



Delft University of Technology

## SDI Research and Strategies towards 2030: Renewing the SDI Research Agenda Workshop Report

Vancauwenberghe, Glenn; van Loenen, Bastiaan

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# SDI Research and Strategies towards 2030: Renewing the SDI Research Agenda



AGILE 2018 Pre-conference workshop  
12 June, Lund (Sweden)



AALBORG UNIVERSITY

## Workshop Report

Authors: Glenn Vancauwenberghe & Bastiaan van Loenen  
TU Delft – Knowledge Centre Open Data

KU LEUVEN

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# 1. Introduction

## 1.1 About the workshop

### Aim & objectives

The aim of the 'SDI Research and Strategies towards 2030' Workshop was to initiate the definition of a renewed Spatial Data Infrastructure Research Agenda for 'SDI Research and Strategies towards 2030', incorporating both technical and non-technical perspectives and research challenges.

The workshop had three objectives:

1. To provide an overview of recent and ongoing research on SDI and related topics
2. To identify gaps and challenges in SDI research and define a research agenda for future SDI research
3. To (re-)establish a research community for SDI research that promotes and enables active collaboration and engagement across multiple disciplines and regions

### Background

In the past 30 years, public administrations in Europe and worldwide have invested considerable resources in the development and implementation of Spatial Data Infrastructures (SDIs) for promoting, facilitating and coordinating the exchange and sharing of geographic data. SDI research has been an important driver and enabler for SDI development and implementation. Researchers across the world have been exploring various issues around the development and implementation of SDIs. While over the last decade SDIs significantly matured, new research challenges emerged and new researchers and research disciplines entered the domain of SDI research. There is, however, a risk of SDI research becoming more fragmented into separate – disciplinary, organizational and geographic – silos, due to a lack of initiatives enabling and facilitating collaboration and exchange of knowledge and experiences among SDI researchers.

The 'SDI Research and Strategies towards 2030' workshop wanted to build further and continue the work done in past initiatives to promote knowledge sharing and collaboration among SDI researchers. In 2009 and 2010 two SDI research workshops were held at the GSDI Conferences in Rotterdam (the Netherlands) and Singapore, allowing especially early stage researchers in the domain of SDI to present their ongoing research and exchange views and ideas on new research challenges. One of the last attempts to develop an SDI research agenda already dates from 2005, when Bernard et al. drafted their proposal for an SDI research agenda, identifying several key research issues raised by the transition from GIS to SDIs. The 'SDI Research and Strategies towards 2030' workshop aimed to initiate the definition of a renewed Spatial Data Infrastructure Research Agenda.

## 1.2 Workshop organizers



**TU Delft, The Netherlands**

Glenn Vancauwenberghe ([g.vancauwenberghe@tudelft.nl](mailto:g.vancauwenberghe@tudelft.nl))

Bastiaan van Loenen ([b.vanloenen@tudelft.nl](mailto:b.vanloenen@tudelft.nl))

The logo for KU Leuven, consisting of a dark blue rectangle with the text "KU LEUVEN" in white, bold, sans-serif capital letters.

**KU LEUVEN**

**KU Leuven, Belgium**

Joep Cromptvoets ([joep.cromptvoets@kuleuven.be](mailto:joep.cromptvoets@kuleuven.be))



**Aalborg University, Denmark)**

Lars Bodum ([lbo@plan.aau.dk](mailto:lbo@plan.aau.dk))

**AALBORG UNIVERSITY**



**Lund University, Sweden**

Ali Mansourian ([ali.mansourian@nateko.lu.se](mailto:ali.mansourian@nateko.lu.se))

**LUND UNIVERSITY**

## 1.3 Workshop participants

Bodum, Lars (Aalborg University) - [lbo@plan.aau.dk](mailto:lbo@plan.aau.dk)

Bulens, Jandirk (Wageningen University and Research) - [jandirk.bulens@wur.nl](mailto:jandirk.bulens@wur.nl)

Chantillon, Maxim (KU Leuven) - [maxim.chantillon@kuleuven.be](mailto:maxim.chantillon@kuleuven.be)

Chouder, Mohamed Tahar (NCGI, Algeria) - [hakim\\_chouder@yahoo.fr](mailto:hakim_chouder@yahoo.fr)

Cömert, Çetin (Karadeniz Technical University)

Eriksson, Helen (Lund University) - [helen.eriksson@nateko.lu.se](mailto:helen.eriksson@nateko.lu.se)

Huang, Weiming (Lund University) - [weiming.huang@nateko.lu.se](mailto:weiming.huang@nateko.lu.se)

Indrajit, Agung (TU Delft) - [a.indrajit@tudelft.nl](mailto:a.indrajit@tudelft.nl)

Kotsev, Alexander (EC JRC) - [alexander.kotsev@ec.europa.eu](mailto:alexander.kotsev@ec.europa.eu)

Lydia Kayondo, Mazzi Ndandiko (Makerere University) - [Lndandiko@gmail.com](mailto:Lndandiko@gmail.com)

Mansourian, Ali (Lund University)- [ali.mansourian@nateko.lu.se](mailto:ali.mansourian@nateko.lu.se)

Sang, Neil (Swedish University of Agricultural Sciences)

Sjoukema, Jaap-Willem (Wageningen University) - [jaap-willem.sjoukema@wur.nl](mailto:jaap-willem.sjoukema@wur.nl)

van Loenen, Bastiaan (TU Delft) - [b.vanloenen@tudelft.nl](mailto:b.vanloenen@tudelft.nl)

Vancauwenberghe, Glenn (TU Delft) - [g.vancauwenberghe@tudelft.nl](mailto:g.vancauwenberghe@tudelft.nl)

Vandenbroucke Danny (KU Leuven) – [danny.vandenbroucke@kuleuven.be](mailto:danny.vandenbroucke@kuleuven.be)

Welle Donker, Frederika (TU Delft) - [f.welledonker@tudelft.nl](mailto:f.welledonker@tudelft.nl)

## 1.4 Workshop webpage:

<http://kcopendata.eu/sdi2030>

# 1.5. A brief history of collaboration and exchange in SDI research

## Glenn Vancauwenberghe (TU Delft)

2005 – Towards and SDI Research Agenda

Towards an SDI Research Agenda

Lars Bernard<sup>1</sup>, Max Craglia<sup>1</sup>, Michael Gould<sup>2</sup>, Werner Kuhn<sup>3</sup>  
 1 Joint Research Centre European Commission, Ispra, Italy  
 2 University Jaume I, Castellón, Spain  
 3 University of Münster, Münster, Germany

2006 - IJSDIR – International Journal of Spatial Data Infrastructure Research (2006)



2007 - Research and theory in advancing spatial data infrastructure concepts (H Onsrud).



2008 - A multi-view framework to assess SDIs (Crompvoets, J., Rajabifard, A., van Loenen, B., & Fernández, T.)



2009 - PhD workshop 'Theory-based SDI research: North and South' (Delft)



2010 – PhD Student Workshop 'Sharing SDI Research Approaches' (Singapore)



2011 – Spatial Data Infrastructures in Context: North & South (Nedovic-Budic, Crompvoets & Georgiadou)



2012 - SDI past, present and future: a review and status assessment (Harvey, F., Iwaniak, A., Coetzee, S., & Cooper, A. K.)



2013 - IJGI Special Issue on 'Spatial Data Infrastructures, Cyberinfrastructure, and e-Science for GIScience'



2014 – INSPIRE Conference Aalborg (& other conferences)



2015 - A review of SDI literature: Searching for signs of inverse infrastructures (Coetzee & Wolff-Piggott)

Chapter 9  
 A Review of SDI Literature: Searching for Signs of Inverse Infrastructures

Serena Coetzee and Brendon Wolff-Piggott

2016 - GI-N2K Body of Knowledge WIKI





## 2. Researchers' presentations

## 2.1 The 'governability' of Spatial Data Infrastructures (SDIs)

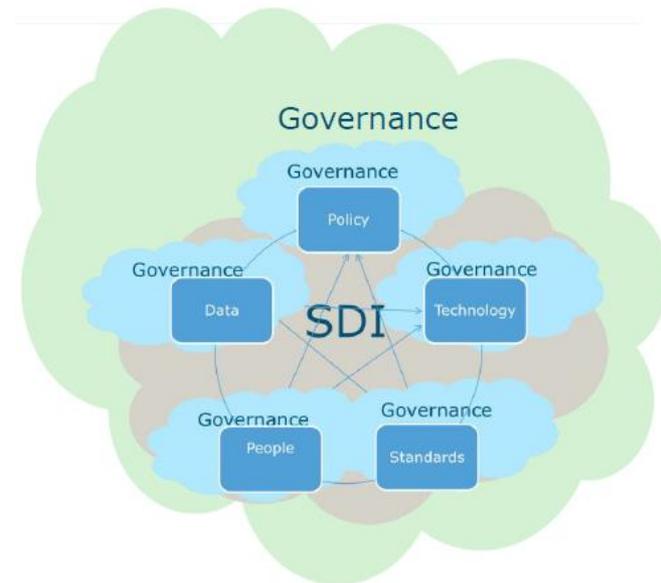
Jaap-Willem Sjoukema (Wageningen University, the Netherlands), Arnold Bregt & Joep Crompvoets

### Current research

Almost all Spatial Data Infrastructures (SDIs) have a clear goal and vision. However, the road to implement these goals into reality is not a straightforward one. SDIs are constantly challenged by new technologies and user demands. This is partly due to the complex, multi-stakeholders, multi-level, technical and open nature of SDIs. SDIs should therefore not be seen as stationary, but more as evolving over time. What we now think of 'good SDIs' could be very different of how we evaluate them in the future. Adaptability appears therefore an important feature of SDI governance. But in practice this ability to adapt seems in many cases limited by project-based budgets, low political awareness and difficulties managing the continuously growing group of SDI stakeholders. On the other hand, an SDI should also be stable so that users will trust the SDI and build upon it, which seems to contradict with its need to be adaptive. These contradicting objectives make SDI governance not an easy task. In our research we try to identify effective governance mechanisms for SDIs. Important questions therefore are 'how governable is an SDI?' and 'how can the governability of an SDI be influenced?'. Governability is defined as "the overall capacity for governance of any societal entity or system" in which we will evaluate governance 'ingredients' such as interactions, instrumentation, structures and the SDI system itself.

### Future research:

There is a clear need to better understand SDI governance. Key SDI governance challenges should be – further - determined, but at the same time the question rises whether SDI governance should be seen as a topic on its own, since also links and similarities with other types of governance (IT governance or governance of larger projects) should be explored?



## 2.2. Developing and connecting SDIs: Bringing in and clarifying the role of public values

Maxim Chantillon (KU Leuven - Belgium), Joep Crompvoets & Vassilios Peristeras

### Current research

The research presented in the workshop focused on public governance in the context of SDI and e-government. Public values steer (at least partially) policy makers and public administrations in geospatial and e-government policy making and practice, but within single policy fields often various – conflicting and also changing– values are in place. A key challenge is the alignment of different values and the creation of commonly shared values, which is necessary for the solid cooperation between actors and institutions. Existing research, however, strongly focuses on a limited number of public values in practice, and especially in research on e-government and SDIs there is a lack of attention for public values. Current research and practice show that e-government leads to a changing balance of public values, and most examples show that duty oriented and service oriented values are more present than socially oriented values, which are undermined by digitalization. A policy motivation value analysis of the PSI Regulation and the INSPIRE Directive shows that especially duty oriented and service oriented values are mentioned, while socially oriented values are less mentioned.

### Future research

Governance can be seen as a way to deal with this changing balance of public values and ensure that basic values remain respected. This leads to two main topics for further research:

- Link between public values and the governance of GI/SDI
- Connections to and conflicts with value logic of other policy fields

- [PSI Regulation \(2003 / 2013\)](#)

Duty oriented	Service oriented	Socially oriented
<a href="#">13 references</a>	<a href="#">9 references</a>	<a href="#">5 references</a>

→ [9 references to economic stimulation](#)

- [INSPIRE Directive \(2007\)](#)

Duty oriented	Service oriented	Sociale oriented
<a href="#">18 references</a>	<a href="#">18 references</a>	<a href="#">5 references</a>

→ [‘third parties’: economic & societal stimulation](#)

## 2.3 Assessing the openness of Spatial Data Infrastructures in Europe

Bastiaan van Loenen (TU Delft) & Glenn Vancauwenberghe

### Current research

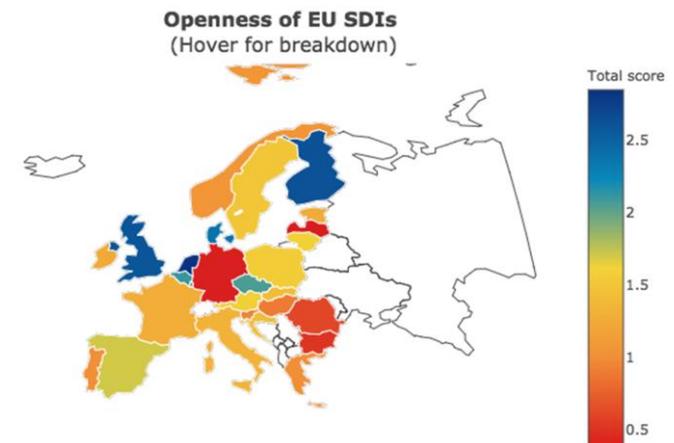
This presentation introduced the Open Spatial Data Infrastructure (SDI) Assessment Framework as a new approach for assessing the openness of SDIs. Open SDIs are SDIs in which non-government actors such as businesses, citizens, researchers and non-profit organizations can contribute to the development and implementation of the SDI, use spatial data with as few restrictions as possible and benefit from using these geographic data. The Open SDI Assessment Framework builds further on existing approaches for assessing SDIs and open data, but particularly focuses on the openness of SDIs. To demonstrate the relevance and test the applicability of the Open SDI Assessment Framework, the framework was used to create a Map of Open SDI in Europe, which shows the level of openness of National SDIs in Europe and the differences within Europe with regard to the openness of national SDIs.

### Future research

In the presentation, three topics for further research were identified:

- SDI assessment: how to automate the process of assessing SDIs and how to monitor the use, users and impact of SDIs?
- SDI governance: how to define the roles, responsibilities and rights of non-government actors in more open forms of SDIs?
- Open spatial data ecosystems: how to define, describe and assess open spatial data ecosystems and what are requirements for strengthening/improving these ecosystems

	Readiness	Availability	Use	Impact
Global NSDI Survey	+++	+	o	o
SDI First generation	++	o	o	o
GINIE	++	++	+	+
SDI State of Play	+++	++	o	o
SDI Generations	++	+	o	+
SDI Effectiveness	o	++	++	++
Clearinghouse suitability	++	++	+	o
Organisational maturity	++	o	o	o
SDI Readiness Index	+++	++	o	o
SDI Theoretical Framework	++	++	++	+++
SDI Socio-economic Impact	o	o	+	+++
INSPIRE M&R	+++	+++	++	++
SDI BSC	++	++	++	+
SDI Process Performance	+	+	++	++

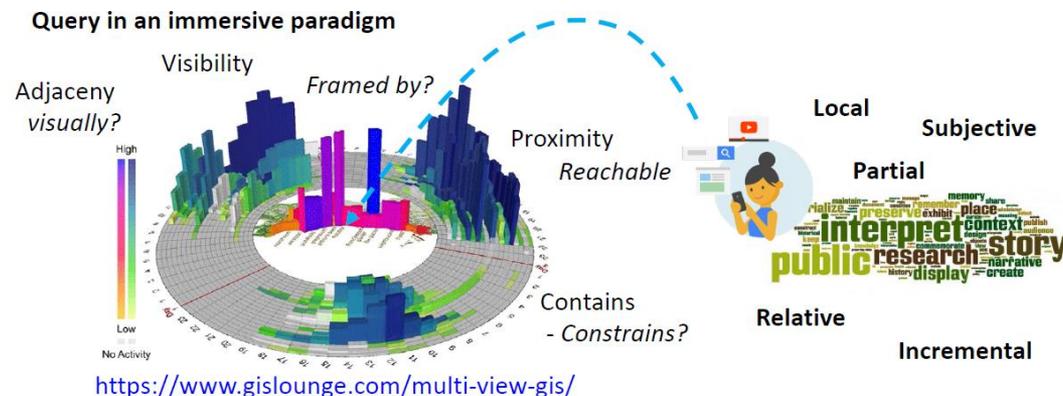


## 2.4 SDI for exploration of the Digital Earth

Neil Sang (Swedish University of Agricultural Sciences, Sweden)

### Current research

The vision of a Digital Earth set out by Gore (1999) and others goes beyond simple transference of Geo-data to digital globes and the solving of traditional Geo-spatial problems in 3D. Geo-browsers and GPS driven applications have introduced the utility of spatial data to a larger audience leading to a broader range of questions. "Users expect virtual globes to answer a different kind of query, one that is less precise and quantitative, and more attuned to exploration". GIS has traditionally sought an objective overview of space, the challenge now is to support subjective narration of place. Spatial units, broadly-bounded topologies, networks, and scale are all standard concepts in GIS and have expression in existing SDI. However, in this new immersive environment, they need to be redefined around a user centric model where, for example, boundaries of place are defined by the affordances of the environment. Indeed some experienced 'complements' to an object may be non-contiguous with the object itself (e.g. a viewshed).



### Future research

Two central topics for further research were mentioned:

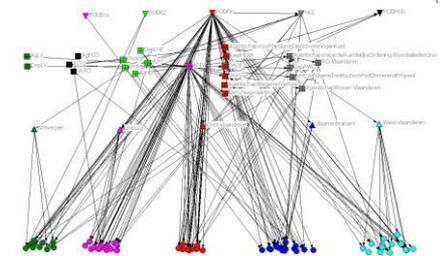
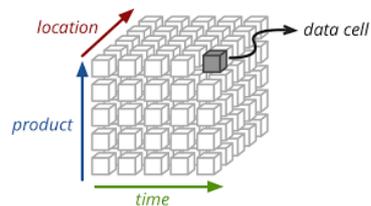
- Graph based SDI (and how can this be done)
- Immersive SDIs ("Not a monolithic structure to be adhered to but a way to let datasets grow with use")

## 2.5 Beyond traditional SDI: new research topics and methods

Danny Vandembroucke (KU Leuven)

### Current research

The focus of current SDI research (and practice) has been a lot on the 'Publish-(Search)-Find-Bind' paradigm. SDI research itself includes both research on SDIs as a research object, but also SDI implementation and usage as a research activity. In general, there has been relatively few research on the actual usage and uptake of SDIs and how this works. Also very little research exists on the impact of the federated SDI approach. While many technological and non-technological challenges remain, new challenges arise through ongoing technological and societal developments. The definition of a roadmap based on these technological and societal trends should steer the future SDI research agenda.



### Future research (topics)

In the presentation, several topics that require further research were identified. These include:

- Extending and integration of SDI models: integration of geodata from different sources, integration with other information, enriching SDI with other information from the web using linked data techniques
- 3D/4D models: integration with BIM, indoor location, AR/VR
- Resolving the problem of time and dynamic information: working with data cubes and O&M for dynamic processes
- SDI and workflows: orchestration and chaining of web services and embedding/automating these in e-Government processes
- Geospatial API's for exploitation ('location enablement')
- Open data and secure access

## 2.6 Integration and visualisation of geospatial data using Semantic Web technologies: an SDI perspective

Weiming Huang (Lund University, Sweden)

### Current research

The motivation of the research project on the topic of “Integration and visualisation of geospatial data using Semantic Web technologies is the fact that the application of Semantic Web technologies, particularly the part concerning Linked Data, has developed considerably in the last decade in geospatial domain as they address several challenges of e.g. data integration, reuse and knowledge formalisation. And they also foster a promising approach to connect SDIs with the mainstream IT to augment the application of geospatial data. The research project consists of several studies:

- The first study addresses a long-standing visualisation issue in view services. The view services are often presented in the form of map mashups, in which the thematic data simply overlay various base maps. This simple overlay approach often raises geometric deficiencies due to geometric uncertainties in the data. This issue is particularly apparent in a multi-scale context because the thematic data seldom have synchronised level of detail with the base map. Therefore, we propose a relative positioning approach in which the thematic data are positioned based on shared geometries and relative coordinates. A Linked Data-based technical framework is used to realise the relative positioning approach. The proposed framework can be used as a new way of modelling geospatial data on the Web, with merits in terms of both data visualisation and querying. This is a use case of how the released geospatial data (particularly Linked Data, as the releasing of INSPIRE-compliant data is under investigation) can help others to position their data.
- The second study focuses on a new paradigm for geovisualisation – a knowledge-based approach. The study addresses the semantic challenges of geovisualisation, that is, the knowledge concerning how the geospatial data needs to be formalised to foster better transfer, interpretation and reuse of such knowledge. Therefore, we propose an approach to formally represent the geovisualisation knowledge in a semantically-enriched and machine-readable manner using Semantic Web technologies. Specifically, we represent the knowledge for geovisualisation in several aspects coupling ontologies and rules, and the knowledge base can enable inference to derive the corresponding geometries and symbols for visualisation under different conditions. The proposed approach can form the foundation for the vision of web of knowledge for geovisualisation. And this approach is in line with some underway trends: approaching data-centric GIS and the vision of the transition from SDIs to spatial knowledge infrastructures.
- A third study will utilize the ideas from previous two studies, in order to develop a new approach to visualise the cycle path according to their safety level. calculation of cycle path safety indexes in ontologies and rules. This study will develop further in both relative positioning and the knowledge base of geovisualisation and demonstrate how the Linked Data paradigm could augment the use of geospatial data to other domains.

## 2.7 INSPIRE2030: A vision for the European Spatial Data Infrastructure of the Future

Alexander Kotsev (EC JRC), Vanda Lima, Robert Tomas, Vlado Cetl, Michael Lutz, Sven Schade

### Future research

Eleven years after the adoption of the INSPIRE Directive, the authors shared their perspective on (i) several recent developments, and (ii) challenges that could determine the future of European SDIs. These included the following topics:

- **Implications of disruptive technologies.** Innovative technologies such as cloud computing, new algorithms, streaming and asynchronous data exchange, are developing at a pace that makes it very difficult for standardisation and SDI initiatives to follow. The need for SDIs to adapt new technologies is pressing in order to not become obsolete. Within this context, multiple organisational, technological and legal implications arise. A delicate balance between innovation and stability should be obtained, deciding on what technology to adopt based on user demand. In addition, the discoverability and usability of SDI data through the internet should be tackled.
- **Dependency on standards.** Standardisation bodies such as OGC and W3C are increasingly looking into new ways of working that include (i) faster uptake of technological innovations, and (ii) measures to ensure that standards are easy to implement (through hackathons, interoperability experiments, etc.). At the same time, questions regarding the extent to which SDIs should be reliant on standards, which standards to follow, and how to ensure backwards compatibility are still to be investigated.
- **Complementarity of data sources.** Phenomena such as (i) Citizen Science, together with the rapid growth of the (ii) Internet of Things supplement, and increasingly substitute public sector data. In addition, the private sector is playing an important role in the creation, storage and maintenance of data, but also in extracting value from it through the application of sophisticated, often proprietary, algorithms. That is why, the SDIs of the future would very likely be less infrastructures of public authorities, but hybrids bringing together heterogeneous data sources and algorithms. How to break existing silos while ensuring the sustainability of such an approach should be addressed.



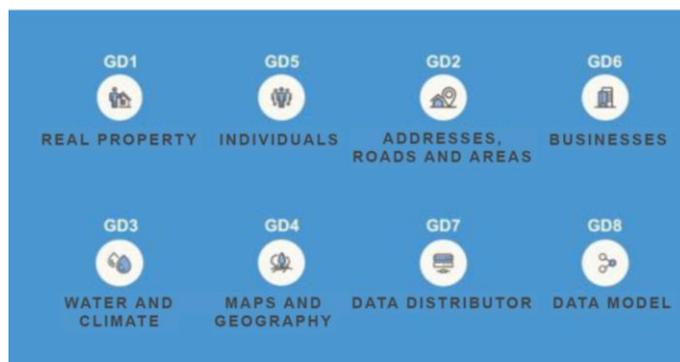
## 2.8 Two different cases of free and open data in Denmark – The National Basic Data Program and the Opendata.dk

Lars Bodum (Aalborg University, Denmark)

### Current research

In this research, a comparative analysis was made between two cases of implementing free and open data in Denmark: the National Basic Data Program and the Opendata.dk. The Basic Data Programme was launched in 2013 as part of the national eGovernment Strategy for 2011-2015. The programme contained a number of specific improvements and initiatives in public sector basic data that underpin greater efficiency and economic growth. Basic data are widely used throughout the public sector and are an important basis for public authorities to perform their tasks properly and efficiently. Within the framework of the Danish Basic Data Programme, several key data sets were made freely accessible and re-usable for public authorities, companies and other users. Opendata.dk started in 2014 as a collaboration between five municipalities (Aalborg, Aarhus, Copenhagen, Vejle, and Odense) and one region. The project aimed to function as a national platform for OD and encourage other municipalities to start working and publishing open data on the portal. Between 2016 and 2017, several other municipalities and regions joined the collaboration. The case of opendata.dk shows that open data portals can be run as a community solution among municipalities with same type of datasets

### ALL 8 PARTS OF THE BASIC DATA PROGRAM



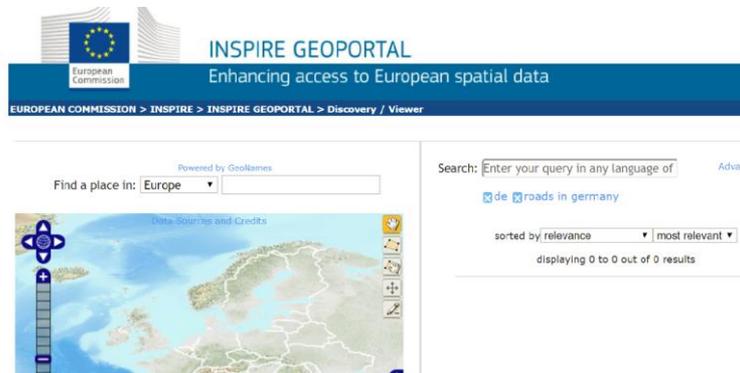
The screenshot shows the Opendata.dk website interface. At the top, there is a navigation bar with links for 'Forside', 'Datasæt', 'Organisationer', and 'Om'. The main content area features a search bar with the text 'Søg efter data' and a search input field containing 'fleks. parkering'. Below the search bar, there are several buttons for popular tags: 'Populære tags', 'Vejle', 'fritid', 'Kort', 'trafik', 'aarhus kommune', and 'Teknik og Miljø'. The main content area is divided into two columns. The left column has a section titled 'Sidst opdateret' (Recently updated) with two items: 'Energiregnskaber i Region Midtjylland 2013' and 'Boligselskabs- og grundejerservice'. The right column has a section titled 'Populære' (Popular) with two items: 'Open Data DK licens' and 'Skoler og daginstitutionersdata'. The website has a clean, modern design with a blue and white color scheme.

## 2.9 Is NSDI dead?

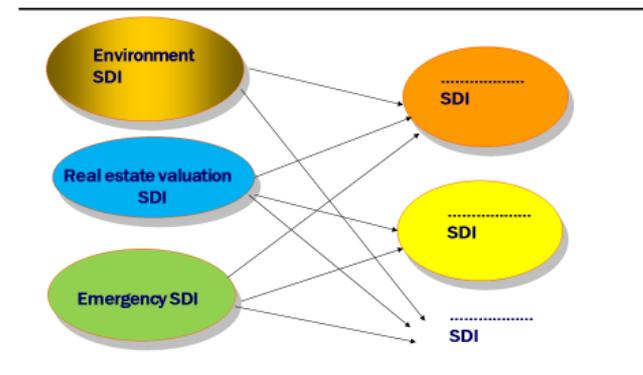
Çetin Cömert & M. Emre Yıldırım (Karadeniz Technical University, Turkey)

### Current research

This study tackles the question of whether countries without an NSDI should still struggle to build one or go just with open data. Our proposal is in favor of open data through a number of factors: First of all, NSDI projects are generally long term projects. The US NSDI started in 1994 by the executive order of President Clinton, but the appearance of its Geo-portal, GOS (Geospatial One-Stop) was no earlier than 2003. EU's INSPIRE project having roots in much earlier than its official start of May 2007 has a road map extending 2021. The second factor is related to the "schema-based" nature of NSDI approaches. That is, in a specific SDI, application schemas have to be defined with respect to the expected applications or use cases of that SDI. INSPIRE, for instance, is geared towards environmental policies of EU; The aim was to manage environment related directives of EU. Hence, the information content of 34 INSPIRE themes have been determined accordingly. What happens when a user needs some information which is not covered by application schemas? For instance, the "bed-capacity" information of hospitals which would be needed in an emergency use case may not be available in an environmental SDI like INSPIRE. Open data approaches overcome this problem by serving just any data or the data that is not limited by a certain schema. Although, the burden is on the user or the developer side concerning the filtering out the needed content, this would not cause a problem with much larger and powerful developer communities than that of the times of NSDI proposals. Thirdly, due to its much broader content, the user communities and thus economic values will naturally be much larger in the case of open data.



Several SDIs with different contents naturally...



# 3. Discussion

# Discussion and next steps

## Scope: the development and implementation of a renewed Spatial Data Infrastructure Research Agenda ('SDI2030')

### DEVELOPMENT

= identification of research topics in order to stimulate relevant and promising SDI research

Questions:

- *What should be the scope of the research agenda?*
- *SDI, broader, or narrower?*
- *Which concepts or topics should be included in the research agenda?*
- *How to structure these concepts and topics in a logic framework?*
- *How to link with other domains and other disciplines?*
- *How to build further on past and ongoing SDI research?*

### Discussion approach:

1. Individual input via online voting system
2. Breakout group discussions
  1. Scope and content of SDI research agenda: 5 key topics
  2. Future collaboration and exchange: 3 key actions

### IMPLEMENTATION

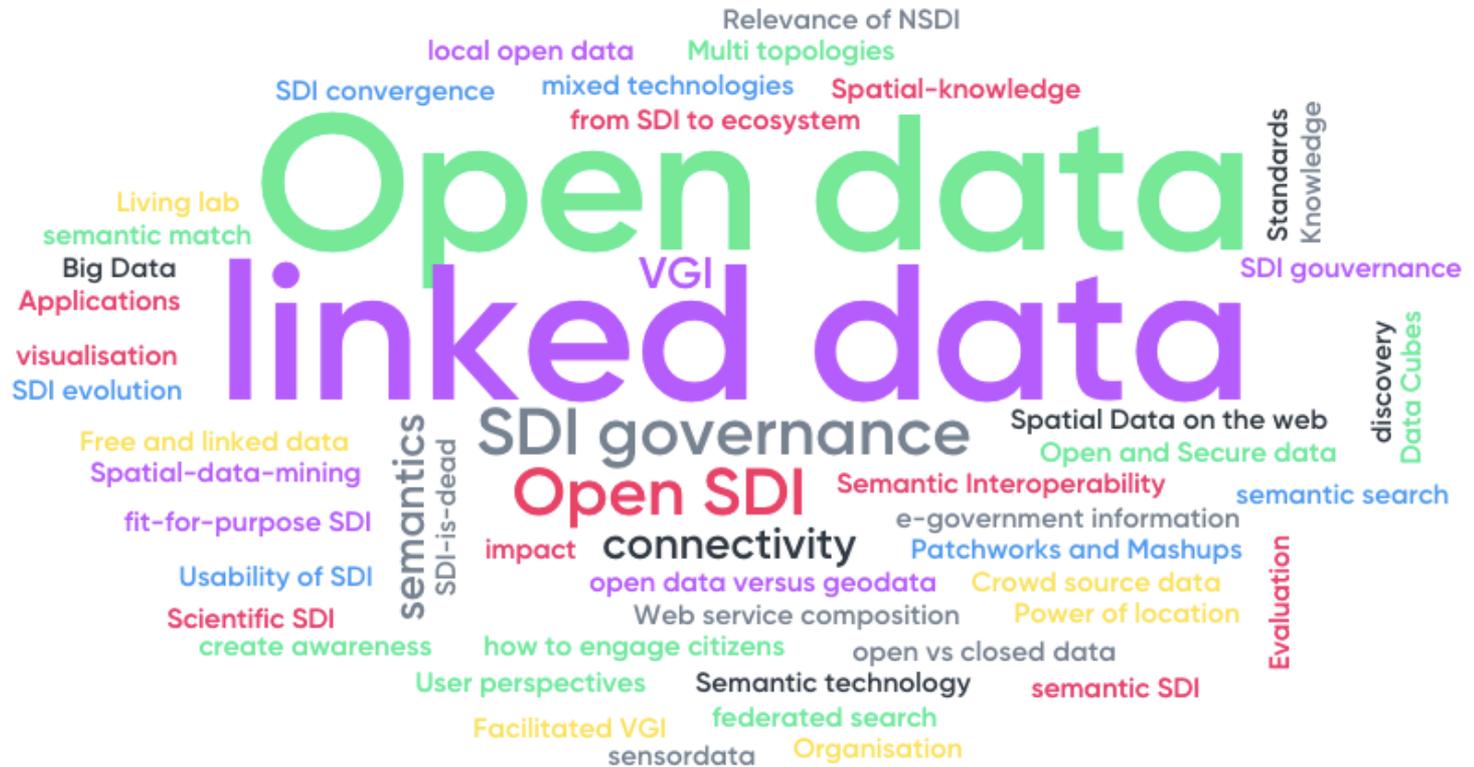
= foster collaboration and exchange and increase the connectedness between SDI researchers

Questions:

- *Do we need more collaboration and exchange of ideas?*
- *How to realize this?*
- *What should be next steps on shorter term?*
- *What could be next steps on a longer term?*
- *How to structure and coordinate the collaboration?*
- *Do we need a – new – formal –organization?*
- *Can we collaborate with existing networks and organizations?*
- *How to coordinate and sustain the collaboration?*

## Discussion

Prior to the discussion in smaller groups, participants were asked to share their view on topics for further SDI research through an online voting system. The figure below shows the word cloud of the research topics proposed by the workshop participants. Among the most often mentioned topics are open data, linked data, VGI, governance, connectivity and semantics.



# Breakout group discussions

## BREAKOUT GROUP 1

### Research topics and questions

- Spatial data ecosystems
- User engagement and empowerment
- Steering INSPIRE implementation
- Connecting worlds: open SDI; domains; disciplines
- Instruments for measuring SDI impact
- Putting SDI on the political agenda provided the socio-economic context

### Actions

1. global SDI research agenda connected to the SDG
2. Innovation/living labs (bottom up)
3. Informal but in-depth workshops (at least 2 a year)
4. Simple interactive platform to share knowledge
5. Engage (SDI?) researchers from other sectors

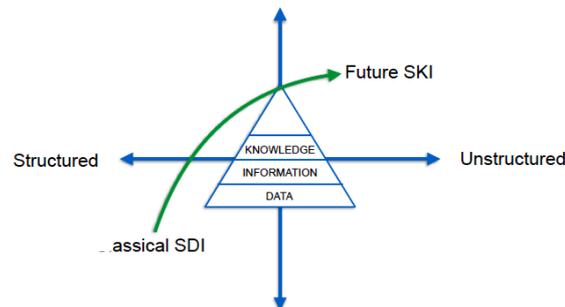
## BREAKOUT GROUP 2

### Research topics and questions

- New domains
- New models
- Integration of concepts from different domains

### Actions

1. IJSDIR - Create a platform for discussion on new ideas
2. Visionary video
3. Workshop where we focus on a specific domain - example BIM



## BREAKOUT GROUP 3

### Research topics and questions

- Scenario-based projects with beyond the base structured data in SDI
- SDI and IoT intersection points
- Automating the incorporation of unstructured data into application through data mining, knowledge discovery.
- Feeding un(semi) structured Open Data in Semantic web services composition
- Streamlining NSDI curricula within the context of current research agenda.

### Actions

1. Apply for research fund
2. Capacity building projects for exchange of good practices and experiences
3. In-depth conferences and workshops

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