2017

NSDI Good Practices Denmark

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List of Abbreviations

DAiSI	Danish Academy for Spatial Information
GST	National Geodata Agency
KL	Local Government Association
KMS	National Survey and Cadastre
OIO	Public Information Online Committee
SDFE	Agency for Data Supply and Efficiency

1. Executive Summary

Denmark is regarded as one of the good practice examples of developing a National Spatial Data Infrastructure (NSDI). Already in the 1990s the importance of digital information was acknowledged. Back then, the information was mainly collected in registers and maps. The municipalities and the National Cadastral and Survey (KMS) were the main actors.

Gradually, the need for sharing and connecting the information brought about the introduction of key and cross-reference registers. The eGovernment program in 2001 created a great change in the information sharing landscape. The target was to provide all the data digitally reducing costs and strengthening sharing of information. Geoinformation had a central role in the eGovernment strategy and was seen as the backbone in effective digital administration. In order to implement the strategy collaborations in terms of committees and working groups were established.

Arrangements and collaborations between authorities brought about the first joint websites and web services sharing geospatial information. However, these efforts were uncoordinated and isolated due to the lack of a national strategy.

This need was fulfilled with the Infrastructure for Spatial Information Act (2008) which set the framework for establishing the NSDI by integrating the INSPIRE Directive. According to the Act, the KMS under the Ministry of Environment would be the overall responsible authority to implement and maintain the Danish NSDI.

The NSDI development was in line with the eGovernment and the Basic Data Program. In 2012, within the Basic Data Program, the Basic Data Agreement was published according to which basic data had to be open and free.

Denmark has today a fully functional NSDI with open data and metadata being shared on a national portal, opensource technologies and international standards being widely used and an organizational structure that is in place and well understood.

The remainder of this report is organized as follows. In section 2 some information about the country is provided. Section 3 and 4 are dedicated to the pre-NSDI landscape in Denmark and the activities undertaken to establish the NSDI. In section 5 and 6 an overview of the NSDI today is give and in section 7 the maturity level assessment is provided.

2. An Introduction to the Country

Basic Data

Population	5,707,251 (2016)
Area	43,560 square kilometres
Population density	132 per square kilometre
Geographic region	Scandinavia
Gross domestic product	268.70 billion euros (2015)
GDP per capita	46227 euros (2014)
Capital	Copenhagen (2016)
Form of state	Monarchy
Ethnic distribution	5,003,378 Danes. Immigrants and their descendants constitute 703,873 (2016)
Life expectancy	Women 82.5 years, men 78.6 years (2016)
Language	Danish
Religion	76.9% Protestant (members of the National Church, 2016)
Currency	Danish Kroner,

Denmark is one of the Scandinavian counties and the southernmost Nordic country. It consists of the mainland (Jutland) and 443 islands. It also includes Faroe Islands and Greenland. It is a relatively flat country with the average elevation above sea being 31 meters. Its climate is temperate with mild winters and cool summers.

Regarding its political structure, Denmark has monarchy and exercised parliamentary democracy.

Denmark was divided into sixteen counties and 270 municipalities. After a reform in 2007, these were merged into 5 regions and 98 municipalities.

Regarding the rankings per GDP (nominal), Denmark ranks 35th according to the International Monetary Fund (2016), 37th according to the World Bank (2015) and 34th according to the United Nations (2015).

According to Brande-Lavridsen (2002) it is one of the most mapped societies worldwide. It has a very strong eGovernment infrastructure with most of the daily interaction between public organizations and between citizens and the state being digital (Commission, 2016).

In 2008, Denmark was ranked as number two in the UN eGovernment readiness rankings. The Danish eGovernment strategy 2011-2015 introduced a paradigm shift in digital communication with the ambitious target of 80 percent of all interactions between citizens and the public sector being digital by the end of 2015. The statistics from 2015 show that the target has been reached.

3. The pre-NSDI landscape (-2008)

Denmark has a very strong geospatial tradition with public and private organizations being very active in collecting and digitizing geospatial data for many years. In the 1990s, the development of data, metadata and discovery services started in a rather uncoordinated way. Several organizations were producing and sharing sometimes the same datasets.

Data sharing was not always easy not only due to technical interoperability problems, but mostly because of disagreements at the organizational level and the missing culture of collaboration. This was fostered by economic disagreements between the data producers.

KMS, the Danish governmental organization for National Survey and Cadaster (www.kms.dk) was formed in 1989 by the merger of the Geodetic Institute, the Hydrographic Department and the Danish Cadastral Department. It is the governmental authority responsible for:

- mapping and charting of geodata and cadastral registrations
- the authorization of licensed surveyors

Until 1994, KMS produced topographic paper maps at scales 1:25000, 1:50000, 1:100000, 1:200000, 1:250000. 1:500000 and 1:1 million and nautical charts. Since 2002, no paper maps are produced except for nautical charts. Digital maps are available and published on CDs – but not printed.

By law it has the obligation to coordinate the public use and creation of geodata. KMS and the municipalities played the pivotal role in the pre-NSDI landscape. Due to the missing policy or central vision of a coordinated SDI, bottom up cooperation and some initiatives in the public-sector lead to nationwide spatial products.

The Danish spatial data was traditionally organized as maps and registers (Brande-Lavridsen, 2002). In 2005, the maturity level of the SDI was assessed (Table 1).

Table 1: Maturity of SDI in 2005 (source: Bastiaan van Loenen, 2006)

	Stage			
Aspect	**Standalone/initiation**	**Exchange/standardisation**	**Intermediary**	**Network**
Vision	Focus on individual organization	Developed with all stakeholders	Implementation	Commonly shared and frequently reviewed
Leadership	Focus on individual organization	Questioned	Accepted	Respected by all stakeholders
Communication	Focus on individual organization	Open between public parties	Open between all stakeholders	Open and interactive between all
Self-organising ability	Passive problem recognition	Neutral problem recognition	Actively helping to solve identified problems	Actively working on innovation
Awareness for GII	Professionals in one organization: organizational GII	Professionals of organizations together: GII	Awareness at many levels including decision making	Commitment at all levels/continuous support in politics and management
Financial sustainability	Limited to projects	Neutral	Guaranteed for certain period	Sustainable but frequent review
Delivery mechanism	Project	Product portal (geo-portal)	Clearinghouse	Clearinghouse with information/service (e.g. downloads)

3.1 Geospatial Information in the pre-NSDI landscape

3.1.1 Registers

In the late 1960's many national public registers were established such as the Centralised Civil Register (CRS est. 1968), the Buildings and Dwellings Register (BDR est. 1968), the Real Property Valuation Assessment Register and the Municipal Property Register (Overgaard and Hansen, 2008).

At that time, the registers were purpose oriented and independent from one another so that the access from different authorities was prohibited. Each register followed different modelling and technological solutions as well as quality and update requirements. The responsibility for those registers was shared between the state and the municipalities (Daugbjerg and Brande-Lavridsen, 2001).

With the introduction of the Crossreference Register in 2000, the registers were linked to each other via administrative keys (Daugbjerg and Brande-Lavridsen, 2001; Vanderbroucke and Biliouris, 2010).

In 2004, following public registers existed:

- Cadastral register
- Building & Housing register
- Planning register
- Central population register
- Sales and valuation register
- Central enterprise register

- General agricultural register
- Central domestic animal register
- Central forest register
- Building preservation register
- National health register
- Information system of the road sector

3.1.2 Geoinformation Products

Since 1980, large scale maps of 1 meter accuracy were produced by different authorities. The municipalities produced their own digital maps of 1 meter resolution in rural areas and 0.1-0.2 meter is urban areas.

In 1990, the Cadastral dataset was digitized in cooperation of the public and private sectors. The project was completed in 1997. By joining forces with the Ministry of Environment, the end product did not only include registered parcels and administrative boundaries, but also areas of special interest such as forests, coastal zones and contaminated areas. From 1998, the information had been available on the web for professional use (Ryttersgaard, 2000). In order to get access to the system, a subscription to the Webcadastre was essential (Daugbjerg and Brande-Lavridsen, 2001). Sea charts had been digital since 1997 (Ryttersgaard, 2000).

The private sector was also very active in providing geospatial information such as private photogrammetric companies that were producing and selling digital colour orthophotos (resolution 8-40 cm) and other private companies which produced road and street maps and navigation devices (Daugbjerg and Brande-Lavridsen, 2001).

In 2000, the National Survey and Cadastre provided the topographic map database (TOP10DK) of 46 themes at scale 1:10000. It included also the Digital Terrain Model and was the result of a public-private cooperation. KMS specified TOP10DK and put the production into public tender. The production was done by private companies, and was fully paid by KMS (who also owned the Intellectual Property Rights (IPR)). In 2002, the database was made available via the web based Digital Map Supply Service.

Counties and municipalities provided technical maps from 1:1000 to 1:10000 for different purposes, as well as thematic web maps and regulation plans. Counties had GIS datasets and provided their data via web mapping services at http://www.miljoeportal.dk/borger/Sider/Borger.aspx .

From 2001, products from the National Survey and Cadastre were already provided as WMS and WFS services (Overgaard and Hansen, 2008). At the same time the use of GIS in public and private sector was increasing (Brande-Lavridsen and Daugbjerg, 2001)

Digital thematic maps were available in following domains: geological maps and soil classification maps, agricultural maps, maps of administrative divisions and, road networks.

3.1.3 Address Data

The address dataset is very important and has a long tradition in Denmark. Since 1970 address data has been collected nationwide by different authorities, i.e. municipalities and the public sector (e.g. the Kampax company which produced the Danish Address and Road register (Daugbjerg and Brande-Lavridsen, 2001)).

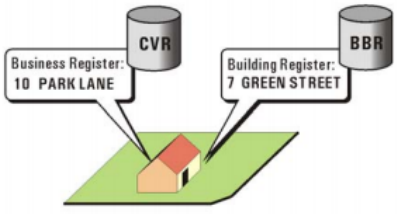

Figure 1: Differences between addresses in business register and buildings register (source: Lind, 2008)

Address data was kept in several databases, and semantics of the data definitions and the quality requirements varied a great deal (Fig. 1). In 1980 after a common agreement, a unified address format was shared between the Population Register (CPR), the Buildings and Dwellings register (BBR), the Property Assessment Register (ESR) and the Business Entity Register (CVR) which facilitated sharing of information (Fig. 4). During 1994 – 1996, a data model for the Danish address system was established with object classes such as: road name, municipality, address number, postcode, town name etc. (Fig. 3).

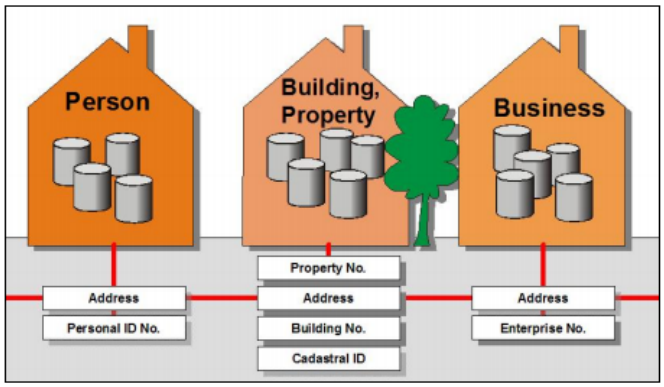

Figure 4: Linking of registers with the aid of addresses (source: Lind, 2008)

In 2000, the Buildings and Dwellings register was appointed as the base register for addresses (Fig. 5).

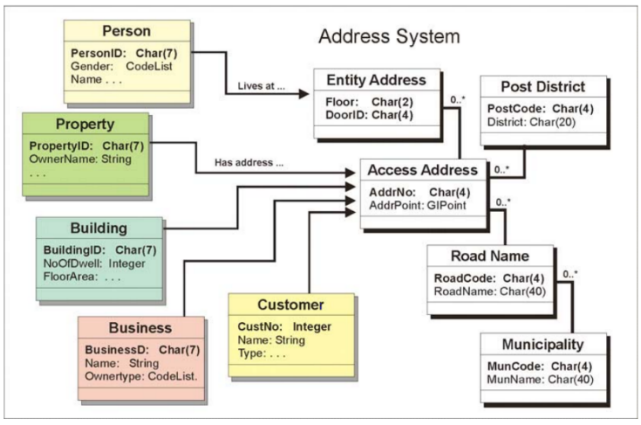

Figure 3: Address Data Model (source: http://www.ec-gis.org/ginie/doc/SDI_initiatives/GINIE_EBP_Section6.pdf)

Georeferencing of the addresses was performed by the municipalities within the Address-project (1995-2001) (Fig. 6). The project was coordinated by KMS and the Local Government Denmark. KMS funded the project with 0.003 euros per address.

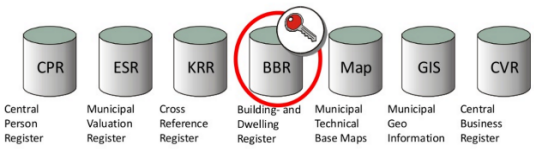

Figure 5: Buildings and Dwellings register as base register for address data (source: https://www.slideshare.net/Mortlin/addresses-and-address-data-experiences-from-denmark)

The address dataset raised very high interest in the public and private sector and was made freely available to public and private users with only a small payment for the distribution costs in 2002 (Vanderbroucke and Biliouris, 2011).

The costs for implementing and opening up the centralized address dataset was 1.3 million euros for compensation of local governments and 1.3 million euros for distribution costs between 2005-2009.

Since the 'Free of charge address data agreement' in 2002, the data is provided for free for non-commercial use. The economic benefit of opening up the data was measured to be 63 million euros between 2005-2009.

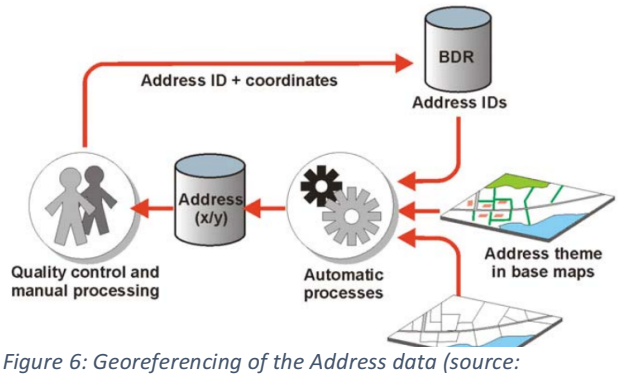

Figure 6: Georeferencing of the Address data (source: http://www.ec-gis.org/ginie/doc/SDI_initiatives/GINIE_EBP_Section6.pdf)

By combining topographic and cadastral maps with the Buildings and Dwellings Register and the addresses, a system for georeferenced building ID's was established. (Daugbjerg and Brande-Lavridsen, 2001).

3.1.4 Metadata

Except for data, a small-scale metadata service based on CEN standards existed since mid-1990 (Vanderbroucke and Biliouris, 2010). The KMS was responsible for the Metadata Service and the data providers were responsible for adding the necessary information (Ryttersgaard, 2000).

The Geodatainfo.dk was introduced in 2005 as a catalogue for describing metadata about digital maps and registers. The metadata included a short overview of the data, the owner of the data and where to get more information (Brande-Lavridsen, 2002). It was implemented in CEN and later in ISO TC 211 standards.

3.1.5 Web based access to geoinformation

3.1.5.1 Area Information System (AIS)

In 2000, the National Environmental Research Institute launched the Area Information System (AIS) as a central node for collecting and sharing environmental data such as land use, hydrology, natural resources etc. from different regional and national authorities.

It was a joint activity of the National Environmental Research Institute, The Geological Survey of Denmark and Greenland, The Danish Forest and Landscape Research Institute, The Danish Forest and Nature Agency, The Danish Environmental Protection Agency, The Danish Energy Agency, The Danish Survey and Cadastre, The Spatial Planning Department, The Ministry of Energy, Fisheries and Food, the Danish counties, The Municipality of Copenhagen and The Royal Danish Administration of Navigation and Hydrography. It was financed by the Ministry of the Environment.

Data was provided in several formats (Table 2). Metadata was described in the "Metadata for Area Information System" (in Danish).

Table 2: Data formats at the AIS (source: http://www.dmu.dk/1_Viden/2_Miljoe-tilstand/3_samfund/AIS/2_Rapport/ais_rapport.pdf)

Data Type	**Format**
Vector data	ArcView shape format, Arcinfo export format (E00), MapInfo TAB-format
Raster data	Tiff with different header files (WMF, TAP)
Image data	WinChips image format
TIN models	ArcView TIN format

Copyright was always remaining at the producer's side, and only user rights for non-commercial purpose were given to the users with the mandatory citation of the source of the AIS-data.

In a series of seminars, the functionality and use of the AIS system was demonstrated and users were familiarized with the AIS environment.

At the same time the importance of object-oriented models was acknowledged (Daugbjerg and Brande-Lavridsen, 2001), and a shift to representing geographic features as real world objects became more and more prominent.

3.1.5.2 Public Information Server (OIS)

In 2001, the Ministry of Housing and Urban Affairs according to the government's general IT policy launched a Public Information Server (Fig. 7) (www.ois.dk) with the view to providing free access to services delivering, mainly property, environmental, business, land and personal data.

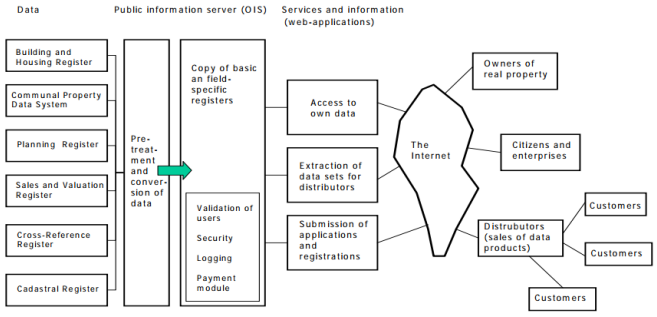

Figure 7: Public Information Server (source: http://icaci.org/files/documents/ICC_proceedings/ICC2001/icc2001/file/f14004.pdf)

In its first version, it only delivered attribute data from the public property registers and not maps (Daugbjerg and Brande-Lavridsen, 2001). The data was provided to the public over the internet (Overgaard and Hansen, 2008) on certain pricing and terms of use for different user groups such as property owners, distributors, value adding companies etc. (Brande-Lavridsen, 2002).

3.1.5.3 The Map Service

The KMS launched in 2001 The Map Service, providing the TOP10DK, the cadastral maps and small scale topographic maps. The service was provided as an OGC WMS Service and was accessible both by the public and private sector (Brande-Lavridsen, 2002) (Fig. 8).

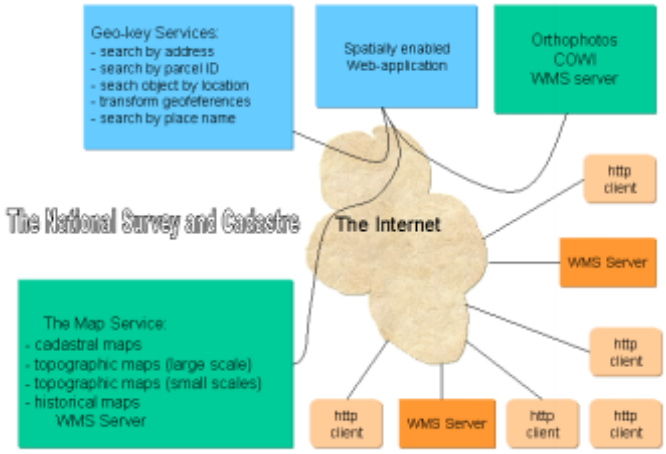

Figure 8: Map Service Architecture (source: Brande-Lavridsen 2002)

3.1.5.4 Kortserver

In 2002 municipalities started to share their maps on a common portal (kortserver.dk) (Brande-Lavridsen, 2002). Data is provided based on OGC and GML standards.

3.1.5.5 The Danish OIO-XML Project

With the view of implementing the eGovernment strategy which facilitates smooth information, the exchange format xml was adopted on the implementation side. The aim of the OIO-XML project, launched in 2003, was to implement and standardize interfaces and vocabularies.

It was connected to the "White Paper on Enterprise Architecture", published by the Danish Ministry of Science, Technology and Innovation in 2003 according to which service oriented architecture (SOA) and IT solutions designed in a modular way were suggested for the public sector.

With the aid of the OIO-XML project, an organizational model was developed which aimed at standardizing data, data fields and exchange formats that were to be used by the public sector.

The goals of the project were:

- *Improve the exchange of data both internal in the public sector and between the public and private sector.*
- *Improve the processing of data, and facilitate easy access to already collected data and the re-use of these data.*
- *Make it easier to implement e-services.*

3.1.5.6 InfoStructureBase

In 2003, the public data repository "InfoStructureBase" was launched by the Danish Ministry of Science, Technology and Innovation in cooperation with the Data Standardization Committee (Lind, 2008). It was one of the outputs for implementing the OIO-XML project's goals focusing on enabling interoperability between systems. In its initial form, it was a public repository for xml schemas of widely used data such as the Danish personal identification number.

3.2 Standards

Danish Standards Foundation, DS, is the national standardization organization in Denmark. It was originally founded in 1926. It is a private, non-governmental organization and member of the following entities:

- ISO,
- International Electrotechnical Committee (IEC),
- European Committee for Standardization (CEN),
- European Committee for Electrotechnical Standardization (CENELEC)
- European Telecommunication Standards Institute (ETSI).

DS is involved in a wealth of activities such as development of standards to sale of standards, training activities and consultancy services.

Some of the initiatives taken by DS were:

- the "white paper on IT-architecture" promoting service oriented architecture within the Public Information Online website providing online guides and manuals on technologies and standards,
- the Danish OIOXML project, standard for naming and designing of public XML schemas as a common language for exchanging public data
- the Danish eGovernment Interoperability Framework in which open standards had already been mentioned and suggested to be used (Overgaard and Hansen, 2008).

KMS participated in ISO as a representative for the Danish Standard Organisation in the process of developing standards for geographic information (Ryttersgaard, 2000).

XML was adopted for implementing the eGovernment strategy (see 3.10) and the OIO Data Standardization Committee was responsible for ensuring coherence while standardizing vocabularies and interfaces.

In 2006, the Parliamentary Resolution B103 was adopted by the Danish parliament on the use of open standards for software in the public sector.

3.3 Data Models

The importance of data models was acknowledged very early and the public authorities were encouraged to design their own data models (around 2000). Some of the published data models were:

- the County Data Model to be used for planning and environmental data on county level
- PlanDK to be used for the physical aspects of planning data. PlanDK is aligned with the County Data Model and the Planning Register
- the logical data model for property data
- FOT Data Model to be used for common objects in topographic and technical maps

Many data producers had already defined their specification for the map production, and based on that could perform quality checks. For instance:

- the Danish Cadastral Map was based on the "Specification on Digital Cadastral Maps" (1997).
- the Digital large-scale vector maps (technical maps) in scales from 1:1000 to 1:10000 were based on the "Specifications for technical maps" (2000).
- the TOP10DK nationwide vector map in scale 1:10000 was based on the "TOP10DK Specifications" (2000).

3.4 Initiatives

3.4.1 Digital Denmark – adaptation to the network society

In 1999, *Digital Denmark – adaptation to the network society* was published. In 2000, it was followed by the *Adaptation to the network society, IT and tele-political statement for the Folketing* document. Both set the scene for the governmental IT strategy. Spatial information had a key role in it. In the documents, the need for a policy demonstrating how citizens, the private and public sector would benefit from maps and registers was expressed.

3.4.2 Digital Management

In 2001, *Digital Management* was published, emphasizing particularly the need for legal changes so that broader use of data is facilitated. Following, the *Course for the digital country* was published, highlighting that in order to fully benefit from the use of geospatial information, obstacles such as privacy, ownership, pricing have to be clarified.

3.5 Collaborations and Committees

3.5.1 The Map and Geodata Council

In 1999, the Map and Geodata Council was established by the Minister of Housing and Urban Affairs. It consisted of representatives of users and providers of geoinformation from the public sector, the private sector and academia. It had an advisory role and focused on geodata policy.

3.5.2 Geoforum

Geoforum, the Danish Society for Geoinformation (www.geoforum.dk) (NGO) was formed in 2001 by bringing together the Danish Society of Photogrammetry, Surveying and Remote Sensing, the Danish Cartographic Society and the Danish Academy for Spatial Information (DAiSI). Its main role was to promote the use of geoinformation in the Danish society (Ryttersgaard, 2000; Vanderbroucke and Biliouris, 2011).

3.5.3 The Spatial Data Service Community

The Spatial Data Service Community was formed by the Digital Taskforce in 2002 as an outcome of the eGovernment program. It was focusing on providing technical and organizational solutions for sharing spatial data (Hansen et al., 2011). It was headed by the Ministry of Environment and replaced the unorganized/bottom-up existing cooperations and forums and facilitated the transition to a more organized and structured geoinformation sector.

Its steering group had representatives from the Ministry of Environment, Local Government Denmark, The Association of County Councils in Denmark, the National Agency for Enterprise and Housing, the Directorate for Food, Fisheries and Agricultural Business and the National Survey and Cadastre. The Spatial Data Community and the Geoforum collaborate on developing guidelines.

3.5.4 XML-committee

XML was adopted for implementing the eGovernment strategy. The XML-committee was introduced for implementing the standardization of XMLbased interfaces and vocabularies. It focused on the development of the XML standards in the Danish public sector.

3.5.5 Connection between the Public and Private Sector

KMS collaborated strongly with the private sector; essentially mapping companies and surveying companies. In 2003, a quarter of the workload was subcontracted. The TOP10DK was produced by KMS and geoinformation companies. Similarly, 80% of the digitization of the cadastre was subcontracted to private companies.

The relation to the private sector with regard to data production was mainly a buyer/seller relationship. Production jobs were put in public tender and KMS purchased the data and the Intellectual Property Rights

3.6 Users of spatial information

In the pre-NSDI period, geospatial information was mainly consumed by technical and administrative professionals in the public sector. Although much of geospatial information can be of advantage for different sectors such as the private financial sector or the social and health sector, it was not actually used.

This was probably mainly due to cost considerations. Geodata carried a heavy price tag due to the cost recovery paradigm KMS operated under.

In the beginning, citizens' level of involvement and use of geoinformation was limited to "find your way" web services but with the implementation of the eGovernment strategy, ICT and spatial literacy increased and citizens started using counties' and municipalities' web services to look at property information, planning restrictions etc. (Brande-Lavridsen, 2002). By 2008, citizens have reached the level of transactions on the SDI maturity level (Fig. 9).

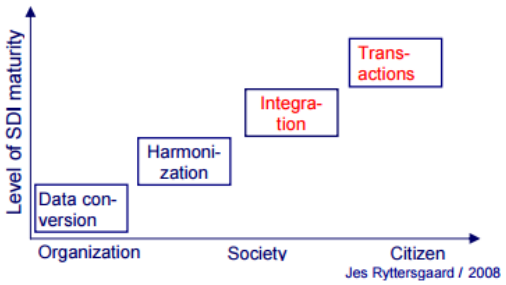

Figure 9: SDI Maturity level until 2008 (source: http://inspire-danmark.dk/media/gst/76915/Paper%20til%20GSDI%20konferencen%202008.pdf)

3.7 Research Activities

As integrating heterogeneous datasets is a tedious task, the contribution from the academic sector was catalytic. The Copenhagen Business School, Aalborg University and National Survey Cadastre established in 2000 a collaboration focussing on the research Initiative on Danish Spatial Data Infrastructure. In the context of this initiative, four projects were developed (Daugbjerg and Brande-Lavridsen, 2001):

- The *Geographic Information Market* investigated how network technologies will influence data provision, market expansion, frequency of data update, pricing, legal issues.
- *Spatial Data Modelling* investigated how the multi-representation of geographic features in different datasets can be homogenized.
- *Distributed Geographic Information Prototype* investigated how the data model resulted from the former project can be shared as a web-service via the internet.
- *Visualization of Spatial information*, investigated new ways of representing geoinformation and unveiling new possibilities of use in the geographic information society.

3.8 Legislation

Although no dedicated legislation for geospatial data was proposed in the pre-NSDI period, an important IT strategy of opening up data that had been created with public resources existed since 1999 that is "The Digital Denmark - adaptation to network society" proposed by the Ministry of Research and followed by the "Adaptation to the network society", IT and tele-political statement for the Parliament" in 2000 (Daugbjerg and Brande-Lavridsen, 2001).

Other relevant laws were:

- Act no 572, December 1985: Access to Public Administration Files – for right of access to governmental information
- Copyright Act 1996, laws
- Act on the Processing of Personal Data 2000 (implementing the Directive 95/46/EC) The Danish Data Protection Agency exercises surveillance over processing of data to which the Act applies
- Implementation of the Directive 2002/58 on privacy and electronic communications

In 1998, an agreement was made and an Action Plan (Handlingsplan for information om arealreguleringer I det abne land, maj 1998) was signed by the Ministry of Environment, the Ministry of Agriculture, Farmers association, "green" NGOs, County Association. According to that all counties had to provide a map based regulations and plans free of charge and as downloadable services.

3.9 Economic and Accessibility Aspects

In the pre-NSDI landscape until 2009, KMS was partially funded by the government and operated using a cost recovery model. The data was bought by the user with a rights-to-use license. The delivery expenses were not included and therefore were paid extra. Until 2002, charges were made to the public and private sector for most register data. Everybody could get access to the same data on equal terms.

In 2002, the "Better Access to Public Data" was published which granted access to the address data of the Buildings and Dwellings Register at distribution costs for the public and private sector.

In 2005, the total disbursal of KMS was 27 million euros half of which was covered by the government and half by the users.

3.10 eGovernment

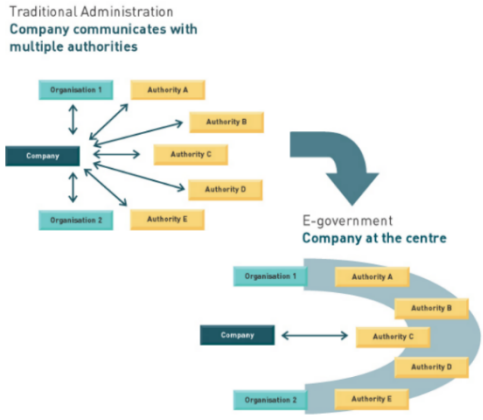

Figure 10: Transition from traditional administration to eGovernment (source: White Paper on Enterprise Architecture)

The introduction of eGovernment in 2001 was very important because it signified a mind change from independent and isolated information silos to information provided on the internet on an as-needed basis (Fig. 10). This brought about the need for new agreements, technical solutions for making the geodata interoperable and new business models for providing the data.

The eGovernment period started in 2001 with the eGovernment project "The Digital Task Force", coordinated by the Ministry of Finance.

The tasks of the Digital Task Force were[1]:

- *To promote the spread of e-Government by providing information on the aims and content of the e-Government strategy.*
- *To carry out cross-cutting following-up and co-ordination on behalf of the Board.*
- *To contribute process skills to projects prioritised by the Board.*
- *To maintain ongoing monitoring of the need for cross-cutting initiatives, and propose these to the Board.*
- *To carry out projects in selected focus and business areas in co-operation with interested parties.*

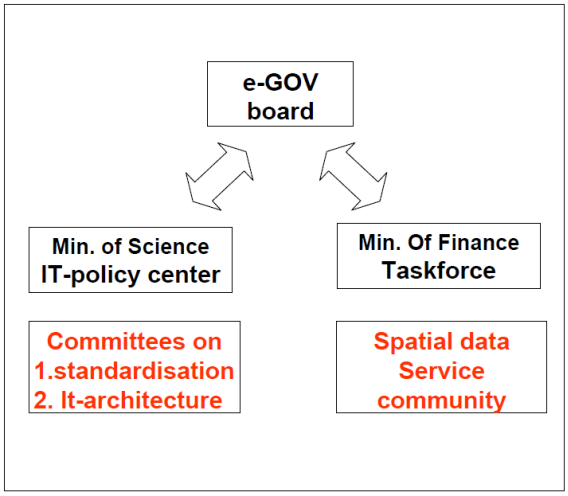

Figure 11: The Danish eGovernment Initiative (source: Ryttersgaard, 2006)

Great changes included information being available on the web, workflows going digital and information being updated directly from the source and shared over a centralized infrastructure (Overgaard and Hansen, 2008). The eGovernment strategy was created by the Danish Government, Local Government Denmark and Danish Regions using the following statements:

- *No more printed forms and letters*
- *No digital welfare*
- *Digital solutions for closer collaboration*

In order to realize the eGovernment strategy, collaborations and committees were built, eGovernment initiatives were developed, research projects were undertaken and standards were brought to focus. The organizational structure is shown in Fig. 11.

[1] (source: http://unpan1.un.org/intradoc/groups/public/documents/caimed/unpan019380.pdf)

4. Developing the NSDI

The development of the Danish NSDI was already well under way when in December 2008 the Infrastructure for Spatial Information Act (GI Act/SDI ACT) was adopted by the Parliament. It was put into force on 15 May 2009 providing a strong driver for the further development of the NSDI.

4.1 Organizational

4.1.1 Nationals Survey and Cadastre (KMS)

The National Survey and Cadastre (KMS) became the overall responsible authority for implementing the NSDI in Denmark under the Ministry of Environment. It became the national contact point for INSPIRE and was responsible for developing and maintaining the national geoportal and metadata portal geodatainfo.dk. It was decreed to be the main provider of the following spatial data:

Data Provided by KMS

- National Geodetic Reference System
- Digital Terrain Model
- Place Names and Points of Interest
- Cadastre

- Cadastral Archives
- Nautical Charts
- Administrative Boundaries
- Common Object Types - lare and small scale map databases

4.1.2 Coordination Committee of Infrastructure for Spatial Information

The Coordination Committee of Infrastructure for Spatial Information was established in 2010 consisting of experts and representatives from organizations and authorities responsible for spatial data defined by the Act i.e. Danish Regions, Universities of Denmark, Geoforum, Local Government of Denmark, Danish Ministry of Climate Energy and Building, Danish Ministry of the Environment, Ministry of Food, Agriculture and Fisheries in Denmark, Danish Ministry of Transport, Danish Ministry of Housing, Urban and Rural Affairs.

One of its tasks was to provide assistance in implementing the Act and the INSPIRE directive. It was also in charge of promoting the NSDI and coordinating cooperation of the spatial data sector with other fields. It provided material and guidelines to the authorities that were responsible for providing data.

The committee met four times yearly. It had to make the link between eGovernance (section 4.7.4), the Basic Data Program (section 4.7.2), the implementation of the INSPIRE Directive (section 4.7.3) and national initiatives such as FOTDanmark (section 4.7.1) (Storgaard and Thomsen, 2013).

4.1.3 Public Information Online Committee (OIO)

The OIO Committee was responsible for developing standards, data models and IT architectures. It was following the objectives of the OIO (Open Public Information Online) project and the use of XML and SOA technological solutions (Hansen et al., 2011).

4.1.4 Spatial Data Service Community

In 2010, the scope of the Spatial Data Service Community (www.xzy-geodata.dk) was broadened and opened to all the producers, users and organizations responsible for geodata. It functioned as a discussion forum on geoinformation and has a supportive role for the Spatial Data Coordination Committee.

4.1.5 Joint Secretariat

For the better collaboration of the Spatial Data Service and the Coordination Committee, the Joint Secretariat was introduced with representatives from both. The coordinator of the Joint Secretariat was the KMS.

4.1.6 Cooperation Forums

For implementing the NSDI and INSPIRE a number of forums between users, producers, service providers, coordinators were formed such as:

- the Danish INSPIRE follow up Group as a contact point for all the organizations that contribute data to the NSDI
- the INSPIRE Network for organizations interested in INSPIRE such as universities, consultants and IT experts

In a number of joint seminars, the Danish Association for GI, the Geoforum and KMS, brought together data producers, IT experts and researchers.

4.2 Data - Services

4.2.1 The Digital Map Supply

Via the Digital Map Supply Service (launched in 2001 – in full service since 2002), KMS offers a wealth of vector and raster topographic and cadastral datasets at different scales. It also offers the TOP10DK database as a GIS. The data was provided as WMS/WFS services. An overview of the architecture is shown in Fig. 13.

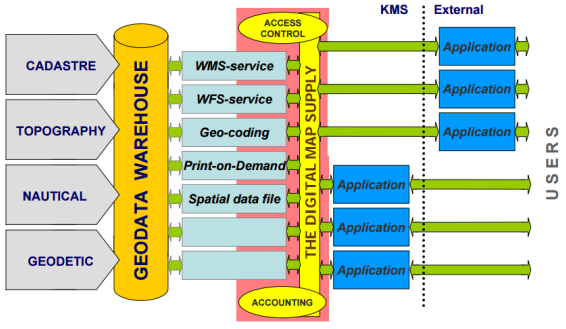

Figure 13: Digital Map Supply Architecture (source: http://www.isotc211.org/WorkshopCopenhagen/ISO_Workshop_DK/4_SDI_DK_ISOmeeting_2008.pdf)

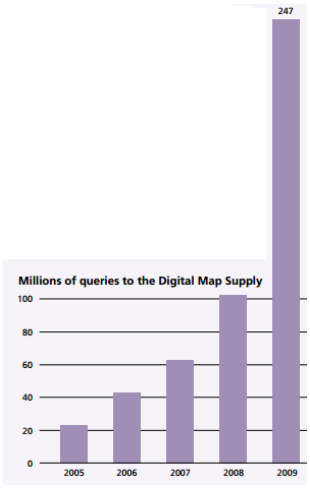

Figure 12: Traffic increase of the Digital Map Supply (source: http://gst.dk/media/gst/64802/KMS_Infrastruktur_2009_UK.pdf)

In 2009, a great increase of the number of hits is shown (Fig. 12). This can be explained by the opening up of the Digital Map Supply to all governmental bodies via the National Geodata Agreement (section 4.5.2).

4.2.2 Open Public Information Server (OIS)

The Open Public Information Server (OIS) (www.ois.dk) launched in 2001 maintained by the Danish Enterprise and Construction Authority provided free access to personal property data via a web based interface.

4.2.3 PlansystemDK

PlansystemDK (plansystemdk.dk) (introduced in 2002) provided standardised municipal and state plans. It was initiated by the Nature Agency of the Ministry of Environment and Food. The system was acknowledged as one of the most valuable local SDI approaches (Hansen et al., 2011).

4.2.4 Danish Nature and Environmental Portal

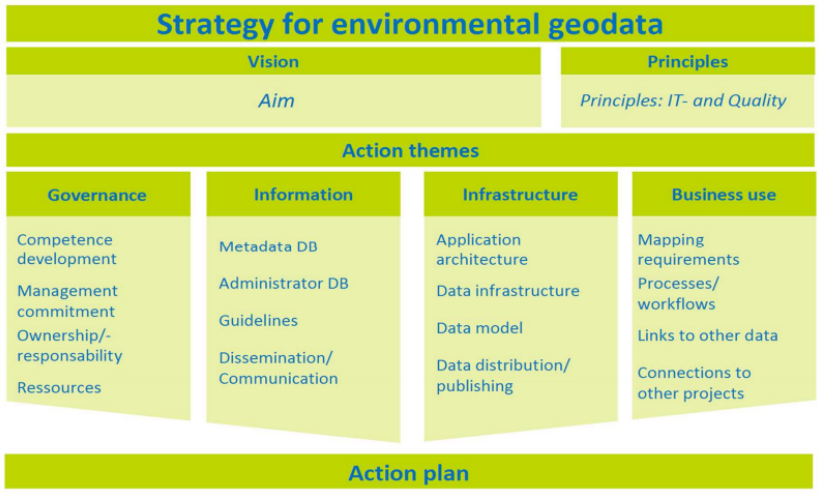

Figure 14: Strategic Model behind the Nature and Environmental Portal (source: http://inspire.ec.europa.eu/events/conferences/inspire_2012/presentations/29.pdf)

In 2007, the Danish Nature and Environmental Portal was developed in a collaborative effort between the National Association of Local Authorities in Denmark, Danish Regions and the Ministry of the Environment with the view to providing different environmental data on the web (Vanderbroucke and Biliouris, 2011). Its strategic model is shown in Fig. 14. In 2010, the datasets that were available as WFS downloadable services are (below):

Downloadable data at the Danish Nature and Environmental Portal

- Antiquities, Protected areas
- Forest construction line, church construction line, protected stone and earth embankments
- Protected habitats and protected streams
- Area classification (soil)
- Natura 2000 areas
- Natural data
- Coastal proximity zone
- Nitrate-sensitive water catchments
- Pearls, wetlands, agri-environmental areas, sensitive agricultral areas, ammonia buffer zones, fallow land

4.2.5 Danish Digital Elevation Model

The Danish Digital Elevation Model (DHM) established in 2007 and maintained/improved over time was made available to all central governmental bodies and 85 of 98 municipalities in 2008 (Vanderbroucke and Biliouris, 2010; Just, 2012). A quality control of the model was completed in 2009.

4.2.6 Show the location and Show the map

"Show the location (Vis Stedet)" and "Show the map (Vis Kort)" web services were introduced in 2009. The aim was to provide map based thematic information to citizens such as schools, hospitals etc.

These services were part of the common components of the eGovernemnt strategy. Common components were used as citizen's services such as the digital signature, the easy account etc. for the digital interaction with the public sector. They were developed on the public portal Borger.dk (Vanderbroucke and Biliouris, 2010).

4.2.7 Danish Address Web Service (AWS)

The Danish Address Web Service (AWS) was launched in 2009 by the Ministry of Housing, Urban and Rural Affairs in collaboration with KMS and the Enterprise and Construction. It was developed as a central distribution node of geocoded addresses. The service was provided for free and the data could be used without any restrictions including commercial use (Storgaard and Thomsen, 2013).

4.2.8 National Geoportal geodata-info.dk

In 2010, the already existing national geoportal geodata-info.dk (see section 6.4.5) was modernized supporting also Web Coverage Services (CSW) as required by INSPIRE.

4.3 Standards

The government of Denmark and the Danish Regions in September 2007 agreed on the mandatory use of open standards for software in the public sector. The agreement came into force in 2008. In the geoinformation domain the application of open standards was supported by the project "Open Standards for Spatial Data" (Vanderbroucke and Biliouris, 2011). For metadata, ISO 19139 and ISO 19115 standards were used.

4.4 Metadata

At geodata-info.dk, metadata can be accessed and downloaded. The metadata refers to:

- content
- source
- access restrictions and licensing
- data owner
- accuracy

Most of the datasets are INSPIRE and ISO compliant and are under the responsibility of KMS.

4.5 Legal Aspects – Agreements

4.5.1 Infrastructure for Spatial Information Act

Establishing the Danish NSDI started in 2008 when in December the Infrastructure for Spatial Information Act (GI Act/SDI ACT) was adopted by the Parliament and put into force on 15 May 2009 (Survey and Cadastre, 2011).

According to the Act, the National Survey and Cadastre (KMS) under the Ministry of Environment would be the overall responsible body for implementing the NSDI (Vanderbroucke and Biliouris, 2010). The Act integrated the INSPIRE directive into the national law and expanded it in two ways:

a) the Minister of Environment could expand the INSPIRE themes to fit best to the national strategy after making agreements with the ministries responsible for the data and
b) the Minister of Environment could define the authoritative spatial reference data and register data.

KMS was set as the national contact point for INSPIRE and was also a member of the INSPIRE Committee. The Danish NSDI principles were:

- *Data shall be collected only once.*
- *Data shall be maintained where it is most effective.*
- *It shall be easy to obtain an overview of the data and network services that exist.*
- *It shall be possible for data to be used together regardless of where the datasets come from.*
- *The conditions shall ensure that data can be used in many different contexts.*

4.5.2 National Geodata Agreement

In 2009, the National Geodata Agreement was published which gave to all Government Ministries, universities and schools free access to the KMS datasets such as topographic data, DEM, nautical charts. The data is shared via web services in the Digital Map Supply.

4.5.3 Municipal Geodata Agreement

In 2010, the Municipal Geodata Agreement, an agreement with Local Government Denmark, was made according to which local authorities got free access to a number of data and services from KMS.

4.6 Economic Aspects

As far as the pricing is concerned the cost recovery model was in place until 2012. Under this model, a mandatory subscription arrangement was made with the central government in 2009 (section 4.5.2) and the municipal government in 2010 (section 4.5.3).

Geodatasets affected by the agreement were:

- Topographic Data Collections
- Nautical Chart Data
- Web Services such the Digital Map Supply

- The Danish Digital Elevation Model
- Property Register Maps and Data
- Reference Network Data

In 2013, free and open data was introduced by the government (Fig. 15). This was also applicable to the geospatial data provided by the Danish Geodata Agency. In order to fulfil this goal, the Danish Geodata Agency (former National Survey and Cadastre (KMD)) developed a model-driven process for distributing the data and sharing it as WFS and download services over the web (Feng, 2016).

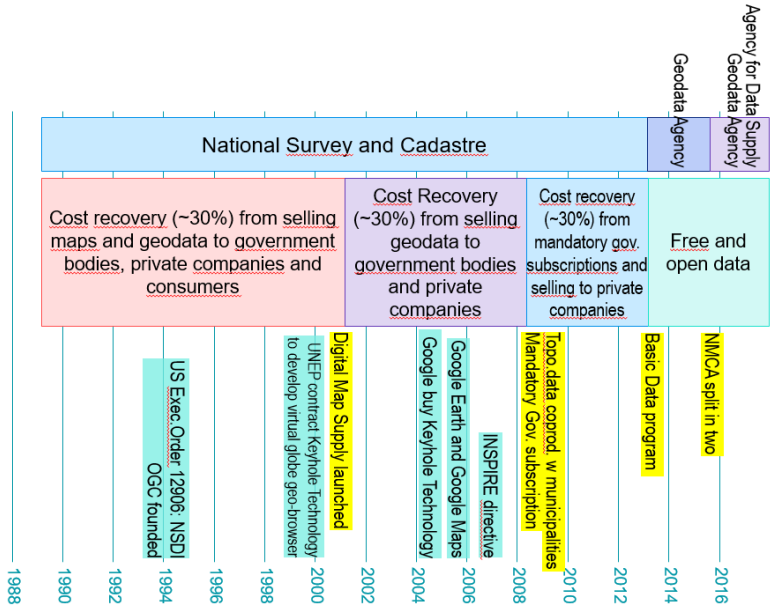

Figure 15: NMCA timeline (source: T. Hansen, 2017)

4.7 Key Initiatives

4.7.1 FOTDanmark

FOTDanmark was introduced by the Spatial Data Service Community, the Local Government Denmark and KMS in 2006 (Dael and Jrgensen, 2008) as a joint activity between KMS and the municipalities. The aim of FOTDanmark was to produce a unified topographic map to be used across the country (Vanderbroucke and Biliouris, 2011).

The FOT data was supposed to replace the TOP10DK topographic databases. By 2008 the members had increased from 50 to 82 municipalities. By 2009, 90 of the 98 municipalities had joined the FOTDanmark and in 2012 complete country coverage was reached.

4.7.2 The Basic Data Program

The Good basic data for everyone – A driver for growth and efficiency program was part of the eGovernment strategy and particularly the digitization process. It was introduced when the worldwide economic crises started in 2008 and coincided with a new government that showed a strong political will to exploit spatial data for economic advances (McMurren and Young, 2016). The Ministry of Finance was the overall responsible authority. The program was approved by the government in September 2012. The coordination structure is shown in Fig. 16.

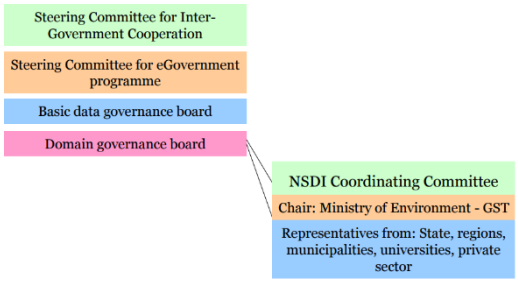

Figure 16: eGovernment Basic Data organizational structure (source: https://s3.amazonaws.com/webapps.esri.com/esri-proceedings/proc13/papers/1395_114.pdf)

The program referred to the foundation data (base data) that all authorities should use on a daily basis i.e. addresses, digital maps, data on individuals and businesses etc. The goal of the program was to provide a framework to assure high quality and large scale use of the basic data by all public authorities. These data was provided and updated by a dedicated authority.

With the basic data agreement, the data was provided open and free (except for sensitive personal data such as the Civil Registration System) to the public sector, citizens and businesses.

The Basic Data Committee (Fig. 17) is in charge of the Basic Data Program and incorporates a broad range of government agencies that is: the Ministry of Business and Growth, the Ministry of Housing, Urban and Rural Affairs, the Ministry of the Environment, the Ministry of Taxation, the Ministry of Economic Affairs and the Interior, the Ministry of Justice, Danish Municipalities and Danish Regions. It is mandated to operate by the Ministry of Finance.

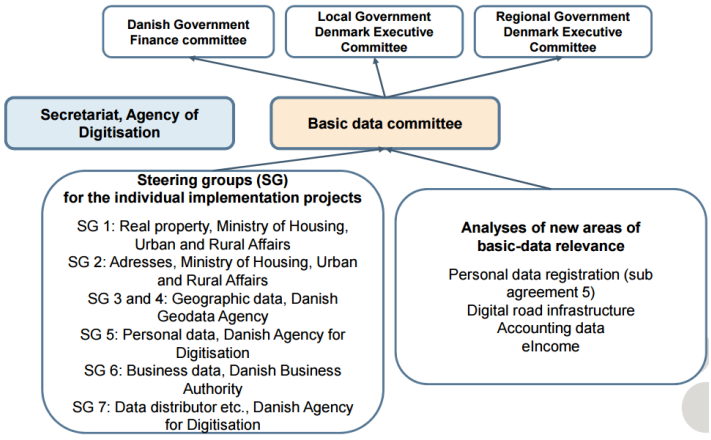

Figure 17: Basic Data Organization Schema (source: http://www.bolagsverket.se/polopoly_fs/1.9763!/Menu/general/column-content/file/2_egov_open_data_rgh.pdf)

The implementation of the program is subdivided into seven sub-agreements (sub-programs):

1. Efficient real property management and reuse of real property data (Ministry of Housing, Urban and Rural Affairs).
2. Efficient re-use of basic data on addresses, administrative units and place names (Ministry of Housing, Urban and Rural Affairs).

3. Common basic data for water management and climate change adaptation (Danish Geodata Agency, former KMS).
4. Open and efficient access to geographic data (Danish Geodata Agency).
5. Efficient basic registration of people and fewer shadow registers (Danish Agency for Digitisation).
6. Efficient re-use and sharing of basic data on businesses (Danish Business Authority).
7. Common basic data distribution solution (Danish Agency for Digitisation).
   (source: http://www.bolagsverket.se/polopoly_fs/1.9763!/Menu/general/column-content/file/2_egov_open_data_rgh.pdf)

SDFE, the Agency for Data Supply and Efficiency (section 6.1.1.2) was responsible for five of the basic data subprograms.

- Sub-program 1: Effective property management and reuse of property data.
- Sub-program 2: Effective reuse of basic data on addresses, administrative units and place names.
- Sub-program 3: Common basic data for water management and climate adaptation.
- Sub-program 4: Free and efficient access to geographic data.
- Sub-program 7: Joint distribution solution for the basic data (distributed data).

4.7.2.1 Basic Data Registers

- The Central Business Register (CVR) - contains information about Danish companies: VAT number, legal form, address, owners, industry etc.
- Company Registry - contains similar CVR information on Danish companies.
- Buildings and Dwellings Register (BBR) - includes details of Danish buildings.
- Property Register - provides information of ownership of real estate in Denmark.
- Map Data - contains geographical information cities, roads, etc.
- National Administrative Geographical Classification (DAGI) - provides details on the border between geographic divides of Denmark: municipalities, postal codes, jurisdictions and regions on.
- Denmark's elevation model - contains data on the height of the terrain and surface in Denmark
- Place name Register - containing 200,000 Danish place names.
- The Central Person Register - contains the Danish civil registration with name, address, date of birth, kinship, nationality, membership of the Church. This register is subject to the Privacy Legislation

4.7.2.1 Funding and Economic Revenues

In order to finance the production and maintenance of basic data, the Government and the Local Government Denmark agreed that public authorities should contribute via their allocation or block grant. Before 2013, most of the data in the registers was provided with an

access fee. Within the Basic Data Program, the data was provided for free to private companies, public authorities and citizens.

By providing the data for free a regain of 108 million euros was expected by 2020. The estimated yearly benefits were 35 million euros from the public sector and 65 million euros from in the private sector. The gains from opening the data had already been observed when the Buildings and Dwellings Register was released. The societal benefits from 2005 to 2009 were 63 million euros and the public sector saved 5 million euros.

TOTAL PUBLIC-SECTOR NET SURPLUS/DEFICIT

DKK MILLION	2013	2014	2015	2016	2017	2018	2019	2020
Ministries	-108	-81	-50	-26	3	9	29	42
Municipalities	-24	24	79	143	165	169	174	175
Regions	1	11	23	33	43	43	43	43
TOTAL IMPACT	**-131**	**-45**	**52**	**149**	**211**	**221**	**246**	**260**

TOTAL NET SURPLUS/DEFICIT, BY SECTOR

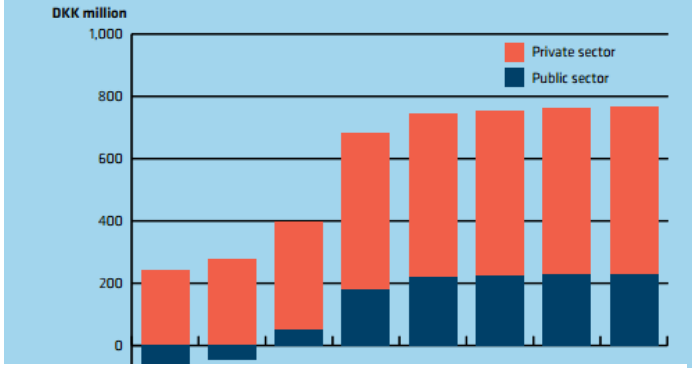

Figure 18: Economic benefits of opening up the data (source: http://www.eurogeographics.org/sites/default/files/BasicData_UK_web_2012%2010%2008.pdf)

In 2012 and 2016, the value of geodata was measured demonstrating an increase from 210 million euros to 460 million euros. This can be further analysed into 130 million euros efficiency gain and 330 million euros productivity gain. The use of geodata was 4 times more, the number of users 75 times more and the value of geodata was doubled.

When the open data access will be fully implemented, a societal revenue of 100 million euros annually and 65 million annual revenues for the private sector are expected (Fig. 18).

4.7.2.3 Licensing

The data provided under the Basic Data program, is free with a non-exclusive license to use. The source of the data has to be acknowledged and the use has to be in accordance with the Danish law.

4.7.2.4 Users

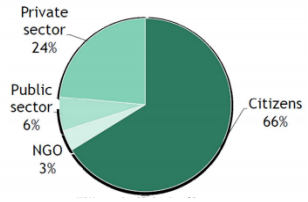

Figure 19: Users type of the base data (source: https://www.fig.net/resources/proceedings/fig_proceedings/fig2014/ppt/ts05j/TS05J_juulsager_7267_ppt.pdf)

In a study on the use of the open basic data important observations were made on the benefits of the open data program. The number of registered users increased from 800 to 12000 in 2013, 25% of which were not from geo-related domains and 44% of which would not have used the data if they had to purchase it. In Fig. 19, the user types are shown.

4.7.3 INSPIRE implementation

KMS was the overall responsible authority for the implementation of the INSPIRE directive which started in 2010 and was completed in 2013 (Fig. 20). Authorities with significant contribution of data to the INSPIRE annexes were: the National Survey and Cadastre, the Agency for Spatial and Environmental Planning, the Enterprise and Construction Authority, the Road Directorate, the Coastal Directorate, the Geological Survey of Denmark and Greenland, the Forest and Nature Agency, the Civil Aviation Administration and Statistics Denmark.

Figure 20: INSPIRE implementation time plan (source: http://gst.dk/media/gst/64817/Review%202010%20of%20the%20spatial%20data%20infrastructure.pdf)

In a number of reports, the implementation of INSPIRE is monitored yearly http://inspire-danmark.dk/for-the-eu-english/monitoring-and-reporting/ .

4.7.4 eGovernment

Denmark has been very active in introducing and implementing eGovernment policies since 2001. Within 10 years, the central government, regions and municipalities collaborated with each other realizing the vision of the eGovernment strategy (Fig 21).

A great number of initiatives are described in "The Digital Path to Future Welfare" document on advancing the eGovernment strategy

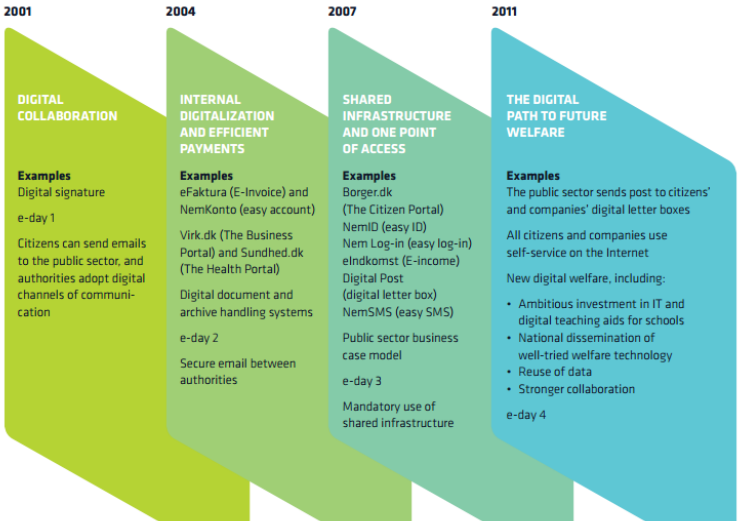

Figure 21: eGovernment Strategy 2001 - 2011 (source: https://www.digst.dk/~/media/Files/Strategier/Engelsk_strategi_tilgaengelig.pdf.)

that was initially launched in 2001 (section 3.10). Some of these are shown in Fig. 22. Two out of 12 initiatives are related to geoinformation (Focus area 8 and 10). Milestones and timelines for implementing the initiatives are analysed in the document.

As far as the *Focus Area 8: A shared platform for efficient environmental administration* is concerned, the goal is to establish connections between Danmarks Miljøportal (Denmark's Environmental Portal), the local planning data portal plansystem.dk and the metadata portal geodata-info.dk.

As far as the *Focus Area 10: Shared core data for all authorities* is concerned, core data is defined as fundamental authoritative data that is supposed to be used within the public sector. Core data is spatial and non-spatial. For following categories, core data is provided in a standardized way:

- properties, housing, buildings and addresses
- geography, roads, real estate
- personal identity, residence, family relation
- companies and their key related persons
- personal income, assets and education

Figure 22:Initiatives of the eGovernment strategy (source: https://www.digst.dk/~/media/Files/Strategier/Engelsk_strategi_tilgaengelig.pdf)

5. The NSDI today

NSDI The Danish NSDI is well developed and functioning nowadays. It is in line with the eGovernment program and the INSPIRE directive.

The Danish Geodata Agency under the Ministry of Energy Utilities and Climate is the overall responsible organisation for the NSDI. After a structural reform in 2016, the Agency was split into the new Danish Geodata Agency and the Agency for Data Supply and Efficiency (SDFE) and SDFE is now responsible for establishing and maintaining the NSDI as well as implementing the INSPIRE directive.

Basic data in Denmark is mature and well established in base registers. It is shared either via the registers' portals or the Map Supply Service as open data. The data is maintained in a well-defined process and according to strict quality assurance methods. Metadata is provided at the geodatainfo.dk. metadata portal. The central node for sharing base data is the National Data Distributor which is the central access point to all base data.

Open data and international standards are widely used. Service Oriented Architecture enables interoperability between loosely coupled systems.

The NSDI is used across many parts of the public and private sectors. Great notification services of the Data Distributors and the Map Supply communicating the operation status of the services, strengthen the connection between providers, systems and users.

6. The five elements of the NSDI: Organization, Standards, People, Data and Technology

6.1 Organization

A strong political mandate played a pivotal role in establishing the NSDI in Denmark. The economic challenges up to 2020 that were articulated to foster the need for the NSDI are:

- *Denmark's competitive position weakened and productivity has grown too little*
- *Demographic profile – ageing population*
- *Tight public-sector budgets*

6.1.1 Governance

6.1.1.1 Danish Geodata Agency

The Danish Geodata Agency (GST) (formerly KMS), is now the overall responsible body for the Danish NSDI under the Ministry of Energy, Utilities and Climate. It is in charge of the Spatial Information Act and the INSPIRE directive. It was established in 1989 as a state-owned enterprise. Due to a reconstructuring, "Bedre balance – statslige arbejdspladser tættere på borgere og virksomheder" ("Better balance – state jobs closer to citizens and companies") in 2016 the Danish Geodata Agency was divided into two separate agencies:

- the new Danish Geodata Agency that is located in Aalborg
- the Danish Agency for Data Supply and Efficiency (SDFE) that is located in Copenhagen

The Danish Geodata Agency describes in annual reports the Agency's professional and financial performance.

6.1.1.2 Agency for Data Supply and Efficiency

The Agency for Data Supply and Efficiency (SDFE) is responsible for the geographic information infrastructure that is for data, technologies, policies, standards and human resources necessary for the collection, processing, storage, distribution and improvement of geodata, and the implementation of INSPIRE. As a national INSPIRE contact point, SDFE is responsible for communicating with the European Commission and representing Denmark in the INSPIRE Committee. SDFE is also responsible for the implementation of the GI Act. It has a representative role in international initiatives and forums such as the UN GGIM, the Arctic SDI, Eurogeographics, CEN, OGC and ISO, and draws up policies and regulations for information security. SDFE consists of 12 offices each of which specializes on a certain theme.

The themes are grouped into four categories namely basic theme (reference system, methods and technologies, resources), data (geodata, data management), data supply (database, data distribution) and data use (streamlining, policy).

SDFE is responsible for the geodetic reference system and the implementation of transformations and registers. Its core tasks are:

- The creation, development and operation of the basic data registers Denmark Address Register , Denmark Administrative geographical division (DAGI) , and Danish Place Names
- The Implementation of the basic data program
- The Distribution of address data
- Updating data in Denmark Administrative Geographical Classification (DAGI), Danish place names and GeoDanmark based on reports from authorities and other users
- Maintenance of Denmark's elevation model and derived products

6.1.1.3 Coordination Committee on Spatial Infrastructure

The Coordination Committee on Infrastructure for Spatial Information is advising the Minister on the application and promotion of the NSDI. It consists of members from government, municipalities, counties, science institutions and was initiated by the Ministry of Energy, Power and Climate. The Committee, which meets 3-4 times a year, also acts as a communication channel for open discussion of political and strategic aspects of the NSDI.

6.1.1.4 Geoforum

Geoforum is an association of geoinformation-related public and private companies. Its members are 250 companies and organizations from the public and private sector and 350 individual members. It is initiating many training activities, seminars and workshops on promoting and familiarizing users with spatial data. A complete list of courses and events is published on the website and the presentation material is publicly available. Geoforums' events and activities are supported by volunteers. Geoforum is also publishing manuals and specifications within the geoinformation sector.

6.1.1.5 GeoDanmark

GeoDanmark is a collaboration between SDFE and all the municipalities on creating a common digital mapping of Denmark. It was founded as an association in 2007 under the name FOTdanmark (see section 4.6.1). Members of GeoDanmark are all the municipalities of the country and SDFE. The association has 99 members (all municipalities + SDFE).

Members are contributing with an annual membership fee. Funding of GeoDanmark is covered by both the municipalities and the Danish Geodata Agency. The annual budget can be found in http://www.geodanmark.dk/Materiale/geodanmark-budget-2017-2019 .

6.1.2 Legislation

Given the fact that geospatial information is multifaceted and applied to different sectors, cross domain national laws and European directives are applicable i.e. right of access to public information (Act no. 572, 19.12.1985), access to environmental information (Access to Environmental Information Act. Directive 2003/98), intellectual property rights (Copyright Act

no. 706, 29.09.1998), personal data protection (Act no 429, 31.05.2000, implementation of the 2002/58 Directive on privacy) (leg, 2017), access to public documents (Access to Public Administration Documents Act, 2014) (Commission, 2016). The NSDI is also aligned with the Open Government Partnership (OGP) and the National Action Plan promoting open data and open governance.

According to the basic data agreement, public sector basic data are provided free and without any restrictions in use. However, it the data has to be used in accordance with the national law and although no strict copyright terms exist, it is required to acknowledge the source of the data. Important legal documents are:

- Act on Danish Geodata Agency (repealed d. July 1, 2017)
- Law on spatial information (effective d. July 1, 2017)
- Act on Infrastructure for Spatial Information (INSPIRE)
- Law on Geodetic Institute trigonometric stations, etc. (repealed. July 1, 2017)
- Act on registration of pipeline owners
- Law on Buildings and Dwellings Register
- Address Act (entry into force in part d. July 1, 2017, the majority of law only enters into force later, probably in the first half of 2018)
- Order on delegation of functions and powers to the Agency for Data Supply and Efficiency
- Notice of the free use of the data
- Notice of the sale of Danish Geodata Agency products and services
- Guidance on reporting of user interests in Danish Geodata Agency
- Act on registration of pipeline owners (LER Act)
- Law on construction and housing registration

(source: http://sdfe.dk/om-os/lovstof/)

6.1.3 Accountability and Responsibility

Accountability and responsibility is shared in the Danish NSDI (Table 3) i.e. for the cadastral parcels, NMCA is accountable and the chartered surveyors responsible, for the Administrative Units, Named Places, Elevation Model, Topographic Maps NMCA is both accountable and responsible, for the Basic Topographic Features and the orthophotos both NMCA and the municipalities are accountable, the NMCA is additionally responsible. In general, rules and

Table 3: Distribution of roles and responsibilities (source: T. Hansen, 2017)

	NMCA	Municipality	Chartered Surveyor	Private Sub-contractor
Cadastral Parcels	A		R	
Administrative Units	A+R			
Named Places	A+R			
Addresses	A	R		
Basic Topographic Features	A+R	A		X
Elevation Model	A+R			X
Topographic Maps	A+R			
Orthophotos	A+R	A		X

regulations are formed by the overall responsible body for the NSDI and the Government but the provision and maintenance of the data is done by the responsible authorities.

6.1.4 Terms and Conditions of Data Use

Terms and conditions for using geodata in Denmark are documented in Terms of Use GeoDanmark data . SDFE is responsible for, the intellectual property rights. For the basic data there is a worldwide, free, non-exclusive right of use. Data can be:

- copied, distributed and published,
- modified and combined with other material
- used for commercial and non-commercial purposes

Data must not be used in a way that may lead to the misconception that data providers approve, endorse or recommend user's products or services. It must be ensured that the use of the data is in accordance with the Danish law. The data providers are not responsible for the content, origin, defects or any damage resulting from the use of the data.

For data published by SDFE that are not part of the free data, the Agency provides under the copyright law general rules of copyright for data, applications, services and other products. Following copyright information must be provided:

1. in a reasonable place on the product, the following claim has to be stated: “Contains data from the Agency for Data Supply and Efficiency”.
2. the name of the data set(s).

3. time when the data set (s) are taken by the Authority or whether there is a data service.
   (i.e.: “Contains data from the Agency for Data Supply and Efficiency, Kort10, January 2016”. Or: “Contains data from the Danish Geodata Agency, Cadastral map, WMS service”).

4. ensure that the “Agency for Data Supply and Efficiency” appears on the front of the service, if other sources also mentioned on the front page.

The above conditions also apply if the user transmits data from SDFE to third parties.

6.1.5 International Cooperations

6.1.5.1 The Arctic Spatial Data Infrastructure (ASDI)

SDFE works closely with geodata agencies in the other Nordic countries as well as Canada, Russia and the United States on the development of a digital infrastructure for geographical data in the Arctic (Arctic SDI). The goal of the cooperation is the cross-national use and free exchange of data between the Arctic countries.

The Arctic SDI is based on national data collections provided in a coherent way via the Arctic SDI geoportal. Location search and metadata search functionalities are provided at the portal.

6.1.5.2 Nordic Cooperation

The Nordic Cooperation brings together Denmark, Finland, Faroe Islands, Greenland, Iceland, Norway and Sweden to cooperate and exchange ideas and experiences on geoinformation. SDFE is representing Denmark in the Nordic Cooperation. Concrete joint projects such as standardization and use of spatial data across borders are run by number of working groups that work together.

Countries that are members of the Nordic Cooperation have joint representation in international organizations such as EuroGeographics and the Arctic Spatial Data Infrastructure (ASDI). The members are also sharing experiences on the implementation of EU directives.

Twice per year, meetings of the leaders of the Nordic Cooperation take place. In the spring only the directors of the members meet and discuss strategic issues. In late summer, a slightly larger group of executives meet and discuss the results of the joint Nordic projects and the new projects and collaborations that should be prioritized. Nordic cooperation is a valuable platform for sharing knowledge and resources.

6.2 Standards

International standards are mostly used. These include geospatial standards such as ISO/TC211 and OGC Standards, Information and Communication Technology standards such as IEEE, ISO, OASIS, W3C etc. Since 2008, the use of open standards in the public sector is mandatory. Guides and manuals are provided by the Digitalization Agency. A list of standards used within the public sector is provided in Appendix I.

For the implementation of INSPIRE DS / EN ISO 19115 Geographic Information - Metadata, DS / EN ISO 19119 Geographic Information - Services and DS / CEN ISO / TS 19139 Geographic information – XML schema implementation are used.

In an online document "Modelregler for grunddata", guidelines for using standards in the context of the basic data program are provided. The document is targeted at data users, data owners, developers and data model providers (an English version is also provided). The use of standards should:

- provide a uniform modelling of basic data
- encounter such a level of abstraction so that all stakeholders' needs are accommodates
- make reuse of existing standards as much as possible
- make it easy for data users to build applications on top of the basic data

Denmark makes also sure that the standardization is aligned with the Nordic partners (Storgaard and Thomsen, 2013).

Converters for translating UML model to XML schemas have been developed under the implementation of INSPIRE. Similarly, UML models are translated to RDF.

SDFE has been very active in the standardization work and in providing guidance and information on the use of geostandards. It is also part of the national and international standardization projects.

6.3 People

6.3.1 Human Resources

The Danish Geodata Agency employs approximately 117 employees distributed in a Management Committee and four academic areas which are:

- Properties and Jura
- Marine Charts
- Arctic and Surveying
- Resources and IT

At the Academic level the University of Copenhagen and the University of Aalborg are internationally very active and acknowledged for innovations in the geoinformation domain.

6.3.2 Users of the NSDI

The main users of the NSDI are involved in the financial, environmental, emergency management, tourism, parcellation, eGovernment, agriculture, navigation, physical planning, military and the route-planning sector. In Fig. 23 the architecture for the provision of geodata to the users is shown.

On the brugstedet.dk website, examples of how geoinformation is adding value for companies, individuals and public authorities are shown.

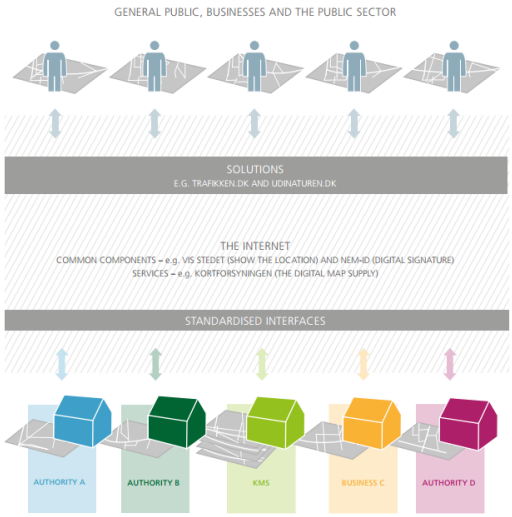

Figure 23: Users of the Danish NSDI (source: http://eng.gst.dk/media/gst/64820/_Strategi_UK_Final_web.pdf)

6.3.3 Communication Channels

6.3.3.1 Notification Distributor

Within the National Data Distributor (section 6.5.1) the Notification Distributor is provided. Its aim is to provide information to authorities about the change in a dataset. As the basic data is shared throughout the public and private sector, changes in one dataset are triggering changes in the business and administrative processes of several other organizations.

6.3.3.2 Communication plan of the Map Supply portal

The Map Supply portal has a communication plan . In case of a malfunctioning of the portal, a number of communication channels are used to announce the operation status (twitter, mail, RSS feeds). The content of the messages provided by the communication channels are typically:

- "Currently disruption in the Map Supply Service"
- "It concerns the following applications / services ..."
- "We expect to be back in normal operation on ..."
- "For you as a user, this means ..."
- "The technical explanation is ..."

The aim of the communication plan is that the affected users have the right information at the right time, in a language they can understand. Two types of malfunctioning are distinguished:

- Crisis: An application / service does not work and it will affect many users for a long period - the cause, extent and resolution is usually unknown
- Critical situation: An application / service does not work and this will affect few users for a limited period of time.

6.3.3.3 Operating Status of the Map Supply

The operating status of the Map Supply is indicated by three different flags (Fig. 24):

Figure 24: Flags indicating operational status of the Map Supply services (source: https://kortforsyningen.dk/indhold/om-drift)

- Green flag means that all services are running properly and that there are no recorded problems.
- Yellow flag indicates that there is high load and waiting time for individual services and that error and timeouts may occur.

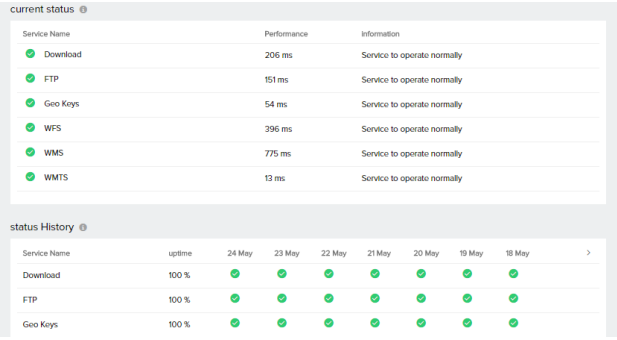

Figure 25: Map Supply Operation Status website (source: https://www.site24x7.com/sv.do?id=I0s1DBEcJmIQQ4zzx%2FsZd8HMN7GkuJ926JxdfdUY3JWh%2FR1xZMoA295dRuHP2wNqvWBeo9R4VTt2%0AlZX81BIklHoiIFDuVU4z)

- Red flag indicates that a service for some reason is not available. In such cases a lot of effort is put to correct the errors quickly.

More details about the operation status of the services is provided at Map Supply operating status website (Fig. 25).

6.3.4 Citizen's involvement

In the Common Reporting Portal for spatial data, users who often have in-depth local knowledge, are encouraged to contribute to the quality, timelines and value of geodata by proposing corrections to several types of geodata, i.e. GeoDanmark data, height data and topographic data.

6.4 Data

6.4.1 Basic Data

Basic data in Denmark is authoritative high quality data such as buildings, addresses, businesses etc. that is maintained by various public authorities in base registers. This data is reused throughout the public sector increasing the efficiency and performance of the everyday tasks. In Fig. 26, the connection of different base registers is shown.

The data is provided to the public and private sector via the Data Distributor (section 6.5.1). The update of the data is

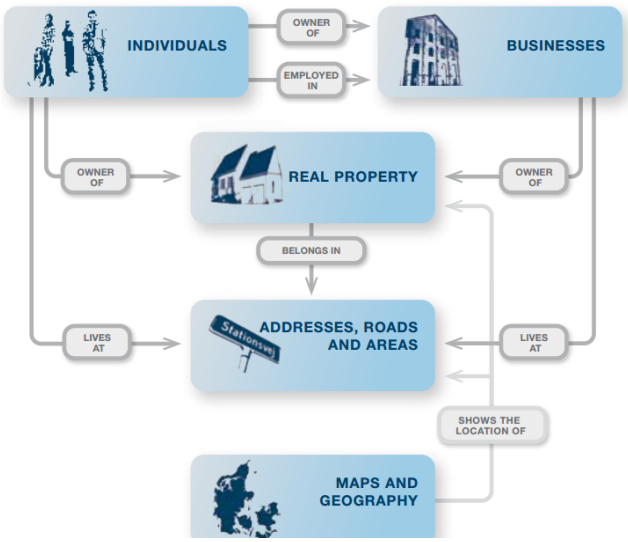

Figure 26: Connection of base registers (source: T. Hansen, 2010)

undertaken at the producer's side. Basic data can be retrieved under http://grunddata.dk/ within the available themes (Table 4):

Table 4:Basic Data Themes (source: http://grunddata.dk/)

Basic Data Themes	
Real Estate	People
Map and geography	Addresses, roads and fields
Companies	Water and climate

Indicative Base Registers are:

- Danish Address Register (DAR)
- Danish Place Names
- Denmark's elevation model
- Danish Administrative Boarders
- Cord Register (LER)
- Denmark's fixed point Register
- Buildings and Housing Register (BBR)

On top of the base data, sector specific data that is used only within one administrative area and multisector data which is shared between several parties are available in the Danish NSDI (Fig. 27).

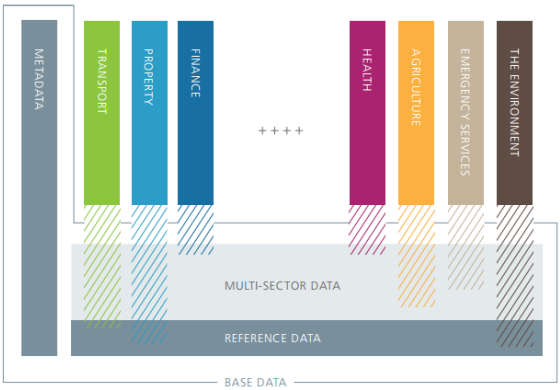

Figure 27: Infrastructure model (source: http://gst.dk/media/gst/64817/Review%202010%20of%20the%20spatial%20data%20infrastructure.pdf)

6.4.2 Data Acquisition and Maintenance

The Agency for Data Supply and Efficiency (SDFE) under the Ministry of Energy, Climate Affairs is the overall responsible body for managing the basic data. Its main goal is to provide the public and private sector with high quality data. Basic data is collected and maintained under a well-defined three steps process (Fig. 28) leading to three data categories:

1. Received data
2. Master data
3. Derived data

Figure 28: Dataflow in SDFE (source: T. Hansen, 2017)

Received Data is raw data i.e. point cloud of geodetic measurements, point cloud from laser scanning, legislative text defining municipal boundaries etc. that is delivered to the SDFE. This data is either collected by the responsible authority or outsourced to external parties or closed crowdsourcing. Although crowd sourcing is encountered as a way of collecting data, it is currently not used by SDFE.

Master data is a structured datasets and product of the received data. It is also the input for the derived data. Master data, is the foundation or basic data and is the basis for all the governmental data. It must be well documented and in case of shortcoming, master data is where the corrections are carried out.

Derived data is further edited master data. It is based on user requirements and is adjusted to special needs i.e. data representation at different scales. Most of the derived data is automatically generated from master data. In some cases, a change in the master data will trigger changes in the derived data. Data processes involved in the data chain are (Fig. 29):

1. Acceptance control
2. Data maintenance
3. Data work up
4. Data distribution

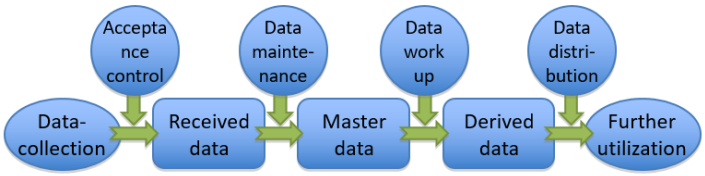

Figure 29: Data Processes (source: T. Hansen, 2017)

6.4.3 Data Model

In order to facilitate interoperability between all the different registers in which basic data is maintained and provided, the basic data model was developed. It is the result of an interdisciplinary project that was launched in the Basic Data Program and aimed at providing the model rules for the basic data. The Digitization Agency, has together with SDFE made a common set of model rules. With those in hand, the authorities can model their data so they can more easily be exchanged and used in conjunction with other data. The model rules are following international standards i.e. ISO, UML etc. and are in line with the INSPIRE requirements.

Two very important general characteristics that have to be attached to the data are:

- Unique identification for ensuring cohesion across registers
- Metatemporality which is the information about when the data was registered and for how long it will be valid

The basic data model consists of domain models - i.e. data models for all business domains in the basic data program (i.e. "Person", "Address", "Company"). Each domain model has a model manager that is the basic data authority, which is responsible for the corresponding register. The basic data model is used for displaying basic data from the Data Distributor. The basic data model can be found under http://data.gov.dk/model/ and is documented in a diagram and an xml documentation form.

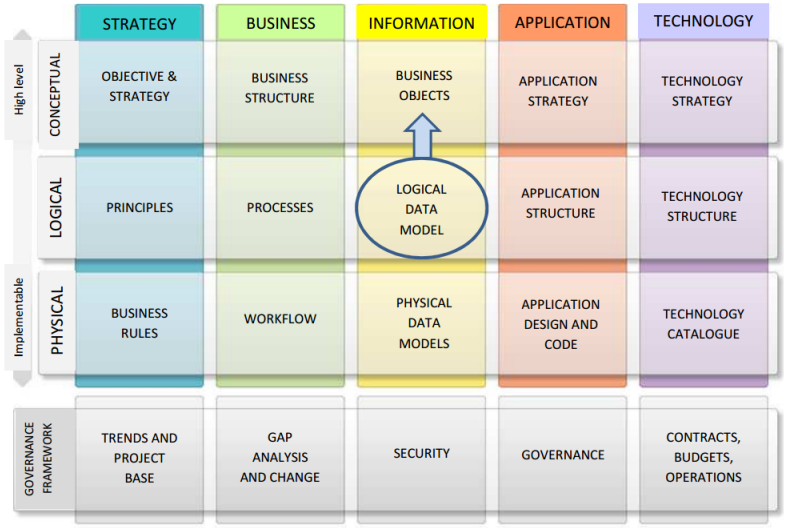

Figure 30: Data Models in the Basic Data Program (source: http://www.eurosdr.net/sites/default/files/images/inline/dm_ws_224d_doc2_model_rules_for_basic_data.pdf)

Additionally, an information model focuses on the logical information modelling of the basic data.

A conceptual model provides an overview of the basic data such as the concepts and their definitions and relations.

A logical data model, describes data models that define the organization of the data in a way that reflects the logical Structure in an IT system. The physical data model reflects the physical structure of the IT system. In Fig. 30, the data model overview is provided.

The data models are made operational for developers via data interfaces. Data interfaces and the conceptual model are linked together with the aid of the information model which functions as a central data model node.

6.4.4 Quality Aspects

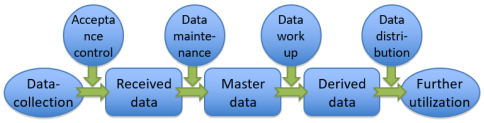

Figure 31: Acceptance Control (source: T. Hansen, 2017)

In the data process, the collected data is undergoing an acceptance control process (Fig. 31) against a delivery agreement. The data is validated on the adequacy of the content, the format and the consistency. This is done with the aid of different tools and methods either manually or automatically.

Data is maintained with the aid of automatic tools. Updates of large topographic areas and the nautical areas are utilized automatically. Update of individual real world objects is mainly undertaken in the cadastral field, where the miniMAKS-system (section 6.5.4) offers a high degree of automation.

6.4.5 Metadata

Descriptions of data sets and services related to the basic data are provided at the geodata-info.dk. The Agency for Data Supply and efficiency (SDFE) is responsible for the operation and the continuous development of the portal as well as for making the metadata available.

In the portal, metadata about where to find information, what data exists, when it was last updated, how to get access to data, who is responsible for the data etc. is provided. Geodata-info.dk includes the Danish search service under the INSPIRE Directive.

The information is provided for free directly by the data owners, typically public authorities, which are responsible for the correctness and up to date of the metadata. The users can directly integrate metadata in their GIS clients via the metadata web services.

For the data at the National Data Distributor, following metadata can be downloaded (Table 5).

Table 5: Metadata available at the National Data Distributor (source: http://datafordeler.dk/om-data/metadata-for-datasaet/)

Dataset	Download file
Buildings and Dwellings Register, BBR	Metadata File
Centrale Persons Register, CPR	Metadata File
The Central Business Register, CVR	Metadata File
Denmark Administrative Geographical Classification, DAGI	Metadata File
Danish Place Names	Metadata File
Denmark's elevation model, DHM (Surface)	Metadata File
Denmark's elevation model, DHM	Metadata File
Property Location	Metadata File
GeoDanmark	Metadata File

6.5 Technology

The Danish NSDI is developed based on Service Oriented Architectures. In such a manner, heterogeneous IT-environments are made interoperable (Fig. 32). The NSDI is built upon the "publish-find-bind" paradigm. Services based on international standards such as OGC WMS, WMF, WCS etc. are used at the implementation side.

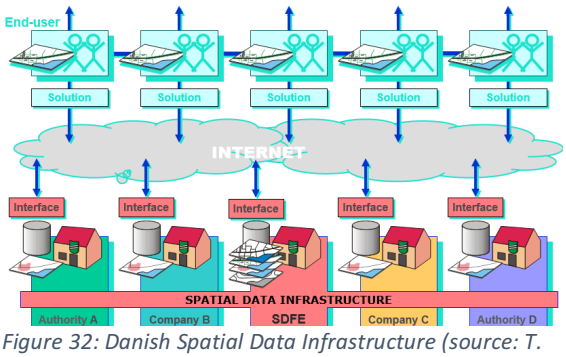

Figure 32: Danish Spatial Data Infrastructure (source: T. Hansen, 2017)

Opensource technologies are increasingly used. At the database side Postgis is widely used. Mapserver and Geoserver are used at the server side. For the search components Geonetworks and at the GISystems side, Qgis and

Openlayers is used. Opensource technologies are catalytic for scaling up the NSDI architecture as they don't bring upon additional costs

6.5.1 The National Data Distributor

The National Data Distributor is the central access point for basic data (Fig. 33). It replaces a number of public distribution solutions and ensure that authorities and companies have easy and secure access to basic data in a single system rather than via many different systems and interfaces.

The main advantages are:

- Uptime of 99.9%
- Better handling of security
- Lower operating costs
- Uniform technical interfaces
- Uniform data modelling principles

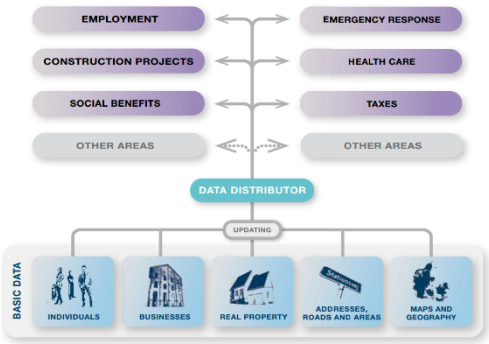

Figure 33: The Data Distributor (source: T. Hansen, 2017)

The Agency for Data Supply and Efficiency is responsible for the development and operation of the National Data Distributor. Data responsibility lies within the authorities that distribute data via the Data Distributor. This means that each data authority is responsible for handling administrative, regulatory and other issues. Data authorities are also responsible for the content, quality and updating of data. Following authorities are providing data to the Distributor:

- Agency for Data Supply and Efficiency
- Danish Geodata Agency
- Business Authority
- Social Security Office

Users have access to the Data Distributor Portal after registration. The Data Distributer provides data from the registers and the Map Supply (section 6.5.2). Spatial data services from the Data Distributor can be directly imported into GIS clients. Spatial data services are provided under the webservices section of the portal and similarly are the interface descriptions. Additionally, documentation and GIS Guides are published.

6.5.2 Map Supply

The Map Supply is the data distribution channel of SDFE. It provides easy access to national, current and updated data on an as need basis. The data can be accessed via a huge number of web services available at the services section and accompanied with documentations. The services can be used after registration. In annual reports, the performance and availability of the Map Supply is monitored and documented.

6.5.3 MIA – Cadastral Information Update System

MIA is a Cadastral Information and Update System, which is used for cadastral purposes and digital data exchange. It is a Windows application that helps private surveyors to create data for cadastral purposes in digital form and transfer this data to the Danish Geodata Agency and the municipalities via the Internet. Based on this data, the Danish Geodata Agency updates the cadastral register and cadastral map.

6.5.4 miniMAKS

MiniMAKS is a cadastral updating and quality assurance system of the Danish Geodata Agency. A list of controls that are activated when data is received is provided at the website. It is based on SOA (Service Oriented Architecture), making it possible for others to use or extend it extended with other applications based on SOA. The Danish Geodata Agency establishes the system in close cooperation with IBM Public Sector.

6.5.5 Valdemar – Application for fixed points in Denmark

The web application Valdemar, provides the data of the Fixed-Point Register for Denmark, Faeroe Islands and Greenland.

7. Maturity Level Assessment and Reasons

7.1 Organization

In 1960, the fist ad hoc (Maturity level 1) geoinformation initiatives existed. At that time, many national registers were established which were purpose oriented and independent from one another. Around the year 2000, Denmark had reached level 2 in the Maturity Model. In 2000, the Area Information System (AIS) was developed as one of the very important initial attempts of organization and coordination activities.

Similarly, in 2000, after an agreement the different address datasets were merged and the Buildings and Dwellings register was defined as the base register for the address dataset. This was achieved under a funded project from 1995 to 2001. The Area Information System (AIS) established in 2000 and funded by the Ministry of the Environment, was also an example of a centrally funded initiative. Data was sporadically shared between the Buildings and Dwellings register, the topographic and the cadastral maps. In 2004, registers were defined followed by custodianship and stewardship principles.

With the Basic Data Program introduced in 2012, the NSDI reached Level 3. The governance structure as well as the implementation and investment plan were well defined. Public and private partnerships were already in place (i.e. between the Cadastral and private companies), and data sharing with elements of success existed between the Cadastral and the Buildings and Dwellings register.

Nowadays, Level 4 to 5 in the Maturity Model is reached. The legal framework and the custodianship and stewardship roles are well defined. The Danish NSDI is operating on a shared accountability and responsibility model. Some monitoring activities are performed such as monitoring of the INSPIRE implementation and monitoring of the performance and availability of the Map Supply portal. Data sharing is consistent and mature with the National Data Distributor being the one stop shop for data acquisition. An overview of the maturity level assessment is provided in Table 6.

7.2 Data

Before 1970, address data was collected by several authorities leading to data duplications. At that time, data in registers was collected in a purpose oriented manner (Level 1). In 1998, the common agreement on address data was one of the first peer to peer data sharing arrangements.

As far as metadata is concerned, in 1990 a metadata service based on CEN standards was launched. This was followed by the geodatainfo.dk metadata portal (est. 2005). In this pre-NSDI period, Level 2 was reached.

In 2012, the Basic Data Program and the implementation of the INSPIRE directive were the driving force for reaching Level 3 in the Maturity Model. Base data themes were defined, the Data Distributor was the central node for data sharing. The data was provided open and free to public and private authorities in line with the Danish national law. Data within the Basic Data Program and INSPIRE was published with the compliant metadata.

In 2017, Level 4 to 5 in the Maturity Model is reached. All data is published with compliant metadata at the geodatainfo.dk metadata portal and open data policies are widely implemented. A study in 2013 has documented the ever-growing open data and spatial data usage also from non-geo related disciplines. An overview of the maturity level assessment is provided in Table 7.

7.3 Standards

Around the year 2000, Denmark has reached Level 3 in the Maturity Model. Within the Area Information System (AIS) data and metadata were shared based on international standards. The Danish Standardization Foundation has been involved in OGC and ISO. E-enabled services were sporadically exploited and OGC standards such as WMS and WFS were used i.e. in the Map Server (2001), the Kortserver (2002) and Infostructurebase (2003) projects.

With the Basic Data Program (2012) Level 4 was reached. Common data models for the base data and manuals for their implementation have been published. After the parliamentary resolution in 2006, the mandatory use of open standards in the public sector was introduced.

The broad use of international standards such as OGC WMS, WFS, GML etc. in services such as the Map Supply (2009), the Address WMS (2009), the Nature and Environment Portal (2010) facilitate interorganizational data sharing.

Nowadays, Level 4 to 5 is reached. International standards are widely used and guidance on their use is provided. The Agency for Data Supply and Efficiency (SDFE) actively participating in CEN, ISO and OGC. An overview of the maturity level assessment is provided in Table 8.

7.4 Technology

In 1960, technology choices were made on a project basis and interoperability was vendor dependent (purpose oriented registers, multiple address datasets). Around 2000, Level 2 was reached. Keys were introduced for creating links between the registers. Some elements of organizational spatial data architecture were implemented i.e. the AIS portal (2000),

Plansystem DK (2000), OIS program (2001), the Map Service (2001), Kortserver (2002), FOTDanmark (2006).

Currently (2017), Level 4 to 5 has been reached. Service level agreements are robust particularly for the base data provided by the National Data Distributor node. Quality, availability and responsibilities are well defined. For the Map Supply portal, a monitoring service controls the performance and availability of the portal. The use of opensource technologies on the implementation level, leads to the architecture being very flexible and scalable. An overview of the maturity level assessment is provided in Table 9.

7.5 People

In the 1990', no real collaboration culture existed. This was not only due to technical and organizational differences but also due to economic disagreements between the data producers.

From 2000 to 2010, some criteria of Level 3 were fulfilled. A research initiative on the Danish Spatial Data Infrastructure was established between the Copenhagen Business School. Aalborg University and National Survey and Cadastre. Examples proving the initiation of a cooperative culture are Geoforum (2001), FOTDanmark (2006) and the Spatial Data Service Community (2010).

In 2017, Denmark has reached Level 3 to 4 in the Maturity level. Since 2008, ICT and spatial literacy of the citizens have increased leading to increased use of counties' and municipalities' web services. Seminars and online material shared by the Geoforum contributes to growing users' skills.

An example of effective coordination and communication is the well-defined communication plan of the Map Supply portal and the Notification Distributor. Promotional activities of the geoinformation sector can be seen in brugstedet.dk. The main goal of burgstedet.dk is to present the added value of geoinformation for companies, public authorities and citizens. User engagement is shown by crowdsourcing activities and the participation in the Geoforum. An overview of the maturity level assessment is provided in Table 10.

In Fig. 34, the evolution of the maturity of the Danish NSDI is shown. As can be seen, the data and organizational components started from Maturity Level 1 while the technology component started from Maturity Level 2. The standards and people component started from Maturity Level 3. Nowadays, Maturity Level 4 to 5 has been reached for all the components.

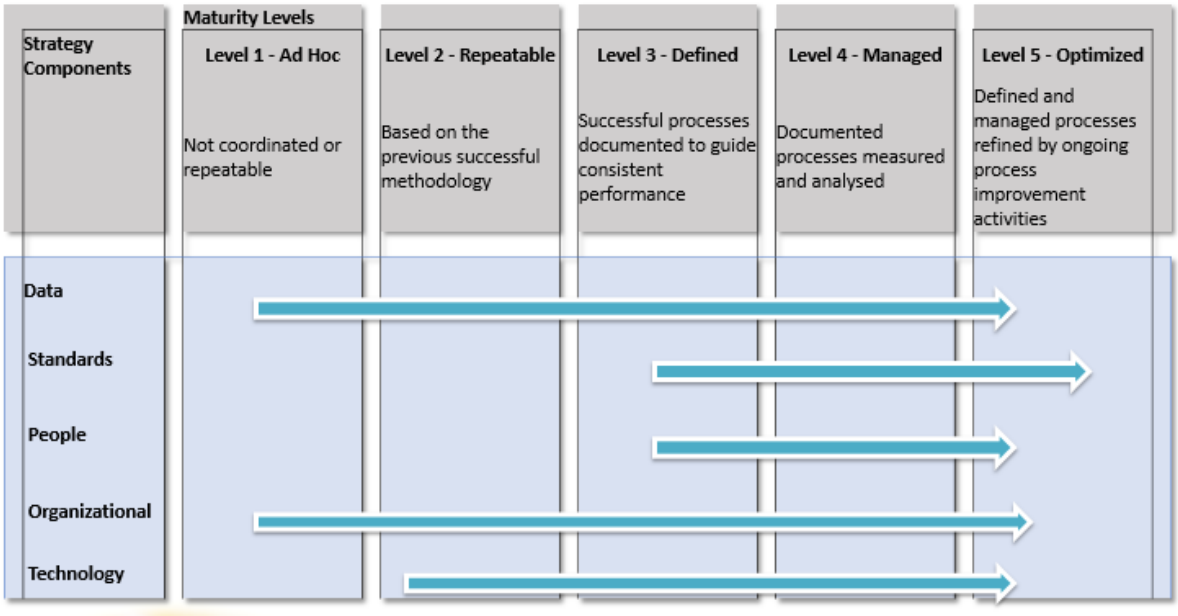

Figure 34:Maturity Level Assessment for the Danish NSDI

Table 6: Organizational Maturity Level Assessment

ORGANIZATIONAL								
LEVEL 1 - Ad Hoc		**Level 2 - Repeatable**		**Level 3 - Defined**		**Level 4 - Managed**		**Level 5 - Optimized**	
No cross-organizational governance framework in place		Initial whole of organization coordination activities		Whole of organization governance structures established	2010 2012	Mandate and legal frameworks in place	2017	Ongoing monitoring and continuous improvement	2017
No standard operating procedures (SOPs) identified, compliance and tracking not consistent		Custodianships and stewardship principles defined	2004	SOPs consistently tracked and verified		Formal custodianship and stewardship roles defined	2017	Measuring ROI and benefits realization	2017
Project by project funding		Some SOPs documented		Defined strategy and Implementation Plan	2012	Strategy implemented, KPIs monitored		Data sharing is consistent, mature and successful	2017
Case by case partnerships		Some whole of organization funded initiatives	1995-2001	Whole of Organization investment plan	2012	Business case driven investments			
No market coordination or focus		Sporadic data sharing	2000	Public / Private Partnerships	2000	Operational budget allocations			
No successful initiative in data sharing	1996			Inconsistent Data sharing with elements of success		Data sharing in place but still immature			

Table 7: Assessment of the Maturity Level of the Data Component

DATA									
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	1980	Single Point of truth principles		Foundation Data published, shared and maintained		Ongoing monitoring and continuous improvement	
Data duplication	1970	Some (meta)data publications	mid 1990's	Foundation Data Themes defined	2012	All data published with compliant metadata	2012 2017	Growing spatial data and open data usage throughout community	2017
Project by project data and metadata collection	1960			Open Data policies established	2012	Open Data policies implemented	2012 2017		

Table 8: Assessment of the Maturity Level of the Standards Component

STANDARDS									
LEVEL 1 - Ad Hoc		**Level 2 - Repeatable**		**Level 3 - Defined**		**Level 4 - Managed**		**Level 5 - Optimized**	
No common standards identified or implemented	1960	Documented spatial data standards framework		All (meta)data published in standards compliant formats, protocols and services	2000	Monitoring and expansion of standards compliance		Proactive, contributing role in (international) standards, organizations ensure organizational needs are reflected in emerging standards	2017
		Selective standards adoption		Observer role in (international) standards organizations	2000	Common data models defined for Foundation Data	2012		
		e-enabled services not exploited		e-enabled services sporadically exploited	2001-2003	Partial integration with other organization wide e-enabled service standards	2009	Fully integrated e-enabled services standard	2017

Table 9: Assessment of the Maturity Level of the Technology Component

TECHNOLOGY								
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	1960	Defined or organizational spatial data architecture	2000 2001	Organizational spatial data architecture being implemented		Robust spatial data services with defined SLAa	2017	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	2000 2001 2002	Compliant spatial data services		Service monitoring	2017	Business systems integration mature and effortless	
Case by case interoperability. Often vendor dependent	1960	System specific interoperability		Vendor agnostic		Business systems routinely using spatial data services	2017		

Table 10: Assessment of the Maturity Level of the People Component

PEOPLE									
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		Growing skills base	2008 2017	Ongoing monitoring and continuous improvement	
Ad hoc training and development		Informal knowledge sharing		Formal education and knowledge sharing resources	2000	Coordination with education facilities		Targeted sources and R&D activities	
No coordination communication		Case by case user needs analysis		Coordinated, whole of organization user needs analysis		Regular user feedback captured		Mature user engagements	2017
Project by project user focus		Informal communication standards		Formalized communications plan	2017	Effective, coordinated communications	2017	Pervasive awareness of spatial information benefits and availability	
No collaboration culture	1990's	Untrusted and sporadic collaboration culture		Cooperative culture	2001 - 2010	Coalition and alliance culture		Strong collaboration and transparent partnership culture	

Information Sources

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APPENDIX I

Standards used in the public sector (source: https://www.digst.dk/Arkitektur-og-data/Standardisering/Aabne-standarder--vejledning/De-syv-saet-af-obligatoriske-aabne-standarder)

Standards for data exchange between public authorities (OIOXML)

- Manual (pdf)
- XML
- XSD

Standards for the electronic document (FESD)

- Instructions
- FESD Cases and documents
- FESD Name & address model
- FESD Exchange Package
- FESD Scanning Module
- FESD LIS (Management information)
- Case and document standards

Standards for electronic procurement in the public sector (OIOUBL)

- Instructions
- UBL
- UN / SPSC

Standards for digital signatures (OCES)

- Instructions
- Certificate policies

Standards for public websites and availability

- Instructions
- WCAG
- HTML (version 4 or later)
- XHTML
- CSS

Standards for IT Security (DS-484 - State only)

- DS484 is replaced as mandatory information security standard of the international standard ISO27001 since January 2014. More information on the standard can be found here .

Standards for document exchange (ODF / OOXML)

- Manual (pdf)
- ODF
- OOXML