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Arctic Spatial Data Infrastructure evaluation report 2015-2016

G. Giff

2017

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Canada

ARCTIC SDI EVALUATION REPORT 2015-2016

Prepared for: Arctic SDI

Abstract

This document provides a concise report on the evaluation of the Arctic SDI. The report includes an introduction to the Arctic SDI Evaluation Project, a brief discussion on the concept and benefits of SDI evaluation, SDI evaluation methodologies, the Arctic SDI evaluation methodologies, the development of the Arctic SDI Evaluation Framework, the application of the Evaluation Framework, presentation of the results, analysis of the results, recommendations based on the results of the evaluation, and a discussion on benching the current implementation status of the Arctic SDI.

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Table of Contents

Executive Summary.....	4
<i>Project Overview</i>	4
<i>The Evaluation</i>	5
<i>Summary of Results</i>	6
<i>Bench-marking the Arctic SDI</i>	8
1. Introduction and Overview.....	9
<i>Project Overview</i>	10
2. SDI Evaluation.....	12
<i>SDI Evaluation Methodologies</i>	13
3. Arctic SDI Evaluation.....	14
<i>Methodology</i>	14
<i>The Evaluation Framework</i>	15
<i>Defining the Implementation Levels</i>	17
<i>Benchmarking the Arctic SDI</i>	18
4. Results of the Evaluation.....	20
<i>Organizational Readiness</i>	21
<i>Capacity Building</i>	23
<i>Information Infrastructure</i>	23
<i>Arctic SDI Geoportal</i>	24
<i>Arctic Circle Geoportals</i>	24
<i>Data and Information Environment</i>	25
<i>Standards</i>	25
<i>Summary of Results</i>	26
5. Analysis of the Results.....	27
<i>Analysis of the Organizational Readiness of the Arctic SDI</i>	27
<i>Analysis of the Capacity Building Component of the Arctic SDI</i>	28
<i>Analysis of the Information Infrastructure Component of the Arctic SDI</i>	28
<i>Analysis of the Arctic SDI Geoportal</i>	29
<i>Analysis of the Arctic Circle Geoportals</i>	30
<i>Analysis of Data and Information Environment of the Arctic SDI</i>	30
<i>Analysis of the Standards Component of the Arctic SDI</i>	31
6. Bench-marking the Arctic SDI.....	32

7. Conclusion..... 33

Bibliography 34

Appendix A: The Arctic SDI Evaluation Framework..... 35

Appendix B: Persons Interviewed 35

Appendix C: Arctic Circle Geoportals 36

List of Figures

Figure 1: The Key Components of the Arctic SDI Encapsulated by the by the Implementation Guidelines of Best Practices and Users Priorities 10
Figure 2: Arctic SDI Assessment Work Plan Flow Chart 11
Figure 3: Positioning the Arctic SDI within the Natural Development Phases of an SDI 32

List of Tables

Table 1: The Pros and Cons of an SDI Evaluation 12
Table 2: Snap Shot of the Arctic SDI Evaluation Framework 16
Table 3: Components and Sub-components of the Arctic SDI that were Evaluated 20
Table 4: A Summary of the Implementation Activities for the Organizational Readiness Component.. 22
Table 5: A Summary of the Implementation Activities of the Capacity Building Component 23
Table 6: A Summary of the Implementation Activities of the Information Infrastructure Component . 23
Table 7: A Summary of the Implementation Activities of the Arctic SDI Geoportal Component 24
Table 8: A Summary of the Implementation Activities of the Arctic Circle Geoportals Component 25
Table 9: A Summary of the Implementation Activities of the Data and Information Environment 25
Table 10: A Summary of the Implementation Activities of the Standards Component 26
Table 11: The Implementation Status of the Seven Component of the Arctic SDI 26
Table 12: Implementation Priority Areas for the Organizational Readiness Component 28
Table 13: Implementation Priority Areas for the Capacity Building Component 28
Table 14: Implementation Priority Areas for the Information Infrastructure Component 29
Table 15: Implementation Priority Areas for the Arctic SDI Geoportal..... 29
Table 16: Implementation Priority Areas for the Arctic Circle Geoportals 30
Table 17: Implementation Priority Areas for the Data and Information Environment oponent..... 30
Table 18: Implementation Priority Areas for the Standards Component 31

Executive Summary

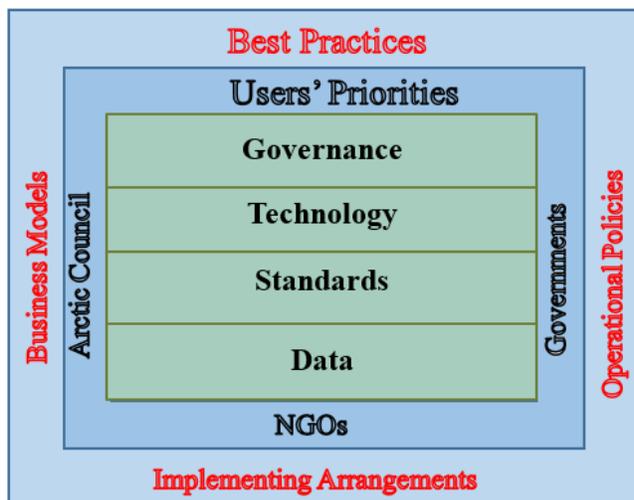
Project Overview

The Arctic Spatial Data Infrastructure was formally launched in 2011 with the following mission:

*“...to promote cooperation and development of a Spatial Data Infrastructure that enables discovery, visualization, access, integration and sharing of Arctic geospatial data, while pursuing best data management practices”.*¹

This mission, along with the vision, and objectives of the Arctic SDI will be achieved through the implementation and operation of the key components identified by the Arctic SDI Reference Model. The Arctic SDI Reference Model is a multi-dimensional integration of the following key components: data, standards, technology, operational policies and governance. These key components of the Arctic SDI are to be implemented and operated within the criteria of international best practices and users’ priorities (Figure EX 1).

Figure Ex 1: The components of the Arctic SDI



A key tool for providing valuable information to support the efficient implementation of the current and future phases of the Arctic SDI is readiness evaluation. A multifaceted evaluation of the current status of the Arctic SDI will provide information on which components have been implemented, gaps in the implementation process, areas that are working, areas where work is still required, and areas to be prioritize for future implementation. Based on the above facts it was decided by the Arctic SDI stakeholders that an Arctic SDI evaluation should be carried out to provide vital information to assist in the ongoing implementation of the

Arctic SDI, as well as the planning of future implementations.

The Arctic SDI Evaluation Project is a Natural Resources Canada initiative aimed at providing the Arctic Council, the Arctic SDI Board, and the stakeholders with information on the current implementation status of the Arctic SDI. Based on the project scope a cursory evaluation of the Arctic SDI will be performed, focussing on desktop research and interviews with key stakeholders.

The main objectives of the Arctic SDI Evaluation are as follow:

- a. To communicate to the Arctic Community the current status of the Arctic SDI;
- b. Identify implementation gaps; and
- c. Identify priority areas to support the evolution of the Arctic SDI.

¹ Arctic SDI Strategic Plan 2015-2020 (Nov. 2015); http://arctic-sdi.org/wp-content/uploads/2014/08/20151119-Arctic-SDI-Strategic-Plan-2015-2020_FINAL.pdf

These objectives will be achieved through the performance of the following two key tasks:

1. The development of an Arctic SDI Evaluation Framework ;and
2. The performance of a cursory evaluation of the Arctic SDI using the Framework developed in task one.

To effectively perform these two tasks and their associated sub-tasks the project was divided into two phases, with each phase aligned to the two main tasks to be performed. That is, phase 1 of the project will consist of the activities associated with the development of the evaluation framework. While, phase 2 will focus on the activities associated with conducting the cursory evaluation and reporting the results.

The Evaluation

An evaluation of an SDI is important in that it provides information to justify the global existence of an SDI, as well as support its day-to-day coordination and operation. Three distinctive methodologies have evolved for evaluating SDIs. These methodologies were designed based on the purpose of the evaluation, the components to be evaluated, the integration of the components, and the objectives of the SDI. The three distinctive categories/methodologies are as follow:

- ***Readiness Assessment;***
- ***Performance Assessment; and***
- ***Multi-view Assessment Framework:***

Methodology

SDI evaluation methodologies are chosen or developed based on the purpose of the evaluation and the complexity of the SDI to be evaluated. The main purpose of the Arctic SDI evaluation was to provide a snapshot of the current status of the SDI. In addition, the Arctic SDI implementation timeline indicates that the Arctic SDI is in the early phase of an SDI development and thus, will have less complexity. Based on these two key factors the Readiness Assessment methodology was chosen and customized to evaluate the Arctic SDI.

The application of the Readiness Assessment methodology to the evaluation of the Arctic SDI was carried out in two phases. The first phase focused mainly on the customization of the Readiness Assessment Methodology, and the development of an evaluation framework was based on international best practices and the Arctic SDI environment. The secondly phase utilized the developed Framework to perform a cursory evaluation of the Arctic SDI.

The Evaluation Framework

The Arctic SDI Evaluation Framework (the Framework) was designed to identify the key components and sub-components of the Arctic SDI, the expected outcomes of the components, and the extent to which the outcomes are achieving the expect goals. Indicators were also developed to identify the extent to which the outcomes are achieving the expect goals. For a readiness evaluation the expected outcome of a component would be functional implementation (i.e., the level to which the component has been implemented and its current functionality). Therefore, the objective of the Framework is to identify the extent to which the components and sub-components have been implemented and the level to which they are functioning.

Defining the Implementation Levels

In order to determine the current implementation status of the Arctic SDI it was necessary to develop a ranking system based on the assessed values of the indicators of the evaluation Framework. That is, based on the values of the indicators—as determined by the evaluation—the implementation status of the components and sub-components were defined. The following four levels of implementation were defined for the Arctic evaluation project:

1. **Early Phase of Implementation**
2. **Component Actively Being Implementation**
3. **Major Implementation Completed**
4. **Implementation Completed**

Benchmarking the Arctic SDI

The development and implementation of SDIs often tend to follow a natural path of evolution. One of the objectives of the Arctic SDI Evaluation is to identify the current status of the Arctic SDI along this natural evolutionary path (i.e., bench-mark or create a baseline of the Arctic SDI implementation status). This will provide the stakeholders with tools to track the implementation of the Arctic SDI overtime and comparing and contrasting the implementation and evolution of the Arctic SDI with other SDIs.

For the purpose of benching the Arctic SDI the natural evolution of an SDI was classified within the following six phases:

- **Phase 1 – Awareness**
- **Phase 2 –Inception**
- **Phase 3 –Realization/Enactment**
- **Phase 4 – Diffusion**
- **Phase 5 – Integration**
- **Phase 6 – Axiom**

Summary of Results

The results of the evaluation clearly identified the implementation status of the seven components of the Arctic SDI (Table Ex 1). As expected the components and sub-components were at different levels of the implementation cycle. The implementation levels of the components ranged from early phase of implementation to implementation completed for the current phase of the SDI.

Table Ex 1: The Implementation Status of the Seven Component of the Arctic SDI

Component	Implementation level
Organizational Readiness Component	<i>Component actively being implemented</i>
Capacity Building	<i>Early phase of implementation</i>
Information Infrastructure	<i>Implementation completed</i>
Arctic SDI Geoportal	<i>Major implementation completed</i>
Arctic Circle Geoportals	<i>Early phase of implementation</i>
Data and Information Environment	<i>Early phase of implementation</i>
Standards	<i>Major implementations completed</i>

From Table Ex 1 in can be seen that three components capacity building, Arctic Circle geoportals and data and information environment were in the early phase of implementation, with the organizational readiness component being considered as actively being implemented, the components Standards and Arctic SDI Geoportal had major implementation completed, and the information infrastructure component evaluated as implementation completed for this phase of the SDI. The results indicated that tremendous work has been undertaken in both the planning of this phase of the Arctic SDI, as well as the actual implementation of some of the key components of the SDI.

The analysis of the results of the Arctic SDI Evaluation identified a number of implementation priority areas that if addressed can significantly improve the implementation status of the SDI, the operations of the SDI, the usage of the SDI, as well as the effectiveness of the SDI to the Arctic Community (Tables Ex 2).

Table Ex 2: Priority Areas for the Arctic SDI Implementation

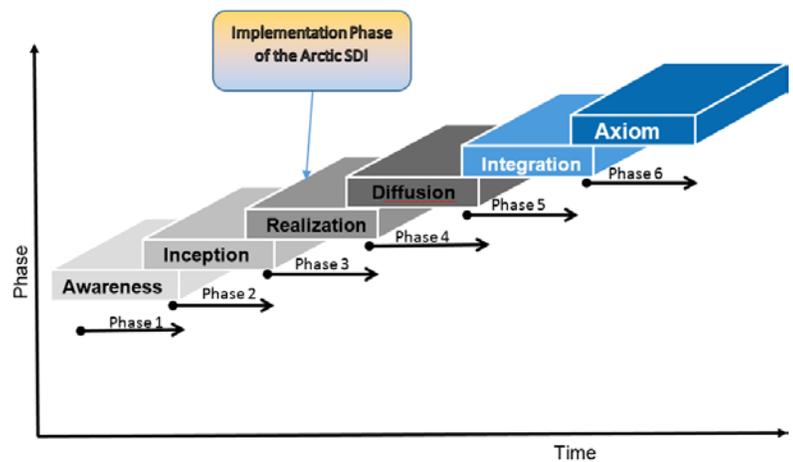
Component	Implementation Status	Priority Areas
<i>Organizational Readiness</i>	Component actively being implemented	<ul style="list-style-type: none"> • The development and implementation of a performance management framework; • The development and implementation of an authoritative framework that includes polices, directives or regulations to guide the implementation, usage, and operation of the SDI ; • Deployment of a full time management team to drive the implementation and manage the day-to-day operations.
<i>Capacity Building</i>	Early phase of implementation	<ul style="list-style-type: none"> • The development and publication of an Arctic SDI Manual; • The development and publication of a Geoportal Users' Guide; • The development and publication of a document to guide the collection of interoperable data across the Arctic.
<i>Information Infrastructure</i>	Implementation completed	<ul style="list-style-type: none"> • The implementation of infrastructure (hardware and software) to support the linking of the Arctic SDI Geoportal to key Arctic Circle Geoportals and to facilitate automated data transfer.
<i>Arctic SDI Geoportal</i>	Major implementation completed	<ul style="list-style-type: none"> • The implementation of download and upload services for geospatial data; • The linking of the geoportal to other Arctic Community geoportal; • The implementation of a helpdesk to assist the users; • The development and implementation of indicators to measure the performance of the portal.
<i>Arctic Circle Geoportals</i>	Early phase of implementation	<ul style="list-style-type: none"> • Perform a more detailed investigation on the Arctic related geoportals; • Prioritize the national geoportals for linking to the Arctic SDI Geoportal; • Prioritize the community geoportals for linking to the Arctic SDI Geoportal;

Table Ex 2 Cont'd: Priority Areas for the Arctic SDI Implementation

Data and Information Environment	Early phase of implementation	<ul style="list-style-type: none"> • The definition of reference datasets; • Policies for the sharing of data that will results in more datasets being made available to the SDI by custodians; • Definition of data and metadata policies to support interoperability; • The definition of relevant thematic datasets (inclusive of hydrographic data).
Standards	Major implementations completed	<ul style="list-style-type: none"> • Document and publish all standards that have been agreed upon; • Develop a standard document for the Arctic SDI

Bench-marking the Arctic SDI

Numbered phases Awareness, Inception, Realization, Diffusion, Integration, Axiom. Based on the results of the evaluation the Arctic SDI was benched-marked in phase 3, the realization phase of the natural path of implementation of an SDI. The results of the evaluation indicate that the Arctic SDI components implemented, as well as the level to which they were implemented match those of an SDI that is normally at the realization phase of implementation. Some key achievements within the realization phase are the implementation



of technology to support data sharing, standards, strategic plan to guide the implementation process, a coordinating body, data sharing policies and fundamental datasets. The results of the evaluation indicated that a number of these criteria were met by the Arctic SDI. However, it should be noted that implementation level of these components vary from early phase of implementation to implementation completed, therefore, it can be concluded that the Arctic SDI is at the early stage of the realization implementation phase. That is at the overlapping stage between inception and realization (see figure).

1. Introduction and Overview

Over the last 16 years today's information oriented society has seen the implementation of a number of Spatial Data Infrastructures all aimed at creating an environment to support discovery, access, viewing, assessment, dissemination, sharing, and re-use of geospatial information. A Spatial Data Infrastructure (SDI) is a complex multi-dimensional integration—based on stakeholders' perspective—of data, standards, policies, technology, and human resources to support the efficient and effective sharing of geospatial information. Spatial Data Infrastructures have been implemented at different levels of the society (e.g., local levels, provincial/state level, national levels and regional levels) to facilitate more efficient access, sharing and reusing of geospatial information by the different communities, stakeholders and users.

The Arctic Spatial Data Infrastructure (Arctic SDI), a regional Spatial Data Infrastructure was conceptualised and brought to life in order to provide politicians, governments, policy makers, scientists, private enterprises and citizens of the Arctic Region with greater access to geographically related Arctic data, digital maps and tools to facilitate better monitoring and more informed decision-making². This voluntary, multicultural, and multilateral cooperation was brought to life through formal cooperation between the National Mapping Agencies of the eight nations forming the Arctic Council (i.e., Canada, Denmark [including the Faroe Islands and the Greenland], Finland, Iceland, Norway, Russia, Sweden, and the USA).

The Arctic Spatial Data Infrastructure was formally launched in 2011 with the following mission³:

“...to promote cooperation and development of a Spatial Data Infrastructure that enables discovery, visualization, access, integration and sharing of Arctic geospatial data, while pursuing best data management practices”.

This mission, along with the vision, and objectives of the Arctic SDI will be achieved through the implementation and operation of the components identified by the Arctic SDI Reference Model. The Arctic SDI Reference Model is a multi-dimensional integration of the following key components: data, standards, technology, operational policies and governance. These key components of the Arctic SDI are to be implemented and operated within the criteria of international best practices and users' priorities (Figure 1). Figure 1 is an illustration of the integration of the components of the Arctic SDI that are to be implemented (i.e., data, standards, technology, operational policies and governance) within the guidelines of users' priorities and best practices.

² Arctic Spatial Data Infrastructure Framework Document. Available at: http://arctic-sdi.org/wp-content/uploads/2014/08/20150825-Arctic-SDI-Framework-Document_V2-0.pdf

³ Arctic Spatial Data Infrastructure Strategic Plan. Available at: http://arctic-sdi.org/wp-content/uploads/2014/08/20151119-Arctic-SDI-Strategic-Plan-2015-2020_FINAL.pdf

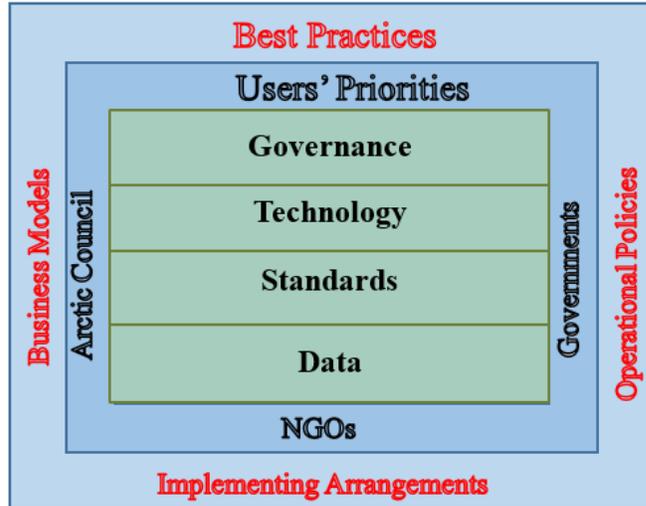


Figure 1: The Key Components of the Arctic SDI Encapsulated by the by the Implementation Guidelines of Best Practices and Users Priorities

Similar to most SDIs the implementation of the Arctic SDI is currently being carried out on a phase basis. The current planned implementation activities of the Arctic SDI is described in the Arctic SDI Implementation Plan 2015-2020. The implementation, maintenance and administration of the Arctic SDI is the responsibility of the Arctic SDI Board.

A key tool for providing valuable information to support the efficient implementation of the current and future phases of the Arctic SDI is readiness evaluation. A multifaceted evaluation of the current status of the Arctic SDI will provide information on which components have been implemented, gaps in the implementation process, areas that are working, areas where work is still required, and areas to be prioritize for future implementation. Based on the above facts it was decided by the Arctic SDI stakeholders that an Arctic SDI evaluation should be carried out to provide vital information to assist in the ongoing implementation of the Arctic SDI, as well as the planning of future implementations.

Project Overview

The Arctic SDI Evaluation Project is a Natural Resources Canada initiative aimed at providing the Arctic Council, the Arctic SDI Board, and the stakeholders with information on the current status of the Arctic SDI implementation. Based on the project scope a cursory evaluation of the Arctic SDI will be performed, focussing on desktop research and interviews with key stakeholders.

The main objectives of the Arctic SDI Evaluation are as follow:

- d. To communicate to the Arctic Community the current status of the Arctic SDI;
- e. Identify implementation gaps; and
- f. Identify priority areas to support the evolution of the Arctic SDI.

The objectives of the project will be achieved through the performance of the following two key tasks:

- 3. The development of an Arctic SDI Evaluation Framework ;and
- 4. The performance of a cursory evaluation of the Arctic SDI.

To effectively perform these two tasks and their associated sub-tasks the project was divided into two phases, with each phase aligned to the two main tasks to be performed. That is, phase 1 of the project will consist of the activities associated with the development of the evaluation framework. While, phase 2 will focus on the activities associated with conducting the cursory evaluation and reporting the results (Figure 2).

The key expected outputs of the Arctic SDI Evaluation Projects are as follow:

- A state-of-the art Assessment Framework—based on international standards—which will be used to evaluate the current status of the Arctic SDI, as well as support future measuring and monitoring of the Arctic SDI;
- A snap shot of the current status of key components of the Arctic SDI, as well as, an overview of the overall status of the SDI;
- The areas where work is still required to advance the Arctic SDI;
- Priority areas for future development;
- A baseline which will be used to benchmark future implementation and performance.

It is expected that outputs of the Arctic SDI Evaluation project will serve as a tool to aid the Arctic SDI stakeholders in current implementation process, as well as assist them in guiding the development and prioritization of future implementation activities.

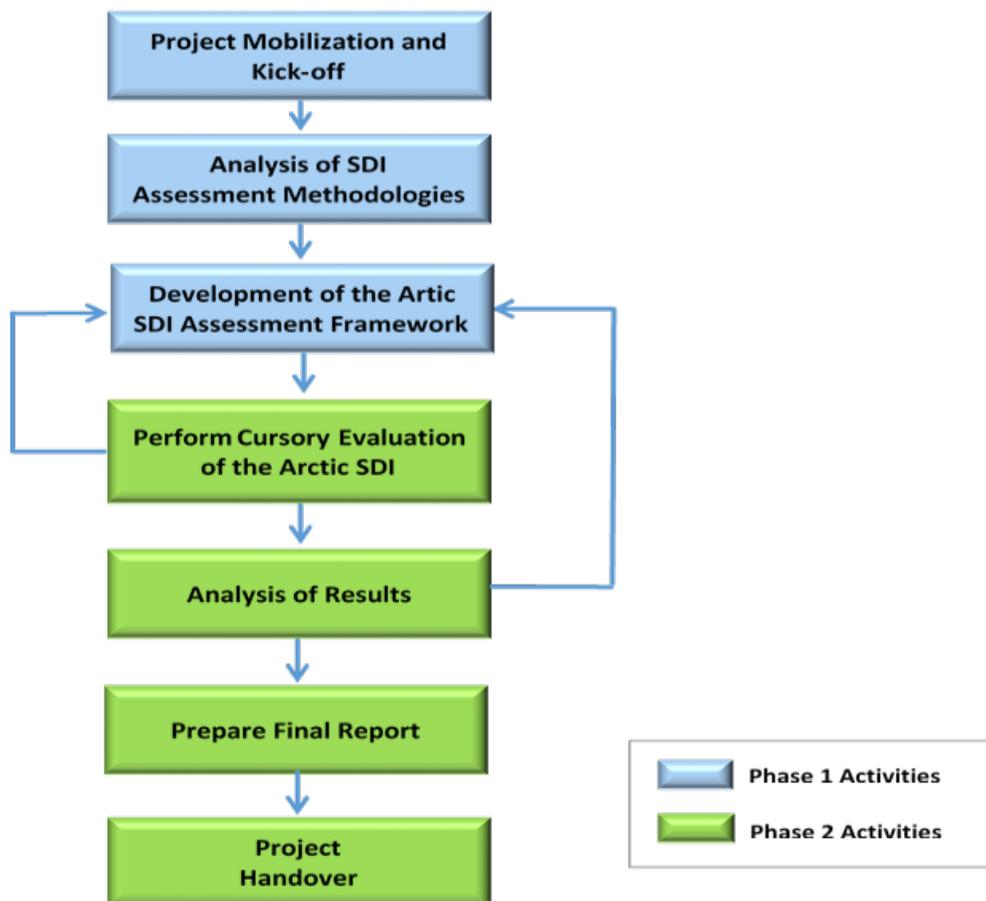


Figure 2: Arctic SDI Assessment Work Plan Flow Chart

2. SDI Evaluation

One of the features of modern society is public fiscal responsibility and accountability. This has resulted in public sector program managers/coordinators having to include regular program justification in their management activities. SDIs are usually coordinated by public sector agencies and thus, the growing awareness of the need to measure and report on their performance or their current status. That is, SDI program coordinators are becoming more aware of the need to evaluate their SDIs to justify expenditure and provide information on whether or not their SDIs are achieving their goals and objectives in an efficient manner.

The information gained from an SDI evaluation not only justify the global existence of an SDI but also support the day-to-day coordination and operation of the SDI. That is, an SDI evaluation can clearly identify components of an SDI that are operating efficiently and effectively and those components that require improvement to achieve the desired goal(s).

Within the SDI community program evaluation is often viewed as an additional coordination activity that can be costly. However, from Table1 it can be seen that the benefits to be gained from an SDI evaluation clearly out weights the additional efforts and cost incurred. In addition, if an SDI evaluation is carried out within a Performance Based Management Framework, then the additional efforts, knowledge, and cost required to perform the evaluation will be reduced with time⁴. That is, SDI evaluation that are systematic in design and implementation in a timely and efficient manner are more cost effective and productive.

Table 1: The Pros and Cons of an SDI Evaluation

Pros	Cons
<ul style="list-style-type: none"> ▪ Assist in the identification of key components of the SDI 	<ul style="list-style-type: none"> ▪ Can be costly to develop and implement the evaluation framework
<ul style="list-style-type: none"> ▪ Provide implementation information (what exist and identify gaps) 	<ul style="list-style-type: none"> ▪ Require knowledge of program evaluation and SDI evaluation
<ul style="list-style-type: none"> ▪ Provide information on areas that are working and those that need improvement 	<ul style="list-style-type: none"> ▪ Additional time demand on SDI coordinators and stakeholders
<ul style="list-style-type: none"> ▪ Provide information on whether or not the SDI is achieving its goals and objectives 	<ul style="list-style-type: none"> ▪ Evaluation information are sometimes ignored or misinterpreted
<ul style="list-style-type: none"> ▪ Provide information to demonstrate accountability 	
<ul style="list-style-type: none"> ▪ Provide information to support capacity building 	
<ul style="list-style-type: none"> ▪ Provide performance information from both the stakeholders and users perspective 	
<ul style="list-style-type: none"> ▪ Provide information to support future development of the SDI 	
<ul style="list-style-type: none"> ▪ Provide information to assist in demonstrating the outcomes and impact an SDI is having on the society 	
<ul style="list-style-type: none"> ▪ Provide benchmarking information 	
<ul style="list-style-type: none"> ▪ Provide information that can assist in the development of “best practices” and “lessons learned” 	

⁴ G. Giff and J. Cromptoets. 2013 “Measuring and Monitoring Impacts and Benefits.” In “Spatial Data Infrastructure (SDI) manual for the Americas” http://unstats.un.org/unsd/geoinfo/RCC/docs/rcca10/E_Conf_103_14_PCIDEA_SDI%20Manual_ING_Final.pdf

SDI Evaluation Methodologies

The main challenge facing most SDI coordinators and stakeholders in performing an SDI evaluation is the development of a functional, cost-effective frameworks to evaluate this complex—multiple components, multiple stakeholders and multi-dimensional— infrastructure known as the SDI⁵. Due to the complexity of an SDI, early SDI assessments mainly focused on the activities of the geoportal and the other components were mainly marginalized. In addressing this issue, the SDI community developed and structured three distinctive methodologies for evaluating the different components of an SDI, as well as evaluating the SDI from different perspectives. These methodologies were designed based on the purpose of the evaluation, the components to be evaluated, the integration of the components, and the objectives of the SDI. The three distinctive categories/methodologies are as follow:

- ***Readiness Assessment***: a fact-gathering exercise carried out to determine the as-is status of an SDI. It provides an insight into whether or not the components, tools and personnel are in place to achieve the stated objectives. An example of this type of evaluation is the COGO led assessment of the Framework Dataset of the United States of America NSDI.
http://cogo.pro/uploads/COGO-Report_Card_on_NSDI.pdf.
- ***Performance Assessment***: goes beyond readiness; seek to determine the level to which selected components are performing. An SDI performance assessment also provides information on the level to which an SDI is achieving its desired outputs, outcomes and impact. This is usually determined through the use of performance indicators that are consistently measured and monitored. An example of this type of evaluation is the GeoConnections led evaluation of the Canadian NSDI (the Canadian Geospatial Data Infrastructure).

2015 Assessment of the Canadian Geospatial Data Infrastructure:

<http://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=297880>

2012 Assessment Report for the Canadian Geospatial Data Infrastructure - Executive Summary and Case Studies:

<http://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=295667>

- ***Multi-view Assessment Framework***: consists of nine SDI assessment methodologies from which an SDI practitioner can select the best methodology(s) that will facilitate the most effective assessment of the SDI from the required viewpoint. The multi-view framework does have its drawbacks in that the application of multiple frameworks will require personnel with knowledge of the different frameworks selected, as well as, combining frameworks to suit the assessment needs will be an iterative process. The 2010 evaluation of the Netherlands NSDI employed the Multi-view Assessment Framework. For more information on the Multi-view Assessment Framework see:

http://www.csdila.unimelb.edu.au/publication/multi-view-framework/Chapter_5.pdf

⁵ L. Grus, J. Crompvoets, and A. Bregt 2011 "Theoretical introduction to the Multi-view Framework to assess SDIs." In A Multi-view Framework to Assess Spatial Data Infrastructures. http://www.csdila.unimelb.edu.au/publication/multi-view-framework/Chapter_5.pdf

For the evaluation of a particular SDI, it is expected that the SDI coordinator will select a methodology(s) from the above categories based on the purpose of the evaluation, the components of the SDI, the skills of the personnel involved, ease of use, cost, and the time it takes to perform the evaluation.

3. Arctic SDI Evaluation

The Arctic SDI evaluation was carried out in two phases. Firstly, an evaluation framework was developed based on international best practices and the Arctic SDI environment. Secondly, the developed Framework was used to perform a cursory evaluation of the Arctic SDI, to provide stakeholders with information on the development and current status of the Arctic SDI. It is expected that this information will inform the stakeholders of areas of the SDI where additional work is required, as well as provide a benchmark (baseline) that will assist in positioning the future growth and continued relevance of the Arctic SDI.

Methodology

SDI evaluation methodologies are chosen or developed based on the purpose of the evaluation and the complexity of the SDI to be evaluated. The main purpose of the Arctic SDI evaluation was to provide a snapshot of the current status of the SDI. In addition, the Arctic SDI implementation timeline indicates that the Arctic SDI is in the early phase of an SDI development and thus, will have less complexity. Based on these two key factors the Readiness Assessment methodology was chosen and customized to evaluate the Arctic SDI.

The application of the Readiness Assessment methodology to the evaluation of the Arctic SDI utilized the following methodologies:

- ***Customization of the Readiness Assessment Methodology:*** this evaluation technique was customized with respect to the purpose of the evaluation, the components of the Arctic SDI, the objectives of the Arctic SDI and the unique operating environment of the Arctic SDI.
- ***The development of an Arctic SDI Evaluation Framework:*** developed within the context of the Readiness Assessment methodology (i.e., designed to capture the readiness/current status of the Arctic SDI). The Framework was developed through an iterative process that involved consultation with key stakeholders (Appendix B).
- ***The performance of the cursory evaluation:*** the application of the Framework. This included defining the values of the indicators of the Framework through literature/desktop review and interviews with key stakeholders (Appendix B). Review of the Arctic SDI Geoportal and other Arctic Community geoportals. The analysis of the results to identify the implementation gaps, determine priority areas for future implementation, and benchmark the SDI.

The Evaluation Framework

The Arctic SDI Evaluation Framework (the Framework) was designed to identify the key components and sub-components of the Arctic SDI, the expected outcomes of the components, and the extent to which the outcomes are achieving the expected goals. For a readiness evaluation the expected outcome of a component would be functional implementation (i.e., the level to which the component has been implemented and its current functionality). Therefore, the objective of the Framework is to identify the extent to which the components and sub-components have been implemented and the level to which they are functioning.

The Framework was developed through an iterative process with each iteration seeking to fine tune different aspects of the Framework. That is, the Framework development involved repetitive analysis of the SDI, the operational environment and the Framework itself. The process also included consultation with key stakeholders and the review of the Framework by key stakeholders. Similar to the project plan, the Framework development was divided into two phases. In Phase 1 the iterative processes focused mainly on the identification of the components and sub-components of the Arctic SDI, as well as the outcomes of these components. The second phase focused mainly on the development of the indicators to measure the status of the components and sub-components. The indicators were developed through iterative analysis of each outcome. This facilitated the identification of the most suitable variables (indicators) that will effectively communicate whether or not that particular outcome is achieved (i.e. extent to which it was implemented). The iterative process was also used to ensure that the number of indicators were kept to a minimum—but were effective in measuring the outcome—in order to minimize the cost of applying the Framework.

The iterative analysis resulted in the development of an average of four indicators for each sub-component. These indicators will be used to determine the extent to which components and sub-components were implemented. The analysis also facilitated the identification of the methods to be used for collecting the information necessary to define the values of the indicators. Table 2 below is a snapshot of the skeleton of the Arctic SDI Evaluation Framework. Please see Appendix A for the complete Evaluation Framework.

Table 2: Snap Shot of the Arctic SDI Evaluation Framework

Environment	Component	Sub-Component	Outcome	Intent of the indicator	Indicator/Metric	Evaluation Methodology	
Readiness	Organizational Readiness	<i>Governance</i>					
		<i>Strategy</i>					
		<i>Human Resources</i>					
		<i>Community Development</i>					
		<i>Performance Management</i>					
		<i>Authoritative Framework</i>					
		<i>Funding Arrangements</i>					
		<i>Management</i>					
	Capacity Building	An environment exist to support the growth of the concept of data sharing, the usage of the SDI, and the application of geospatial information to informed decision-making					
		<i>Communication and Outreach</i>					
		<i>Capacity Strengthening</i>					
	Information Infrastructure	Adequate Infrastructure exist to facilitate efficient access and dissemination of geospatial information					
		<i>Reliable Infrastructure</i>					
		<i>Technical Infrastructure Transfer Environment</i>					
	Arctic SDI Geoportal	The Arctic SDI Geoportal facilitates the discovery, viewing, assessing, analysing, and downloading of geospatial information					
		<i>Access</i>					
		<i>Data Transmission</i>					
		<i>Services</i>					
		<i>Geoportal development</i>					
	Arctic Circle Geoportals	<i>National Geoportals</i>					
		<i>Community Geoportals</i>					
	Data and Information Environment	The Arctic SDI facilitates access to current, reliable and relevant data					
		<i>Reference Datasets</i>					
		<i>Relevant Thematic Datasets</i>					
		<i>Non-spatial Information</i>					
	Standards	Standards are in place and promoted to support geospatial interoperability					
		<i>Data Standards</i>					
		<i>Web Services Standards</i>					
<i>Data Exchange Standards</i>							
		<i>Technology Standards</i>					

Defining the Implementation Levels

In order to determine the current implementation status of the Arctic SDI it was necessary to develop a ranking system based on the assessed values of the indicators of the evaluation Framework. That is, based on the values identified for the indicators—through the evaluation process—the implementation status of the components and sub-components were defined. Four levels of implementation were defined for the Arctic evaluation project. For a components or sub-components to be placed in a level, two or more of the key activities of the level should be completed. The four levels of implementation are described below.

5. Early Phase of Implementation

This is the first and lowest implementation level. Within this category, the following implementation activities have been carried out:

- Components and sub-components defined;
- Preliminary implementation plan(s) for the components and its sub-components discussed and in some cases documented;
- Working group(s) or stakeholder volunteer(s) owns the implementation
- Implementation activities carried out on some of the minor sub-components.

6. Component Actively Being Implementation

Within this category (the second level of implementation) the following implementation activities have been carried out:

- Implementation plan(s) for the components and its sub-components completed;
- Implementation lead assigned
- Implementation started on key sub-components
- Implementation process is ongoing

7. Major Implementation Completed

Within this category the following implementation activities have been carried out:

- Implementation activities are carried within a project management framework;
- Implementation has begun on all sub-components
- The implementation of key sub-components have been completed;
- Implementation process is ongoing

8. Implementation Completed

This is the final and completed level of implementation. Within this category, the following implementation activities have been carried out:

- The implementation of component is completed;
- The component is functional and has been handed over to a management team for operation and maintenance;
- Plans have been made for timely review and upgrading of the component based on users' needs or development in technology.

Benchmarking the Arctic SDI

Although SDIs are usually different in terms of the definition of the components, integration of the components, and their objectives to name a few, they often tend to follow a natural path of evolution⁶. One of the objectives of the Arctic SDI Evaluation is to benchmark or create a baseline of the Arctic SDI implementation status. This will provide the stakeholders with tools to track the implementation of the Arctic SDI overtime. Benchmarking the Arctic SDI will also facilitate the Arctic SDI Board in comparing and contrasting the implementation and evolution of the Arctic SDI with other SDIs.

For the purpose of benchmarking the Arctic SDI the natural evolution of an SDI was classified within the following six phases:

Phase 1 – Awareness

At this level, members of the thematic community start to explore the benefits to be gained from formalizing current ad hoc geospatial information (GI) sharing arrangements. The concept and practicality of an SDI are researched and enthusiasts may invest personal time in learning more about the organizational, technical and socio-political issues associated with SDI implementation (SDI champions are born). Enthusiasts introduce the concept of an SDI to informal GI sharing groups. Within this level, an SDI coordinating body is usually formed with the purpose of making recommendations on the formalization of the SDI and the implementation arrangements. In summary, within this level the need for a structure to support the formal sharing of GI is identified, the awareness of an SDI is raised, and a coordinating body evolves to plot the way forward.

Phase 2 –Inception

Within this level the innovation-decision process is carried out. Sufficient interest in the sharing of GI has been garnered and the thematic community decides to implement an SDI. During the inception phase preliminary SDI initiatives are undertaken. Typical SDI initiatives in this level usually consist of the formation of working groups to develop frameworks to facilitate GI sharing. Fundamental spatial datasets and the need for common standards are normally identified within this level. A greater percentage of the community now participates in bringing the concept to reality. The benefits of the SDI are clearly defined.

Phase 3 –Realization/Enactment

In the realization phase, stakeholders participate in the phased implementation of key components (e.g., data, policies and technology) of the SDI. The implementation although driven by the stakeholders is steered by the coordinating body and the outcomes of the working groups. Implementation can either take on the top-down or bottom-up approach. In some unique cases there is a mix of the 2 approaches. Investment in the SDI usually comes from the stakeholders with support from a central government organization (e.g., National Mapping Agency [NMA]). Main SDI components example, fundamental datasets, data sharing policies and the technology to facilitate the sharing of GI are usually implemented in this phase. An interoperability framework is developed and stakeholders begin to manage GI within a sharing environment. Standards and custodianship of fundamental datasets are clearly defined in the way forward. Implementation is usually supported by a strategic and implementation plans. Usage of the SDI

⁶ ADSIC

is limited to the early adopters—mainly professionals with geospatial training—however, the stakeholders are fully aware of the benefits of an SDI.

Phase 4 – Diffusion

At this level the SDI is now widely accepted by the thematic community and its significance is growing within the other sectors. This results in an increase in the number of participants in the implementation of the SDI and evolving components to meet the needs of the society. With multiple stakeholders' participation, the SDI moves beyond GI sharing to encapsulate the sharing of spatially enabled services as well. Information and in some cases infrastructure redundancy is greatly reduced throughout the community. The SDI is viewed as the first choice environment for discovering, viewing, accessing, assessing and sharing GI. Multiple sectors of the society access the SDI's facilities to enhance their business activities. With the growing acceptance of the SDI, citizens become more aware of its benefits. SDI usage is now distributed across a wide cross-section of the thematic community. The evolution of the SDI also benefits from the knowledge of a wider community. Within this level a detailed roadmap is usually developed to support the evolving implementation of the SDI.

Phase 5 – Integration

At this level, the SDI is integrated into the business activities of the stakeholders and the wider thematic community to a lesser extent. That is, SDI services are imbedded into the relevant business process of the stakeholders and play a key role in GI activities of the wider community. During this phase, applications and technology are implemented to improve viewing, accessing and downloading of GI. SDI services are simplified and become more user friendly to non-GI professionals. The community in general looks to the SDI for GI solutions. That is, the SDI now facilitates a secure GI environment where GI and GI services can be easily located, viewed, reviewed and acquired. This level also sees the growing participation of other sectors and citizens in the evolution of the SDI. At this stage the SDI is widely used by the thematic community and in a limited capacity by the general society. During this phase the SDI evolves from an information and technology driven facilitator to a service facilitator. The focus is on spatially enabling processes and services.

Phase 6 – Axiom

At the axiom level, the SDI is widely accepted as an infrastructure—similar to the acceptance of roads, utility and railways—to facilitate the efficient and effective usage of GI and GI related services. The SDI is now seamlessly integrated into the activities of government, business and citizens. That is, the services of the SDI are widely used in societal activities without the necessity of an extra step or GI knowledge. The distinction between GI and other services is now blurred; the SDI facilitates an environment where GI is used to enhance citizens' way of life, and the business processes of government and non-government entities both within and outside of the environment in which it operates. SDI services are on-demand, wherever demanded, as the focus on mobile applications and personalized tools increases. Within this level a framework is developed to support innovation of not only the SDI but GI applications in general. For SDIs at the axiom level the utilization of their services are carried out without the users recognizing that they are using an SDI. SDIs at the axiom level are key facilitators and enablers of smart cities and eSocieties.

Although the Arctic SDI is a very unique SDI, it is expected that in most part it will follow the natural progression of an SDI as illustrated by the six levels above. Based on this concept, the results of the Arctic SDI evaluation will be used to benchmark the Arctic SDI within one of the six levels listed above. That is, the Arctic SDI will be positioned within one of the six evolutionary levels of an SDI based on the implementation status—identified by the evaluation—of its key components and sub-components.

4. Results of the Evaluation

The implementation and maintenance of a complex infrastructure such as an SDI requires long-term commitment, dedication, professionalism, knowledge, adaptability, cooperation and collaboration, and of course strong commitment to the sharing of GI. The implementation and maintenance of the Arctic SDI is even more challenging given the unique nature of this SDI. In implementing the Arctic SDI the Arctic SDI Community is not only faced within the complex, multi-dimensional aspects of an SDI but with the unique multi-cultural, multi-perspective and multi-lingual aspects of the Arctic SDI. The Arctic SDI Community should be congratulated on its efforts in bringing to life the Arctic SDI. The implementation of the Arctic SDI is well on its way and the results of the evaluation clearly shows the tremendous efforts the Community has put into implementing the Arctic SDI.

The evaluation identified seven key components and twenty five sub-components of the Arctic SDI (Table 3).

Table 3: Components and Sub-components of the Arctic SDI that were Evaluated

Component	Sub-Component
1. Organizational Readiness	I. Governance
	II. Strategy
	III. Human Resources
	IV. Community Development
	V. Performance Management
	VI. Authoritative Framework
	VII. Funding Arrangements
	VIII. Management
2. Capacity Building	IX. Communication and Outreach
	X. Capacity Strengthening
3. Information Infrastructure	XI. Reliable Infrastructure
	XII. Technical Infrastructure Transfer Environment
4. Arctic SDI Geoportal	XIII. Access
	XIV. Data Transmission
	XV. Services
	XVI. Geoportal development
5. Arctic Circle Geoportals	XVII. National Geoportals
	XVIII. Community Geoportals
6. Data and Information Environment	XIX. Reference Datasets
	XX. Relevant Thematic Datasets
	XXI. Non-spatial Information
7. Standards	XXII. Data Standards
	XXIII. Web Services Standards
	XXIV. Data Exchange Standards
	XXV. Technology Standards

The components and sub-components were all evaluated to determine the extent to which they were implemented and their functionality to a lesser extent (Appendix A):

The results of the evaluation indicated that implementation activities have been carried out on all the key components (data, standards, technology, governance and operational policies) of the Arctic SDI as identified by the Arctic SDI Reference Model. The completed implementation activities, as well as those currently in progress were performed using international best practices and were designed to meet the users' needs as stipulated by the Arctic SDI Reference Model.

Organizational Readiness

The Arctic SDI Evaluation project identified eight key sub-components of *organizational readiness* that should be implemented to facilitate the effective operation of the Arctic SDI (Table 4). The results of the evaluation indicate that different levels of implementation activities have been performed on six of these eight sub-components (see Table 4 for more details).

Table 4: A Summary of the Implementation Activities for the Organizational Readiness Component

Component	Sub-Component	Implementation Activities	Implementation Level
Organizational Readiness	Governance	A coordinating body is in place (the Arctic SDI Board) to support the implementation of the SDI. The Arctic SDI Board is a representation of most of the major interest groups in the Arctic. The Board is currently supported by six active working groups.	Major implementation completed
	Strategy	There is a strategic plan in place for the Arctic SDI. This strategic plan clearly outlines the vision and direction of the Arctic SDI for the term 2015-2020. The strategic plan is also supported by other key documents e.g., an implementation plan, a roadmap and a framework document.	Implementation completed
	Human Resources	The Arctic SDI has a unique model for the deployment of qualified personnel to support its implementation and operation. Personnel are volunteers from stakeholders' organization who balance their time between Arctic SDI activities and that of their regular jobs. For this model to be more successful, additional personnel are required. Currently, there is insufficient staff to support the implementation and maintenance activities of the SDI.	Component actively being implemented
	Community Development	The Arctic SDI is based on collaboration amongst the 8 countries of the Arctic Region, thus, partnership at the national level is strong. However, there are other interest groups operating within the Arctic which are not yet fully participating in the SDI.	Component actively being implemented
	Performance Management	No performance management program implemented for the SDI. However, the need for one is documented in the Implementation Plan.	Early phase of implementation
	Authoritative Framework	The Arctic SDI MOU and the Governance Document are currently the two main components of the Arctic SDI's Authoritative Framework. These documents are very high-level and do not provide sufficient details to cover e.g., intellectual property, privacy, security, liability, data sharing guidelines, data archiving, and confidentiality issues.	Early phase of implementation
	Funding Arrangements	The Arctic SDI funding arrangement is very unique. Funding is provided through non-monetary contributions from the budget of the NMAs of the 8 countries forming the Arctic. Contributions are in the form of services, software, and infrastructure. No structured budget or business plan implemented.	Component actively being implemented
	Management	Currently no management structure in place. Full-time management team is required to drive the implementation and maintenance of the SDI	Early phase of implementation
	Current Implementation Status of the Organizational Readiness Component		

Capacity Building

For the *capacity building* component, two sub-components were identified as key to the successful operation of the Arctic SDI. These sub-components are communication and outreach—one of the six objectives of the Arctic SDI Strategic Plan—and capacity strengthening. Although implementation has begun on this component the activities to-date are very limited (see Table 5 for details).

Table 5: A Summary of the Implementation Activities of the Capacity Building Component

Component	Sub-Component	Implementation Activities	Implementation Level
Capacity Building	<i>Communication and Outreach</i>	A communication and outreach program is currently being design by the Communication Working Group. A key communication and outreach tool implemented to-date is the Arctic SDI website.	Early phase of implementation
	<i>Capacity Strengthening</i>	No capacity strengthening program developed. However, the Arctic SDI has worked with CAFF on structuring their data collection techniques to support data sharing.	Early phase of implementation
<i>Current Implementation Status of the Capacity Building Component</i>			Early phase of implementation

Information Infrastructure

For an SDI to operate successfully and achieve its goals there need to be in place modern and reliable infrastructure. The evaluation identified that significant efforts have been made to implement a modern information infrastructure to support the goals and objectives of the Arctic SDI (see Table 6 for details). The results of the evaluation show that the implementation of the *information infrastructure* component was completed for this phase of the SDI.

Table 6: A Summary of the Implementation Activities of the Information Infrastructure Component

Component	Sub-Component	Implementation Activities	Implementation Level
Information Infrastructure	<i>Reliable Infrastructure</i>	Reliable infrastructures that meets international standards are in place to support the functions of the Arctic SDI. The Arctic SDI utilizes the infrastructure of the key stakeholders.	Implementation completed
	<i>Technical Infrastructure Transfer Environment</i>	Within the Arctic SDI a security sound technical environment exist for the management of geospatial information. That is, all technology platforms and processes are compliant with security best practice.	Implementation completed
<i>Current Implementation Status of the Information Infrastructure Component</i>			Implementation completed

Arctic SDI Geoportal

The geoportal is the most visible component of an SDI and is often used as the single measure of the success of an SDI. The evaluation revealed that significant work has been done on implementing the *Arctic SDI geoportal*. All four key sub-components identified by the Framework were implemented to some extent, with three of these sub-components in advanced stage of implementation. However, the absence of data in the geoportal greatly reduces its functionality. The evaluation results show that major implementation has been completed within this component. Table 7 provides additional evaluation results on the *Arctic SDI geoportal*.

Table 7: A Summary of the Implementation Activities of the Arctic SDI Geoportal Component

Component	Sub-Component	Implementation Activities	Implementation Level
Arctic SDI Geoportal	Access	The access sub-component of the geoportal is well developed. Five of the six indicators used to evaluate this sub-component were achieved.	Implementation completed
	Data Transmission	Currently the geoportal does not transmit (download or upload) geospatial data. That is, shape files cannot be downloaded. Other files e.g., CSWs can be transmitted.	Early phase of implementation
	Services	The Oskari software implemented on the geoportal consist of a number of tools capable of performing the services normally required of a geoportal. In the case of the Arctic SDI a number of these tools are functional. An example is the map publishing tool which facilitates the making of embedded maps. The decision to make other tools functional will be dependent on the results of the users' needs survey.	Implementation completed
	Geoportal development	An environment exist for the development of the geoportal that follows best practice and encapsulate the feed-back of stakeholders. A test area has been created where stakeholders can go to test the latest addition to the geoportal and provide feedback before these additions are permanently implemented.	Implementation completed
Current Implementation Status of the Arctic SDI Geoportal			Major implementation completed

Arctic Circle Geoportals

The component *Arctic Circle Geoportals* was included in the evaluation to facilitate preliminary identification of the number of Arctic related geoportal that currently exist and the possibility of linking these geoportals to the Arctic SDI Geoportal in order to better facilitate the sharing of Arctic related geospatial information. The evaluation indicates that this component is in the early phase of implementation. See Table 8 and Appendix C for more details.

Table 8: A Summary of the Implementation Activities of the Arctic Circle Geoportals Component

Component	Sub-Component	Implementation Activities	Implementation Level
Arctic Circle Geoportals	National Geoportals	Currently there are eight national geoportal within the Arctic Community. These geoportals are not directly linked to the Arctic SDI geoportal. However, data are used from these portal to create the Arctic SDI Background Map.	Early phase of implementation
	Community Geoportals	There are a number of community geoportal across the Arctic. These geoportals are not directly linked to the Arctic SDI geoportal. However, the Arctic SDI does provide access to selected data from CAFF's geoportal.	Early phase of implementation
Current Implementation Status of the Arctic Circle Geoportals			Early phase of implementation

Data and Information Environment

The Data and Information Environment component is one of the most challenging component to implement. It is a very time consuming task to arrive at consensus on which datasets should be classified as reference and relevant thematic datasets. The task is even more daunting when eight countries are involved. The Technical Working Group is actively working on implementing this component. However, the evaluation indicates that this component is in an early stage of implementation. Table 9 provides a summary of the results.

Table 9: A Summary of the Implementation Activities of the Data and Information Environment

Component	Sub-Component	Implementation Activities	Implementation Level
Data and Information Environment	Reference Datasets	The Technical Working group is currently working with the stakeholders to define the reference datasets for the Arctic SDI. An output of this work is the Arctic Thematic/Background Map. Still a lot of work to be done on this component.	Component actively being implemented
	Relevant Thematic Datasets	The community is yet to define the relevant thematic datasets. The users' need survey when completed will greatly assist in defining the relevant datasets. Some CAFF thematic dataset currently accessible through the Arctic SDI.	Early phase of implementation
	Non-spatial Information	The community is yet to define the categories or types of non-spatial information which will be accessible through the Arctic SDI.	Early phase of implementation
Current Implementation Status of the Data and Information Environment			Early phase of implementation

Standards

The evaluation revealed that significant work has been done on the standards component in particular within the sub-components of web services and data exchange. A number of standards have been developed and agreed upon, however, these standards are yet to be published. The evaluation indicated

that in general major implementation activities have been completed within the standards component (see Table 10).

Table 10: A Summary of the Implementation Activities of the Standards Component

Component	Sub-Component	Implementation Activities	Implementation Level
Standards	Data Standards	The technical Working Group is currently working on standards for the harmonization of data. Metadata standards have been agreed upon but not yet published.	Component actively being implemented
	Web Services Standards	Web services standards developed (based on international standards) and agreed upon by the key stakeholders. The standards are yet to be published, however, most key stakeholders have adopted the standards.	Major implementation completed
	Data Exchange Standards	Data exchange standards developed and adopted by most of the key stakeholders. Others are still working on implementing these standards.	Major implementations completed
	Technology Standards	Technology standards based on international standards have been implemented.	Implementation completed
Current Implementation Status of the Standards Component			Major implementation completed

Summary of Results

The results of the evaluation clearly identified the implementation status of the seven components of the Arctic SDI (Table 11). As expected the components and sub-components were at different levels of the implementation cycle. The implementation levels of the components ranged from early phase of implementation to implementation completed for the current phase of the SDI.

Table 11: The Implementation Status of the Seven Component of the Arctic SDI

Component	Implementation level
Organizational Readiness Component	<i>Component actively being implemented</i>
Capacity Building	<i>Early phase of implementation</i>
Information Infrastructure	<i>Implementation completed</i>
Arctic SDI Geoportal	<i>Major implementation completed</i>
Arctic Circle Geoportals	<i>Early phase of implementation</i>
Data and Information Environment	<i>Early phase of implementation</i>
Standards	<i>Major implementations completed</i>

From Table 11 in can be seen that three components capacity building, Arctic Circle geoportals and data and information environment were in the early phase of implementation, with the organizational readiness component being considered as actively being implemented, the components Standards and Arctic SDI Geoportal had major implementation completed and the information infrastructure component

evaluated as implementation completed for this phase of the SDI. The results indicated that tremendous work has been undertaken in both the planning of the first phase of the Arctic SDI, as well as the actual implementation of some of the key components of the SDI.

5. Analysis of the Results

The Arctic SDI Evaluation provided essential information on the current status of the Arctic SDI implementation. This information can be used by the Arctic SDI stakeholders to further drive the implementation and operation of the SDI. This section of the report will analyse the results with respect to their usefulness in driving and strengthening current implementation activities, as well as defining future implementation goals.

Analysis of the Organizational Readiness of the Arctic SDI

The *organizational readiness* component is one of the most intricate components to implement in an SDI. This is evident from the eight sub-components deemed necessary to better evaluate this component. Implementation activities on five of these eight sub-components are progressing satisfactory. However, the three sub-components *performance management*, *authoritative framework* and *management* require additional focus. Although the need for a performance management framework to measure the implementation status and the effectiveness of the Arctic is clearly identified and clearly articulated in the Arctic SDI Implementation Plan⁷, this sub-component is yet to be addressed in detail. Work on the performance management framework is still in an infancy stage.

For an SDI to be effective there need to be in place an authoritative framework to guide the stakeholders' cooperation and collaborations, as well as, govern the usage of the SDI with respect to: data sharing, data reuse, intellectual property, privacy, security, and liability to name a few. Currently, for the Arctic SDI the only published authoritative framework documents are the MOU and the Arctic Spatial Data Infrastructure Governance Document. These two documents are high-level and do not provide sufficient details to effectively govern the implementation, operation and usage of the Arctic SDI. Therefore, additional efforts are required in the development and implementation of an authoritative framework for the Arctic SDI.

Managing the implementation and operation of an SDI is a very demanding and time consuming task that requires special skills. Currently, the Arctic SDI board is responsible for the managing the implementation of the Arctic SDI at a very high-level while the day-to-day management is performed by the different working groups and volunteer stakeholders. However, efficient and effective implementation of the Arctic SDI will require a full-time management team to drive the implementation process and manage the day-to-day operations. This team will be responsible for introducing project management guidelines for the implementation activities, coordinating across the different teams working on the implementation, manage the day-to-day operations, identify the cost associated with the implementation and operation of the SDI—this information will be used to support the development of a funding model—and identify the human resource require to support the efficient operation of the SDI.

⁷ Arctic Spatial Data Infrastructure Strategic Plan: Implementation Plan, available at: http://arctic-sdi.org/wp-content/uploads/2014/08/201511-Arctic-SDI-Implementation-Plan_FINAL.pdf

Table 12 below provides a summary of the priority area within *organizational readiness* component that require additional attention.

Table 12: Implementation Priority Areas for the Organizational Readiness Component

Component	Implementation Status	Priority Areas
<i>Organizational Readiness</i>	Component actively being implemented	<ol style="list-style-type: none"> 1. The development and implementation of a performance management framework; 2. The development and implementation of an authoritative framework that includes policies, directives or regulations to guide the implementation, usage, and operation of the SDI ; 3. Deployment of a full time management team to drive the implementation and manage the day-to-day operations.

Analysis of the Capacity Building Component of the Arctic SDI

The capacity building component of the Arctic SDI is the early phase of implementation with both sub-component (Communication and Outreach and Capacity Strengthening) yet to be formalize for implementation. This component is important for growing the usage of the SDI, increase stakeholders and developing partnerships. The importance of this component is well recognized by the Arctic SDI stakeholders. This is evident from the fact that the sub-component communication is an objective (Objective 6) of the Arctic SDI Strategic Plan. In addition, there is an actual working group (Communication Working Group) dedicate to develop and implement this component. A key achievement of the working group to-date is the implementation and operation of the Arctic SDI website.

The evaluation identified three implementation priority areas within this component that would significantly influence the usage of the Arctic SDI, as well as drive its implementation (see Table 13 below).

Table 13: Implementation Priority Areas for the Capacity Building Component

Component	Implementation Status	Priority Areas
<i>Capacity Building</i>	Early phase of implementation	<ol style="list-style-type: none"> 1. The development and publication of an Arctic SDI Manual; 2. The development and publication of a Geoportal Users’ Guide; 3. The development and publication of a document to guide the collection of interoperable data across the Arctic.

Analysis of the Information Infrastructure Component of the Arctic SDI

The *information infrastructure* component can be considered has been completely implemented for this phase of the Arctic SDI. An information infrastructure environment exist to facilitate secure discovery, viewing, analyzing, and downloading of Arctic related geospatial information. This information

infrastructure environment is provided by key stakeholders who own, operate and maintain the infrastructures.

It is expected that in addition with keeping abreast with technology, the next implementation activities for this component would be the up-grading of the infrastructure to support the linking of the Arctic SDI Geoportal to other Arctic Community geoportals (Table 14).

Table 14: Implementation Priority Areas for the Information Infrastructure Component

Component	Implementation Status	Priority Areas
<i>Information Infrastructure</i>	Implementation completed	1. The implementation of infrastructure (hardware and software) to support the linking of the Arctic SDI Geoportal to key Arctic Circle Geoportals and to facilitate automated data transfer.

Analysis of the Arctic SDI Geoportal

The Arctic SDI Geoportal is in an advanced stage of implementation and is functional. The software of the Geoportal (Oskari) has the capabilities to provide the main services normally associated with a geoportal. However, in the case of the Arctic SDI Geoportal a number of these services are not active. The reasons why a number of these services are non-functional could be considered as outside the implementation activities of the geoportal. One of the main limitation of the functionality of the geoportal is the absence of data which is not a geoportal implementation problem but a problem more related to the absence of an authoritative framework to guide the sharing of data across the Arctic. The Arctic SDI Geoportal is also not directly linked to the other Arctic related geoportals and this also greatly reduces the datasets made available through the portal.

Another key issue affecting the functionality of the geoportal is the absence of a users' needs study. Without the knowledge of the users' requirements, it is difficult for the operators of the geoportal to decide on which functionalities to make active. It should be noted that a users' needs study is one of the strategic objectives of the Arctic SDI (Objective 1). It is expected that once objective 1 is completed that the additional required functionality—identified by the study—will be made active.

Table 15 summarizes key areas of the geoportal implementation that require additional attention.

Table 15: Implementation Priority Areas for the Arctic SDI Geoportal

Component	Implementation Status	Priority Areas
<i>Arctic SDI Geoportal</i>	Major implementation completed	<ol style="list-style-type: none"> 1. The implementation of download and upload services for geospatial data; 2. The linking of the geoportal to other Arctic Community geoportal; 3. The implementation of a helpdesk to assist the users; 4. The development and implementation of indicators to measure the performance of the portal.

Analysis of the Arctic Circle Geoportals

This component was included in the Evaluation Framework to provide preliminary identification of the number of Arctic related geoportals that currently exist. This information will lay the foundation for a more detailed investigation which will be necessary before the linking of the Arctic SDI Geoportal to other geoportals is carried out.

Table 16 provides a summary of some of the activities that should be performed in this areas to support the implementation of the Arctic SDI.

Table 16: Implementation Priority Areas for the Arctic Circle Geoportals

Component	Implementation Status	Priority Areas
<i>Arctic Circle Geoportals</i>	Early phase of implementation	<ol style="list-style-type: none"> 1. Perform a more detailed investigation on the Arctic related geoportals; 2. Prioritize the national geoportals for linking to the Arctic SDI Geoportal; 3. Prioritize the community geoportals for linking to the Arctic SDI Geoportal;

Analysis of Data and Information Environment of the Arctic SDI

Data is a key component of any SDI. Without data there is no SDI. Therefore, it is important that the Arctic SDI provides easy and reliable access to Arctic related datasets as defined by the stakeholders. The Technical Working Group is responsible for implementing this component with their main priority being the establishment of the reference datasets. The reference datasets are fundamental and should be clearly defined by the stakeholders. This is an objective (Objective 2) of the Arctic SDI Strategic Plan.

The Arctic SDI Thematic/Background Map is the first reference dataset to be defined by the stakeholders. Significant work still need to be in this areas especially in the definition of the key datasets that will be made available through the Arctic SDI. The Arctic SDI strategic objectives 2, 3 and 4 are key to the successful implementation of this component. It is expect that once these objectives are achieved implementation of the component will move ahead speedily.

Table 17 below identifies some focus areas which if addressed could improve the availability of Arctic related data through the SDI.

Table 17: Implementation Priority Areas for the Data and Information Environment component

Component	Implementation Status	Priority Areas
<i>Data and Information Environment</i>	Early phase of implementation	<ol style="list-style-type: none"> 1. The definition of reference datasets; 2. Policies for the sharing of data that will results in more datasets being made available to the SDI by custodians; 3. Definition of data and metadata policies to support interoperability; 4. The definition of relevant thematic datasets (inclusive of hydrographic data).

Analysis of the Standards Component of the Arctic SDI

Standards are required to support interoperability and thus, the sharing of data. The Evaluation Framework identified four types of standards (data standards, web services standards, data Exchange standards, and technology standards) that are key to the development and operation of the Arctic SDI. The results indicated that major activities have been carried within this component, with significant work done on all the sub-components.

Although standards have been developed, adapted and adopted by the Arctic SDI Communities these standards have not been made public. For the standards to be used by the stakeholders they need to be aware that they exist. Therefore, it is important that the standards are effectively communicated to the community. It is recommended, therefore, that once the standards are agreed upon they are published. In addition, an Arctic SDI Standards Document should be developed and published. This document should inform the stakeholders on the benefits of standards, the standards adopted by the Arctic SDI Community by categories, and provide clear explanation on the aims and objectives (i.e., the purpose of implementing the standards) of the standards.

Table 18: Implementation Priority Areas for the Standards Component

Component	Implementation Status	Priority Areas
<i>Standards</i>	Major implementations completed	<ol style="list-style-type: none">1. Document and publish all standards that have been agreed upon;2. Develop a standard document for the Arctic SDI

6. Bench-marking the Arctic SDI

This section will describe the benchmarking of the Arctic within one of the six natural implementation phases of an SDI described previously. The Arctic SDI will be bench-marked to identify its current status in the natural progression of an SDI. This information will be used to assist in the planning of future development and implementation of the SDI.

Based on the results of the evaluation the Arctic SDI was bench-marked in phase 3, the realization phase of the natural path of implementation of an SDI. The results of the evaluation indicate that the Arctic SDI components implemented, as well as the level to which they were implemented match those of an SDI that is normally at the realization phase of implementation. Some key achievements within the realization phase are the implementation of technology to support data sharing, standards, strategic plan to guide the implementation process, a coordinating body, data sharing policies and fundamental datasets. The results of the evaluation indicated that a number of these criteria were met by the Arctic SDI. However, it should be noted that implementation level of these components vary from early phase of implementation to implementation completed, therefore, it can be concluded that the Arctic SDI is at the early stage of the realization implementation phase (Figure 3). That is at the overlapping stage between inception and realization (Figure 3).

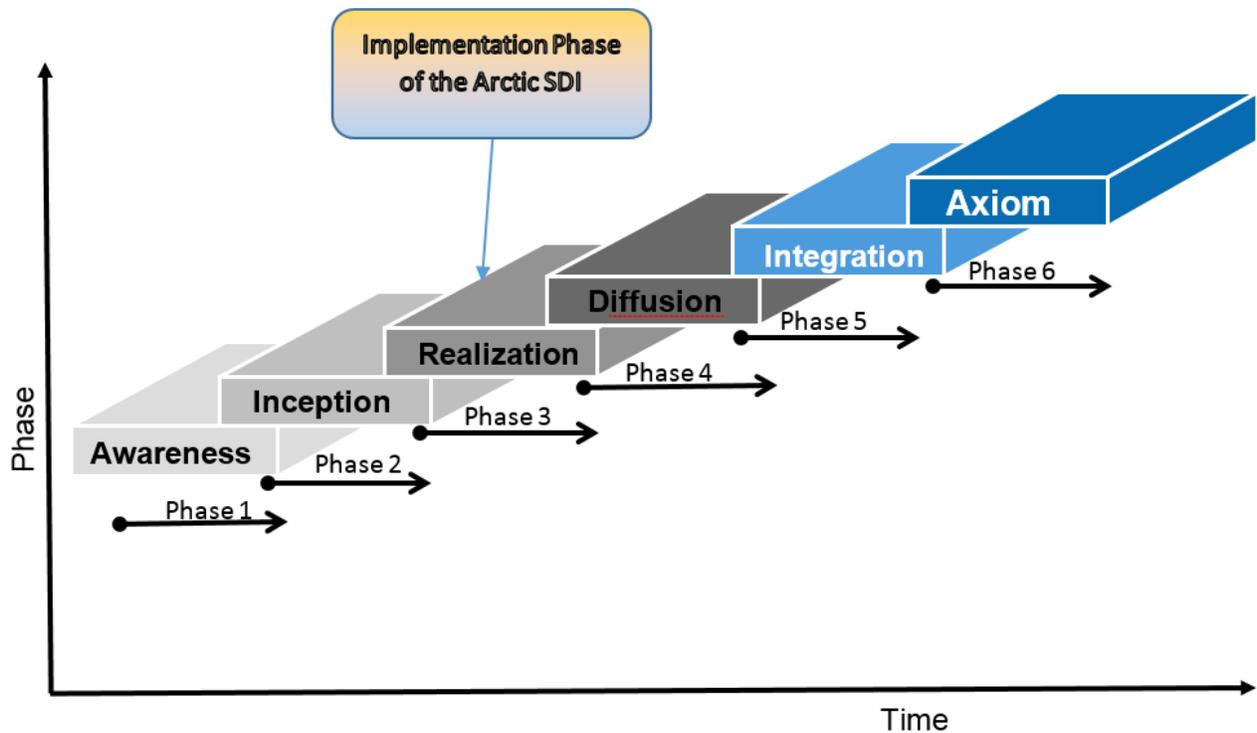


Figure 3: Positioning the Arctic SDI within the Natural Development Phases of an SDI

From Figure 3 it can be seen that the Arctic SDI is bench-marked at the early stage of the realization phase. The figure also indicates that there are overlaps between phases due to the qualitative nature of the classification of the phases.

7. Conclusion

The Arctic SDI Evaluation project was completed successfully. The two main tasks of developing an evaluation framework for the Arctic SDI and performing a cursory evaluation of the Arctic SDI were completed. The results of the evaluation indicated that main components of an SDI and those components unique to the Arctic SDI were identified and defined. In addition, implementation activities were carried on all these main components. That is, implementation activities were carried out on all seven components identified in the Evaluation Framework. The status of the implementation of the components varies, ranging from early phase of implementation to implementation completed. Although, the implementation level of the Arctic SDI varies from component-to-component the foundation has been established in all components to grow the SDI to meet the needs of both the stakeholders and the users.

The evaluation also identified implementation areas that if addressed can significantly improve the implementation status of the SDI, the operations of the SDI, the usage of the SDI, as well as the effectiveness of the SDI to the Arctic Community (Tables 12-18). In addition, the implementation status of a number of these selected priority areas and other sub-components of the Arctic SDI will be significantly improved upon the achievement of the six strategic objectives of the Arctic SDI.

The Arctic SDI Board, the working groups, the stakeholders and the volunteer staff should be congratulated on the current implementation status of the Arctic SDI. The Arctic SDI is a unique multi-cultural and multi-dimensional SDI and thus, requires unique implementation strategies. In concluding, given the current implementation status of the Arctic SDI, it is evident that significant efforts and time have been employed in implementing the Arctic SDI.

8. Recommendations

The cursory evaluation of the Arctic SDI is only the first step in ensuring that the Arctic SDI is implemented and operated within a performance based management framework where performance is measured and monitored in a timely basis to identify whether or not the SDI is achieving its goals and objectives. It is recommended that the next steps toward implementing a performance based management framework of this nature should include, but not limited to:

- The measure of the performance of the SDI prior to the development of the next strategic plan as stated in the Arctic SDI Roadmap; and
- The implementation of regular measuring and monitoring processes of the different components of the SDI.

In addition to addressing the key implementation areas identified by the evaluation, it is also recommended that for the strategic objectives of the Arctic SDI to be achieved and for the Arctic SDI to be implemented and operated in an efficient and effective manner, additional human resources and more structured project management strategies should be employed.

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<http://staceybarr.com/downloads/WhitePaperMeasureWhatMatters.pdf>
- A number of presentations on the Arctic SDI were also reviewed.

Appendix A: The Arctic SDI Evaluation Framework

Please see [Arctic SDI Evaluation Framework Final.xlsx](#)

Appendix B: Persons Interviewed

1. Rebecca Anderson
Senior Science Advisor
U.S. Geological Survey
Office of the Regional Director – Alaska Region
Lead of the Strategy Working Group
2. Tom Barry
Executive Secretary
Conservation of Arctic Flora and Fauna (CAFF)
3. Jani Kylmäaho
Senior Expert, SDI Services
Finnish Geospatial Research Institute FGI National Land Survey of Finland
Lead of the Geoportal Working Group
4. Fredrik Persäter
Senior Adviser Swedish Mapping, Cadastre and Land Registration Authority
National Contact Point Person, Sweden
Lead of the Technical Working Group
5. Peter Pouplier
Danish Agency for Data Supply and Efficiency
National Contact Point Person, Denmark
Lead of the Operational Policies Working Group
6. Simon Riopel
Member of the Operational Policies Working Group
Geomatics Advisor, Natural Resources Canada
7. Cameron Wilson
Manager, Natural Resources Canada
National Contact Point Person, Canada

Appendix C: Arctic Circle Geoportals

There are a number of Arctic related geoportals that are currently in operations. These geoportals are operated by the eight countries forming the Arctic Circle (National Geoportals), NGOs, universities, and research science groups. Below is a list of some of the main Arctic related geoportals. The list is by no means comprehensive.

Geoportals at the National Level

- Canada: Canadian Geospatial Data Infrastructure
- Denmark: Danish infrastructure for spatial information (DAISI)
- Finland: Finnish National Spatial Data Infrastructure
- Iceland: National Spatial Data Infrastructure
- Norway: Norway Digital
- Russia: National Spatial Data Infrastructure
- United States of America: National Spatial Data Infrastructure
- Sweden: National Spatial Data Infrastructure

Some Arctic Community Geoportals

- ABDS (CAFF)
- Arctic Voyage Planning Guide
- Toolik Arctic Geobotanical Atlas
- Alaska Center for Conservation Services
- Arctic Science Portal