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A framework for the evaluation of marine spatial data infrastructures - Accompanied by an international case-study -

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Abstract

In Germany currently the development of a marine data infrastructure takes place with the aim of merging information concerning the fields coastal engineering, hydrography and surveying, protection of the marine environment, maritime conservation, regional planning and coastal research. This undertaking is embedded in a series of regulations and developments on many administrative levels from which specifications and courses of action derive. To set up a conceptual framework for the marine data infrastructure (MDI-DE) scientists at the Professorship for Geodesy and Geoinformatics at Rostock University are building a reference model, evaluating meta-information systems and developing models to support common workflows in marine applications.

The reference model for the marine spatial data infrastructure of Germany (MDI-DE) is the guideline for all developments inside this infrastructure. Because the undertaking is embedded in a series of regulations and developments this paper illustrates an approach on modelling a scenario for the Marine Strategy Framework Directive (MSFD) using the Unified Modelling Language (UML).

Evaluating how other countries built their marine spatial infrastructures is of main importance, to learn where obstacles are and errors are likely to occur. To be able to look at other initiatives from a neutral point of view it is necessary to construct a framework for evaluating marine spatial data infrastructures. Spatial data infrastructure assessment approaches were used as bases and were expanded to meet the requirements of the marine domain. As an international case-study this paper will look at Canada's Marine Geospatial Data Infrastructure (MGDI), COINAtlantic and GeoPortal.

Keywords: spatial Information science, interoperability, web-based, marine, data infrastructure, evaluation

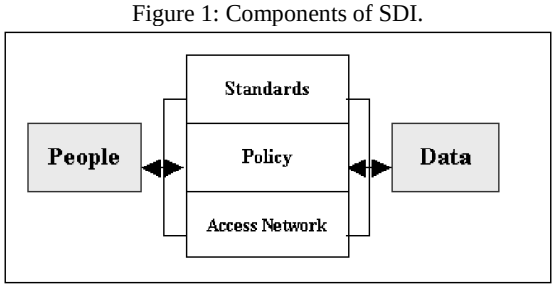
1 Building the evaluation framework

Apart from building models and looking into directives it is always wise to learn from others which is why an evaluation framework has been built to define criteria to check when analysing other approaches towards MSDIs

1.1 Bases for the framework

The components of an SDI were outlined inter alia in [4] which answered the question how people can be linked to data (both are already components of an SDI): by standards, policies and access networks (see figure 1).

Figure 1: Components of SDI.



Source: [4]

[5] takes these components and defines areas that should be inspected when assessing spatial data infrastructures (SDIs): Policy Level - Policy, Management Level - Standards and Access Network, Operational Level - Access Network and Data, Other Influencing Factors – People, Performance Assessment. For the defined areas the paper then suggests possible indicators for the evaluation of SDIs (see table 1). The paper also outlines that "[...] evaluation is about finding answers to questions such as 'are we doing the right thing' and 'are we doing things right'".

Table 1: Possible indicators for evaluating SDIs.

Area	Possible indicators
Policy Level – *Policy*	• existence of a government policy for SDI • handling of intellectual property rights, privacy issues, pricing • objectives for acquisition and use of spatial data
Management Level – *Standards*	• standardisation arrangements for data dissemination and access network • institutional arrangements of agencies involved in providing spatial data • organisational arrangements for coordination of spatial data • definition of core datasets • data modelling • interoperability

Management Level – *Access Network*	• access pricing • delivery mechanism and procedure • access privileges • value-adding arrangements
Operational Level – *Access Network*	• type of network • data volume • response time
Operational Level – *Data*	• data format • data capture method • definition of core datasets • data maintenance • data quality and accuracy
Other Influencing Factors – *People*	• number of organisations and people involved • opportunities for training • market situation for data providers, data integrators, and end-users
Performance Assessment	• degree of satisfying the objectives and strategies • user satisfaction • diffusion and use of spatial data and information • turnover and reliability

Source: [5]

[3] is undertaking a similar approach for the assessment of SDIs by proposing three components (data and metadata, web services, standards) accompanied by several indicators for each of the components. Since indicators could have a technical or organizational meaning, they are further classified by these two factors (see table 2).

Table 2: Indicators for comparing SDIs on the basis of Web services and data management.

Component	Indicator	
	Technical	*Organizational*
Data and metadata	1. Data capture process 2. Definition of core datasets 3. Data format and conceptual model 4. Data management 5. Data quality and accuracy 6. Common modelling language and tools 7. Harmonization of data and metadata	8. Custodianship 9. Data sharing and partnerships agreements 10. Business models 11. Coordinating arrangements
Web services	12. Application profile 13. Clearinghouse and geoportal	14. Clearinghouse organization
Standards	15. Interoperability	16. Organizational arrangements for standardization

Source: [3]

Because we want to evaluate and compare marine spatial data infrastructures (MSDIs), which are "the component of a National SDI that encompasses marine and coastal geographic and business information in its widest sense. An MSDI would typically include information on seabed bathymetry (elevation), geology, infrastructure (e.g. wrecks, offshore installations, pipelines, cables); administrative and legal boundaries, areas of conservation and marine habitats and oceanography." [2].

We may have to adjust even the components outlined at the beginning. When having a look at [1] we find out that "the four main components of a successful coastal and ocean information network (COIN), as an important component of an SDI, are:

- online access to data using recognized standards
- metadata catalogues that can be used to search for geospatial information
- a web interface that allows users to search, access and retrieve the best available information from the most reliable sources
- active participation of data providers and data users to ensure that the right data are available to contribute to more effective decision-making."

These components are more or less equal to the five components just in another form. When we compare them we come to:

- online access to data using recognized standards
  - people, data, standards and access networks
- metadata catalogues that can be used to search for geospatial information
  - people, data, standards, policies and access networks
- a web interface that allows users to search, access and retrieve the best available information from the most reliable sources
  - people, data, standards, policies and access networks
- active participation of data providers and data users to ensure that the right data are available to contribute to more effective decision-making
  - people, data, policies

Because we have seen that the components of a general SDI and a MSDI are equal we can assume that we are able to apply the indicators mentioned in the two beforehand shown papers to the evaluation of a MSDI.

Due to the fact that MSDIs are special SDIs we had to ask ourselves if more indicators are needed to compare MSDIs. In [5] in the list of possible indicators we do not find metadata at all although metadata is mentioned in the paper several times. [3] on the other hand lists metadata as a component so that the first 11 indicators also apply to metadata and indicator 7 (harmonization of data and metadata) mentions metadata explicitly. But what is not mentioned in both papers is the availability of metadata in general and a metadata catalogue (CSW) in particular. After all in times of widespread and agreed on metadata specifications (like ISO's 19115) and services (OGC's CSW) this would fit as an indicator to look at. In what way and by which institutions metadata is handled (metadata coordination) might also be a thing to look at in the wide area of marine data with its mass of stakeholders. Since metadata is linked to "real" data we should also define an indicator which looks at the availability of web (map) services enabling interoperability and availability. To better understand how other marine initiatives got to their infrastructures and how they are built a glance at the architecture should be

thrown. The last thing which could be checked is whether the definitions for shorelines and/or maritime zones differ in varying MSDIs.

1.2 Compiling the framework

Because we are aiming for a holistic approach and when we compile everything from 1.1 we end up with several indicators (see table 3). For clarity purposes the indicators are classified into the factors technical and organizational.

The first area (A) covers the organizational and technical indicators regarding data. Because data is the most important thing in a MSDI this is the first area looked at. We have to think about the basic reference spatial data so that we are able to orientate ourselves. Regarding interoperability we also have to look at the offered coordinate reference systems so that the data do not have to be transformed on the fly resulting in slow performance. Lastly we look at the level of involvement of institutions because the aim of a MSDI should be that it integrates as much marine-themed data as possible.

The indicator A1 (core datasets) can be found in [5] and [3], too, and describes what basic reference spatial data is covered by a country's MSDI. The datasets which could be covered are as follows:

- Bathymetry
- Shoreline and other maritime zones like EEZ
- Marine Cadastre
- Coastal imagery
- Marine navigation
- Tidal benchmarks
- Benthic/Nature conservation habitats

Indicator A2 (coordinate reference systems) lists all the supported CRS of the MSDI while the last indicator (A3) looks at the degree of involvement of different agencies resp. institutions by reason that a MSDI has to incorporate various datasets coming from a wide range of agencies/institutions and these will be listed for this indicator and – if possible – compared to the ones that were left out.

For area B it is important that data is augmented by metadata so that one is able to find it and is able to know what the data is about later on. The indicator B1 (availability of metadata/metadata catalogue CSW) looks at the availability of metadata and tries to answer the questions: is it searchable, how is it held and is it available through a standardized catalogue (CSW) interface? Because we are in the marine field much data will be sensor data thus making data quality and accuracy of the data a big issue. That is why indicator B2 especially tells if metadata is available that handles how the measurements were done and how accurate they are (if OGC's Observations and Measurements O&M standard is used for the metadata this field is already covered). In general it would be wise to use internationally approved standards and if needed build profiles to meet special requirements. For this purpose indicator B3 (coordination) is designed because metadata should be homogeneous inside the MSDI it would be good if there is a central coordination unit dealing with implementing metadata rules (what standard to use, how to build a profile and so on).

Having data and metadata for the data is a good thing so far but having services to use data on the fly without having to send files back and forth would increase efficiency immensely. For that purpose area C (services and interfaces) deals with the availability of services, their performance and the presence of a geoportal (or clearinghouse). From an organizational standpoint access privileges and value-adding arrangements are important, too.

For interoperability it is important that you are able to get marine-related data into any application of your choice and to not depend on a geoportal alone. Thus the indicator C1 (availability of services) lists all the available services categorized in Discovery, View, Download and Transformation services. Not to forget here is the availability of a gazetteer. When you want to work with the data provided by services it is important that the services meet certain criteria regarding response time (indicator C2 - performance). Furthermore the system has to be able to cope with large data sets and there should be an update cycle with short intervals which is well documented. The MSDI should have a central entry point to access its data which is the geoportal resp. clearinghouse (indicator C3). It is important that there is a search functionality and map viewer. Additionally indicator C4 (access privileges/custodianship) asks if there was a focus on a role model which deals with actors or stakeholders of the system when the MSDI was modelled.

All areas so far involved standards in some way. Area D (in its only indicator D1 - Interoperability) analyses which standards are used and checks whether their usage lead to interoperability. Apart from that it asks if the stakeholders of the infrastructures are involved in standardization processes or organizations.

The last area focuses on the modelling of MSDIs from an organizational viewpoint. It considers the existence of a government policy for (M)SDI (indicator E1) and thus answers the question if the government backs up the developments. This area also gazes at the varying definitions for shorelines and/or maritime zones in diverse MSDIs (indicator E3). To better understand how other marine initiatives got to their infrastructure and how they are built the architecture (indicator E2) and in particular the underlying business models (indicator E6) are examined.

Table 3: Indicators for the evaluation of marine spatial data infrastructures.

Area	Indicator	
	Technical	Organizational
A – Data	1 *Core datasets*	3 *Degree of involvement of different agencies/institutions*
	2 Coordinate reference systems	
B - Metadata	1 Availability of metadata/metadata catalogue (CSW)	3 Coordination
	2 *Data quality and accuracy*	
C - Services and Interfaces	1 Availability of Services	4 A*ccess privileges*/ Custodianship
	2 Performance (*response time*, Data management)	
	3 Clearinghouse and geoportal	

D - Standards	1 *Interoperability*	
E - Modelling		1 E*xistence of a government policy for SDI*
		2 Architecture
		3 Definition shoreline / Maritime Zones
		4 Business models

* *[SRW08]*, [NRWG07]

2 International case study: Canada

After a brief introduction to the Canadian approach(es) we are using our framework for evaluating the Canadian approach(es) and look into every area and indicator and check whether the approach(es) fulfil the requirements of an SDI.

2.1 Introduction

The national spatial data infrastructure (NSDI) in Canada is called Canadian Geospatial Data Infrastructure (CGDI) but is also known as "GeoConnections" which is the more market-oriented title. It is divided into twelve committees resp. nodes. The CGDI "recognizes that governments have a responsibility to make geospatial information available, and to 'play their role' in developing a knowledge economy in response to the needs of citizens, industry and communities in support of the economic, social and environmental well-being." [9]. The CGDI aims to help users access and integrate said geospatial information by facilitating the infrastructure. Thus the CGDI does not house the spatial data but provides the framework so that various authorities can provide their data through the use of common standards. The CGDI mainly consists of:

- "the GeoConnections Discovery Portal (GDP), a national search engine that allows providers to catalogue their data sets and users to determine which data sets exist where;
- GeoGratis, a national repository where suppliers may place data for free distribution;
- GeoBase, a national suite of framework layers coordinated by the Canadian Council on Geomatics that includes place names, a national digital elevation model, a national layer of satellite imagery, a national road network, national geodetic (survey reference) points, and a national layer of administrative boundaries" [6].

One component of the CGDI is the Marine Geospatial Data Infrastructure (***MGDI***) which goal is to "to satisfy the geographic data needs of water-oriented stakeholders." [11]. The development of the MGDI is led by the Marine Advisory Network node which is one of the CGDI's twelve nodes whereupon the Department of Fisheries and Oceans (DFO) and the Canadian Centre for Marine Communications (CCMC) are the key participants of the node [8]. The MGDI assists the economic and social needs of Canada's marine regions and assists the management of Canada's water resources [11]. As a key partner of both CGDI and MGDI the Department of Fisheries and Oceans (DFO) is developing the (DFO) ***GeoPortal*** which is a key component of the MGDI and provides services that enables DFO employees to index and publish their and find, view and download other spatial data. The GeoPortal does not intend to be a data warehouse but rather acts as a clearing house for marine spatial data by using an open standards-based architecture [7]. Another initiative inside CGDI is ***COINAtlantic*** which "has implemented a coastal and ocean information network for the western North Atlantic." [1] The initiative is led by the Atlantic Coastal Zone Information Steering Committee (ACZISC) and aims at the provision of open access to spatial data to support integrated coastal and ocean management (ICOM) by adopting all standards of and complying with the architecture of the CGDI [12].

2.2 Evaluation and Summary

With its many core datasets, its open policy to coordinate reference systems and the broad variety of involved agencies/institutions Canada's approaches perform very good in area A. In area B a few points have to be deducted because there is no central marine-only CSW available and data quality does not have seemed to be of great importance. But apart from that there is much metadata available in catalogues and everything is well organized with recognition of international trends in standardization. Area C is where the most points are lost because there could be more services available and a central geoportal is lacking. Unfortunately nothing really can be stated for C2 (performance) and C4 (custodianship). The performance in area D and E is overall great due to the facts that the CGDI is endorsing and/or investigating a multitude of standards and that the CGDI is the national spatial data infrastructure (NSDI) of Canada which means that it is implemented by the Canadian government and that the CGDI "[...] recognizes that governments have a responsibility to make geospatial information available [...]." [9].

Table 4. Evaluation of Canadian efforts

Area	Indicator	
	Technical	Organizational
A	1 ++	3 ++
	2 ++	
B	1 +	3 ++
	2 +	
C	1 +	4 +/-
	2 +/-	
	3 +	
D	1 ++	
E		1 ++

++ v. good, + good, +/- not appraisable, - not so good, -- bad

In summary it can be stated that a lot has been done to overcome the tradition of holding data in silos for in-organization/institution-use only in Canada (see table 3). Through the adoption of the Canadian Geospatial Data Infrastructure (CGDI) Canada got to an interoperable MSDI based on widely adopted international standards which offers marine-themed data for (almost) everybody. The only problematic area to be seen is the division into several projects and thus missing a central entry point for marine data so that users do not have to look at several places to get the data they need.

Although not being part of the evaluation framework Canada made its first steps to a marine cadastre, too. For the case study area of St. Margaret's Bay, Nova Scotia, a prototype marine cadastre has been built, which was the first time that funds went into research outside academia. [10]

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