NSDI Good Practices
Sweden

This document is meant to present an overview of the NSDI status in this country. Even though every possible care has been taken by the authors to refer to and use valid data from authentic sources, the World Bank does not guarantee the accuracy of the included information, nor does it accept any responsibility for any use thereof.

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EXECUTIVE SUMMARY

Sweden has a long tradition of transparency, citizen engagement and of policies to build an effective and accountable government. Confidence and trust are among the most important pillars of the Swedish democracy. The Swedish principle of public access to official data guarantees to the general public and the media an unimpeded view of activities pursued by the Government and local authorities. An efficient and accessible administration, together with well-managed public finances, forms the basis of the Swedish model. The Geospatial infrastructure, as an essential part of the information technology, is a prerequisite for the implementation of this model.

As the term "collaboration" is highly visible in the Swedish definition of the Spatial Data Infrastructure "*NSDI provides geodata together with regulations, services for searching, finding and using the information and systems for cooperation between different parts*" (www.geodata.se, 2011-08-10), the concept of the Swedish SDI is called "Geodata collaboration".

Today, 290 Municipalities, 33 government agencies, 21 counties and 3 State enterprise companies participate in this nationwide cross-sector cooperation, operating a comprehensive and advanced geographic information infrastructure, covering many needs of the society. "Geodata" is the name of the access point for this infrastructure.

Due to the fact that the NSDI is a dynamic and not static framework, since it meets current needs of the society while at the same time generates new needs and solutions, the study uses a maturity model for the assessment of the NSDI instead of inappropriate terms such as "end" and "completed". Assessing the maturity level of various NSDIs is necessary for the evaluation of their implementation.

The objective of this study is the assessment of the "Geodata Collaboration". To achieve this, the maturity level of the five core elements of the NSDI is evaluated through time: Organizational, Standards, People, Data and Technology.

The study is structured as follows:

The first chapter presents the political structure of Sweden and the ICT's relation to the study indicators.

The second chapter is used for the determination of the initial maturity level of the Swedish SDI. Since 1996, Sweden has moved steadily towards a spatially enabled digital governance by collecting data, making institutional arrangements and adopting standards. Active networks between the Nordic countries at specialist level, for example, on standardization and other technical elements have facilitated this development.

Although these steps are important components of e-Governance, the legal, institutional and technological frameworks facilitating the information flow between agents, are needed for a successful nationwide spatial enabled e-Governance. However, the INSPIRE process has facilitated the development of formal national SDI's, and after the INSPIRE Directive, which came into force on 15 May 2007, Sweden like all Nordic countries has adopted new legislation on establishing infrastructures for geographic information.

In summer 2006, the Swedish Parliament approved legislation that officially appointed Lantmäteriet (the Swedish mapping, cadastral and land registration authority) as the coordinator for the Swedish NSDI. This is considered as the ending year of the Pre-SDI period in Sweden.

In the third chapter, the development of multi-sectoral activities is presented. These activities establish the "Joined-up Government", transform the society and prepare the

Open Government Era. During this period, the geospatial information becomes a natural part of the daily life of the people in the public and the private sector. New products and services, and new forms of communication are being developed, and used, in even more areas. Trust in, and familiarity with, the geospatial infrastructure has become greater. It affects more and more areas of society, from business development, through education and culture, to health and welfare. These developments have political consequences. They form the basis of, and create the need for, a new geospatial policy that removes any barriers and obstacles from access to the infrastructure by the whole society.

This new policy is outlined in chapter 4. The goals for the establishment of an open government and the foundations for the "smart government era" have been prepared. Also, a short summary of the current NSDI status today is presented.

The fifth chapter offers a detailed description of the five elements of the current Swedish SDI.

- In the Organizational structure, the Governance scheme, the political will and support, the accountability to the society, the licensing and pricing models and the partnerships are described.
- A detailed description of the Standards used in the data, metadata and services as well as the business process aspects.
- Resources' skills and qualifications, educational status and support, the ecosystem's parties and the management and professional culture are examined in the People component.
- The Data component includes the themes and the custodians, the metadata, the quality aspects of the whole infrastructure and how all the infrastructure is accessible from the Swedish SDI-Hub, the Geodata.
- The overarching architecture, the technical principles, the interoperability and openness of the spatial data infrastructure and the enabling technologies are cited in the Technology component.

In the sixth chapter, the maturity of the Swedish SDI is analyzed using a geo-maturity model. An introduction to the model and its underlying concepts and an analysis of the initial and current landscape of the Swedish geospatial infrastructure through the model's requirements, are presented.

This study was based on the analysis of the websites and other documents, as they are presented in the references section.

The amounts which are presented in this study, are written in SEK (with a reference to their relative year). The € equivalent, next to them, has been calculated using the reference mid-year's rate (reference year-July-01), as it would be incorrect to state each figure as in 2017. http://www.xe.com/currencytables/?from=EUR&date=

1 AN INTRODUCTION TO THE COUNTRY

In the first chapter the political structure of Sweden and the ICT's relative to the study indicators, are presented.

1.1 Basic Data

Area: 528,447 Km^2 (2017)
Population: 10,023,893 (March 2017)
GDP in current prices: 447,928 (€, 2016)
GDP volume growth rate: 2.2% (2014)
GDP per capita: 441,000 (SEK, 2016) (46,922€) in PPS[1] (EU 28=100): 124 (2015)
General government surplus: 39.2 billion SEK (2016) (4.18B €)
Unemployment: 6.8% (March 2017)
Source statistics Sweden, (last access 21/05/2017)

1.1.1 Indicators

Broadband internet access: 94% of Households, 97% of enterprises (2016)
Interaction with public authorities via internet: 78% of citizens (2016)
Obtaining information from e-government sites: 78% of citizens (2016)
Satisfaction with the use of e-government sites: 62% of citizens (2013)
Percentage of **ICT sector in GDP: 6.41%** (2014)
Source: Eurostat (last access 21/05/2017)

The world's first computerized Land Information System (1976) Wiberg_2002
Ranked in **2nd** position for the most prolific technology hub on a per capita basis behind Silicon Valley and ranked in **3th** position globally for the savviest digital countries. WEC 2016
Ranked in **3nd** position in Digital Economy and Society Index (2017, DESI, EU)
Ranked in **27th** position in (OUR)-Open, Useful, Reusable Data, OECD 2014
Ranked in **3th** position in use of e-government services OECD 2015
Ranked in **14th** position globally in e-Government Readiness Index UN_Survey_2014
Ranked in **2nd** position out of 53 countries in Information Society Index IDC
Ranked in **9th** position out of 127 counties with 97% of the world population and 96% of the world GDP, in Change Readiness Index (CRI). Overall rank results from the following individual ranks: **13th** position in Enterprise capacity, **9th** position in the Government capacity and **3rd** position in People and Civil Society capacity. KPMG_CRI_2015
Ranked in **6th** position in E-Government Development Index and in **27th** position in E-participation Index UN_Survey_2016
Ranked in **20th** position in the Global Open Data Index (2016) with a score of 53% GODI

According to a survey for the "Global Geospatial industry Outlook, 2017 edition" produced by Geospatial Media and Communications, among 50 countries representing the 75% of the world's population and 89% of the world's total GDP:

- Sweden will make the largest gains (40%) in productivity, among all countries, with the adoption of Artificial intelligence (AI) in 2035
- Ranked in **21st** position in the Geospatial infrastructure and the Policy Framework
- Ranked in **12th** position in the Geospatial courses and the available skilled manpower
- Ranked in **19th** position in the level of user adoption of the geospatial technology
- Ranked in **13th** position in the geospatial industry penetration
- Ranked in **15th** position overall in the geospatial readiness index

Detailed indicators in e-Government Factsheets 2017 EU report (Joinup.ec.europa.eu, 2017).

[1] Purchasing Power Standards

1.2 Political structure

All public sector power is derived from the people. This is the foundation of parliamentary democracy in Sweden. Everyone has the same rights and is free to scrutinize how politicians and public agencies exercise their power. The general elections are held every four years, with the last one held in September 2014, which saw a minority coalition of Social Democrats and Greens taking over after the Centre-right Alliance.
The Swedish Constitution defines how Sweden is governed. It regulates the relationships between decision-making and executive power, and the basic rights and freedoms of citizens. Four fundamental laws make up the Constitution: the Instrument of Government, the Act of Succession, the Freedom of the Press Act and the Fundamental Law on Freedom of Expression.

The Act of Succession regulates the right of members of the House of Bernadotte to accede to the Swedish throne. The monarch is the country's head of State. The Swedish head of State, since September 1973 King Carl XVI Gustaf, exercises no political power and does not participate in political life. As head of State, he is the representative of the country as a whole, and in that capacity performs mainly ceremonial duties and functions.

The 349-member Riksdag, representing the people, makes the decisions and the Government implements them. The Government also submits proposals for new laws or law amendments to the Riksdag.

Sweden has three levels of domestic government: national, regional and local.
Sweden is divided into 21 counties. The county councils undertake political tasks at this level. The county councils are responsible for overseeing tasks that cannot be handled at the local level by municipalities but rather require coordination across a larger region, most notably health care. The county councils are entitled to levy income taxes to cover their costs. At the regional level there are also county administrative boards, the government bodies for the counties.
At the local level, Sweden is divided into 290 municipalities, each with an elected assembly or council. Municipalities are responsible for a broad range of facilities and services including housing, roads, water supply and wastewater processing, schools, public welfare, elderly care and childcare. The municipalities are entitled to levy income taxes on individuals. They also charge for various services. As a result, municipalities have significant latitude in deciding what services they should offer. They are, however, legally obliged to provide certain basic services.

Sweden joined the EU in 1995, after a positive vote of the people in a referendum in 1994. In a second referendum in 2003, the citizens of Sweden refused the introduction of the Euro (€). Swedish system of Government

2 PRE-SDI TIME PERIOD (-2006)

This chapter is used for determining the initial maturity level of the Swedish SDI. Since 1996, Sweden has moved steadily towards spatial enabled digital governance by collecting data, making institutional arrangements and adopting standards. Active networks between the Nordic countries on standardization and other technical elements, at specialist level have facilitated this development. Although these steps are important components of e-Governance, the legal, institutional and technological frameworks facilitating the information flow between agents, are needed for a successful nationwide spatial enabled e-Governance.

However, the INSPIRE process has facilitated the development of formal national SDI's, and after the INSPIRE Directive which came into force on 15 May 2007, Sweden like all Nordic countries, adopted new legislation on establishing infrastructures for the geographic information. In summer 2006, the Swedish Parliament approved legislation that officially appointed Lantmäteriet (the Swedish mapping, cadastral and land registration authority) as the coordinator for the Swedish NSDI. This is considered as the ending year of the Pre-SDI period in Sweden.

2.1 Brief History until 2006

Sweden was one of the first countries to address Spatial Data Infrastructure's matters and has, over several decades, developed one of the world´s most complete Spatial Data Infrastructure. The first ideas in this field – to give to the basic public information a spatial dimension and use computers for analysis – was presented by Professor Torsten Hägerstrand in 1955. The ideas influenced the design of the Swedish Land Data Bank System – the world's first computerized Land Information System.[Wiberg 2002]

Up to 2008, the Ministry of Environment had the responsibility for the geospatial information and the "Swedish mapping, cadaster and land registration Authority" (**Land Survey, NLS, Lantmäteriet, LM**) led the coordination, management, technical support, R&D activity and supervision of the geospatial projects.

Although a full operational NSDI existed in 2005, there was a lack of legislative initiatives for both a formal organizational structure and a national geospatial strategy. The approval of the national strategy in 2007, the formal appointment of Lantmäteriet as a Geodata Coordinator and the establishment of the Geodata Council as a supportive body to its geospatial operations, in 2006, are considered in this study, as the initial start of the NSDI's development period. In the Pre-SDI section, the existing elements of the SDI will be described, as a starting point of reference for the maturity model.

2.2 Legislation Framework and Political will

2.2.1 Freedom of Information

(1766) The Freedom of the Press Act (1766, 1949:105) is widely considered the oldest piece of freedom of information legislation in the world. Since 1766, the Act was thoroughly renewed, with latest additions coming into operation in 2003. The initial purpose of the Act was to abolish the political censorship of public documents and to ensure the right for everyone to publish written documents. Right of access to public documents was also listed in the first versions of the Act. According to the Act, everyone - including companies and foreign citizens - was entitled to gain access to official documents. An official document might either be a text, a picture, a sound clip, a movie, a computer-readable file or any other piece of information. Like in other Nordic countries, the requester did not have to reveal his/her name, address or reason for request.

(1980) The Freedom for information Act included some exceptions. These exceptions to the rule, were more thoroughly examined in the Publicity and Secrecy Act 2009, which detailed what government agencies can keep secret, what type of document, under what circumstances, and towards whom.

(2010) The purpose of this law Act (2010:566, re-use of public information) was to promote the development of an information market by facilitating the use of documents which are provided by the authorities.

2.2.2 GI data: Protection / Privacy / Pricing

Maps with geographic information are protected according to the Swedish Copyright Act (1960:729). The copyright belongs to the State and is administered by the Lantmäteriet (www.lantmateriet.se. (2017). Prices and Purchases)

(1960) Provisions on copyright were included in the Act (1960:729) on Copyright in Literary and Artistic Works
(1993) Provisions on requirements for permission to set up databases containing landscape information and for disseminating maps and other compilations of landscape information were included in the Act (1993:1742) on the Protection of Landscape Information
(1996) Provisions on security protection were included in the Security Protection Act (1996:627) and its regulations (Riksdagen.se, 2017)
(1998) Provisions on processing personal data were included in the Personal Data Act (1998:204)
(2000) Provisions on processing personal data contained in the land registry were included in the Real Property Register Act (2000:224)
(2005) Sweden transposed the 2001 directive on copyright in the information society in May 2005 (Ggim.un.org, 2017)

The Parliament gave NLS the right to set fees for services from the real property register, and set principles for license fees for use of geographical information. The fees covered the costs for dissemination and a contribution to maintenance - a modified marginal cost principle. The pricing should give no profit. The real property register contained personal data, therefore each request of access was met with a formal decision by Lantmäteriet. (Corbin, 2003) StateOfPlay_2010

2.2.3 Flagship initiatives – political support

(1970) Land Act , Real Property Register (2000)
The creation of the GIS based Cadaster was a cornerstone for the development and dissemination of the GI information in Sweden. The new law on the Real Property Register (Act 2000:224) replaced the old legislative framework for the Land Data Bank System from the 1970s and established a base for a partly new structure for Real Property Information. These laws were of vital importance for the first steps of the SDI activities, which started in the mid-1990s and were under operation in 2002.

The Swedish Administrative Development Agency (VERVA), which closed in December 2008, was working on a guideline regarding the application of the Public Sector Information (PSI) directive within the Swedish public sector. VERVA's main task was to support cooperation between public authorities and the private sector, with the main focus on e-government. It had the mandate to issue instructions to administrations and agencies regarding information management. Municipalities were not bound by these instructions, but they could follow them voluntarily. Parts of VERVA business was taken over by the State Treasury, and Administrative Services Agency, the National Courts Administration and the new Skills Council for the Development of the State StateOfPlay_2010

(2003) A Knowledge Nation (SOU 2003:129 d1)
The objective of this law was the provision of information to research and education, aiming to meet the needs of the rapid development of technology and the innovation of the scientific publishing.
The main proposals were part of efforts to strengthen Sweden as a knowledge nation and IT country, and to increase the ability for the country to be competitive. The government wishing to be at the forefront, decided that the State would invest in developing the digital information.

2.3 Roles and Responsibilities

2.3.1 Ministry of Environment, Lantmateriet

Lantmäteriet, under the Ministry of Environment, was responsible for the production, maintenance and dissemination of geographic information at scale 1:10,000 and smaller, and for the real property formation. NLS was a member of EuroGeographics and had the responsibility to co-ordinate the development of national spatial data.

2.3.2 Development Council for GI (informal)

(1986) ULI **Geoforum Sweden** was and continues to be the trade association for the geodata.

From early 1990's, this non-profit interdisciplinary association of Swedish organizations (200 organizational members today from government, industry and academia) worked towards a more efficient use of GI. Its members collected, analyzed, enriched and visualized geodata. The forum undertook initiatives in the GI industry, and helped politicians, authorities and the media to understand the benefits of using accurate geodata. It offered conference centers and other venues for training, creative discussions and new collaborations.

With an independent platform, the forum provided factual and qualitative information to the industry and to the outside world. The forum's web page hosted a GI news feed, a meeting places page for conferences and calendar events, their views on GI initiatives and a page with projects on the theme of education and related studies.

ULI was the name of the Development Council for Geographic Information. It was the name of the association from 1986, when it was founded, until 2010. At the annual meeting in 2010 the name was changed to ULI Geoforum. Geoforum is also used today for the sister associations in Norway and Denmark.

2.3.3 Data production

The municipalities were responsible for large scale mapping, and in many cases carried out the real estate property formation, which gave them a strong co-operation with NLS. Also, the counties were increasingly involved in spatial data collection and use. Government agencies such as the Swedish Environmental Protection Agency (SEPA), the National Road Administration, the Swedish Post Office, etc. were involved in and co-operated in data production and/or had responsibilities in different user sectors of spatial information.
The private companies acted as data producers for part of NLS production, or service providers.

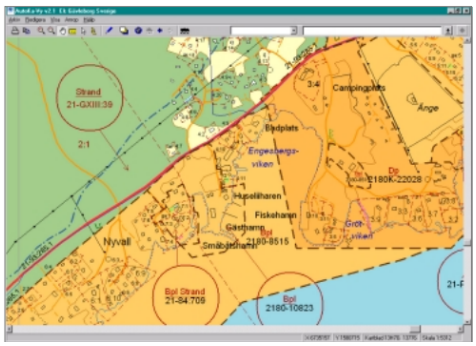

Figure 1: Example of the Cadastral Index Map (source: H. E. Wiberg, 2002)

2.3.4 Standards

The Swedish Standards Association is a collaborative organization for the three Swedish standardization organizations: the ITS - Swedish Information and Telecommunication Standardization, the SEK Swedish Export Credit Corporation and the SIS - Swedish Standards Institute.
(1990) From early 1990's, the SIS worked to develop and manage standards and guidelines within the geodata area.

Within SIS, a project called Stanli was already set up in 1990 to promote standardization within the geographic information. The work was financed by approximately 30 different organizations. Through
Stanli, Sweden has taken an active part in the ISO/TC 211 and CEN/TC 287 developments of framework standards. Based on the results from this work, a Swedish framework was set up. Additionally, a number of standards for different application areas have been developed, for example, for road and railway networks, utility networks, addresses, cadastral parcels, and hydrology. StateOfPlay_2005

Up to 2005, standards in use in the Swedish NSDI included:
- GGD-specification – used for mapping and elevation (height) models
- Swedish Standard SS 63 70 03 – used for addresses
- Swedish Standard SS 63 70 04 – used for description of road and railroad networks
- Swedish Standards for utility networks
- Hydrology (lakes, rivers, catchments etc.), SS 63 70 08
- Cadastral parcels
- Building plans
- Metadata

Land Survey was heavily involved in the development of geodata standards. A lot of efforts and money were spent in that period to produce their own bespoke standards, which had to be replaced in later years with international ones.

2.4 Partnerships

2.4.1 Public Sector collaborations

Swedish authorities have always had a long tradition of cooperation. In the environmental and water management, the cooperation of Marine and Water Authority with water authorities and the Geological Survey of Sweden, took place under the Swedish implementation of the Water Framework Directive (2000/60 / EC). Marine and Water Authority was also the convening authority for the coordination Group for Marine and Water Environment (SAMHAV), which was established by the government in 2006. The purpose of the Coordination was to create a forum for increased cooperation between authorities with responsibility for marine and water environment issues. The group consisted of 21 agencies.

The Environmental Protection Agency (EPA) had an extensive collaboration with other agencies and organizations, such as county councils, municipalities and trade associations in the industry. To support the cooperation, the Environmental Protection Agency created a digital meeting place where the cooperating authorities and organizations with the help of a moderator could interact and share documents with others participants. All materials in the forum were public documents and could be claimed even by those who didn't participate in the forum.

The EPA, the Marine and Water Authority, the county administrative boards and the water authorities, also in collaboration, developed a multi-agency approach to environmental data management on behalf of the strategic business collaboration Council for support in the environment and nature area (MIT). The strategy included a vision guidance with the

associated recommendations for data management and environment. So far, it has been signed by the heads of 13 Swedish authorities.

Lantmäteriet has had a strong tradition of cooperation with both other national agencies and the local authorities. The cooperation was built through a lot of projects which are described in detail in the next paragraphs. One of the most important cooperation agreement deals was the one for the National Road Database. The database was built in conjunction with the Road Administration, Lantmäteriet, the forest authorities and the municipalities.

Another joint effort database was the Address Register. This was built in cooperation with Lantmäteriet, the municipalities, the Post and the National Tax Board. These agreements usually didn't take the form of formal contracts.
Land Survey also interacted with the Finnish Maritime Administration (FMA) about a common national shoreline (which was included in the theme Administrative Units).

Lantmäteriet also cooperated directly with the municipalities. Until today, Swedish municipalities have a high level of independence, and they are not obliged to provide any spatial data to the government, except in a few cases, such as maps for planning. The cooperation with the municipalities was traditionally based on an incentive model. The municipalities were paid for providing their data, by a division of revenues from Lantmäteriet, depending on the level of data the municipalities provide, and on their population numbers. If the municipalities wanted to use Lantmäteriet's data, they had to pay for it.

The common vision for the cooperation between Lantmäteriet and the municipalities was laid down in a general agreement which mentioned the principles for cooperation and the financial model. The Association for Local Authorities made a framework agreement with Lantmäteriet in 2000, and a new one in 2003. Standard agreements were negotiated with the Association for Local Authorities and were then used for concluding individual agreements with the local authorities. In addition, an object catalogue was created and the use of standards was included in the agreements. StateOfPlay_2005

2.4.2 Other collaborations - partnerships

2.4.2.1 Public-private partnerships

(1985) Private companies (T-kartor 1985, Liber 1983) became involved, from the early 1990s, in building the NSDI in different ways, either as data producers for certain parts of the NSDI or as service providers for some forms of spatial information. In public sector projects, they participated as contractors for technical development, or production, or as vendors.

Moreover, the private commercial firms made "value-added" products from the core data. Lantmäteriet supported the establishment of value added resellers (VAR's) and agreed with a number of new companies to be VAR's during 2004. StateOfPlay_2005

2.4.2.2 Local Authorities

The local authorities also had many cooperation agreements amongst each other, to build common databases, sell them together and share the revenues. These agreements usually included the right to show the data on the Internet.

2.5 Flagship programs

2.5.1 GIS based Land Use and Topographic Maps

(1970-1997) In the 1970s and 1980s, the National Land Survey produced a new Land Use Map and a new Topographic Map. Over time the production became more computerized but the result was still, to a large extent, printed maps. User demand for digital spatial data grew dramatically when PCs and Geographic Information Systems entered the market in the late 1980s and early 1990s. The National Land Survey responded to this and launched a program for digitizing the basic information content in the Land Use Map and the Topographic Map. The program was completed for the whole country in 1997. Other governmental producers of spatial data and the municipalities carried out similar programs.

2.5.2 Land Data Bank System – first IT cadaster worldwide

(1976-1995) The Land Data Bank System - a combined Cadaster and Land Register - was first established in one county in 1976. The implementation in the whole country was finished in 1995. Central coordinates - based on the national geodetic reference system – for parcels and buildings were implemented in the system and gave a spatial dimension to all information that could be connected to the parcels or buildings for instance for owners, citizens, property value and different services.

This very fundamental system was carried out by an organization specifically created for this task – The Central Board for Real Estate Data. The National Land Survey – responsible for cadastral services – and the National Courts Administration – responsible for land registration – participated in the reorganization and the system was managed and maintained by the new National Land Survey, (Lantmäteriet). The cost for design, implementation and maintenance of the system was covered by government grants and some of that was financed through reductions of costs from the aforesaid participating authorities. Wiberg_2002

2.5.3 RIX 95 project - SWEPOS

(1994) The origin of the project was a government's mission to Lantmäteriet in May 1994, aiming to establish a geodetic network for GPS technology. The implementation and the project started in the summer of 1995 and finished in 2006, under Lantmäteriet's responsibility. The network was calculated in the RT90 (old) and SWEREF 99 national reference systems, as well as in the RH70 (old) and RH 2000 national elevation systems. The total cost was 62.5 million SEK (2006, 6,790,000 €) and today consists of 305 reference stations and is used by 2400 users (RTK) (Andersson, B., Alfredsson, A., Nordqvist, A. and Kilström, R. (2015)).

2.5.4 Cadastral Index Map

(1996-2003) In the middle of the 1990s, substantial digital data were available but were not structured and integrated to a Spatial Data Infrastructure. The necessary coordination and organization of information and systems began in 1996 and in a few years a real national spatial data infrastructure was established. **A key activity** in this process was the merging of the Central Board for Real Estate Data and National Land Survey into the National Land Survey, Lantmäteriet in 1996. Main objectives for this merging were to coordinate and integrate the information in the Land Use Map and Topographic Map with the information in the Land Data Bank System. This integration began in 1996 when Lantmäteriet started the production of a new National Cadastral Index Map.
The Cadastral Index Map contained spatial information on properties, parcels, plans and regulations and easements. It was produced out of data from the Land Use Map and from Large Scale Maps in the municipalities. It became the base for all geographic data sets that presented property information. The properties and other objects were handled with

unique identifiers integrated with the information in the Real Property Register. The Cadastral Index Map was stored and managed in a system run by Lantmäteriet and like all information in the Real Property Register, was updated by the source of information daily. It was completed for the whole country before the end of year 2003 and was available via Internet and other channels (CD-Rom by post etc.).

A new law on the Real Property Register (Act 2000:224) was introduced in Sweden in 2000. The law replaced the old legislative framework for the Land Data Bank System from the 1970s and was a base for a partly new structure for Real Property Information. The Cadastral Index Map was a part of the Real Property Register. The information in the Real Property Register was divided into five different parts with the information listed below:

Real Property Part	**Land Register Part**
property unit, joint property unit, coordinates, precincts, joint facility, cadastral index map, plans, regulations and rights	Title, leasehold, mortgage, rights, notifications
Building Part	**Address Part**
building unit, address, coordinate	address unit, property unit
Property Tax Assessment Part	
total assessed value, assessed value for land, assessed value for buildings, basis for valuation, owner	

The new structure of the Real Property Register and the establishment of the new Cadastral Index Map gave Sweden a highly modern system and the Real Property part of the Swedish SDI fulfilled all demands from the society and the market. Wiberg 2002

2.5.5 Addresses

(1996) The location address and the postal address for property units and buildings were stored and handled in the Address Part of the system for the Real Property Register at Lantmäteriet. The address situation in Sweden was not overall satisfactory. Especially in rural areas, there was a lack of location addresses. Lantmäteriet, the municipalities, the Swedish Post Company and the Swedish National Tax Authority together launched a program in order to improve the situation and establish a system that would fulfill the demands of an SDI in this aspect. The municipalities were responsible for creating and updating location addresses. Within the program, they set new location addresses in the form of street addresses, village addresses or other kind of addresses in the rural areas. The addresses were delivered to Lantmäteriet.

In co-operation with the Swedish Post Company, post codes and postal places were added to every location address. The complete addresses were stored in the Address System and disseminated for use in the whole society as a key-register. These addresses used from the National Taxation Authority, allowing to relate individuals, business and organizations with a geographic location.

This joint program improved the Swedish address system, provided cross-reference with key-registers of business enterprises and individuals and met the demands of the society and the market from the address component of the SDI. Wiberg 2002

2.5.6 Transportation network

(1996) The transportation networks; streets, roads and railways, have always been a part of the information in the Topographic Map and the Land Use Map. The information had to a great extent been stored in databases and mainly used for map production without a proper structure with nodes and links, identities and topology that is required

in an SDI. The Swedish National Road Administration had managed a Road Database with information mainly used for management and maintenance of the main roads and with poor geographic presentation. This database covered only the roads managed by the government authority, about 100,000 km out of a total of more than 500,000 km in the country.
In 1996 the Swedish National Road Administration was assigned by the government to establish a national road database in cooperation with Lantmäteriet, the municipalities and the forestry industry. The Swedish National Road Database (SNRD) was established in a system and included the basic network along with other information such as identities, nodes, links and topology. Network and attributes were updated by the municipalities and others. The information in the SNRD was based on a Swedish standard and was the basis for all information concerning the Swedish road network. This system was a part of the reference data in the SDI and fulfilled the demands of the transportation network part of the SDI. Wiberg_2002

2.5.7 StrateGIS –public sector's education

(1999) In 1999, the government instructed the 21 county administrations of Sweden to coordinate and launch a nationwide education project called StrateGIS, which aimed to enhance the use of geographical information systems in the public sector, especially municipalities, cities, and county administrations. The education was conducted independently in each county, within a framework drawn up by a central project steering committee. In order to penetrate the administrations from top to bottom the program was divided into three phases aimed at different target groups:

Table 1: The three phases of the StrateGIS project (source: M. Söderberg)

Phase	Target Group	Objective	Performance
1	Politicians and decision makers (senior officials)	The benefit with GIS	Centrally produced information package
2	Geographic information officers	How to implement and manage GIS	Regional co-ordination groups
3	End users	How to utilize GIS	Local training

The StrateGIS project aimed to, a) increase the use of GIS in public service, b) make the usage of GIS enable presentation of societal planning on the Internet – thus increasing the option for influence from the citizens, and c) be a prerequisite for increased use of GIS in higher skills among the personnel within the regional governments and city administrations.

By raising the knowledge and awareness of GIS and geographic information, at all levels, it improved:
- the information exchange within the societal planning process,
- the democratic influence for the citizens on the societal planning activities,
- the efficiency within the regional and city administrations, and
- the implementation of Internet/intranet in societal planning process (Corbin, 2003).

2.5.8 E-Government, e-Europe

(2000) Sweden had also been active in e-Government and e-Europe initiatives. The Parliament passed an IT Bill in April 1996 and the Swedish State e-Forum was established in 2000. Particular components of their vision were 24-hour agencies that were designed to make e-government a reality. This occurred in the context of Sweden, receiving the highest rating as an information economy, according to the 2002 IDC/World Times Information Society Index (ISI).
An infrastructure for data dissemination was maintained in the public sector, since then.

2.5.9 Administrative Units, Ortho-imagery, Elevation, Hydrography

(2001)

- The Units of Administration were well established in the Real Property Register and in the system with basic geographic information. It was possible to generate most kinds of administrative units out of the system, with an example being the Swedish part of the Seamless Administrative Boundaries of Europe (SABE)
- elevation models were established for the whole country
- hydrography was established in the system for basic geographic information; this information was still in quite simple structure but a program to make it more adjusted to the infrastructure began in 2002.
- Orthoimagery was well established and there were orthophotos covering the whole country[Wiberg_2002]

2.5.10 Water portal

(2003) The Geological Survey of Sweden, the National Board of Housing, Building and Planning and the SEPA were responsible for a Water Web Portal. Until 2005, the portal comprised general information but metadata, data distribution services and GIS applications were not supported. The surface water database included information on watercourses, drainage basins and lakes in Sweden, as well as on the surrounding coastal waters and sea areas.

The Geological Survey of Sweden (SGU) which was the national data custodian for monitoring data (groundwater), developed a GIS application for the presentation of its data sets (http://maps.sgu.se/sguinternetmaps/miljoovervakning/default.htm) [StateOfPlay_2005]

2.5.11 Pressure Portal

(2003) Sweden developed a Pollutant Release and Transfer Register (PRTR) containing information on emissions and discharges of chemical substances and groups of chemical substances from large point sources. The Swedish PRTR was released in May 2003 and was updated with a geographical interface for the public, where they could localize major pollutant sources near their home or workplace.[StateOfPlay_2004]

2.5.12 Geology's Information Center

(2003) The Geological Survey of Sweden (SGU) held multiple datasets such as: the geo-register, bedrock, geology for surface deposits, hydrogeology, geophysics, geochemical, mineral supply, and a bedrock database. The SGU web site was connected to the NSDI and provided database definitions and description (information through discovery services). [StateOfPlay_2004]

2.5.13 County Administrations' GIS-portal

(2004) At the regional level, the county administrative boards made efforts to establish an SDI built on a common network (an intranet called lst-Net). The aim of the GIS service (lstGIS) in this network was to provide access to common databases and also data and information available to the public on the Internet. The Swedish County Administrations GIS-portal (www.gis.lst.se) was maintained by the County Administration West Sweden. It contained:

- ✓ Various ESRI Arc/IMS-based public national and regional Geo-Services
- ✓ Catalogue service - data upload/download, search, metadata display and map preview interface. Contained about 1500 GIS-related datasets produced by the Swedish County Administrations and uploaded them as shape-files. Some of these, about 30 datasets, already were or were in process of being 'harmonized'. These datasets were

continuously merged to national datasets. Most of these datasets were related to environmental issues and were legislative/protected areas (www.gis.lst.se/lstgis/)

- ✓ Links to a few initial ArcIMS MapServices / OGC WMS. StateOfPlay_2005

2.5.14 Geodata's Access to the universities

(2004) With the increased utilization of geodata, it was quickly realized that easy access to data for education and research purposes was needed at a low cost. Between 2004 and 2011, the universities had access to basic geodata for a highly reduced fee through an agreement between the National Library of Sweden and Lantmäteriet. Because of organizational and legal changes, this agreement ceased to be in effect in 2012. (Harrie, L., Larsson, K., Tenenbaum, D., Ridefeldt, H., Lysell, G., Adelsköld, G., ... Sahlin, E. (2014))

2.5.15 Species' Information Center

The Swedish Species Information Centre works with knowledge about biodiversity in Sweden. Their main tasks were to collect, evaluate and store the most important information about threatened and rare plant and animal species. A basic part in this work was to assess the significance and the types of threat and to prepare the national so called Red Lists and Red Data's Books.

2.6 SDI's Content

2.6.1 Reference data

(2005) StateOfPlay_2005

Table 2: Swedish NSDI 2005 – Reference Data

Data at national level	Details
Geodetic reference system	ETRS89 adjustment, SWEREF 99 is a Swedish realization of ETRS 89, RT90 national map coordinate system, RH70 National Height System Permanent GPS beacons provided differential GPS service (SWEPOS)
Administration Units	1:10,000
Geographical Names	The GSD PlaceNames dataset has approximately 450,000 place names
Property rights units	Real Property Register, Cadastral Index map 1:10,000
Property map series (Fastighetskartan)	Orthophoto, Boundaries including property boundaries, Names and register numbers of property units, Place names, Line enhanced planimetric details, Arable land, Contours with a 5-m interval, The national grid
The Mountain Area Map (Fjällkartan)	1:50,000 , 1:100,000
The Road Map (Vägkartan)	1:100,000
Addresses	
Topographic maps 1:250,000	General map + general description General road networks General administrative boundaries
Ortho imagery	(being updated each year for 25% of the Country surface area)
Other	Maps of Sweden; 1:1,000,000 Generalized versions of Sweden including administrative boundaries 1:5 – 1:20 mil. Terrain Elevation database + general description Contours at 5m, 10m, and 25m vertical intervals

Data at national level	Details
	Digital orthophotos Land Cover Data (Corine Land Cover + Swedish more detailed land cover database) The National Road Database Geological database, Statistical data, Agricultural data

2.6.2 Metadata

(2005) There were different metadata catalogues available on-line, either directly on the NLS pages or on the web sites of key players. The Stanli project, a standardization project concerning metadata, had just started. The aim was not to develop a new standard, but to set up implementing rules for the existing ISO 19115 standard and to make necessary adjustments to meet specific Swedish needs.

Lantmäteriet also took part in the establishment of EuroMapFinder – a service being set up by EuroGeographics, the European co-ordinating body for all National Mapping Authorities.

A GeoLex service existed for metadata for the Swedish reference database (available via the NLS web site), and was based on national standards (GINIE).
A separate service (MEGI) existed for metadata on thematic data. The MEGI, or metadata for geographic information was a web based service following the standard CEN 12657. StateOfPlay_2005

2.6.3 Language and culture

(2005) Metadata was provided in Swedish and in some cases, but not all, in English. Accompanying documents for the data and maps were provided. Several of the existing standards, e.g. on road and railway network and hydrology, as well as existing database specifications were also available in English. StateOfPlay_2005

2.7 SDI Technology

2.7.1 Technical framework

(2001) A Lantmäteriet' document provided a number of statements and proposals concerning the continued development of the information infrastructure and the technical systems for the core process Information Services. Its objective was to make the management of Lantmäteriet' basic data more efficient. The following were found in the document (Ollén, 2001):
- separation of systems and data for a) maintenance, and b) for analysis and provision
- a uniform concept for maintenance of data
- a flexible concept for provision of data
- system independent models for all information
- managing data as business objects
- systems development with object-oriented methods and tools
- multi-tiered and object oriented system architecture
- UML (Unified Modeling Language) was utilized for information modeling
- use of metadata and quality requirements
- use of standards from ISO-19100

2.7.2 Access to information

2.7.2.1 Online access – geo processing services

The services for the access to metadata have been already described in the *Metadata* sub-Chapter of this Chapter. Metadata
There were also discovery services for the reference data (e.g. MapSearch and Geographical Data Sweden) on the Lantmäteriet website.

Statistics Sweden contributed to the collection of information that was freely available for users on the Internet. The Internet databases had statistical data on the country, county and commune levels. The data could be used in conjunction with the Internet map server "SCB Maps".
Geo processing services were well supported at the National level.

2.7.2.2 SDI User Applications

- The MakeAPoint application was a geocoding service that allowed the user to get map coordinates for specific objects (e.g. office locations, customers, etc). It was a system in which the client's own specific data could be integrated with geographic data from the NLS over the Internet. Once the coordinates were assigned, the mapping was possible. MakeAPoint allowed the user to retrieve map coordinates in a logical way.
- InstantMap was a separate service that allowed the users to combine standard background maps and other official data with their own data (e.g. customer related data).
- Other customized services included: Landscape models, MapSupport and Rescue services, MapSupport Taxi, Sverige 1000 Professional, Tactile maps.
- Property Search for all. In this service, there was information about the area, the latest prices and tax assessed values for individual dwellings and the second homes. The system could be queried and the answer included an overview map of the relevant property unit. The information was taken directly from the Real Property Register. A search on this database, costed SEK 30 (3.25€). This site had about 10,000-12,000 visitors per month (2001).
- New version of the Real Property Barometer. The combination of the Real Property Barometer and the Property Search for all was an effective tool for following the developments of the housing market (2001).
- Historical Maps offered a large amount of information. It was possible to search through 2,000 old maps and documents: town maps, topographic map series, Economic map series. This site had about 20,000 visitors per month. (2001)
- YourMap service provided customized maps on the Internet. The visitors could choose a map size and a center point of their choice (e.g. a house or any point of interest) and then place an order for only the relevant part of the General Map, the Road Map, the Topographic Map and the Cadastral Index Map. The maps were delivered (as images) either by e-mail or as CD-Roms delivered by the post. Monthly visits to the site ranged from 35,000-45,000 people (2001). StateOfPlay_2005

2.7.3 Interoperability

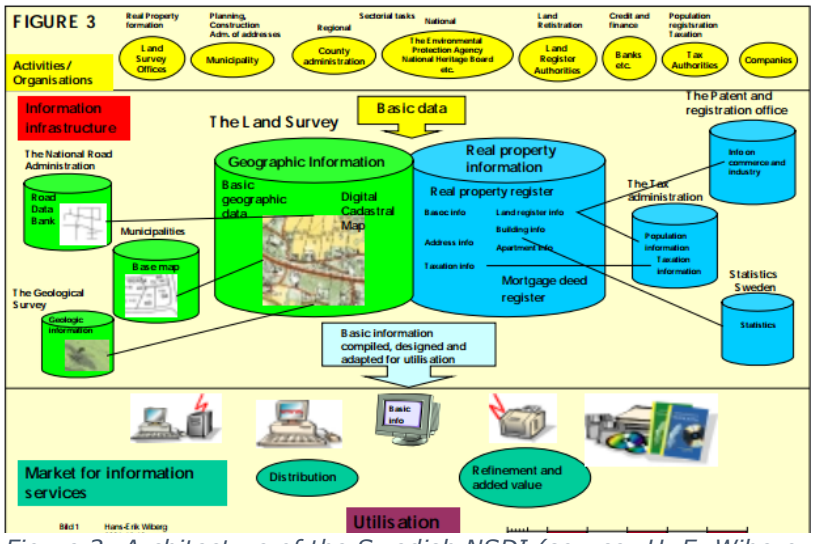

Figure 2: Architecture of the Swedish NSDI (source: H. E. Wiberg, 2002)

(2005) The co-operation between responsible bodies and the commitment to use common standards led to a satisfactory inter-operability. The dissemination of base information, for instance via Internet, and the development of applications by service providers led to a widespread use of the information. The bodies responsible for the activities that created the information, also updated it in the SDI. Within the SDI, the responsible bodies co-operated.

There was an efficient dissemination for service providers and users.
Under Lantmäteriet's coordination, the Municipalities, the County administrations, the National Agencies, the Banks, the tax authorities and private sector's companies participated in the creation and maintenance of the geospatial data.

The Statistics data of Statistics Sweden were georeferenced with building information of Real Property database. The tax administration's data (information about population and taxation) and the Swedish Patent and Registration Office's data (information about commerce and industry) were georeferenced with land register database.

The geospatial information consisted of the Base maps (large scale) produced by the Municipalities, the Road Data database from the National Road Administration, the geologic information form the Geological Survey, the basic geographic data and the digital cadastral maps form the Land Survey. [Wiberg_2002]

The NLS was the first Swedish authority to have a commercial presence on the Internet via the MapStore service. Other available Internet-based services and applications included Property search, SwedeImages and MapSearch. [StateOfPlay_2005]

2.8 Facts and Numbers

(2002) In order to illustrate the costs for and benefits of a NSDI, some figures from the Swedish experience are presented as they were in 2002.
A well-known fact is that the funds needed to build up the databases are the main investment in the SDI. That was also the experience in Sweden. The cost for the build-up of the Swedish Land Data Bank System was estimated to be about USD $ 80 million (94,120,000 €) and for the build-up of the Cadastral Index Map about USD $ 30 million (35,300,000 €).
The program for the development of the databases of the Land Use Map and the Topographic Map were estimated to about USD $ 50 million (58.83M €).
The annual cost for managing the SDI at Lantmäteriet was about USD $ 30 million (35.3M €).
These figures could be compared with some macro-economic figures for Sweden. The total market value for all real property units was estimated at about USD $ 600,000 million (705,900,000,000 €). The total amount of mortgage based on real property was, in December 2001, USD $ 213,000 million (250,600,000,000 €).
The total value of the shares at the Stockholm Stock Exchange Market was, in January 2002, USD $ 296,000 million (348,200,000,000 €). The annual tax for real property, paid to the government was, for the year 2000, USD $ 2,300 million (2,700,000,000 €) and the annual transaction tax for title transfer and mortgages was US $ 470 million (553,000,000,000 €).[Wiberg_2002]

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3 DEVELOPING THE NSDI

This chapter presents the development of multi-sectoral activities. These activities established the "Joined-up Government", transformed the society and prepared the Open Government Era. During this period, the geospatial information became a natural part of the daily life of the people in the public and the private sector. New products and services, and new forms of communication were developed, and used, in even more areas. Trust in, and familiarity with, the geospatial infrastructure became greater. It affected more and more areas of society, from business development, through education and culture, to health and welfare. These developments had political consequences. They formed the basis of, and created the need for, a new geospatial policy that removed any barriers and obstacles from access to the infrastructure by the whole society.

3.1 Transforming the society- the political aspect

3.1.1 Legislative support

(2005) The ministry of Justice was responsible for the Land Registry, which was then transferred to Lantmäteriet by a parliamentary decision in 2005 which took effect from 2007 onwards.

(2006) The Swedish Government appointed the Geodata Advisory Board, which would: a) participate in the formulation of a national geodata strategy for the coordinated provision of information, b) carry out the preparatory work and process questions of both basic and common national interest, c) contribute to the development of a national and international infrastructure by, for example, supporting the implementation of standards, and d) contribute to increased coordination of the activities of involved authorities and agencies concerning the development and provision of information.
In 2006, the Geodata Advisory Board had nine members besides the General Director of Lantmäteriet, who was the chairman. (Development of SDI in Sweden. (2017))

(2006) In summer 2006, the Swedish Parliament approved legislation that officially appointed Lantmäteriet (the Swedish mapping, cadastral and land registration authority) as the coordinator for the Swedish NSDI. Government commissioned Lantmäteriet and the Geodata Advisory Board to prepare a strategy for the development of a national infrastructure for geodata in Sweden. Since then, work was carried out in close collaboration with the Swedish Association of Local Authorities and Regions and a range of other relevant organizations.
The objective of the effort was to maximize the benefit to the society from the geodata that existed in Sweden. To achieve this, the following requirements had been fulfilled:

- the improvement of the efficiency of the processing and making it simple to find and access information
- the creation of the preconditions for increased use of geodata

The harmonization of the information made it possible to exchange and combine geodata from different sources, which is a precondition for efficient collaboration, both between players in the public sector and in the interaction between companies and the general public.

(2007) On October 31st, 2007 Lantmäteriet presented a report listing the changes to current Swedish legislation that would be necessary as a consequence of the implementation of the EC directive INSPIRE. The report concluded that the legislation did not meet the requirements of the directive and recommended that the necessary amendments should be introduced in the form of a special act on infrastructure for spatial information. Current laws in place considered different interests and had other purposes, for example the purpose of giving a right to the public or protecting personal data (e.g. limited access amendment to the Secrecy Act, regulating grounds for limiting public

access, specific laws that dealt with electronic access to datasets which included personal data ought to be modified, definition of general rules on public access to spatial data through network services and electronic data-sharing between public authorities, removal of obstacles which could affect the use of automated applications for the exchange and use of geodata.)

(2009) The metadata and geodata of the NSDI were provided in accordance with the Public and Privacy Act (2009: 400) and were approved for dissemination according to the Act on Protection of Landscape Information (1993: 1742).

3.1.2 National Geodata Strategy

(2007) In June 2006, the government gave Lantmäteriet, along with the Geodata Advisory Board and in consultation with other affected government agencies and the Swedish Association of Local Authorities and Regions, the task of formulating a national strategic plan for the integrated provision of information within the geodata sector. The plan, entitled National Geodata Strategy, was presented to the government on March 30th, 2007 (a revised version was issued in May 2008, and a revision was made in 2012).

The vision for the national geodata strategy, in a 10-year perspective, was that organizations that managed and used geodata in their daily activities should:
– Create increased benefits for the society through a national infrastructure for the provision of geodata based on co-operation across organizational boundaries at the lowest possible price.
– Co-ordinate information resources in a network and make them available via uniformly structured services and descriptions of the information.
– Provide services to public sector administrations, companies and the general public and satisfy demands at local, regional, national, European and global levels.

Eight work packages were identified in the geodata strategy. These were, without any order of priority:
1. The co- operation networks as the basis for the infrastructure,
2. The information structure,
3. The technical infrastructure,
4. The national metadata catalogue,
5. The geodetic reference systems,
6. Research, development and education,
7. The legal framework, and
8. Financing and price models

(Sweden's strategy report for social protection and social inclusion, n.d.)

3.1.3 The Geodata project

(2008) There were clear links between a numbers of the action areas described in the geodata strategy. Those that had the strongest links were included in a common project – the Geodata Project (action in the geodata strategy).

Over a period of three years, the project created a general cooperation model and the technical infrastructure on how geodata and services should be made available to the Swedish society and Europe. Work on the cooperation model included organizational issues as well as contractual, pricing and financing issues. The technical and practical implementation of the EC directive INSPIRE was undertaken within the project. The solution was developed together with other players who were involved in the provision of geodata.

The targets for the project were to: increase the value of the provision of geodata for customers, increase co-operation within and between public's service administrations and

companies, create flexible business processes, decrease the costs for the provision of geodata, increase growth and competitiveness for companies which provide geodata products and services.

The project comprised two parts – cooperation model and technical infrastructure. The technical infrastructure included the development of: a geodata portal, a network for making services available, search and metadata services. (Sweden's strategy report for social protection and social inclusion, n.d.)

The project was divided into three main phases. The first phase, which was completed during the autumn of 2008, focused on the geodata state of play in Sweden in terms of provision, demands and needs. A number of cost benefit analyses, research projects, as well as standardization activities were carried out.

Phase 2, which was completed during the first half of 2009, involved the designing of an architecture for the future business model as well as formulating what was required for the implementation of the model.

Finally, in phase 3, the management organization for the Geodata Portal was established and set up. The completed portal, with a technical solution that functioned together with the business model and administrative routines, operated in 2010.

The Swedish government invested 50 Mkr/year (~ 4.65 M€/year) on the implementation of INSPIRE over three years (2010-2012).
30 Mkr/year (~ 2.79 M€/year) was earmarked for coordination activities, 20 Mkr/year (~ 1.86 M€/year) was designated for public sector authorities that had the responsibility for providing metadata, datasets and services that were covered by the INSPIRE Directive. StateOfPlay_2010

The distribution of the cost was:
- IT infrastructure 6,000,000 SEK (666,600€)
- 259xmetadata 6,000,000 SEK (666,600€)
- 23xdata sets harmonization 700,000 SEK (77,770€)
- 73xDisplay services 4,500,000 SEK (499,950€)
- 34xdownload services 7,000,000 SEK (777,700€)
- 600xreports 300,000 SEK (33,330€)
- Coordination 20,000,000 SEK (2,220,000 €) member_report_2016

3.1.4 E-Government action plan

(2008) The Swedish government intended to increase the efficiency of public sector administration and the accessibility through e-governance. On 17th January 2008, therefore, the government decided on an action plan for e-governance. The government's action plan for e-governance highlighted the implementation of the EC directive INSPIRE and the development of an infrastructure for the provision of geodata as priority issues during 2008. (Sweden's strategy report for social protection and social inclusion, n.d.)

3.1.5 INSPIRE Action plan

An action plan for implementation of the EC directive INSPIRE was carried out. The plan contained the time schedules which should be applied in accordance with INSPIRE, the activities that ought to be carried out in order to achieve the purpose of the Directive and the responsibility for different actions. An important conclusion was that the time schedule for the implementation of the Directive was rather tight. Relevant net services had to be established and metadata had to be created by 2010, at the latest. The information produced by government agencies that was covered by the Directive had to be adapted, or become accessible through the use of transformation services no later

than 2011. This fact highlighted the problem that the involved agencies in this area were dependent on the Directive's implementation rules. In order to be able to follow the time schedule, the agencies had to begin the work before the implementation rules were formulated.

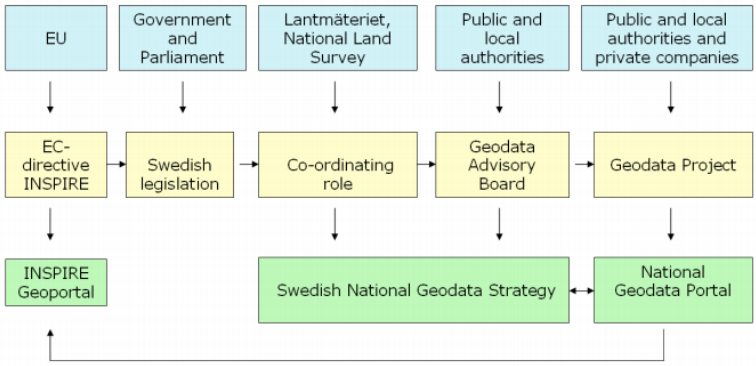

Figure 3: Actors and roles, INSPIRE, NSDI (source: D. Vandenbroucke & D. Biliouris, 2010)

In the INSPIRE action plan there were five players, or groups of players, who, in different ways, had responsibility for the implementation of the Directive. The same group of players was involved in the work with and national infrastructure for geodata: The European Commission, the Parliament and the government, the geodata co-coordinator (Lantmäteriet), the Geodata Project and the Governmental agencies and organizations.

3.1.6 Licensing, Funding and pricing policy

(2009) The pricing model for fundamental geographic data was based on decisions by the Parliament and the Government. There was no delivery of data directly from Lantmäteriet, but requests for information had to go through a system of resellers. The government position was that the real users should pay for the data. The viewing services were decided to be free of charge, but downloading data was charged. Under the 2009 Geodata strategy, priorities with regard to licensing included the development of agreements and licensing and pricing models for geodata.
Lantmäteriet was financed at that time, 20% by government grants and 80% by fees of different kinds. Its turnover was approximately 170 million €. The fees came from three sources: licenses for using data, orders for property information services, and consultancy services.

The work of ULI (Development Council for Geographic Information) was mainly financed by membership fees and by a NLS grant and revenues from conferences and from sale of publications.

Rather limited funds were specifically allocated by the government to establish the NSDI activities. Funds were raised for fostering standardization and for the development of metadata services. The different governmental authorities had, however, spent substantial amounts of money on developing datasets, standardization, establishment of efficient methods for delivering data etc. According to Wiberg, the annual cost for managing the NSDI was around 30 million €. StateOfPlay_2010
The Geodata project contained work on financing and pricing models for geodata, with a priority for models for the data handled via the Geoportal. An important task was to harmonize the different licensing and charging principles.

3.1.7 EC directives with influence to the GI sector

Except INSPIRE, other EC directives and initiatives, such as the Directive concerning reuse of public service information (PSI), the Directive concerning assessment and management of flood risks (2007), Galileo and GMES (Global Monitoring for Environment and Security) influenced the development within the geodata sector.

3.1.8 Open Government Partnership

(2011) Sweden joined the Open Government Partnership (OGP) in 2011. Since then, it published three action plans (2012, 2014, 2016) and reaffirmed its commitment to open government efforts, both in principle and in practice.

3.1.9 Digital First

(2016) Digital First was a governmental strategy, for the digital renewal of the Swedish Public Sector aiming to develop a smart government for welfare and growth. The whole strategy was entitled "Bringing the Citizen to the Heart of Government" (Medborgaren i Centrum) and a road map for zero bureaucracy was established by the implementation plans of the Ministries (Ministry of Enterprise and Innovation, Minisrty of Finance).

3.2 Implementing the transformation

3.2.1 Elips program

(2005) Lantmäteriet (LM) started the Elips program for the replacement of the old mainframe system and the acquisition of a data storage with a SOA-architecture. The system would support new comprehensive processes for the creation, maintenance, exchange, storage and dissemination of spatial data. The storage would also support the information for the buildings, the addresses and the apartments.
The project's secondary objective was to define requirements for the storage and exchange of basic land data for the overall land information process. The work of Elips included the establishment of common concepts and definitions between producers and users; the identification of common information needs, definition of objects and relations between objects; the establishment of system independent models for information exchange and dissemination; and the definition of a common technical interface, e.g. standardized exchange format based on GML.

The program started with an analysis of the processes and roles and the available IT support. LM moved to the implementation phase and started with the migration to Oracle Spatial Database. This replaced the internal proprietary systems and programs. The migration finished by the end of 2008. StateOfPlay_2006

3.2.2 National shoreline

(2005) Since 2005, the Maritime Administration and the National Land Survey have worked on the project National shoreline aiming to build, update and maintain a common and basic version of the Swedish coastline. The goal of NLS was to ensure that the version was updated in accordance with wherever the professional shipping was conducted. Therefore, the project included the addition to the Swedish coast, the Great Lakes and the Canal. Detailed information can be found online (Nationell strandlinje).

3.2.3 Metadata standardization

(2006) As we have seen in previous paragraphs, in the Swedish SDI metadata existed but were not structured according to standards. However, the Land Survey worked on standardization. The Elips program aimed at standardizing descriptions, and a working group on metadata was installed by the GI Advisory Board in the process towards the first version of the National GI strategy. The working group ensured that the standards were developed.

The focus was on ISO 19115. The working group selected 22 elements to use as core metadata and added a limited number of other elements at a later stage. A Swedish translation of the ISO standards was done by technical committee 489 of the Swedish Standards Institute.

In 2006, there was no central geoportal for all GI available. There was only a possibility to query the LM website. [StateOfPlay_2006]

3.2.4 Developing skills, common knowledge base

(2006) In 2006 an educational section within the Swedish Cartographic Society was formed. The aim was to fulfill the need for a common platform for educational matters at all levels, and for increased student recruitment within the areas of interest for the Swedish Cartographic Society, such as land surveying, spatial planning, geography and geomatics.

An important issue that was encountered during the first years of the educational section was the operationalization of the Bologna model in 2007 whose purpose was to upgrade education in the EU member states. Therefore, in an attempt to improve both cooperation between universities and to produce GIS course syllabi in line with the new Bologna rules, the educational section of the Cartographic Society decided to develop a harmonized syllabus template.

The educational section of the Swedish Cartographic Society also arranged an annual conference for teachers at all levels as well as other interested parties. Since 2012, the conference was arranged to coincide with Swedish Map Days every second year, in order to highlight the importance of education at the largest national event within the field. (Harrie, L., Larsson, K., Tenenbaum, D., Ridefeldt, H., Lysell, G., Adelsköld, G., ... Sahlin, E. (2014))

(2008) A program for research, development and education in the geodata sector was prepared. In the program, the focus was on describing needs in the sector relative to the areas of activity which gave priority in the geodata strategy. The following strategic goals were identified:
– The creation of a better national overview and co-operation
– A clarification of where the responsibility for research in the geodata sector was undertaken
– Provide better co-coordinated information about the availability of funds for R&D which supported the geodata strategy
– The development of better international co-operation
– The establishment of a testing environment
– The stimulation of development in the private sector (Sweden's strategy report for social protection and social inclusion, n.d.)

(2010) Lantmäteriet led a project together with the municipality of Västerås with the aim of integrating the use of geodata and spatial analysis in high school education. Since 2010, the national curriculum of geography stated that pupils should develop skills related to GIS, and this was therefore the focus of the project's first phase.

(2012-2016) In response to the increased utilization of geodata and ongoing developments regarding data access, both at the European and national levels (EU directive INSPIRE), the Association of Swedish Higher Education and the Swedish Research Council jointly sought a national solution that ensured that all universities would have continued, easy access to various types of spatial data from the national data producers.

A growing awareness of the importance of geodata resulted in the Swedish Research Council, as part of a national investment in research infrastructure, granting financing for the years 2012-2016. The grant covered data license fees, distribution service development and the assessment of long term solutions. The basis for the

implementation was the cooperation and the development of common national solutions.

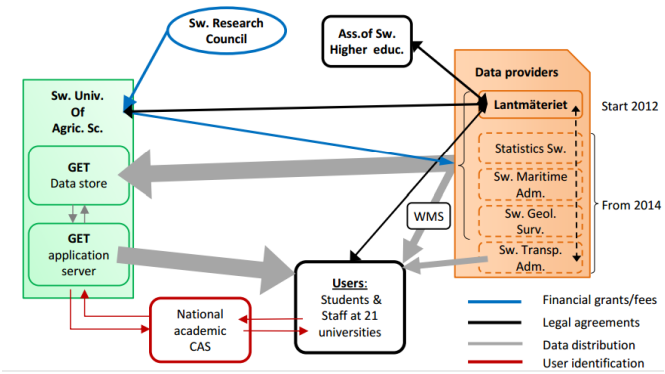

Figure 4: Outline of data provision via GET distribution system (source: L. Harrie et al, 2014)

It was agreed that the Swedish University of Agricultural Sciences would develop and operate a distribution system that would serve all universities. A prerequisite was the utilization of the existing national infrastructure for user authentication to which almost all universities were connected. During the initial two years, data from Lantmäteriet, e.g. digital general maps, elevation data, and aerial photographs were included. The distribution system, GET (Geographic Extraction Tool), was successfully developed and made available in 2012 and the service found widespread use. Other geodata that were incorporated and made available were, quaternary deposit mapping from the Geological Survey of Sweden, hydrographical data from the Swedish Maritime Administration, gridded population data from Statistics Sweden, and the National Road Database from the Swedish Transport Administration. (Harrie, L., Larsson, K., Tenenbaum, D., Ridefeldt, H., Lysell, G., Adelsköld, G., ... Sahlin, E. (2014))

One of the main sources of funding for GET, came from the Swedish Research Council, which contributed approximately 425,000 € per year from 2014-2016. This money financed development work, costs of operation and support, as well as license fees to the authorities that contributed geodata (European Spatial Data Research, 2016).
An interesting report for the use of GET service can be found online (Adelsköld, 2016).

(2014) Hack for Sweden (H4S) is a competition where the participants solve societal challenges with the help of open data over the course of 24 intense hours. H4S is also a unique collaboration among 30 government agencies and organizations that wanted to enable the development of new services and products using their official open data. The event was supported financially by the government and the Ministry for Public Administration. The Employment Service, the Land Survey, the Environmental Protection Agency, the Central Bureau of Statistics, the Swedish Meteorological and Hydrological Institute and the Geological Survey of Sweden were the organizers.

3.2.5 Geodata portal

(2008) The creation of an access point – a geodata portal - for the supply of geodata and associated services, was a main objective in the geodata project. The portal had to meet the requirements that applied for data services in the EC Directive INSPIRE and ought to form the Swedish node of the INSPIRE Community Geoportal. The first version of the portal became operable at the end of 2008 and the complete portal, with a technical solution that functioned together with business models and administrative routines, was operable in 2010.

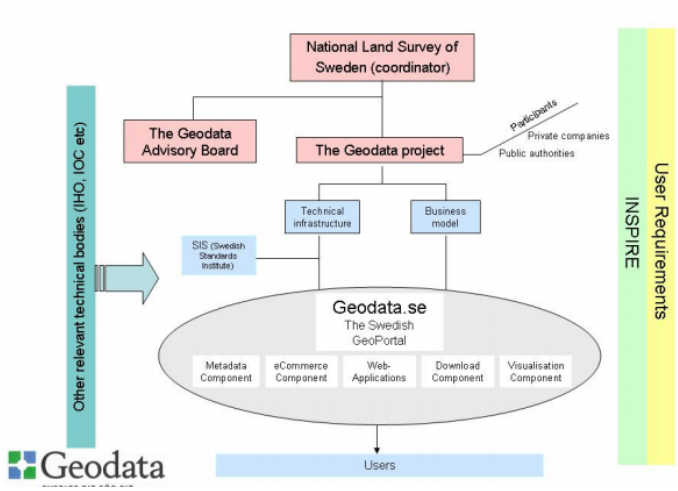

Figure 5 The Joint Geodata Project (source: https://www.iho.int/mtg_docs/rhc/NHC/NHC52/NHC52_8A_Development_SDI_in_Sweden.pdf)

Data and services from at least 16 public authorities were published (135 discovered, 35 downloaded and 46

viewed). The metadata production and access to several services (based on data sharing agreement) was undertaken and data and services were constantly produced for the portal. The available services included services from the Lantmäteriet, the Swedish road administration, Swedish Meteorological and Hydrological Institute, the Geological Survey of Sweden, the National Heritage Board, etc.

With the creation of the national geodata portal, metadata publication by a number of producers became available. Metadata was produced for a significant fraction of geodatasets of the themes of the INSPIRE annexes. According to INSPIRE's report in 2010, 94%, 75% and 68% of the data sets had metadata for the Annexes I, II and III respectively.

3.2.6 National elevation model

(2009) A national elevation model was developed with laser scanning, according to a plan where the requirements for use in climate adaptation and other environmental applications were specifically taken into account. The ambition was that the nationwide elevation model, with a mean error of height that was better than 0.5 m for a 2 m grid, would be completed by 2017.
The new model give valuable information to new areas like transport logistics, forestry and searching for old historical settlements. It has been financed by government grants and have over the years costed around 300,000,000 SEK (30,970,000 €).
Detailed information can be found online (www.lantmateriet.se. (2017). Fakta om laserskanning)

3.2.7 Swedish geoprocess plan

(2011) The project Swedish geoprocess, which took place during the period 2011 - June 2016, was a collaboration between municipalities, SKL and Land Survey. The purpose was to simplify as much as possible, the efficient provision of the Unified geodata. The collaborative project enabled deliveries of future unified geodata, regardless of the administrative boundaries. The aim was to contribute to a simpler and more effective government's services (planning work, property development and construction work management, environmental and crisis management and infrastructure construction). Since there was no common data standard at that time, the project's main task was to collaborate to draft uniform national specifications for some selected geodata - Building, Address, Communication, Hydrography, Land Use, Field Details, Orthophotos and Elevation model.
Detailed information can be found online (www.lantmateriet.se. (2017). Svensk geoprocess)

3.2.8 Cross-border agreements/collaborations

(2011) The **Blue light**-agreement (crisis management services) was signed between the map agencies in Denmark, Sweden, Finland, Iceland and Norway. The agreement gave mutual access to the map data, addresses and location names in a 100 km zone around the borders of each country (PDF1 (Nordisk Avtal, 2011); PDF2 (AVTAL AVSEENDE UTBYTE AV, 2017) of Agreement).

(2012) **Data sharing in the Nordic region** was a collaboration between the Nordic map agencies. The aim was the establishment of methods for the improvement of data sharing between the countries based on the existing services in each country.

One collaboration project called «Harmonized Cross Border Data", was signed in autumn 2016 and is to be carried out during 2017. The goal is to improve cross-border geodata solutions to support all of the actors involved in emergency response.

3.2.9 Blue Light Map

(2014) Land Survey initiated a new project to continue the collaboration to develop a Blue Light Map - a custom dataset with the address and map information from the National Land Survey combined with information about the roads and railways from the Swedish Transport Administration. The aim was to facilitate the emergency operators to choose a better common map support, and thus increase the possibilities of cooperation in communicating on the same, single map, with current data. The project received funding support from the MSB-Swedish Civil Contingencies Agency 2:4 grants program for emergency preparedness.
Detailed information can be found online (www.lantmateriet.se. (2017). Geodata för Blåljus)

3.2.10 Arctic SDI

(2014) The Arctic SDI was a cooperation based on a Memorandum of Understanding signed by the eight National Mapping Agencies from Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the United States, with the aim to produce a tool for better informed decisions and more efficient administration in the Arctic.

3.2.11 Geodata in 3D

(2015) A national framework for 3-D geodata was developed during 2015-2016 by the National Land Survey, the Transport Administration, the Geological Survey of Sweden, the Swedish Maritime Administration, the Swedish Forest Agency and the Swedish Defense Materiel Administration and the City of Gothenburg, Linköping Municipality and the Municipality of Falun on behalf of the government.

In 2017, the authorities and the municipalities in the joint action for geodata in 3D, have a 3D demonstrator for joint visualization of the selected geodata. In 2018, a joint national map display service (e-services + APIs) will be developed for the national geodata in 3D. In 2020, nationwide basic geodata in 3D images -height, depth, topography, geology, roads / railways, buildings and more-, will be available through the API, as well as download services, as it gradually develops.

3.2.12 Hydrography

(2016) According to the plan 2016-2017 for nationwide coverage, the reconstruction of the hydrographic network was underway with a basin at a time. Services that reported this information were described on the product pages Hydrography download and Hydrography Display Inspire. Detailed information can be found online (www.lantmateriet.se. (2017). Hydrografi i nätverk)

3.2.13 National Archives site

(Mid 2016) The National Archives was commissioned by the government to promote all the government agencies' work with making data available for re-use. The portal served as a catalog, in the sense that it was pointing out the data sources and their owners (the portal was not a depository for data). The goal was that the portal should be simple to use, should have clear licenses and conditions, should provide support for that data that can be re-used and should allow sharing of resources and solutions. The geospatial services are described in the National Archives website (Riksarkivet, 2017).

3.2.14 Safe and secure

(2016) Safe and Secure was a three-year collaborative project that developed Norrbotten and Västerbotten municipalities' ability to communicate geodata for cooperation in times of crisis. Digital collaboration placed great demands, especially on the municipalities of the northern regions with major challenges in terms of reduced population and large geographical distances and surfaces. The project aimed to strengthen the capacity of

municipalities, within the geographical area of their responsibility to raise the awareness and the ability to use digital spatial data before, during and after a crisis.
Detailed information can be found online (www.lantmateriet.se. (2017). Tryggt och säkert)

3.3 Cross-strategies development

The development of the geospatial infrastructure must be in connection with other initiatives such as Digital First, the strategy for environmental data management, the Swedish Association of Local Authorities and Regions' framework for open data, the space strategy, the Copernicus data policy, GEOSS Data core, UN GGIM, MIG's working programme for 2016-2020 for continued implementation of Inspire.

4 THE NSDI TODAY

In this chapter the new geospatial policy is outlined. The goals for the establishment of an open government were set and the foundations for the "smart government era" have been prepared. Also, a short summary of the current NSDI status is presented.

4.1 Current status

Sweden today has a national infrastructure for geodata that promotes innovation and growth within industry, enables public sector processes to be digitized and streamlined and actively contributes towards citizens enjoying a good, secure and sustainable living. This infrastructure is an important national asset for social development, and Sweden's geodata is freely available to the whole of society. Geodata is created, administered and made available to the public (290 municipalities and many state authorities) and private sectors within shared frameworks, thus contributing towards openness, availability and combinability.

Knowledge about the opportunities offered by digitization and the benefits of open data is well established among politicians and decision-makers. Significant economic and legal barriers have been removed through regulations and reforms. The fragmentation of public sector data sources has been reduced through a combination of standardization work and establishing national services within the field of data.

Core geodata is open, up to date, national, standardized, of the required quality, easily accessible and efficiently used. More open geodata is needed and a new governmental funding policy is prepared to support the open free of charge data policy.

State and municipal authorities have clearly stated infrastructure assignments that give the public sector and industry access to the best possible data.

4.2 Geodata strategy 2016-2020

The National geodata strategy 2016 – 2020 entitled "Advanced cooperation for open and usable geodata via services", states that the key to success is a long-term approach by the leadership within the work assignment and financing, as well as continuous, highly effective, cross-sectoral national and regional/local cooperation between the public geodata producers and key public and private user groups.

The four most important **goals** during the period 2016-2020 are:

1) **Geodata is open**
   The total fee financing of geodata at state and municipal level is estimated at about 700 million SEK per year (74,480,000 €) In order to encourage development, innovation and entrepreneurship and to achieve increased use of dissemination and social benefit from core geodata, new financing models must be introduced for State and municipal geodata producers, who will enable core geodata to be made available as open data free at point of use.

2) **Geodata is accessible**
   In order for geodata from a public administration to provide full benefit in society, it must be easy to use and readily accessible. Through machine interfaces that are stable, access to geodata should be integrated into different operational systems.

3) **Geodata is usable**
   Through open machine interfaces and appropriate e-services, innovation and easier public and private sector enterprise is made.

4) Cooperation is highly advanced

One important success factor in terms of continued development within the field is that the strategic cooperation between the State, municipalities and businesses takes place across social sectors and at both central and regional/local levels.

4.3 Geodata Advisory Board : Action plan 2017

According to the action plan 2017, eleven activities have been scheduled:

1. To define the basic data in the National Geodata Infrastructure.
   Define which geodata from basic national and municipal mapping should be the basic data in the national infrastructure, as well as propose tools and demonstrate the need for data skills. In order to ensure quality, the proposal must include coverage, dissolution, compatibility, documentation and management of these national base data. The proposal should be based on international initiatives on core data and existing national frameworks, e.g. Swedish Geoprocess, Framework for Geodata in 3D etc. The proposal should also contain solutions for data performance, e.g. how the authorities that produce geodata can increasingly receive, quality assure, manage and access geodata developed by external actors. It should also be stated here which kind of information types are most appropriate to begin with, as well as the usefulness and estimated cost. (Responsible for the action: SGU)

2. To provide developed decision support for open geodata.
   In dialogue with the relevant ministries, the government provides a basis for determining what financial and other measures are required to open such geodata, taking into consideration which are the basic data in the national infrastructure for geodata. (Responsible for the action: Land Survey)

3. Are there any basic data that should not be made open data free at point of use?
   To clarify this basic data, there is geodata that for privacy or security reasons should not be made available as open geodata. (Responsible for the action: Land Survey)

4. Vision, Claim and Prototype on Common National Base Map Service
   Develop a vision, requirement, plan, and prototype for development and management of a single national base map service (API) for open free at point of use base data to be included in the National Geodata Infrastructure. (Responsible for the action: Land Survey)

5. Strategy Dilemma - Forest Data
   Create the prerequisites for ongoing strategic cooperation in the forest sector regarding the geodata supply and the use of geodata. An important goal is to secure access to updated and freely accessible geodata products, such as Forestry basic data, useful for a wide range of users who need good descriptive support for the forest and terrain. Another important goal is to clarify the conditions for joint solutions where the needs of authorities and forest companies are coordinated and possibly co-financed. (Responsible for the action: Forestry Board)

6. Strategy Dilution - Crisis preparedness and blue light
   Create a common strategy for geodata supply in emergency preparedness and blue light operations and ongoing strategic cooperation in the area. An important goal is to secure access to unified, updated and accessible geodata products for a wide range of emergency preparedness and blue light users at national, regional and local levels. Another important goal is to clarify the principles that should be applied to managing privacy for aggregates of geodata which are not separately confidential.

(Responsible for the action: MSB)

7. Strategy Dilution - Green Infrastructure
   Ensure that green infrastructure is an easy-to-use tool for prioritizing social planning. A joint analysis of the design and development needs of the relevant geodata available and presented for green infrastructure (eg new land cover data layers and maps used by county administrative boards and municipalities in summary and detailed planning) should be made and assess how the geodata lives up to the environmental data management strategy. Any obstacles and development areas must be identified and described. Through close cooperation with the planned production of national land cover data, it is ensured that results from the production can quickly and easily benefit from the work of green infrastructure.
   (Responsible for the action: Swedish Environmental Protection Agency)

8. Strategy Dilemma - Geodata for Sweden's coastal and coastal zones
   A national program is being drawn up for mapping Sweden's coastal zones (the coastal zone and the shallow coastal areas with 0-10m water depth). Such a program is needed for the development of coastal and coastal zones and is important for Social planning, crisis preparedness and environmental work, such as flood modeling, erosion mapping, climate adaptation, environmental research, dispersion modeling, habitat modeling, cultural mapping and marine organisms. The program will be a natural continuation of the work on the new high-resolution elevation model that the Lantmäteriet was commissioned to develop across Sweden. The work should be done in collaboration between SjöV, SGU and Lantmäteriet. It includes Regional laser scanning of deep conditions with complementary vessel measurements of shallow water areas (see methodology conducted by the Swedish Maritime Administration and SGU on behalf of MSB). (Responsible for the action: Maritime Administration)

9. A clear picture of initiative / cooperation in the field of social housing.
   Create a combined understanding in the geodata council of ongoing development and cooperation in the field of civil society. (Responsible for the action: Land Survey)

10. How do we interact with the coordination of geodata - environmental data?
    Find forms to strengthen interactions between the geodata council and coordination on the environmental data area. (Responsible for the action: The Swedish Environmental Protection Agency)

11. How can we collaborate on production and production planning?
    Develop working methods for cooperation on planning and implementation of national production of geodata. (Responsible for the action: SGU)

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5 THE FIVE ELEMENTS OF THE NSDI

In this chapter, a detailed description of the five elements of the current Swedish SDI is presented.

- In the Organizational structure the Governance scheme, the political will and support, the accountability to the society, the licensing and pricing models and the partnerships are described.
- A detailed description of the Standards used in the data, metadata and services as well as the business process aspects.
- Resources' skills and qualifications, educational status and support, the ecosystem's participants and the management and professional culture are examined in the People component.
- The Data component includes the themes and the custodians, the metadata, the quality aspects of the whole infrastructure and how all the infrastructure is accessible from the Swedish SDI-Hub, the Geodata.
- The overarching architecture, the technical principles, the interoperability and openness of the spatial data infrastructure and the enabling technologies are cited in the Technology component.

5.1 Organizational

5.1.1 History and key initiatives

All the relative information has been provided in the chapters 2 and 3.

5.1.2 Legislation

5.1.2.1 Georgaphical Environmental Information Act

(2010) The Act (SFS 2010: 1767) aims to create a coherent system - an infrastructure - which makes it easier to access and share digital geodata. The infrastructure should include useful geodata and activities and actions that affect human health or the environment.
The law is implementing INSPIRE Directive 2007/2/EC (2007) and requires all the information of the responsible authorities to be made available to the public. In particular:

- the public is able to search, view and download spatial data over the Internet,
- the responsible authorities should provide metadata and spatial data to each other through data sharing,
- the search and display using the services are free of charge.

The regulation on geographical environmental information (SFS 2010: 1770) regulates:

- ✓ the coordination and reporting,
- ✓ the responsibility of the distribution of information: responsible departments for the information and the data themes,
- ✓ the meaning of information responsibility: services, metadata, security and other conditions,
- ✓ the national and European cooperation, and
- ✓ the voluntary participation.

5.1.2.2 INSPIRE

INSPIRE is a European cooperation for a common geographic infrastructure, rooted in Directive 2007/2/EC. The Directive sets a series of deadlines for when the different parts of the infrastructure will be in place.
The INSPIRE geoportal is accessible from the Swedish geoportal GeoData.

The INSPIRE Implementation RoadMap is shown in the following figure and and the deadlines described in the Roasmap have been met until now.

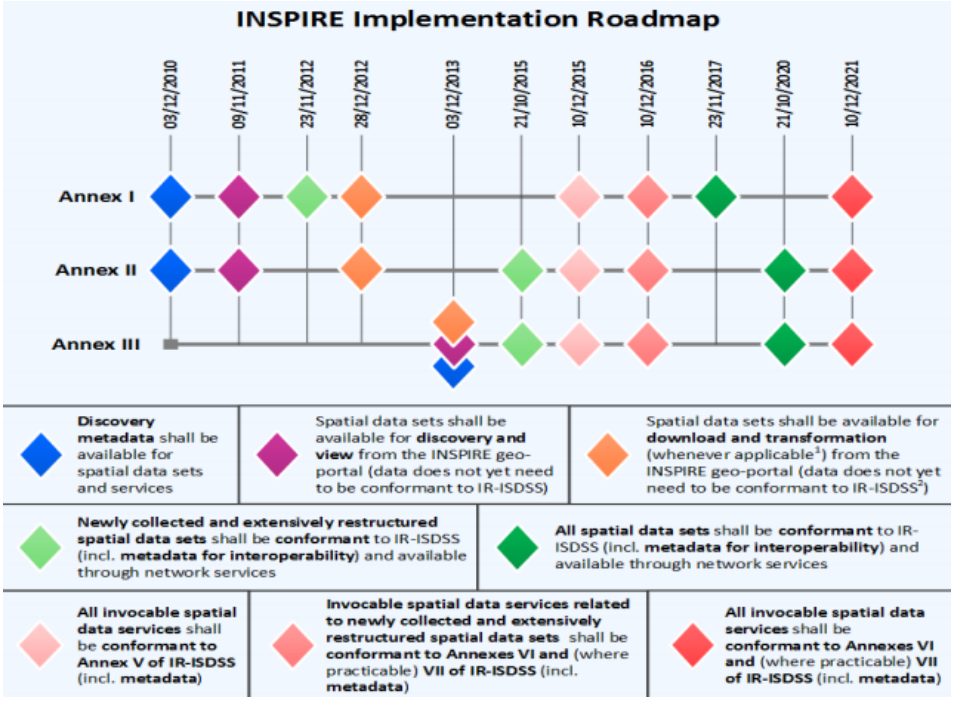

Figure 6: The timeframe for the INSPIRE Initiative (source: M. Östling, 2016)

5.1.3 Governance, support, audit

5.1.3.1 Governance

5.1.3.1.1 Ministry of Enterprise and Innovation (Policy / Strategy)

The Ministry is responsible for matters relating to housing and urban development, State-owned enterprises, information technology, enterprise and industrial policy, rural affairs, regional growth, post issues and infrastructure.
The monitoring of the geospatial infrastructure tasks at the ministerial level and the provision of guidelines for the Geodata Coordinator work are also under the Ministry's responsibility.

5.1.3.1.2 Ministry of Environment and Energy (INSPIRE Policy)

The Ministry is responsible for the INSPIRE Directive implementation in Sweden.

5.1.3.1.3 Land Survey (coordination)

Land Survey coordinates geodata nationally (2006) and is a driving force in the implementation of the National Geodata Strategy. The implementation is based on cooperation between stakeholders. The Geodata Advisory Board has an important role in the work.

Land Survey also coordinates and manages the implementation of the INSPIRE Directive in Sweden. The coordination role involves providing advice and support to the authorities concerned with the infrastructure, manage the Swedish metadata catalog, manage Geodata Portal, develop and manage the interaction model as the basis for an efficient sharing of data between the Swedish authorities. Its responsibility for INSPIRE coordination is based on the regulation on geographical information on the environment (Act SFS 2010: 1770). Land Survey is represented in the ME-C and ME-T (Maintenance Implementation Group - Policy / Technical) and the INSPIRE Committee.

5.1.3.1.4 Geodata Advisory Board (advisory/monitoring body)

The Board provides support to the National Land Survey in its role as national coordinator. The Geodata Advisory Board deals with matters of national interest and

contributes to the development of the Swedish infrastructure including the support in the implementation of the standards. Geodata Advisory Board also contributes to increased coordination between agencies on issues related to information development and delivery of information. The Geodata Advisory Board is appointed by the government and has thirteen members. The Land Survey's General Director is the Chairman of the Board.

5.1.3.1.5 Working Groups/Forums (Support)

The INSPIRE task force is a network of agencies initiated by the Geodata. The Working Group is run by the National Land Survey under the Ministry of the Environment and Energy. The working group includes representatives of the agencies that have responsibility for information under the regulation on geographical environmental information (SFS 2010: 1770).

The INSPIRE working group has formed nine thematic working groups. The groups give the authorities the opportunity to discuss and support each other concerning responsibilities within the same data themes or related data themes.

The Technical Forum is a network of agencies focusing on technology and various types of services in the infrastructure. The forum helps the participants with knowledge, act as a reference base and also participate in different types of testing.

Swedish ME (Maintenance and Implementation Group) is a network for Swedish participants in the various working groups initiated under the MIG process at EU level *(the EC expert group called INSPIRE Maintenance and Implementation Group (MIG) with representatives of the INSPIRE national contact points).*

INSPIRE Nordic region is an informal network of the Nordic contact points of the INSPIRE from the responsible ministries. The group exchanges experiences of implementation in each country, informs and discusses common Nordic issues, both at regional and at European level.

Adenosine is a common technical forum for the Nordic region where users share experiences in the development of the Nordic Geoportals.

5.1.3.2 Audit-Assurance

5.1.3.2.1 Swedish National Audit Office

The Swedish National Audit Office (NAO) is part of the central control power of the Swedish Riksdag (Parliament). It ensures that the Parliament receives a coordinated and independent audit of the State finances. This assignment is unique as the Swedish NAO is the only body that can audit the entire State finances.

5.1.3.2.2 Data Protection Authority (DPA)

The DPA is a public authority. Its task is to protect the individual's privacy in the information society. The DPA works to prevent encroachment upon privacy through information and by issuing directives and codes of statutes. The DPA also handles complaints and carries out inspections. By examining government bills the DPA ensures that new laws and ordinances protect personal data in an adequate manner.

5.1.3.2.3 Lantmäteriet

Lantmäteriet, applies a functional QA process that is integrated into the entire geodata management system.

5.1.4 Policies and licensing

The conditions and charges for the use of the spatial data are different according to the type of usage:

- Commercial processing: the user can develop products or services for sale to other users (some agencies allow commercial processing under CC 4.0 free of charge, detailed information can be found at the pricing paragraph).
- Commercial end-use: the user can use the data for internal business activities
- Noncommercial use: the user can use the data either for personal use (e.g. PC, GPS) or for a nonprofit association's internal operations (voluntary service)
- Use the data in the public sector
- Use the data for research, education and culture

A detailed flowchart of what type of licenses can be used for spatial data can be found online (Almstrom, 2012)

5.1.4.1 Public sector (Geodata Collaboration)

Authorities, county councils / regions, municipalities and organizations with a public task can sign user agreements for geodata. They then have access to a product range of geodata and services for public use (examples of what accounts as public use can be found in the Flowchart), the Examples of public and non-public sectors , and the Municipal activities covered by the license for public use). The product range of geodata contains geodata and services from the Land Survey, the Maritime Administration, the Swedish Meteorological and Hydrological institute (SMHI), the Statistics Sweden (SCB) and the Geological Survey of Sweden (SGU).

The agreement provides access to the geodata for an annual fee and according to the terms, the user receives a non-exclusive, non-transferable, right to use the public data for public purposes use according to the conditions set out below.

- Internally in the public sector
- Enabling transfer of geodata products to third parties, for example in connection with external information and advisory activities directly linked to the performance of public information, for example through e-services on the Internet. The external availability must be adapted to the purpose of its own specific public task. Furthermore, the licensee's own information can be supplied to the geodata product. The functionality and content of an e-service, application or similar is limited to the purpose of its own public task.
- In cooperation schemes between authorities and / or actors with public information or via collaboration with research, education and cultural activities. It is required that all actors involved in such collaboration have their own license for current use.
- The user may grant the right to use geodata to contractors aiming to complete public assignments for the user. The user shall inform the contractor about the terms and conditions attached to the assignment. The contractor is not authorized to transfer rights or to use the rights or the geodata in activities other than the mission.

5.1.4.1.1 Restriction of Use Rights

- The user may not distribute geodata or render unprocessed or processed geodata accessible to third parties in addition to the above.
- When accessing geodata on the Internet, geodata should be displayed in grid form
- The availability of geodata must not be made against payment or equivalent.

5.1.4.1.2 User commitments

- When making geodata available, it should be clearly stated that the data provider according to the Act on Copyright to literary and artistic works has protection of geodata as follows: "© Data Provider".

- The user shall take reasonable steps to prevent the data provider's geodata from being used in an unauthorized way.
- The user shall take reasonable information security and IT security measures during the use of geodata, according to the user agreement for geodata collaboration.
- The user undertakes to notify without delay the Data Provider for third-party claims. A compensation is based on the claim that the data supplier's geodata or geodata services infringe third party's intellectual property rights.

5.1.4.1.3 Data supplier's commitments

If a third party makes a claim or appeals against the user under the claim that the data supplier's geodata or its use in accordance with this agreement infringes the third party's rights, the data provider shall be liable in connection with such claim or such action on his / her own expense.

5.1.4.1.4 Disclaimer

The Data Provider disclaims liability for errors, delays, interruptions or other errors or interference which may occur in the technical operation and, thus, in the availability of geodata unless this is due to gross negligence from the data provider's side. The data provider also accepts no responsibility for errors that may occur due to the technology or software that the user uses to gain access to the geodata product. The data provider also disclaims liability for damage or any other inconvenience that may arise from the use of geodata individually or together with other information. The data provider disclaims liability for errors or changes in geodata since it was delivered / distributed from the data provider to the user.

5.1.4.2 Creative Commons licenses

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This license (2.5, 4.0) means that, the author permits others to use, distribute, redo, modify and build upon its work, even for commercial purposes. Those using this type of license must state the name of the author, when they use the information, process or distribute the author's work.

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5.1.4.3 Licenses for Research, Education and Cultural Activities

Students, researchers, teachers and employees of cultural institutions can access free geodata from several agencies. A license for research, education and cultural activities is however needed to access the data.
Products and services form the Land Survey, the SCB, the SGU and the Maritime Administration are included under this license.
The reference to the source is necessary.
Presently, 22 colleges and universities and 33 schools have entered into this type of agreement. More information can be found online (forskning utbildning och kulturverksamheter; Geodata.se, 2017)

5.1.4.4 Open GeoData

Open geodata can be described in simple terms as geodata that no fees are required for the data to be used, modified and distributed.
352 datasets reported in May 2017 as open data from the geoportal, and 277 as downloadable open data.
Anyone can create a user account, read the terms and to start downloading the open data free of charge.

A useful tool and a maturity model for organizations which want to evaluate their own management of open data, can be found in the ODI Open Data Maturity Model.

5.1.4.5 Internationally

5.1.4.5.1 License for the Norwegian Mapping Authority's products

The Land Survey and the Norwegian Mapping Authority have a cooperation agreement for data sharing that makes it possible to use the Norwegian geodata for public information in Sweden and vice versa. The Governments, regional and local authorities can use freely the following spatial data for cross-border information:
N50 map data (1:50,000), N250 map data (1:250,000), N1000 map data (1:1M), ELVEG / VBASE (National Road Database)
These datasets and services are free and accessed via Map Administration WMS and cache services.

5.1.4.5.2 Nordic geodata for crisis management (Blue Light)

The Nordic mapping agencies (Denmark, Finland, Iceland, Norway, Sweden) have an agreement for data sharing that give rights of use to map data, addresses and place names in preparedness and crisis management in the Nordic countries. The agreement (Nordisk Avtal, 2011) and its Appendix (AVTAL AVSEENDE UTBYTE AV, 2017), aim to be easier for blue light and business actors to execute cross-border operations in the neighboring country using the necessary geodata.
The agreement applies to data sharing across an area covering a 100-kilometer zone from the neighboring country's border. Each Mapping Authority determines whether they choose to allow access to areas outside it.

5.1.4.5.3 Data sharing with EU institutions and bodies

EU organizations and agencies, as well as agencies in other countries have access to free geodata from the Swedish authorities. Fees and conditions are applied when the authorities provide fee-based geodata.

Land Survey has developed contract templates that follow the EU's recommendations for the provision of geodata to EU organizations and bodies. On request, any agency can use these templates to sign contracts.

5.1.4.6 Other terms and conditions

- The conditions of the product's delivery like the licensee's responsibility, the background downloading, the delivery time and the terms of supply can be found online (Lantmäteriet (n.d.). LEVERANSINFORMATION).
- The terms for becoming a dealer of geodata products can be found online (www.lantmateriet.se. (2017). Hur blir jag återförsäljare?.).
- The retail terms for commercial end-use can be found online (Lantmäteriet (2016). SLUTKUNDSVILLKOR KOMMERSIELL SLUTANVÄNDNING).

5.1.5 Funding and pricing

5.1.5.1 Funding

The geodata is financed through:

- government funds
- licensees' own funds
- contributions from parties
- revenues from sales

In the Budget for 2017, the government decided that some national digital services and the exchange of basic data between government agencies should be funded centrally. During 2017, the State will propose a financial charging model for the exchange of basic data between the agencies and local governments.

5.1.5.2 Pricing

5.1.5.2.1 Fee for Geodata Collaboration

The majority of the Swedish information authorities provide their INSPIRE data without fees and many of them refer to the Creative Commons licenses 8 for use of their data. Five information authorities, however, according to the instructions, charge fees. These five agencies are the National Land Survey, Statistics Sweden (SCB), the Swedish Maritime Administration, Sweden Meteorological and Hydrological Institute (SMHI) and the Geological Survey of Sweden (SGU). To allow the sharing of spatial data from these agencies that need to charge fees for their data and services, a geodata sharing model has been created. The figure shows how this model is constructed. member_report_2016

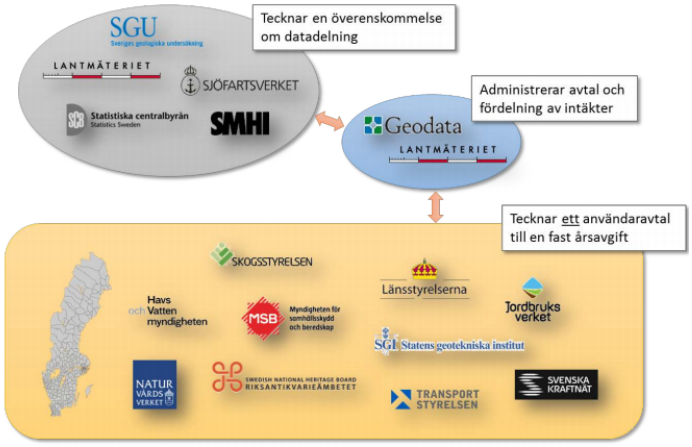

Figure 7: Pricing model of Geodata (gray for fee charged, orange for free) (source: A. Rydén, 2016)

290 Municipalities, 33 government agencies, 21 counties and 3 State enterprise companies participate in the Geodata Collaboration, having the right to use a range of geodata (Peter, 2016) paying an annual fee.

The fee model for the determination of the annual fee is based on parameters. According to these parameters every user is placed in one category where a fixed price has been defined.

There are three common parameters that are used for all users:

✓	**Geographical area of activity**	Factor
	Municipality	0.5
	Counties or larger regions (up to 1/3 of Sweden's surface)	2.0
	National Coverage	4.0
✓	**Benefits from used data**	Factor
	Background Information	0.5
	Needed for the performance of public tasks	1.5
✓	**Needs**	Factor 10

The users are divided into three groups: 1. Municipalities, 2. County councils/Regions and 3. Agencies / State Enterprise Companies.

Every group has specific parameters based on the urban area, the population density, the municipal area and the population. Multiplying the specific parameters' factors by the common parameters' factors results in a category factor and a corresponding category.

Every group has its own categories and different fixed prices in every category.
A detailed description (user groups, parameters and categories) for the fee model can be found online (Geodata, 2016)

The total fee in 2017 prices is **77,955,700 SEK** (8,052,824€), consisting of:
-The total annual fee for municipalities in 2017 prices is 59,226,800 SEK (6,118,128€)
-The total annual fee for Counties in 2017 prices is 7,376,900 SEK (762,034€).
-The total annual fee for the State Enterprise Companies is 6,482,000 SEK (669,591€).
-The total annual fee for the Government Agencies is 4,870,000 SEK (503,071€)

In the fee model, one factor for the agencies is determined according to the agency's turnover (of previous year; in abnormal cases of an annual turnover an average turnover from 2-5 years' period is calculated). The turnover of each Authority is calculated based on the following rules:
- The amount from user charges for public operations is counted
- The amount from the grants is counted
- The revenue from business or non-business activities which are irrelevant with public tasks is excluded
- If one authority receives appropriations which are not used in their own activities but finance activities of other authorities, this amount of appropriations is excluded
- If one authority receives financing from other authorities for activities relative with public tasks, this amount is counted
- The turnover form abroad activities is excluded

5.1.5.2.2 Prices for commercial use

The agencies have their own pricing models for their products.
The Swedish Meteorological and Hydrological institute (SMHI), the Geological Survey of Sweden (SGU) offer open data with licensing terms as specified in the Creative Commons Attribution 4.0 SE license.
The Statistics Sweden offers open data and an API providing access to any table or part of table from the Statistical Database.
The Maritime Administration offers open data and fee based data (Depth Data price list, charts (Sjofartsverket.se, 2017, a)).
The Land Survey offers open data and fee based data. The pricing model depends on the type of usage of the data, and the pricing model includes:

- lowest fee 500 SEK per year (51.4€), maximum fee with alternative choices
- fee for the service and data charge
- different prices for view or/and download

- in images, the number of pixels determine the price
- decreased prices for extensive use

Detailed information about the terms, conditions of use and prices can be found online (Lantmateriet.se, 2017).

5.1.6 Partnerships

(2009) The participation to the infrastructure of the National geodata is voluntary, under the INSPIRE and the Law and the regulation of the Geographical Environmental Information. The Swedish national and local authorities can sign either a collaboration or a contribution agreement.

- The Geodata Cooperation Agreement regulates a sustainable cooperation within the spatial data infrastructure. It presents how to handle organization, steering, coordination and responsibilities as well as technical prerequisites, forms of supply and terms of use of spatial data. The parties in the Geodata Cooperation Agreement offer each other their spatial data for official use on payment of an annual fee.
- The Geodata Contribution Agreement offers all actors that fulfill basic requirements the right to publish metadata and make their spatial data products available via the Swedish national Geodata Portal. A condition for contribution is that metadata should be described according to the national metadata profile. Metadata should also be of public interest and well adapted to its purpose. To join as a contributing partner is free of charge.

The agreement document can be found online (Lantmäteriet, 2010).
Information about partnerships, exist in previous paragraphs (Partnerships, Arctic SDI, Cross-border agreements/collaborations)

5.1.7 Evaluation & Benefits

5.1.7.1 Evaluation & Monitoring

The Swedish government requires evaluation of the national geodata strategy. This is undertaken through annual reports issued by Lantmateriet or special reports based on cost/benefit analysis.
No framework with defined KPIs has been found during the study for the evaluation of the infrastructure.

The monitoring of the infrastructure is made through the following:
- The INSPIRE list of dataset and services kept by the NSDI unit at Lantmäteriet
- The Geodesy Department at Lantmäteriet requests all public sector organizations to report on the status of the implementation of the new Swedish reference systems, SWEREF 99 and RH 2000, each year
- Satisfaction surveys of geoportal users
- reports on the number of public sector authorities and municipalities that have signed the agreement to cooperate and share data according to INSPIRE and national geodata strategy
- automatic KPIs measurement for geoportal's services

5.1.7.2 Market value

One goal proposed by the new geodata Strategy for 2016-2020, is to open more data (free of charge) and to achieve this, central funds will be included in the State's Budget for 2018. The Market size of geodata in Sweden is not found during this study but a reference is made to an EU study for the 28 countries.

Open geodata promotes innovation and entrepreneurship, and this is confirmed by investigations and surveys from the Land Survey, the European Commission's "Creating Value Through Open Data" (Tinholt, 2015) study, and a survey conducted by users in June 2016. It is estimated that Direct market size of Open Data is 55,3 billion EUR for 2016 and is expected to grow by 36,9% by 2020 in the EU 28+"

5.1.7.3 Benefits from the infrastructure

An attempt to estimate the benefits from the establishment of the NSDI was done by the Land Survey in 2014.
The calculations of the benefits were based on standard assumptions, as in the following example: All data and services are described with metadata in the Geodata Portal. Assuming that all signed agreements for geodata (which was 192 pieces in 2014) saves an average of two days of work per organization, and time to search, find and access geodata, it gives a saving of around 10,000 per use organization year, or about 1.8 million SEK in total: [16 hours * 590 SEK / hour. * 192 parties = 1,812,480 SEK / year] (196,560 €)
The whole calculations are shown in the following table:

Table 3: Estimated benefits from the establishment of the Swedish NSDI (source: W. Carrara et al, 2014)

RESULT	Observed Benefits	Benefits Accrue	Description	Estimated value (SEK)
Geodata is well described and the descriptions are integrated in one single catalog - Geodata Portal	*The data necessary for business has become easier to find and evaluate*	*The entire Geodata sector*	Saved time to find and evaluate the data for those who signed agreement geodata	1,800,000 (196,560€)
	Reduced and simplified administration of contracts	*Geodata producer and user*	simplified contractual actions, the administration of contracts, billing etc. for all for those who signed a geodata agreement	6,600,000 (720,720€)
Only an agreement needs subscription to get access to geodata from 18 authorities called - a fixed annual fee	*Simplified budgeting for purchases data to an organization*	*geodata User*	Time saved for special priorities and negotiations for the purchase of data - for users in geodata	1,600,000 (174,720€)
	Simplified internal management Geodatabases of the municipalities	*geodata User*	Time saved for internal annual budgeting, coordination of purchase of data etc. simplified for users in geodata	6,200,000 (677,040€)
Geodata is possible to combine	*Less time is required for the adaptation into a business*	*The entire Geodata sector*	Saved time for adapting data to their own activities - based on the ones that signed agreement geodata	1,800,000 (196,380€)
Geodata provided through standard services	*Efficiency of operation and IT environment*		Reduced storage costs data, GM services. Here based on the double storage of Lantmäteriets	6,500,000 (709,800€)

RESULT	Observed Benefits	Benefits Accrue	Description	Estimated value (SEK)
			orthophotos and savings of 15 municipalities	
Forums and venues for experience has created	*Increased cooperation between different actors*		Reduced costs by consulting experience and technical cooperation. 5 days per year, for 10 authorities.	400,000 (43,640€)
Geodata from the source instead for copies of geodata used (updated direction and Current data)	*Faster handling times with safer and more accurate decisions*	*The entire Geodata sector, Business, Individuals, Geodata collaborations*	Based on one million private individuals Are prepared to pay 1 kr per year for faster processing ("existence value")	1,000,000 (109,200€)

5.2 Standards Component

5.2.1 Introduction

The Swedish Standards Association (SIS) is a collaborative organization for the three Swedish standardization organizations: the ITS (Swedish Information and Telecommunication Standardization), the SEK (Swedish Export Credit Corporation) and the SIS (Swedish Standards Institute).

The SIS works to develop and manage standards and guidelines within the geodata area. The work on setting standards takes place in technical committees (TK). Within these committees, Swedish experts work with the development of national and/or international framework standards, application standards, technical specifications, reports and manuals. There are various technical committees in the SIS for different geodata teams and areas; Road and rail information, overall management of geodata (e.g. data quality), water systems, location addresses, metadata, physical planning, building information, forestry Information and web cartography.

SIS is a member and representative of Sweden in the European standardization body CEN and the global organization ISO. Until today, it has published more than 18,000 standards in a number of areas. In 2017 has 1,700 member-companies, 14,000 customers and sales about 262 million SEK (28,300,000 €, 2015).

Sweden also has been active in the development of Standards within ISO 19100 series for several years and arrives at year-end 2017 also to have an even more important role in it. From 2017, Sweden will hold the chairman and the secretariat of the ISO TC/211.

SIS follows mainly ISO and CEN. A decision from SIS is required for an ISO standard to be a national one. CEN standards automatically become national standards.

Following an overview of the used international (ISO, CEN, OGC, W3C) and national standards developed from SIS; the following standards are given, classified in specific areas of interest. (Paasch and Rydén, 2016)

5.2.2 International Standards

5.2.2.1 General

5.2.2.1.1 Basics, rules and overview

The following standards from ISO/TC 211 are published also as Swedish standards:

ISO 19101-1	Geographic information - Geodata Reference Model
ISO 19101-2	Geographic information - Image Reference model
ISO/TS 19103	Geographic information - Conceptual schema language
ISO/TS 19104	Geographic information - Terminology
ISO 19110	Geographic information - Methodology for feature cataloguing
ISO 19118	Geographic information - Code Rules – Encoding
ISO 19146	Geographic information - Cross-domain vocabularies
ISO/TR 19122	Geographic information / Geomatics - Qualification and certification of personnel
CEN/TR 15449	Geodata infrastructure report

5.2.2.1.2 Interfaces, UML, XML, filters

ISO 19106	Geographic information – Profiles - Profile of schedules, rules and guidelines for adaptation
ISO 19118	Data Exchange Coding Rules, XML Interfaces
ISO 19156	Observations and measurements
ISO 19136	GML, XML vocabulary for geographic information

5.2.2.2 Geographic objects and vector geometry

5.2.2.2.1 Basics, rules and overview

ISO 19103	Modeling, language for data writing schedules
ISO 19109	Modeling, Application Schedule Rules
ISO 19110	Cataloging
ISO 19126	Feature concept dictionaries and registers

5.2.2.2.2 Interfaces, UML, XML, filters

ISO 19107	Geometry and topology, model for spatial aspects
ISO 19108	Time aspects, model to describe
ISO 19125-1	Architecture for handling simpler objects
ISO 19136	GML, XML vocabulary for geographic information
ISO 19137	Core profile on spatial aspects
ISO 19141	Motion, schedule of phenomena in motion

5.2.2.3 Interface technology

5.2.2.3.1 Basics, rules and overview

ISO 19119	Service Interface, Framework for Software Developer
ISO 19125-2	SQL Interface, Specification for Object Management
ISO 19128	Web Map Server, Interface to Map Server

5.2.2.3.2 Interfaces, UML, XML, filters

ISO 19117	Portrayal (User Interface, Schedule for Data Visualization)
ISO 19142	Web feature Service (Service Interface)
ISO 19143	Filter encoding - Questionnaire for selection

5.2.2.4 Metadata, Quality and Data Specifications

5.2.2.4.1 Basics, rules and overview

ISO 19105	Conformance and testing - Compliance Test
ISO 19113	Data quality-Principles for classification of quality
ISO 19115	Metadata

ISO 19131	Specifications of geographic data product
ISO 19135	Object register, procedures for registration
ISO 19149	Rights expression language for geodata - GeoREL

5.2.2.4.2 Interfaces, UML, XML, filters

ISO 19115	Metadata
ISO/TS 19139	Metadata - XML schema implementation
ISO/TS 19139-2	An XML schedule for implementation Of ISO 19115-2
ISO/TS 19135-2	Procedures for item registration - Part 2: XML schema implementation

5.2.2.5 Reference system and positioning

5.2.2.5.1 Basics, rules and overview

ISO 19111	Coordinate-based reference system
ISO 19112	Non-Coordinated Reference Systems, (ref by geographic identifiers)
ISO 19119	Service Interface, Framework for Software Developer
ISO/TS19127	Geodetic codes and parameters
ISO 19132	Location-based services, reference model
ISO 19144-1	Structure of the classification system

5.2.2.5.2 Interfaces, UML, XML, filters

ISO 19116	Position services, Interface
ISO 19133	Navigation and tracking
ISO 19134	Multimodal routing and navigation

5.2.2.6 Sensors and images

5.2.2.6.1 Basics, rules and overview

ISO 19101-2	Image Model Reference Model
ISO 19117	Schedule for visualization of data (portrayal)
ISO/TS 19129	Framework for image and raster data

5.2.2.6.2 Interfaces, UML, XML, filters

ISO 19115-2	Metadata for raster data
ISO 19123	Surface geometry, schedule
ISO/TS 19130	Imagery sensor models for geopositioning
ISO/TS 19130-2	Part 2: SAR/InSAR, LIDAR and SONAR

5.2.2.7 Reference models, Frameworks

ISO 19145	Registry of representations of geographic point location Specifies the process for establishing, maintaining and publishing registers of representation of geographic point location in compliance with ISO 19135
ISO 19147	Location based Services – Transport modelling - Transfer Nodes It is applicable for transport infrastructure owners and operators when defining and/or describing their transport infrastructure and for transport-related Service Providers when providing information to travellers and others. It is limited to the transport of persons and is also limited to the static getting-on and getting-off points. The main focus is on transfer nodes being part of public transport networks, that are located in road networks, but this International Standard is also applicable for transfer nodes in rail networks and in air and sea transport networks.
ISO 19144-2	Classification systems - Part 2: Land Cover Meta Language It specifies a Land Cover Meta Language (LCML), expressed as a UML meta-model that allows different land cover classification systems to be described based on the physiognomic aspects. It provides a common reference structure for the comparison and integration of data for any generic land cover

classification system, but does not intend to replace those classification systems.

ISO 19150-1 Geographic information - Ontology - Part 1: Framework
Specifies a framework for the semantic interoperability of the spatial data

ISO 19150-2 Geographic information - Ontology - Part 2: Rules for developing ontologies in the Web Ontology Language (OWL)

ISO 19152 Land Administration Domain Model (LADM)
A Standard that defines a schedule for both the administrative and the technical aspects of surveying the land registry and other data that regulate various actors' rights and obligations in relation to geography. The schedule is divided into five packets of persons, property, rights, land surveying and geometry. It describes how to mix the areas expressed as 2D and 3D geometry.

ISO 19153 Geospatial Digital Rights Management Reference Model (GeoDRM RM)
It defines how rights management (DRM) for geographic information resources, such as databases for the Web, are to be managed and expressed digitally as well as the demands placed on the systems involved.

ISO 19154 Ubiquitous public access - Reference model
It defines a reference model for ubiquitous public access (UPA) to geographic information. This reference model uses standard concepts from the Open distributed processing — Reference model (RM-ODP)

ISO 19155 Place Identifier (PI) architecture
It specifies an architecture that defines a reference model with an encoding method for an identifier of a place. The concept of "place" within ISO 19155:2012 includes "places" not only in the real world, but also those in the virtual world. These "places" are identified using either coordinate identifiers, geographic identifiers, or virtual world identifiers such as URI.

ISO/TS 19158 Quality assurance of data supply
It provides a framework that enables a customer to satisfy itself and its suppliers, both internal and external, that they capable of delivering geographic information to the required quality. Fundamental to the framework is the assurance of the supplier's ability to understand and meet the quality requirements. Through the quality assurance framework both the customer and the supplier are able to consider the quality required at the earliest opportunity in the production/update process.

5.2.2.8 OGC standards

OpenGIS Web Feature Service (WFS) Implementation Specification WFS 1.1.0 standard is still used in many server and client implementations.

WFS 2.0: OpenGIS Web Feature Service 2.0 Interface Standard and ISO 19142: 2010. An OGC and an ISO standard, which is required by INSPIRE through technical guidance documents. WFS 2.0 requires GML 3.2.1 or later by default (NS-EN ISO 19136:2009).

OpenGIS Filter Encoding 2.0 Encoding Standard and ISO 19143:2010.
Filter Encoding is an OGC and ISO standard.

5.2.3 National Standards

The following National Standards will be replaced with international ones, according to the Swedish policy on standards.

5.2.3.1 Application-specific standards

5.2.3.1.1 Basics, rules and overview

SS 637006 Generic representation of geographic phenomena
SS 637007 Representation of changes in data sets
SIS/TR 23 Development Methodology

(This technical report (TR) describes the methodology to develop interface specifications for the exchange of primary geodata. The methodology, however, is also applicable to other types of data, such as e-government).

SIS/TR 25 Handbook of spatial aspects and time aspects

SIS/TR 28 Manual identifier
(This technical report recommends methods for encoding, generation, registration and handling of common, persistent identifiers for spatial data in the national and European infrastructure for geodata.

5.2.3.1.2 Interfaces, UML, XML, filters

SS 637003 location Address
SIS/TR 33 Handbook Location Addresses
SS 637004 Road and rail networks - Conceptual and application schema
SS 637008 Surface water systems - Rules for national applications and for the INSPIRE hydrography theme
SIS/TR 22 Manual surface water system
SS 637040 Detailed development plan - Application schema for regulations
SIS/TR 14 Metadata in Swedish
SIS/TR 24 Application Schedule Handbook and GML

5.2.4 Data

5.2.4.1 Models and relevant issues

The modeling of geographic information in Sweden is based on the standardized methods from ISO/TC 211. The Framework document recommends for the parties in "Geodata collaboration", to use model driven architecture (MDA), a model defined by OMG (an international, open membership, not-for-profit technology standards consortium, founded in 1989) thus ensuring portability, interoperability and reuse. The XML Metadata Interchange (XMI) standard is used for the exchange of UML models between different platforms and tools (ISO/IEC 19509:2014).

5.2.4.1.1 General Feature Model

ISO 19101-1:2014 describes the theory that a data model, being a key part of a language for discourse, is tied to a community of practice, and must be developed and governed by that community. This is the notion of interoperability and the standard sets the fundamentals by which this standardization takes place.

ISO 19109-2015 defines the rules for creating and documenting application schemas, including principles for the definition of features. It introduces the "General Feature Model" (GFM), using a series of UML class diagrams for the details. The feature instances within the GMF are primarily typed by their conceptual significance within the application-domain (e.g. measurement, borehole, geological boundary, mine).

Advantages of this approach are that:
- semantics, rather than the representation, are primary
- the feature instance carries the type of the feature, rather than its package (e.g. the host layer), thus allowing flexible packaging
- a feature may have more than one geometry associated with it, either representing different spatial properties of the feature implementing different representations of a property (e.g. at different scales, or using different geometry models such as triangulation and grid for surfaces)

Information models (application forms) based on the GFM emphasize the conceptual significance of the data, not just its structure.

The General Feature Model is a model of the concepts required to classify a view of the real world. The Conceptual Schema Language UML that is used to represent the conceptual schema of spatial data in INSPIRE, has its own meta-model. As explained by ISO 19109, both the General Feature Model and the UML meta-model deal with classification, as thus the concepts are very similar. Still, there is one important difference: the concepts in the General Feature Model establish a basis for the classification of spatial objects, whereas the UML meta-model provides a basis for classification of any kind.

5.2.4.1.2 Coverage Model

ISO 19123:2007 defines a conceptual schema for the spatial characteristics of coverages. Coverages support mapping from a spatial, temporal or spatiotemporal domain to feature attribute values, where feature attribute types are common to all geographic positions within at the domain. A coverage domain consists of a collection of direct positions in a coordinate space (defined in terms of up to three spatial dimensions as well as a temporal dimension).

Examples of coverages include raster, triangulated irregular networks, point coverages and polygon coverages. Coverages are the prevailing data structures in a number of application areas, such as remote sensing, meteorology and mapping of bathymetry, elevation, soil and vegetation. This International Standard defines the relationship between the domain of a coverage and an associated attribute range.

5.2.4.1.3 Modelling and encoding

ISO 19103:2015 provides rules and guidelines for the use of a conceptual schema language within the context of geographic information. It describes, 1) a profile of UML to be used for application schemas, including some restrictions on the use of optional elements of UML, 2) some base types to be used in models (Measure, ScopedName, Record, Any, Integer, etc)

ISO 19107 specifies the aforesaid for spatial schemas including topology.

Two standards, address the issue of encoding geographic information in XML. ISO 19118:2011 presents a general methodology and a number of options, some of which are based on the use of WXS (W3C XML schema) as the intermediate conceptual schema language. ISO 19136:2009 for Geographic Markup Language (GML) is a detailed XML implementation of the GFM. Rules for mapping GML to and from UML models are carefully described in Annex E and Annex F of ISO 19136. These rules can be applied providing the UML follows the profile described in ISO 19103.

5.2.4.1.4 Object Catalog

When defining an application schema using the GFM, the key aspect of the schema is the Catalogue of Feature Types for the application domain.

ISO 19110:2016 describes a general method for describing the feature-types in a feature catalogue. Procedures for maintenance and update of definitions of items of interest are described in ISO 19135-1:2015, along with a register model for hosting.

ISO 19126:2009 brings these principles together in a "profile" of feature-type catalogues hosted in a register, and also extends the model to dictionaries of property types. Extracts from catalogues from several application domains are given.

5.2.4.1.5 Product specification

ISO 19131-2008 describes the requirements for the specification of geographic data products, based upon the concepts of other ISO 19100 International Standards.

According to the standard, a product specification contains general identification, description of the content and structure of the data (application form in the form of an implementation-independent and platform-independent UML model), a description of the reference system, quality, delivery information and description of the format and coding on the supplied metadata.

5.2.4.1.6 Interfaces and formats

Follows a number of essential interfaces for access and formats for exchanging geodata in the infrastructure.
GML (3.1.1, 2.2.0), WMS (OGC v 1.3, 1.1.1), WMTS (OGC 1.0), WCS (OGC 1.0), SOAP (1.1, 1.2), GeoJSON (1.0).

5.2.4.1.7 Character set

The default character set encoding for all data in all kinds of deliveries is UTF-8.

5.2.4.1.8 Provision of Data

The data sets are distributed to the responsible organizations. The geodata portal contains only links to these data.

5.2.4.1.9 Useful Documentation

- ISO/TC 211 Geographic Information / Geomatics – Standards Guide (International Organization for Standardization, 2009)
- Technical FrameWork (Geodata, 2016) Version 2016
- Data on standards (Geodata, n.d.) Version 2016
- Standards and standardization of geodata (Paasch and Rydén, 2016) Version 2016
- Report Web cartography (Swedish Standards Institute, 2015) Version 2015
- Object Types Catalogue (Swedish Standards Institute, 2010) Version 2010
- SIS-TR 22: 2008 Surface Systems – Manual
- SIS-TR 33: 2010 Location Addresses – Manual

5.2.4.2 Coordinate systems

The national geodetic reference systems SWEREF 99 and RH 2000 has good interoperability with both its immediate neighbors, like the rest of Europe.
The introduction of SWEREF 99, the realization of the European reference system ETRS89, took place in 2007. The practical work with the introduction of SWEREF 99, at both the national and local authority level, is still in progress.

The new height system RH2000, related to the European height system EVRS, was formally adopted in 2005. The practical work with the introduction RH 2000, at both the national and local authority level, is also in progress.
Interactive services are provided by the Land Survey for transformation of coordinates or computation of geoid models through different Swedish reference systems.

Land Survey holds the responsibility for the national reference systems: SWEREF 99 in three dimensions and on the plane, RH 2000 in height and RG 82 for gravity.

According to the Swedish recommendations (Lantmäteriet, 2013), the following reference and coordinate systems should be supported by the display services:

Table 4: Reference and Projected Coordinate Systems of Sweden (source: Lantmäteriet, 2013)

Reference Systems					
Name	ESPG	Name	ESPG	Name	ESPG

	code		code		code
SWEREF 99	4619	ETRS89	4258	WGS84	4326
Projected Coordinate Systems					
ETRS89 / ETRS-LCC	3034	ETRS89/ ETRS-LAEA	3035	ETRS89 / ETRS-TM 32	3044
ETRS89 / ETRS-TM33	3045	ETRS89/ ETRS-TM34	3046	ETRS89 / ETRS-TM35	3047
SWEREF99 TM	3006				

5.2.5 Metadata and Services

5.2.5.1 National Metadata Profile

The National Metadata Profile contains the metadata elements which are necessary to document the portal's published Geodata resources, including the metadata elements required by INSPIRE. The profile has been developed by the Swedish Standards Institute (SIS) Technical Committee for Geodata Metadata (SIS / TK 489) in cooperation with the Geodata Secretariat, Land Survey, and is primarily a national application of SS-EN ISO 19115: 2005 and SIS-CEN ISO / TS 19139: 2009, Metadata - Implementation with XML Schema.
From 2010, the profile SS-EN ISO 19115:2005 Version 3.1.1 has been used and it is valid until 2020 (Technical Guidelines for INSPIRE Metadata implementation based on EN ISO 19115 and EN ISO 19119 version 1.3.)
From autumn 2017 (as expected to be completed by SIS), the profile SS-EN ISO 19115:2005 Version 4.0 will be used. (Technical Guidance for the implementation of INSPIRE dataset and service metadata based on ISO / TS 19139: 2007 Version 2.01 - published 2017-02-03)
The above two profiles are valid in parallel during the transitional period (2017-2020).

5.2.5.1.1 Types of metadata

According to the guidelines for metadata there are three main types of metadata (boundaries between them are not accurate, so there may be some overlap):

- Descriptive Metadata is metadata that is primarily intended for humans to read (title, summary, keywords, responsible organization)
- Technical Metadata is metadata that is automatically read by computers to improve automatic communication between systems (Connected Resources, Online Link Protocols, Identifier for Resource, Identifier for Metadata Amount)
- Administrative Metadata is metadata that is needed for the management of metadata and to describe metadata in a way that facilitates automated communication (Metadata Standard, Metadata Language, Metadata Contact, Character Set)

In the geodata infrastructure in Sweden, the term "resources" is used for datasets, Series (series of datasets with similar properties) and services.

The National profile includes the following categories of items:

- General Information (language, contact, date, standard, Resource, UUID)
- Resource Description (title, alternative title, date. Status. Contact, identifier, language, extension text, extension geographical, extension vertical, extension temporal, subject matter, summary, sample image, initiative, service rating, spatial representation, resolution, interconnected resources, service type)
- Restrictions (usability limitations, access restrictions, utilization restrictions, security restrictions)
- Data quality (extent, lineage, conformity)
- Maintenance of the resource (maintenance)
- Reference system (spatial reference system)
- Provision of the resource (distributor contact, format, online source)

More detailed information can be found online (Geodata, 2017).

5.2.5.1.2 Metadata profiles and standards

- ✓ ISO 19115 (SS- EN ISO 19115) is a nationalized model for GI metadata, in particular dataset metadata. The standard specifies a schema for information that describes one or a series of geodata amounts or an IT-based geodata service. The standard is very flexible and allows for someone to make separate descriptions involving arbitrary parts or aspects of a data set or a service (metadata scopes), example data of a particular object or data on a specific geographic area. The standard also specifies how to add theme-specific metadata. The metadata includes reporting of data quality.
- ✓ SS-EN ISO 19119 defines various forms of architecture and service interface for geographic information. It complements also ISO19115 metadata elements for services.
- ✓ SIS-CEN ISO/TS, SIS-ISO/TS 19139, is an XML encoding rule (gmd) developed for implementation of 19115, covering also the raster data.
- ✓ SIS-TR 14: 2008 A complement to ISO:19115 standard in Swedish
- ✓ OAI-PMH: Open Archives Initiative Protocol for Metadata Harvesting. Protocol harvesting metadata between directories
- ✓ Thredds Data Server: A Web server that provides metadata and data access for scientific data, using a variety of external data access protocols. Can be used for harvesting metadata between directories

5.2.5.1.3 Publishing metadata

5.2.5.1.3.1 Publishing via the online web editor

With this option, a user can log into the Geodata Portal and create or edit existing metadata records. The Geodata Portal provides a web form where all the elements of the national profile can be edited. This can be useful for smaller organizations or organizations during the start-up of the metadata work.
To publish metadata in the Geodata Portal, you need to register as a publisher for your organization. The whole editing and publishing of metadata can be undertaken in the following publishing interface.

5.2.5.1.3.2 Publication via the directory interface CSW

Harvesting
If an organization has its own catalog with metadata that conforms to the CSW, this directory can be harvested by the National Geodata Portal. The metadata must meet the requirements of the national metadata profile. Normally this is undertaken by setting up metadata in a directory service as standard CSW (Catalog Service Web) while the Geodata portal is configured to read this directory service. The use of a CSW catalog has the advantage that facilitates the capability to make the metadata available to multiple portals. Combining CSW catalog with the publication via CSW-T, provides a more direct feedback in the portal, in such a way as, when a new resource is created to become directly visible in the portal.

Charging via CSW
Metadata can be published via the service interface CSW-T. Metadata can be sent to the portal from external applications. To be published by CSW-T, a user account in the Geodata portal is required (Geodata.se, 2017. Support).

5.2.5.1.3.3 Uploading XML files

The Geodata Portal allows one to manually upload the metadata. The metadata must follow a specific XML Schema (ISO19139) and meet the requirements of the national metadata profile. Metadata is created in the agency's own environment and after that, a form from the Geodata Portal can be opened. Through this form, the metadata file is loaded into the Geodata Portal and is available for search.

5.2.5.1.3.4 Publishing to the Open Data portal

The Open Data portal (Oppnadata.se, 2017) serves as a directory that automatically collects open data sources in Sweden from the public sector and other organizations. For this to work, the organizations need to make use of data portals that works with metadata (DCAT-AP), such as the open version CKAN.

The Data Catalog Vocabulary (DCAT) is an RDF vocabulary designed to facilitate interoperability between data catalogs published online. The DCAT-AP Manager is a tool to create and manage descriptions of catalogs and datasets of standard "DCAT application profile for the data portals in Europe". The tool developed by Meta Solutions AB and provided free of charge on dcat-editor.com.

CKAN is a powerful data management system that makes data accessible – by providing tools to streamline publishing, sharing, finding and using data. CKAN is aimed at data publishers (national and regional governments, companies and organizations) wanting to make their data open and available.

5.2.5.1.4 Search for Metadata

Geodata is the main national metadata source where searching of metadata for datasets, and services is available. Geodata also provides the capability to display WMS services in a map window, download data and has links to other applications.

Another application to search the directory, is a standard interface for computer to computer searches. This interface is called CSW (Catalog Service Web) and runs the version CSW ISO API 2:02.

5.2.5.1.5 Useful documentation

Useful documents in the context of metadata, are:

- ISO/TC 211 Geographic Information / Geomatics (International Organization for Standardization, 2009)
- Technical guidance for metadata (Geodata, 2017)
- Guide to metadata (Geodata, 2017)
- National metadata profile (Swedish Standards Institute, 2017)
- Object Types Catalogue (Swedish Standards Institute, 2010)
- Status report of the national metadata profile (Swedish Standards Institute, 2015)
- Inspire Metadata (Dimos, 2008) and Implementation Rules (Drafting Team Metadata and European Commission Joint Research Centre, 2010)
- Technical Framework – Development Methodology SIS-TR 23: 2009

5.2.5.2 Services

5.2.5.2.1 INSPIRE services

According to INSPIRE, there are a number of types of geodata services. These include, inter alia, search services, viewing services, download services, conversion services, and connection services. The requirements for the services which are covered by the INSPIRE's themes and thus follow the INSPIRE's framework are described in the Guidelines for Display (Geodata, 2013) and Download (Geodata, n.d.) Services.
According to the Technical Guidelines, the services can be published to the Geodata portal are of a different nature.

- **Network Services**: (Discovery (CSW), Display Services (OGC: WMS), Download Services (OGC: WFS, Atom), Transform, General Web Services (SOAP, REST))
- **Invocable** Spatial Data Services

5.2.5.2.2 Display services

Display Services is often synonymous with WMS services. The interface offered in the Web Map Service (WMS) standard [ISO 19128 WMS 1.3] simplifies the creation of infrastructures for geographic data from local to global level. The standard's simplicity would easily bring users into the distributed thinking, e.g.to use services and data from different providers in the same tool.

WMS is an ISO standard. Open Geospatial Consortium (OGC) have also prepared:
- the specification of Styled Layer Descriptor (SLD), which enables users to expand capabilities of WMS
- the Web Map Tile Service (WMTS) Implementation Standard (OGC WMTS 1.0.0), which complements the WMS standard, providing a standard based solution to serve digital maps using predefined image tiles.

For all the WMSs which are accessible in the Swedish infrastructure and via the Geodata portal there are some national requirements to be met. These national requirements also apply to the WMSs which are provided according to the INSPIRE specifications. These requirements are:
- A WMS must be able to respond to a GetFeatureInfo call
- Signatures are needed to understand the graphical representation of the geodata which are included in the services (Legend)
- The MinScaleDenominator and MaxScaleDenominator items must be defined
- When WMS are displayed in a map component, the geodata must be presented according to the supplier's symbol set (WMS cartography)

More detailed information can be found online (Geodata, 2016) and (Swedish Standards Institute, 2015).

The display services support the following image formats: PNG, GIF (without compression), JPEG and TIFF.

5.2.5.2.3 Download and instant access Services

The services for direct access are mainly based on standards from the W3C and the OGC. Service interfaces based on Web service technology using the SOAP protocol and object types in many cases are constructed using GML (Geography Markup Language) to describe their geographical features.

Download Services is a collection of services that allows users to transfer data in their original form either as predefined files (file downloading) or through asking mechanisms to extract information from data sets. A predefined amount of data can also be a subset of data in a database accessed via a Predefined (Stored Query) query.
Until the full implementation of INSPIRE (2020), the format does not need to be a GML 3.2.1 format, so the alternative formats like GML 3.1.1, Shape, Tab-Mapinfo, Tiff or GeoTiff can be used.

The Technical Guidelines document recommends that the following existing standards must be used at the implementation of download services:
• Atom syndication formats (Atom) for services with predefined data sets
• Web Feature Service (WFS), primarily for direct access services, but it is also possible to use WFS for predefined data sets
• A "Hybrid solution" (hybrid implementation) where Atom is used for the compulsory download operations and WFS for the volunteers

Web Feature Service standard (WFS 2.0 OGC/ISO 19142:2010) describes how a download service (WFS) will produce and distribute geographic vector data. The standard is based on the geographical information distributed in GML format. The specification

must be seen in conjunction with Filter Encoding Standard (ISO 19143:2010), which describes in more detail how various filter queries can be set up and formulated.
Although WFS services are classified by INSPIRE as download services, WFS-Transactions (WFS-T, ISO 19142) can also upload, update and delete geographical objects.

To implement INSPIRE regulation 1088/2010, an alternative to the WFS is the Atom Feed download service. Atom feed is an international standard, recommended by INSPIRE which meets geodata legal requirements for download services. Atom feed is based on Web standards: Atom Syndication Format (ASF) (IETF RFC 4287) and Atom Publishing Protocol (APP) (IETF RFC 5023). The ASF is XML-based and describes the contents and the structure of a feed while the APP describes mechanisms to send, create, modify and delete feeds via HTTP.
Download services created with atom, provide great flexibility in the ability to package different files for an individual data set. The package can be done with different formats, different reference areas and different geographical origins, without having to create new metadata records for each file.

The Technical Guidelines document describes only WFS services. Web Coverage Services (WCS) are not described in the document, but are used in the infrastructure. The purpose of the WCS specification is to make available "coverages" or surface-covering matrix data, representing one or more phenomenon variation in space, via http - protocol. The WCS specification has been developed by OGC (WCS 2.0 Interface Standard - Core, 2010). The standard provides access to the underlying data and can be used to publish 2D and 3D raster data. In addition, data sets being distributed, should have time information so that the service can deliver raster from a given time. The Technical document in near future, will provide guidelines for the OGC Sensor Observation Service (SOS) and the Linked Data.

The POWDER – the Protocol for Web Description Resources- is used as a mechanism to describe and discover Web resources and helps the users to make a decision whether a given resource is of interest. A complex, semantically rich variety, called POWDER-S is used for semantic web searches.

5.2.5.2.4 Other Services

Services that are not display or download services, according to INSPIRE's definition of network services (such as REST or SOAP), are developed by the organizations with the relevant responsibility, according to the Law and the regulation on the geographic environmental information. There are different levels of documentation available for these services. Description of these requirements is provided in the Technical Guidelines (TG) for metadata (Geodata, 2017) and the National Metadata Profile. (Swedish Standards Institute, 2012)

5.2.5.2.5 Documentation of services

The basic principles for documentation of services according to ISO and OGC as well as the technical guidelines of INSPIRE, are:

- Both the service and its underlying data must be documented.
- Must be able to access the metadata of the service directly from the service
- Metadata of the data should be accessible from the service

According to the technical guidelines, the following alternatives can be used to document the services in Swedish infrastructure:

5.2.5.2.5.1 ISO

ISO19115 has primarily been developed to document data sets and maps. Within the area of standardization of geographic information (ISO191xx), secondary standards have been developed e.g. ISO19119 describing services from a general perspective. ISO19139

is an XML schema for uniform encoding of XML files that are suitable for both ISO19115 and ISO19119. With these standards, it is acceptable to describe the data and services from a general perspective.

5.2.5.2.5.2 OGC

Parallel to ISO, the Open Geospatial Consortium develops standards. Examples of these standards are GML, CSW, WMS and WFS. WMS is the kind of service that is highly focused today in the Swedish infrastructure and is also available as an ISO standard ISO19128 (WMS 1.3). According to the WMS, a WMS service documenting its properties in the Capabilities document. There are, in principle, two partially overlapping ways to document a WMS service.

- ISO19115 / ISO19119 / ISO19139
- WMS GetCapabilities

There is no ideal solution. INSPIRE has defined an extension of the elements (called extended capabilities) which can be specified in the Capabilities document. It solves some problems but it will still be an overlap in the documentation which is created.

5.2.5.2.5.3 W3C

There is also a third standardization body (World Wide Web Consortium) accounting for many communications standards on the Internet. W3C has defined a type of metadata description (WSDL - Web Service Definition Language) for services. This is a general XML format not only for the geographic services. This is the format normally used for the documentation of general web services via SOAP 1.1 HTTP and GET / POST. In relation to ISO19139 and WMS capabilities, this is a more technically oriented format that describes how the call to a service should be done and what answers it returns. WSDL is a format most used by the traditional developers, compared to the more GEO specific ISO19139 and WMS capabilities. A challenge in the future is to be able to manage these overlapping specifications so that the information is not managed in several places.

More detailed information and examples can be found online (Geodata, 2017).

5.2.5.2.6 Useful documentation

- ISO/TC 211 Geographic Information / Geomatics (International Organization for Standardization, 2009)
- Guidelines for download services (Geodata, n.d.)
- Guidelines for view services (Lantmäteriet, 2013)

5.2.6 Business process aspects

5.2.6.1 Committees

World Standard ISO 19100 forms the basis for the technical framework of the spatial data used in Sweden. The SIS / TK 323 Committee for Geodata is the hub of the SIS various committees for geodata extensions and aims to coordinate the need for standardization of geodata. The Committee also produces various technical reports that support the development of a national infrastructure for geodata. The committee's task is to influence the development of the ISO 19100 standard and to support the Swedish implementation. The Committee creates a forum for Swedish action in international standardization, by actively participating in both the European and international standardization bodies CEN and ISO.

The SIS/TK 489 Committee works to develop support and guidance on the metadata Swedish players must use to manage geodata. The committee's work helps:
-Swedish players who manage geodata to be supported for metadata management
-the benefits of using metadata to be established and clarified

-metadata to be registered in accordance with set / developed guidelines
-the development of compatible tools for metadata
-it becomes possible to compare data from different sources
-it becomes easy to find the data originator's information
-it becomes easy to get started with standardized metadata

The Committee has published two reports:
• National metadata profile - Specification and Guidance Version 3.1.1
• SIS TR 14 Metadata in Swedish

Internationally, the Committee participates in ISO/TC 211 and influences the design of the metadata standard ISO 19115. The Committee received expertise from representatives of public organizations, software vendors and consultants. The work of the Committee, provides participants with a deeper understanding of the area. The participants are also involved in shaping the future of standards, which also leads to new insights and early information that can be put into the organization's operations and business development. It also creates opportunities for skills development, networking and personal development of the participants.

5.2.6.2 Access, Authentication and Security (GeoRM)

It is becoming more common that organizations do not operate all the applications themselves. SAAS (Software As A Service) means that the applications are not operated internally, but by an ASP (Application Service Provider) or moved to the cloud.

5.2.6.2.1 Recommendations about access control

When providing services across organizations it is necessary to take into account the authentication process. The following requirements have been set for the authentication solution:

- to be standardized and cross-platform
- to handle "cloud services"
- to handle Single Sign On (SSO)
- user information and passwords to be stored in one place but not necessary the same place
- for the services, user authentication must be provided

5.2.6.3 Quality assurance and control

Quality-assured data and services is the core of the "GeoData collaboration". This requires quality control of all aspects of the infrastructure, from the overall coordination between different services and portals to the underlying technology.

Data and services are implemented according to the standards and should comply with the compliance requirements, as they are described in these standards.

5.2.6.3.1 Data quality according to the product specification

Principles for describing the quality of geographic data and specifying components for reporting quality of ISO 19113 and ISO 19115 have been revised by ISO 19157, but the current TGs (technical guidelines) are not based on this revision.

Data quality of geographic datasets is divided into five categories: completeness, Location Fixing Accuracy, Attribute Quality, Accuracy of timing and Logical consistency (how well rules primarily in the product application form, are met). The first four quality criteria describing the relationship between the data set and the reality and the last one describe the relationship between the data set and application form. The table below explains the relationship between quality categories and quality objectives

SS-EN ISO 19131:2008 requires that the product specification shall specify the Data Quality Requirements based on quality objectives.

Table 5 Quality criteria for the data

Category	Quality element
Completeness	• Missing data • Excess data
Attribute Quality	• Non-quantitative attribute Correctness • Quantitative attribute Accuracy • Thematic classification Correctness
Location Fixing Accuracy	• Absolute External Positional Accuracy • Relative Internal Positional Accuracy • Position Accuracy in raster data
Accuracy of timing	• Time validity • Time Consistency • Time Accuracy
Logical consistency	• format Consistency • domain Consistency • conceptual consistency • topological consistency

For a specific dataset, you can specify one or more quality reports.
The quality report can be of two main types:

- ✓ Quantitative: As a quality control of the dataset is made, the quality results can be presented. For example, a quantitative quality report can mention: -A database containing 97% of all actually occurring events (confidence level).
- ✓ Qualitative (Specification Fulfillment): The quality control of a dataset is made, but the metadata reports only that the dataset meets the set claims. The actual outcome of the quality checks is not reported in metadata.

The Metadata model for products is defined in EN ISO 19115. The metadata that is required, must always be included in a delivery of a dataset. Metadata should be coded according to ISO/TS 19139:2007 Metadata -XML Implementation, should be current and updated continuously by the publishing Organization. The Geodata Coordinator initiates an annual review and quality control of the metadata. Any deficiencies should be addressed by the organization that publishes metadata on the Geodata portal.

5.2.6.3.2 Tools for Services

Web service interoperability compliance for SOAP based services should be ensured using test APIs for example Soap UI. This is an open source API testing tool for SOAP and REST APIs, offering SOAP Web Services functional testing, REST API functional testing, WSDL coverage, message assertion testing and test refactoring.
For testing the requests of all the operations of the SOAP based services, SOAP UI or WcfTestClient (.NET) is recommended for use according to the Framework document.

The use of services included in INSPIRE and in the national infrastructure for geodata is reported by the respective responsible organization to the Land Survey. The routine queries and reporting support is provided by the geodata coordinator.

5.2.6.3.3 Recommendations on the availability of the services

In terms of availability, the Technical Guidelines defines the following requirements and recommendations:

- The availability is measured by placing at least 10 requests per hour to a service throughout its life.

- It is recommended that the same types of queries used in the performance tests to be used for the accessibility tests.
- The availability of the services applies to 99% of the time of every day and the evaluation of this requirement is done on a year basis (3.63 days per year is the upper limit being inaccessible). For the download services, only unplanned shutdowns should occur in this time period. Planned downtime must be notified at least a week in advance and is not included in this time.

5.2.6.3.4 Recommendations on the Performance of the services

The technical guidelines (TG) document, describes a set of requirements and recommendations for how the benchmarks should be implemented. In summary:

- Performance is measured by setting at least 10 requests per hour, to a certain service. It is recommended that new measurements are made every month in connection with system maintenance.
- It is recommended that the requests made, shall be (download services): 10% for the Get Download Service metadata issues, 10% for the Describe Spatial Data Set or the Describe Spatial Object Type and 80% for the Get Spatial Data Set or the Get Spatial Object. At least 2% of the requests will be for the Get Spatial Data Set. The TG document provides also a number of detailed examples of performance tests.
- It is recommended that under normal conditions (90% of the time) for an image of 470 KB (eg 800 × 600 pixels with a bit depth of 8 bits) the response time for sending the answer to a Get Map request for a viewing service, may not exceed 5 seconds (display services)

5.2.6.3.5 Recommendations on the capacity of the services

For the capacity tests, the TG document defines requirements and recommendations for what to test:

- The capacity is measured by placing 10 new requests every second for a minute, but with a maximum of 50 simultaneous queries. This should be done at least once before a new service is accepted into production. It is recommended that new measurements be made every month in connection with system maintenance.
- It is recommended that the requests made shall be (download services):10% for the Get Download Service metadata issues, 10% for the Describe Spatial Data Set or the Describe Spatial Object Type and 80% for the Get Spatial Data Set or Get Spatial Object. At least 2% the requests will be for the Get Spatial Data Set.
- According to the criteria for service quality performance, the lowest number of view service requests expedited at the same time shall be 20 per second.

5.3 People Component

5.3.1 Lantmäteriet

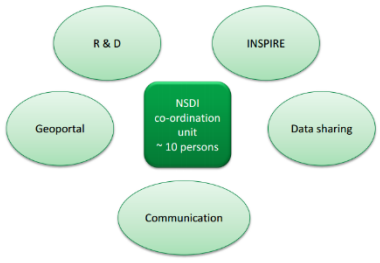

Figure 8: The NSDI unit 5.3.1 of Lantmäteriet (C. Wasström, 2014)

The NSDI co-ordination unit in the Land Survey consists of about ten people in the fields of data sharing, R&D, Geoportal, communication and INSPIRE.

The average salary per month for women and men is 34,152 SEK (3,633€).
Total employees are 1997 people, 1143 women and 854 men.

In the core competence category, basic grade staff total 1,313 people, in the management competence 189 people and in the support competence 495 people.

In 2015, the withdrawals of the permanent employee were 220 people with average age of 47.5 years while external recruitment of permanent employees were 238 people with average age of 34.9 years. Staff turnover: 11.26%

Figure 9: Staff Turnover and Competence Types (Lantmäteriet, 2016)

The total revenue from GI was 71,400,000 € in 2016, 72.7M € in 2015 and 70,000,000 € in 2014.
The revenue from appropriations was 29.1M € in 2016, 28,800,000 € in 2015 and 28,700,000 € in 2014.
The revenue from fees was 41,000,000 € in 2016, 42,400,000 € in 2015 and 39,100,000€ in 2014.
Revenue from other activities was about 1,500,000€ per year.
Expenses in 2016 was 73,500,000 €, in 2015 70,600,000 € and in 2014 70,300,000 €.

5.3.1.1 Relationship with third parties

The Geodata Secretariat works actively on behalf of research financiers and decision makers with a view to establishing a strategic basis for how research and development within the spatial data sector is to be enhanced in the future. An action program has been drawn up which highlights the importance of increased cooperation between universities, institutions of higher education, industry and stakeholders in the public sector, as well as an increase in research funding within the sector. One step towards increased cooperation is the establishment of a national research and development forum.

An action program has also been drawn up for education within the spatial data sector, focusing on INSPIRE-related matters. The matters concern the continuing training of professionals within various sectors who use the infrastructure or whose work involves its implementation. The action program also deals with how matters relating to the infrastructure for spatial data can be integrated more clearly into relevant courses at universities and institutions of higher education.

The Geodata Secretariat also has contacts with the ULI Geoforum [ULI: the Swedish Development Council for Geographic Information], in particular in the area of education and the provision of skills. The ULI Geoforum is a national association and a forum within the area of spatial data and geographic information technology and has nearly 200 members from among public authorities, municipalities, county councils, companies, institutions of higher education and other organizations. Lantmäteriet's regional spatial data coordinators are an important resource for the Land and Geographic Information Division at regional and local level. Their task is to promote the further development and increased use of spatial information and property information within society, particularly in the municipalities. The municipalities are also represented in the Geodata Advisory Board and the INSPIRE working group via the Swedish Association of Local Authorities and Regions (SKL). Member_report_2013

5.3.1.2 R&D activities

(2008) Forskningsprogram is a 4-year R&D program in the Geodata field, focusing on the following areas: Geovisualization and webcartography, Information structure and semantics, test lab Geotest and coordination of services. The program was funded with 20,000,000 SEK per year (2,110,000 €). (Ridefelt, 2011)

(2015) One of the targets in Lantmäteriet's research strategy is that four industrial doctoral students should carry out research within the areas prioritized in the national geoadata strategy. The final doctoral student was appointed in 2015, and this target has now been met. The doctoral students were linked to KTH Royal Institute of Technology, Lund University's Faculty of Engineering, Lund University and Uppsala University (Annual Report 2015, 2015).

5.3.2 Users, providers and administrators

Main users of the Swedish SDI are the government agencies, the municipalities, the county councils and State-owned companies. Public enterprises and municipalities use the geographic information every day in their planning as the basis for providing their services and making better decisions. Through their collaboration since late 2011, they are also the producers of the large part of the existing geographic information, and have realized the benefits for them and the society.

The private companies, if they wish so, can publish metadata in the Geodata Portal, and provide data in accordance with the standards used by other players. Private companies are not currently assisting the Swedish infrastructure for geodata but receive an indirect benefit of the infrastructure when they, in turn, work on behalf of the State authorities and municipalities. Many agencies also use the help of the private sector in order to harmonize the data and publishes the services as INSPIRE prescribes.

A survey from the R&D coordinator of the Geodata secretariat in consultation with the SKL, (2012; (Geodata, 2012)), shows that users from the public sector need further education in some areas. 200 from 205 municipalities and 17 Authorities with information responsibility have participated with their answers. The majority of respondents have stated that there is a need for education within most of the surveyed areas. In total, only 14% of the authorities and municipalities had no particular need of training (4% for the Authorities and 15% for the municipalities).

According to the survey:
Within the Authorities there is a major need in these areas: Metadata of Geodata, INSPIRE and geodata collaboration, Data specifications
Within the municipalities there is a major need in these areas: Metadata of Geodata, Geodata portals, INSPIRE and geodata collaboration, standardization issues, data specifications, the technical infrastructure.

The users need (results from the 2016 Lantmateriet's users' survey (Delredovisning av uppdraget Effekter och konsekvenser av öppna data, n.d.) are included):

- open free of charge data to develop map solutions without the need for immediate revenue, background maps in GIS applications, various environmental reports, opportunities to use data instead of Google Maps for positioning purposes, mapping applications on the municipality's website, GIS analysis of ecological relationships, develop mobile applications, facilitate the development of public and commercial services,
- more data (in 3D and Building Information Models (BIM) formats)
- updated and accurate data to rely on

The Administrators ask for a national GI knowledge base, which meets the important social needs and helps them to make even better decisions. They expect more participation from the private sector and the society (crowdsourcing), and business development. To achieve this, they ask for more Open – free of charge data.

Private business uses geographic information in various digital products and services. Value creation based on geographical information is significant, but the potential is still much higher.

5.3.3 Resources in infrastructure

Senior managers and principal officers, innovators and experts from different disciplines having some geomatics background and project managers for merging processes are the main resources needed for a successful geospatial strategy. The well-established governance and coordination scheme support, safeguards an effective implementation of this strategy.
These main actors coming mainly from the public sector, shall also share the same vision which stems from their role: "the nation to be a leader in e-government services for the benefit of the society"

5.3.4 Skills and qualifications

A prerequisite for a good utilization of the geographic infrastructure is knowledge at all levels - both about opportunities and challenges. The use of geographic information is changing in line with the available technology, but the lack of user skills to facilitate the data usage, can be an obstacle for a good utilization of the data and services. A broad cooperation on a national level to boost knowledge in the field is required to support the future technologies. The education sector has a central and long-term role in this context. Economists, lawyers, Land surveyors, ICT Engineers, Civil and Environmental Engineers, Urban planners, Natural Resource Management specialists, Geographers and Cartographers are mainly involved in geospatial information projects.
Expertise in the following fields are necessary: Geomatics, human geography, physical geography, photogrammetry and laser scanning, intelligent 3D models via internet and geo-apps, geodesy and GPS, nature management and outlying management, cartography and field mapping, satellite and aerial images analysis, 3D terrain models, nature environmental health, landscape modeling, project management.

5.3.5 The industry's voice - Competence

Competence to the geodata industry, tops the list of challenges for both private and public actors.

Here is some of the ULI Geoforum Sweden feedback in the area of competence:

- The use of geodata and geographical IT is an important factor in the development of society and the impact of skills shortages could be significant.
- There is great potential for new and growing companies in the industry. With skills shortages, there is a lack of enough potential and Sweden is losing competitiveness in an area which is important for growth and prosperity.
- The need for skills is changing and the focus now is on skills that can contribute to new ways of working, providing access to new tools to manage and analyze data such huge volumes of collected data, the so-called Big Data.

The goal of the Forum concerning the skills is: to encourage more graduates to train to match demand in the geodata industry, and to achieve this, the requirements are:

- courses designed for the geodata industry's needs, for today and tomorrow
- the courses to have strong appeal and get more applicants than today.

The Land Survey also need surveyors and Urban developers, predicting the need of hundreds in the future. Statistics show that college and graduate engineers in Urban Development and Land Surveying are highly sought after. Today unemployment in this area is less than 1%.

5.3.6 Education

5.3.6.1 Universities

GIS courses, Bachelor and Master's programs in Geospatial IT can be found in the following universities and disciplinary sectors:

- ✓ University of Gothenburg
  Department of Earth Sciences, Department of Human Geography
- ✓ Dalarna University
  Geography I , Geography II (given remotely by distance learning)
- ✓ Gävle University (HiG)
  Lantmätarprogrammet, Master of Science in Geomatics, IT / GIS - Information Technology with GIS specialization, Urban and Regional Planning, also has courses in surveying, geographic information technology and SDI (Spatial Data Infrastructure).
- ✓ University of Skövde
  Ecology Program, geographic databases and cartography and geographic analysis and presentation of GIS
- ✓ Gotland University
  Initial training (distance) in Human Geography , Geography
- ✓ Karlstad University
  Regional Planning program, Bachelor of Science in Surveying Engineering and Geographic IT , Surveying and mapping technology program, Masters in social sciences: Targeting human geography , also offers courses in GIS.
- ✓ Linköping University
  Master of Science in communication, transportation and Society, Human geography, Department of Computer Science, IDA
- ✓ Linnaeus University
  courses in GIS and remote sensing.
- ✓ Luleå University of Technology
  Department of Environment and Natural Resources (and distance learning), Systems Science
- ✓ Faculty of Engineering (LTH), Lund University
  Master of Science in Surveying, Master of Science in Civil Engineering, Scientific Study Program, Physical Geography, Bachelor's Program in Urban and Regional Planning, Human Geography education, Master of Information Systems, railway engineering or road and traffic technology, Department of Earth and Ecosystem Sciences, a large number of courses focusing on the geodata are also given as distance education, MSc in Geographic Information Systems, Masters geomatics, Master Program in Physical Geography and Ecosystem Analysis, Masters in social sciences, social geography, GEM MS course
- ✓ University of Stockholm
  Master of Geomatics remote sensing and GIS, Masters landscape analysis with remote sensing, GIS and cartography, Master Program in Physical Geography and Quaternary Geology, Masters in human geography, Master's Program in Spatial Planning, Bachelor's Program in Human Geography with intelligence, Urban and Regional Planning
- ✓ Swedish University of Agricultural Sciences
  Landscape Architecture Program, Landscape engineer program in Alnarp, Forests as a Natural Resource , Department of Forest Resource Management
- ✓ Södertörn University
  Infectious Disease Control, In GIS, GIS II
- ✓ Umeå University
  Archeology Program, Urban and Regional Planning, Master's Program in Spatial Planning and Development, Master program in ecology
- ✓ Uppsala university

Bachelor Program in Earth Science, Master Program in Earth Science, Urban Planning Program, Department of Archeology and Ancient History , Department of Earth Sciences, Science program Environment and Water Engineering

5.3.6.2 Institutes, Colleges

- ✓ Chalmers
  Graduate programs Architecture and Architecture and Technology, Master programs Architecture and Design for Sustainable Development
- ✓ Blekinge Institute of Technology
  Physical Planning, Master of Physical Planning
- ✓ Halmstad
  Build Engineer - real estate and energy, Nature conservation and species diversity , Environmental Strategist
- ✓ Royal Institute of Technology (KTH)
  Master of Environment, MSc in Geodesy and Geoinformatics, Masters in Transport and Geoinformatics

5.3.6.3 Handbooks

The Land Survey issues a series of guidelines for surveying and mapping, called HMK documents (handbook of Surveying and mapping issues), aiming to facilitate standardized handling of the geographical data. The regulatory documents are related to image data, laser data, terrestrial laser scanning, elevation, ortho-imagery, photogrammetric topo, geodetic infrastructure, GNSS based topo, control networks and reference and geodesic measurements. The technical documents are related to the use of new technologies in data capture and the handling of the location uncertainties through different acquisition methods.

A national book about GI (Geografisk informationsbehandling - Teori, 2017) in Sweden, was first published in 1999 and is updated regularly. The book has been used in the basic university education.

5.3.7 Communication

5.3.7.1 Communication

5.3.7.1.1 Geoportal

- ✓ Subscription to the newsletter channel, provide information from Geodata about new services, messages from the parties and other relevant news for Geodata collaboration. The newsletter is sent once a month
- ✓ Online information about events, workshops, forums etc is provided online on the geoportal
- ✓ Subscription via RSS
- ✓ Social media channels
- ✓ Contact by email
- ✓ Support by email

5.3.7.1.2 Communication between parties

Communication groups are established for new projects. Technical solutions and possible investments are often forwarded to the group by the Mapping Authority. One party holds the secretariat role (usually from the relevant collaboration secretariat). Skype and physical meetings are organized.

Communication plans have supported all initiatives in the geospatial industry. A recent example is the Swedish geoprocess (www.lantmateriet.se. (2017). Svensk geoprocess) initiative.

Forums, meeting places, and collaborations have already been mentioned in previous paragraphs.

5.3.7.2 Promotion

- The Land Survey presents and implements various initiatives within the EU, participates in UN activities, participates in International organizations and Nordic cooperation, and through Services' exports contributes to the Swedish policy for global development.
  Provides the opportunity of the free access to the infrastructure by providing an one month try-license.
  Organizes relevant GI events (map days, Hack for Sweden)
  Provides Open data for MineCraft
  Promotes the benefits of the use and participation in using the geospatial infrastructure to the public sector agencies through the Swedish geoprocess initiative.
- The Swedish Association of Local Authorities and Regions promotes the geospatial capabilities to the regions and municipalities.
- Geoforum Sweden works for greater and broader use of geodata and IT - for an effective and sustainable society!

5.3.7.3 Technical Knowledge management

The useful technical Knowledge for the stakeholders and the users of NSDI is contained in the various topics of the geoportal and the documents (www.lantmateriet.se. (2017). Handbok i mät- och kartfrågor) of the Land Survey.
Technical Courses and seminars from the Land Survey are also helpful.

5.3.7.4 Satisfaction Surveys

Satisfactions surveys have been undertaken in years 2012 (Geodata, 2013), 2013 (Geodata, 2014) and 2014 (Geodata, 2016) providing useful feedback for the new geoportal. Satisfaction surveys are also made sporadically by universities and the geodata administrator.

5.3.7.5 International Third-party partnerships

5.3.7.5.1 Eurogeographics

The task of EuroGeographics is to cooperate with the EU institutions and to coordinate and Represent members' positions in relation to different initiatives within the EU. Through EuroGeographics, Lantmäteriet participates also in the EU-funded project ELF (European Location Framework). The project aims at providing current cross-border geographic Information to both the EU and end users.

5.3.7.5.2 UN-GGIM Europe

The General Director of the Lantmäteriet is the chairman of UN-GGIM-Europe which is one UN initiative, aimed at finding ways to better integrate statistically and geographically information. The initiative is part of the UNGGIM (United Nations Initiative on Global Geospatial Information Management) which is a forum that allows UN Member States at senior level to havediscussions, and to promote and coordinate global activities within the geodata area.

5.3.8 Ecosystem

5.3.8.1 System integrators, consultants, add value-added resellers

A detailed list of the ecosystem partners can be found online (ULI, medlem (Geoforum.se, 2017)).
T-Kartor, Swedesurvey are important members of the national and international geospatial community and are mentioned separately because they do not participate in the previous list of the Geoforum Sweden.

5.3.8.2 Dealers

Data and services can be ordered by authorized dealers.

- ✓ resellers of Lantmäteriets geodata
- ✓ resellers of aerial photos and orthophotos
- ✓ resellers of height data and laser data
- ✓ reseller of the information from the Land Registry
- ✓ Resellers of mapping products

5.3.9 Culture

The main characteristics of the society's culture, as it is reflected in the activities of the geospatial sector, are:

- **Leadeship**

"Sweden is to be the best in the world at utilizing the opportunities of digitalization."

- **Quality**

Quality is a core part of GI in Sweden. Open data policies require quality and accuracy of the information they provide, securing a reliable relationship with the society and the private sector.

- **Collaboration**

Joint solutions between the counties, the municipalities and smaller State agencies provide the opportunity to take advantage of economies of scale. It will be costly to maintain and further develop a well-functioning infrastructure with the needed data.

- **Digital First – the political moto**

"The Public Sector should primarily target digital channels for citizens and companies in their service delivery. Digital Government refers to the use of digital technologies to create public value and is a prior step which is necessary for welfare and growth of smart government"

- **Open and democratic society**

The focus on open public data and the further utilization is about giving to business, researchers and Civil society access to the public-sector data in a way that allows them to use the data in new contexts. Among other reasons for this commitment is that an open and democratic society must have access to the basis for the public sector's decisions and priorities.

- **Innovation, education**

The impact of skill shortages is significant in the digital era. The needs change rapidly and the focus now is on skills that can contribute to the new ways of working and to the development of knowledge. Educational and R & D initiatives to support new technologies and government funding programs are supported due to the political will for competence in all sectors of the geodata industry.

5.4 Data Component

5.4.1 Themes

5.4.1.1 Themes, datasets, participating parties per theme

The geoportal provides access to 524 datasets (last access 8/5/2017) which are classified in 19 thematic categories. The following table shows:

- the thematic categories and the number of datasets per category (a hyperlink exists for more details on the datasets)
- the initiatives per category and the dataset per initiative, and
- the organizations per category and the datasets per organization.

Table 6: Themes, Initiatives and Responsible Organizations (source: Lantmäteriet, 2016)

Theme (Number of Datasets)	INITIATIVE	data sets	Organization	data sets
Transportation (145)	Open Data	135	Transport Administrator	129
	INSPIRE	39	Land survey	12
	Collaboration	4	Maritime Administration	2
			City Planning Office	2
Images-Maps (57)	Open Data	12	Land Survey	54
	INSPIRE	3	City Planning Office	2
	Collaboration	30	Municipality of Varmdo	1
Administrative Boundaries (27)	Open Data	12	Land Survey	22
	INSPIRE	4	National Heritage Board (1), POST Service (1)	2
	Collaboration	4	City Planning Office (1), Statistics (1)	2
			Maritime Administration (1)	1
Defence (38)	Open Data	6	Armed Forces	29
	INSPIRE	0	Land Survey	9
	Collaboration	32		
Environment (71)	Open Data	24	Armed Forces	29
	INSPIRE	20	Geotechnical Institute	12
	Collaboration	40	Geological Survey	9
			Forest Agency	7
			The County Administrative Boards	6
			Agriculture Department	3
			University of Agriculture Sciences	2
			Environmental Protection Agency	1
			Land Survey	1
Society and Culture (58)	Open Data	13	Armed Forces	29
	INSPIRE	9	Statistics	23
	Collaboration	45	National Heritage Board	5
			National Agency	1
Earth Sciences (84)	Open Data	17	Geological Survey	64
	INSPIRE	27	Geotechnical Institute	14
	Collaboration	36	Civil Contingencies Agency-MSB	4
			Transport Administrator	2
Atmosphere, Climatology and Meteorology (67)	Open Data	64	Meteorological and Hydrological Institute	67
	INSPIRE	25		
	Collaboration	0		
Lakes and Rivers (34)	Open Data	24	Land Survey	16
	INSPIRE	13	Meteorological and Hydrological Institute	14
	Collaboration	7	Maritime Administration	2
			Civil Contingencies Agency-MSB	1
			Geological Survey	1
Coast and Sea (32)	Open Data	11	Meteorological and Hydrological Institute	13
	INSPIRE	17	Geological Survey	7
	Collaboration	12	Land Survey	6
			Maritime Administration	4
			Geotechnical Institute	2
Buildings and Facilities (24)	Open Data	16	Land Survey	11
	INSPIRE	8	City planning Office	4
	Collaboration	3	Civil Contingencies Agency-MSB	4
			National Heritage Board	3
			Meteorological and Hydrological Institute	2
Elevation Data (24)	Open Data	1	Land Survey	13
	INSPIRE	5	Maritime Administration	11
	Collaboration	8		
Real Estate and Urban Planning (19)	Open Data	4	Land Survey	10
	INSPIRE	5	Transport Administrator	5
	Collaboration	3	Geotechnical Institute	4
	Open Data	10	Forest Agency	7
	INSPIRE	11	University of Agriculture Sciences	4
	Collaboration	7	Agriculture Department	2

Theme (Number of Datasets)	INITIATIVE	data sets	Organization	data sets
Biology and Ecology (14)			The County Administrative Boards	1
Health (11)	Open Data	4	Civil Contingencies Agency-MSB	3
	INSPIRE	11	Welfare	3
	Collaboration	3	The County Administrative Boards	1
			Inspectorate for Health Care	1
Positioning (9)	Open Data	0	Land Survey	9
	INSPIRE	2		
	Collaboration	6		
Agricultural Sciences (6)	Open Data	5	Agriculture Department	5
	INSPIRE	6		1
	Collaboration	0		
Technical Supply (3)	Open Data	2	The County Administrative Boards	2
	INSPIRE	3	Swedish power grid	1
	Collaboration	0		
Economy (2)	Open Data	2	The County Administrative Boards	2
	INSPIRE	2		
	Collaboration	0		

More detailed information can be found online (Lantmäteriet, 2016).

5.4.1.2 Providers, Custodians

Regulation on geographical environmental information (SFS 2010: 1770) regulates the organizations which have the responsibility for information. Responsibility means that organizations are required to make their information available. Information responsibility ensures that the data: 1) is public data, 2) is in electronic format, as well as 3) covered by one or more of the themes listed in Annex I, II or III of the INSPIRE Directive.

According to the law, the responsible authorities for information are shown in the following table. In the paragraph 2 of the second chapter of the Regulation (2010: 1770), is stated that "If a theme is divided into two or more information managers, they must coordinate their work, appoint someone to be the coordinator and inform the National Land Survey who is coordinator of the theme".

Progress towards a functioning and effective NSDI governance structure and capacities

	1. Coordinate reference systems	2. Geographical Grid Systems	3. Geographical names	4. Administrative units	5. Addresses	6. Cadastral parcels	7. Transport networks	8. Inland hydrography	9. Protected sites	10, Elevation (height and Depth)	11. Land Cover	12. Orthoimagery	13. Geology	14. Statistical units	15. Buildings	16. Soil	17. Land use	18. Human health and safety	19. Utility and governmental services	20. Environmental monitoring Facilities	21. Production and industrial facilities	22. Agricultural and aquaculture facilities	23. Population distribution and demography	24. Area management / restriction / regulation	25. Natural risk zones	26. Atmospheric conditions	27. Meteorological geographical features	27a. Oceanographic geographical features	28. Sea regions	29. Bio-geographical regions	30. Habitats and biotopes	31. Species distribution	32. Energy Resources	33. Mineral Resources
The Public Health Agency (1)																		X																
Marine and Water Authority (4)																				X				X							X			
Inspectorate for Health Care (1)																			X															
Land Survey (12)	X	X	X	X	X	X		X		X	X	X	X		X																			
CAA (1)							X																											
County administrative boards (4)																			X	X	X			X										
Civil Contingencies Agency (4)																		X	X		X				X									
Environmental Protection Agency (8)									X		X					X				X					X						X	X	X		
National Heritage Board (2)									X						X																			
Sami Parliament (1)																	X																	

	1. Coordinate reference systems	2. Geographical Grid Systems	3. Geographical names	4. Administrative units	5. Addresses	6. Cadastral parcels	7. Transport networks	8. Inland hydrography	9. Protected sites	10, Elevation (height and Depth)	11. Land Cover	12. Orthoimagery	13. Geology	14. Statistical units	15. Buildings	16. Soil	17. Land use	18. Human health and safety	19. Utility and governmental services	20. Environmental monitoring Facilities	21. Production and industrial facilities	22. Agricultural and aquaculture facilities	23. Population distribution and demography	24. Area management / restriction / regulation	25. Natural risk zones	26. Atmospheric conditions	27. Meteorological geographical features	27a. Oceanographic geographical features	28. Sea regions	29. Bio-geographical regions	30. Habitats and biotopes	31. Species distribution	32. Energy Resources	33. Mineral Resources
Maritime Administration (6)				X			X			X			X											X				X					
forest Agency (4)									X															X						X	X		
Welfare (1)																		X															
National Energy (1)																											X						
Board of Agriculture (5)																X	X					X		X							X		
National Agency for Education (1)																			X														
Statistics Sweden (3)														X					X				X										
Radiation Safety (1)																				X													
Swedish power grid (2)																			X		X												
Geological Survey , SGU (7)													X			X				X				X					X			X	X
Geotechnical Institute, SGI (2)													X												X								
University of Agricultural Sciences (1)																				X													
SMHI (7)	X							X																X		X	X	X	X				
Transport Administrator (4)							X						X					X	X														
Total Authorities	2	1	1	2	1	1	3	2	3	2	2	1	5	1	2	3	2	4	7	6	3	1	1	8	2	1	2	2	2	3	3	2	1	1

5.4.1.3 Identifiers for Thematic maps

The technical committee "Framework for geodata" (TK 323) has developed a technical report, "Geographic information - Technical framework - Identifiers for geodata" (SIS-TR 28: 2009. Identifiers are unique keys in themes and datasets used for unique identification of every entity of the data set or/and for cross-reference with other themes or data sets. This technical report recommends methods for encoding, generation, registration and handling of common, persistent identifiers for spatial data in national and European geospatial infrastructures.

5.4.1.4 Free of charge data

5.4.1.4.1 Effects and Consequences of Open Data

In June 2016, the Land Survey and the Geodata Council sent a joint letter to the Ministry of Industry, entitled: "Sweden needs to open geodata". The purpose was to draw attention to the government on the need for a new financing model for Lantmäteriet's business with basic geodata. The letter highlights the problems with the current fee model and the possibilities of the open geodata.

On September 30, 2016, The Land Survey submitted an interim report (Delredovisning av uppdraget Effekter och konsekvenser av öppna data, n.d.) and an appendix (analysis about the costs resulting from open geodata) (Öppna geodata från Lantmäteriet Reviderat finansieringsbehov, 2016) to the Ministry of Industry and the Ministry of Finance. The final report was submitted in May 2017.

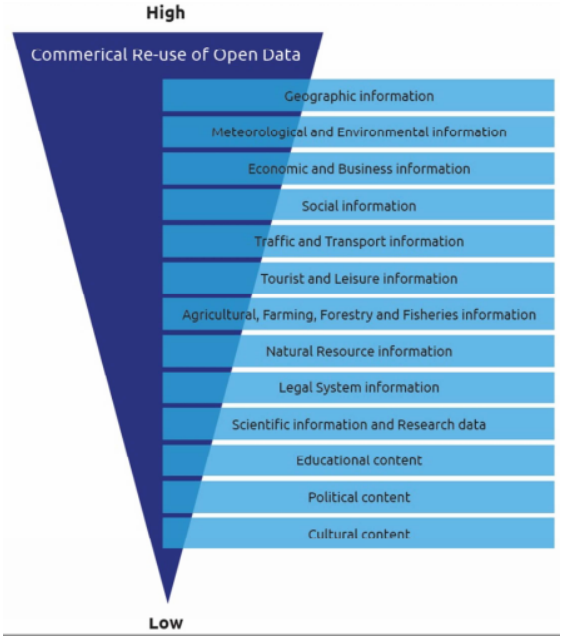

Figure 10 Illustration from the European Commission's study "Creating Value through Open Data" (source: Lantmäteriet, 2016)

The following points are worth mentioning from the Interim Report:

- Open geodata promotes innovation and entrepreneurship, and this is confirmed by investigations and surveys from the Land Survey, the European Commission's "Creating Value Through Open Data" study, and a survey conducted by users in June 2016. It is estimated that Direct market size of Open Data is 55,3 billion EUR for 2016 and expected to grow by 36,9% by 2020 in the EU 28+"
- It is hard to calculate the value of open data is the conclusion from the EU Commission's 2016 Office of Auditor General (OAG) report "The Public administration digitization - A simpler, more open and more efficient management?" as well as the Swedish document "One step further - new rules and measures to promote re-utilization Of actions ". However, the investigation shows that open data is essential, which if measured as economic growth, usually involves several tenths percentage increase on the GDP.
- Finnish Researcher Heli Koski, from the Enterprise Research Institute in Helsinki, noted that in countries where authorities made digital Geographic information freely available or at very low cost (Marginal cost), the companies had developed services and products based on the GI, resulting in 15 percent higher annual growth than in countries that did not do this.

- A study in 2013 by Erik Lakomaa and Jan Kallberg states that the finance of a large amount of geodata through fees, with associated limiting use conditions, is not economically optimal, as it operates as an obstacle to the innovation and entrepreneurship and impedes efficiency enhancements in both private and public sector. The Land Survey, where open data are available for research, education and cultural activities perhaps needs to open data more. To get the right effect it has been proved it is not enough for data to be free of charge for certain groups. The geodata must be open data, so everyone can spread and reuse these without restrictions.
  An example of the open data reuse in the universities is in the Linköping University. They created a maps service covering the whole Sweden with a detailed elevation model from laser data. It could have been useful to millions Swedes, to explore the woods and fields. Unfortunately, the terms of Distribution did not allow this.
- In 2012-2013, the Land Survey opened up a small amount of geodata, the overview map, height and positioning information. This corresponds to a few percent of the Land Survey's total collection of fees for geodata (about 2% of the total fee for geodata and approximately 6.5% of fee for GI). As a result, Sweden currently has more than 12,000 registered users of their open data and it is individuals who are the largest user group (figure on the right).
  In early 2016 the National Land Survey released the mountain map as open data. Bengt Noläng, experienced mountain hikers and programmers for over 40 years took the opportunity to process the map material and create new mountain maps. In the process of preparing for open data, the Land Survey had in 2015 and 2016 costs of approximately SEK 2,300,000 (250,470€). Lost charges for these products have been estimated at SEK 7,000,000 (762,020€) during this period.

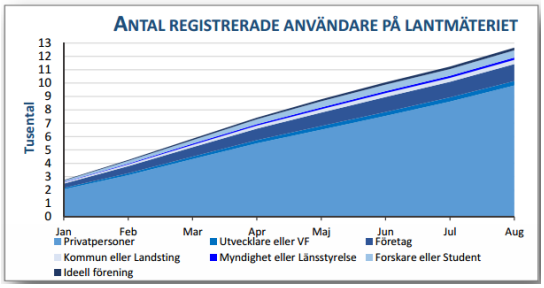

Figure 11 : Number of registered Lantmäteriet users over time (source: Lantmäteriet, 2016)

- According to a survey, forest sector's open data can provide an economic surplus of 450-3800 million SEK per year (49,000,000-413,800,000 €) and contribute to 400 – 1,800 new jobs. This will be achieved among others from better care of the forests which will increase the forests' growth, provide more efficient harvesting and the opportunity to take wood prices higher internationally.
- The Land Survey assessed in 2013, that the costs of opening up altitude and image information, map data, addresses and a satellite based positioning service, to be approximately 100 million SEK per year (11,490,000 €).
- For the period 2017-2019, the costs of developing, managing and providing the property boundaries and property names were estimated by the Land Survey to approximately 150 million SEK per year (15,440,000 €), if the data shown in the next figure will be open free of charge. This cost does not include the size of the tax revenue lost by the Lantmäteriet. The table includes the development cost. The contributions from other authorities refer to contributions for work linked to various collaborative projects, such as common shoreline, hydrographic network, scanning of historical aerial photos, etc

	Annual costs a			
Extent	**2016**	**2017-2019**	**2020-2022**	**2023-2026**
Maps, height, image, byggna d & Address	297	299	298	297
Property boundary and designation	19	19	20	20
Total cost	**316**	**318**	**317**	**317**
Financing				
Existing estimates	- 177	- 163	- 150	- 150
Contributions from other agencies	- 7	- 7	- 7	- 7
Part of the duration anslagsomföring (B.prop 2017)	n / a	- 19	- 19	- 19
Revised financing requirement	n / a	**1:29 a.m.**	**1:41 a.m.**	**140**

Figure 12: The costs for the maintenance of the cadaster (source: Lantmäteriet, 2016)

- The Board of Agriculture has estimated that open data from the National Land Survey could cause a reduction in the use of phosphorus in agriculture. According to a research example at farms in central Sweden (a total of approximately 700,000 hectares) the fields could be fertilized with phosphorus only where needed, using

geodata's analyzes. An estimated 1,600 tons of phosphorus can be saved, which corresponds to a cost of SEK 27.2 million (2,800,000 €).

- In March 2016, the Swedish Financial Supervisory Authority proposed that information exchange of the basic data between State authorities shall be free of charge. To make this achievable, the Swedish Companies Registration Office, Landmäteriet, Tax Agency and Statistics Sweden have been allocated appropriations (through a cost-neutral redistribution involving 190 authorities) on the Government budget to provide basic registry information. In line with the proposal, the government states in the budget proposal of 2017, that "Funding for open free geodata in the public sector should be through a redistribution of funds from the State Authorities"
- The results from a comparative study between the Nordic countries shows that the other countries have released significantly more data than Sweden has done. Map information, ortho-photos, historical maps, property information including the enrollment register (Denmark), addresses and zip codes (Norway). All these data, except Denmark and Iceland, are under the license terms as described in Creative Commons License CC BY 4.0.

5.4.1.4.2 Research and Education

Any student or researcher at any of the colleges or universities of the country can access geo-Data from a number of authorities. For example, maps, aerial photographs and laser data from Lantmäteriet, charts From the Swedish Maritime Administration, data on rock and earth from the SGU (Swedish Geological Survey), Population statistics from Statistics Sweden and traffic related data from the Swedish Transport Administration.

Through a web service (GET), they can zoom in any area of interest, then selection and download of the relevant geodata is permitted. (www.lantmateriet.se. (2017). student-och-forskare)

5.4.1.4.3 Land Survey's open geodata

The Land Survey's free products are licensed under Creative Commons Attribution 4.0 International (CC BY 4.0). Most of the products are in downloadable form and need a GIS software that can handle Shape or MapInfo formats.

Table 7 Descriptive information of downloadable Geodata (source: Lantmäteriet)

Data	Description
GSD districting	The district is a geographical division of Sweden and GSD District Division includes districts surfaces, codes and names. District Division Applies from January 1, 2016.
GSD Fjallinformation, Vector	The product contains timely and reliable scale information, including routes, bridges, fords and cottages
GSD terrain map, vector	Map in a scale of 1:50,000 which includes roads, paths and detailed descriptions of the different types of woods and fields.
GSD roadmaps, vector	Map Scale 1: 100,000 with information such as roads, road numbers and road bearing capacity.
GSD overview map, vector	Map Scale 1: 250,000 with information such as roads, buildings and boundaries.
Positioning service DGNSS	SWEPOS DGNSS service is a nationwide service for positioning in real time with GPS / GNSS receivers. Location Uncertainty is about 1 meter.
Download map images	Through a selection of a part of the country, the downloading of images is permitted in .png format.
Sweden Maps	Sweden Maps as images suitable as background map and the different types of themed presentations. Grids and raster format at scale 1: 1 million.
Topographic web map display	The service has an open API in the form of a zoom and pan. Map scale from Sweden Map 1:5M down to the corresponding terrain of the map information.

Data	Description
	View services are provided to those who want to use the National Land Survey maps and images into proprietary systems and applications or GIS software.
Sweden maps, vector	Sweden maps, the scale areas 1: 1, 5, 10 and 20 million, suitable as background maps and the various types of theme presentation.
GSD Elevation data, grid 50+	The product contains altitude values on the background in a grid (grid) at 50 m intervals.
Open source code	The code which is used for the topographic site map for simple downloads of map images is available as open source. It can be used as code examples for how to use topographical site map, as the basis for the development of applications or to submit suggestions for changes directly in the code. The source code is made available under the license Apache version 2.0, which broadly means it can be used in private or open applications, but there are limitations in the use of the trademark. The source code is available to download or for development on Github.

Detailed information about the downloadable open geodata, can be found online (www.lantmateriet.se. (2017). Hämta öppna geodata).

5.4.2 Quality aspects

In a geospatial infrastructure, the following critical success factors must be achieved: Data must be available, be accessible, fit for purpose and be in use
It is obvious, that the quality must be ensured at all levels of the management of information, from data capture to the maintenance and management of the spatial data services to the users.
Handbooks of surveying and mapping issues, guidelines for the data specifications, symbolization requirements, standardization guidelines of geodata are provided through the coordinator to facilitate and harmonize the agencies' production.

The Geodata coordinator ensures that the data meets the product specification's requirements as it has been described in the above paragraphs. Furthermore, instead of reporting quantitative quality reports, conformance reports are used. In this way, the conformance of a dataset is undertaken by a reference to a specification and a value of Pass=true/False. The same method is used against the technical Guidelines (data specifications) or against subsets of specifications by referencing the specific sections in ATS (Abstract tests). Data validation is done through the following conformance tests:

- ✓ Normative: Application Schema, Reference Systems, Data Consistency, Data Quality Conformance, Metadata IR Conformance, Information Accessibility, Data Delivery and Portrayal.
- ✓ Informative : Technical Guidelines (Multiplicity test, CRS http UTI test, Metadata encoding schema validation test, metadata occurrence test, metadata consistency test, encoding schema validation test, coverage multipart representation test, coverage domain consistency test, style test) (Östling, 2016)

The harmonization of data and existence of the metadata are verified by the coordinator and as it is shown in the following paragraph, 100% of the 448 reported data sets under Annex I, II and II of INSPIRE have metadata and all of them are compliant with INSPIRE requirements.

More information can be found online (European Catalogue Dashboard for Sweden) (Geodata Portal Sweden, 2017)

5.4.3 Metadata

5.4.3.1 Availability of metadata

According to the legislation, all datasets and services in the Geodata portal should have metadata. The metadata for geodata and geodata services are produced and published, according to the national Metadata profile, in the National Metadata Catalog, which forms a fundamental part of the Geodata Portal. The national metadata catalog is based on the National Metadata Profile, SIS/TK 489 N247.
Metadata are produced and managed for a very significant part of the spatial data. This is confirmed by the figures of the INSPIRE Monitoring and Reporting (MR) (last reported status 2016; Lantmäteriet, 2016):
100% of the reported data sets under Annex I, II and II have metadata (448) and all of them are compliant with INSPIRE requirements.
The reported datasets are 97,27% for Annex I, 97,8% for Annex II and 98,26% for Annex III, resulting in 97,91% for all annexes (18.65% of them are compliant)

Overall 50% of the metadata are accessible through the discovery service (100% of the metadata of data sets, 61.9% of the metadata for services,
50% of the spatial data services conform to INSPIRE requirements.

5.4.3.2 Metadata details

The details have already been mentioned in the paragraphs above.

5.4.3.3 Metadata quality

Metadata for data and services in Geodata follow the ISO 19115 parts for the metadata and the ISO 19119 for the services.

The national metadata profile describes the metadata to be registered for the resources (Data sets, data series and services) which are included in the national infrastructure for geodata. The metadata profile also contains a description of which metadata elements should be provided according to European Parliament directive on the establishment of an infrastructure for spatial information (INSPIRE Directive). By registering metadata according to the national metadata profile, both national and INSPIRE requirements are fulfilled.

The geodata portal complies with the Swedish metadata profile, so a validation routine for this has been developed. The routine checks that all required fields in the metadata profile are completed before publication.
The figure which is included in 2016 member state report (follow up from 2015) to INSPIRE, shows that Sweden has some quality problems with the provision of data via services, but overall the level of compliance is relatively good.

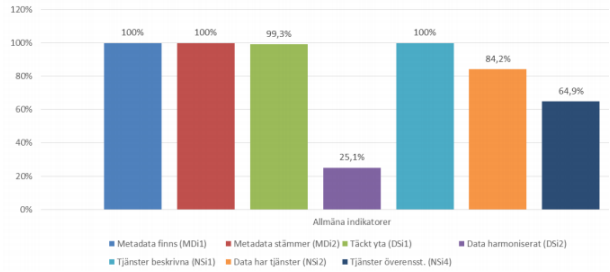

Figure 13: The implementation of INSPIRE based on the follow-up of 2015 (source: A. Rydén, 2016)

5.4.4 Accessibility and Transferability

The geospatial infrastructure in Sweden is decentralized and the starting point is the responsible authority which creates and manage metadata, geodata and services according to the rules. The center is the national metadata catalog, which represents the total registry for all the data and services in the Swedish infrastructure. The register is maintained by those responsible authorities, which publish and update their metadata in the metadata catalog, either manually or by harvesting from own portals or other

metadata catalogs. The Swedish Geodata portal is the search interface to the national metadata catalog.

All foundation data in Geodata are accessible through web services from the Geodata portal on behalf of licensees of the geospatial information. A graphical environment with advanced search capabilities facilitates the selection of the required data.

The service catalog has interfaces for both manual searches via a graphical user interface and automated machine based searches via CSW-interface. The user interface provides also the ability to visualize the geospatial information. A search of services will result in a list of all types of services in Geodata. In the metadata of each service, one can find key information that describe the content and the structure of the service, and the connection information for using the service.

In the following figures -presenting a view and a download service-, we see the needed relations: Coupled resources (between services and datasets), online linkage (between services), metadata URL (between services) and metadata URL (link between service and each layer dataset). (Östling, 2016)

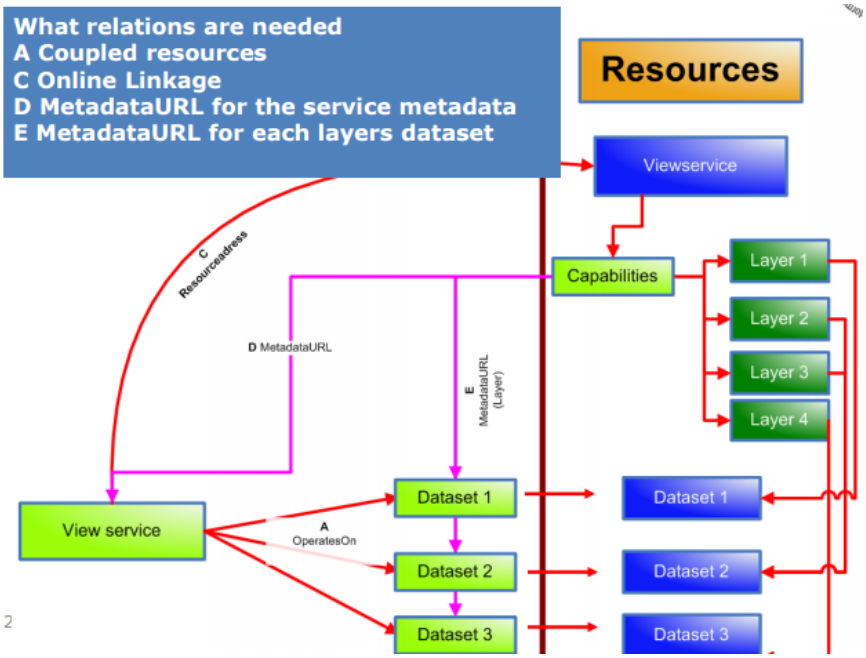

Figure 14: An overview of the view service (source: M. Östling, 2016)

Delivery data to the user may be the result of a composition/chaining of services according to three different approaches:

- Custom chaining, where the user administers the entire work flow
- Workflow administered chaining, where the user invokes workflow service that controls the chaining. The user is aware that several services are involved
- Aggregation of services, where the user invokes a service that performs chaining without the user being aware that there are multiple individual services

Requested geodata are downloaded from the various agencies' own servers.

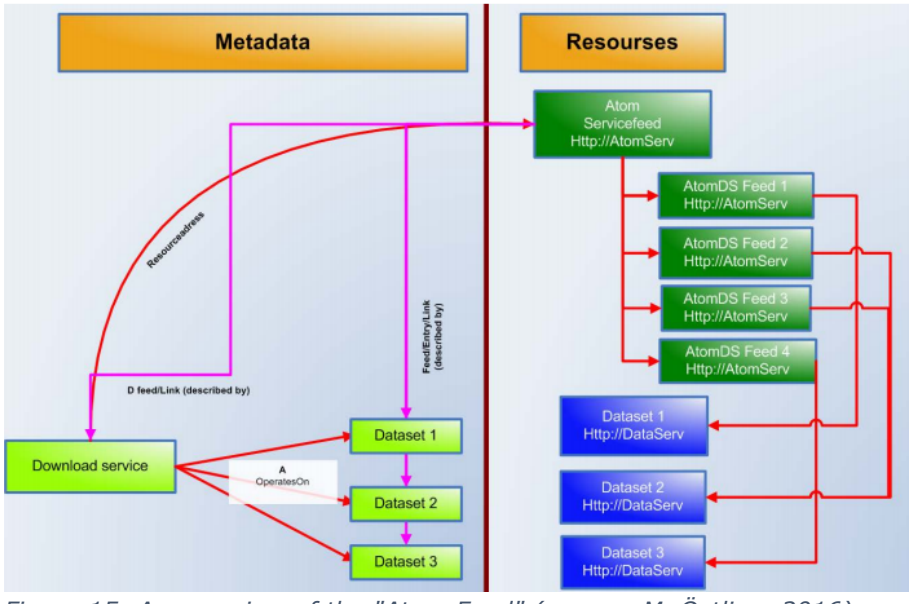

Figure 15: An overview of the "Atom Feed" (source: M. Östling, 2016)

View/download Services are provided from agencies for specific data-sets:
- searchable information and metadata on aerial photographs and orthophotos.
- satellite images of Sweden, covering each decade from the 1970s onwards.
- Hydrography download , Location services, Historical maps
- My Property service gives owners of properties free access to detailed information about their own real properties and site leasehold rights.
- Search maps and place names

5.5 Technology Component

5.5.1 Principles for the technical infrastructure

According to the technical framework, the systems of the infrastructure must be based on service oriented architecture and processes. Open source development of the general IT components is required to support the demand for rights, access and secrecy. Data and services must be based on common standards and agreements (ISO, CEN, OGC, W3C). No reference to semantic interoperability exist in the framework.

The initial design of the infrastructure was based on a decentralized solution.

The geoportal provides data and web services based on:

- ✓ A search engine to search geodata. The search is built on metadata.
- ✓ A map viewer to be able to search and view the requested geodata based on services.
- ✓ An e-business system is mentioned in the strategy but is not developed yet.
- ✓ License and security functions

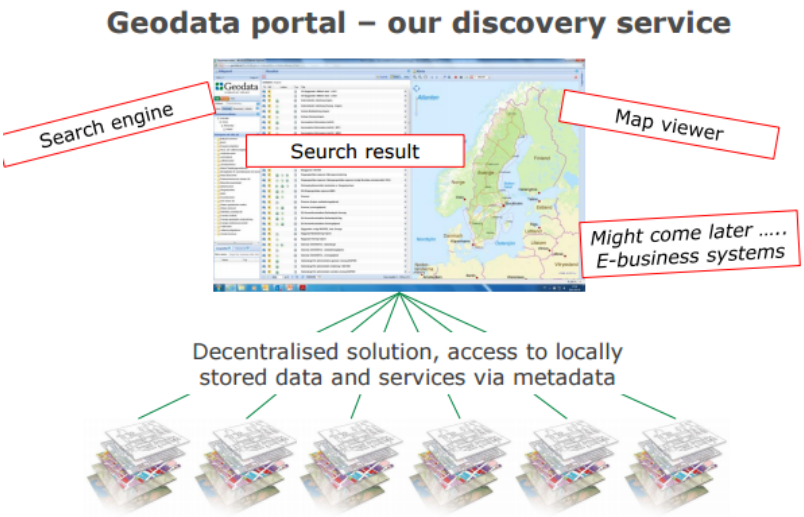

Figure 16: The services of the Geodata portal (source: C. Wasström, 2014)

5.5.2 Systems and services

An introduction to the National Geoportal and the underlying fully distributed and service orientated infrastructure of Geodata Collaboration, follows:

✓ **National directories, services and registers**

National industry components for storing metadata for government, municipal and private enterprises' geodata and services.

- Provide functionality for service directory
- Enable creation, distribution and control of harmonized data sets, through common industry components

✓ **Business data sets and services**

Data sets and services are published in accordance with open standards and in the most harmonized form. A number of guidance documents are used to achieve this goal.

✓ **Web portal with map client**

- A window for the public, to view all data sets and services in the geographic infrastructure, as well as how to contribute to more data sets and services in the infrastructure

- A publishing system - Content Management System (CMS) for the "Geodata" and the other Geoportal sites
- Map client for graphical viewing

✓ **Integration with other systems**

Provides access to common industry components through open standards.

- Machine-to-machine services that allow parties and system vendors to search, harvest and manage metadata in their own systems
- Provides the opportunity to establish new value creation solutions

✓ **Download solution**

Provides to all users the ability to download updated geographic data sets through the infrastructure, according to the assigned rights

✓ **Authentication and Access Control**

A common, standard, authentication solution and access control for the whole system

- manages the access to the services, to the data download, to the metadata management

The geoportal, the core part for accessing the geospatial information, can be layered in 3 tiers:

✓ The presentation tier, which consists of portals and solutions that use the industry components together with the various business services

✓ The common industry components and the service layers, that make up the core of the national geospatial infrastructure (authentication and access control, download solutions, metadata for data and services, common register data –search tags, code lists, object catalog, drawing rules etc.)

✓ The organization's architecture (the parties), which actually delivers the data or service

5.5.3 Interoperability

Using map services is the solution to increase availability, access, integration and sharing of geographic information. OGC Web services' (OWS) portfolio contains three main services: WMS, WFS and WCS. We can mix OWS in the same map service (client application) which in turn can use OWS services on one or more machines simultaneously. These services are linked to a server acting as a client (cascade Server) against other servers. A benefit of a linked service is that map services can relate to fewer requests to the server(s), so the management of the client is a minimum. A map service can also take advantage of other services that are not OWS (for example search). All the services and metadata which are published by the parties of the Geodata Collaboration, must be registered in Geodata's catalog. From this catalog via a user interface they are accessible from the public or other parties.

5.5.4 Enabling Technologies

Swedish NSDI clearing house (Geodata) was developed and operated in 2010 by the Land Survey on behalf of the parties in Geodata Collaboration. The main software is based on open source.

- MapFish is a flexible and complete framework for building rich web-mapping applications, which provides a complete RIA-oriented JavaScript toolbox, a JavaScript testing environment, and tools for compressing JavaScript code. The JavaScript toolbox is composed of the OpenLayers , GeoExt and ExtJs JavaScript toolkits. It is used in Geodata portal, where the *web client uses GeoExt and ExtJS and the map client is built on OpenLayers*.

- Catalog application Geotnetwork, is used for metadata editing and search functions (metadata catalog /CSW server (Geonetwork)).

- The portal is based on the EpiServer CMS for the publishing tools on the server side.

- Metadata catalogue is stored in PostgreSQL.
- Apache Struts is a free, open-source, MVC framework for creating elegant, modern Java web applications. It favors convention over configuration, is extensible using a plugin architecture, and ships with plugins to support REST, AJAX and JSON. Apache Struts is used in the portal infrastructure.

- License and security manager are implemented though Con Terra solution.

6 THE SWEDISH's SDI MATURITY

In this chapter, the maturity of the Swedish SDI is analyzed using a geo-maturity model. An introduction to the model and its underlying concepts and an analysis of the initial and current landscape of the Swedish geospatial infrastructure through the model's requirements, are presented.

6.1 The geo-maturity model

For the assessment of the maturity of the Swedish geospatial infrastructure a geo-maturity model is used, which is based on the following concepts:

- ✓ A strategy components model
- ✓ A capability Maturity Levels analysis

The Strategy Components model consists of five interrelated components, designed to ensure that the strategy and the implementation plan has covered all the required elements for a successful geospatial infrastructure.

The five Key elements required for an effective geospatial strategy are:

- The Organizational components
- The Data components
- The Technology components
- Standards, and
- People

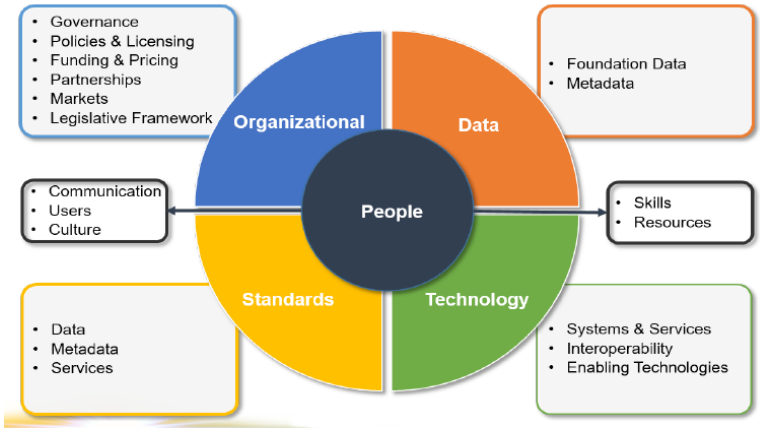

Figure "The five elements of the NSDI" Copyright Dr. Vanessa Lawrence CB, Gilles Albaredes, John Schonegevel, Maurits van der Vlugt

A detailed assessment of this information is carried out against a defined Capability Maturity Model, which consists of five levels and includes definitions of Maturity for each of the components within the Geospatial Strategic Components Model. The five levels are:

- ✓ Level 0 (Non-existent): Management processes are not applied at all
- ✓ Level 1 (Initial / Ad Hoc): Processes are ad hoc and inconsistent
- ✓ Level 2 (Repeatable): Processes follow a regular pattern
- ✓ Level 3 (Defined): Processes are documented and communicated
- ✓ Level 4 (Managed): Processes are monitored and measured
- ✓ Level 5 (Optimized): Good practices are followed and automated

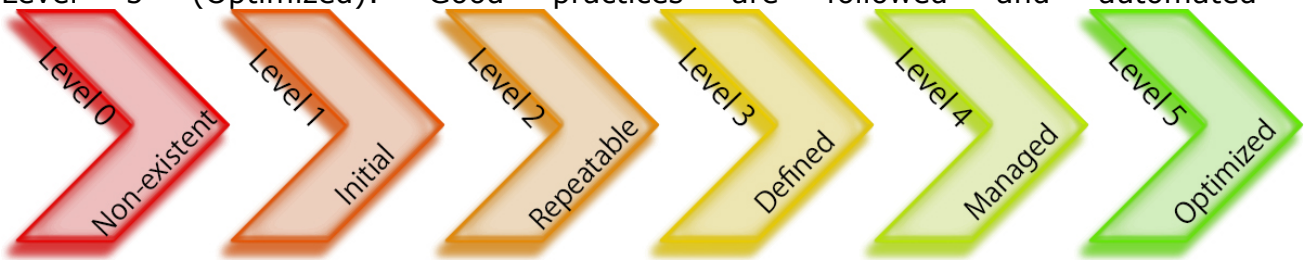

Figure 17: The Maturity Levels

6.2 Maturity level Assessment and Reasons

6.2.1 Organizational

It can be found that by 2000, the Lantmäteriet (NLS), under the Ministry of Environment, is responsible for production, maintenance and dissemination of geographic information and for the real property formation. NLS also has the responsibility to co-ordinate the development of national spatial data. Many collaborations have been established between public agencies, also between the public and private sectors.

In many sectors, business-driven investments, resulted in specific geographic information systems. 190,000,000€ was spent to build-up the Swedish Land Data Bank System, the Cadastral Index Map and the databases from the Land Use Map and the Topographic Map.

Around 2001, the annual cost for managing the SDI at Lantmäteriet is about 35,300,000 € (operational budget allocations)

A national SDI is highly visible and operates since 2000.
In 2006, the Swedish Government appointed the Geodata Advisory Board and the Swedish Parliament approved legislation that officially appointed Lantmäteriet (the Swedish mapping, cadastral and land registration authority) as the coordinator of the Swedish SDI.

In June 2006, the government gave Lantmäteriet, together with the Geodata Advisory Board, and in consultation with other affected government agencies and the Swedish Association of Local Authorities and Regions, the task of formulating a national strategic plan for the integrated provision of information within the geodata sector. The plan, entitled National Geodata Strategy, was presented to the government on March 30th, 2007.

For the above reasons, we ranked the maturity level of the Swedish SDI in the early part of level 4, in 2007.

In 2010, the legal frameworks for the infrastructure were established through Act (SFS 2010: 1767) and its regulations. The law is implementing Directive 2007/2/EC (2007) and requires all the information of the responsible authorities to be made available to the public. Regulation on geographical environmental information (SFS 2010: 1770) regulates the organizations which have the responsibility for information. Responsibility means that organizations are required to make their information available
No ROI reports have been found during the study.

The Swedish government requires evaluation of the national geodata strategy. This is undertaken through annual reports issued by Lantmateriet or special reports based on cost/benefit analysis. No framework with defined KPIs has been found during the study for the evaluation of the infrastructure.

Sweden today has a national infrastructure for geodata that promotes innovation and growth within industry, enables public sector processes to be digitized and streamlined and actively contributes towards citizens enjoying a good, secure and sustainable living. Data sharing is consistent, mature and successful.
For the above reasons, we ranked the current maturity level of the Swedish SDI as beign in the early part of level 5.

6.2.2 Data

Before 2005, the co-operation between responsible bodies and the commitment to use common standards had led to a satisfactory inter-operability. The dissemination of base information (foundation data), via Internet, and the development of applications by service providers has led to a widespread use of the information. The bodies responsible for the activities that create the information also update it in the SDI. Within the SDI the responsible bodies co-operate. There is an efficient dissemination to service providers and users.

Open data policies which ensure the data is available free of charge, are established clearly in the new geodata strategy (2016).
For the above reasons, we ranked the maturity level of the Swedish SDI in 2006, in the middle part of level 3.

The new geoportal started to be operated in 2010. Foundation data with compliant metadata has been published, shared and maintained. A lot of new and improved data has been included in the infrastructure from the initial operation of the Geodata portal. New projects replace existing data providing more detailed, accurate and up to date information.

A plan for using a common data standard for the detailed basic topographic maps is continued under the Swedish geo-process model.
Open data is growing and with the new government funding, in the near future the majority of the data will be free of charge.

For the above reasons, we ranked the current maturity level of the Swedish SDI, in the middle part of level 5.

6.2.3 Standards

In 1995, within project Stanli, Sweden has taken an active part in the ISO/TC 211 and CEN/TC 287 developments of framework standards. Based on the results from this work, a Swedish framework has been set up. Additionally, a number of profiles for different application areas have been developed, for example, for road and railway networks, utility networks, addresses, cadastral parcels, and hydrology.

Before 2000, Swedish standards (SS-series) for the geographical data are well developed. Typically, standards are established for data produced by co-operation between different organizations. Sweden participates in global and European standardization through ISO/TC 211 and CEN/TC 287.

Before 2005, different metadata catalogues are available on-line, either directly on the NLS pages or on the web sites of key players. A GeoLex service exists for metadata for the Swedish reference database (available via the NLS web site), and is based on national standards. A separate service (MEGI) exists for metadata regarding the thematic data. The MEGI, or metadata for geographic information is a web based service following the standard CEN 12657.

For the above reasons, we ranked the maturity level of the Swedish SDI in 2006, in the middle of level 4.

Inter-operability standards were implemented in the infrastructure, and the new geodata portal operated in 2008 (fully with a business model in 2010).
Sweden is a member in the European standardization body CEN and the global organization ISO. Until today, it has published more than 18,000 standards in a number

of areas. Sweden also has been active in the development of Standards within ISO 19100 series for several years and arrives at year-end 2017 also to have an even more important role in the International geodata standardization process. From 2017, Sweden will hold the chairmanship and the secretariat of the ISO TC/211.
For the above reasons, we ranked the current maturity level of the Swedish SDI in the middle of level 5.

6.2.4 Technology

Around 2000, spatial data architecture has been defined and implemented in many organizations as well as for the whole operation of SDI.
Many spatial data services allow the users to view the data, to combine standard background maps and other official data with their own data, to get information about properties, to access historical maps, to deliver the ordered data etc.
The technologies used are not tied to a particular vendor, meaning that underlying technologies can be implemented by any of the shelf platforms and shared natively.

For the above reasons, we ranked the maturity level of the Swedish SDI in 2006, in the middle of level 3.

The Geodata portal, in 2010, implements the business model, applying the service license agreements. Monitoring of the defined KPIs in the infrastructure takes place automatically. Organizations from the public and private sector uses the infrastructure for their main activities.
The enabling technologies are now based on open source solutions. Data architecture is flexible allowing constant improvement and increased business efficiency. Business systems integration has to be developed and be accessible from the geoportal, providing easy access to specific needs.
For the above reasons, we ranked the current maturity level of the Swedish SDI in the middle of level 5.

6.2.5 People

From early 1990, ULI Geoforum Sweden is the geospatial industry's voice. It is working towards more efficient use of GI within Sweden. The forum takes actions and initiatives in the GI industry, and gets politicians, authorities and the media to listen. It represents more than 200 organizational members from the government, industry and academia.
Their web page hosts a GI news feed, a meeting places page for conferences and calendar events, their voice on GI initiatives and related aspects, and a page with projects on the theme of education and studies.

GIS courses, Bachelor, Master's and Phd's programs in Geospatial IT can be found in a lot of universities and disciplinary sectors.

In 1999, the government instructed the 21 county administrations of Sweden to coordinate and launch a nationwide education project called StrateGIS, which aimed to enhance the use of geographical information systems in the public sector, especially municipalities, cities, and county administrations.

With the increased utilization of geodata it was quickly realized that easy access to data for education and research purposes was needed at a low cost. Between 2004 and 2011, the universities had access to basic geodata for a highly reduced fee through an agreement between the National Library of Sweden and Lantmäteriet.

Before 2000, cooperative and coalition culture, between organizations from the public and private sector, resulted in an early build of the SDI. Communications channels have been established through the infrastructure's structure, the national and international

collaborations, the SDI portal, the conferences and the workshops and the satisfaction surveys, ensuring the regular users' feedback.
For the above reasons, we ranked the maturity level of the Swedish SDI in 2006, in the middle of level 4.

The Geodata Secretariat works actively on behalf of research financiers and decision makers with a view to establishing a strategic basis for how research and development within the spatial data sector is to be enhanced in the future.

Ongoing monitoring and continuous improvement of the skills is applied. In 2012, a survey from the R&D coordinator of the Geodata secretariat in consultation with the SKL, shows that users from the public sector need further education in some areas. 200 from 205 municipalities and 17 Authorities with information responsibility participated in the survey.

A lot of targeted R&D activities are implemented by the Lantmateriet, with governmental funding support.

Safe and Secure is a three-year collaborative project that develops Norrbotten and Västerbotten municipalities' ability to communicate geodata for cooperation in times of crisis. The project aims to strengthen the capacity of municipalities, within the geographical area of their responsibility to raise the awareness and the ability to use digital spatial data before, during and after a crisis.

Sweden today has a national infrastructure for geodata that promotes innovation and growth within industry, enables public sector processes to be digitized and streamlined and actively contributes towards citizens enjoying a good, secure and sustainable living. Geodata is created, administered and made available to the public (290 municipalities and many State authorities) and private sectors within shared frameworks, thus contributing towards openness, availability and combinability.
For the above reasons, we ranked the current maturity level of the Swedish SDI, in the middle of level 5.

6.3 Overall assessment of the Swedish SDI's maturity

The results of the Maturity Level Assessment of the five Key elements required for an effective geospatial strategy, are shown in the figure of the next page. When all the requirements of the level are not met, an intermediate point of the level is used (e.g. middle, close to end).

Table 8: Maturity Level assessment of the Swedish SDI

Strategy Components	Maturity Levels				
	Level 1-Ad Hoc	Level 2 - Repeatable	Level 3- Defined	Level 4 - Managed	Level 5 - Optimized
Organizational				2007 2010	2017
Data			2006	2013	2017
Standards				2006	2017
Technology			2006	2010	2017
People				2006	2017

In the next pages, the maturity of the Swedish SDI is examined using temporal aspects (where applicable) in the intermediate phases of each SDI's component. Each component has five maturity levels and each level has its own requirements. When a requirement is met, a time reference and a cross-reference in the document's paragraphs are used as evidence of fulfilling the requirement. When a requirement of a higher level is met, it is considered that the relative requirements of lower levels are also met.

In the cases that the exact time reference isn't found in the available sources, but according to the study's references the requirement is met, we use the word "YES" instead of the exact year.

6.4 Organizational

Table 9: Maturity Level of Organizational Component of the Swedish SDI

LEVEL 1 - Ad Hoc		Level 2 - Repeatable		Level 3 - Defined		Level 4 - Managed		Level 5 - Optimized	
No cross-organizational governance framework in place		Initial whole of organization coordination activities		Whole of organization governance structures established	2006	Mandate and legal frameworks in place	2010	Ongoing monitoring and continuous improvement	2010[2]
No standard operating procedures (SOPs) identified, compliance and tracking not consistent		Custodianships and stewardship principles defined	2000	SOPs consistently tracked and verified	Before 2000	Formal custodianship and stewardship roles defined	2010	Measuring ROI and benefits realization	N/A [3]
Project by project funding		Some SOPs documented		Defined strategy and Implementation Plan	2007	Strategy implemented, KPIs monitored	2010	Data sharing is consistent, mature and successful	2015
Case by case partnerships		Some whole of organization funded initiatives		Whole of Organization investment plan	2000	Business case driven investments	2000		
No market coordination or focus		Sporadic data sharing		Public / Private Partnerships	2000	Operational budget allocations	2000		
No successful initiative in data sharing				Inconsistent Data sharing with elements of success		Data sharing in place but still immature	2000		

[2] No framework with defined KPIs found during the study. Annual reports and special reports based on cost/benefit analysis found.
[3] NO ROI reports found during the study.

6.5 Data

Table 10: Maturity Level of Data Component of the Swedish SDI

LEVEL 1 - Ad Hoc		Level 2 - Repeatable		Level 3 - Defined		Level 4 - Managed		Level 5 - Optimized	
Internally focused data management		Emerging, peer to peer data sharing arrangements		Single Point of truth principles	2005	Foundation Data published, shared and maintained	2010	Ongoing monitoring and continuous improvement	2010-
Data duplication		Some (meta)data publications		Foundation Data Themes defined	before 2005	All data published with compliant metadata	2010	Growing spatial data and open data usage throughout community	2017
Project by project data and metadata collection				Open Data policies established*	2016	Open Data policies implemented	2013[4]		

**Open data, by the mean: formal, free of charge*

[4] Landmateriet in 2012-2013 has opened a small amount of opened data.

6.6 Standards

Table 11: Maturity Level of Standards Component of the Swedish SDI

LEVEL 1 - Ad Hoc		Level 2 - Repeatable		Level 3 - Defined		Level 4 - Managed		Level 5 - Optimized	
No common standards identified or implemented		Documented spatial data standards framework	1995	All (meta)data published in standards compliant formats, protocols and services	2005	Monitoring and expansion of standards compliance	2005		
		Selective standards adoption		Observer role in (international) standards organizations	1995	Common data models defined for Foundation Data	2001	Proactive, contributing role in (international) standards, organizations ensure organizational needs are reflected in emerging standards	2000
		e-enabled services not exploited		e-enabled services sporadically exploited		Partial integration with other organization wide e-enabled service standards	before 2005	Fully integrated e-enabled services standard	2008

6.7 Technology

Table 12: Maturity Level of Technology Component of the Swedish SDI

LEVEL 1 - Ad Hoc		Level 2 - Repeatable		Level 3 - Defined		Level 4 - Managed		Level 5 - Optimized	
Technology choices addressed on a project by project basis		Defined or organizational spatial data architecture	2005	Organizational spatial data architecture being implemented	2005	Robust spatial data services with defined SLAs	2010	Spatial data architecture is flexible allowing for constant improvement and increased business efficiency	2014
No organizational spatial data architecture defined		Some elements of organizational spatial data architecture being implemented		Compliant spatial data services	2005	Service monitoring	2010	Business systems integration mature and effortless	
Case by case interoperability Often vendor dependent		System specific interoperability		Vendor agnostic	2005	Business systems routinely using spatial data services	2010		

6.8 People

Table 13: Maturity Level of People Component of the Swedish SDI

LEVEL 1 - Ad Hoc		Level 2 - Repeatable		Level 3 - Defined		Level 4 - Managed		Level 5 - Optimized	
Diverse skills and resource availability		Defined skills and requirements		Defined skills and training requirements	1999	Growing skills base	2004	Ongoing monitoring and continuous improvement	2012
Ad hoc training and development		Informal knowledge sharing		Formal education and knowledge sharing resources	2000	Coordination with education facilities	2006	Targeted sources and R&D activities	2008
No coordination communication		Case by case user needs analysis		Coordinated, whole of organization user needs analysis	2000	Regular user feedback captured	2000-	Mature user engagements	2009
Project by project user focus		Informal communication standards		Formalized communications plan	2008	Effective, coordinated communications	2012	Pervasive awareness of spatial information benefits and availability	2014
No collaboration culture		Untrusted and sporadic collaboration culture		Cooperative culture		Coalition and alliance culture	2000	Strong collaboration and transparent partnership culture	2010

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The main sources for the information provided by this study, is taken from the various pages and documents in Geodata and Landmateriet site. (access May 2017, verified access 26 June 2017).

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