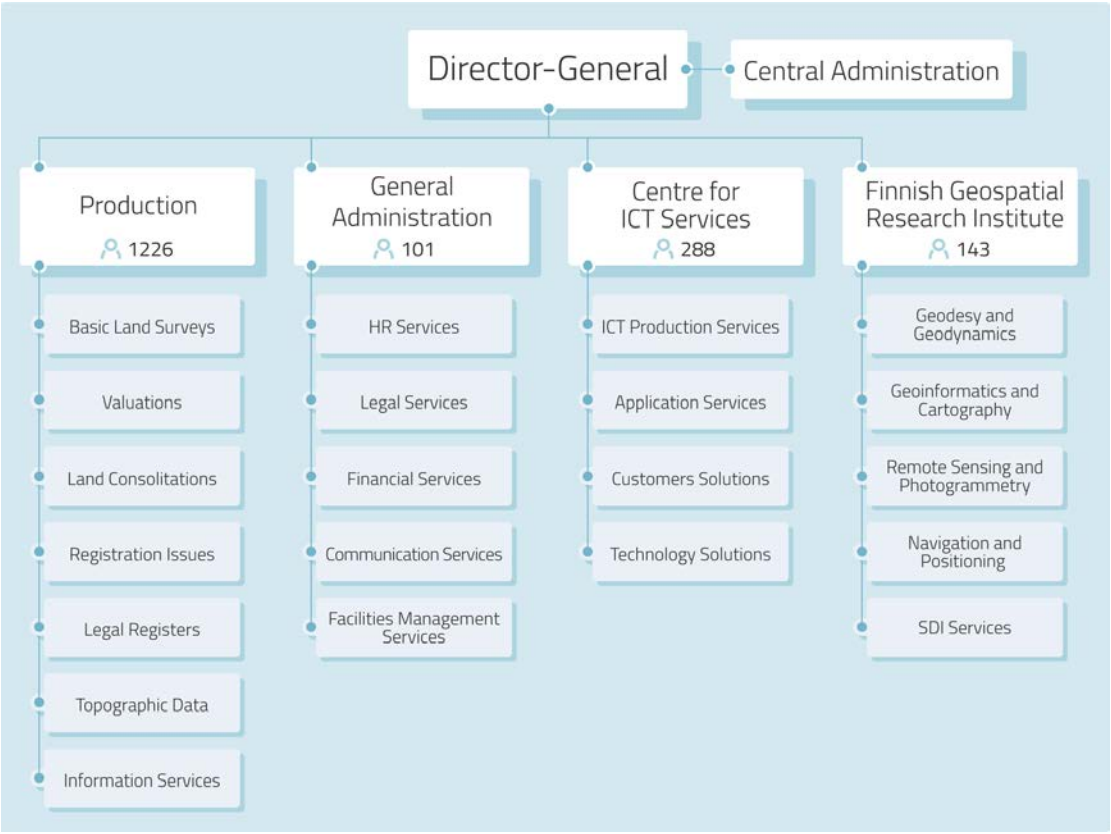

Figure: 1 The organisation of the National Land Survey of Finland

2 THE NATIONAL LAND SURVEY'S STRATEGY

The National Land Survey's new strategy was created in 2014–2015, when the agency reformed its organisation from a regional to a centralised organisation, and the Finnish Geodetic Institute and the ICT development functions of the Information Centre of the Ministry of Agriculture and Forestry were merged with the National Land Survey.

Our new mission at the National Land Survey is Information, services and research about the Earth.

Our vision is to show the way.

The vision consists of four parts:

- We are responsible for the Land Information System and the Topographic Data System.
- We are at the forefront of international spatial data research.
- We offer advanced and customer-oriented e-services.
- Our data enables new growth in society.

The current strategy is shown in brief in Figure 2.

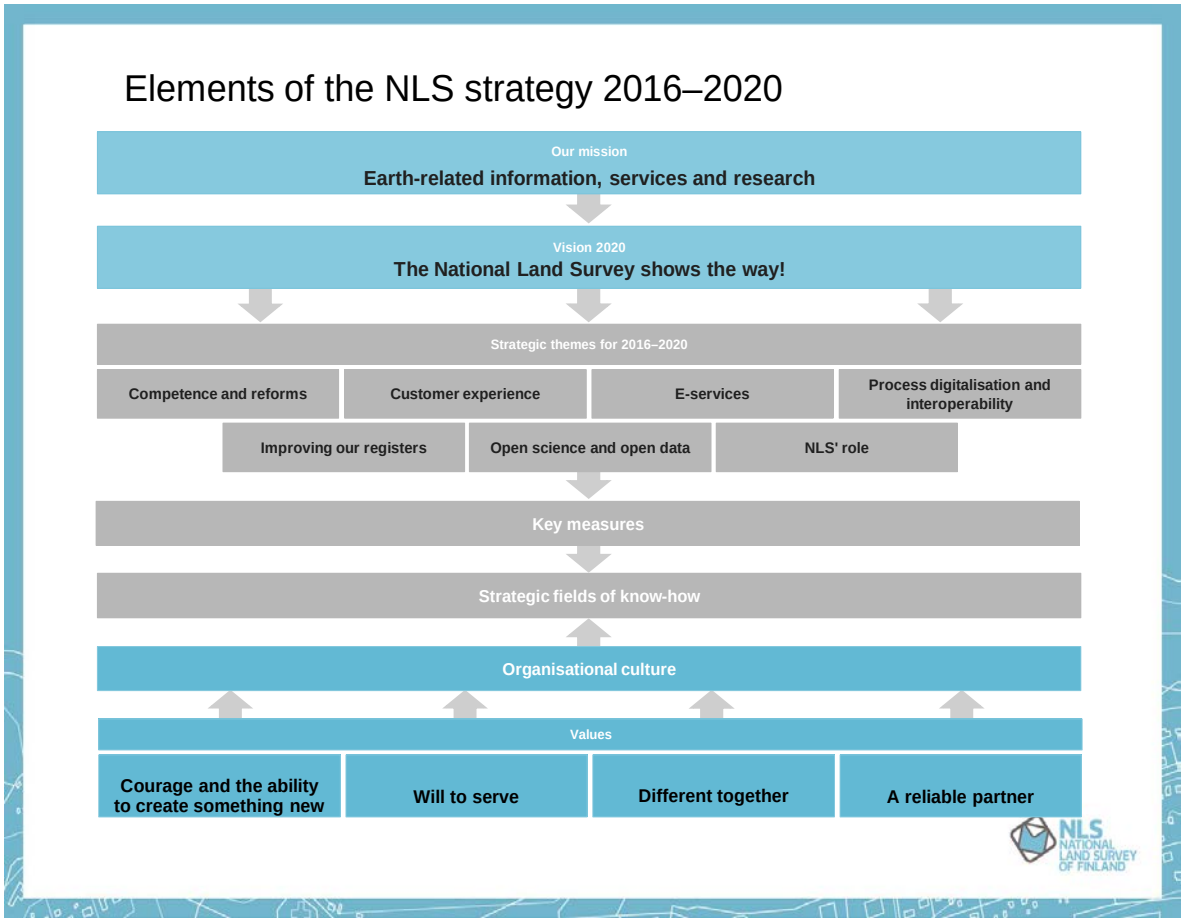

Figure: 2 The National Land Survey's Strategy

The strategic themes for the next five years are described in the strategic roadmap.

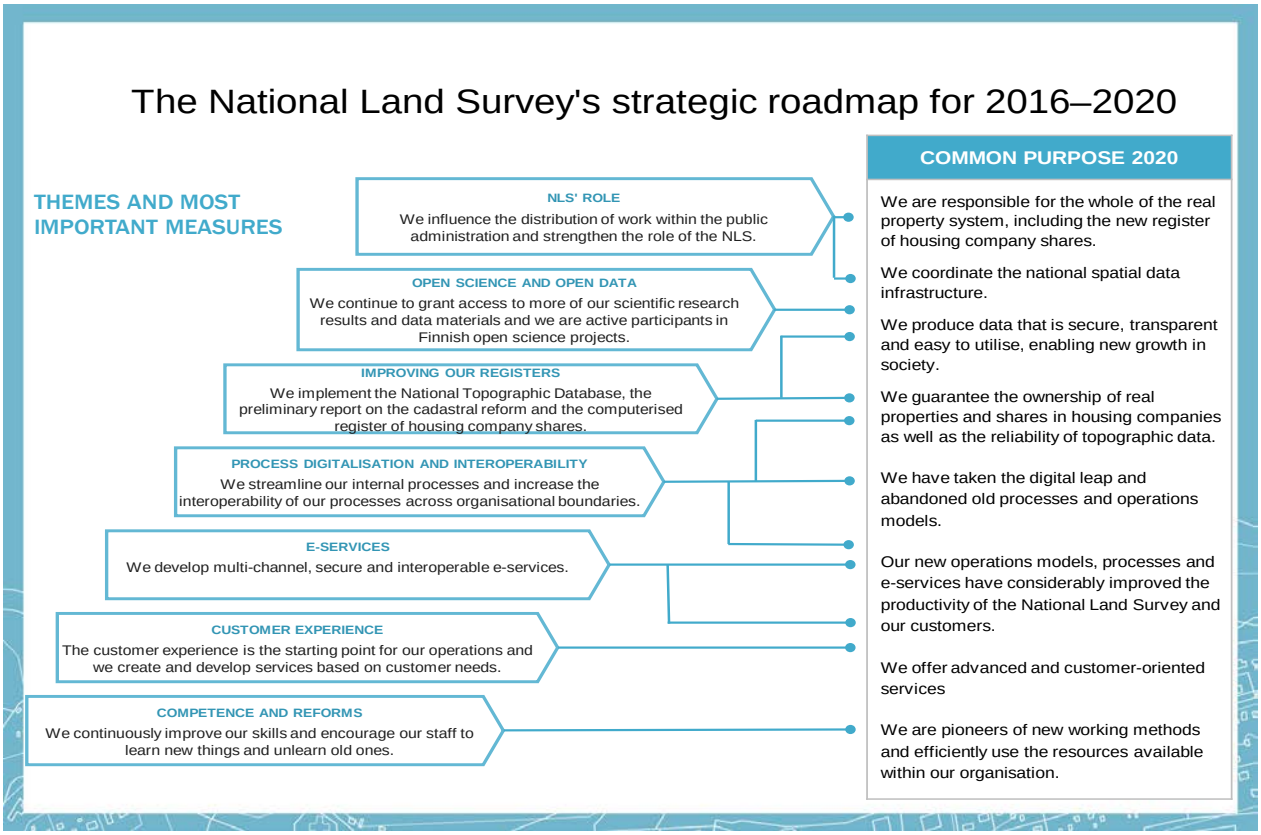

Figure: 3 The National Land Survey's strategic roadmap

3 WHY IS IT NECESSARY TO UPDATE THE FGI RESEARCH STRATEGY?

3.1 Merger with the National Land Survey

At the start of 2015, the Finnish Geodetic Institute was incorporated into the National Land Survey as a part of the government's research institute reform. The researchers of the Geodetic Institute and the National Land Survey's spatial data/INSPIRE group merged and became the new Finnish Geospatial Research Institute FGI. Starting in 2014, representatives of the Geodetic Institute participated in the drafting of the National Land Survey's new strategy. In the National Land Survey's new strategy, research became one of the agency's core processes and the promotion of open and transparent science was set as a strategic goal. Digitalisation and digital services also concern the Finnish Geospatial Research Institute and the spatial data services it provides, such as the geoportal Paikkatietoikkuna and the coordinate transformation service. The FinnRef positioning and navigation services depend largely upon the competence of the Finnish Geospatial Research Institute, although the Centre for ICT Services is responsible for its operations.

3.2 Factors influencing change in the operating environment

Geographic information and the spatial data infrastructure

Digital interfaces that are open to authorities and the public and new implementations and applications have enabled the utilisation of spatial data for various uses. Many countries are developing national programmes for the development of spatial data infrastructures. Global

corporations (e.g. Google, Nokia, and Microsoft) increasingly develop and utilise spatial data technology in their consumer businesses. This increases the renown of the field as well as research and development in it.

Spatial data infrastructure (SDI) has become a crucial tool in promoting the use of spatial data. In Europe, this development is regulated through the INSPIRE Directive and national legislation that is based upon it. In Finland, a spatial data policy report is underway to study the possibilities of creating a more broad-based national spatial data infrastructure. The spatial data infrastructure under development must implement an ever better integration between different operational sectors, machine-readable data and the smooth linking and combination of data in various services. A uniform and open national spatial data infrastructure should lead to considerable savings and productivity improvements in the state government, municipalities and the private sector.

Satellite positioning and geodesy

As the precision and usability of positioning data in satellite navigation systems improve, the importance of satellite-based navigation increases and the market for spatial data grows. The National Land Survey offers an open, corrected satellite positioning signal with a positioning precision of approx. 0.5 m. In Finland, the development of smart traffic infrastructure is based on precise satellite positioning. The prerequisites for it improve following the FinnRef reform, where the network is increased to 50 stations and the coverage extended to sea areas.

Continental drift and land uplift change the absolute locations of control benchmarks by more than 3 cm a year. As observational precision and the demand for accurate observations increase, static coordinate systems are no longer accurate enough. Currently, the location of many features deviates by approx. 80 cm from where they should be according to the official national coordinate system. Research concerning coordinate transformations that are sufficiently precise and work seamlessly across Europe , as well as time-dependent coordinate systems guarantee that systems remain up-to-date and accurate in the future. The research is also connected to the challenges for the near future listed in Geodesy in Finland – Vision and Strategy 2017–2026.

The Metsähovi research station is a part of the Global Geodetic Observing System (GGOS) of permanent geodetic stations. Services that are a part of GGOS continuously collect measurement data to maintain coordinate systems, monitor movements of the Earth's crust, measure the orientation and gravitational field of the Earth, as well as for the functioning of satellite navigation systems. The Metsähovi research station is being developed as a part of the GGOS network, and it is Finland's contribution to the 2015 UN General Assembly resolution on Global Geodetic Reference Frame for Sustainable Development and related infrastructure maintained by UN member states. Metsähovi is also the fundamental station of the national FinnRef positioning network consting of permanent observation stations.

The renewed FinnRef network is a part of the European fundamental network of GNSS stations. Among other things, the network guarantees compliance with the INSPIRE Directive's requirement of compatibility between different countries. Open data provided by the FinnRef network and a soon to be launched support service for positioning and navigation will significantly affect the national spatial data infrastructure. Metsähovi and the FinnRef network are also a part of Finland's contribution to the European Plate Observing System (EPOS) research infrastructure.

Satellite-based gravitational field observation systems are creating ever better prerequisites for monitoring movements of the Earth's crust globally. A significant national project based on this work is the creation of a new gravity system and a more precise geoid model for Finland and the forecasting of changes in sea levels in the Baltic Sea as a consequence of melting glaciers.

Remote sensing

Copernicus of the European Union is an operational system of Earth observation satellites and it aims at creating services related to the environment and security, which utilise satellite observations, modelling and *in situ* measurements. Copernicus offers Finnish research

institutes the opportunity to particiate in the creation of a European environment monitoring system and to utilise the information produced by the system in their operations.

The digital imaging and measurement systems used for collecting spatial data that are mounted on aircraft, satellites, drones and cars are developing rapidly. The new systems are producing more diverse and accurate three-dimensional data. This enables a more precise and faster measurement and an automatic interpretation of objects, as well as a more efficient updating cycle. The opportunities offered by distributed mapping grow significantly in society and ever smaller business can become significant mappers of a particular kind of data. Already, 90% of remote sensing research of the FGI involves research into distributed mapping.

Real property research

A new field of research at FGI is real property research. The focus of this research is on the project Katasteri2035 to study alternatives for a possible future cadastral system in Finland. A crucial part of the investigation stage is to study how systems in other countries are being developed. Another field of study is to investigate, using futures studies methods, what the future operational environment will look like.

3.3 Changes in public administration

Public administration is undergoing significant reforms and centralisation. The trend in government is to centralise services and to break barriers between sectors to save public funds and improve productivity. The aim of the central administration reform is to eliminate barriers between different ministries and to increase cooperation between administrative sectors. The social welfare and healthcare reform and the closely related regional government reform will significantly alter the relationship between state and municipal administration. Its effects on the National Land Survey will only become clear once the reform has been approved. The Finnish Geospatial Research Institute was significantly affected by the research institutes reform, during which research institutes were merged with other organisations. At the same time, more than a fifth of the budget financing of research institutes was cut to form a clearing fund under the aegis of the Strategic Research programme of the Academy of Finland and the Prime Minister's Office. During the research institute reform in 2015, the Finnish Geodetic Institute was merged with the National Land Survey, where it continues its operations as a research unit, the Finnish Geospatial Research Institute (FGI), of the National Land Survey. These were not the last changes in the research field either, changes occur continuously and there is still an aim to create larger research institutes. In addition, the division of labour between universities and research institutes is being clarified and cooperation increased.

The current Policy report on spatial data is going to significantly affect the spatial data field and the National Land Survey. The policy report can enable the construction of a new kind of national spatial data infrastructure and research cooperation, as well as the distribution and maintenance spatial data of a high quality from the public sector.

3.4 The Research Policy of the National Land Survey and Open Access Publishing Policy

In the National Land Survey's Research Policy (MML 2314/00 01 00/2017), approved on 14 June 2017, the general focus areas and principles of the National Land Survey's research and its support functions are described for the next three-year period. It does not address any issues concerning the internal operations and organisation of operation units. The key development areas concerning research at NLS for the period 2017–2019 are:

- Strengthening visibility in and impact on society
- Improving the quality of research
- Increasing the share and quality of EU-funded research projects
- Launching research on land administration and management, property law and real estate economics as part of the scientific research to be conducted at NLS

- Maintaining NLS research fields that have been successful in gaining research funding and investing in key strategic research fields
- Ensuring that research and science are open and ethical
- Effectively utilising the NLS's multidisiplinary expertise in spatial data technology in research and development
- Promoting the career paths and international mobility of research personnel

The National Land Survey's Research Policy provides the common goals of the NLS's research operations. By contrast, the FGI research strategy is focused on the core operative strategies of research.

Maanmittauslaitoksen tieteellisten ja ammatillisten julkaisujen Open Access julkaisupolitiikka (MML 3514/00 01 00/2017) (National Land Survey's Open Access Publishing Policy for scientific and professional publications) was approved on 18 September 2017. The purpose of the publishing policy is to outline the NLS's principles for open access publishing. The number of publications written by National Land Survey employees is a part of NLS's overall efficiency. Open access increases the impact of scientific and professional publications and therefore it is also extremely important for FGI.

4 CORE TASK 2018–2023

The Act on the National Land Survey of Finland (900/2013) requires the agency to perform the following tasks related to spatial data and which are the responsibility of FGI:

- FGI engages in scientific research in the fields of geodesy, positioning, navigation, geoinformatics, cartography, spatial data technology, photogrammetry, laser scanning and remote sensing;
- FGI sees to the geodetic and photogrammetric metrology and metrology related to laser scanning and other spatial data metrology;
- FGI carries out the national geodetic basic measurements, maintains the standards for geodetic and photogrammetric measurements and acts as the National Standards Laboratory for length and acceleration of free fall;
- FGI develops and tests methods and equipment for geodesy, spatial data technology, positioning and remote sensing and promotes taking them into use;
- FGI supports the maintenance and development of the Spatial Data Infrastructure;
- FGI publishes information on the research results and promotes their utilisation.

5 VISION 2023 AND STRATEGIC GOALS

5.1 Vision 2023

Geospatial science and solutions for society

- We provide cutting edge science and technology
- We help the public and decision-makers understand the importance of geospatial infrastructure and solutions
- Our solutions enhance the competitiveness of industry and well-being of society

5.2 Strategic goals

- Research and development projects and research and expert services are implemented in such a way that it is possible to take advantage of the entire knowledge capital of the agency and so that results can be utlised widely in society.

- FGI is participating in a large number of research and specialist projects concerning the spatial data infrastructure and related metrology at the national and international level.
- FGI's scientific competitiveness is strengthened through top-level competence suppoerted by postgraduate degrees, a modern research infrastructure, current high-level research, cooperation and internationally acclaimed publications.
- FGI is engaged in networking with the scientific community, the private sector, and public administration and communicates its research results actively.

6 VALUES

The values of the National Land Survey of Finland are:

- A reliable partner
- Will to serve
- Courage and the ability to create something new
- Different together

7 ANALYSIS OF THE CURRENT SITUATION

7.1 Strengths

High-level research

The high-level research carried out at FGI is internationally recognised and highly regarded in the spatial data field. As a result of research, more than 100 peer-reviewed publications are written annually as well as a large number of other publications, conference presentations and reports. Representatives of FGI are active in international scientific organisations and they have been invited to speak at several events and conferences. The field of research is exceptionally extensive. FGI is exceptional internationally, because its research operations cover all fields of research needed in the development of a modern spatial data infrastructure. The National Land Survey is able to carry out extremely varied development work in the spatial data field. The services provided by and research conducted at FGI concerning spatial data, geodetic fundamental networks and mobile technology are significant for the development of an information society.

Skilled and motivated employees

FGI employees enjoy their jobs. Their educational level is very high. As the employer, FGI offers opportunities to conduct research in the long term, further and additional education and individualised career planning. In addition, research scientists who wish to do so have good opportunities of transferring into operational specialist jobs in other operation units, and similarly employees working in operational jobs can transfer to FGI to strengthen their skills or to complete a postgraduate degree.

Networks of cooperation

At FGI, extensive national and international cooperation is well established. Networks of cooperation are crucial in initiating research and development projects. FGI is a part of an extensive international research network guaranteeing the completion of international cooperation, high-quality applications and research and development projects in cooperation with international research and business partners. The international appreciation for FGI provides us with new opportunities and skilled employees. FGI is involved in intense cooperation with the national and international security field. The Spatial Data Network (formerly INSPIRE Network) has been working on the Finnish spatial data infrastructure for

more than ten years and it has provided FGI with excellent opportunities for strengthening effectiveness and cooperation. Networks of cooperation should be widened in scope and directed at people who are not spatial data professionals and at communicating information to various professional fields to ensure the realisation of the potential benefits of spatial data. In cooperation networks, staying in one place and remaining closeted with one's own professional circles can be a threat and quickly become a weakness.

FGI as a part of the NLS is a part of the TULANET network of research institutes. This provides the agency with the opportunity of developing its scientific research and supporting functions in cooperation with other research institutes to improve efficiency. Through cooperation within the network it is possible to create good solutions and computational methods to manage and analyse data concerning natural resources and the environment, for example via the Academy of Finland-financed project Open Geospatial Information Infrastructure for Research (oGIIR).

Financing

The resources available to FGI have improved during the last five years. The institute has been successful in aquiring external financing. Results have exceeded expectations in utilising crucial research instruments, such as the Centre of Excellence in Laser Scanning Research of the Academy of Finland, EU projects, Business Finland top projects, Council for Strategic Research projects and cooperation with the European Space Agency ESA. In addition, strategic cooperation with key business parterns and other organisations has broadened the opportunities for financing and created spin-off businesses.

These developments have increased the opportunities for developing spatial data research, at the same time as the significance of this field has increased in society and business life.

7.2 Challenges

Decreased financing from the state budget

A challenge to operations is the decrease in financing from the state budget in such a way that it is not possible to do enough jointly-financed research in addition to fulfilling our legal obligations. Unless it is possible to fill the financing gap through commissioned research, this development means a smaller amount of research and a decrease in effectiveness and influence. Increasing the number of commissioned research projects requires that employees' working energy , well-being at work and project skills constantly improve.

Implementing the INSPIRE Directive

The extensive data contents of the INSPIRE Directive make developments in the digitalisation of society possible. The Directive also improves the conditions for international competition, because European data contents are uniform within the Directive's wide scope of application (data contents of Annex I–III). Society should invest more in the implementation of the Directive, although the implementation is considered to occur as a part of the statutory operations of authorities and mainly without a separate investment in resources to the authorities responsible for the data, in spite of the fact that the task is considerable in scope. It is, however, apparent that the implementation of the Directive will probably be delayed. For now, implementing the Directive within data provider organisations is the only way and means to achieve cross-border interoperability of spatial data, one of the main purposes of the Directive.

Weak level of integration in SDI

In accordance with the INSPIRE Directive our spatial data infrastructure (SDI) covers the components of interoperability to search for, browse and download individual spatial datasets. The fragmentation of spatial data techology means that combining data from various sources

of spatial data or with other data, as well as using spatial datasets as resources for application developers is relatively limited in scope and often demands a lot of time and resources. SDI requires stronger integration.

The current SDI requires an integration layer to support it. The task of the integration layer should be to facilitate finding existing information and making it available significantly more easily than currently, and to enable use of data online and machine readability in web applications and for application developers. Automation and artificial intelligence should also be used in more various ways than currently. The integration layer also has to provide tools to combine spatial data with mainstream technology and to make it possible for application developers to use spatial data. Steps in this direction have been taken in the Spatial Data Platform project run by the Ministry of Agriculture and Forestry. The purpose of the project is to effectivise the searchability of spatial data and a service for linked data. Strengthening the integration layer demands further investments into its continuing development and maintenance as a part of the information infrastructure of society.

To improve this situation, the Ministry has initiated a report on the national spatial data policy.

Information security and protecting privacy

Concerning personal data protection, spatial data is in a group of its own, because by combining different kinds of spatial data, it may be relatively easy to identify an individual. It is possible to identify a person relatively reliably by tracking his or her movements through cellular networks, for example. Strengthening data protection for spatial data is an important field of research and focus area with the potential for achieving significant and internationally competitive results. Through the new EU legislation concerning data protection, the significance and effects of data protection will be felt in all handling of spatial data.

8 CORE COMPETENCIES

The operations of FGI are determined by core competencies consisting of the tasks and development responsibilities of one or more departments. Core competencies contain the subject matters of specialist positions, implemented research programmes and individual projects. FGI core competencies:

- Spatial Data Solutions Supporting Digitalisation
- Dynamic Earth
- Smart Environments and Interaction
- Robotics and Intelligent Transportation Systems

8.1 Spatial Data Solutions Supporting Digitalisation

The spatial data infrastructure (SDI) consists of spatial data products available in an online service environment, metadata supporting the finding and taking into use of such products and services to forward spatial data to various applications utilising the SDI. Key principles of SDI are the distribution of data maintenance and the use of data directly from the information pools of the organisation maintaining the system, the extensive utilisation of data through agreed standards and the integration and reuse of data. The core of SDI consist of spatial data contents that are clearly defined, of known quality, current and complete, and that are based on mutually agreed coordinate reference systems.

As SDI advances, more advanced processing services, sensor networks for environmental monitoring and advanced services for data visualisation are incorporated into it. The increasing use of mobile equipment in the utilisation of SDI causes new demands on, for example, the development of multi-channel enabled visualisations. Spatial data analysis within an online service environment offers new opportunities for the development of new

kinds of applications. Ontology-based methods are being developed to manage the semantics of spatial data contents.

Spatial Data Solutions Supporting Digitalisation

Central themes of this core competency are, for example:

- Updating spatial data
- Mobile mapping
- Spatial data systems and services to support decision-making
- SDI as a part of the spatial data ecosystem
- Web-based processing services
- Spatial data ontologies
- Spatial data harmonisation and integration
- Standardisation
- Cloud computing
- Big Data
- Blockchains
- Participation of the public and crowdsourcing
- Privacy protection and spatial data security
- Reliable navigation and positioning
- Use of dynamic coordinate reference systems
- Machine learning and artificial intelligence in spatial data applications
- Cadastral system of the future

8.2 Dynamic Earth

Movements of the Earth's crust cause changes in coordinate reference systems. Significant changes in the mass of glaciers and flows in the Earth's mantle have an impact on the global climate, glaciers and sea level. Measuring and understanding these phenomena requires modern measurement techniques and long time series. Nuclear safety, flood protection and the development of urbanisation are examples of changes occuring around us at a local level. Analytics and visualisation of continuous factors of change are important to the understanding of these phenomena.

FGI's key operations include reference systems, measurements, measurement quality control, the development of measurement techniques and studying and modelling the processes of change. Uniform coordinate reference systems, satellite positioning and modern communications technology have made possible the use of spatial data and promoted business activity in the field. As the use of spatial data keeps increasing, it sets ever greater demands on the reliability of the reference frames, updating frequency and accuracy of spatial data and the monitoring of changes in such data as time goes on.

Dynamic Earth

Central themes of this core competency are:

- Spatial data metrology
- The development of the Finnish coordinate reference system, height system and gravity system
- Time management in spatial data systems
- Precise measurements and positioning
- The development of the Metsähovi research station as a part of the international network of fundamental stations
- Changes in land use
- Land uplift, deformation of the Earth's crust and deformation models
- Sea level changes
- Measuring the Earth Orientation Parameters (EOP) and their temporal variation
- Temporal and spatial changes of gravity

- The environment and related security applications
- National laser scanning and related technology
- Map updating
- Satellite, aerial photography and laser scanning time series and change detection and interpretation
- Connecting 4D measurements to climate research

8.3 Smart Environments and Interaction

Processes become smart through digitalisation. They provide situational awareness to assist in decision-making. The interaction between processes and decision-making is becoming seamless. Generally situational awareness systems require digital, three-dimensional spatial data, precise positioning and real-time information about the environment. This situational awareness system enables a high degree of automation in smart agriculture and smart forestry, where the aim is to automatise many processes to be as independent of human input as possible. In an urban environment it signifies smart cities and their design, construction and related functional packaged services, where it is possible to combine real world objects and virtual reality with precise 3D models. At sea, situational awareness systems can be used to improve the safety of shipping, improve environmental monitoring and improve the response of rescue services.

Smart Environments and Interaction

Central themes of this core competency are, for example:

- Modelling the built environment
- Digitalisation of forest data
- Automatisation of agriculture
- Support systems for maritime spatial planning
- Services related to nature and trekking
- Usability and visualisation of spatial data
- Situational awareness
- Virtual worlds and augmented reality
- Easy-to-use user interfaces
- Machine learning and artificial intelligence
- Responsive and adaptive maps
- Linked data and ontology technologies

8.4 Robotics and Intelligent Transportation Systems

The market for remote sensing using small unmanned aerial vehicles and robots are growing exponentially. Important implementations include surveying and mapping, the built environment, precision agriculture and forestry, aquatic monitoring, evaluation of environmental effects, energy economy, applications related to routes and infrastructure, law enforcement, security, science and education.

Our aim is to facilitate the development of innovations in navigation and positioning technology for the good of society. Currently we have two top-level research projects. We are developing techniques related to smart traffic (primarily on the road and at sea as well as pedestrian traffic). Our second aim is to develop various kinds of techniques for collecting spatial data. Big data collected from a large number of users (crowdsourcing) makes the creation of new services and business models in the field of navigation and positioning services, for example. Through new positioning technologies, it will be possible to use navigational services in new operational environments, such as indoors. All positioning methods have their weaknesses, which means that in applications where security is critical, such as traffic, navigational services must be fault tolerant.

Robotics and Intelligent Platforms

Central themes of this core competency are, for example:

- Multi-source positioning methods
- New mapping systems
- GNSS technologies
- Operational environment-independent navigation
- Spatial data applications for mobile devices
- Information security of positioning and navigation services
- Cloud computing
- Drones
- Smart traffic
- Route optimisation and autonomous navigation
- Autonomous systems
- Measuring the conditions of roads
- Power line mapping

8.5 The focal areas of department operations

9 SPECIALIST TASKS

The skills and operations of research and specialist tasks undertaken at FGI departments cover the entire value chain of spatial data. The value chain can be said to begin with geophysics and geodetic reference systems and to continue through the collection of spatial data using positioning, remote sensing and navigational methods and concluding with the processing, distribution and utilisation of spatial data in end-user applications. The strength and competitive advantage of FGI are based on this entity. This value chain provides research topics both for researchers and research units so that the subjects and units can complement and support each other and from the spatial data research value chain create a service package that benefits different fields of activities and administrative sectors.

Specialist tasks involve research and development on a continuous basis. These are used to ensure that the nation has access to reliable information and skills for the long-term development and maintenance of SDIs.

Specialist tasks at FGI include:

- the national implementations of geodetic systems (coordinate reference system, height system, gravity system and their maintenance and development)
- spatial data metrology and national standards laboratory (length, gravity, levelling, aerial photography, laser scanning) and the quality of spatial data
- evaluation of the usefulness of mapping methods
- maintenance and development of national infrastructures (Metsähovi, geodetic networks, the Nummela standard baseline, test fields, GNSS, EGNOS)
- development and promotion of spatial data interoperability (tasks related to the implementation of the INSPIRE Directive, increasing integration in SDI, use online and via applications, cooperation networks)
- data protection and licensed use practices
- development and maintenance of cooperation networks
- promoting the taking into use of new methods
- issuing instructions, recommendations and statements

10 Partnerships

Through its operations, the National Land Survey is expected to support the public administration and the business sector as they maintain and develop our national SDI, which is of a high quality and multi-tiered. The public adminsitration's primary tasks in this include the develoment and use of the basic information pool.

FGI's primary partners include universities and research institutes, partners in research projects and programmes. Partnerships are built with the security sector, governmental agencies and companies, particularly if they can participate in research-driven cooperation or in the utilisation and commercialisation of research results. Partners in SDI development are companies, the public administration and members of the public, depending on the focus group of each project.

Customer relationships and partnerships are maintained through stakeholder events, personal communication, active communication, seminars on specific topics and joint positions, such as joint professorships.