

## **A Framework for Comparing Spatial Data Infrastructures An Australian-Swiss Case Study**

Christine Najjar<sup>1</sup>, Abbas Rajabifard<sup>2</sup>, Ian Williamson<sup>2</sup>, Christine Giger<sup>1</sup>

<sup>1</sup>Institute of Geodesy and Photogrammetry  
ETH Zurich  
8092 Zurich, Switzerland  
<http://www.geoit.ethz.ch/>

<sup>2</sup>Centre for Spatial Data Infrastructures and Land Administration  
Department of Geomatics, The University of Melbourne, Victoria 3010, Australia  
[http://www.geom.unimelb.edu.au/research/SDI\\_research/](http://www.geom.unimelb.edu.au/research/SDI_research/)

### **Abstract**

One of the important aspects of developing Spatial Data Infrastructure (SDI) is to facilitate data sharing and data access. In order to achieve optimum access and use of spatial data within an SDI there is a need of knowledge about the management of data, metadata, and web services and their related processes. There are many SDI initiatives under development in many jurisdictions, and hence there are different ways to understand and assess the level of their success. One important way to achieve this goal is to compare SDIs.

This paper describes the development of a framework for comparison of SDI initiatives on the basis of their web services, data and metadata management. The research is of particular relevance since it develops a management model which facilitates the operational aspects and the development process of National SDI initiatives. The paper adopted a case study methodology and the study has been conducted between Australia and Switzerland. The National SDIs of these two countries are compared and assessed.

### **Introduction: General SDI Situation**

Many countries are developing SDIs to better manage and utilise their spatial data by taking a perspective that starts at a local level and proceeds through state, national and regional levels to the global level. This has resulted in the development of different forms of SDI at and between these levels and giving more attention to the SDI hierarchy which assist in decision-making.

Since SDI development, maintenance and operation is a huge investment for the involved institutions, there is a need for indicators to judge their success and cost/benefit relations. Stakeholders are interested in monitoring both, an SDI's status of development as well as its impact on the geoinformation market.

Although, nearly all of the SDI initiatives use the same or similar basic technology and standards, they are hard to compare because of their different legal and organizational backgrounds. Best practice solutions do not seem to exist because the organizational framework plays an important role for an SDI's success and cannot

easily be transferred from one institution or even country to another. The clear measurement of an SDI's status of development is lacking as well as indicators for its success concerning positive impact on the geoinformation availability and usage in a country or region.

Based on this situation, this paper aims to discuss the development of a framework for comparison of SDI initiatives by using a set of clear defined indicators, which are as much as possible independent of the organizational backgrounds of the SDIs. The paper presents the results of an ongoing research on SDI and metadata management activities in Switzerland and Australia. The paper argues that the framework and management model can facilitate the operational aspects and the process of any National SDI initiative.

To achieve this aim, a review of current SDI monitoring and evaluation methodologies is presented followed by a discussion on problems of interoperability on the horizontal, National SDI level as well as the general and specific indicators for a component-based comparison. The paper then applies the proposed key indicators on case studies in Switzerland and Australia.

Further, the importance of developing a comparison framework for SDI components is to assess and to characterize the various complex enabling platforms and the diverse peculiarities in a simple way. Thus, understanding both organisational and technical issues within national SDIs and offering the possibility of improving the developing process and exchange of elements. Finally, the paper discusses how the framework could be applied on other case studies.

The main objective within this research is to understand both organizational and technical issues within National SDI development, offering the possibility of improving the development process and elements of SDIs as well as their impact through a component based comparison.

***Success for National SDI.*** Many governments and organizations have recognized the importance of SDIs as a means to maximize economic, social, and environmental benefits. Therefore, there are many SDI initiatives in different hierarchical levels; according to Borrero et al. (2002) and Cromptvoerts et al. (2003) in more than half the countries of the world. Only a few years later, in 2005, Warnest stated that most countries have national SDI initiatives (Warnest et al. 2005). These were established on different levels (global, regional, national and local), but the majority at national level (Rajabifard et al. 2003), in order to facilitate data sharing and coordination of spatial data activities within an agreed framework (Figure 1).

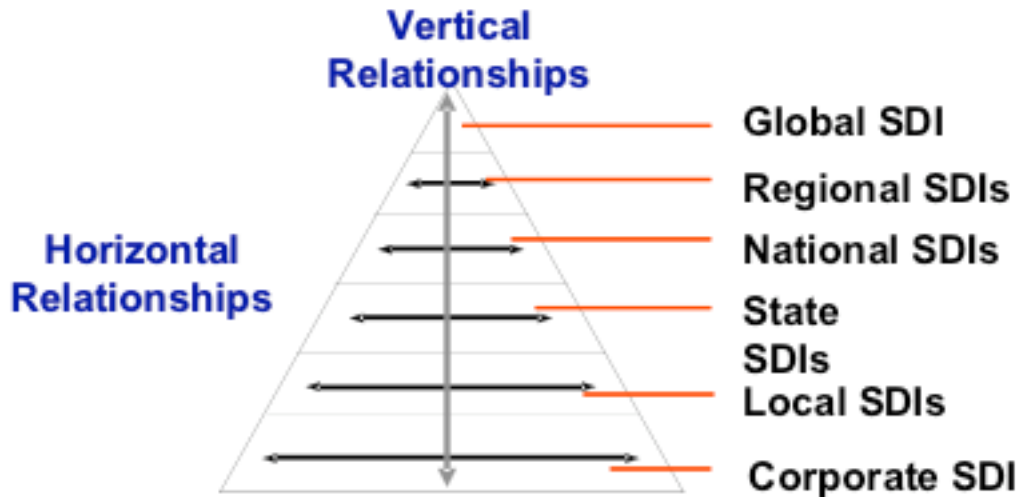


Figure 1: Hierarchy Levels (Rajabifard et al. 2000)

SDI development is a long term process which needs long term investment and the consideration of organizational and technical issues. The national level is of special significance to SDIs as this is often where juridical, political and administrative decisions are taken for a country and thus guidance and framework is given for the local levels.

As Masser et al. (1999) points out, successful National SDIs are increasingly composed of three elements, identification of core datasets for a wide range of users, development of meta-datasets and a coordination framework to develop the infrastructure.

Although the necessity of core spatial data is clear to stakeholders, their awareness of the need to provide adequate metadata is not always given. Metadata are needed to describe and label the spatial data sets and thus make them findable for search engines. Furthermore, metadata management as well as its standardization and modelling are important keys to interoperability within an SDI (Giger et al. 2003).

Web services support the user in processing, accessing and visualizing spatial and non spatial data. In a worldwide assessment of developments of spatial data clearinghouses it was found that one of the main factors that will have positive impacts on the development is the inclusion of web services in current SDI initiatives. The latest definitions of clearinghouse put more emphasize on the inclusion of services (Crompvoets et al. 2004).

It can therefore be concluded that web services and metadata/spatial data are currently important components of an SDI, which are needed to make existing National SDIs successful. Nevertheless, we want to stress that these are not the only characteristics to describe NSDI. Furthermore, it is not clear why and how these aspects influence the success of SDI developments and impacts. Other existing approaches for SDI comparison, which try to give answers to these questions are mentioned in the following paragraphs.

The comparison and evaluation of SDIs can help to better understand the issues to find best practice for certain tasks and improve the system as a whole (Williamson et

al. 2005). There are different ways of comparing SDIs with each other, such as technically, institutionally or conceptually. This depends on the objectives of the comparison.

***Comparisons between SDIs.*** As SDI initiatives have appeared in several countries many years ago more or less simultaneously, whereas in other countries the attempts have only just started it is interesting to compare different SDIs and thus be able to learn from other countries problems and achievements. Also, the SDIs were developed in many jurisdictions and hence there are different ways to understand and assess the level of their success. By establishing a general framework and then focus on the main components metadata, spatial data, standards and web services it should be easier to find a common denominator to compare organizational and technical issues in a national SDI.

There have been several procedures and indicators introduced in literature. A few attempts focusing on the institutional, political and financial aspects are described shortly:

Rackham and Rhind compare the UK SDI (NGDF) to international initiatives by looking into the issues of inclusion of public and private sector within the NGDF Board, existence of formal political support and central government funding as well as (Rackham et al. 1998) the concern with fostering services and facilitating business rather than a concern with data per se.

Current work in assessing the success of National SDIs of the Netherlands and United States of America (Kok et al. in press) has created the indicator called the “organisational maturity matrix” and thus looks into four organisational “context shaping” components (leadership, a vision, communication channels, ability of self-organisation) which assess the level of coherence and thus the success of the SDI development.

Another indicator, called SDI readiness, is based on the e-Readiness index which can be defined as the degree to which a country is prepared to participate in the networked world (Group@IMRB et al.2003) and on factors identified by reviewing several previous studies (Giff et al. 2002, Kok et al 2005, Cromptvoets et al. 2004). An SDI readiness index uses a majority of qualitative factors such as organization, information/data availability, people, access network and financial resources as well as decision criteria like politicians vision-commitment-motivation, institutional leadership and umbrella legal agreements based on a model using fuzzy-compensatory logic and compares SDI progress over time within a country (Delgado Fernandez et al. 2005). This framework was applied to the Cuban SDI.

Rather on the technical side and component based, the comparison of worldwide developments of national spatial clearinghouses by (Cromptvoets et al. 2004) used a list of characteristics which were periodically measured and recorded: Year of first implementation, Numbers of data suppliers, monthly number of visitors, number of web references (Alta Vista and Google), languages used, frequency of web updates, level of metadata accessibility, number of datasets, most recently produced dataset, use of maps for searching, registration-only access and metadata standard applied (Cromptvoets et al. 2004).

Also, the framework for land administration developed and suggested by D. Steudler (Steudler 2004) is an evaluation approach combining technical, institutional and

political framework and also considers the different stakeholders. This study extends this specialized framework for land administration to SDI. As a result, it will be able to assess SDIs with a general framework and also look into the components metadata which is closely linked to spatial data and Web services.

**The objective for SDI success: Interoperability of SDIs on the National Level.** In order to find suitable indicators to judge an SDI's success, clear goals or objectives have to be defined. It has to be clear, which are the goals that are to be achieved by building an SDI. What characterizes an SDI development status and what can be regarded as a positive impact of an operating SDI? Therefore, we define briefly the general environment and specify the challenges for a national SDI.

On a national level, there are many different organizations (private and public sector) involved in producing, maintaining and offering spatial data sets (Figure 2). Often they work as islands or are only partly interconnected. The ideal SDI connects these sources by Internet and provides the users with different web services to find, process and analyse the required spatial data on the spot.

In order to collect and share different datasets using a common platform, there is a need to overcome the challenge of interoperability. Figure 2 shows different ways how institutions can connect to a National SDI in the web. There are many data providers who manage a great variety of data in different scale, quality, topic, format, acquired by different methods and for many purposes, plus, usually the data sets do not have common data models. This heterogeneity is partly due to missing technical regulations and standardization, but also due to institutional obstacles, e.g. communication between different national administrations. Also, within one agency, the same complex situation can occur in different departments or groups with different functions and tasks. Most organizations are simultaneously data providers and users.

Although many of the perceived problems of access (to data in SDIs) seem likely to decline without additional technical advances being necessary, problems of data incompatibility or unsuitability for reasons of scale, coverage or methodology will be much less tractable (Bayfield et al. 2005).

As a result, the exchange of data is only possible with accurate, computer-processable metadata description, which labels the data sets in a standardized way and thus informs users and web services about the contents of spatial data sets. This is important for Web services such as a national Clearinghouse, which is able to search for ASCII based metadata and for other web services.

In summary, within a National SDI, the horizontal level of interoperability is a crucial issue for communication and therefore an important goal to judge on an SDI's success.

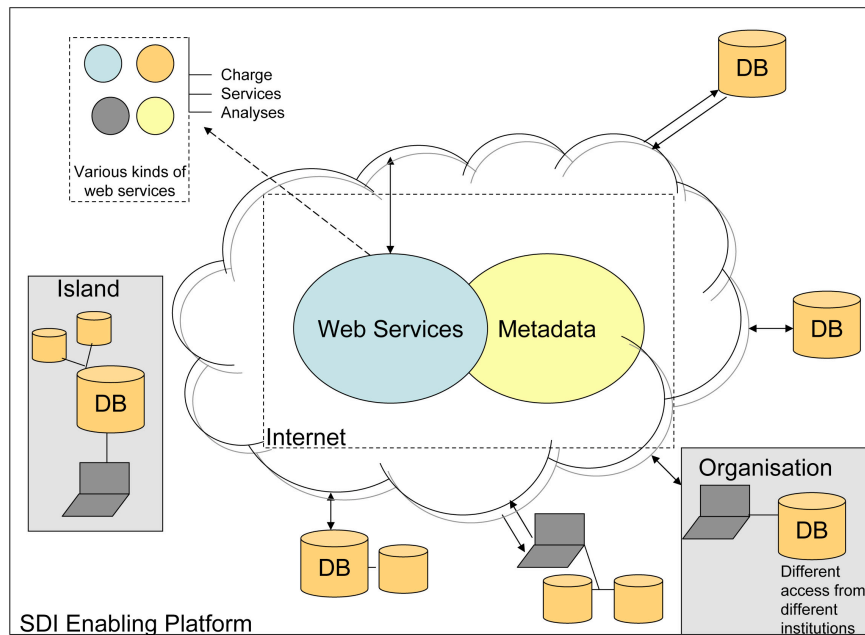


Figure 2: Interoperability on the horizontal level in a National SDI

### Framework for Comparison of Spatial Data Infrastructures

A comparison of National SDIs through metadata, spatial data and Web services and their related processes will lead to a better understanding of best practices for supporting the actual usage of spatial data within SDIs. Moreover, it will deliver evidence for new approaches to improve the interoperability of an enabling platform, e.g. the concept of integration of spatial data and metadata in common data sets and models (Giger, C. and Najar, C., 2003).

A case study approach is utilized to compare the National SDI initiatives of Australia and Switzerland and will first describe the general situation in both countries' SDI and then focus on the important components and processes for metadata and web services.

In a primary, general assessment it is important to understand the situation of the National SDI in the country and the context in which it was created from the

geographic, historic and political point of view

- General Characteristics of a National SDI:**
- History of Spatial Information and SDI Development
  - The Objectives of the National SDI
  - The Components of the SDI
  - Relationships to Global Level
  - SDI Coordinating Agency
  - Main Stakeholders and their Tasks
  - Institutional Arrangements and Partnerships of SDI
  - Existence of Government Policy or Mandate for SDI
  - Policy for Data Sharing
  - National Standards

Figure 3). A definition of objectives for the development, organization and maintenance of an SDI characterize the vision and focus as well as the components. In addition, the main stakeholders' and the coordinating agency's tasks should be well defined in institutional arrangements and partnerships, also to other participants of the SDI.

In order to understand how the SDI is oriented towards the future and its coordination within, it is essential to understand the government policy and the policy of data sharing. This can include e.g. the handling of intellectual property rights, privacy issues and pricing.

Therefore, the evaluation of the two components considers the three areas 'data-metadata' 'web services' and 'standards' (**Error! Reference source not found.**), which work closely together from a technical point of view as well as an organizational perspective.

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Figure 3: General Framework for Comparison between SDIs

Components	Technical Indicators	Organizational Indicators
Metadata-Data	[1] Data Capture Process	[8] Custodianship
	[2] Definition of Core Data Sets	[9] Data Sharing and Partnership Agreements
	[3] Data Format and Conceptual Model	[10] Business Models
	[4] Data Management	[11] Coordinating Arrangements
	[5] Data Quality and Accuracy	
	[6] Common Modeling Language and Tools	
	[7] Harmonizing Metadata and Spatial Data	
Web Services	[12] Application Profile for Geo Web Services	[14] Clearinghouse Organization
	[13] Clearinghouse and Geoportals	
Standards	[15] Interoperability Standards	[16] Organizational Arrangements for Standardization

Table 1: Framework for Component Based Comparison between National SDIs using Metadata, Spatial Data and Web Services

In order to receive high quality and consistent spatial data it is necessary to standardize the procedure and steps of the data capture and update, thus ensuring that the same rules are applied for every area or region (**Indicator 1**). This might be achieved for example by certifying the data capture method with ISO 9001. Besides standardizing the update and capture process, it is essential to provide good documentation of these well-defined steps and make the latter accessible as well as checkable.

The standardized process of data capture and update is also important for core data sets, sometimes called reference data (**Indicator 2**), especially if these are acquired by different organizations. The core data sets are the basic data that everyone uses who is involved with geographic information. Therefore, core data should have the highest priority in capture, update and quality. INSPIRE's RDM working group has defined three functional requirements for core data sets. They:

- \_ Provide an unambiguous location for a user's information
- \_ Enable the merging of data from various sources
- \_ Provide a context to allow others to better understand the information that is being presented



Altogether it is necessary for an SDI to define core data sets. For the positive assessment a clear and well documented definition has to exist and be accessible for the public.

For the integration of data from heterogeneous sources in a network environment it is necessary to provide a neutral format or conceptual description which guarantees the possibility of exchange. In order to know the relationship and hierarchical structure of a spatial data set, a conceptual model is needed (**Indicator 3**). The existence of such standardized formats and conceptual models must exist for all areas of application.

The **Indicator 4** “data management” is signified by standardized update cycles and the existence of standardized metadata. It is not sufficient that metadata exist, but they must be provided in a computer-processable way.

For a good management the infrastructure should be available 24 hours for seven days a week and there should be standardized, frequent and documented updates cycles. Furthermore, it is important that the consistency between metadata and spatial data is provided in a standardized, documented way. As SDIs deal with large data sets, e.g. photogrammetric imagery, it is necessary to have provisions for management and dealing with large files or databases. The latter should be well documented.

Data quality (**Indicator 5**) depends on which application the data are needed for. Therefore, every area of application needs to define its own requirements for quality (e.g. update cycles, precision, actuality, reliability). These requirements must be comparable and thus well documented, accessible, checkable as well standardized.

As mentioned for indicator 3 conceptual models are needed. These are described in a standardized modelling language (e.g. UML). In order to be able to work, import the models in different GIS systems, test the quality of the conceptual model and check for mistakes, tools should be provided. They support the quality management of the data (**Indicator 6**).

As mentioned for Indicator 4, it is necessary to have standardized metadata. These are of even greater value if the metadata and spatial data are consistent. Meaning that for example the metadata are updated simultaneously with the spatial data. Consequently, standards for the harmonization are needed and the data models of spatial data and metadata must be coordinated (**Indicator 7**).

The degree of horizontal interoperability can be characterized by the existence of homogeneous metadata-spatial data sets and catalogues. This is only possible if the participating organizations have clear guidelines and visions. Therefore, Indicators 8-11 represent the current realization of horizontal interoperability in a country from an organizational point of view.

It is first of all necessary to find a set of guidelines concerning principle topics like licensing, regulations for custodianship, restrictions for use and reproduction of spatial data as well as juridical issues (**Indicator 8**). These general guidelines should be well documented, accessible, checkable and standardized for all participants of an SDI.

More specific agreements should be signed between the different partners. These can be contracts or data sharing agreements which apply to the dissemination of firstly core spatial data sets and secondly all the other data. In the further development of the SDI it is important to find principles for all offered spatial data. Also rules for

commercial use, reproduction and pricing must be clarified (**Indicator 9**). Again these data sharing and partnership agreements should be well documented, accessible, checkable and standardized.

From a financial point of view, the minimal functioning of a basic SDI must be secured. This is possible with a business model which defines the support of the basic infrastructure by a neutral organization, e.g. a governmental organization is obliged (**Indicator 10**).

Coordinating arrangements for participating organizations, working groups or panels are important (**Indicator 11**). This is a continuous process and affords workflows and rules, e.g. for quality management and its organization. If for example a new organization wants to participate in the SDI, it needs to be provided with a set of rules and arrangements which it must follow. Therefore, these coordinating arrangements must be clearly defined and documented.

In an ideal SDI, the horizontal and vertical interoperability will be supported by diverse Web services. Indicators 12-14 analyse basic needs for important Geo Web Services take a look at the future at the “Service Data Infrastructure”.

There is a large diversity of technical standards for Web services proposed by organizations like the Open Geospatial Consortium, ISO/TC211, CEN/TC 287 and the World Wide Web Consortium (3WC). An application profile for Geo Web Services (**Indicator 12**) limits, specifies and therefore realizes an interoperable use of different Geo Web Services.

Another important aspect is the Clearinghouse which has both a technical perspective (Indicator 13) and an organizational relevance (Indicator 14).

From a technical point of view a Clearinghouse is considered to be a specialized, complex and important Web service which assists in offering the exchange and sharing of spatial data between different users and suppliers in an SDI (**Indicator 13**). A geoportal is the access point of an SDI on the Internet. Both need a search engine for finding and retrieving spatial data. Therefore, the existence of such an extended spatial data search engine is a basic function for the SDI

In order to make spatial data sets accessible to the community, it is also necessary to have a Clearinghouse network which determines policies, an institutional framework and agreed technical standards (**Indicator 14**). The metrics of this indicator includes the question whether there is a neutral organization or committee which is officially entrusted with important decisions for the organizational aspects of the Clearinghouse. Does for example a defined organizational chart exist?

With the aim to realize data transfer, not only the data itself but also the functions must be transferred. It is necessary for all the participants in the SDI to use generally acknowledged standards. Therefore, it is important to offer a list of standards that should be used for a specific SDI (**Indicator 15**).

In order to identify potential organizations and allocate different tasks of preparation and implementation of standards related to spatial data, there is a need to arrange and define the responsibilities related to spatial data (**Indicator 16**). As a metric to assess

this indicator the question is whether there is an organization in charge of defining and implementing international standards such as ISO to national profiles. Altogether, the indicators in Table 1 pinpoint the most important characteristics of a National SDI and offer metrics of what is good and bad.

### **Case Studies: Australia and Switzerland**

Switzerland and Australia are both highly developed countries. They both share the aspect that they are administered in a federal structure. Nevertheless, they belong to different hemispheres and are integrated into different cultural and organizational frameworks. Specific characterizations of the two countries follow in the next chapters together with a comparison according to the suggested framework. Finally, an assessment using the indicators as well as metrics is executed.

***Australian SDI: ASDI.*** Australia is the 6th largest country in land area in the world and the only country to cover an entire continent. Australia is on the one hand one of the least populated countries in the world and on the other hand one of the most urbanised, due to approximately 85% of the population residing in urban areas along the east and south-eastern coastline. Australia has a federal government, which is called the Commonwealth and comprises 8 States/Territories.

The National SDI is coordinated by ANZLIC since 1986 with the vision that Australia's spatially referenced data, products and services are available and accessible to all users.

The ANZLIC Council comprises ten members representing the Australian Government, the New Zealand Government and each of the State and Territory governments of Australia. A key concept of the Council is that each member represents a spatial information coordinating structure for whole-of-government within their jurisdiction.

On the national level ANZLIC, the Spatial Information Council as well as the Intergovernmental Committee for Surveying and Mapping (ICSM) and Public Sector Mapping Agencies Australia Ltd. (PSMA) are the key stakeholders of the Australian National SDI initiative.

***Swiss SDI: E-Geo.ch.*** Switzerland is a small but heterogeneous country, comprising four official languages and a federal government with 26 cantons and 7 million people. This results in a patchwork of political, legal and technical issues that must be accounted for and harmonized in a national SDI.

The Swiss Federal Council decided officially on 15th June 2001 to give the interdepartmental GIS Coordination Group (COGIS) a mandate for creating a concept for an NSDI in Switzerland. This project is embedded into an initiative called e-geo.ch, which offers an E-government framework for cooperation among public bodies on all administrative levels and private industry.

The COGIS centre is administratively attached to the Swiss Federal Office of Topography, the national mapping agency, but practically independent.

### **Component-Based Comparison of Australian and Swiss SDI**

In the following chapter the most important indicators and their assessment for Australia and Switzerland are described. This comparison is finally summarized in a table (Table 2) which gives the overview for the assessment of both countries.

Based on the fact that Australia is 183 times larger than Switzerland and contains vast areas of desert the data capture methods are very different. Both countries have well established rules and regulations for data capture in the area of cadastral data and most of the spatial data is digitalized. The Swiss federal mapping agency is certified according to ISO 9001. Therefore, the data capture and update for the federally acquired cadastral data is standardized up to the printing of maps. Nevertheless, the data capture on lower levels of the federal system are not certified. It is possible to say for the cadastral data capture that the process is well covered, but other areas of application are not as well documented and standardized. In Australia on the other hand, national standards are provided by ANZLIC and are based on ISO 9001. They are recommended to the states for implementation. Most states are certified according to ISO 9001. (**Indicator 1, Table 2**)

Australia has defined core data sets organized in five themes (primary reference, administration, national environment, socio-economic and built environment). Yet, each state in Australia defines its own core data sets. Switzerland is currently working an inventory for basic spatial data of national interest. This will be legally finalized in the national law for geo-information which is currently discussed (**Indicator 2, Table 2**).

The data formats usually depend on the GIS system used, but in Switzerland there is an additional standardized format called INTERLIS which helps the transfer between different GIS systems and models. The use of INTERLIS is mandatory for the cadastral data and is also establishing itself in other fields. The data is stored in both countries in a decentralized way, meaning that the custodians of the data are also in charge of the metadata description and the update.

In Australia each jurisdiction has established different solutions, data models and processes for their digital cadastral data systems. Overall coordination of cadastral standards is being facilitated through ICSM with promotion of the Harmonized Data Model (Dalrymple et al. 2003). In Switzerland, a national data model for cadastral surveying was established at the beginning of the 1990s and every canton is obliged to follow it with the possibility to extend it for different needs. Along with the national model which is defined in the previously mentioned INTERLIS come several modeling tools e.g. for checking the data to comply with the model ([www.interlis.ch](http://www.interlis.ch)). In both countries metadata and spatial data are saved in separate files or data bases (**Indicator 3, Table 2**).

The Australian Spatial Data Directory (ASDD) and the Environmental Data Directory (EDD) are the two main metadata catalogues on national level in Australia. The latter is offered by the Department of the Environment and Heritage and is specialized on environmental data by the Biological survey, documentation of species, vegetation data and biological nomenclature. The former is maintained by Geoscience Australia on behalf of ANZLIC which contains 40 000 metadata records on 25 distributed nodes (24 public sector and one private) of various topics. The two metadata catalogues are not linked to each other by one portal. Update cycles for spatial data are determined at a jurisdictional level (e.g. each state determines their own update cycles for cadastral data). In Switzerland, Geocat.ch is the main metadata catalogue on national level. It was launched in the internet in 2004 and offers metadata in three

different languages: English, German and French and on various topics. The infrastructure of Geocat.ch is well documented and is available 24hours for seven days a week. Nevertheless, this mainly covers the metadata and there are no special provisions known for large data sets like photogrammetric data. On the technical side both countries are trying to harmonize historically grown metadata sets. Various metadata schemas have been launched in Australia (ANZLIC metadata profile version 1.0 and 2.0) and in Switzerland (SIK-GIS, CDS) in the last 10 years. Currently, Switzerland has already defined its national profile of ISO 19115 in 2004 and Australia is in the process. In both countries, this is combined with the development of freeware or open source metadata entry tools, which support the acquisition in the ISO 19115 profile (**Indicator 4, Table 2**).

In both Switzerland and Australia, the main geo web service used is the OGC (Open Geospatial Consortium) Web Map Server (**Error! Reference source not found.**). In Switzerland a few SOAP-based web services were developed for the request of metadata, Swiss names and geo-coded addresses. Latter is based on data by the Swiss Federal Office for Statistics. These basic services were coordinated by KOGIS. Other web services exist for specialized purposes, e.g. for geodetic transformations and are offered by national agencies (e.g. the national mapping agency, swisstopo has coordinate transformation services, services for Conversion of national map coordinates (Swiss grid) to geographical coordinates (WGS84 datum etc.: <http://www.swisstopo.ch/en/online/calculation/index>), but these are not coordinated by the national SDI and thus not linked directly, e.g. by URL to a common portal. Similarly, Geoscience Australia offers various services on its web page, e.g. for geodetic applications, e.g. auspos for static GPS data which is then calculated into Geocentric Datum of Australia (GDA) and International Terrestrial Reference Frame (ITRF) coordinates. In Australia, there is a common situation as in Switzerland: WMS is the most used international standard and other services are mainly contributed by other national agencies. In Switzerland the Application Profile for Geo Web services already exists and in Australia it is being developed by on national level by ANZLIC (**Indicator 11, Table 2**).

In both countries there are no national Clearinghouses as such, but the metadata catalogue takes over the function of a search engine. In Australia, a geospatial shop is offered by Geoscience Australia, the national mapping agency, for national maps: <http://www.geoscience.gov.au/geoportal/maps.html>. It contains a list of URL links which enables the user to access the different institutions offering maps. Further, in Australia through ANZLIC a discussion and assessment has been done to define the level of services provided through Australian SDI and associated tools (**Indicator 12, Table 3**).

In Switzerland, there have been discussions whether KOGIS as the coordinating agency should be the provider of basic services. This will be also linked to the upcoming law for Geo-information, which is currently in working progress in Switzerland. Its basic aim is to give a legal framework for federal standards in modeling, acquisition and exchange of spatial data. It regulates copyright and privacy issues as well as responsibilities and competences for the coordination of spatial data within the federal administration. In Australia each state has its own Clearinghouse, which determines policies, institutional framework and technical standards, however ANZLIC also provides an national umbrella and offers national standards as well as

policies for all jurisdictions to implement.

Components	Technical Indicators	Switzerland	Australia	Organizational Indicators	Switzerland	Australia
Metadata-Data	[1] Data Capture Process	Well documented +/- Standardized +/- Accessible +/- Checkable +/-	Well documented +/- Standardized +/- Accessible +/- Checkable +/-	[8] Custodianship	Well documented: -- Accessible: -- Checkable: -- Standardized: --	Well documented: ++ Accessible: ++ Checkable: + Standardized: +/-
	[2] Definition of Core Data Sets	Standardized for whole National SDI: ++	Defined for each state: +	[9] Data Sharing and Partnership Agreements	Well documented: +/- Accessible: +/- Checkable: +/- Standardized: +/-	Well documented: + Accessible: + Checkable: + Standardized: -
	[3] Data Format and Conceptual Model	Format for some areas of application exists: + Conceptual model for some application areas exists: +	Different formats for different areas of application: +/- Different conceptual models for different areas of application: +/-	[10] Business Models	Existence: ++	Existence: +
	[4] Data Management	Availability: + Standardized update cycles: + Consistency: - Provisions for large data sets: no +	Availability: + Standardized update cycles: + Consistency: +/- Provisions for large data sets: no -/+	[11] Coordinating Arrangements	Exist and clearly defined: +/- Documented: +/-	Exist and clearly defined: + Documented: +
	[5] Data Quality and Accuracy					
	[6] Common Modeling Language and Tools	Accessible: ++ Usable: ++ Useful: ++	Accessible: ++ Usable: +/- Useful: +/-			
	[7] Harmonizing Metadata and Spatial Data	Harmonization coordinated: + Common modes: +	Harmonization coordinated: +/- Common modes: +/-			
Web Services	[12] Application Profile for Geo Web Services	Exists: ++	Under development: +	[14] Clearinghouse Organization	Neutral organization exists and is defined: ++	Neutral organization exists and is defined: +/-
	[13] Clearinghouse and Geoportals	Only metadata catalogue: +	Only metadata catalogue: +			
Standards	[15] Interoperability Standards			[16] Organizational Arrangements for Standardization		

++ very good  
+ good  
+/- first steps in a positive direction  
-- bad

Table 2: Summary of the Framework for Assessment of the Australian and Swiss National SDI

Summarizing our results of the case study, we found that our indicators could be applied easily to the different national SDI although their cultural, organizational and legal background differed significantly. The indicators are still not suitable to judge on an SDI development and impact from a cost/benefit point of view. Overall success of an SDI cannot be stated or neglected by applying the proposed indicators. But, our major goals can be achieved: the identification of best practice solutions and areas of possible improvement or useful cooperation between countries and institutions. For example, in our case study Switzerland can offer relevant experience and working solutions on technical components, whereas Australia provides excellent expertise on some of the organizational issues.

## Conclusion

This paper suggests a framework for comparison of SDI on basis of web services and spatial data/metadata management aspects, which takes a holistic approach considering technical as well as organizational perspectives of SDI.

The federal system in both countries results in a complexity of an organisational, institutional, and technical patchwork which has to be balanced with an SDI organization which includes local bodies as well national representatives and experts.

Australia has a longer history in SDI development and has therefore more experience and more intermediate results, such as two metadata catalogues, with which it tested and developed different technologies (Z39.50, three metadata standards). The SDI is

very well documented and clear guidelines e.g. for adding metadata to the ASDD metadata catalogue exist. Nevertheless, these two independent metadata catalogues, confuse users and complicate interoperability.

Switzerland has a strong data modelling tradition, especially in cadastral data sets. The common modelling (conceptual schema) language INTERLIS which goes with a variety of free tools for GIS experts are an important contribution to interoperability. All SDI components in Switzerland have to provide user interfaces in at least two languages (French and German), which increase their development effort. Yet, the solutions for multilingual components are possibly interesting for other countries.

Both countries struggle with inhomogeneous and inconsistent metadata. Common metadata-spatial data models are especially feasible in Switzerland where the nationally standardized model for e.g. cadastral data allows integration of different layers. It is recognized in both countries that free metadata acquisition tools must be offered by the government to help coordinate and facilitate the metadata management. In Switzerland these exist on the Web offered by KOGIS in geocat.ch according to the Swiss profile of ISO 19115. In Australia this work is in progress.

### **Acknowledgments**

The authors would like to acknowledge the support of the Institute for Geodesy and Photogrammetry, Swiss Federal Institute of Technology Zurich (ETH), Centre of Coordination of Geo-information (KOGIS), the University of Melbourne, and the members of the Centre for Spatial Data Infrastructures and Land Administration at the Department of Geomatics, the University of Melbourne, in the preparation of this paper and the associated research. However, the views expressed in the paper are those of the authors and do not necessarily reflect the views of these groups.

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