Methodology to Describe, Analyse and Assess Sub-national SDIs: Survey, Experiences and Lessons Learnt[*]

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Abstract

Over the last ten years development of Spatial Data Infrastructures (SDIs) has become an important subject being a driving force towards the vision of Digital Earth increasing the availibility and accessibility of geographic information exchange and sharing of spatial data. Worldwide, large investments have been made to develop SDI initiatives. Given the expenditure and society's interest in the proper and effective use of these funds, it has become a necessity to have reliable methods and instruments to assess these SDI initiatives. However, the assessment and evaluation of SDIs is an extremly challenging task due to a number of reasons. Although the literature provides a number of assessment methods, all of them either concentrate on only some aspects of an SDI or on one specific region, or are still conceptual in nature (Crompvoets et al, 2009). In this paper, the authors introduce a new pragmatic appoach to identify, analyse and assess SDI solutions having the principles of Digital Earth, INSPIRE and

GMES in mind. This approach has been developed by the Thematic Network eSDI-Net+ and has been validated in a comprehensive survey involving about 200 SDIs from 26 European countries as well as different stakeholders involved in the creation and use of SDIs throughout Europe. The main purpose of the paper is to introduce this unique SDI assessment methodology as well as to demonstrate the possiblities of its practical application. Furthermore, the paper critically reflects the experiences made and lessons learnt by applying this methodology in a survey of the subnational SDIs in Europe in 2008-2010 and discusses the main implications for future SDI research, in Europe and worldwide.

Keywords: Sub-national Spatial Data Infrastructures, SDI assessment, Digital Earth, GMES, INSPIRE compliance

1. INTRODUCTION

The spatial data infrastructure (SDI) field goes back twenty years but it did not really take off until about ten years ago. Since then it has been transformed by two momentous developments. The first of these is the accelerated diffusion of SDIs throughout the world during the last ten years. As a result, most countries in Europe have now taken steps to implement at least one component of a national SDI. The INSPIRE initiative has played an important role in promoting this diffusion process in Europe but similar developments have taken place throughout the whole world.

The second momentous event is the shift in emphasis that has taken place in the second generation of SDIs from national (strategic) SDIs to subnational (operational) SDIs (Masser, 2009). Whereas a great deal of the discussion in earlier years revolved around talking about (national) SDIs much more time is currently being spent of discussing different ways of doing (subnational) SDIs and success at the subnational level has become a crucial yardstick of overall success.

These two developments have been recognised in a number of recent European initiatives. These include a workshop on Advanced Regional SDIs that was held at the Joint Research Centre in Ispra in May 2008 (Craglia et al, 2009) and the series of national and regional workshops organised throughout Europe as part of the eSDI-Net+ project (http://www.esdinetplus.eu/). This is a Thematic Network co-funded by the eContent*plus* Programme of the European Commission and coordinated by the Technical University of Darmstadt, Germany which has promoted cross-border dialogue and stimulated the exchange of best practices on Spatial Data Infrastructures in Europe. The project started in September 2007 and ended in August 2010.

The findings of the eSDI-Net+ project are particularly interesting in that it brought together a substantial number of SDI players in a Thematic Network which provided a platform for the communication and exchange of ideas and experiences between different stakeholders involved in the creation and use of SDIs throughout Europe. The network also promoted Europe-wide debates as well as sub-national, national and regional discussions within Europe. In the process it has made an important contribution towards the characterisation of SDI implementation throughout Europe and collected information about more than 200 working, accessible and intelligible solutions. To facilitate this task a unique SDI assessment methodology was developed by consortium.

Over the last ten years development of Spatial Data Infrastructures (SDIs) has become an important subject being a driving force towards the vision of Digital Earth[1] increasing the availibility and accessibility of geographic information exchange and sharing of spatial data. Worldwide, large investments have been made to develop SDI initiatives. In particular in Europe the investment requirements for an Infrastructiure for Spatial Information at European, national and subnational levels are estimated to be from 202 to 273 million EUR each year (Dufourmont, 2004). Given the expenditure and society's interest in the proper and effective use of these funds, it has become a necessity to have reliable methods and instruments to assess these SDI initiatives.

Although the literature provides a number of assessment schemes, all of them either concentrate on only some aspects of an SDI or on one specific region, or are still conceptual and theoretical in nature (Crompvoets, 2009). Therefore, the methodology developed by the eSDI-Net+ Network, being very practice-oriented, might be a helpful and useful instrument in SDI assessment. It provides a pragmatic approach to analyse and evaluate subnational SDIs, considering best practices from which SDI stakeholders can learn from as well as the key factors of their success.

With these considerations in mind this paper introduces the unique SDI assessment methodology developed by the Network, demonstrates the possiblities of their practical application. It critically reflects the experiences made and lessons learnt during the SDI survey in Europe in 2008-2010 and discusses the main implications for future SDI research, in Europe and worldwide.

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[1] The concept of the Digital Earth was proposed by the former US vice president Al Gore on January 31, 1998. It describes a virtual representation of the Earth that is spatially referenced and interconnected with the digital information sources worldwide. (Gore, 1998).

2. SDI IDENTIFICATION AND ANALYSIS

The SDI assessment methodology and approach described below base on the experiences made during the SDI survey performed in the context of the eSDI-Net+ project co-funded by the European Commission. This unique pragmatic appoach to identify, analyse and assess subnational and thematic SDI solutions considers both the principles of Digital Earth, INSPIRE and GMES as well as the good practices in already implemented solutions.

This approach has been developed by the Thematic Network eSDI-Net+ and has been validated in a comprehensive survey analysing about 200 SDIs from 26 European countries as well as different stakeholders involved in the creation and use of SDIs throughout Europe. This approach has been used as a guideline for interviews of sub-national and thematic SDI officials and for recording the results of the twelve national workshops, which were held in the framework of the SDI survey with its culmination in the SDI Best Practice Award 2009, held in November 2009 in Turin. Nevertheless the information collected during this survey makes no claim to be complete but is rather supposed to indicate the direction and give impulsed for further studies.

2.1. Definition and Naming

The starting point for the SDI assessment was a clear definition of what an SDI is. Literature provides numerous definitions. The first institutional definition (US 1994) was:

"National Spatial Data Infrastructure (NSDI) means the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data" (Executive Order 12906, April 13, 1994, http://www.fgdc.gov/publications/ documents/geninfo/execord.html). This definition focuses on overall goals of SDI.

"Infrastructure for spatial information means metadata, spatial data sets and spatial data services; network services and technologies; agreements on sharing, access and use; and coordination and monitoring mechanisms, processes and procedures, established, operated or made available in accordance with this Directive" (Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community, INSPIRE, Art.3, http://www.ec-gis.org/inspire/). This second definition, given in the context of the INSPIRE Directive, describes the components of SDI instead.

Spatial Data Infrastructures are formal arrangements with the main goal to increase access and availability of geographic data across a given area. The goal

is to share experiences, analysis or data between the organisations involved, to realise or to foster their services, to reduce costs, and to enhance the diffusion of public data to other stakeholders, especially private companies and citizens. Extended goals of an SDI include the enablement of easier GI development, use, and collaboration between participants (individuals and organisations) in order to enhance the knowledge of the area and its shared comprehension. Thematic communities and communities of practice are often organised in an SDI. The SDI is meant to be used at the user level.

SDI differs from, for example, a complex geographic information system of a territorial body as an SDI cannot operate without catalogues, assign key role to metadata and serve data to external users. It requires solving issues related to integration and harmonisation of data from different owners and data producers. Similarly Web services and Web-GIS differ. The former is a mechanism over the Web offering services regarding data where the latter offers the usual GIS functionalities (mainly analysis functions) over the Web. In this context, the lack of understanding of the definition of a geoportal is evident. Most regions are advertising their systems as geoportals, but apparently these systems are only Web-GIS, publishing locally managed resources. Some SDI solutions, e.g. in Italy, used the term GIS to identify their name. This fact highlights an interesting issue: these regions look at SDIs as an evolution of their GIS. In France or in UK they even did not use the term SDI to qualify their SDI.

At the beginning of the survey, it was also important to define level of the SDIs to be analysed. In many countries, spatial data infrastructures are developed at a subnational level. In the context of the survey described in this paper, subnational means NUTS 1, NUTS 2, NUTS 3 levels or any of their aggregations according to the administrative structure of the countries, referring to the nomenclature defined by the European statistical office EUROSTAT[2]. It means that SDIs developed at lower levels (LAU 1 and LAU 2, former NUTS 4 or NUTS 5[3]) were not considered unless they are recommended as real good practice in the national context. In some countries NUTS 4 were considered when they play effectively a stronger role than NUTS 3. Sub-national SDIs that are not fitting within the administrative structures of a country may also exist. They have also been considered if they have either a large extension (at least as wide as a NUTS 3 area) or have a trans-national nature. Nonetheless, the methodology is applicable at any level of government notwithstanding the fact that INSPIRE applies to the lower level of government when the law assigns them a data responsibility.

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[2] http://ec.europa.eu/eurostat/ramon/nuts/home_regions_en.html
[3] http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/local_administrative_units

Regarding the definition of what is an SDI best practice we agreed that it was more appropriate to talk about good practices than best practices due to the fact that there is no "ideal" SDI and that there are many perspectives to look at an SDI. A first general conclusion made during the performance of the SDI analysis and assessment campaign is that a mature SDI is difficult to find. For instance, in France most of subnational SDIs created are less than three years old but are almost operational SDI. Nevertheless, it must be recognised that some components of SDIs exist in all French regions and some Italian areas.

2.2.   Contents of the SDI Analysis

The main stages of the evaluation process are summarised in Figure 1. The first of these was devoted to the development of an initital methodology for describing sub national SDIs. This methodology helped in the selection of SDIs during the second stage to participate in a series of national and regional workshops that were organised by the different consortium partners throughout the whole of Europe. Following these workshops an evaluation framework was developed and a table of indicators was created in the third and forth stages which was used by a jury consisting of representatives of the consortium members and the project's advisory board to select SDIs that they considered to be examples of good practices in Europe as a whole.

Figure 1: SDI Analysis, Evaluation and Selection Process

At the beginning of the SDI identification phase eSDI-Net+ network invited all types and sizes of stakeholders in charge of SDI developments from any region of Europe and at any level, from local through regional to national. The

application should be submitted by organisations facilitating access to geographical content or providing geo-information services to end-users.

SDIs to be considered had to meet the following criteria:

1. They must have been operating for at least the last one year;
2. They should meet the overall profile outlined in the invitation;
3. The SDI application must also be web-based;
4. The application must include an accessible web address.

With these considerations in mind, the partners in the eSDI-Net+ project were asked to identify SDIs in their areas and set up interviews with key officers of the SDIs using an agreed questionnaire. These considered the administrative context of each SDI, the extent of SDI usage, the user networks that had been created by the SDIs as well as their socio-economic impacts, and their legal, organisational and technical characteristics.

To describe and to analyse subnational SDIs the partners developed a common document serving as an operative guideline for the SDI selection process, in particular for the interviews of SDI officials. This questionnaire called "Evaluation Framework for describing sub-national SDIs" based on the on the assessment methodology containing detailed information about the SDIs. The contents of this Evaluation Framework are the SDI ID Card, detailed information as well as a summary provided by the national contact points about the SDIs in each reagion.

The Evaluation Framework contained 106 questions. The main topics that were included in the questionnaire are listed in Table 1.

Table 1: Information Used to Describe a SDI

Sub-national SDI identity card	15 questions
SDI usage assessment	14 questions
Networking people assessment	10 questions
Socio-economic impact analysis	9 questions
Organisational assessment	12 questions
Coping with legal aspects	6 questions
Technical functionalities-facilities-components	28 questions
Geoportal assessment	12 questions

This questionnaire provided a common basis for the interviews and the analysis of sub-national and thematic SDIs. The role of interviewers was substantial with

regard to the aim of assessing subnational SDIs, and also with regard to the goals of INSPIRE and GMES.

The interviewer activity consisted of five steps:

- Identifying the sub-national officials, i.e. the person that chairs the "executive" committee of the SDI and the person that is responsible for the day to day running of the SDI;
- Undertaking a direct interview of the identified officials and invite them to participate in the national workshop. If possible, interviewing also some politician in charge of or interested in the SDI;
- Compiling any written materials from the SDI officials that relate to the assessment;
- Performing control using the internet and analysing the SDI geoportal;
- To minute the interview and producing an assessment sheet by elaborating a synthetic report written in a homogeneous and comparable way.

While many interviews were carried out personally, some of them were performed by phone. The Evaluation Framework summarizing the interview was sent to interviewed persons to confirm its contents and to integrate eventually missing data and information. Some partners, such as Italy, have supplemented the analysis of the SDI with an Internet-based performance control of the SDI geoportal. In some cases, e.g. in Spain, it was not necessary to arrange personal interviews with SDIs officials since the necessary information was already available, due to advanced development of the country in the SDI area. If there was the need of translating the Evaluation Framework, it was suggested to also have the original version in English available during the interview as some specific terms used by the GI community do not have proper translations in the national languages. Applying the Evaluation Framework in practice, we clearly realized that it better refers to mature SDIs, yet most sub-regional SDIs are still in an inception or development phase.

Some difficulties experienced by the partners occurred due to following factors:

- the extensive length of the Evaluation Framework, which took at least two hours to complete;
- the subjectivity of some questions that are more based in the manager's personal opinion;
- the non-applicability of some questions to the interviewed person and the evaluated SDI which is complicating the direct comparison with other evaluated SDIs.

In any case, while discussing and compiling the Evaluation Framework, interviewed people were led to rethink their experiences and they used the

Evaluation Framework as a check list of what was done or had to be done. Nevertheless, it has to be highlighted that considered sources of information were officials in charge of SDI and, only in some cases, evaluations of SDI geoportals done by interviewers. No direct analysis of SDI users and user's satisfaction was planned and done.

After an initial evaluation of the applications on a regional level, a number of promising SDIs were selected for detailed interviews to provide further information. Each interviewed SDI was evaluated by the national representatives of the eSDI-Net+ project, focusing on the key aspects such as:

1. The technological, innovative level and originality of the project
2. Implementation of and/or readiness for the INSPIRE principles
3. The level of fostering cooperation between different users (proof of visibility and/or user feedback)
4. Possibility of extension or transfer to other countries and regions

2.2.1. The SDI ID Card

First of all, a list of basic information to be collected had to be defined. We call this list *SDI Identity Card.* It contains following information:

- Country name
- NUTS level
- Sub-national entity name
- SDI name
- Mission and objective
- Legal status
- Funding mechanisms
- Human resources of the permanent team:
- Legitimacy (that means: there is an official act establishing the SDI, e.g. a Regional Law)
- Year of creation
- Partners in the SDI (who pays, who benefits from)
- Binding mechanisms for the partners
- Development status (inception, in development, in operation)
- URL

2.2.2. Detailed Information

The following list includes issues to be investigated and criteria that may be used in analysing subnational SDIs:

Qualitative Analysis:

Information to be obtained here tackles the quality of data, metadata and services. In particular, compliancy to standards and INSPIRE Implementing Rules (IR) needs assessment.

Quantitative Analysis:

Quantitative aspects of data, metadata and services include information about the number and percentage of information layers as well as services provided with metadata that is compliant with the INSPIRE Metadata Implementing Rules. Furthermore, the availability of discovery, view or download services is important in this context. This information could be gathered during direct interviews but required verification by analysing the geoportal.

SDI usage assessment:

This set of questions intends to analyse SDI usage based on user requirements and satisfaction. The basic information to acquire is whether the SDI development has been based on clear and well defined user requirements. The definition of the users in each specific context (and their classification) is let to the interviewed persons. Existing actions to verify user satisfaction need further investigation. Direct interviews with users might be necessary to open up an additional perspective.

Social impact:

The SDI workflows, its influence on the relationships between citizens and Public Administration and SDI impact in comparison with GIS impact makes the core of the social impact analysis.

Networking and consensus building:

This set of questions intends to understand the networking issue the sub-national SDI has to face in order to create a climate of opinion, to identify common interest, shared interest, and to build consensus. It relates to the humaneness and tries to identify what exists beyond the digital façade (the emerged part of the iceberg visible on the net).

Socio-economic impact analysis:

This set of questions intends to evaluate whether the sub-national SDI has undertaken socio-economic impact analysis, e.g. cost benefit analysis, and cost

avoidance. The objective here is to collect results, if any, and identify innovative methods.

Organisational aspects:

This set of questions intends to assess the place of the sub-national SDI in the overall organisation of the territory. Questions in the area of administrative area governance, funding and responsibility and other organisational aspects are raised.

Coping with legal aspects:

Legal aspects of sub-national SDI are two fold. On the one hand it copes with the laws and regulations that the SDI has to comply with and on the other hand what is the legal status that the SDI should have to reach sustainability.

General remarks:

Here it was posiible to make some general remarks about the future perspective and sustainability of the SDI.

Geoportal evaluation:

These questions are related to visibility, multilingualism, consistency in the nomenclature and effectiveness of the view service. This section was not an obligatory part of the interview. It could be filled in back-office after appropriate analysis on the web.

After the accomplishment of the interviews and selection of national and regional SDI good practices, twelve national and regional SDI Best Practice workshops were organised throughout Europe. The workshops focused on common issues, usability and socio-economic impact of SDIs and addressed the integration between SDIs and e-government policies. They brought together stakeholders, and showed use cases and questions. The national and regional workshops were held during one or two days, a period appropriate to represent some SDI solutions and to exchange experiences.

The interviews and workshops were helpful to get an overview about the state-of-the-art of SDIs, to collect experiences, success cases and obstacles in each country. It also helped to understand the different primary goals and focuses of existing SDIs (e.g. involvement of participants on communal level, technical interoperability, addressing financial/technical obstacles of participants).

3. SDI EVALUATION AND ASSESSMENT

3.1. Evaluation of SDI Good Practices

Following the workshops SDI officers were asked by the organisers to register their activities on a common eSDI-Net+ database. By October 2009 this database provided details of 135 SDIs from 24 different countries which were subsequently evaluated by the jury.

An indispensable step mady by the jury was building, from collected information, a set of indicators, easy manageable in a database, useful for summarizing descriptions of analysed SDIs of various European countries and for running the SDI Best Practice Award[4]. These indicators had to be tightly characterized with reference to the vision of a common European Spatial Data Infrastructure on what are key issues in establishing successful SDIs, and also to collected information included in the Evaluation Framework.

3.2. SDI Assessment Indicators

The indicators definition process begun with focusing on 5 macro-criteria (see list below). In the framework of these five macro-criteria, 32 indicators were defined.

The whole process of macro-criteria and indicators definition has been shared and intensively discussed among experts and key players in the GI field. These indicators have been harmonized and integrated, as far as possible, in order to increase the value of cultural, normative and technical differences. Within the SDI analysis and selection process, the assessment criteria list has been continuously revised in order to create a strong evaluation basis for the SDI Best Practice Award 2009.

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[4] Indicators (and indexes) are defined in different context in various ways. In eSDI-Net+ Project OECD definitions, often quoted, were assumed. See: OECD Organisation for Economic Co-operation and Development, 2003, OECD Environmental Indicators. Development, Measurement and Use, http://www.oecd.org/dataoecd/7/47/24993546.pdf

Table 2: Evaluation Criteria and Indicators

Five main criteria	32 weighted indicators
1. SDI «size» (quantity)	6
2. SDI «quality» (meeting user requirements)	7
3. Co-operation and subsidiarity	7
4. Sustainability	4
5. Users usability	8

The following list summarizes the 32 indicators:

Quantitative aspects (6 indicators):

- Number of information layers / datasets
- Percentage of information layers provided with visualisation or download services (WMS)
- Percentage of information layers and services provided with standard metadata (ISO19115, INSPIRE IR, Dublin Core, etc.)

Data and service quality (7 indicators):

- Importance of precision and quality
- Promotion of value-adding services (spatial analysis, cartography, indicator computation, etc.)
- Availability of geoportal facilities to support data sharing
- Availability of discovery or view services
- Availability of a metadata catalogue with a search engine
- Availability of Web-GIS for view functions

Co-operation and subsidiarity (7 indicators):

- Information on parties responsible for the SDI development and implementation
- Handling of costs
- Information about structure and networking
- Provision of users training

Sustainability (4 indicators):

- Socio-economic impact
- Sustainable business model and specific budget
- Legal status and dealing with legal aspects (IPR, PSI, DBP)

Users and usability (8 indicators):

- Multilingualism
- Consideration of user requirements
- Level of openness (access, payment)
- Target users (public or private sector)
- Consideration of SDI usage and user satisfaction
- Availability of service performance measurements

The final assessment step consisted of synthesising indicators and in building weighted indexes.

3.3. Some Remarks about Indicators and Assessment

Not all indicators involve obvious evaluation criteria and a univocal value hierarchy, or better, the majority does not. Some examples: "Number of information layers" or "Level of openness" issues are to be related with SDI objectives: in fact, a "good" SDI can include a limited number of layers, because this is its aim, or can be not open for general public on purpose, because e.g. sensitive information are managed.

Some indicators are not univocal in measuring "goodness" in an even more complex way: For example, the indicator "Legal status" and related issues. With reference to Italy we could say that a clear institutionalisation (likely) means the involvement of politicians, a more clear definition of cooperation agreements among various parties and a more stable budget. With reference to the UK on the other hand, a less defined legal status could be considered a key strategic factor since it could relate to a much higher flexibility. In summary it can be stated that these indicators are useful for describing SDIs, yet they are less useful in assessing them. Therefore, these indicators were not considered in the assessing process.

3.4. Sub-setting the Assessment Process

In analyzing and evaluating SDIs, as highlighted e.g. by the French experience, two issues proved to be quite important: for general purpose SDIs, its territorial level (the NUTS level) and the fact of being a thematic SDI. These two issues are addressed in the SDI database structure.

Considering that at the present time the majority of SDIs (or all of them) are still not mature, considering specific SDI components resulted in an effective and fertile approach. With reference to Italy, for example, we can say that the Piemonte region can be considered as a good practice in relation to the data policy issue, the Lombardia region in relation to the subsidiarity issue, the Sardegna region in relation to technological aspects and the Friuli Venezia Giulia region in relation to the legal status.

3.5.   From Indicators to Weighted Indexes

Originally quantitative indicators were normalized on common scale, from 0-10, in order to make them comparable. Qualitative indicators were graded. Since this is a highly subjective step these grades were revised several times during the process.

Indexes resulting from previous steps were weighed and aggregated in order to build synthetic indexes. Firstly, five aggregated indexes were created with reference to the five focused macro-criteria. A further step was to aggregate macro-criteria 1 and 2 (quantity and quality) and 3 and 4 (cooperation and subsidiarity, sustainability).

This assessing process was applied to general purpose SDIs (85 SDIs out 135). Thematic SDIs were dealt separately: an overall index was created for this category. The described assessing process was performed against analysed SDIs: grades, weights, how far to go in building aggregated indexes were discussed in front of real data, considering the sensitivity of results to tentative change the jury was inserting.

The jury always kept clearly in mind that establishing indexes does not mean an automation of assessment but a clarification of the process. Weights and indexes do not transform intrinsically subjective processes in objective ones, but were useful in order to clarify assessments of various components and aspects of SDIs and to give an overall comparative coherence to assessments.

Weights and indexes are highly debatable, questionable; in the sense they are useful for debating and reasoning. This was exactly what happened inside the jury. Various factors influencing the creation of an SDI and its implementation trajectory have been considered in the self-assessment framework described in the chapter 3.7. Some of them are structural, "hard" factors, like favourable legislation, strength of local authorities, overall technological development of the country, the economic situation etc. Others are "soft" factors like attitudes of involved people and their willingness to cooperate.

3.6.   SDI Best Practice Award

Considering all SDI submissions, the jury finally selected the 12 SDIs, listed in Table 3 below, who were subsequently invited to the Best Practice Awards Ceremony in Turin in November 2009. They jury also found that there were considerable differences between the selected SDIs and decided that all the selected SDIs were winners in terms of their own best practices and that it would be invidious to select overall winners from such a diverse group. The extent of this diversity can be seen from a more detailed analysis of the presentations of the 12 SDIs. These were grouped into four broad categories:

- Technology, with particular reference to quantitative and qualitative aspects of data and service quality,
- Organisational and institutional aspects including cooperation and subsidiarity as well as sustainability,
- User involvement, and
- Thematic SDIs.

3.6.1. Technological Aspects

Three of the presentations fell into this category. The first of these from the **Forth Valley GIS in Scotland** described the evolution of the present local authority public company from an informal collaborative agreement between three local authorities in 1993 to combine their GIS activities. This company has been driven by business needs to develop a wide range of applications in many different parts of Scotland as well as the components of a SDI for its three main shareholders. Its success in meeting these needs was recognised in a recent survey of local authority services in Scotland as a whole when it was described as the 'most frequently mentioned example of good practice.'

The second presentation of **Portugal's Sistema Nacionale de Informacao Geografica (SNIG)** discussed the resurgence of one of the oldest SDIs. SNIG was set up by law in 1990 and played an important role during the nineties in modernising local government in Portugal. In recent years issues of affordability and sustainability together with education have been central to its latest phase of development.

The last presentation in this group considered the work of **IDERioja**, the SDI that has been developed for the autonomous region of Rioja in Spain. With a population of only 300,000 Rioja is a relatively small region. Its SDI has evolved over the last ten years into a neat example of centralised GI management which has won awards in Spain with respect to both good practice and eGovernment.

3.6.2. Organisational and Institutional Aspects

Three presentations were made of SDIs that were primarily selected as best practices with respect to their treatment of organisational and institutional aspects. The presentation of the **Centre Regional de Information Geographique for the Provence-Alpes-Cote d'Azur (CRIGE-PACA)** described the development of a SDI for the public sector in a large region extending over six Departements in south east France where one job in every five is in the tourism industry. The strong thematic dimension to this SDI was evident from the twelve different applications that had been established and the staff saw one of their main objectives as coordinating communities of practice within the region.

The second presentation about the development of the **SDI for the state of Nordrhein-Westfalen in Germany** also covered a large area. Its population of more 18 million is more than that of many European Union member countries. An important feature of this SDI is the strong links that exist between the state organisation and the municipalities in the region because the lower level authorities were responsible for the collection and maintenance of cadastral information. The information that is held in this SDI is made widely available to private as well as public sector bodies and more than a million maps are downloaded from the SDI by users every month.

The final presentation in this section was by staff from the **Infrastruttura per l'Informazione Territoriale della Regione Lombardia in Italy**. This SDI was strongly driven by spatial planning considerations and its main emphasis was on the creation and maintenance of a regional topographic database which acts as a platform for other applications. Information held in this database was also made freely available to private sector users.

3.6.3.   User Involvement

Two SDIs were selected with respect to their strong user involvement. The first of these presentations of the **Infraestructura de Dades Especiales de Catalunya (IDEC)** in Spain described itself as 'a network of labelled web services' The main objectives of this SDI were to facilitate the use of geographic information and to motivate all kinds of users. As a result of IDEC's activities more than half the municipalities in the region are actively making use of geographic information in their work and private sector users account for forty per cent of all usage. The second presentation in this group was made by staff from the **X-Border GDI** that is led by the province of Limburg in the Netherlands introduced another dimension into the discussions. As its name suggests this SDI is a collaborative venture which involves four Dutch provinces, three Belgian provinces and 12 districts (Kreis) from Germany. Its activities are very much problem oriented and user driven, with particular reference to emergency management and spatial planning in a densely populated border region.

Table 3: Award winners

Award Winners	Region and country	URL
Tecnological aspects		
Forth Valley GIS	Scotland, UK	www.forthvalleygis.co.uk
SNIG - Sistema Nacional de Informação Geográfica	Portugal	http://snig.igeo.pt
IDERIOJA: Infraestructura de Datos Espaciales del Gobierno de La Rioia	La Rioja, Spain	www.iderioja.org
Organisational and institutional aspects		
Centre Régional de l'Information Geographique (CRIGE-PACA)	Provence-Alpes-Côte d'Azur, France	www.crige-paca.org
GDI Nordrhein-Westfalen	North Rhine-Westphalia, Germany	www.geoportal.nrw.de
Infrastruttura per l'Informazione Territoriale (IIT) della Lombardia	Regione Lombardia, Italy	www.cartografia.regione.lombardia.it
User involvement		
IDEC Infraestructura de Dades Espacials de Catalunya	Catalunya, Spain	www.geoportal-idec.net
X BORDER GDI (Cross border Geo-data infrastructure XGDI)	Province of Limburg, Netherlands	www.x-border-gdi.org
Thematic SDIs		
National Land & Property Gazetteer and National Street Gaze	English Regions & Wales, UK	www.nplg.org.uk
SIG Pyrénées	Aquitaine, Midi-Pyrénées et Languedoc-Roussillon, France	www.sig-pyrenees.net
Plansystem.dk	Denmark	www.plansystem.dk
Norway Digital-ND	Norway	www.geonorge.no

3.6.4. Thematic SDIs

This group raised important questions about the nature of SDIs. Some participants felt that they should have been disqualified on the grounds that they were not 'proper' SDIs at all but it was pointed out that 43 out of the original 135 submissions fell into this category and that many of them contained good examples of best practices. The latter is evident from the four shortlisted examples. The first presentation discussed the creation of the **National Land and Property Gazetteer and the National Street Gazetteer in England and Wales**. The initial stage of this project took ten years to complete and required the active participation of nearly 500 local authorities to create databases to a common set of standards. This highly decentralised initiative provides a consistent platform for local authorities to develop a wide range of thematic applications.

There was also a strong applications emphasis in the second presentation from the **French SIG Pyrenees** staff. This SDI recognised the different needs of five main groups of users from agriculture, forestry, climate, economy and spatial planning respectively and created bespoke solutions for each of them using open source software and content management systems platforms such as Joomla! as well as conventional GIS software.

The main objective of the **Danish Spatial Planning System**, the third presentation in this group, was to eliminate duplication in the reporting of the 30,000 local plans that have been prepared by the 98 municipalities in Denmark. The basic philosophy of this system is summarised by the slogan 'data are available in one and only place.' Unfortunately, no one from the staff of the fourth group, **Digital Norway**, was able to attend the awards ceremony. This nation-wide program for co-operation with respect to the establishment, maintenance and distribution of digital geographic data has attracted a great deal of attention in international circles in recent years. Its main objective is to enhance the availability and use of quality geographic information among a broad range of users, primarily in the public sector.

3.7.   SDI Self-Assessment Framework

The experiences with the SDI assessment show that "each spatial data infrastructure is a special case" (Vico 2009). To single out and to follow a successful implementation path in developing an SDI needs understanding of its own strengths and weaknesses. Self understanding implies comparisons and measuring against others. These issues are strictly linked to one of the aims of the SDI Self-Assessment Framework, which was derived from the general SDI assessment methodology.

The SDI Self-Assessment Framework (SDI-SAF) was developed on the basis of the experiences made with the SDI analysis and assessment. This SDI Self-Assessment Framework is intended to help SDI officials or SDI steering committees in characterising and describing their SDI. It can be seen as a check-list useful to better focus key issues in developing an SDI. The structure of the SDI-SAF is based on the SDI database structure. This self-assessment tool will soon be available online at http://www.esdinetplus.eu/_assessment/self.html. It will allow SDIs using it and being interested in publishing their data to transfer their data directly into the online SDI database. The SDI Self-Assessment Framework is intended to facilitate comparison among various SDI practices, and consequently to foster networking and sharing experiences among similar SDIs.

4. RESULTS OF THE SDI ANALYSIS

4.1. Database of SDI Best Practices

All collected and categorised information about the SDIs is documented in a common SDI Best Practice database containing the data from all national and regional sub-databases gathered within the SDI analysis process. In its initial version the database was used by the eSDI-Net+ Network for internal purposes, mainly as the basis for the SDI Best Practice Award 2009. The second iteration has been made publicly available online. This public version of the database can be found at www.esdinetplus.eu/best_practice/database.html (see Figure 2).

In order to make the data base information available and to publish it, officials in charge of the included SDIs, were contacted and asked to check and update the information in the database and to provide an official permission for publishing.

Figure 2: Online SDI Database

Taking into consideration the experience collected, some slight changes are introduced in database structure:

- Some fields of minor significance were dropped;
- Some numerical fields were transformed in classified fields, in order to simplify and stabilize the completion of them.

While the confidential database contained 52 fields, the public database now only has 32. The results of this database restructuring are quite positive: the number of gaps and unfilled fields was significantly decreasing.

European SDI Best Practices were documented and categorised according to the criteria and indicators described above. Following the approval of the SDI owners the publicly available Online SDI Best Practice database contains a subset of the entire database information. Currently 124 SDIs from 21 European countries are referenced there (see Table 4). 69% (85) of the analysed SDIs are non-thematic, 31% (39) are thematic SDIs.

As you can see, the distribution is quite unequal. In our opinion these numbers are only partly correlated with the actual distribution of SDIs in various countries: other factors, some of them casual, influenced this result. For instance, about 44% of the SDIs in the database are French: this partly depends on the fact that AFIGéO, the French national contact point, is a national GI association well rooted in the French context, connected to all subnational SDIs.

The database contains information collected during the SDI identification and analysis phase and provides data from the SDI ID Card as well as further details (see Figure 3). The users of the online database have the opportunity to view the SDIs according their search criteria. These are:

- Country
- NUTS
- Thematic/not thematic (i.e. general purpose SDI)
- Legal status
- Leading partner (Coop_1)
- Number of partners (Coop3_5)
- Workforce
- Numbers of datasets

The database allows data interpretation in various ways, e.g comparisons between several SDIs. Besides the facts describing the SDIs, a radar graph is added in order to visualise the SDI characteristics and to compare SDIs.

Table 4: Distribution of SDIs in the Database per Country

Albania	1	Italy	14
Belgium	1	Norway	1
Croatia	3	Poland	7
Czech Republic	4	Portugal	6
Denmark	1	Portugal/Spain	1
Finland	3	Republic of Macedonia	1
France	55	Slovenia	2
Germany	6	Spain	4
Hungary	6	Turkey	2
Iceland	1	United Kingdom	3
		TOTAL	124

Indicators are graded or normalised in a scale 0-10 and summarised in 4 weighted indexes:

- Technology & INSPIRE compliance: first group of indicators, in light grey in the table
- Cooperation & subsidiarity: second group of indicators, in light yellow in the table
- Sustainability: third group of indicators, in light grey in the table
- Uses/users: last group of indicators, in light yellow in the table.

The radar graph depicts these 4 weighted indexes for selected SDIs. Meanwhile this graph includes two more axes for characterizing the "size" of SDIs referred to fields "number of datasets" and "workforce". The reader will find an exapmle of an SDI comparison in the Online Database illustrated in the Figure 4.

The goal is to extend the database further with additional information and new submissions. At the website, the SDIs not yet registered in the database have the opportunity to fill in an online registration form and to insert their data. After the submission of new SDI data, the system automatically generates an email to the network coordinator. The coordinator reviews the entry and releases it for the publication in the online database. Authorised persons in charge of SDIs have the opportunity to update their data online at any time. The data updates have to

be confirmed and released by the network coordinator as well, in order to avoid misuse of the database. The confidential contact data of the submitting person do not appear in the public database and are only visible for the coordinator.

Figure 3: Example of an SDI Presentation in the Online Database
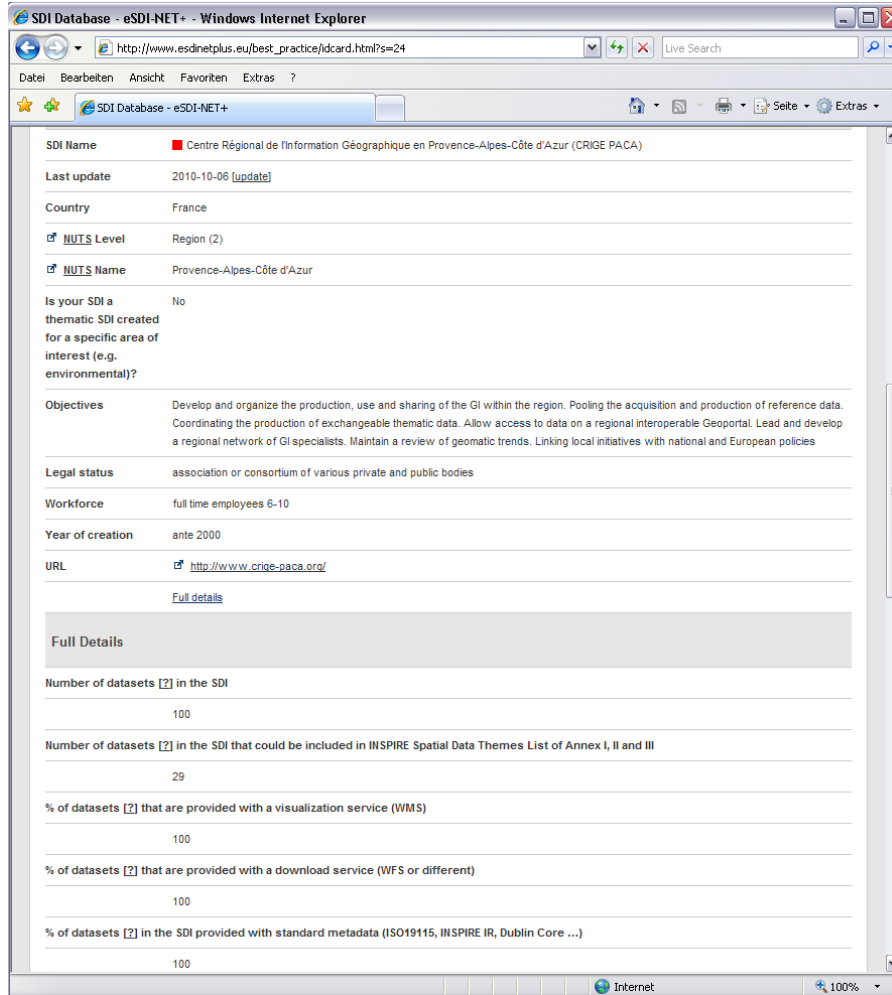
All sub-national and thematic SDIs are invited to self-assess themselves using the eSDI-Net+ SDI self-assessment framework and to feed the reference database registering at http://www.esdinetplus.eu/best_practice/register.html.

Joining it incurs no costs or obligations. Even partial information about an SDI will still enable users to find similar operations in their own or other countries. The database facilitates the exchange of information about common issues even though applications or levels of administration may be very different.

Figure 4: Example of an SDI Comparison in the Online Database
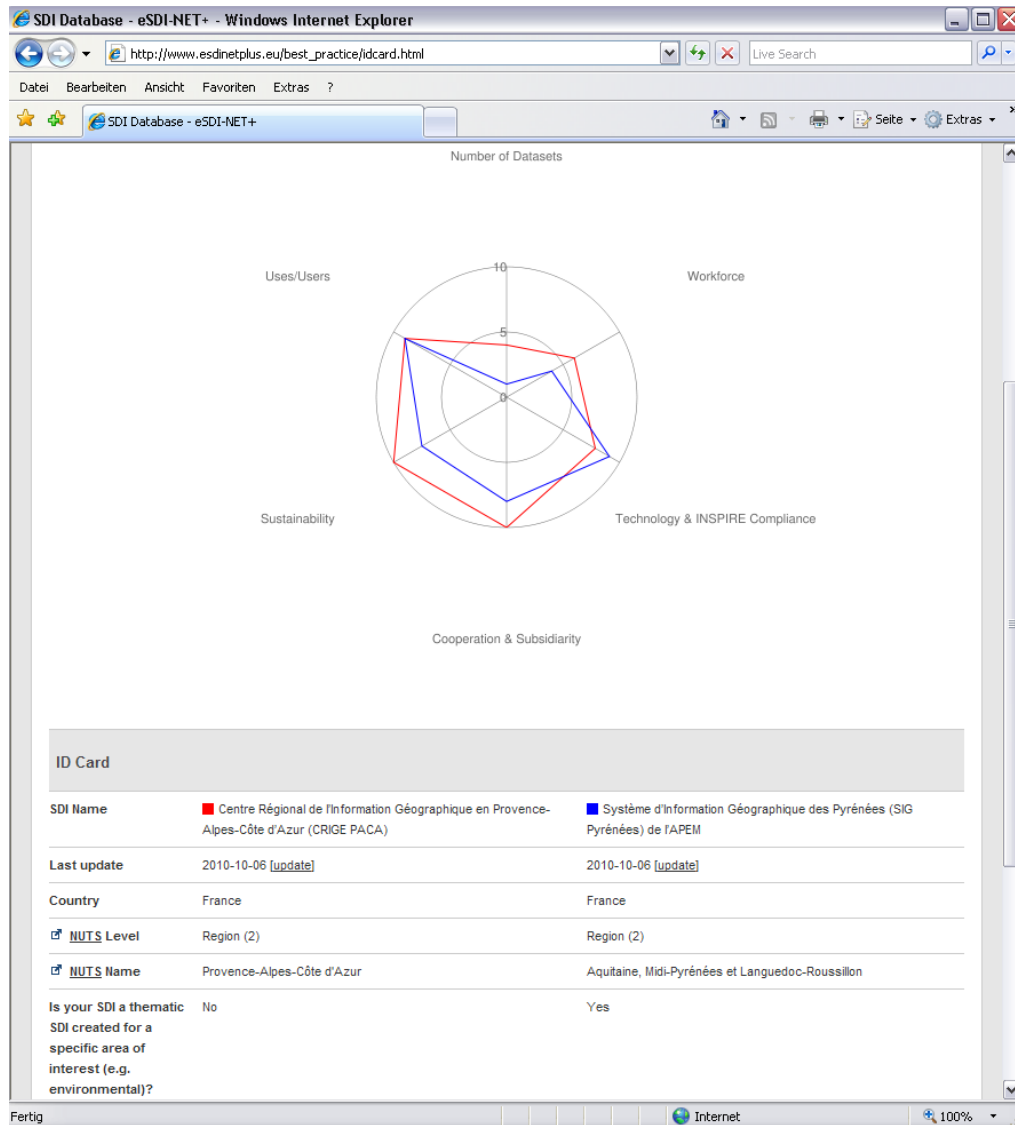
4.2. Interpretation of Information Contained in the Database – Some Examples

There is quite a variety of alternatives to use and interpret the content of the database. For example the self assessment framework offers to opportunity to analyse or identify one's own plans and development effort, either as an existing SDI to identify opportunities for functional or quality improvements or as a new SDI to build awareness about issues to be considered. Along with such a self-analysis the database offers the opportunity to compare my assessment solution with other established SDIs. Comparing the key parameters with other SDIs and the interpretation of relations or dependencies of such parameters can support the decision process about future developments.

Those issues for example might be:

- Which SDIs run a similar mission?
- Are there SDIs with equal objectives to compare with?
- Is there an impact of the legal structure (public or private) on the financial model of the SDI?
- Is there a relationship between the NUTS level and the required resources for an SDI?
- How do SDIs on the same level differ in terms of functionality or services?
- How do I access my user community and select user requirements to fulfil?

Finally this comparison is not limited to the output of the database, but should also initiate the dialogue among the SDIs to exchange their experiences and learn from each other. The database analysis will help to identify those SDIs with common goals, structures, or conditions and can be contacted for further and more in depth information. This direct or even personal contact is of a high interest of the thematic network eSDI-Net+ and of importance for the community to strengthen the exchange among SDIs on the different levels: local, regional, national, cross boarder, European. This shall help to answer questions like:

- What is my neighbour doing?
- What can we learn from this?
- How can we benefit from this?
- What are the approaches in other countries?
- How can we support the harmonisation and integration with others?

To push and ensure such communication started the eSDI-Net+ network decided to continue its efforts in this direction also after the end of the project.

The EURopean Umbrella Organisation for Geographic Information, EUROGI, is committed to take over the results so far and take further actions to continue this network effort. On the one side EUROGI will continue to update the public web

site and to run and maintain the tools (database and self assessment framework) to allow a stable availability. On the other side EUROGI will initiate the continuation of the dialogue started through national, regional and European events, with the goal to run another Best Practice Award in a two year timeframe.

5. DISCUSSION

The SDI assessment methodology and the database reflect both the number and the diversity of SDIs and SDI like activities that are currently under way throughout Europe. Both can be seen as practical instruments for SDI assessment in Europe and worldwide and are potentially valuable resources for further SDI research.

Within a broader context, the expertise achieved carrying out the methodology to assess SDIs as well as that coming out from the SDI assessment activity are very important values for SDI community. Such a methodology will need to be updated while INSPIRE process is going on; it will need to be improved regarding criteria and indicators to take into account changes of technologies, organisations, (geo) culture, user perspectives and so on. It should also be borne in mind that more work is needed to measure socio economic impacts of SDIs as their sustainability over time is likely to depend on the extent to which the experiences of SDI implementation can be benchmarked against investments made and benefits derived from the process (Craglia and Campagna, 2010).

On this line, the SDI self-assessment tool, carried out starting from the methodology introduced in this paper, is a first step in that direction. It may aid SDI stakeholders and people in charge of SDIs to understand the strengths and weaknesses of their organisation themselves and their SDIs as well as to find other SDIs with similar characteristics or features or even for comparable thematic areas.

The advantage of the database and the self-assessment framework for the SDIs is that handling of the questions "forces" the persons responsible for the SDI development to reflect on the organisational aspects and to (re-)organise ideas and strategies on their own SDI strategy. They allow the SDIs to learn from the mistakes and successes of other similar SDIs, can help to increase the know-how and to provide technical guidance and important strategies for those who intends to develop a successful SDI. Furthermore, the visibility and motivation of existing SDIs might lead to a willingness to "take the train" by other organisations.

In the same way, also the methodology carried out in order to have a tool to measure a confidence degree of an SDI with respect to the European

Interoperability Framework (EIF)[5] could be suitable. It could allow SDI managers/stakeholders to auto-verify strengths and weaknesses on which to take actions in order to improve the interoperability of their organisation, in tune with the definition of such a characteristic given in the EIFv2.0, hence orienting its services towards Pan-European eGovernment services.

The methodology and the database can also be used for training activities in GI and SDI field and the definition of a European certificate for SDI in the framework of the ECDL[6]. The studies and work done should continue. They can be used in learning environments, such as universities and SDI training courses and workshops. An example of such activities is the colaboration of the eSDI-Net+ members AGISEE and the University of Rome "La Sapienza" who already got active in this area.

However, it should be noted that the entries in the database must be treated with some caution as there are considerable variations between countries in the number of entries included. This reflects to a large extent the different perceptions of the national and regional organisers of the workshops but there is also an element of self-selection in some cases. Notwithstanding this the findings of the project suggest that there are at least 200 SDIs in operation at the subnational level in Europe at the present time and that this number could rise to somewhere around 300 if all the possible candidates were included.

It can also be argued that some workshop organisers took a rather catholic view of what constitutes a SDI. This is particularly the case with respect to the inclusion of thematic SDIs which accounted for nearly a third of the total number. Yet, as the experience of the 12 SDI best practices awarded in Turin in 2009 shows, a great deal can be learnt from examining them as well as the experiences of the more conventional SDIs that have been created for local and regional administrative purposes.

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[5] The European Interoperability Framework (EIF) supports the European Union's strategy of providing user-centred eGovernment services by facilitating, at a pan-European level, the interoperability of services and systems between public administrations, as well as between administrations and the public (citizens, businesses). It is an action of the eEurope 2005 Action Plan, under the eGovernment heading. EIF v2 defines an interoperability framework as "an agreed approach to interoperability for organisations that wish to work together towards the joint delivery of public services", and notes that "within its scope of applicability, it specifies a set of common elements such as vocabulary, concepts, principles, policies, guidelines, recommendations, standards, specifications and practices". (EIF 2.0, 2010)

[6] ECDL (European Computer Driving Licence) Foundation is the certifying authority of the leading international computer skills certification programme – ECDL / ICDL*. The quality and reputation of their certification programmes are built on over a decade of experience in successfully delivering ICT certification programmes to millions of people in various languages around the world.

The inclusion of thematic SDIs also brings a much stronger user perspective into the discussion as most thematic SDIs are driven to a considerable extent by specific sets of user requirements. When examining cases such as these, special attention must be given to the arrangements that have been made by the users to meet their requirements and the organisational structures that have emerged for this purpose.

The findings made performing the SDI analysis and assessment also draw attention to the importance of taking the dynamics of SDI development into account in future research. Many of the subnational SDIs considered in the database began life as relatively straightforward GIS applications which have evolved over time into SDIs. It is also worth noting that many of these developments have yet to use the term 'SDI' to describe their current activities. Findings such as these highlight the need for more longitudinal studies in SDI research.

The framework used to analyse sub-national and thematic SDIs proved to be effective in assessing them but complex to operate. It involves a lot of work for the organisation responsible for each identified SDI and for the SDIs officers themselves. On the other hand, SDI officials are keen to identify possible targets and opportunities for their own endeavours as well as to compare themselves with other SDIs. Lack of resources for such tasks is often quoted and budget restrictions may limit the ability to travel abroad and physically meet other SDIs. Nevertheless, if benchmarking is considered to be an important issue, then some form of additional competition to identify Best Practice SDIs may be necessary.

In order to overcome such limitations, it may be important to provide tools that will enable each SDI to self-assess its operation, identify its maturity level and timeline and find equivalent SDIs or SDIs that are ahead. The concept will involve the development of a web-based questionnaire that each SDI can fill in, including mandatory code lists that enable comparisons throughout Europe. The responses to each of these questionnaires will populate a database and a system, starting from the present database, which will also provide contacts of the closest SDIs according to the scores. Having done the assessment once, the SDI staff may repeat this process at a later stage. This will enable them gradually to develop their own trajectory and compare it to the trajectories of similar SDIs.

Such a system may also generate reports that will describe how the SDI situation is developing in different European countries, and provide information on how INSPIRE is being implemented at the sub-national level, thus complementing the national reports that the Directive asks each country to provide regularly.

Finally, the experience made applying the methodology in practice underlines the importance that must be attached to capacity building in SDI development and

the creation of appropriate mechanisms to facilitate the exchange of ideas and experience between those involved. Participants in the national and regional workshops in particular felt very strongly that they had played an important role in this respect and that more activities of this kind were needed to further develop the field. In consideration of the fact, that INSPIRE is nearly exclusively dealt with on national level, further steps should be done to share knowledge and raise awareness of spatial data infrastructures and INSPIRE on local level.

Although the SDI assessment methodology and the experiences in evaluating SDI Best Practices had a strong focus on Europe and the INSPIRE implementation process, they can also be useful as a model for an international discussion (United Nations, 2009).

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