NSDI Good Practices
Norway

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

Globally, the Governments using the technology are transformed from the e-Government era (2000) to the Smart Government era (2015+), passing through the "Joined-up Government" (2005) and the Open Government era (2010). The Spatial Data Infrastructure is a vital cornerstone for a government's IT maturity.

The concept of the Norwegian SDI, which is called "Digital Norway", was defined in 2003 by the Parliamentary white paper "Digital Norway – a joint fundamental for value adding".

Norway today has a comprehensive and advanced geographic information infrastructure, covering many needs of the society. The infrastructure of data, common solutions, services, standards and rules of administration, distribution and use of geographical information has been largely developed through the agreement-based collaborated Norway Digital.

"Norway Digital" is a nationwide cross-sector cooperation, established in 2005 in order to organize the national spatial data infrastructure (NSDI) in Norway, and its development is highlighted in the Norwegian e-government strategy. Today, 612 parties from the private and the public sector at national, regional and local level participate in the activities, aiming to increase the use of geographic information at all levels and in all areas of the public sector in Norway.

"Geonorge" is the name of the access point for the national geographic information; the core or the hub of the geospatial 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 generating 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 "Digital Norway". To achieve this, the maturity level of the five core elements of an NSDI is evaluated through time: Organizational, Standards, People, Data, Technology

The study is structured as follows:

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

The second chapter is used for the determination of the initial maturity level of the Norway's SDI. The participation of Norwegian experts in International Standard Organizations, the development and use of National and International standards in data and technology, the export of expertise within consultancy in international geospatial projects, a long-term cooperation of the public sector in geospatial information, a completed program for the creation of a National GIS, a completed program of an INSPIRE-type web portal and initiatives for the establishment of an e-government environment, define the background of the pre-NSDI period in Norway (-2003).

Although in the second chapter the establishment of the SDI as well as other e-government steps are visible, the legal, institutional and technological frameworks facilitating the information flow between agents are needed for a successful nationwide enabled geospatial environment. The INSPIRE process has facilitated the development of formal national SDI's, and after the INSPIRE Directive entered into force on 15 May 2007, Norway similar to all the Nordic countries, has adopted new legislation on establishing infrastructures for geographic information. The activities for the development of a formal NSDI and the harmonization with INSPIRE directive, are described in the third chapter.

A sort summary of the current status of the Norwegian SDI and the future goals are presented in chapter 4.

In the fifth chapter, a detailed description of the five elements of the current Norwegian 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 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 Norwegian GI-Hub, the Geonorge.
The overarching architecture, the technical principles, the interoperability and openness of the spatial data infrastructure and the enabling technologies are presented in the Technology component.

In the sixth chapter, the maturity of the Norwegian 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 Norwegian geospatial infrastructure through the model's requirements, are presented.

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

The amounts which are presented in this study, are written in NOK (with a reference to their relative year). The Euro (€) 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 at 2017. http://www.xe.com/currencytables/?from=EUR&date=

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1 AN INTRODUCTION TO THE COUNTRY

In this chapter the political structure of Norway and the ICT's -relative to the study- indicators, are presented.

1.1 Basic Data

Area: 385,203 Km^2 (2017)
Population: 5,258,317 (2017)
GDP in current prices: 377,009€ (2014)
GDP volume growth rate: 2.2% (2014)
GDP per capita: 600,596 NOK (2016) (64,624€), in PPS (EU 28=100): 160 (2015)
General government surplus: 97.4B NOK (2016) (10.49B €)
Unemployment: 4.2% Statistics Norway, Eurostat, EFTA
(ssb.no, 2017), (Ec.europa.eu, 2017), (Efta.int, 2017)

1.1.1 Indicators

Broadband internet access: 97% of Households, 98% of enterprises (2016)
Interact with public authorities via internet: 85% of citizens (2016)
Obtain information from e-government sites: 78% of citizens (2016)
Are satisfied with the use of e-government sites: 64% of citizens (2013)
Percentage of **ICT sector in GDP: 3.29%** (2014) Eurostat (Ec.europa.eu, 2017)
Ranked in **2nd** position for faster average internet speed (21.3MB/s) and ranked in **4th** position globally for the savviest digital countries (Global Information Technology Report 2016, 2016). WEC_2016
Ranked in **2nd** position in Digital Economy and Society Index (2017 DESI EU) (Digital Single Market, 2017)
Ranked in **8th** position in (OUR)-Open, Useful, Reusable Data, OECD 2014 (Oecd-ilibrary.org, 2017)$_a$
Ranked in **4th** position in use of e-government services OECD 2015 (Oecd-ilibrary.org, 2017)$_b$
Ranked in **13th** position globally in e-Government Readiness Index UN_2014_EGOV_RI (Publicadministration.un.org, 2017)$_a$
Ranked in **9th** position out of 53 countries in Information Society Index IDC (Idc.com, 2017)
Ranked in **4th** 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: 17th position in Enterprise capacity, 3rd position in the Government capacity and 1st position in People and Civil Society capacity. KPMG_CRI_2015 (Stiles, Davies and Cooper, 2015)
Ranked in **18th** position in E-Government Development Index and in **27th** position in E-participation Index UN_Survey_2016 (Publicadministration.un.org, 2017)$_b$
Ranked in **13th** position in the Global Open Data Index (2016) with a score of 61% GODI (Knowledge, 2017)

According to a survey for the "Global Geospatial industry Outlook, 2017 edition" (Geospatialmedia.net, 2017) 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:

- Ranked in **24th** position in the Geospatial infrastructure and the Policy Framework
- Ranked in **24th** position in the Geospatial courses and the available skilled manpower
- Ranked in **13th** position in the level of user adoption of the geospatial technology
- Ranked in **20th** position in the geospatial industry penetration
- Ranked in **18th** position overall in the geospatial readiness index.

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

1.2 Political structure

Norway is a constitutional monarchy. The power of the King is mainly representative and ceremonial. In practice, the political system is based on representative democracy with the legislative body of the 169-member Storting (Parliament) ruling the Kingdom of Norway, the Government having the executive power and the courts the judicial power. The country has a multi-party system with a general election held every fourth year. Norway is one of few West-European countries which has opted not to join the European Union.

Local democracy is strong and the local government sector is a well-established institution in Norway. Local authorities' rights and responsibilities are defined by Law.

Norway has a two-tier system of local government: the county authorities and the municipalities both have elected representatives. There are 428 municipalities and 19 county authorities. More than half of the municipalities have less than 5,000 inhabitants and 14 have more than 50,000 inhabitants.

- Local government consumption amounts to 13.9% of GDP
- Income in local government sector amounts to 18% of GDP (Local Government in Norway, n.d.)

2 PRE-SDI TIME PERIOD (-2003)

In this chapter, a lot of useful information is mentioned for the determination of the initial maturity level of the Norway's SDI. The participation of Norwegian experts in International Standard Organizations, the development and use of National and International standards in data and technology, the export of expertise within consultancy in international geospatial projects, a long-term cooperation of the public sector in geospatial information, a completed program for the creation of a National GIS, a completed program of an INSPIRE-type web portal and initiatives for the establishment of an e-government environment, define the background of the pre-NSDI period in Norway (-2003).

In this period, the Ministry of Environment has the responsibility for the geospatial information and the National Cadastre and Mapping Authority (NCMA) leads the coordination, management, technical support, R&D activity and supervision of the geospatial projects.

2.1 History until early-1990's

Maps made in the '90ties were basically fully digital, structured through GIS technology. They delivered on a standard exchanged format (SOSI), ensuring direct import from the various GIS systems of the users. Many public organizations were producing maps, and much effort was put into making standards for map content, data formats, and exchange formats. The Norwegian Mapping Authority put large resources into the establishment of an infrastructure for the distribution of geodata and **by 1996 the main parts of the maps belonging to the Mapping Authority were in digital form**. A goal established in 1992, was a service for data management and distribution of the GI named National Geographic Information Center (NGIS) (Kartverket, 2017)$_a$, operated in 1996, giving users easy access to NMA's data (www.statkart.no/ngis). One of the key elements of NGIS was the **metadata catalog**.

The landscape of digital products during this period, consisted of:

- Municipal maps produced for local needs at scales 1:500 – 1:2000
- A digital "names" database containing all the names from the maps, a total of 340,000 names. The database was completed in 1991, including a gazetteer
- All contours, spot heights and water borders had been digitized and stored in databases. From these data, a DTM covering the country was generated
- 727 maps within a 1:50K series produced by the Norwegian Mapping Authority
- In 1990 the establishment of a digital road data bank was started, in 1994 the entire series of Economic map of Norway were completed (geocoded by a grid of 1Kmx1Km) and Norwegian Arctic and Antarctic areas were mapped by Norwegian Polar Research Institute

In research, SATMAP and sister program SATOBS were funded by the government on mapping and remote sensing. A lot of GIS based solutions were developed under these programs, adding experience to the knowledge base.

NGO1948 (Kartverket, 2017)$_b$ was the local reference frame (geodetic datum) until 1993 when it was replaced by EUREF89 (Kartverket, 2017)$_b$, which is widely used (common reference system)

NAVSTAR GPS (Astronomy, 2013) is used from 1988 (Location services) (Andersen, n.d.)

2.2 Legislation Framework and Political will

2.2.1 Freedom of Information

(1970) The Freedom of Information Act (1970, repealed 2006) states that any member of the public has the right of access to documents held by public authorities (PSI, Public Sector Information). In 1985, this right was extended to digital files.
(2006) The purpose of this Act is to facilitate an open and transparent public administration, and thereby strengthen the freedom of information and expression, democratic participation, legal safeguards for the individual, confidence in the public authorities and control by the public. The Act shall also facilitate the re-use of public information (Freedom of Information Act, 2006).

2.2.2 GI data protection / Privacy / Pricing

(1961) The Norwegian Copyright Act (Wipo.int, 1995) (1961, amended 2005) relates to copyright in literary, scientific and artistic works, includes the protection of "investments" as well as "large compilations" and prolongs the protection period from 10 to 15 years. Article 43a stipulates that a person who produces a photographic picture (aerial photography) shall have the exclusive right to make copies thereof and to make it available to the public. These rights extend either 15 years after the photographer's death or 50 years after the production of said photo (which is longer).

(1994) The government white paper Til informasjonens pris (Nb.no, 2017), states that pricing of information should be used as to secure the most effective use of resources, secondly for cost recovery for the operation, and most definitely not as a general contribution for the financing of the public sector. But if the information is used for commercial purposes within private or public activities, market price could be claimed.

(2000) The Personal Data Act (Lovdata.no, 2001) mainly restricts access to spatial information containing detailed information on ownership to properties.

2.2.3 Flagship initiatives – political support

(1995) Land Act (Ministry of Agriculture and Food, 1995)
The establishment of the Digital cadastral maps (DEK) is based on this very significant law for the cadaster in Norway.

(2000) "eNorway Action Plan" (handelsdepartementet, 2000)$_a$ for the governmental IT policy, supported the development of geographic information via the Internet (in 2000, the state mapping and geospatial activities amounting to more than 900 million NOK, (109.8 million €)) (Regjeringen.no, 2003)$_a$. The increase of access to local information through binding co-operation agreements with local authorities, the establishment of a first version of Net portal for national geographic data, the development of the Net-based learning in the field of Geospatial Information Technology (GIT) were included in the first Action Plan. In 2001 the actions had been completed (handelsdepartementet, 2000)$_b$.

(2002) "e-Norway 2005" (handelsdepartementet, 2004) for the governmental IT policy, includes a strategy to increase the access to PSI and exploit the electronic content. In GI context, it established a project for the development of a geoportal as a hub for the national infrastructure of geographic information. *"The focus in this project will be on obligatory cooperation between Government bodies, although other organizations – especially local Government – may also be included as required" (NHD eNorge, n.d.)*.

(2002) White paper "Digital Norway" – a common foundation for wealth creation" (Regjeringen.no, 2003)$_b$ is the most significant political initiative **for the establishment of the NSDI**. The major concept in the White paper is the establishment of the national

geospatial infrastructure in support of the eGovernment program. The **Key-changes In the GI context were:**

- change from isolated solutions to a national management concept,
- more coordinated digital services across sectors and levels of administration,
- better exploitation of common basic data,
- cost-efficiency in public sector, and
- one geoportal as a hub for the infrastructure.

The custodians, the governance scheme, the coordinator, the primary and thematic data are established. The paper was also a framework for a nation-wide co-operation in the public sector (called Norway Digital). Geospatial information received a massive boost in **2003**, after **the approval of the paper by the Parliament** (Flathen, 2007).
The benefit to business due to increased efficiency, better security and better service was estimated to 2.6 billion NOK (314.6M €). Through this initiative, the infrastructure to support the e-Government plan was built (eNorway 2009 – the digital leap, 2009).

2.3 Expertise

2.3.1 Standards

Norway has a long tradition in the standardization of geographic information, first at national level, onwards at European and global level. The development is based on a broad cooperation between the public and the private sector.

A national standard for describing and exchanging digital geodata (SOSI) (Kartverket, 2017)$_a$ was developed in 1982, covering more than 40 thematic areas since 1987. The standard, ensuring a common reference for an adaptation to international standards, has been continuously revised and developed and since 2006, it is fully compliant with ISO/TC and OGC.

In 2001, OGC standards were used in WMS, WFS, GML, Catalog and registry services as well as ISO/TC 211 standards 191xx for Metadata, Schema, encoding and definition of services (Strande, 2006) (Country report of Norway To the United Nations Committee of Experts On Global Geospatial Information Management, 2015).

Norway, participates in European standards (Cen.eu, 2017) since 1991, investing in ISO/TC 211 since 1994 and they started to follow OGC in 1995.
Standards Norway has the secretariat and the chairperson through the Norwegian Mapping Authority in ISO.

A national standard for digital cadastral maps was established in 1991(Mjos, 2002).

Geovekst (Kartverket, 2017)$_b$ is a collaboration on joint creation, management, operation, maintenance and use of geographic information, initiated in 1992. Among others, the participants defined a common standard FKB (Common Map Base) which is presently the most detailed and accurate dataset in the NSDI infrastructure.

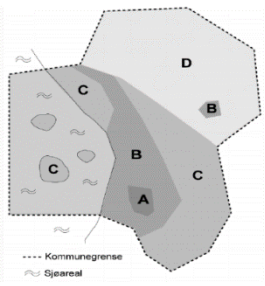

Figure 1 FKB data do not overlap (source: Kartverket, 2014)

In the largest cities one standard (FKB-A), in urban areas a different standard (FKB-B), in rural areas a third standard (FKB-C) and in undeveloped areas a fourth standard (FKB-D). The objective of the FKB was that there **will be no overlap between** the various FKB standards. **Detail and quality of data varies** depending on the

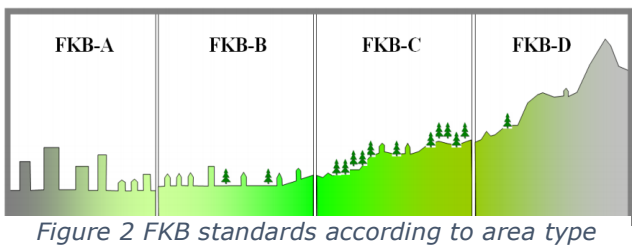

Figure 2 FKB standards according to area type (source: Kartverket, 2013)

type of region (Ny.geomatikkbedriftene.no, 2017).

2.3.2 IT, Geospatial Knowledge

Around 2000, the Norwegian geospatial public and private community led several areas internationally due to its expertise. Notable efforts included:

- Research and development where Norwegian companies, agencies and research institutes managed several EU projects that developed the use of geographical information.
- Standardization where Norway has gravitas, amongst others, through its chairmanship of the ISO standardization of geodata.
- Norway has been active and at times has led the work on the management and distribution of navigation tools in the International Hydrographic Organization (IHO) and the International Maritime Organization (IMO).
- Amongst the leading countries in the world when it came to the prevalence of PC, Internet and mobile (handelsdepartementet, 2000)$_a$.

2.4 Partnerships

2.4.1 GEOVEKST (public sector collaboration)

The "Geovekst" (Kartverket, 2017)$_b$ voluntary collaboration was established in June 1992, among public authorities already cooperating in the domain of large scale digital geographic data. The general agreement was signed by the State Road Department, the Board of Electricity Companies, the Norwegian Association of Local Authorities, the Norwegian Mapping Authority and the Telecommunication Department. The Ministry of Agriculture joined the co-operation half a year later. The Geovekst program was based on a shared responsibility concerning mapping production and cost of mapping. The National Agreement committed each main participant to do their best to take part in all projects. The parties had the option not to participate in all projects.

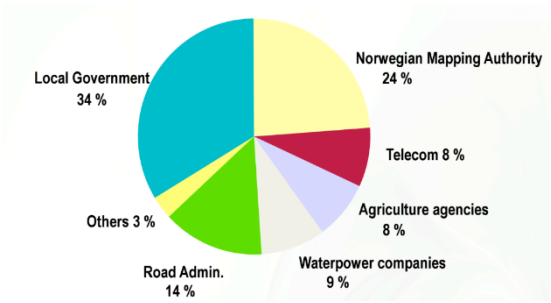

Figure 3 Cost-sharing in Geovekst cooperation (source: A.C. Frøstrup)

The Key element for the establishment of this collaboration is the moto **"Give a little, get a lot"** comprising: pay a yearly fee related to the importance of the base data and the size of organization, make ones geodata available to all other partners and get free access to all geodata from other partners.
Data capture was funded by partners, according to the above chart. Moreover, every participant had the mutual right of access to the whole data. The NMA undertakes the co-ordination role in the collaboration. Technical manuals, guidelines, software for data production and control procedures are defined and used from all parties. **Geovekst is the producer and licensee of FKB data** (core data of the NSDI). Geovekst was and remains to this day a cornerstone in the NSDI infrastructure.

For 1998 the total amount invested on Geovekst projects was nearly 8 million €, for 2002 were nearly 13 million € (Hall and Beusen, 2003)

In 2001, state mapping and geospatial activities geared towards basic geospatial amounted to more than 900 million NOK (113.4 million €) (handelsdepartementet, 2000)$_a$.

2.4.2 Private sector initiatives

GeoForum, a Norwegian umbrella organization for GI, was founded in May 1969 under the name Norway Map Technical Association. Norwegian members of EUROGI worked to make the importance of geomatics subjects visible to society. Its expertise and participation in public authorities and agencies was indispensable for the NSDI; a body with influence in geospatial industry to the present day.

Since the development of Geovekst, an Association of Enterprises in Geomatics **(GBL)** was formed, from privates companies involved in data production. The objective was to join forces in communication with the public sector, parliament, ministries, Geovekst and other stakeholders. In 2002, 20 large companies participated and today there are 24.

The Norway Mapping Group, is another alliance; this time of seven major Norwegian companies offering mapping systems and services regarding GI technology that resulted in a collaboration agreement with the NMA.

On the basis of a survey carried out for the Ministry of Environment in 1999-2000, it is estimated that the geomatics industry includes just under 200 enterprises which had a turnover of at least 2.4 billion NOK (298.08M €) and employed a minimum of 2,800 FTEs. (Full time employees) (handelsdepartementet, 2000)$_a$.

2.4.3 Other partnerships

Co-funding partnerships between Ministries and public agencies, mainly for production or/and maintenance of the **thematic data**.

2.5 Flagship programs

2.5.1 Cadastre

(1994) The cadastral law of 1980 introduced a new property register in Norway – the Ground Addresses Buildings (GAB) system. The objective had been changed in XXX year from being a system for tax revenues, to a tool that in addition facilitated local and central public administration. The GAB system is established as a central system under governmental administration with municipal responsibility for updating the system.
The (G) register was implemented in 1980-1983, the (A) and (B) registers were established in 1983. **In 1992-94** all buildings greater than 15sqm were digitized and registered with respect to a label point, a code indicating the use of the building and references to the ground property unit.
Digital cadastral maps (DEK) are under establishment, mainly as joint projects where the municipalities establish the digital cadastral map in urban areas based on cadastral survey maps, and where the Norwegian Mapping Authority establishes the cadastral map in rural areas on the basis of economic maps. By January **2002** property boundaries are digitized and registered in DEK for 70 % of all property units in Norway (Mjos, 2002).

2.5.2 AREALIS – The Norwegian Inspire version

(1997) AREALIS (Strande, 2001) aimed to be the **environmental branch of the NSDI**, achieving efficient area and resource planning, combining environmental/natural resource data, basic data, property data, positioning data, existing area plans and environmental preservation measures. A very similar program to the yet to be invented **INSPIRE initiative** with a major difference: **designed in a user-oriented way.** The participation of 10 Ministries, 20 public agencies and of some counties and municipalities, highlighted another key element of Arealis: the establishment of collaboration at central and regional level.
The thematic content included **150 datasets organized into 12 themes**.
In the technology context, principles of UML modelling according to ISO 191xx standards, exporting models by XML, ISO/TC 211 Feature Catalog methodology, Catalogue of Data

Sources (EEA, CDS) (Sdi.eea.europa.eu, 2017) tools using GEMET (Eionet.europa.eu, 2017) were applied.
The site was in operation **in 2002** and in the following years continuous improvements took place (Hall and Beusen, 2003).

2.5.3 TITAN – the regional SDI

(1998) One of the very first web-mapping applications running in Norway was launched by the TITAN (Tactical Integration of Telematics Applications Access Intelligent Network) project in **1998** (1998-2000). The main objective of the project was to make it easier to gather and present information about the Sogn og Fjordane region, and to develop interactive services involving the public sector, the private sector companies and the citizens by integrating existing and new web services. The project soon realized that the map was a natural entry point and integrator and thus decided to develop the application with a geographic interface.

The application was based on Autodesk Mapguide internet map server and Oracle dbms. A java based client was developed. This approach had the disadvantage of requiring a plug-in, but on the other hand enabled the use of 'intelligent' vector data on the part of the client.
The base map was the NMA's topographical databases (maps in scales 1:5K to 1:5 million). Many of the stakeholders had a lot of information already collected and stored in databases (Oracle).During the project, all the information was geo-referenced using both direct and indirect geo-referencing, but still separating the GI-part of the information from the existing information stored in the DBMS. The AREALIS members made a valuable contribution with their data sets. The overall result was a collection of **64 GI data sets**, generally grouped into three main categories: **environment, transport and tourism.** The information was made available to the user in two ways. Firstly, as a set of predefined thematic maps which are selectable from a list, and secondly as an option for a user's composition of selected thematic maps. The TITAN project is regarded as an early attempt to establish a Regional Spatial data infrastructure (RSDI). The service has gained much attention both through media, the GI community and a large amount of visitors.

2.5.4 Broad band services

(1999) A 3-year period program called Höykom (Hansteen, 2005) was a government initiative, with objectives to increase the competence and the use of broad band services, providing more innovation in the public sector and more efficiency and capability for a modernized public management and services. The programme contributed strongly to the development of broad band based services within education, health and social services and in the municipalities. New and improved services were developed both by private enterprises and the public. **Høykom provided financial support for more than 400 projects initiated by the public sector with up to 50% of total project costs**. It was another cornerstone for the establishment of the e-government era.

2.5.5 Geodata on Line – interoperability experience

(2001) The lack of interoperability within the Geographic Information Technology (GIT) had been a serious challenge. However, the technical specifications (GML, WMS and WFS) from OGC and the standards from ISO/TC211 provided a basis for developing interoperable geospatial database services and clients as elements in a National Geospatial Data Infrastructure (NSDI).
To gain experience with, and take advantage of the OGC and ISO work, the AREALIS programme sponsored the project "Geodata on line" (Høyhastighetskommunikasjon for utveksling av geodata Fase I, n.d.), launched in June 2001. The project terminated in June **2002**. The project has demonstrated how geospatial data, managed by different agencies, can be accessed over the Internet and freely combined by users as needed. It

is focused on testing interoperability between GI servers through WMS clients, under the collaboration of the County of Hedmark, the Directorate for Nature Management (DN), the Norwegian Geological Survey (NGU), the Norwegian Institute for Land Inventory (NIJOS), the Norwegian Mapping Authority and the Public Roads Administration.

The content included all NMA's topographical map databases, several environmental datasets from NIJOS, NGU and DN. Main data-sets with national coverage were established as geodatabases at this stage (ARC IMS, WMS extension). On this platform three WMS-clients were developed:

- A thematic client was developed by NGU and DN. The client accesses topographic layers from the NMA server and thematic information from the NGU and DN servers. Thematic information is from the main thematic group nature and includes geological data sets and conservation of nature data sets, and more.
- NIJOS developed another thematic client. Thematic information includes suitability for crops and soil erosion susceptibility.
- A generic client was developed by NMA. The user can **compose** the map from a list of datasets available from the NGU/DN, NIJOS and NMA servers (Strande, 2006).

The goal was to establish a portal for geographic information related to the broadband network. **In 2002, the portal was available for the administration and the public.** Using standard Internet technology allows the user direct access to the professional body's own databases. The technological solutions continued to work on the AREALIS Internet portal (Regjeringen.no, 2003)$_b$.

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3 DEVELOPING THE NSDI

Although in the second chapter the establishment of the SDI as well as other e-government steps are visible, the legal, institutional and technological frameworks facilitating the information flow between agents are needed for a successful nationwide enabled geospatial environment. The INSPIRE process has facilitated the development of formal national SDI's, and after the INSPIRE Directive entered into force on 15 May 2007, Norway similar to all the Nordic countries, has adopted new legislation on establishing infrastructures for geographic information. The activities for the development of a formal NSDI and the harmonization with INSPIRE directive, are described in this chapter.

3.1 Transforming the society- the political aspect

3.1.1 "Norway Digital"

(2003) "Digital Norway" (Regjeringen.no, 2003)$_a$ stated that all public enterprises having geodata responsibility or who were major users of such data, should contribute to the establishment, operation and maintenance of the "Norway Digital". The cooperation would be based on mutually binding agreements, and each party should commit to a two-part solution involving shared financing of basic geodata and an obligation to supply their own thematic data.

The "Norway Digital" cooperation was formally **established in 2005**, with more than **600 partners** of Norwegian public authorities (427 municipalities except Oslo, 18 counties, 118 energy supplies, 2 other regional parts, 40 national bodies).
The government was initially responsible for the overall management and financing of this infrastructure, with the Ministry of Environment (now the 'Ministry of Local Government and Modernization') responsible for the coordination of national partners. The Ministry directed the Norwegian Mapping Authority, which since then has held primary responsibility for administrating cooperation between partners. To serve its new role in an efficient way, NMA sold its competitive activities to the private sector and the distribution of data to commercial players to Ambita, a state owned company specializing in property information.
The decisions on standard formats of delivery and access and the joint technical solutions were also established in this Agreement.
The partners of Norway Digital can use all data of infrastructure, based on a set of two contracts:

a) the general agreement of Norway Digital; and
b) a specific contract between the partners involved, that includes the annual cost, the delivery requirements and specific conditions or limitations.

The partnership fee was calculated per dataset, according to base value of the dataset, the value of use and a partner factor.

3.1.2 ICT-policies and e-Norway 2009 "the digital leap"

The European INSPIRE initiative, initiated in 2007, laid the foundations for a "digital leap" in public sector services with the Norwegian e-Government Program in 2009.
(2005) "e-Norway 2009" (eNorway 2009 – the digital leap, 2009) is the government policy for an 'Information Society' that aims at increasing the use of digital resources, including geo-information. The programme played an essential role in the Norwegian Spatial Data Infrastructure (NSDI), establishing the following goals in the GI content:

- ✓ reuse of public data to increase value creation and development of new services, based on a **no cost principle**
- ✓ **evaluation/reporting** of the re-use directive's **impact** on value creation and consequences for official bodies (until 2007)
- ✓ sole rights' agreements for use of official data, which **conflict with the EU** Directive concerning re-use of public sector information, shall be reviewed and changed

The digital interaction in the public sector is one of the objectives of the plan. To achieve this objective, it was stated that all government agencies with responsibility for geodata and most municipalities shall join 'Norway Digital' and update their data by 2005.

3.1.2.1 Implementation influences

During the execution of 'e-Norway 2009' plan, the following tasks are carried out:

- Definition of ICT architecture principles: Service orientation, interoperability, accessibility, security, openness, flexibility, scalability
- Definition of ICT infrastructure for the national common components in the public sector: Register for legal entities, Population Register, Cadastre, Altinn components, common infrastructure for e-ID public sector
- Interoperability between information systems in various sectors and level of authorities

Figure 4 Interoperability between information systems in various sectors and levels of authorities (source: K. Jordbakke, 2012)

3.1.3 Planning and building Act

(2008) According to the act (Environment, 2017), the municipalities shall ensure that there is **an up-to-date**, public set of basic map data for the objectives specified in the Act. The central government authorities shall make national map data available to all municipalities. Central government, regional and municipal bodies shall organize geodata in such a way as to ensure that the information is readily available for use in processing planning and building applications. The basic map data must also be available for use for other public and private purposes.
The municipality may require from any person who presents a plan proposal or project application, to prepare maps when this is necessary in order to be able to make a decision on the proposal or application. The municipality may incorporate such maps into the public sector basic map data. The municipality may require that planning proposals, applications and maps be submitted in digital format.

3.1.4 Norway universally designed by 2025

(2009) In the context of the implementation of government program "Norway universally designed by 2025", the government drew up an action plan for universal design and increased accessibility for the period 2009-2013 (Norway universally designed by 2025, 2009). The ambitious but possible plan came after a period of three years of pilot projects in municipalities, involving **all the ministries** in its implementation.
Measure P2 of the plan refers to the support by the geospatial infrastructure for obtaining and presenting universal design data. It comprises the development of geospatial information relating to universal design, which includes the mapping and gathering of accessibility data for buildings and outdoor areas. The information is to be used to measure the status and development of universal design at a national, local and user level.

3.1.5 The Spatial data act

(2010) The transformation of the voluntary collaboration to one by law was brought about by the Geodata Act (Regjeringen.no, 2010) and its regulations for the implementation of the INSPIRE Directive. Until then, there wasn't a legal base and every action was based on the white paper 'Norway Digital'.

Norway which is part of the European Economic Area (EEA) has always followed closely the INSPIRE initiative. The EEA decided in 2010 to apply INSPIRE as well, even though

the member countries are not members of the EU. The cost for the implementation of the Geodata Act was estimated at 2 million € for the national level and 2 million € for the municipalities (ÅRSRAPPORT 2016, 2016).

The new law is broader than Norway Digital since the initiative only deals with the public sector, **not the public**. The law aims (with its amendments in 2012, 2014, 2016) to promote good and effective access to the public spatial information for public and private purpose.
According to the law the **organizations dealing with the GI are still permitted to charge the costs of gathering the information and a reasonable return on investment**. The search and display services should be freely available to the public. Data that is available free of charge through the viewing services, may be in a form that prevents further use for commercial purposes. Display Services for use in commercial and other spatial data services can be made available against payment. Access to spatial data services can be made dependent on the user agreement regarding the terms of payment, use and exploitation.

The new law goes further than a simple translation of INSPIRE and is different from Digital Norway in that:
1) it can also deal with other data
2) the duties are not applicable for all authorities in the same way (e.g. municipalities should not make their geodata accessible themselves).

A detailed time-table is defined for the 34 spatial datasets and services, from the end 2015 to the end of 2024. Adaptation of network services to handle new metadata requirements according to EC 1311/2014 is to be defined at the end of 2017.
Norway in 2016 published the performance indicators and prepared a three-year report (Report INSPIRE: Norway 2013-2015, 2016) for the reference years 2013 to 2015.

3.2 Implementing the transformation

3.2.1 The New Cadastre

(2003) The land market in Norway was serviced by a dual registration system, in line with many western European countries: The Land Register (maintained by 87 local courts, administratively supervised by the Ministry of Justice) and the Cadaster (maintained by 434 municipalities, supervised by the Norwegian Mapping and Cadaster Authority-NMA now).
However, in 2002 the Norwegian Parliament decided to go for the single agency solution. Starting in 2003 the responsibility for the land register will be transferred from the local courts to the national mapping and cadaster organization.
The Land Register is supporting a title registration system while the Cadaster contains technical information on the GAB system. With the aim to facilitate an integrated on-line service to citizens, the two ministries agreed to outsource the operations of their two databases to a state owned company Ambita. The new cadaster included a central database with graphical information as well as information about public restrictions on land and buildings.
The Land Registration Act was adapted in 2007, and the amendments taken effect in January 2010, linking the Cadaster to the national Register, the cultural heritage register and the register for polluted areas (Onsrud, 2003).

3.2.2 Geoportal, a pre-shared vision with Inspire

(2004) The one point access geoportal Geonorge commenced operation in January 2004 by the Mapping Authority on behalf of the parties in 'Norway Digital' co-operation. It developed further, to satisfy additional requirements and in June 2017 the "New national

GeoPortal" (Geonorge.no, 2017)$_a$ will be available. Geonorge implemented the common vision of NSDI and EU SDI with the following values:

- ✓ data should be collected once and maintained at the level where this can be done most effectively
- ✓ it should be possible to combine seamless spatial information from different sources and share it between many users and applications
- ✓ it should be possible for information collected at one level to be shared between all the different levels, high resolution for detailed investigations, general for strategic purposes

The New National Geoportal had two overall objectives:

- ✓ all participating businesses, as defined in geodata law / regulation, use by 2018 the Geoportal as their first choice for the publication, provision and access of their digital geographic information.
- ✓ access to all available public geographic data is simplified in that they can be located from an integrated site in 2018

3.2.3 Implementation of Digital Norway at Regional level

(2005) Acting as a bridge between the local and national levels, the federal government at regional level is an important element in NSDI infrastructure. However, difficulties arose during start-up due to factors including the high cost of GIS licenses, high demand for support, and the high level of expertise needed to use the systems. In addition, large numbers of people within an organization were unaware of their need for geo-information and the benefits to be gained from GIS.

To increase the use of GIS within federal government, a co-operative project began in 2005 involving four departments in the counties of Hedmark and Oppland. The project, which resulted in the implementation of the Digital Norway concept at regional level, had a two-step approach.

As a first step, an internet application (www.innlandsgis.no) was implemented to help new users familiarize themselves with GIS and accommodate day-to-day geo-information needs. The application gives access to dynamic and up-to-date base-maps and thematic data as WMS, and uses web services for national database search. The data is divided into themes giving access to predefined thematic maps for specific management needs. Some of the data is stored locally: a temporary solution, until such time as more data producers supply their data as standardized map services.

The second step, was to develop applications in the form of thin clients for the more advanced users and tasks (Government.no, 2017) (Persson, 2007).

3.2.4 R&D environment

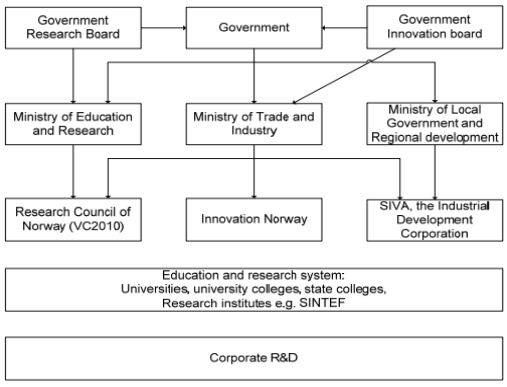

Figure 5: Norwegian innovation system (source: E. Ramstad & T. Alasoini, 2008)

There is no single forum with an innovation policy responsibility in Norway, but the responsibility for innovation as well as R&D matters is divided between several Ministries.

At the governmental level two boards focus on the coordination of innovation and R&D policy issues. These are the Government's Innovation Board and the Government's Research Board. The Ministry of Trade, Industry and Fisheries is responsible for comprehensive innovation policy, while the Ministry of Education and Research is responsible for coordinating sectoral R&D policies, e.g. organizational research and development. Research programs are funded directly from the ministries or through governmental funding institutes like Research Council of Norway, Innovation Norway and the state owned enterprise SIVA, the Industrial Development Corporation of Norway.

Public funding of research and innovation efforts of work-oriented innovations in Norway has relied to a large extent on programs set up by the Research Council of Norway. There are three main divisions in the Research Council. The Division of Science is responsible for basic research, Strategic Priorities assists ministries in policy issues and the Innovation Division promotes value creation.
The Research Council works closely with the Innovation Norway. The main functions of Innovation Norge are regional development through funding of companies, running networks, encouraging investments and counselling inventors.

The main R&D performers in Norway are the universities, university colleges, state colleges, research institutes and corporate R&D units. The higher education sector carries out approximately one fourth of Norway's total R&D activities. The R&D efforts are financed through basic funding from the state, grants from the Research Council and contracts with private and public workplaces.

The Norwegian National Research Ethics Committees are independent agencies for questions regarding research ethics, and investigation of misconduct, within all subject areas.

Act No. 56 of 30 June 2006 regulates the ethics and integrity in research (the Research Ethics Act), and amendments have been proposed by a consultation paper (Consultation paper – Research Ethics in Norway, 2015) published by the Ministry of Education and Research in July 2015.

3.2.5 MAREANO program

(2006) The MAREANO program maps depth and topography, sediment composition, biodiversity, habitats and biotopes as well as pollution in the seabed in Norwegian offshore areas. 20,000Km^2 are annually surveyed and the results are made available on a web site and visualized using maps. In addition, it supplies a range of partners with data and maps from his business. (See images from the seabed, See videos from the seabed)
The program is funded by the Ministry of Fisheries and the Ministry of Climate and the Environment Ministry through grants from the state budget.
The allocated funds from 2006 up to today, are estimated at 806 million NOK (101.2 million €).

3.2.6 Omløpsfoto

(2006) This is the National program for current photography (Kartverket, 2017)$_c$, providing updated aerial images and orthophotos for the entire country. Photographing and arrangement of the images follows a 5 year plan. All new orthophotos of current photography are produced with a ground resolution of 25 cm (70,000 to 100,000 Km^2 annually). Orthophotos are managed in norgeibilder.no and are available for Norway Digital parties through WMS services.

3.2.7 Open source instead of COTS

(2007) Through the participation in Norway Digital, the amount of WMS (Web Map Services) requests has increased dramatically. Where in 2007 already about 50,000 map images were requested on an average day, this has increased to roughly 300,000 in 2009, tendency rising.
The Norwegian Mapping Authority is funded by the national government of Norway. Although there is no dedicated budget for the IT infrastructure, as the main priority is to have an efficient and functioning system, the national government encourages publicly funded bodies to reduce IT costs by using free and open software, where this is possible.

In the years before 2007, the Mapping Authority paid annual licensing fees to the software provider ESRI. These were relatively expensive and with the increasing amount of data requests, the Mapping Authority either had to purchase additional licenses or had to find more economical solutions, which would cope with the requirements equally well and would not undermine the quality of services provided.
In late 2007 the team started to implement an infrastructure based on open source software in parallel to the proprietary software based one already in place. At first, this was not public and just for internal testing purposes, but after three month of testing the solution went live and replaced the proprietary solution.
According to the National Mapping Authority's estimations, 250,000 EUR were saved in 2008 and 750,000 EUR in 2009, by avoiding purchasing additional licenses from ESRI. Of course, the National Mapping Authority also had to make some investments for the new infrastructure and decided to hire a new member of staff to fill the skills gap. The amount spent on this investment was estimated as considerably lower compared to the software licenses.
More detailed information about the NMA's decision to employ an IT infrastructure based on open source software solutions can be found here (Joinup.ec.europa.eu, 2017)$_b$.

3.2.8 The GeoIntegration Project

(2008) The GeoIntegration Project (http://geointegrasjon.no/) was established by the Norwegian Association of Local and Regional Authorities (NALRA) and The Norwegian Mapping Authority (NMA), in cooperation with the major Norwegian information system providers of GIS and archive systems. **It is a cornerstone for the e-government establishment.** The Project was run until 2011, completing its work by implementing the standard and its specifications (the budget was 1,2 million EURO). By end of January 2012, the GeoIntegration standard was placed into the responsibility of the Norwegian Mapping Authority.
From a situation with severe problems in communication between different information systems, despite well-developed standards within various topics, the idea of a common accepted specification of the interfaces for communication between the different information systems occurred.

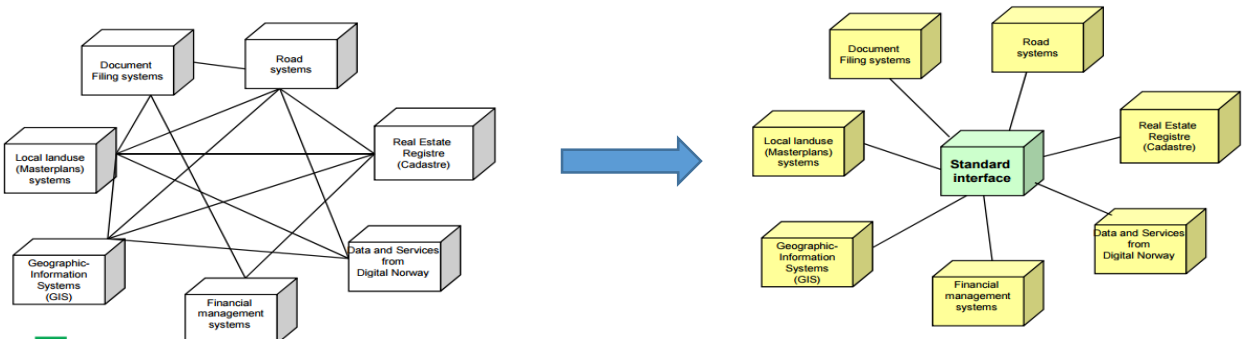

Figure 6 GeoIntegration's concept (source: Norwegian Mapping Authority, 2010)

The aim and the objectives of the project were to develop and ease the communication and interaction between information systems in use by the public sector, by developing and realising common standardised communication interfaces between case-handlings- and archive systems, geographic information systems and other professional task systems. The Geo-integration project is recognized to meet all three criteria set by the EU Commission's office of Information Society to interoperability-ICT-projects; technical, semantic and organisational interoperability.

3.2.9 Central Storage of FKB data (SFKB)

(2011) The Geosynchronization project was intended to determine the specifications for interfaces that enable synchronization of data storage with the geographic data content across different platforms and system solutions. The Geosynchronization standard (Standarder Geografisk Informasjon, 2013) (mid 2013) was created from the project, and efforts began for its implementation through Norway Digital parties' systems, with the objective the FKB data from municipalities be updated directly in a central database in the Mapping Authority.

By mid 2017, 20% of the most detailed and accurate data of the infrastructure called FKB (Common Map Data Base) will be stored in the central common map database (SFKB) (Kartverket, 2017).

The main objective of the new solution is obvious: **updated data to all users in almost real time**. Other positive effects are:

- ✓ Validation / monitoring of central base will give a more homogeneous data base
- ✓ Data flows are automated and resources can be redistributed for the control and the quality improvement of the data itself. This will provide a basis for better data quality
- ✓ It will be possible for several agencies to contribute in updating the same data set
- ✓ It will be easier to utilize other data sources for updating map data as, for example, Right Map (Rettikartet.no, 2017) ("crowdsourcing")
- ✓ It will be easier to achieve a good data flow for generalized map products like the N50 so that Map data becomes more consistent over scale barriers

3.2.10 BarentsWatch

(2011) BarentsWatch is a collaboration between several agencies with an interest in the marine and maritime sectors. The parties develop and share information and services based on combinations of data for ocean and coastal areas around the Barents Sea. The portal was launched in 2012 and has incrementally been developed.

In 2011, the Norwegian Coastal Administration was put in charge of the establishment of BarentsWatch.

3.2.11 Cross-border agreements

(2011) The Blue light-agreement (crisis management services) was signed between the map agencies in Denmark, Sweden, Finland, Iceland and Norway. The agreement gives mutual access to the map data, addresses and location names in a 100 km zone around the borders of each country.

(2012) **Data sharing in the Nordic region** (Nordforsk.org, 2013) is a collaboration between the Nordic mapping agencies. The aim is the establishment of methods for the improvement of data sharing between countries based on the existing services in each country.

One collaboration project called «Harmonized Cross Border Data", (Geodata.se, 2017)has been signed in Autumn 2016 and will be carried out during 2017. The goal is to improve cross-border geodata solutions to support all of the actors involved in emergency response.

3.2.12 Arctic SDI

(2014) The Arctic SDI is a cooperation based on a Memorandum of Understanding signed by the eight National Mapping Agencies from Canada, Kingdom of 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**.

3.2.13 TopoBaty 2014

In 2014, the Mapping Authority completed a pilot project for data collection with laser in coastal zones. The conclusion was that, the latest generation of Lidar technology can be used for good and efficient data collection in these areas and the technology is economically viable (Kartverket, 2014).

3.2.14 Cloud Computing

(2016) Outsourced services allows public enterprises to focus on their core activities and in recent years cloud computing is an important outsourcing alternative. The government announced the "Cloud Computing strategy for Norway" (Modernisation, 2017) as many public sector enterprises consider this as an alternative, which aims to facilitate:

- ✓ more cost-effective ICT solutions,
- ✓ increased focus on core activities,
- ✓ greater flexibility,
- ✓ greater security through more professional and standardized ICT,
- ✓ lower threshold for innovation and startups and
- ✓ reduced carbon footprint from ICT operations.

It also defines measures for the establishment of a legal framework for use and a supportive legislative framework.

3.2.15 National Detailed elevation program

(2016) Norway's largest land-mapping project is underway (Kartverket, 2017)$_c$. The project constitutes the major part of the data collection for establishing a national, detailed elevation model. The whole country will be covered by 2020 with the total cost estimated at 350 million NOK (37.7 million €). **The new dataset will replace all the existing elevation data**. A new management solution with central storage of the data is applied.

3.2.16 Distribution of responsibilities

During the implementation process of the Norwegian's NSDI, a system of distributing responsibilities, offering harmonized services is established:

- ✓ National web viewers for the public,
- ✓ National planning applications, Regional administration systems,
- ✓ Environmental impact assessment applications and
- ✓ Local cadastral and master plan applications.

3.3 Society contributes, not only use - Crowd sourcing

(2013) The Norwegian Mapping Authority officially launched a website for the contribution of the users to their maps and map data, called Rett i kartet ('Fix the Map'). From January 1st until April 30th, the users contributed with 780 registrations, with each registration containing one to several contributions. This includes both correcting errors in the map data and adding currently missing features. In June 2015, a new version of the website was launched, this time also supporting contributions from users **with tablets and smartphones.** Missing information on Norway 1:50K, changes in routes and addresses and reporting trails or outdoor routes are supported by the site.

4 THE NSDI TODAY

A short summary of the current status of the Norwegian SDI and the future goals are presented in this chapter.

4.1 The current status

Norway today, has a comprehensive and advanced geographic information infrastructure, covering many needs of the society. The infrastructure of data, common solutions, services, standards and rules of administration, distribution and use of geographical information has been largely developed through the agreement-based collaborated 'Digital Norway'.

Many actors and users are completely dependent on the access to good geographic information. Social processes such as building management, navigation, flood and security and the emergency services. Use of the residential addresses is also a quite critical approach. Increasing amounts of data and opportunities for linking data also involves increased community utilization of geographic information. People don't use the 'raw' geographic information but the use of GI is wrapped in virtually all sectors and at all levels.

The Geonorge, is the one access point for the whole infrastructure; the core or hub of the geospatial infrastructure. The most accurate and detailed basic data is updated almost in real time. A large part of the geographic information in society is collected by the public actors through methods that ensure good quality and accessibility. Much information is also created in the private sector, on behalf of the public, through commercial activity or through consumer behavior.

The vast majority of the data in the infrastructure is available as open data.

The rapid digitization of society and an increasing demand of updates, raise the question of how to collect, manage, distribute and link them. The aggregate amounts of geographical information are organized.

4.2 The next steps

The political will is, "Norway to be a leader in the use of the geospatial information". To achieve this, a new geodata strategy (Geonorge.no, 2016) was announced in 2016 called "National Geodata strategy until 2025", divided in four areas.

1. Data: A national knowledge base of geographic information, meeting important social needs

2. Technology: Common solutions and technology that support an effective task solution and opens new opportunities in society

3. Frame conditions: A well-functioning co-operation on the management, sharing, development and innovation between the actors in both the public and private sectors

4. Co-operations: A regulatory framework that is predictable and well adapted to the challenges of the digital society

The first two areas address the need for a better knowledge base and a more efficient utilization of the technology while the last two address important tools to make this happen.

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5 THE FIVE ELEMENTS OF THE NSDI

In this chapter, a detailed description of the five elements of the current Norwegian 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 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 Norwegian GI-Hub, the Geonorge.
The overarching architecture, the technical principles, the interoperability and openness of the spatial data infrastructure and the enabling technologies are presented in the Technology component.

5.1 Organizational

5.1.1 History and key initiatives

All the relative information has been provided in the second and third chapter.

5.1.2 Legislation

5.1.2.1 Geodata Act

Geodata Act (Geonorge.no, 2017)$_b$ is the main law that governs the structure of geographical infrastructure. The law aims to promote good and effective access to public geographic information (spatial information) for public and private purposes. The law is implementing Directive 2007/2 / EC of 14 March 2007.
The Act requires from the public authorities to share spatial data, and collaborate on geographical infrastructure. The authorities have to establish and operate a network of online services including searching, viewing and downloading geodata. These services have to be available to the public.
Geodata Regulations have been issued with all necessary rules for the implementation of the Act (2012, 2014). The practical implementation will be applied in stages until 2023.

5.1.2.2 INSPIRE

Inspire is a European cooperation for a common geographic infrastructure (Kartverket, 2016)$_a$, rooted in Directive 2007/2/EC (Eur-lex.europa.eu, 2017). The Directive sets a series of deadlines for when the different parts of the infrastructure will be in place. This is scheduled to occur in the mid-2020s.
Inspire geoportal is accessible from the Norwegian geoportal Geonorge.

5.1.3 Governance, support, audit

5.1.3.1 Governance

5.1.3.1.1 Ministry of Local Government and Modernization (Policy / Strategy)

The Ministry is responsible for the ICT policy, national geospatial policy and Public Sector Reform. In particular, it is responsible for the administration and modernization of the Public Sector as well as for the relevant regulations for the Geodata Act and the implementation of INSPIRE, including the supervision of the Geodata coordinator.

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 Mapping Authority (coordination)

Norwegian Mapping Authority is the national spatial data coordinator. In particular, it safeguards and is responsible for rulemaking, standardization, technological development, administration and supervision of the work for the geospatial infrastructure in Norway. This role is exercised in close cooperation with the municipalities and other public sector suppliers and users of geographic information through Norway Digital.
The NMA has strong international experience and activity in coordination, holding the chair of ISO TC 211, co-chairing the working group on the Global Geodetic Reference Frame on UNGGIM and coordinating the European Location Framework (ELF).

5.1.3.1.3 National geodata council (advisory/monitoring body)

The Council has 15 government-appointed representatives and its mandate is to ensure cooperation between all those who manage and use the community's geographical information. The Council advises the Ministry of Local Government and Modernization on Norwegian geodata policy. Also, it contributes to the cooperation and use of the spatial data by the public authorities and others who use the geographical infrastructure.
The Council monitors the implementation of the Geodata Act and the European INSPIRE directive, and provides advice or statements where it deems appropriate.

5.1.3.1.4 Coordination Group for geographic information (Executive body / support)

The Coordination Group consists of 21 participants which together represent all the parties / participating businesses in Norway Digital. The coordination group is the executive body and has decision-making powers over the parties in Norway Digital. The Mapping Authority leads the group and is the secretariat. The coordination group represents and safeguards the rights and obligations of the parties in Norway Digital co-operation. The group communicates and coordinates input from others with interests in infrastructure and assists the geodata coordinator in operating cooperation in accordance with current requirements, guidance and society.

5.1.3.1.5 Forums

Specific Forums support the development of the infrastructure in all levels: the preparedness Forum, the technology Forum, the Plan Data Forum, the Theme Data Forum, the Cadastre Forum, the Marine-maritime forum and the Geovekst Forum.
INSPIRE Norden is an informal meeting place for Inspire (ÅRSRAPPORT 2016, 2016).[Kartverket_2016]

5.1.3.2 Support at Regional/Local level

5.1.3.2.1 County geodata "utvalg"

The county geodata "utvalg", is administered by NMA's 12 county map offices and ensures cooperation at the regional level. The county governor's offices take care of the central government's responsibility, and co-operates with the Geodata coordinator as a driving force for increased use of geodata in the municipal and regional government.

5.1.3.2.2 Storkommune group

The Group is a geodata partnership where nine of the nation's most populous municipalities cooperate about technical challenges related to maps and geodata. Five of the municipalities are not included in Geovekst, but have made digital agreements for deliveries to Norway Digital (Report INSPIRE: Norway 2013-2015, 2016).

5.1.3.3 Audit-Assurance

5.1.3.3.1 Office of the Auditor General of Norway

The Office of the Auditor General ensures that the community's resources and assets are used and administered in compliance with the decisions of the Parliament.

Data Protection Agency

The Agency is an independent administrative body which is entrusted with the application of data protection laws. It verifies organizations' compliance on processing personal data, regulates processing of sensitive data through licenses and advises on matters of protection of privacy.

5.1.3.3.2 Privacy Appeals Board

The board is the appeal body for decisions made by the foresaid Agency and it considers appeals against decisions made by Agency pursuant to the Personal Data Act and certain other acts.

5.1.3.3.3 National Mapping Authority

The Mapping Authority monitors and controls the deliveries from each participating company and provide feedback on the metadata, geodata and geodata services, ensuring that they are in accordance with the requirements of the regulations, agreements, product specifications and the technological framework for Norway digital.

More information about the audit tasks of the NMA can be found online (Kartverket, 2015).

5.1.4 Policies and licensing

The development of the cooperation is anchored in GeoData Act (Lovdata.no, 2010) and its related regulations (Lovdata.no, 2012). More details about policies and funding can be found online (GENERELLE VILKÅR FOR NORGE DIGITALT- samarbeidet, 2017).

5.1.4.1 Use and access

5.1.4.1.1 Access to the geodata services

The services of Digital Norway are based on electronic licenses. They are offered either free of charge or under payment terms, as described in the following paragraphs, in full detail (Kartkatalog.geonorge.no, 2017)$_c$.

5.1.4.1.2 Sharing spatial data and services between participating business

The participating businesses in Norway Digital:

- grant among (Geonorge.no, 2017)$_c$ each other the right to use the spatial data sets and the related spatial data services. Limitations in sharing can be applicable in cases that put at risk the public security, the national defense or the international relations
- must pay an annual fee for the right of use. The compensation is determined on the basis of the value and usefulness of the data they provide and use
- for their public duties, can give access but no rights of their data and services, to subcontractors can be found online (Kartverket, 2017)$_e$.
- The Ministry may impose conditions on the use and exploitation and provide instructions on the sharing of spatial data and services. Such orders cannot be appealed.

5.1.4.1.3 Sharing spatial data and services with institutions in other countries

Participating businesses will give EU and EEA institutions, public administration and other institutions performing public administrative tasks in other Member States, access to

specific spatial data sets and spatial data services. Access shall be provided via web services. Agreement and license shall comply with regulations.
This provision shall apply correspondingly to institutions created by international agreements to which Norway and the European Union are parties, and for access to online services via the single European GeoPortal INSPIRE.
This provision applies to local and regional authorities when they are obliged to collect or convey specific spatial information under another statute or regulation.
Participating business cannot demand payment for spatial data and services provided to EEA institutions to meet the EEA reporting obligations relating to the Environment.

5.1.4.1.4 Internal use in their own business

The right of use applies to those employees and contractors, and includes analog and digital copying, processing, increased value and use in internal networks and services. Parties may provide subcontractors access to copies of data that are not open for use by the agreed tasks. Such copies shall be deleted when the tasks are completed.

5.1.4.1.5 Use of externally oriented information

Parties may use the data from Digital Norway in remote networks, search and display services for geodata Act. The services must be based on updated data. The services shall be free unless otherwise provided by statute or regulation.

5.1.4.1.6 Source Reference

The Parties shall specify the source when using other licensee data. The name of the source / agency is required, the name and version of the data / data source is recommended. The withdrawal date also should be specified when using the copy of the data.

5.1.4.2 Licensing

External access to the NMA datasets is regulated through a pricing policy for the customers and the value-added resellers. The pricing policy has two main categories:
Usage right: Internal use for company/institutions, Private use for families and close friends, customer limited usage and customer full license by network or PC.
Marketing rights: Interactive (use of services), Re-licensing (special customers on certain conditions).

For the GI held within the government institutions, there is no general pricing policy. The Ministry of Finance is, in principle, in charge of the pricing policy for the Public Sector Information (PSI).
The various Ministries and agencies have various pricing policies. The guidelines from the Norwegian Mapping Authority is that core data shall be partly financed by the end user and some of the production cost will be compensated by the sale income.
Statistics Norway distributes its information largely free of charge or at most at marginal cost. The same is the case for Norwegian Geologic Survey, Directorate of Nature Protection and Norwegian Soil and Forestry Survey. They have a policy not to charge for the information, only for the cost to distribute it. Pricing for cadastral information is based on statutory requirements.

Today's political objective is that the public data, as far as possible, be made freely available for all purposes. The parties must therefore consider whether their data and services can be made available under the open Norwegian license for public data (NLOD) (Data.norge.no, 2017), or another license for further use, such as a Creative Commons (CC-By 3, CC-By 4).

5.1.5 Funding and pricing

5.1.5.1 Funding

The theme Data is financed by each party.
The basic geodata is financed through:

- government funds
- licensees' own funds, possibly augmented by contributions from collaborators
- contributions from parties
- revenues from sales

Parties must submit their own thematic data and share the fund which is relevant to the basic geodata, through an annual cost. Parties' annual costs should be attributed unabridged to current licensees.

5.1.5.1.1 Annual Cost for basic data

5.1.5.1.1.1 Calculation of annual cost

The Geodata coordinator (National Mapping Authority) determines the annual cost in dialogue with each party of the Norway Digital cooperation. Municipalities, counties and energy companies (network companies with area license) are treated as three nationwide parties. Each municipality, county and energy company will pay a proportional part of the annual cost which is calculated as nationwide party. Cost allocation for each municipality is based on the factors: acreage, number of buildings, population and a fixed portion, where each factor accounts for 25%.

The principles of the calculation are applied equally to all parties and are as follows:
• Each party pays for all required product groups even if the party is not a licensee. Two product groups are optional (CPOS, DPOS location services)
• The parties' annual cost of a product group can never be less than the current unit cost of the product group
• Usefulness of all parties is reviewed before the annual cost is determined
• If a product group is "necessary business" or "business-critical" (usefulness 3 or 4) only for a small part of the party's overall business, a new value (Usefulness of product) is determined. The "Part factor" should always be kept fixed for all the parties of the cooperation.
• The unit cost is based on product group availability throughout the year. For product groups that are only available in parts of the year, the cost is calculated from the estimated availability, and deviation between the estimated and actual availability is settled next year. The National Mapping Authority's location service charge is calculated from a fixed price per unit of measurement for each service.
• Value-added tax is not calculated for the parties' annual cost
For further information see template xls, Appendix 1 with unit code prices (Statens kartverk, 2017)
Geodata Coordinator may agree on a lower power factor than the one supplied by ordinary calculation, for a party that has minimal or no use of the product group. The lowest power factor is 1.0 and the minimum price is equal to the unit cost of the product group. Geodata Coordinator informs licensees when a party gets approval of a minimum price.

5.1.5.1.1.2 Payment

The Geodata Coordinator shall bill the parties annually, with a deadline for payment within 30 days from invoice date.

5.1.5.1.1.3 Reversal of annual cost

The Geodata Coordinator shall return the annual cost to the individual licensee by 1st of December.

5.1.5.1.1.4 Information about the total annual cost

The Geodata Coordinator shall inform in full details, the parties and the licensees about the total paid annual cost.

5.1.5.2 Pricing

The new pricing model (2014) consists of 3 levels calibrated to different players:

1. Full subscription (all content – major companies)
2. Semi subscription (substantial parts of content – medium companies)
3. Unit price (price per piece – small firms – personal customers)

The price is fixed and is not related to extensive use (Frøstrup, n.d.).

Business that want data from the cadaster and the land register (registry of property rights), must have a legal basis by disclosure regulations (Lovdata.no, 2014) and also have to entered into agreement with the Mapping Authority. See the annex with the agreement and the prices of services (Holtan, n.d.).

Pricing policies for location services can be found here (Kartverket, 2016)$_b$.

5.1.6 Partnerships

The BarentsWatch, the Arctic SDI and the rest of Partnerships have been mentioned in previous paragraphs.
In general, three data collaboration networks established, all based on split cost concept: Geovekst in 1992, Norway Digital in 2005 and Inspire in 2010.

5.2 Standards Component

5.2.1 Introduction

SOSI stands for "Systematic Organization of Spatial Information", and is built up under the auspices of several working groups with a major national commitment and an overall objective: to ensure that spatial data is easily accessible and the greatest possible benefit for society.
SOSI (Kartverket, 2017)$_f$ standard Version 4 (2006/2007) is compliant with international standards in geographic information. The main standardization arenas for previous and further development of SOSI standards are ISO/TC 211 (Iso.org, 2017)and OGC.

5.2.1.1 Standards from ISO/TC 211

The following standards from ISO/TC 211 are published as Norwegian standards (Standard.no, 2017):
EN ISO 19101 Geographic information - Reference Model
EN ISO 19105 Geographic information - Compliance and Testing
EN ISO 19106 Geographic information - Profiles
EN ISO 19107 Geographic information - to describe the geometry and topology EN ISO 19108 Geographic information - to describe the hour aspects
EN ISO 19109 Geographic information - Rules for application form
EN ISO 19110 Geographic information - Methodology for object cataloging
EN ISO 19111 Geographic information - for localization with coordinates
EN ISO 19112 Geographic information - for indirect localization
ISO 19113, EN ISO 19157 Geographic information - Principles for classification of quality
ISO 19114, EN ISO 19157 Geographic information - Procedures for quality assessment
EN ISO 19115 Geographic information - Metadata
EN ISO 19116 Geographic information - Positioning Services
EN ISO 19117 Geographic information - Visualization

EN ISO 19118 Geographic information - Code Rules
EN ISO 19119 Geographic information - Services
EN ISO 19123 Geographic information - for bridging thematic representation
EN ISO 19125-1 Geographic information - Access to basic geographical objects - Part 1: General architecture
EN ISO 19125-2 Geographic information - Access to basic geographical objects - Part 2: SQL
EN ISO 19133 Geographic information - Location-Based Services - Tracking and navigation
EN ISO 19135 Geographic information - Procedures for registration of geographical elements
EN ISO 19128 Geographic information - Interface for mapping services web
EN ISO 19131 Geographic information - Product Specifications
EN ISO 19134 Geographic information - Location-based services - Multimodal routing and navigation
EN ISO 19137 Geographic information - Core profile of the model, describing the geometry and topology

5.2.1.2 OGC standards

The OpenGIS Web Feature Service (WFS) Implementation Specification WFS 1.1.0 (Opengeospatial.org, 2017)$_a$ standard is still used in many server and client implementations.

WFS 2.0 (Opengeospatial.org, 2017)$_a$: 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) (Standard.no, 2009).

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

5.2.1.3 National Standards

Two important Norwegian standards in working with geographic information are:
- SOSI standard (Kartverket, 2017)$_f$
- Geodata standard (Kvalitetssikring av oppmåling, kartlegging og geodata, 2001)

In addition, some international standards have been adopted and adapted as Norwegian standards, such as the metadata standard (ISO 19115) (19115-1:2014, 2014).

5.2.1.3.1 SOSI standard

SOSI is the national standard for geographic information and SOSI format is a standardized exchange format for geographic information developed over the past decades. Both the standard and the format are administered by the SOSI Secretariat of Mapping Authority.

5.2.1.3.1.1 Part 1 (Kartverket, 2016)$_c$– General Part

This is an introduction to SOSI, describing general object catalog, metadata, directory information, indirect references, requirements and approval of a product etc.

5.2.1.3.1.2 Part 2 (Kartverket, 2017)$_g$– General Object Directory

The purpose of this part is to specify the object types and their properties and associations, generally in a subject area or across multiple areas.

5.2.1.3.1.3 Part 3 (SOSI Generell del SOSI produktspesifikasjoner – Krav og godkjenning, 2014)- Product specifications for mapping and spatial data

The requirements are based primarily on NS-EN ISO 19131:2008 Geographic information - Product specifications (ISO 19131:2007). The framework for the Norwegian national geographic infrastructure specifies that products included in Norway Digital shall be in accordance with this.NS-EN ISO 19131:2008 is using UML models to uniquely specify the contents of a product specification, which are rendered on the basis of ISO / TC211 Harmonized UML model.

5.2.1.3.2 GeoData standard

The purpose of the standard is to contribute to high-quality maps and geodata by:
- describing methods for the production of the maps and the geodata
- describing the quality that can be expected at different production methods and processes
- describing methods for updating maps and geodata
- describe how the production of maps and spatial data is documented
- being a reference document by entering into agreements for spatial data products and services
- being a reference document for the preparation of procedures in a quality according to EN ISO 9000

5.2.1.4 Quick reference

The following table is a quick reference for the standards, according to the information viewpoint of the data, services and metadata.

Table 1: Quick Reference of Standards (Data, services & metadata)

Raster Data	
Services, contents	ISO 19119 Services
Interface for mapping web services	EN ISO 19128:2008
Content, specification of raster and images	EN ISO 19123:2007
Vector Data	
Services, contents	ISO 19119 Services
Web feature Service interface	ISO/CD 19142
Content, Conceptual Schema Language (modeling language) Feature data dictionaries, feature Catalogs, registers Geodetic codes and parameters Above mentioned standards: EN ISO 19107:2005, EN ISO 19108, EN ISO 19109, EN ISO 19110, EN ISO 19111, EN ISO 19112, EN ISO 191118, ISO 19131	 ISO 19103:2015 ISO/DIS 19126 EN ISO 19127
Exchange into Norway Digital	SOSI, GML
Exchange with other communities IHO transfer standard for digital Hydrographic Data Exchange to building / construction environments Exchange of geological data Exchange located, surveying oriented solutions	 ISO / IEC 8211 IFC / XML GeoSciXML LandGML
MetaData	
Services, contents	ISO 19119 Services
Catalog, applications profile OpenGIS Catalog Services Specification 2.0.2 - ISO Metadata Application Profile (1.0.0) OGC Cataloging of ISO Metadata (CIM) over using the ebRIM profile of CS-W (0.1.7) CSW-ebRIM Registry Service - Part 1: ebRIM profile of CSW (1.0.0) CSW-ebRIM Registry Service - Part 2: Basic extension package (1.0.0)	
Content, Metadata (Norwegian profile SOSI)	ISO 19115: 2003

Extensions for imagery and gridded data	ISO/DIS 19115-2
Exchange, XML implementation specification	ISO/TS 19139
Presentation	
Services, contents	ISO 19119 Services
Content, visualization • Graphic design of the map scale of 1:500 2:01: 10,000 • Symbols and Abbreviations in Norwegian charts • S52 Color and Symbol specification for ECDIS • Cartography documents in geoportal	EN ISO 19117:2006 SOSI Kartverket S-52 - IHO Drawing rules
Exchange, Styled Layer Descriptor Scalable Vector Graphics	SOSI part 1 OGC,SLD SVG

5.2.2 Data

5.2.2.1 Models and relevant issues

The modelling of geographic information in Norway, is based on standardized methods from ISO/TC 211. The Framework document recommends that the parties in Norway Digital, use model driven architecture (MDA), a model defined by OMG, thus ensuring portability, interoperability and reuse. XML Metadata Interchange (XMI) standard is used for the exchange of UML models between different platforms and tools (ISO/IEC 19509:2014)

5.2.2.1.1 General Feature Model

NS-EN 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.
NS-EN ISO 19109-2015 describes a general process for developing a community language or "application schema". It introduces the "General Feature Model" (GFM), using a series of UML class diagrams for the details. The feature instances on 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.

5.2.2.1.2 Coverage Model

NS-EN 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 like 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.

5.2.2.1.3 Modelling and encoding

NS-EN ISO 19103:2015 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).
NS-EN ISO 19107 specifies the foresaid for spatial schemas including topology.

Two standards address the issue of encoding geographic information in XML. NS-EN ISO 19118:2011 presents a general methodology and a number of options, some of which are based on use of WXS as the intermediate conceptual schema language. NS-EN 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.

5.2.2.1.4 Object Catalog

When defining an application schema using the GFM, perhaps the key aspect of the schema is the Catalogue of Feature Types for the application domain. In Norway, since the beginning of the 80s, there was a national object directory (SOSI Part 2), which now covers 47 disciplines and is compliant with ISO 191xx since late 2006.
NS-EN 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 NS-EN ISO 19135-1:2015, along with a register model for hosting.
NS-EN 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.

5.2.2.1.5 Product specification

NS-EN 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.

5.2.2.1.6 Useful documents

- ✓ National standards and guidelines (Register.geonorge.no, 2015)$_a$
- ✓ A detailed list with the product specifications, their owner and their status can be found in the geoportal (Register.geonorge.no, 2017)$_a$.
- ✓ Applications schemas and their description (Kartverket, 2017)$_o$ are available in English by the Norwegian Mapping Authority agency's website.
- ✓ Approved GML application forms (Register.geonorge.no, 2017)$_b$ can be found in geoportal
- ✓ Code lists used in SOSI (Register.geonorge.no, 2015)$_b$
- ✓ Code lists from different disciplines (Register.geonorge.no, 2017)$_c$

5.2.2.1.7 Character set

The default character set encoding for all data in all kinds of deliveries is UTF-8, ref Regulations on IT standards in public management (Lovdata.no, 2013).

5.2.2.2 Coordinate systems

Digital Norway basically only regulates the technical requirements that apply to exchange of data and services, such as downloadable data, WMS services, WFS- services, WCS services and WS-services. Therefore, it applies rules concerning datum and projections for the whole data sets and services which are mediated in Digital Norway.
The local datums (NGO 1948, WGS84, EUREF89) and relevant projections have been coded and defined in SOSI (part II). The local and a wide variety of international datums and projections (Register.geonorge.no, 2017)$_d$ (including INSPIRE requirements: ETRS89-LAEA, ETRS89-LCC, ITRS) with a unique EPSG code and relevant technical description, can be found in geoportal. These EPSG codes are used in the Technical Framework document and specified in requests of WMS/WFS/WCS services.
NS-EN ISO 19111:2007 is used for spatial referencing by coordinates with its extension for the parametric values (NS-EN ISO 19111-2:2012)
NS-EN ISO 19108:2005, NS-EN ISO 19108:2005/AC:2008 are used for temporal reference systems (calendars, time coordinate systems, ordinal reference systems)

5.2.2.2.1 Requirements in Norway Digital

- All official map series and horizontal coordinates shall be based on EUREF89 (Kartverket, 2017)$_b$ as geodetic datum (the realization of ETRS89 in Norway). That one uses the ellipsoid of the Geodetic Reference System 1980 (GRS80-ellipsoid). Plan coordinates N, E are given as UTM coordinates with three zones (32, 33, 35).
- Elliptic heights, reference to GRS80-ellipsoid heights.
- Heights of the vertical datum, reference to local new Datum NN2000 (Kartverket, 2016)$_c$ (some of old data to the previous NN1954 datum)
- The datum and projections must be supported by all WMS services, all WFS services, all WCS services and all WS services, are shown in the following table:

Table 2: Datum and Projections supported by services

CodeName	SOSI /EPSG code
UTM zone 29, based on EUREF89, 2d	19/25829
UTM zone 30, based on EUREF89, 2d	20/25830
UTM zone 31, based on EUREF89, 2d	21/25831
UTM zone 32, based on EUREF89, 2d	22/25832
UTM zone 33, based on EUREF89, 2d	23/25833
UTM zone 34, based on EUREF89, 2d	24/25834
UTM zone 35, based on EUREF89, 2d	25/25835
UTM zone 36, based on EUREF89, 2d	26/25836
EUREF 89 Geographic (ETR 89)	84/4258
Latitude/longitude (ETRS89) WGS84 Geographical (no projection)	184/4326

- In the near future, the following future needs of INSPIRE will be implemented:

Table 3: Future Projections to be supported

CodeName	SOSI /EPSG code
Lambert Azimuthal Equal Area	73/3035
Lambeth Azimuthal Conformal Conic	74/3034

Norwegian Mapping Authority publishes transformation libraries for transformations between Datums.

5.2.2.3 Formats

Formats for the data included in deliveries (Kartverket, 2017)$_h$ are:

5.2.2.3.1 Vector Formats

5.2.2.3.1.1 SOSI

A Norwegian standard and exchange format, which remains a mandatory format when transmitting location data.

5.2.2.3.1.2 GML

An international standard, is the mandatory format for new datasets. GML is the new primary format for data sets, and the parties in Norway Digital are entitled to deliver datasets in GML, as it is the primary international format for geographic information and is recommended by INSPIRE.

GML-Supervisor (Veileder for Geography Markup Language (GML), 2015) is one of a series of guidance documents in Norway Digital with main purpose to promote the use of GML for the exchange of geographic information in deliveries and services. The guide is partly based on OGC and ISO standard for GML 3.2.1 OGC/ ISO19136 and GML 3.3.

5.2.2.3.1.3 S-57

For Electronic Navigational Chart (ENC) as used in ECDIS solution, the obligatory format is S-57.

5.2.2.3.2 Raster Formats

GeoTiff

5.2.2.3.3 Global Navigation Satellite System Data

IGS (international GNSS service)

RTCM (Radio Technical Commission for Maritime Services)

5.2.2.3.4 Useful Documentation on Formats

- "Guidelines for data formats when transmitting location data" (Retningslinjer for dataformater ved formidling av stedsdata, 2015)
- List of criteria for evaluating formats (Jonsrud, 2015), a detailed list of formats with full details for evaluation
- Delivery Supervisor (Veileder for leveranser, 2014)

5.2.3 Metadata and Services

5.2.3.1 Metadata

The metadata according to Geodata Act, must always be included in a product delivery, according to the following relationship.

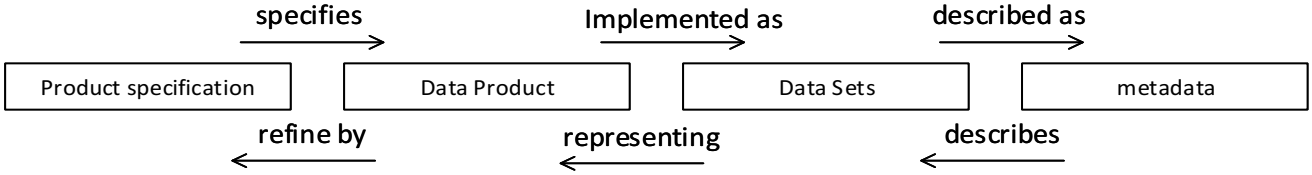

Figure 7: The relationship between product specification and metadata (source: Statens Kartverk, 2016)

5.2.3.1.1 Different levels of metadata

Metadata is published in different levels with different purposes and uses:

- Discovery, having information suitable to search and locate data-sets and services.
- Evaluation, having further information about the data set and the limitations in use. These are established in the national directory.
- Use, which are found in product specifications and object catalog as properties associated with the geometrical objects in the data sets.

5.2.3.1.2 Different metadata profiles and standards

- ISO 19115 (ISO 19115:2003, ISO 19115:2003/Cor1:2006) is a rationalized model for GI metadata, in particular dataset metadata. This standard defines the content of the metadata which are required to describe the geographic information and related services. It provides information on how to identify, delineate, describe the quality, refer to the reference system, describe the spatial and temporal form and distribute digital geographic information. This standard has been revised (ISO 19115-1:2014, ISO/TS 19115-3:2016) but it is not yet implemented in Norway or by Inspire.
- ISO 19119 (ISO 19119:2005, ISO 19119:2005/Amd 1:2008) defines various forms of architecture and service interface for geographic information. It also complements ISO19115 metadata elements for services. The standard has been revised (ISO 19119:2016).
- ISO 19139 (ISO/TS 19139:2007, ISO 19139-2:2012) is an XML encoding rule (gmd) developed for implementation of 19115.

Implementation of INSPIRE rules (ISO 15836:2009 describing different resource types across different fields), will not conflict with ISO19115, but one must add additional metadata elements not required by the Inspire to achieve full compliance with ISO19115.

5.2.3.1.3 Other issues and standards

GI metadata must be registered also in the Open public data portal called Difi. This portal provides a new solution where one can harvest metadata from other directories as RDF or JSON according to DCAT (W3.org, 2017) standard. Metadata located in the Geoportal will automatically be harvested by the open public data portal, so one will not be forced to dual registration.

Other standards used in metadata context are:
CSW:Catalog Services Web. Directory services that are standardized by OGC and define service based search and insertion, deletion and updating of metadata in a catalog (Opengeospatial.org, 2017)$_b$.
DCAT: Data Catalog Vocabulary is an RDF vocabulary designed to facilitate interoperability between data catalogs published online (W3.org, 2017).
OAI-PMH: Open Archives Initiative Protocol for Metadata Harvesting. Protocol harvesting metadata between directories (Openarchives.org, 2017).
Thredds Data Server: 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 (Unidata.ucar.edu, 2017).

5.2.3.1.4 Search for Metadata

Geonorge is the main national metadata source where searching of metadata for datasets, services and applications is available (Kartkatalog.geonorge.no, 2017). Geonorge also provides the capability to display WMS services in an external map window, download data and has links to various web map solutions.

5.2.3.1.5 Useful documentation

Useful documents about the creation of the metadata, are:

- ✓ MetaData Supervisor (Register.geonorge.no, 2016) is one of a series of guidance documents with main purpose to provide an overview 1) for different ways to establish and use metadata to access geographical resources and 2) of the various components of the infrastructure related to the metadata.
- ✓ Better metadata 2017 (Bedre metadata 2017, 2017) with main purpose to help Geonorges' users who are not a uniform group to provide improved metadata.
- ✓ Criteria for metadata control (Selknu, 2013), a detail explanation on metadata items with examples and requirements.

5.2.3.2 Services

The technical framework recommends among others, that services should use Service Oriented Architecture - SOA. The implementation of this recommendation has been done in the following ways:

1) The Web services Architecture (W3.org, 2004), which ensures universal interoperability between applications is used mainly in Norway Digital. According to this architecture, the web service has an interface for its description written in XML (Web Services Definition Language -WSDL). Other systems interact over HTTP with the web service in a platform as an independent way of using messages (Simple Object Access Protocol -SOAP) and standard methods to discover and invoke web services in a registry (Universal Description, Discovery, and Integration -UDDI).
2) There are also services in the infrastructure that have well-defined interfaces but no WDSL descriptions, they do not use SOAP protocol to exchange information but communicate over HTTP and they can be published in a registry UDDI. These services are called REST-based web services.

5.2.3.2.1 Categories of services and relevant standards

The services are classified in categories, as a common way to be identified on. ISO 19119 based on the division of EOS defines classes of services according to the semantic type of the calculations they perform. This classification has been used in the Technical Framework document.

Inspire directive uses the concept of network services for spatial data.

In the following table the mapping of services between Exactly Once Semantics (EOS) and Spatial Data Inspire as also the relevant 191xx standards, is shown.

Table 4: Mapping of services between EOS and INSPIRE (source: Technical Framework of Norwegian SDI, Rammeverksdokument – Norge digitalt, 2012)

ISO 19119/EOS division	Spatial Data/Inspire	Examples
User interface standards (Geographic human interaction services)	**Other services**	Access/Edit clients
• NS-EN ISO 19117:2012 Geographic information – Portrayal (ISO 19117:2012) • ISO 19128:2005 Geographic information - Web Map Server interface		
Model Information (Geographic human interaction services)	**Search services** **Display services** **Download services**	Search (indexes), WMS services, WFS services, national API
• NS-EN ISO 19107:2005 Geographic information - Model to describe the geometry and topology (ISO 19107:2003) • NS EN ISO 19110:2006 Geographic information - Methodology for object cataloging (ISO 19110:2005) • NS EN ISO 19111:2007 Geographic information - Model for the localization of coordinates (ISO 19111:2007) • NS EN ISO 19112:2005 Geographic information - Model for indirect localization (ISO 19112:2003) • NS EN ISO 19115:2005 Geographic information - metadata (ISO 19115:2003) • NS EN ISO 19123:2007 Geographic information - Model for the national thematic representation (ISO 19123:2005) • NS EN ISO 19125-1:2006 Geographic information - Access to basic geographic objects - Part 1: General architecture (ISO 19125-1:2004) • ISO 19128:2005 Geographic information - Web Map Server interface • ISO 19142:2010 Geographic information - Web Feature Server interface		

ISO 19119/EOS division	Spatial Data/Inspire	Examples
Processing services	**Conversion Services**	Tranformers Installation, Inspection/Validation, Analysis, Route calculation
• NS-EN ISO 19107:2005 Geographic information - Model to describe the geometry and topology • NS-EN ISO 19108:2005 Geographic information - Model to describe the time aspects (ISO 19108:2002) • EN ISO 19109:2015 Geographic information - Rules for application form (ISO 19109:2015) • NS-EN ISO 19111:2007 Geographic information - Model for the localization of coordinates (ISO 19111:2007) • NS-EN ISO 19116:2006 Geographic information - positioning services (ISO 19116:2004) • EN ISO 19123:2007 Geographic information - Model for the national thematic representation (ISO 19123:2005) • EN ISO 19118:2011 Geographic information - code rules (ISO 19118:2011)		
Workflow/Task services	**Enabling services**	Chain definition services, workflow, subscription
There is no relevant ISO 19100 standard		
Communication services	**Conversion services**	Coding and exchange SOSI GML GML IFC/XML
There is no relevant ISO 19100 standard		
System Management Services	**Enabling services**	Administration systems components, applications and network
There is no relevant ISO 19100 standard		

5.2.3.2.2 Types of deliverable services under Geodata Act

As specified in the Delivery Supervisor document (Veileder for leveranser, 2014), all data sets that fall under the Geodata Act shall be offered through services. According to Geodata Act (Geonorge.no, 2017)$_b$, *"Participating businesses will, for Specified geodata, establish and operate a joint network of"*: ¨

•search service (automatically check if metadata is registered in geoportal)
•view service (including metadata, product specification, product and presentation rules)
•download service (including metadata, product specification, product and presentation rules)
•conversion services, and
•activation (enabling) services

According to the Regulations, the parties should:

- ✓ deliver display and download services at the same time
- ✓ offer through search services the metadata for data sets and services
- ✓ provide data on National and INSPIRE Harmonized form

5.2.3.2.3 Search services

Geodata Act requires that all data sets, display services and download services should be searchable by search services. Geonorge contains functionality that meets these requirements. The parties can thus fulfill the requirement for search services by registering metadata for their data sets and services in Geonorge.
For search, at least the following combination of criteria is implemented:

a) Keywords,
b) classification of spatial data and services,
c) quality and validity of spatial data set,
d) degree of compliance with rules concerning interoperability of geodata sets and services carried out from regulations,
e) geographical location,
f) conditions relating to access to and use of spatial data sets and services, and
g) public authorities responsible for the establishment, management, maintenance and distribution of spatial data sets and – services.

Via a user interface in geoportal, access is provided to all spatial data, services, applications and their metadata of the Norway Digital and the Inspire, with a lot of advanced search capabilities as foresaid.

5.2.3.2.4 Display services

Display Services is often synonymous with WMS services. The interface offered in the Web Map Service (WMS) standard [ISO 19128], 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, ie to use services and data from different providers in the same tool.
WMS is an ISO standard. The Open Geospatial Consortium (OGC) have also prepared:
- the specification of Styled Layer Descriptor (SLD) (Opengeospatial.org, 2017)$_c$ which enables users to expand the capabilities of WMS.
- the Web Map Tile Service (WMTS) Implementation Standard (OGC WMTS 1.0.0) (Opengeospatial.org, 2017)$_d$ which complements the WMS standard, providing a standard based solution to serve digital maps using predefined image tiles.

WFS Supervisor (Iversen and Bang-Kittilsen, 2010) is one of a series of guidance documents with main purpose to facilitate and increase the use of WMS within Norway Digital.

Via a user interface in geoportal, access is provided to the WMS services (Kartkatalog.geonorge.no, 2017), the WMTS services (Kartkatalog.geonorge.no, 2017) and their metadata, product specifications, product and presentations rules.

5.2.3.2.5 Download Services

Download Services is a collection of services that allows users to transfer data in their original form either as predefined files (file downloading) or having asking mechanisms to extract information from data sets.
Atom feed, WFS or WCS services are used for downloading services according to the Geodata law.

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 classified by INSPIRE as download services, WFS-Transactions (WFS-T, ISO 19142) can also upload, update and delete geographical objects.
WFS Supervisor (Veileder for Web Feature Service (WFS), 2014) is one of a series of guidance documents with main purpose to facilitate and increase the use of WFS within Norway Digital.

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.
Atom Feed Guide (Veileder for Atom feed nedlastingstjeneste, 2014) is one of a series of guidance documents with main purpose to provide an introduction to the standard and how it can be used in Norway Digital.

The purpose of the WCS specification is to make available "coverages" or surface-covering matrix data, representing one or more phenomenon variables in space, via http - protocol. WCS specification has been developed by OGC (WCS 2.0 Interface Standard - Core, 2010). It provides access to the underlying data and can be used to publish 2D and 3D raster data. In addition, data sets to be handed out, having time information so that the service can deliver raster from a given time.

Via a user interface in geoportal, access is provided to the WFS services, the WCS services, the Atom Feed services and their metadata, product specifications, product and presentations rules.

5.2.3.2.6 Conversion Services

Conversion Services are services that can transform between different coordinate systems or compose a data set (for example from national harmonized shape to INSPIRE harmonized form) in near real time.

These services also called processing services, do not include functionality for persistent storage data or transmitting data over the Internet, but modify characteristics of geodata. They are divided in the following main sections:

- Processing Services - vector (spatial)
  Transforming coordinates, Generalization services, Extraction Services (subsetting services), Inspection / validation services (Feature manipulation services), Route calculation services, Positioning Services (LBS), Neighbor Analysis Services (Proximity Analysis Services)
- Processing Services - thematic (thematic)
  Thematic classification service, Generalization Services, Extraction Services (sub setting services), Counting Services (Spatial counting services), Dot Process Rings services, Geoparsing services, Geo referencing services
- Processing Services – temporal
  Of change detection services, Temporal reference system transformation service, Extraction Services (sub setting services), Temporary-neighbor analysis services
- Processing Services – Metadata
  Statistics Services, Comment Services (Geographic annotation services)

5.2.3.2.7 Activation Services

These are services that support specific tasks or work-related activities. These services support use of resources and development of products involving a sequence of activities. Examples of suchlike services are: chain definition services (services to define a chaining and making it possible to process using a workflow enactment service), workflow enactment service (service that interpret a chain and controls the selected services and the sequence of activities), subscription services (service that allows clients to register information about events, and when an event occurs, subscription service to send message to all clients that have registered interest about current events). They are divided into:

- Chaining of services
- Aggregated or connected services
- Communication services
- System management services

5.2.3.3 APIs and interfaces

Several open APIs and interfaces have been developed to provide communication with the individual features of Geonorge portal. Open source code for the most of them can be found on GitHub of Norwegian Mapping Authority.

- ✓ APIs for search into the Map Directory, providing the following information:
  Get metadata of an universally unique identifier (uuid)
  Get related services, datasets and bundles for the uuid
  Catalogue search using a defined set of parameters
- ✓ APIs for search in object directory, offering search capabilities similar to the search in map Directory:
  Get object using a string type parameter
  Directory search using a defined set of parameters
- ✓ APIs registers, for searching the entire Registry:
  Organizations Api: information about organizations
  Api Root: information about registers, sub registers and specific items
  Alert Service: add a service alert
  Post api/Report: reports for Coverage Maps datasets
- ✓ service status : according to the documentation (Statusinformasjon for tjenester:, n.d.), it provides information about services.
  A WMS service, performing automated tests, shows uptime, response time and test results in relation to the technical quality of service that is registered in geoportal.
- ✓ CSW is an open international standard for the retrieval, insertion, modification and deletion of metadata. Geonorge uses software geonetwork as metadata engine, and this supports CSW 2.0 fully.
  All CSW calls may be used to communicate with the map directory (metadata) in geoportal. For input, modification and deletion required the username and password. It is possible to test the CSW against Geonorge in beta environment
- ✓ GeonorgeAPI-a : offers retrieval and updating of the metadata within an abstraction class, from the large and heavy XML standard ISO 19139 used for metadata storage.
- ✓ ID references and Linked Data : resolves id references for known namespaces in the namespace registry
- ✓ NedlastingsAPI-a : is used as a common interface for different systems in Norway which can order data to each other, so that other systems can book data directly from geoportal's map directory
- ✓ Various APIs: offering catalogue in dcat format
- ✓ Metadata Editor : Editing ISO 19139 Metadata in a web interface and save changes with CSW
- ✓ Transformation Libraries : Transformation of coordinates between the official geodetic datum EUREF89, NGO1948 and ED50. Transformation between EUREF89 and global reference frames ITRF2005 and ITRF2008.

5.2.4 Business process aspects

5.2.4.1 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.

5.2.4.1.1 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 in accordance with the BAAT username and password

5.2.4.1.2 Recommendations about Web applications and web services

In Norway, it is common to use Active Directory (AD) for saving user information and passwords internally. AD uses NTLM as the protocol, is not suitable for interoperability with other networks. Because of security and synchronization issues, it is not desirable to duplicate user information and passwords between different security domains. Federated security based on a SAML2 Identity Provider (IdP) or WS-Federation solves most of these challenges, through the following recommendations:

- ✓ Web Applications should support SSO login from SAML 2.0 IdP and should support eGov profile (WebSSO deployment profile). They also can support logon based on passive WS-Federation.
- ✓ SOAP-based Web services should support authentication based on the WS-Federation (WS Security, WS-Trust and WS-SecureConversation).
- ✓ REST-based Web services should support login as for web applications.
- ✓ If authentication is required, REST-based Web services should be considered to be made available via SOAP. If it is not possible, OAuth 2.0 authorization framework can be applied.

5.2.4.1.3 Documentation

More details can be found in the Technical FrameWork document (Rammeverksdokument – Norge digitalt, 2012).

5.2.4.2 Quality assurance and control

Quality-assured data and services is the core of 'Digital Norway'. 'Digital Norway' requires quality control of all aspects of the infrastructure, from the overall coordination between different services and portals and down to the underlying technology.
Data and services are implemented according to the standards and shall comply with the compliance requirements, as these standards describe.

5.2.4.2.1 Data quality according to the product specification

NS-EN ISO 19131: 2008 requires that the product specification shall specify the Data Quality Requirements based on quality objectives. EN ISO 19131: 2008 use some properties and code lists of ISO 19115: 2005 / AC: 2008 Metadata

Data quality of geographic datasets is divided into five categories:

- Completeness,
- Location Fixing Accuracy,

- Attribute Quality,
- Quality of timing and
- Logical consistency (how well rules primarily in the application form product, 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

Table 5: Data's Quality criteria (source: International Organization for Standardization, 2017)

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
Quality of timing	• Time validity • Time Consistency • Time Accuracy
Logical consistency	• format Consistency • domain Consistency • conceptual consistency • topological consistency

The procedures of ISO 19114:2003 (revised by ISO 19157:2013) are used to assess whether the data is of sufficient quality. These procedures are applied to the following information packets of the SOSI product specification:

- General information (*NS-EN ISO 19131:2008)*
  - ✓ *Chapter 8 Specification scopes*
  - ✓ *Chapter 9 Data product identification*
  - ✓ *Annex D Data product specification contents*
  - ✓ *Annex E.1 Identification information*
- Reference System (*NS-EN ISO 19131:2008)*
  - ✓ Chapter 11 Reference Systems
  - ✓ *Annex E3 Reference System information*
- The content and structure (*NS-EN ISO 19131:2008)*
  - ✓ *Chapter 10 Data content and structure*
  - ✓ *Annex E-2 Data content and structure information*
- Data capture (NS-EN *ISO 19131: 2008)*
  - ✓ *Chapter 13 Data capture*
  - ✓ *Annex E.5 Data capture information*
- Maintenance (NS-EN *ISO 19131: 2008)*
  - ✓ *Chapter 14 Data maintenance*
  - ✓ *Annex E.6 Data maintenance information*
- Presentation (NS-EN *ISO 19131: 2008)*
  - ✓ *Chapter 15 portrayals*
  - ✓ *Annex E.7 Portrayal information*

EN ISO 19131:2008 requires that the presentation should be structured in accordance with NS- EN ISO 19117: 2014 Geographic information - Visualization

- Delivery (NS-EN *ISO 19131: 2008)*
  - ✓ *Chapter 16 Data product delivery*
  - ✓ *Annex E.8 Delivery information*
- Additional Information (NS-EN *ISO 19131: 2008)*

- ✓ *Chapter 17 Additional information*
- ✓ *Annex E.9 Additional information*

• metadata (NS -EN *ISO 19131: 2008)*
- ✓ *Chapter 18 Metadata*

Metadata information model for products defined in EN ISO 19115:2005. The metadata that is required according To Geodata Act, must always be included in a delivery. Metadata should be coded according to ISO/TS 19139:2007 Metadata -XML Implementation

5.2.4.2.2 Data

The syntactical control of the data and the content control must be in accordance with the SOSI. SOSI controls / SOSI show are free programs from the Norwegian Mapping Authority, in order to verify the quality of the content of SOSI files. SOSI control checks whether the file is syntactically correct to SOSI format, if the data groups are intertwined geometrically and the surfaces are correct. It is also checked whether the respective data groups in the files are in accordance with applicable specifications. More information can be found in Mapping Agency's web site

5.2.4.2.3 Services

Web service interoperability compliance for SOAP based services should be ensured using testing 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.

5.2.4.2.4 Other requirements

Technical operation of the management system must be documented in order to assure that available data and services of the parties are in accordance with the overall requirements and limits. This will include a description of:

- Securing data
- Technical components
- Access (DRM)
- Backup procedures
- History
- Uptime Services
- Original Responsibility for data
- Comparison to other administrative solutions / actors

5.2.4.2.5 Tools

A tool (visual basic script) can be used to validate UML models based on the rules of SOSI standard rules for UML modeling 5.0. More information can be found on Mapping Agency's web site.
Digital Norway has developed its own metadata validator that automatically checks if the metadata from the metadata catalogue is in accordance with Inspire and ISO 19115/19139. The service validates every night all geographic metadata published on the geoportal.

5.2.4.3 Standards management

The Norwegian Mapping Authority which is the standardization body for geographic information has a coordinating and advisory role through standardization Secretariat.

5.2.4.3.1 Development of Standards

Standardization work should meet society's need for standards in geographic information / geomatics, and the need for standards in the geographic infrastructure in Norway. This is done by developing standards which cover national, European and international standards do not exist.
The document "Developing industry standards Geographical Information" (Frøstrup, 2015), which is one of the Norwegian Mapping Authority's governing documents, gives a detailed description of the standardization work - goals and purpose, definitions and terms, financing and organization of work.

5.2.4.3.2 Standardization Committee on Geomatics

The Standardization Committee on Geomatics was created in order to achieve an ongoing formal contact with the consumer and professional communities in geographic information.
The Standardization Committee for Geomatics will:

- ✓ have representatives from the main government agency, from educational institutions and private users
- ✓ approve and recommend initiation of standardization projects
- ✓ adopt new and revised standards
- ✓ withdraw standards
- ✓ submit proposals for standardization to the council for ICT standards in the public sector, to take geomatics standards into the reference directory
- ✓ organize meetings on demand
- ✓ apply the principle of consensus in decision-making
- ✓ help to follow up on international standardization of geographic information

5.2.4.3.3 Standardization Secretariat

The Standardization Secretariat added the Mapping Authority (Kartverket, 2017)$_i$ and shall:

- ✓ receive need for new standards, revision or withdrawal of standards
- ✓ lead and convey the need for standardization of user communities to the standardization committee for geomatics
- ✓ submit proposals of the standards for approval in the standardization committee for geomatics
- ✓ operate and manage infrastructure in connection with the standardization process (e.g. registers)
- ✓ lead the standardization group in the Mapping Authority, a forum that coordinates the Norwegian Mapping Authority's views on the standardization projects to be initiated in connection with the standards of geographic information
- ✓ ensure harmonization of standards with other standards nationally and internationally
- ✓ secure new management needs for standardization in standardization ring
- ✓ prepare the catalog "Standards geographic information" which provides an overview of international, European and Norwegian standards for geographic information, as well as national standards developed by or under the auspices of the Mapping Authority.

5.2.4.3.4 Enroll standardization proposal

Those who have technical standardization needs that are not covered, and their needs fit into the "Standards Geographical Information", fill in the document "Proposal for new standardization project" (Mardal, 2017). The applications must be submitted to standardiseringssekretariatet@kartverket.no for processing and approval.

5.2.4.3.5 New projects, audits and hearings

Projects for revision or preparation of new industry standards are open for participation. See which standardization projects that are underway right now (Kartverket, 2017)$_j$.

5.2.4.3.6 Supervisors for work in SOSI

- SOSI data interchange (previously the relationship between object types and feature codes) (Kartverket, 2014)
- The relationship object catalog and product specification (Retningslinjer forholdet objektkatalog/produktspesifikasjon, 2004)
- The relationship between object types and feature codes (Borrebæk, 2006)
- Principles of definitions (Principles for definition writing (ISO 704:2000), 2004)
- Guidelines for UML modeling (Part 1 in SOSI) (SOSI Del 1: Retningslinjer for modellering i UML, 2006)
- Principles of maintenance and versioning SOSI standards (Prinsipper for SOSI versjonshåndtering, 2009)

5.3 People Component

5.3.1 Resources

Senior managers and principal officers, innovators and experts from different disciplines with some geomatics background together with project managers for merging processes are the main resources needed for a successful geospatial strategy.
The well-established governance and coordination scheme, support and safeguard an effective implementation of this strategy. These main actors tend to work mainly in the public sector, 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"

5.3.1.1 Norwegian Mapping Authority

The NMA has 860 staff members, operates 15 offices nationwide. It is also operating over 700 servers and has a data storage capacity of 4 petabytes.

5.3.1.1.1 HR Data

Table 6: Human Resources data (source: Kartverket, 2017)

	2013	2014	2015
Number of staff	837	819	814
Salaries per Man-year (€)	66,233	71,904	87,098
Salary share of Operating Expenses	49.2%	48.8%	47.3%
Operating expenses (€)	112.7 million	120.7 million	126 million

According to NMA's annual report of 2015, the operating revenue is analyzed in:
68% from Government funds, 21% from co-financing, 11% from sales (ÅRSRAPPORT 2015, 2015).

5.3.1.1.2 Turnover

Mapping Authority has had for a long time, a relatively low and stable turnover. The average for 2010-2015 was 5.7%. The low turnover used to be an indication of well-being and a good work environment. At the same time it can be negative, as you do not get enough new personnel having updated skills (ÅRSRAPPORT 2015, 2015).

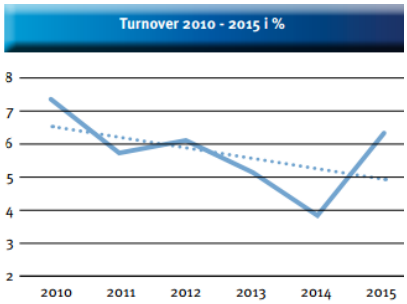

Figure 8: Turnover 2010-2015 (source: Kartverket, 2015)

5.3.2 Skills and qualifications

A prerequisite for a good utilization of the geographic infrastructure is knowledge in 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 of a good utilization of the possibilities. Expertise of data producers, data stewards, innovators and users will be challenged. 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.
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 is 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 and project management.

Education in geomatics in Norway, is offered by 8 colleges and universities: Norwegian University of Science (NTNU), Nord-Trondelag University College, Norwegian University of Science and Technology, Høgskulen in Western Norway, University in Bergen, University of Oslo, University College Southeast Norway, Norwegian University of Life Sciences

Guidance and training is provided by the NMA (Kartverket, 2017)$_k$ and other Ministries and public agencies to Norway Digital's parties.

- ✓ Procedures for the management, the operation and the maintenance of information
- ✓ Courses
- ✓ Guidance and training in Property sector

Videos with detailed information about a specific theme can be sent from Geovekst to the municipalities. Interest surveys follow within municipalities, giving information to Geovekst for further planning on organizing workshops or visits. As a result, workshops or visits are organized by Geovekst, for informing and educating the municipalities about new opportunities.

5.3.2.1 Preparing the future skills

The Government has drawn up a long-term plan for research and higher education which stakes out a course for policy in this area for the period up to 2024, increasing allocations to research and development activity (R&D) in six long-term priority areas: 1) the oceans, 2) the climate change, the environment and environment-friendly energy, 3) public sector renewal and higher quality, more efficient welfare, health and care services, 4) enabling technologies 5) an innovative, adaptable private sector, and 6) world-class research groups
As a part of this effort, the Government will strengthen some of the most important input factors in the research and higher education system during the period from 2015 to 2018. The Government will:

- ✓ increase the number of recruitment positions by 500 new positions;
- ✓ increase allocations to research infrastructure by NOK 400 million (45.7 million €);
- ✓ increase allocations to schemes that encourage extensive Norwegian participation in the EU Framework Programme for Research and Innovation, Horizon 2020, by NOK 400 million (45.7 million €).

Detailed information can be found on research and knowledge future plans (Ministry of Education and Research, 2014)$_a$, on the future skills (Ministry of Education and Research,

2014)$_b$, and on the National Skills Strategy 2017-2021 (Ministry of Education and Research, 2017).

5.3.3 Users, providers and administrators

The Administrators ask for a national GI knowledge base, which meets the important social needs and help them to make even better decisions. They expect more participation from the private sector and the society (crowdsourcing), and business development.

The users need:
- more data (3D, Buldings Information Modelling)
- updated and accurate data to rely on
- easy and free of charge access to the information

The main users of the Norwegian SDI are the public agencies and the municipalities.
Public enterprises and municipalities use daily the geographic information in their planning as the basis for providing their services and making better decisions. Through their collaboration since the late 1990's, they are also the producers of the large part of the existing geographic information, and have realized the benefits for them and the society.
Private businesses use geographic information in various digital products and services. Value creation based on geographical information is significant, but the further potential is still high.
In 2006, two years after the geoportal started its operation, the benefit to the business sector by the use of standards in NSDI infrastructure estimated to a total of about 268 million EURO.

5.3.4 Communication

5.3.4.1 Communication channels

5.3.4.1.1 News Channel

- ✓ Subscription to the newsletter channel, provides information from Digital Norway about new services, messages from the parties and other relevant news for Norway Digital. The newsletter is sent out 4-10 times a year
- ✓ On line information about events, workshops, forums etc is provided on line on the geoportal (Geonorge.no, 2017)$_d$.

5.3.4.1.2 Notifications channel

- ✓ Service alerts channel
- ✓ Technical channel with technical support information, announcements and visual tools for the services provided by the parties

5.3.4.1.3 Channel for the geoportal

- ✓ Feedbacks channel
- ✓ News from Geonorge activities, plans and strategies
- ✓ Videos for the geoportal's users

5.3.4.1.4 Channel for Developers

- ✓ Information about APIs and interfaces for communication with the individual features of Geonorge
- ✓ Open source code, open code libraries published on GitHub
- ✓ Prototypes for tools under development (Geonorge Labs)

5.3.4.1.5 NMA's channels

- ✓ Social Media channels

✓ Channel of notices to specific sectors and users. See the relevant appendix (Kartverket, 2017).

The Mapping Authority is responsible for organizing and conducting a number of professional meeting places and coordination forums. This opens up opportunities for all participating companies and parties to ensure good involvement in the implementation of the cooperation. NMA_responsibilities

5.3.4.1.6 Communication between parties

Communication groups are established for new projects. Technical solutions and possible investments mainly 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.

When a need for a new spatial task is occurred, the parties which are involved in the task with the relevant secretariat body, prepare a document with the inputs from the parties and a relative action plan. The plan is sent on hearing with a defined consultation deadline. Feedback is given to anyone that has given inputs. All inputs and feedback are also provided to others upon request. Finally, new guidelines, specifications and an implementation/transition plan are issued and distributed.

Annual meetings are organized for the Cooperation during the Norwegian Geomatics Days.

5.3.4.1.7 Communication plans

The development of communication plans for the "Digital Norway" and Geonorge is one of the tasks of the National Geodata Coordinator (NASJONAL GEODATAKOORDINATO, 2015). NMA_responsibilities

5.3.4.2 Promotion

- NMA provides International Services, participates in international projects, and is involved in many international programs and organizations.
  - ✓ Organizes events to promote geospatial information to the society. Mapping Authority and Difi invited adults and children to join and compete for the best ideas, services, games and projects. (#hack4no). Resulted in "Gold mine of data that must be exploited smarter" in Difi website
  - ✓ Participates in international conferences and meetings

- The Norwegian Association of Local and Regional Authorities promotes the geospatial capabilities to the regions and municipalities.
- Norway map in Minecraft
- Geomatics page for education

5.3.4.3 Technical Knowledge management

The useful technical Knowledge for the stakeholders and the users of NSDI is contained in the following registers which are accessible from the geoportal.

✓ Object Registry
Contains a collection of the central object catalogs from the SOSI, Inspire and the parties in Norway Digital.

✓ The public map data-coverage map
A map tool showing the coverage of the selected dataset in Norway's territory.

✓ The Municipal public map data
The table shows the confirmed DOK Data of the selected Municipality.

✓ DOC status register

This register provides a list of the data sets included in the public map data and displays their approval status from the geodata Coordinator

- ✓ EPSG codes
  Contains list of the EPSG codes (coordinate systems) used in the Norway Digital and which are referenced by the framework document
- ✓ Code Lists
  Contains the code lists from different disciplines
- ✓ Metadata code lists
  Contains the Norwegian code lists used in ISO / TC 211 19115: 2003 and 19139
- ✓ National standards and guidelines
  The registry contains the national standards and technical documents including specifications, guidelines and templates for deliveries
- ✓ Organizations : Contains the list of the parties in Norway Digital
- ✓ Datasheet
  Contains the product sheets of the geodata, provided by the organizations
- ✓ Product specifications
  Contains the product specifications of the godata, provided by the organizations
- ✓ SOSI code lists : Contains the code lists used in SOSI standard
- ✓ SOSI standard : Contains the SOSI standard - Part 1
- ✓ Drawing rules : Contains technical documents with guidelines for mapping in general and for specific datasets
- ✓ Service Alerts : The register contains all the notifications for the services registered in the geoportal

5.3.4.4 Geospatial Knowledge management

5.3.4.4.1 GeoForum

GeoForum is a nationwide, non-profit industry organization for individuals and companies / agencies that work in mapping, surveying and geographic information and geomatics as currently used as a generic term for these disciplines. GeoForum works to make the importance of geomatics subjects visible to society. Through courses and conference activities is a driving force to develop skills and improve recruitment to the industry.

5.3.4.4.2 GI Norden

GI Norden is founded on the membership of national GI associations represented by one organisation from each country in the Nordic region.

5.3.4.5 Satisfaction Surveys

The NMA IT department performs annual user satisfaction surveys among users in general and the IT leaders in particular. The goal has been established is that 90% of answers will be satisfied better than 4 in a scale 1-6. The survey in 2015 gave a score of 92%.
Another satisfaction survey is performed between the users who use the website in a job context. The average user satisfaction in 2015 was 4.42 in a scale 1-6.

5.3.5 Ecosystem

5.3.5.1 System integrators, consultants, add value-added resellers

An association of 24 leading geomatics companies called Gematikk, provide services as integrators, consultants and value resellers in the public and private sector.

Ambita Infoland is a national dissemination channel that provides access to EDR property register, housing, property profiles.

5.3.5.2 Dealers

Data and services can be ordered by authorized dealers.

- ✓ Dealers of maps
- ✓ Dealer locations for Laser Data
- ✓ Retailers of detailed maps
- ✓ Location Services dealers

5.3.5.3 Solutions made by the public access to free services

- ✓ SunCurves, "Find your sun" ,
- ✓ ForbrukerRadet, "Ride There" ,
- ✓ Bengler, "FerdigKnadde Map",
- ✓ Aetteforsker, Genealogy,
- ✓ Norviz, 3D map of Norway,
- ✓ Bengler, 3D map

Purenviro , "Mapping poison clouds"
GPS3D, "Plot of GPS in 3D"
FlightSimNorway, "Flight Simulator"
Mastermaps, "Geotagged photos"
kulturognaturreise, "Culture Map"
Mobile Maps, App Store and Google Play

5.3.6 Culture

- **Leadership**

"We want Norway to be the leader in realizing the social excitement through increased use of geographic information. In addition, geographic information is used for value creation and useful services"

- **Quality**

Geographic information with good quality is included as a key part of the knowledge base in society processes

- **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.

- **Support of societal needs**

Norway already has a digital geographic infrastructure. However, there is still a way to go, so the knowledge base and infrastructure must meet today's and tomorrow's needs of all the important areas of society.

- **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 be used 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**

"We need R & D initiatives for the location of data, data capture, efficient data management and technologies for data usage (data analysis, visualization etc.). Along with funding agencies (the Norwegian Research Council, Innovation Norway etc.), programs initiatives will be established for geodata based research and innovation.

5.4 Data Component

5.4.1 Themes

5.4.1.1 Basic geodata

Basic maps and other important basic data used for locating and interacting with thematic maps. The Norway Digital parties are the principal users of the data and services. The basic datasets and the licensee of them are shown in the following table:

Table 7: Basic Data of Norwegian SDI (source: Kartverket, n.d.)

Detailed FKB topographic Data, 1:500, continuous updating **Provider:** NMA Owner: Geovekst parties and municipalities of Oslo, Baerum, Stavanger, Bergen and Trondheim for FKB data of their boundaries	
FKB-LedningVa	contains wiring which is visible on the ground surface (basin, drain and hydrant) and not the complete harness
FKB-Water	streams, rivers, canals, ditches, lakes, glaciers and the topographical part of the coast and sea
FKB-Cord	contains wiring which is visible on the ground surface. The data set contains high voltage pathways and masts, posts and cabinets associated with different types of cable networks
FKB-Track	comprises railway infrastructure
FKB-Land Use	describes the physical use of a geographical area (i.e. parking lot, not soil types)
FKB-Elevation	contains contours and other terrain descriptive information
FKB-Nature Info	include tree trunks, individual trees, large rocks
FKB-Measures	aid measures containing new constructions under the Planning and Building Act until they built
FKB-Building	detailed building information including a description of all types of buildings and building appendages (such porch)
FKB-Veg	artificial constructions for vegetation
FKB-Airport	describing geographical data about airports, technical installations and other facilities that are peculiar to the Airport
FKB-BygnAnlegg	contains detailed information about manmade objects that are not classified as building or for vegetation
FKB-TraktorvegSti	contains centreline geometry of tractor roads, footpaths, trails and other types of communications network that is not managed in NVDB / FKB-road network.
Other FKB Data, various scales, continuous updating, Provider: NMA Owner: Geovekst parties and municipalities of Oslo, Baerum, Stavanger, Bergen and Trondheim for FKB data of their boundaries	
FKB-AR5	1:5,000, land resources
FKB-Tekst1000	presentation data in scale 1:1000, additional data to FKB
FKB-Tekst5000	presentation data in scale of 1:5,000, used when drawing N5 Raster and N5 / N20 map data
N5 Map Data	1:5,000, N5 Map data is based on selected, generalized FKB data
N5 raster	Information economic maps at scale 1:5,000
N20 Map Data	1:20,000, N20 Map data is based on selected, generalized FKB data
Agriculture, 1:5,000, continuous updating, Provider: Nibio Owner: Norwegian Institute for bioeconomy	
arable land	Areas where cultivation may be capable
Various Data, various scales, continuous updating, Provider: NMA Owner: NMA	
Topographic maps	Map Data: N50 (1:50K), N250, N1000, N2000, N5000
Cadastre	Address , geographic points (1: 1,000) Building points for existing buildings with building number, status and type of building (1: 1,000) Property map, simplified content and structure for parcel data, in scales from 1:500 to 1: 10,000 Official Land Registryfor real estate

N20 building	contains all buildings with building outlines adapted to scale 1: 20000
Administrative boundaries	National, County and Municipalities at scale 1: 5,000 Maritime Borders at scale 1:50,000
Height Data	DTM 10 (grid 10x10, 1: 10,000)
Depth, Sea data	Sea terrain models DTM25 (resolutions in meters 5x5, 25x25, 50x50), Depth Data at scales 1:10,000 to 1:30,000, depth curves from 1:200K to 1:10,000K, Hydrographic raster : digital versions of the Official charts from the main map series, harbor chart series and the sailing map series
Place	Place on geographical detail based on map series Norway 1:50,000, economic maps, charts and name decisions made pursuant to Acts.
Aerial (ortho), satellites	• Orthophotos 10:Ground resolution is 4-15 cm. • Orthophotos 20: Ground Resolution is typically 20 cm. • Orthophotos 50: Current photography that will cover the entire country. Ground resolution of these are either 50, 40 or 25 cm. From 2012 comes to ground resolution 25 cm orthophotos of current photography.
Transformations and benchmarks	New Height system NN2000 , Height reference model data, Coordinate transformations
Location Services (CPOS and DPOS)	CPOS – centimeter accuracy DPOS – decimeter accuracy

5.4.1.2 Thematic maps

Thematic geodata is expert information within the following sectors disciplines:
Pollution, Outdoors, Geological resources, Cultural heritage, Coast / fisheries, Agriculture, Landscape, Nature and biodiversity, Reindeer, Transport and Communications, Civil Protection and Emergency
For detailed information on the thematic maps of the Norwegian NSDI, their custodians and providers, press here (Register.geonorge.no, 2017)$_e$.

5.4.1.3 Plan data

A notable spatial theme in Norway. It is an overview of the municipal urban plans, showing relevant areas associated with a link for more detailed information. The main purpose is to give the parties access to future urban activities and their current status. The national map services are available for integration in the parties' solutions.
Map administrations' plan pages on the web provide all relative information.

5.4.1.4 Free of charge basic data

(2013) Increased government funding has enabled the Norwegian Mapping Authority to release its central national datasets as Open Data with a government strategy setting out plans to release even more in the future. To competence the loss of revenue resulting from the move to open data, the 2014 national budget has increased funding for the Norwegian Mapping Authority by 25 million Kroner (2.97 million €). More detailed information can be found here (PDF) (Open Data Released in Norway, 2017).

According to the geoportal, 929 datasets and 7 dataset series are reported as open data
last access May 2017

From the above mentioned, 628 datasets are determined as basic spatial information.

The Global Open Data Index (GODI) is the annual global benchmark for publication of open government data, run by the Open Knowledge Network. The crowdsourced survey measures the openness of government data according to the Open Definition. By having a tool that is run by civil society, GODI creates valuable insights for government's data

publishers to understand where they have data gaps. It also shows how to make data more useable and eventually more impactful. GODI therefore provides important feedback that governments are usually lacking.
According to the index, the overall score in 2016 for Norway is 61% (40% open) and ranked in 13th position, according to the GODI.

Today the Norwegian Mapping Authority has released its central national datasets as open and free data.
✓ Map Data in various scales from 1:50K to 1:500K in vector and raster format are free of charge
✓ Place Names: Each name has information on language / form, coordinates of the position (point), municipality belonging, theme code name type, resolution type, date of registration of the name and the context in which the name is used
✓ Administrative units of Municipalities and counties
✓ Elevation Data DTM 10, DTM 50 and sea terrain models DTM 25
✓ Boundaries as maritime borders, Statistics Norway units, voting areas, post code areas, units compatible with the statistical NUTS division
✓ Road network datasets. Contain address information (points and street names), traffic regulations and refuse restrictions, pedestrian and bicycle paths. Network topology, the road type and relevant attributes are also provided. Delivery consists of county and municipal files for scales from 1:5K to 1:25K.
✓ Depth data from 1:10K to 1:30K and depth curves from 1:200K to 1:10,000K
✓ Coastal zones along the sea with government planning guidelines
✓ Addresses : Physical names in table, and points, vector from cadaster with street name, number and zip code (updated monthly)
✓ Historical maps
✓ Geodetic Data
  ✓ Free of charge, web site See property provides a map or aerial view as background, with lots of topographic details and cadastral information: property's physical extent, boundaries, buildings, property and building address, type of property, declared area, number of title. Ownership data is excluded. For more details on property information press here (Kartverket, 2017)$_m$.

Members of Norway Digital have free access to marine primary data through the portal Geonorge.

Except for the geoportal, geodata can be found and/or downloaded within Maps on Line applications. Also, data can be purchased from the authorized retailers or from the municipalities (only for Geovekst products).

5.4.2 Quality aspects

In a geospatial infrastructure, the following critical success factors must be achieved: Data must be available, accessible, fit for purpose and in use.
It is obvious, that 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.

A variety of requirements and standards determine how to deliver the geodata to Digital Norway. Supervisors and tools are designed to simplify the agencies' work.
The Geodata Act and the Regulations, formalize a delivery obligation for government agencies in Norway. According to the legislation, the deliveries must satisfy the following requirements *(*= either WFS with Stored queries or Atom feed)*

Delivery type	ND "requirements"	Geodatal Act	DOK-claim
Datasets	Yes	Yes	Yes
Harmonized data	Yes	Yes	Yes
Metadata	Yes	Yes	Yes
WMS services	no	Yes	Yes
WFS services	no	Yes*	Yes
Atom feeds	no	Yes*	no
Product specifications	Yes	Yes	Yes
Datasheet	Yes	no	Yes
Presentation Rules	Yes	no	Yes
Coverage Overview	no	no	Yes

The National Mapping Authority, as the national geodata coordinator, performs party monitoring and delivery control. The control is performed continuously per party, and this includes control of metadata, data sets and services. A report is produced, if any deviation from the requirements occurs. The Digital Norway Agreement - Appendix 2 forms the basis for delivery control.
Approval status of geodata and quality evaluation can be found in the DOC status register. Evaluation results for services are controlled continuously by the service status.

Suppliers of the data can use the following tools/documents, to improve their products:
Supervisors giving special instructions on how to document their products, to deliver files and provide interfaces for access to the information (API/on line services).
Metadata editor is the main tool to enter information about data sets and geographic services so that it becomes visible in Geonorge. The tool is used for registration, correction and deletion.
SLD Editor is the tool used for style description.
Geonorge object registry is a collection of key object catalogs from SOSI, Inspire and from parties in Norway Digital. Here are data specifications useful in preparing the data set, or as evidence of how the content and structure of a data is set to be interpreted.

Regarding the data production process, each party and the data producer is responsible for describing processes related to the data creation, management, dissemination and coordination, as part of their management of the business. The Mapping Authority has made a strategic decision to focus on quality control in line with ISO 9001, which specifies the following requirements for the parties:
✓ needs to demonstrate its ability to consistently provide product that meets customer and applicable statutory and regulatory requirements, and
✓ aims to enhance customer satisfaction through the effective application of the system
In 2017, it is updating the safety management system according to ISO 27001.

5.4.3 Metadata

5.4.3.1 Availability of metadata

According to the legislation, all datasets and services in Geonorge should have metadata. Metadata are produced and managed for a very significant part of the spatial data. This is confirmed by the figures of the INSPIRE MR (last reported status in 2016 for 2015 period) :
100% of the reported data sets under Annex I have metadata, 86.2% of the data sets under Annex II, and 89% of those belonging to Annex III. In total 91.22% of all the reported data sets have metadata.
For the spatial services 69.36% of them have metadata. In total 82.62% of spatial data sets and services have metadata.

5.4.3.2 Metadata details

The relevant metadata for registering data sets and services in Norway Digital are:
• Data set name and version and summary of the contents

• Brief description of purpose and Data set history
• Description and link to web pages with a function related to the data set/service
• Documentation of URL call to services on the Internet e.g. getmap, getcapability)
• Reference to object catalogue and product specification
• Information on the data set projection and support for transformation
• Key words and illustration (e.g. key to symbols)
• Information on updating and on distribution/coverage
• Quality descriptions (see metadata evaluation form Geonorge) (Register.geonorge.no, 2017)e
• Presentation rules, distribution information and restrictions on use

GI metadata must be registered also in the Open public data portal called Difi. This portal provides a new solution where one can harvest metadata from other directories as RDF or JSON according to DCAT standard. Metadata located in the Geoportal automatically are harvested by the open public data portal.

5.4.3.3 Metadata quality

Metadata for data and services in Digital Norway follow the ISO 19115 parts for the metadata and the ISO 19119 for the services. SOSI part 1 Metadata, describes the national implementation of the international standard, and the ISO 19139 Metadata - Implementation of XML schema is applied.
Based on the above foresaid we conclude the following:

- ✓ Metadata are produced for almost all the geo datasets of the themes, and almost for the entire set of the INSPIRE annexes
- ✓ One or more standardized metadata catalogues are available covering more than one data producing agency
- ✓ There is a coordinating authority for the implementation of metadata at the level of the NSDI

The quality report of the metadata is provided by the geoportal.

5.4.4 Accessibility and Transferability

All foundation data in Norway Digital are accessible through web services from Geonorge portal on behalf of licensees of the geospatial information.
A service catalog has been created in Geonorge, where all services which are offered by the parties in Norway Digital are registered with the relevant metadata. 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 also provides the ability to visualize the geospatial information. A search of services will result in a list of all types of services in Norway Digital. In the metadata of each service, one can find key information that describes the content and the structure of the service, and the connection information for using the service.

The data required by a service are transferred across a network or are available on the geoportal server. Delivery data to the request 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 the 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 data is downloaded from the various agencies own servers. Moreover, 'GeoNorge' makes geographical data available in digital format to citizens; the data is collected in a central system (Norway WEB digital download) which can be accessed by citizens via a user name and password authentication mechanism. By accessing the

system, citizens can consult and download files of elevation data, administrative boundaries, transformation formulas, as well as related topics like cultural heritage, herding and many more. The system provides both county and national data.

Apart from the Geonorge portal, the Mapping Authority has also developed specific web clients where a user can view nation-wide data or/and download or order the entire set or a portion of it.

- ✓ Cadastral data and relative information via View Property
- ✓ Orthophotos from various projects via "Norway Pictures"
- ✓ Elevation Data from various projects via "Height Data"
- ✓ Urban planning data via "sePlan"

5.5 Technology Component

5.5.1 Systems and services

An introduction to the National Geoportal and the underlying fully distributed and service orientated infrastructure of Norway Digital, is shown in the adjacent overall sketch. The main parts are:

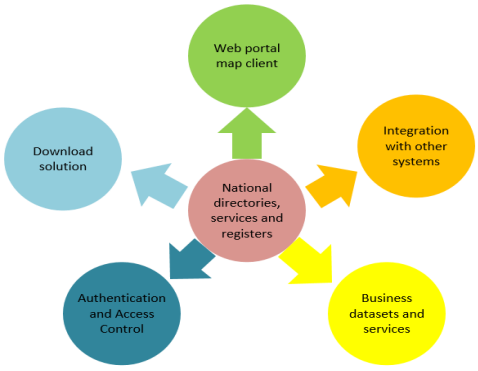

Figure 9 Components of the portal source: Kartverket, 2013)

✓ **National directories, services and registers**

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

- The components form the basis for the distribution and the administration of the metadata, the common registries and the geodata
- 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 supervisors is used to achieve this goal: Download guides (WFS, Atom feed, Geosynchronization), GML Guides, Metadata Supervisors, Supervisors for SOSI product specifications and disciplines

✓ **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 Digital Norway 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 all users with 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 impact, 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 solution, 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

According to the foresaid tiers, the overall system components are oriented as follows:

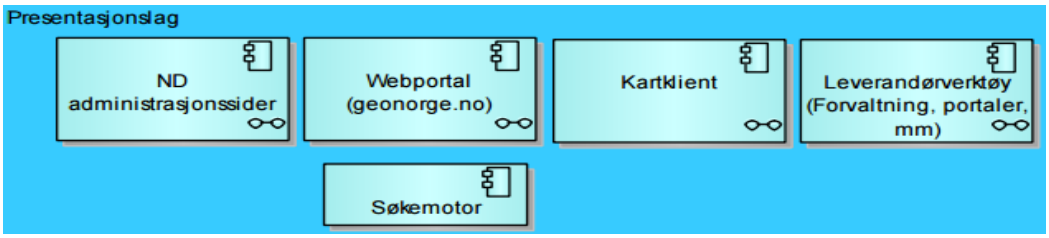

Figure 10 : The presentation tier (source: Kartverket, 2013)

✓ Webportal, is one of the doors to the infrastructure
✓ Search engine, is common, able to search across web pages, directories, registers and files with the aim to simplify access to data for all user groups
✓ ND administration pages, collect administrative functions such as administration of metadata, code lists, product specifications, application forms, namespaces,

Figure 11 : The common industry components tier (source: Kartverket, 2013)

organizational data, suggestions for changes, drawing rules, integration into own web pages, etc. They provide overview and access to management tools for those different registers and directories
✓ Map client, graphic window for the whole infrastructure, showing services and geodata with drawing rules, coverage maps and mapping status
✓ Common solution for downloading presentation layers and services either from the central stored data or from the parties' own servers.
✓ Identification and access control: Seamless login and access to various services.
✓ Registers which manage and facilitate easy access to all relevant geodata
✓ The metadata catalog is the core of the infrastructure and is the gateway for many searches
✓ In SOSI Model registry, standardized descriptions of objects and properties are managed in different Disciplines

Figure 12: The data providers tier Kartverket, 2013)

✓ Services at ND parties which make available their data

The principles of service orientation, interoperability, availability, safety, openness, flexibility and scalability are followed by the geospatial infrastructure.
More detailed information, can be found from the documents provided here (Ny nasjonal geoportal, 2013).

5.5.2 Interoperability

5.5.2.1 System architecture

The use of map services is the solution to increase availability, access, integration and sharing of geographic information. The 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 held at 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 Norway Digital, must be registered in Geonorge's service catalog. From this catalog via a user interface they are accessible from the public or other parties.

5.5.2.2 Service Protocols

The services of the Mapping Authority supports four different protocols that make them highly useful in web applications: WMTS, Google Maps API , Bing Maps API and WMS-C. Find here (Kartverket, 2017)$_n$ a detailed documentation, relevant URLS for these protocols, and cache servers.

5.5.2.3 Aligning with e-government

Geointegration standards have been implemented in many client systems, offering technical, semantic and organizational interoperability, through common interfaces and services between different GIS/IS within the public sector. These standards came from cooperation between users and vendors, government and private companies, civil servants and ICT-developers.

5.5.3 Enabling Technologies

The Norwegian NSDI clearing house (Geonorge) was developed and operated in 2004 by the Mapping Authority on behalf of the parties in Norway Digital. The main software of Geonorge is:

- MapServer (Open Source platform) is used for publishing spatial data and interactive mapping applications to the web.
- Geonetwork's standard functionality is used in the web portal. User interface features from Geonetwork have been used in Web clients.
- Catalog application Geotnetwork, is used for metadata editing and search functions (metadata catalog /CSW server (Geonetwork)).
- Apache HTTP is used as Web Server and Tomcat as application Server.
- Geonetwork's java library Lucene is used for text indexing / search.
- There are several Open Source desktop and WEB-clients who are able to communicate with a WMS service of the geoportal, without requiring the user to develop the code itself. For example, the following desktop clients used: QGIS , uDig or Gaia3. The most common Open Source Web client is OpenLayers
- Oracle commercial software is used as database server (Kartverkets årsrapport for 2013, 2014)

6 THE NORWEGIAN SDI's MATURITY

In the sixth chapter, the maturity of the Norwegian 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 Norwegian geospatial infrastructure through the model's requirements, are presented.

6.1 The geo-maturity model

For the assessment of the maturity of the Norwegian 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

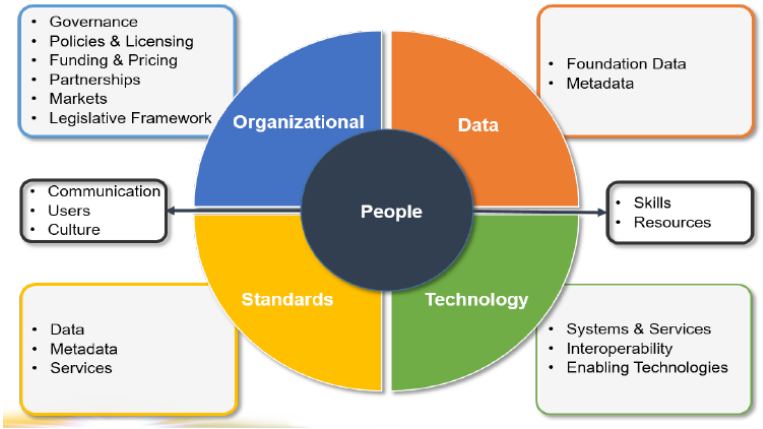

Figure 13 "The five elements of the NSDI" Copyright Dr. Vanessa Lawrence CB, Gilles Albaredes, John Schonegevel, Maurits van der Vlugt

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:

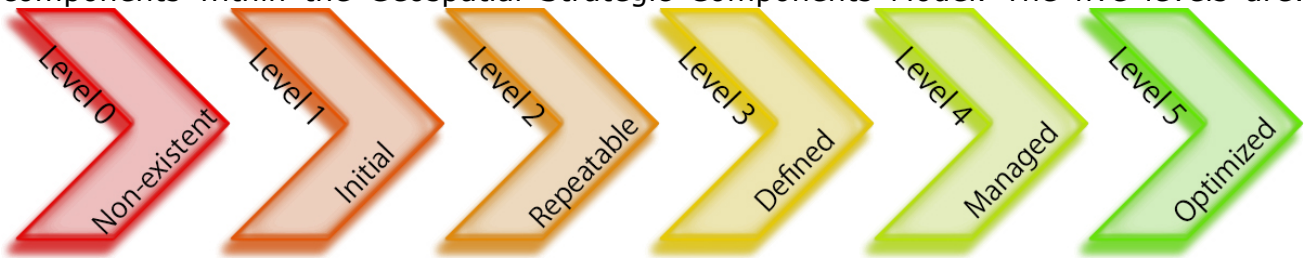

Figure 14 The Maturity Levels

- ✓ 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

6.2 Maturity Level Assessment and Reasons

6.2.1 Organizational

Initial coordination activities have taken place in early 1990's. The National Mapping Authority undertakes the coordination role in the Geovekst collaboration where the State Road Department, the Board of Electricity Companies, the Norwegian Association of Local Authorities, the Norwegian Mapping Authority and the Telecommunication Department share responsibility concerning mapping production and cost production. Technical manuals, guidelines, software for data production and control procedures are defined and used from all parties (Standard Operating Procedures). Sharing data among all the parties of the collaboration was one key-point of the Geovekst agreement. (Level 2)
In 2002, white paper "Digital Norway" – a common foundation for wealth creation" is the cardinal political initiative for the establishment of the NSDI. The major concept in the White paper is the establishment of the national geospatial infrastructure in support of the e-Government program. The custodians, the governance scheme, the coordinator, the primary and thematic data are established. The paper was also a framework for a nation-wide co-operation in the public sector (called Norway Digital), which was initiated in 2003 and formally established in 2005. The government was initially responsible for the overall management and financing of this infrastructure, with the Ministry of Environment (now the 'Ministry of Local Government and Modernization') responsible for the coordination of national partners. In 2001-2002, AREALIS, TITAN and "Geodata on Line" (Høyhastighetskommunikasjon for utveksling av geodata Fase I, n.d.) show data sharing activities (level 3)
For the above reasons, we ranked the maturity level of the Norwegian SDI in the middle of level 3, in 2003.

The INSPIRE Directive and the Geodata Act (2010) and its regulations, established the main legal frameworks that govern the structure of geographical infrastructure. The National Geodata Council monitors the implementation of the Geodata Act and the European INSPIRE directive, and provides advice or statements where it deems appropriate. From 2010, the annual reports from the Geodata Coordinator evaluate also the performance of INSPIRE's implementation. Satisfaction surveys improve the implementation in favour of the users and the society. Omløpsfoto, Mareano and BarentsWatch are among others, business-case driven investments. (Level 4)

After 12 years of the formal establishment of the collaboration, data sharing is consistent, mature and successful among the 600 parties of the 'Digital Norway". The political will for continuous improvement is proven with the New Geodata Strategy "Norway to be a leader in the use of the geospatial information" from 2016 to 2025.
A ROI (return on Investment) monitoring system is not found during this study.
According to the aforesaid, the maturity of the Norwegian SDI today is ranked in the middle of level 5.

6.2.2 Data

In 1992, a service for data management and distribution of the GI named National Geographic Information Center (NGIS), operated in 1996, giving users easy access to NMA's data (www.statkart.no/ngis). One of the key elements of NGIS was the metadata catalog.
In 2002, with the white paper "Digital Norway" – a common foundation for wealth creation" the primary and thematic data are defined. In the same year, the "e-Norway 2005" action plan, established a project for the development of a geoportal as a hub for the national infrastructure of geographic information. *"The focus in this project will be on obligatory cooperation between Government bodies, although other organizations – especially local Government – may also be included as required".*
These initiatives in 2002, have defined the principles of a single point of truth.

The partners of Norway Digital can use all data of infrastructure, based on a set of two contracts, a general agreement and a fee model. This policy is considered as open data policy with the right to each party to define the terms of payment and use for its dataset. For the above reasons, we ranked the maturity level of the Norwegian SDI in the level 3, in 2003.

The one point access geoportal Geonorge commenced operation in January 2004 by the Mapping Authority on behalf of the parties in 'Norway Digital' co-operation. It developed further, to satisfy additional requirements and in June 2017 the "New national GeoPortal" will be available.
According to the legislation, all datasets and services should have metadata to be published in Geonorge (automatically checked). This is confirmed by the figures of the INSPIRE MR, as the implementation of the INSPIRE directive is evolving within the scheduled timetable.
In 2013, increased government funding has enabled the Norwegian Mapping Authority to release its central national datasets as Open Data (free of charge) with a government strategy setting out plans to release even more in the future. To competence the loss of revenue resulting from the move to open data, the 2014 national budget has increased funding for the Norwegian Mapping Authority by 25 million Kroner (2.97 million €). (Level 4 in 2013)

The Mapping Authority, as the national geodata coordinator, performs party monitoring and delivery control of the GI data. The control is performed continuously per party, and this includes control of metadata, data sets and services. A report is produced, if any deviation from the requirements occurs. Approval status of geodata and quality evaluation is sent to each relevant party (improve data).
A lot of new and improved data has been included in the infrastructure from the initial operation pf Geonorge. New projects replace existing data providing more detailed information.
Growth in open datasets (free of charge) was accelerated in the period from 2013 to 2017.
According to the aforesaid, the maturity of the Norwegian SDI today is ranked in the level 5.

6.2.3 Standards

Norway has a long tradition in the standardization of geographic information, first at national level, onwards at European and global level.
A national standard for describing and exchanging digital geodata (SOSI) was developed in 1982, covering more than 40 thematic areas since 1987. In 2001, OGC standards were used in WMS, WFS, GML, Catalog and registry services as well as ISO/TC 211 standards 191xx for Metadata, Schema, encoding and definition of services.
Norway, participates in European standards since 1991, investing in ISO/TC 211 since 1994 and started to follow OGC in 1995.
E-enabled services established from 1992 with the National Georgaphic Information Center (NGIS).
In 1992 the participants of Geovekst Cooperation, defined a common standard FKB (Common Map Base) which is presently the most detailed and accurate dataset in the NSDI infrastructure. Standards issued also for the datasets of the Directorate for Nature Management (DN), the Norwegian Geological Survey (NGU), the Norwegian Institute for Land Inventory (NIJOS), the Norwegian Mapping Authority and the Public Roads Administration. The "GeoData on line" (Høyhastighetskommunikasjon for utveksling av geodata Fase I, n.d.) portal operated in 2002, due to the aforesaid standards and was available for the administration and the public. The portal used standard Internet technology that allowed the user's direct access to some of the public body's own

databases and it is a realization of the partial integration among organization's wide e-enabled service standards.
For the above reasons, we ranked the maturity level of the Norwegian SDI in the middle of level 4, in 2003.

In 2001, Standards Norway has the secretariat and the chairperson through the Norwegian Mapping Authority in ISO. In 2007, SOSI standard Version 4 is compliant with international standards in geographic information. The main standardization arenas for previous and further development of SOSI standards are ISO/TC 211 and OGC.
According to the aforesaid, the maturity of the Norwegian SDI today is ranked in the level 5.

6.2.4 Technology

AREALIS aimed to be the environmental branch of the NSDI, combining environmental/natural resource data, basic data, property data, positioning data, existing area plans and environmental preservation measures from 10 Ministries, 20 public agencies and of some counties and municipalities. In the technology context, principles of UML modelling according to ISO 191xx standards, exporting models by XML, ISO/TC 211 Feature Catalog methodology, Catalogue of Data Sources (EEA, CDS) tools using GEMET were applied. The site was in operation in 2002 and in the following years continuous improvements took place. As a result of its improvements, Geonorge was operated in January of 2004.
Until 2007, the Mapping Authority used ESRI solutions (COTS).
For the above reasons, we ranked the maturity level of the Norwegian SDI in the middle of level 3, in 2003.

The services of Digital Norway are based on electronic licenses. They are offered either free of charge or under payment terms.
A WMS service, performing automated tests on the services. It shows uptime, response time and test results in relation to the technical quality of a service that is registered in geoportal.
Data sets and services are published in accordance with open standards and in the most harmonized form. The geoportal is the GI gateway for the business systems of the public and private sector. (Level 4, around 2010)

In 2017, the Geonorge implemented the common vision of NSDI and EU SDI with the following values:
- data should be collected once and maintained at the level where this can be done most effectively
- it should be possible to combine seamless spatial information from different sources and share it between many users and applications
- it should be possible for information collected at one level to be shared between all the different levels, high resolution for detailed investigations, general for strategic purposes

The New National Geoportal had two overall objectives:
- all participating businesses, as defined in geodata law / regulation, use by 2018 the Geoportal as their first choice for the publication, provision and access of their digital geographic information.
- access to all available public geographic data is simplified in that they can be located from an integrated site in 2018

According to the aforesaid, the maturity of the Norwegian SDI today is ranked near close to a completed level 5.

6.2.5 People

A prerequisite for a good utilization of the geographic infrastructure is knowledge in all levels - both about opportunities and challenges. The education in Geospatial sector, has started from 1992, with universities to offer bachelor and master programs.
In the same year, Geovekst proves the cooperative culture. In the next years, communications plans are drawn up by the National Mapping Agency.
The operation in early 2000 of AREALIS, "Geodata on Line" (Høyhastighetskommunikasjon for utveksling av geodata Fase I, n.d.), "TITAN" and Geonorge in January of 2004, proves that:

- the requirements in skills and training have been defined
- a coordinated, whole of organization user needs analysis has taken place

Moreover besides, on the basis of a survey carried out for the Ministry of Environment in 1999-2000, it is estimated that the geomatics industry includes just under 200 enterprises which had a turnover of at least 2.4 billion NOK (298.08M €) and employed a minimum of 2,800 FTEs. (Full time employees)
For the above reasons, we ranked the maturity level of the Norwegian SDI in the level 3, in 2003.

The main R&D performers in Norway are the universities, university colleges, state colleges, research institutes and corporate R&D units. The higher education sector carries out approximately one fourth of Norway's total R&D activities. The R&D efforts are financed through basic funding from the state, grants from the Research Council and contracts with private and public workplaces.
Communications channels have been established through the governance structure, the national and international collaborations, the geoportal, the conferences and the workshops and the satisfaction surveys, ensuring the regular users' feedback. (level 4, 2006)

The Government is monitoring and improving the research and education environment, through a long-term R&D plan from 2015 to 2024 and a new national skills strategy (2017-2021).
There infrastructure consist of mature user engagements in national and international level due to the strong collaboration and transparent partnership culture.
The private sector mainly supports the SDI (production, maintenance) and shows hopeful trends in the creation of value-added products.
According to the aforesaid, the maturity of the Norwegian SDI today is ranked in the middle of level 5.

6.3 Overall assessment of the Norwegian 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). We note that in standards it is considered that Norway is in level 5 since 2007.

Progress towards a functioning and effective NSDI governance structure and capacities

Table 8:Maturity Level assessment of the Norwegian 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 Norwegian SDI is examined using temporal aspects (when 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 Norwegian 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	1992 1996	Whole of organization governance structures established	YES	Mandate and legal frameworks in place	2010	Ongoing monitoring and continuous improvement	2010 2016
No standard operating procedures (SOPs) identified, compliance and tracking not consistent		Custodianships and stewardship principles defined	1992	SOPs consistently tracked and verified	YES	Formal custodianship and stewardship roles defined	2003	Measuring ROI and benefits realization[1]	
Project by project funding		Some SOPs documented	1992	Defined strategy and Implementation Plan	2002 2003 2010	Strategy implemented, KPIs monitored	Reports 2011 Surveys	Data sharing is consistent, mature and successful	2017
Case by case partnerships		Some whole of organization funded initiatives	1992	Whole of Organization investment plan	2003	Business case driven investments	2006 2006 2016		
No market coordination or focus		Sporadic data sharing	1996 2002	Public / Private Partnerships	YES	Operational budget allocations	2003		
No successful initiative in data sharing				Inconsistent Data sharing with elements of success	2001 2002	Data sharing in place but still immature	2003		

[1] A reporting system, for the ROI of the infrastructure, was not found during the study

6.5 Data

Table 10: Maturity Level of Data Component of the Norwegian 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	2002	Foundation Data published, shared and maintained	2004	On-going monitoring and continuous improvement	2010
Data duplication		Some (meta)data publications	1996	Foundation Data Themes defined	2002	All data published with compliant metadata	2010-	Growing spatial data and open data usage throughout community	2016
Project by project data and metadata collection	1996			Open Data policies established	2003[2]	Open Data policies[3] implemented	2013		

[2] The term "open data" according to the policy, doesn't mean free of charge data. Every party of the collaboration will define under what payment terms will give access to its data.
[3] "Open Data" as free of charge.

6.6 Standards

Table 11: Maturity Level of Standards Component of the Norwegian 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	1987	All (meta)data published in standards compliant formats, protocols and services	2001	Monitoring and expansion of standards compliance	2006	Proactive, contributing role in (international) standards, organizations ensure organizational needs are reflected in emerging standards	2001
		Selective standards adoption	1991-1995	Observer role in (international) standards organizations	1991	Common data models defined for Foundation Data	1992 2002		
		e-enabled services not exploited		e-enabled services sporadically exploited	1996	Partial integration with other organization wide e-enabled service standards	2002	Fully integrated e-enabled services standard	2007

6.7 Technology

Table 12:Maturity Level of Technology Component of the Norwegian 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	2001	Organizational spatial data architecture being implemented	2002 2004	Robust spatial data services with defined SLAs	2010-estimated	Spatial data architecture is flexible allowing for constant improvement and increased business efficiency	2017
No organizational spatial data architecture defined		Some elements of organizational spatial data architecture being implemented	1996	Compliant spatial data services	2002	Service monitoring	2010 estimated	Business systems integration mature and effortless	2017
Case by case interoperability. Often vendor dependent		System specific interoperability	1996	Vendor agnostic	2007[4]	Business systems routinely using spatial data services	2010 estimated		

[4] Vendor agnostic platform

6.8 People

Table 13: Maturity Level of People Component of the Norwegian 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	YES	Growing skills base	1995-	Ongoing monitoring and continuous improvement	2015
Ad hoc training and development		Informal knowledge sharing		Formal education and knowledge sharing resources	YES	Coordination with education facilities	2006	Targeted sources and R&D activities	2015
No coordination communication		Case by case user needs analysis		Coordinated, whole of organization user needs analysis	1997	Regular user feedback captured	2006	Mature user engagements	2015
Project by project user focus		Informal communication standards		Formalized communications plan	1992	Effective, coordinated communications	1992	Pervasive awareness of spatial information benefits and availability	2010 now
No collaboration culture		Untrusted and sporadic collaboration culture		Cooperative culture	1992	Coalition and alliance culture	2000	Strong collaboration and transparent partnership culture	2006

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The main sources for the information provided by this study, is taken from the various pages and documents in Geonorge and Kartverket sites. (last access April 2017).

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