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**Implementation and adoption of standards
for the global geospatial information community**

A Guide to the Role of Standards in Geospatial Information Management

Background Document Prepared cooperatively by the
Open Geospatial Consortium (OGC)
The International Organization for Standards (ISO),
Technical Committee 211 Geographic information/Geomatics
and the
International Hydrographic Organization (IHO)

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1 Executive Summary

The use of geospatial information is increasing rapidly. There is a growing recognition in both government and the private sector that geography² is a vital component of effective decision making. Citizens with no recognized expertise in geospatial information, and who are unlikely to even be familiar with the term, are increasingly using and interacting with geospatial information; indeed in some cases they are contributing to its collection – often in an involuntary way.

In order to effectively leverage the value of geospatial information, the information must be easy to access and use. Given that geospatial information comes from many different sources, and is managed by a very large number of different providers – from mapping agencies to commercial data providers to volunteered geographic information - there is an overwhelming requirement to easily discover and share this information. Standards have a key role in this respect and are essential to delivering authoritative geospatial services and products which meet the requirements of the wider community of users. Standards and conformance provide significant value³ to society and government, are essential for an expanding national economy and vital to the global competitiveness of both industry and nations.

“Geospatial information is the most fundamental tool to support the planet’s joint efforts in resolving global issues. By interconnecting information on natural disasters, poverty and the environment through location data, global issues such as sustainable development and poverty eradication can be effectively managed.” Prime Minister Kim Hwang-Sik, Republic of Korea⁴.

This guide addresses the role of standards in geospatial information management:

- Defines what a standard is;
- Makes a case for open standards;
- Discusses why such standards are valuable;
- Describes geospatial standards and related best practices;
- Introduces a goal-based approach to standards adoption and a multi-tiered standardization maturity model;
- Characterizes emerging standards and trends;
- Gives concrete examples of standards in use; and
- Concludes with suggestions for next steps.

² Acknowledging that “geography” equates to location, place-based information, geospatial, and other terms. For the remainder of this report, the term “geospatial information” will be used.

³ ISO, “ISO/IEC Inventory of Studies on the Economic and Social Benefits of Standardization,” 2013, at http://www.standardsinfo.net/info/benefits/benefits_s1.html

⁴ http://ggim.un.org/seminar_24Oct2011.html

This guide is accompanied by a detailed “Companion Document on Standards Recommendations by Tier” which details available standards and their applications.

“Geospatial information is widely used in New Zealand and already contributes over \$1.2 billion a year to the economy. It also forms a part of New Zealand’s knowledge infrastructure and enables innovation and better decision-making.”⁵

2 Introduction

This guide is intended to:

- Articulate the critical role of standards in geospatial information management;
- Inform policy makers and program managers in Member States of the value in using and investing in geospatial standardization; and
- Describe the benefits of using “open” geospatial standards to achieve standardization, data sharing, and interoperability goals.

Information presented in this guide is intended to be useful for a wide variety of readers, especially in government. These include policy makers, program managers, technical experts and other individuals involved in geospatial information management.

The need for a document of this type was identified in discussions that have occurred as part of the extensive consultations with participants in the ongoing United Nations initiative on Global Geospatial Information Management (UN-GGIM)⁶.

This guide begins with a discussion of what is meant by an “open standard” and the value of using standards, specifically geospatial standards, in private sector, government, and citizen interactions.

2.1 Terms and definitions

What is a standard?

There are many definitions but all incorporate the following central elements:

A standard is a documented agreement between providers and consumers, established by consensus, that provides rules, guidelines, or characteristics ensuring materials, products, and services are fit for purpose.

Why are standards important?

⁵ New Zealand SDI Value: <http://www.linz.govt.nz/geospatial-office/about/projects-and-news/spatial-data-infrastructure>

⁶ <http://ggim.un.org/>

Other sections in this document will provide details on the business value for standards. Behind the scenes, standards make everyday life work. They may establish size or shape or capacity of a product, process or system. They can specify performance of products or personnel. They also can define terms so that there is no misunderstanding among those using the standard. As general examples, standards help assure that:

- A light bulb fits a socket;
- Individuals can withdraw money from their bank accounts through any Automated Teller Machine anywhere in the world;
- Mobile phones work across multiple countries around the world;
- Latitude and Longitude provide a standard reference system for the Earth;
- GPS coordinates are always provided in the same format.

What is an “open standard”?

In this document, the term “open standard” is often used. What does this term mean? The following are the essential characteristics of an open standard:

- Publicly available;
- Unencumbered by patents and other intellectual property;
- Anyone can download and use the standard (non-discriminatory);
- No license fees;
- Vendor neutral;
- Data neutral;
- Agreed to in a consensus decision making process;
- No single entity controls the standard.

Different governments and enterprises may choose to use geospatial information and software applications which do not rely on open standards. The most immediate drawback of such an approach is that the organization has created an information and technology silo that presents users with many hidden challenges such as delays and costs of expanding or adapting data and software tools to work with other resources, software or organizations. In an ever changing world, open standards help assure that organizations can more quickly take advantage of new geospatial information sources and new technology tools. Open standards are a central element in the growing trend to open government.

A goal of open standards is to ensure that "interoperability" (the ability to integrate datasets and related services of different types and from different sources) will minimize such costs and problems. Further, the open process of developing and maintaining standards offers governments, universities, research organizations, and business enterprises the opportunity to have a voice in building and learning about the standards.

How are standards developed?

The majority of international standards are developed in Standards Development Organizations (SDOs) that use a consensus process guided by documented, repeatable and well proven policies and procedures.

Typically, any organization can join an SDO and participate in the standards development process. This helps ensure that the standards developed meet the needs of all users and that they are primarily “demand” rather than “supply” driven.

Key types of geospatial standards

There are two key types of geospatial standards discussed in this document: information (or content) standards and technology (interface, API⁷) standards. The following modified definitions of these two key types of standards are from the GeoConnections website of the Government of Canada⁸.

“Geospatial information standards⁹ provide digital coding to locate and describe features on, above or below the Earth’s surface. Geographically-related features can be naturally occurring (for example: rivers, rock formations, coastlines), man-made (for example: dams, buildings, radio towers, roads) or intrinsic, implied and transient information (for example: political boundaries, electoral districts, weather systems, distribution of population ethnicity).

Technology standards allow different systems and services to work together through standard interfaces¹⁰. Ideally, when the standards are implemented in products or online services independently, the resulting components ‘plug-and-play’, that is, they work together seamlessly.”

Key Standards Development Organizations developing encoding and technology standards for sharing geospatial information.

There are three key international organizations which have the objective of developing standards for geospatial information:

- The International Organization for Standardization (ISO) Technical Committee 211 Geographic information/Geomatics¹¹;
- The Open Geospatial Consortium (OGC)¹²;
- The International Hydrographic Organization (IHO)¹³.

These international standards organizations have representative members from government, industry, research, and academia who arrive at decisions through a consensual process. The organizations develop,

⁷ API: application programming interface. APIs specify how software components should interact with each other.

⁸ <http://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/8902>

⁹ This type of standard is also known as “encoding” or “content model” standards.

¹⁰ From a more technical perspective, programming to the interface reduces dependency on implementation specifics and makes code more reusable. It gives the programmer the ability to later change the behavior of the system by simply swapping the object used with another implementing the same interface. The net effect is to reduce life cycle maintenance costs.

¹¹ www.isotc211.org

¹² www.opengeospatial.org

¹³ www.iho.int

maintain and make publicly available open standards that enable the ability to publish, discover, access, manage and use geospatial information across a range of applications, systems and business enterprises.

These organizations all employ processes and approaches which ensure the development of international open standards that meet the characteristics described above.

2.2 Why are Open Standards valuable?

In 1904, much of the City of Baltimore in the United States was destroyed by a massive fire. Firefighters from hundreds of kilometers away were sent to assist Baltimore firefighters during the height of the blaze. They could do little to help because the fire hoses used by different responders were not standardized. The resultant inability to connect hoses to fire hydrants turned hundreds of firefighters into spectators. This analogy rings true not just in respect of the need to share geospatial information, such as post-disaster imagery, during a crisis, but throughout all implementations of geospatial technologies. Open standards make uniformity, compatibility and interoperability possible for electronic devices, software applications, and processes in all sectors of a global economy.

Open standards facilitate increased return on geospatial investment through a host of mechanisms. Return on investment may be realized through direct means such as improved efficiency, which saves time and effort and thereby money, or through indirect means which allows for new capabilities and capacities. Without standards, the ability to connect systems, data, people, hardware, software, and procedures become much like trying to connect hoses with differing threads to a fire hydrant in a community combating a fire. Loss of time, assets and lives is inevitable.

MapAction

Having operated on every continent since 2006, MapAction works in disaster zones providing frequently updated situation maps showing where relief help is most urgently needed. MapAction is a non-governmental organisation that exchanges many kinds of geospatial information from different sources among open source and licensed software products. MapAction and similar organizations can bring value to crisis situations because their multiple software platforms are based on open geospatial standards (recommended in this document). Without these open standards, it would be impossible for MapAction to operate in a cost-effective and timely manner.

Examples:

- The internet, mobile phone, and banking systems are all heavily reliant on standards in order for various devices and computerized applications to communicate with one another, and with the needed efficiency and volume.
- The economic value of open standards for geospatial information is realized when they enable and simplify rapid exchange of the large amounts of place-based information that is crucial for personal, commercial and public-sector analysis and decision-making.
- The provision of nautical charts to mariners, as regulated by the International Convention for the Safety of Life at Sea (SOLAS), is based on open standards adopted by the IHO in order “to ensure the greatest possible uniformity”.

The Benefits of Open Geospatial Standards

Spatial Data Infrastructure (SDI) initiatives worldwide are implementing a common set of international standards for geospatial data. These standards encapsulate geospatial data development, production, management, discovery, access, sharing, visualization, and analysis. As organizations and jurisdictions develop and agree on a common set of open standards, the ability to share geospatial information is enhanced, reducing costs, improving service provision, and facilitating new economic opportunities.

Geospatial information, technologies and standards help to enable and improve the sharing, integration and application of geospatial information for decision making. However, even with these tools in place, the decision to share information effectively between organizations and governments often depends on pro-active policy. These policy choices must be made in all jurisdictions and enterprises at many levels, but particularly at the level of national governments. A multi-national response to a regional disaster is one example where having clear policy on the sharing of geospatial information is critically important. The shaping of appropriate geospatial policy is beyond the mandate of this guide but it must be addressed. For without a suitable policy framework the standards-based approaches described in this guide will be of limited value.

The remainder of this guide seeks to answer the following questions directly related to the role of standards in geospatial information management.

- What are the common SDI standards adopted by organizations worldwide?
- Which of these standards are appropriate for geospatial information management in the context of the UN initiative on Global Geospatial Information Management?
- What are the appropriate geospatial standards for an organization's needs?

In addition to these questions the overall value proposition associated with open standards should be considered by all stakeholders. The fundamental questions which should be addressed are:

- Can the adoption of open standards be quantified in terms of time and/or money in delivering the services desired?
- How much more productivity or effectiveness can be achieved by using open standards?
- How will uncertainty and risk be reduced by using open standards, and if so, can this be quantified?

These questions have been studied with respect to standards (in general) and with respect to the open standards which underpin most geospatial infrastructure projects. Goals and methodologies vary from one study to the next, but interested readers can find many examples of the net benefits that standards, open geospatial standards in particular, offer.

Examples:

- The German Institute for Standardization (DIN) estimated benefits of 17 billion euros to the German economy in 2010: "Standards promote worldwide trade, encouraging rationalization, quality assurance

and environmental protection, as well as improving security and communication. Standards have a greater effect on economic growth than patents or licenses.”¹⁴

- The Joint Research Centre of the European Union collaborated with the Universitat Politècnica de Catalunya (Spain) in concluding that the establishment of the spatial data infrastructure (SDI) of Catalonia -- based on open geospatial standards -- generated significant internal (efficiency) benefits as well as benefits of more effective service delivery. They quantified these benefits and estimated that the value exceeded four year’s investment in just over six months.¹⁵
- NASA Geospatial Interoperability Return on Investment Study: Of the projects considered for this study, the project that adopted and implemented geospatial interoperability standards had a risk-adjusted ROI of 119.0%. This ROI is a “Savings to Investment” ratio. This can be interpreted as for every \$1.00 spent on investment, \$1.19 is saved on Operations and Maintenance costs.
- Overall, the project that adopted and implemented geospatial interoperability standards saved 26.2% compared to the project that relied upon a proprietary standard. One way to interpret this result is that for every \$4.00 spent on projects based on proprietary platforms, the same value could be achieved with \$3.00 if the project were based on open standards¹⁶.
- New Zealand SDI Benefits: **Spatial Information in the New Zealand Economy - Realising Productivity Gains** is a report commissioned by [Land Information New Zealand](#), the [Department of Conservation](#) and the [Ministry of Economic Development](#). It provides robust economic analysis that quantifies the contribution spatial information makes to the New Zealand economy, as well as opportunities for this contribution to grow. The report concludes that use and re-use of spatial information is estimated to have added \$1.2 billion in productivity related benefits to the New Zealand economy in 2008.¹⁷

Many governmental, non-governmental and commercial enterprises rely on software solutions built on open geospatial standards. By using such solutions to pursue their various missions, all these organizations reap the benefits of lower risk, lower cost and better outcomes than they could achieve using solutions that do not embrace open standards as evidenced by the case studies cited above.

¹⁴ See DIN, “Economic Benefits of Standardization,” 2010, at

http://www.din.de/sixcms_upload/media/2896/DIN_GNN_2011_engl_akt_neu.pdf

¹⁵ See Craglia M. (Ed.), “The Socio-Economic Impact of the Spatial Data Infrastructure of Catalonia,” 2008, at <http://publications.jrc.ec.europa.eu/repository/handle/111111111/7696>

¹⁶ NASA Geospatial Interoperability Return on Investment Study (2005) http://www.ec-gis.org/sdi/ws/costbenefit2006/reference/ROI_Study.pdf

¹⁷ New Zealand <http://www.lin.govt.nz/geospatial-office/about/projects-and-news/productivityreport>

3 Geospatial Standards and Related Best Practices for Geospatial Information Management

The adoption of standards is driven by the desire of organizations and institutions to seamlessly share, integrate and use geospatial information (i.e. to interoperate) for improved decision making. In this context, standards for geospatial information can be seen as a continuum enabling the achievement of increasing levels of interoperability of geospatial information as more standards are adopted to keep pace with evolving requirements, technologies and tools. Reaping the benefits of standards adoption is a journey and organizations, institutions and information communities are likely to be starting this journey at different points in the capability/maturity continuum. This guide provides a model for the phased implementation of geospatial standards that considers the different levels of experience and expertise of the players involved. Some organizations and institutions are far advanced, others are just beginning and some are only considering the use of standards. The model - the standardization maturity model shown in Figure 1, takes into account the different levels of knowledge and experience and describes a standardization trajectory.

Over time, user experience has shown that lack of consensus, leadership commitment and a clear governance structure are the principal factors limiting the full achievement of the benefits of open standards. Constrained funding, inadequate governance arrangements, a lack of understanding of the value proposition of using a standards-based approach and a lack of knowledge and experience in standards implementation are major limiting factors and are often related to a lack of consensus among stakeholders.

As consensus builds, understanding improves and the willingness of stakeholders to commit resources and coordinate activities in an open fashion grows. This helps facilitate a continuing, self-sustainable, and self-governed expansion of open standards. Single agency portrayal of basic information develops into collaborative multi-agency standards development that takes fuller advantage of emerging technological developments. Recognizing the constraints it is best to implement standards in an incremental fashion. Full interoperability can take time as an organization or institution matures in both technical and policy terms.

Community initiatives to share and make geospatial information available are typically oriented around Spatial Data Infrastructure (SDI) initiatives. Standards are a critical element of SDI implementation. In Figure 1, requirements for increasing levels of capability and collaboration, identified as “Tiers”, are shown. These Tiers are:

- Tier 1 - Share maps over the Web;
- Tier 2 - Geospatial Information sharing partnerships - share, integrate and use geospatial data from different providers;
- Tier 3 - Spatially enabling the nation - large scale (typically national) efforts to develop a ‘full-blown’ SDI that provides access to multiple themes of information, applications for using the shared information, and access via a variety of environments (mobile, desktop, etc.); and

- The future - Towards spatially enabling the Web of data - delivering geospatial information into the Web of data, and bridging between SDI and a broader ecosystem of information systems.

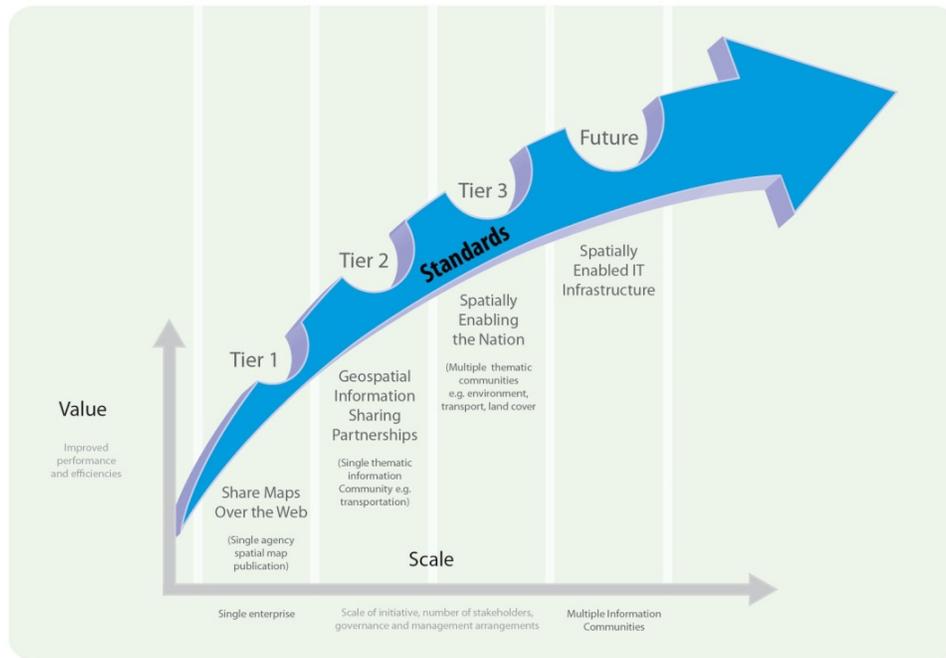


Figure 1 - SDI Standardization Maturity Model

Each Tier shown in Figure 1 is associated with a set of SDI standards. As drivers for interoperability increase, more standards are adopted to move to the next Tier of maturity. The scale and scope of an initiative in terms of the number of stakeholders and the number of information communities are also presented in this diagram. At each Tier, as more stakeholders adopt standards, the scale of the initiative increases. Likewise, as initiatives move from one Tier to the next, from single organization to information communities, the scale of interoperability grows and the value proposition of standards adoption is increasingly realized.

The description of the Tiers provided later in this section depicts the specific suites of SDI standards that are used to achieve them, in the form of vertical blocks that are stacked on top of each other. A separate Companion document details the specific standards associated with each suite.

The Tiers represent a series of steps in an organization's ability to offer increasing levels of geospatial information and associated services as part of an information community. At the beginning of the process (Tier 1), an organization may want to provide access to geospatial information delivered as map images together with a description of them (i.e. metadata). As an initiative matures, multiple organizations may wish to collaborate to provide a means to share, search for, access, integrate and cooperatively maintain and use a particular geospatial information layer (such as transportation) from multiple sources using web services (Tier 2). Larger scale initiatives have a goal of establishing a nation-wide coverage of foundation

or framework¹⁸ data as part of their National SDI. Foundation data is an accurate set of key geospatial data layers needed most by different users (imagery, elevation, administrative boundaries, transportation, land use, and water features for example). Providing access to this geospatial Foundation Data for a range of application areas is the next level of maturity (Tier 3).

Finally, to address emerging needs and leverage new technologies and opportunities such as crowd-sourcing of geospatial information and big data analytics, a community would focus on delivering geospatial information from SDI environments into the Web of data (the future).

Achieving these increasing levels of interoperability is driven by a desire to provide decision makers with access to a knowledge environment in which geospatial information is accessed and processed across the Web and in mobile environments. Thus, data about people, places and things are linked together to provide a deeper understanding of a given situation (such as a disaster, or social environmental or economic phenomena). This trajectory from data to geospatial knowledge, enabled by standards implementation, is shown in Figure 2.

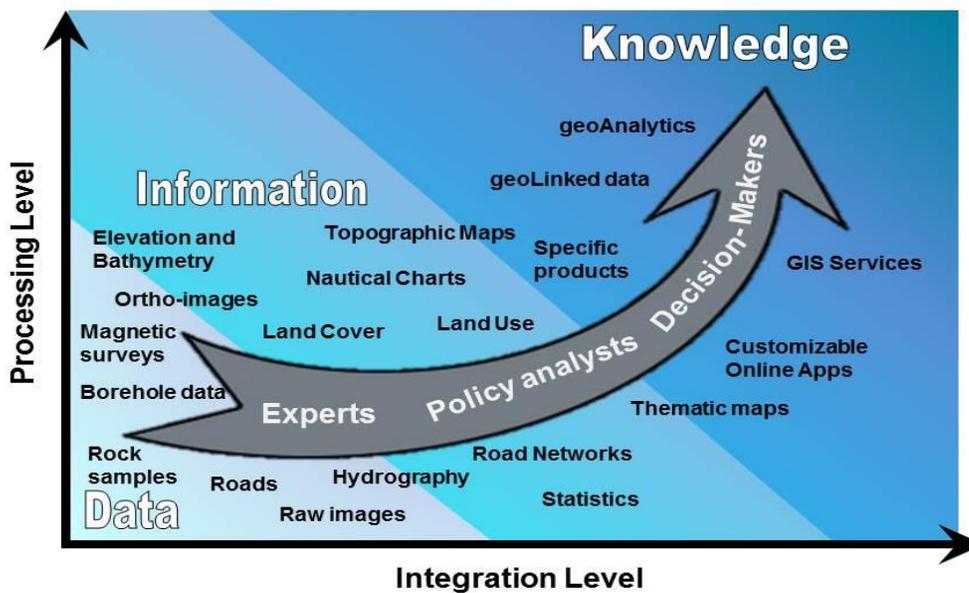


Figure 2 - A continuum of data to knowledge

¹⁸ For 'Foundation' see ANZLIC Australian and New Zealand Foundation Spatial Data Framework <http://anzlic.org.au/FSDF>. For 'Framework' - See US Federal Geographic Data Committee Framework, <https://www.fgdc.gov/framework/handbook/overview>

3.1 Tier 1 - Sharing Maps over the Web

Tier 1 Goal - An organization or institution addresses a requirement for stakeholders and constituents (users) to discover and view interactive maps (geospatial information rendered as a picture or image) on the Web. While an organization may first move to make its geospatial information available on the Web using the capabilities described in this Tier, the ability to share geospatial data will require an organization to understand, describe, organize, collect and manage geospatial information.

An organizational or institutional goal is to provide staff, partners and customers with the ability to view and query geospatial information in client applications using a variety of devices such as a desktop, tablet, or other mobile devices. This can include information developed by an organization itself or web accessible data available from other organizations. By using a web browser or smart phone, users can look up different “layers” of information. They can display, zoom into points of interest, and print maps while keeping the organizational IT infrastructure intact. As more maps are published, catalogs become necessary to enable map providers to advertise the availability of their maps and users to find them.

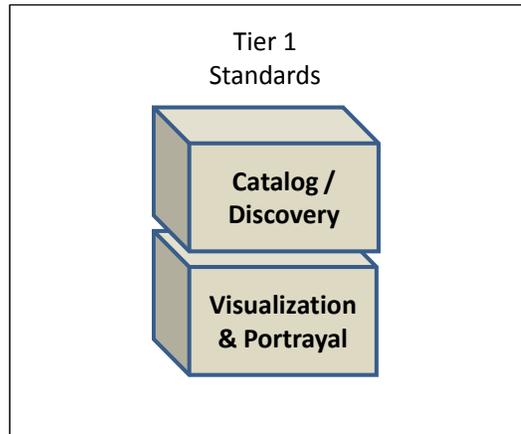


Figure 3: Standards applicable to Tier 1 (see Companion document for details)

Capabilities of Tier 1

- Clear description of the digital map data (metadata);
- Discovery of digital map data via on-line catalogs; and
- The ability to visualize digital geospatial information as maps over the Web;
- The ability to visually overlay geospatial information as maps from different sources.

Typical scenarios for an organization or institution in Tier 1

- Looking for a simple, low cost way to share geospatial information with all stakeholders and constituents;
- Geospatial information may be stored in more than one system using different geospatial (Geographic Information System - GIS) technology and organizations do not wish to standardize on a single technology platform;
- Geospatial information is stored in more than one format and the organization(s) does not want to incur the time and expense of reformatting geospatial information into a single format. The belief that the data should remain closest to the source (owner) of the data that has maintenance responsibility to increase the likelihood of update;
- Publish one or more maps for government and citizen access;

- May be unable or unwilling to distribute the underlying geospatial data but is willing and able to share images of the data;
- At this initial level of capability, policy and governance related to geospatial information management and operations may be somewhat informal.

3.2 Tier 2 - Partnerships - Share, Integrate and Use Geospatial Information from different Providers

Tier 2 Goal - An information community wishes to provide access to geospatial information over the Web, provide geospatial information download services, and in addition, may provide specific data themes, such as roads, from multiple sources that conform to agreed upon standards-based data models¹⁹ to create a consistent and integrated definition or meaning of the geospatial information for users.

The main drivers for a move from Tier 1 to Tier 2 are: 1) the need to share geospatial data rather than maps in order to support more detailed analysis forecasting and other more powerful decision support applications, and 2) the desire to achieve interoperability within a community based on agreed upon standards-based data models for data exchange.

Organizations wish to publish their geospatial information on the web. Furthermore, one or more organizations wish to work with other members of a “community” to build, share, and use datasets that provide a common operational view of important issues such as safe navigation, flood control, road maintenance, disaster management or bush fire management and response. Using this approach, data providers do not need to adopt the same technology solutions or change their database structures provided that they conform to agreed upon data models. Through the use of Tier 2 open standards, they can provide access to view, distribute, or share geospatial information that conforms to these agreed upon standards-based data models.

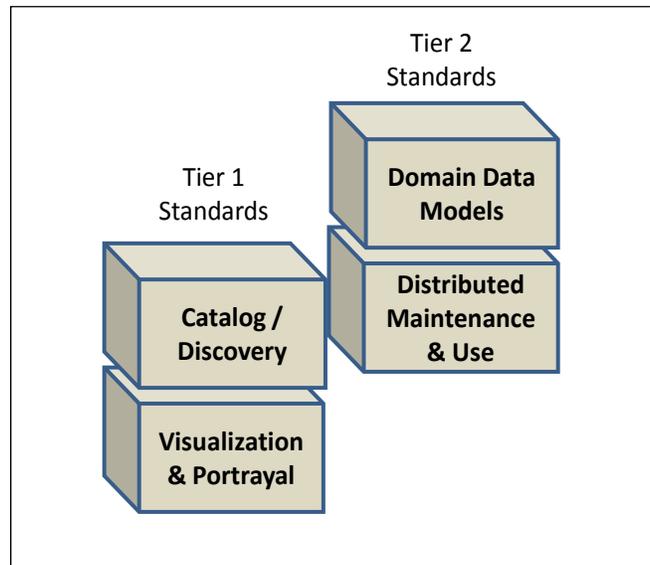


Figure 4: Standards applicable to Tier 2 (see Companion document for details)

As a result of the approach described above, users accessing geospatial content delivered in this way will be able to view, process and analyze geospatial information seamlessly, even though the data may be provided from multiple sources. Other

¹⁹ An OGC White Paper ([Data Models and Interoperability](#)) provides an excellent discussion on standards-based data models for data sharing and enhancing interoperability.

user communities requesting geospatial information will receive the content in a common structure (format), which will facilitate its use in additional end user applications.

Through this approach:

- Tier 1 goals are built upon;
- Access to geospatial information for viewing, analysis and other applications can be provided to all stakeholders and constituents using a consistent, well documented standards-based approach;
- Publishing of geospatial information is enhanced by adherence to agreed upon data content models for distribution and application. Content owners do not need to change their underlying models nor do they need to change their current geospatial technology provider (unless that provider does not provide standards-based approaches);
- Overall costs are reduced since existing geospatial technology can be leveraged;
- Existing geospatial information can be re-purposed, with reduced reliance on format translation, and with enhanced quality of data and services;
- Access to geospatial information and services can be controlled through access authorization;
- Collaborative data maintenance capability is enhanced (see below).

Capabilities of Tier 2:

- *Capabilities of Tier 1*
and
- Ability to access and share detailed geospatial information within each organization and with other cooperating organizations;
- Enhanced ability to apply geospatial data for enhanced situational awareness, analysis, forecasting and decision support;
- Ability to maintain and improve quality of common geospatial information between cooperating organizations and jurisdictions (e.g. transportation, land use data across a county, province, or state boundary, or between nations);
- Through organization agreements to share data using agreed upon standards-based data models, many more geospatial information sources and users can be integrated into the SDI. This is important in many situations, such as emergency response, disaster management, economic sustainability decisions, energy utilization, planning and citizen benefits.

Typical scenario for organizations in Tier 2

- The desire to make geospatial information accessible over the web for use online or for download and offline use;
- Improve effectiveness and efficiency of an established information community with identified common information needs, for example, organizations in neighboring jurisdictions that wish to share consistent thematic data (for example, nautical charting, roads or forest cover) across their borders;
- Common information structures (data models) to support easy geospatial information exchange between cooperating organizations and jurisdictions;

- The ability for users from different organizations to be able to query, exchange and interact with similar geospatial datasets in a consistent way (e.g. road networks) forming an aggregated view;
- The ability to provide information (by way of metadata) about the context in which geospatial data has been collected and used. This provenance and data quality information is critical in allowing users to determine fitness for use of geospatial information within a given application;
- At this level of capability, more formal geospatial information management policies and practices have been adopted, agreed upon data models have been established, and information sharing agreements have been established between cooperating organizations.

3.3 Tier 3 - Spatially Enabling the Nation

Tier 3 Goal - Multiple organizations share foundation/framework geospatial information and services with each other and the broader community to improve knowledge and understanding, thereby contributing to evidence-based decision making, situational awareness, and improved societal outcomes.

Implementations in Tier 3 allow participants and stakeholders to multiply the value of their geospatial information assets by sharing these assets with others - and by leveraging geospatial information from other providers. Groups working in different

application domains are able to share their data, discover and access data produced by others, and benefit from improved understanding and knowledge. The same geospatial information that is needed for land use planning May also have value for flood prevention and mitigation, environmental monitoring and remediation, efficient transportation and logistics, and public safety. Organizations will also have the opportunity to improve their understanding and awareness of rapidly changing events by incorporating new information sourced from smart phones, as well as information from mobile and static sensors. Incorporation of volunteered (“crowd-sourced”) geospatial information can be accommodated.

The development and publication of these “foundation” or “framework” spatial data such as imagery, transportation, administrative boundaries, using content and technology standards and best practices enable geospatial data from different providers to be easily integrated and used across multiple applications domains, so that decision making is based upon a common understanding.

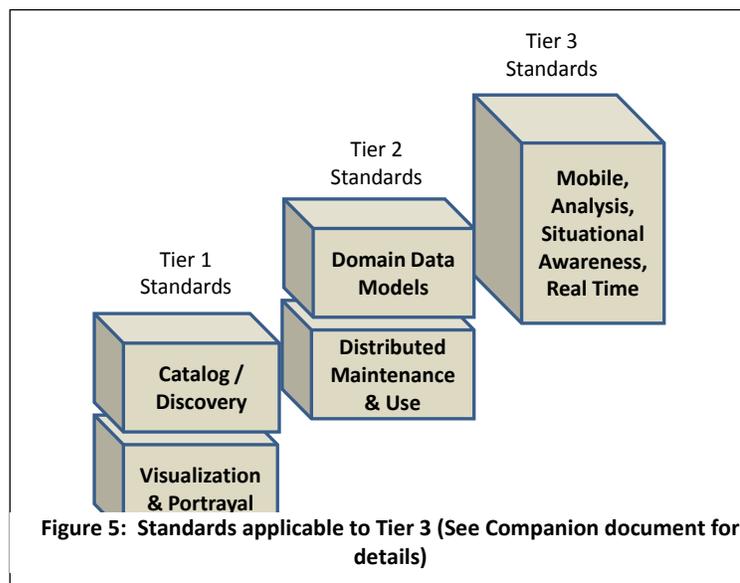


Figure 6 depicts potential “foundation” geospatial information themes that need to be shared between and among many organizations and constituents.



Figure 6: Example: Foundation geospatial information layers (Source, ANZLIC)

Geospatial information can be designed for delivery across multiple platforms and can be discovered, described, and accessed via web based catalogs. Essential geospatial information themes are made available as “foundation” or “framework” data. These foundation themes have known accuracy and currency so that other geospatial data can be consistently integrated.

Capabilities of Tier 3:

- *Capabilities of Tiers 1 and 2
and ...*
- Delivery of foundation or framework geospatial information for online access and download;
- Geoprocessing (also known as Geo-Analytics);
- Mobile applications;
- Customized Web applications;
- Integration of real time sensor feeds;
- Customized geographic information products.

Typical scenarios

- A nation begins the implementation of a National SDI to deliver foundational or framework geospatial data for the nation. This may be an effort that starts from scratch or builds on domain specific activities characterized in Tier 2;
- Geoprocessing over the web;
- Delivery to multiple platforms including desktop and mobile;
- Real time data from a variety of sensors is incorporated;
- Account for data sovereignty.

- A robust framework of geospatial information management policies has been established for organizations operating from the local to national level. In place are well defined geospatial data themes, data content models, policies for data access and sharing, as well as service level agreements between organizations and governments for operations and cooperative maintenance of data themes.

3.4 Emerging Standards, Best Practices and Trends

This document has identified the levels of capability that are enabled by geospatial information and the associated technologies and standards that make up a mature local to global Spatial Data Infrastructure. Through the adoption of standards, increasing levels of interoperability can be achieved, with geospatial information becoming more easily accessed, managed, shared and used for improved situational awareness and decision making. Through use of core standards recommended in the Companion document, the decision to share becomes solely a policy decision; uninhibited by technological limitations or geospatial information incompatibility issues.

With the rapid pace of technological advancement and the emergence of new data sources and innovative

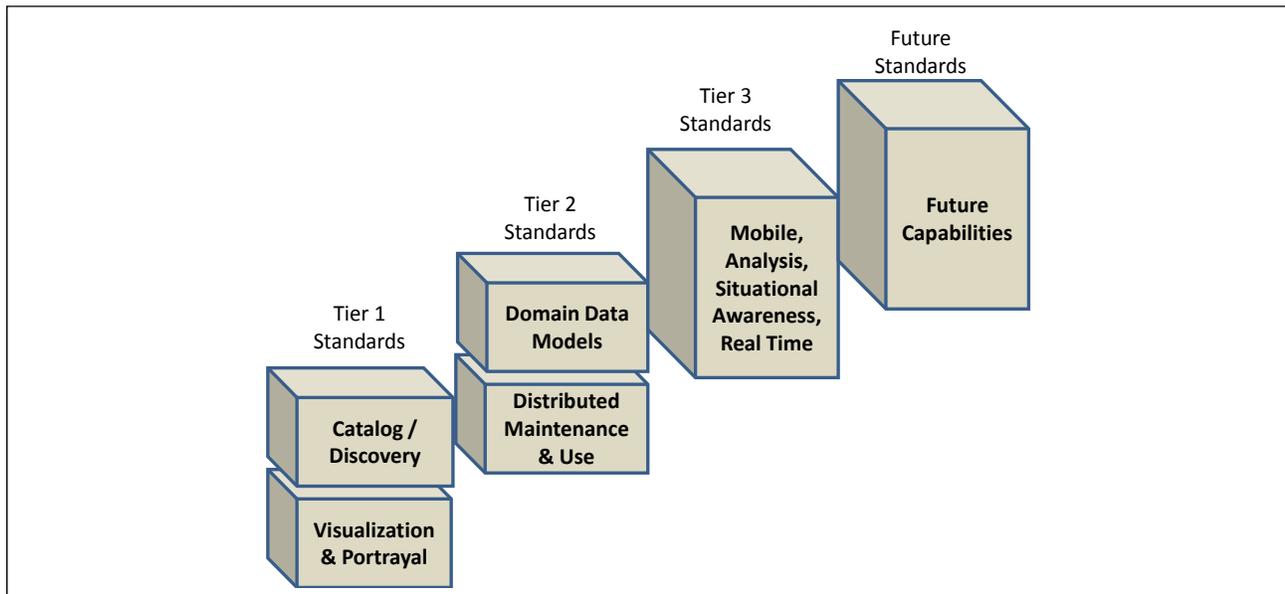


Figure 7: Future Standards that will ease addition of new capabilities

practices, we are seeing the integration of location data and resources in an ever expanding “Geospatial Web”.

Organizational policies, standards, and associated best practices will clearly need to evolve in order to make it easier to apply these new technologies, information sources and processes. There are two key documents already available through the UN-GGIM that cover in detail the key standards organizations and their processes and also information on the future trends for the geospatial community. It is recommended that this document be read in connection with these.

- Establishment and implementation of standards for the global geospatial information community²⁰,
- Future Trends in geospatial information management: five to ten year vision²¹.

These should also be read in the more general context of the importance of geospatial information management to international sustainable development goals as discussed in Monitoring Sustainable Development Contribution of Geospatial Information to the Rio+20 process²².

Without wishing to duplicate the existing content of these documents it is important to highlight here some of the rapidly emerging trends in standards that readers should consider. These include:

- Cloud Computing,
- Linked Data,
- Big Data Analytics,
- Semantic web portals,
- Mobile devices,
- New and dynamic geospatial data collectors,
- Social Media / Volunteered Geospatial Information.

The Maturity Model illustration provided earlier in this document (Figure 1) implies a point in the future when a geospatial infrastructure will be complete or fully realized. The reality, however is that the market is delivering technology advancements on a continual basis. Many of these advancements will help to further improve organizational decision making and reduce cost and effort associated with IT infrastructure. Organizational leadership must be prepared to take advantage of key technology advancements when they become widely available.

To take advantage of these trends we recommend that appropriate organizational staff:

- Leverage the global resources of groups such as the UN-GGIM, standards development organizations, and other major associations mentioned in this document to identify trends, and to adopt best practices.
- Participate in standards development work of ISO/TC 211, OGC and IHO to understand implications and assure earliest implementation of standards that will help ease integration of new technologies. At a minimum, organizations and institutions should consider providing their interoperability requirements to the OGC, ISO, and/or IHO. This does not require much time but

²⁰ http://ggim.un.org/docs/meetings/3rd%20UNCE/E-C20-2013-8%20Establishing%20Geospatial%20Standards%20Summary_en.pdf

²¹ <http://ggim.un.org/docs/Future-trends.pdf>

²² http://ggim.un.org/2nd%20Session/GGIM%20paper%20for%20Rio_Background%20paper_18May%202012.pdf

ensures that these requirements are documented and considered in the ongoing development of international standards.

4 Examples of Standards in Use

This section provides examples of operational implementations for each Tier in the maturity model.

4.1 Tier 1 Use Cases/examples

Australia Globe Applications (Uses KML)

Queensland Globe: <http://www.dnrm.qld.gov.au/mapping-data/queensland-globe>

New South Wales Globe: <http://globe.six.nsw.gov.au/>

Western Australia Globe: <https://mapsengine.google.com/09372590152434720789-00913315481290556980-4/mapview/>

These “globe” applications are designed to provide free and easy access for viewing of geospatial information. They utilize free plug-ins to Google Earth and OGC standards for visualizing the information. These organizations also provide additional tools based on OGC and ISO standards for downloading specific user requested geospatial information resources.

India Geoportal (<https://nsdiindia.gov.in/nsdi/nsdiportal/index.jsp>). Implements Tier 1 OGC and ISO standards for web mapping, metadata and cataloging.

“Encapsulating maps and images into a National Spatial Data Infrastructure (NSDI) has been recognized and the emphasis is on information transparency and sharing, with the recognition that spatial information is a national resource and citizens, society, private enterprise and government have a right to access it, appropriately. Only through common conventions and technical agreements, standards, metadata definitions, network and access protocols will it be easily possible for the NSDI to come into existence.”

NC OneMap (<http://www.nconemap.com/>) Implements several OGC and ISO standards included in Tier 1.

“NC OneMap is a public service providing comprehensive discovery and access to North Carolina USA’s geospatial data resources. NC OneMap, the State's Clearinghouse for geospatial information, relies on data sharing and partnerships.”

4.2 Tier 2 Use Cases/examples

AuScope Portal (<http://www.auscope.org.au/site/>). Implements Tier 2 standards for geospatial data acquisition and management.

“AuScope Limited is a non-profit company formed to facilitate the implementation of a world-class infrastructure system for earth science through the delivery of a range of technologies and capabilities in data acquisition, management, modelling and simulation across the geospatial and geoscience spectrum.”

Baltic Sea Bathymetry Database (<http://data.bshc.pro>) Implements Tier 2 geospatial standards to acquire and manage unique bathymetry data used for safety of navigation and other purposes.

The *Baltic Sea Bathymetry Database* (BSBD) offers authoritative, complete, homogeneous and up-to-date Baltic Sea bathymetry data from all Baltic Sea national hydrographic offices under the umbrella of the Baltic Sea Hydrographic Commission. This is a collaboration and partnership between all Baltic Sea countries.

Geonode (geonode.org) Implements a range of Tier 2 standards to support emergency response and risk reduction applications

“GeoNode is an Open Source, Content Management System (CMS) for geospatial data. It is a web-based application and platform for developing geospatial information systems (GIS) and for deploying spatial data infrastructures (SDI).”

IHO Worldwide Electronic Navigational Chart Database (WEND - <http://www.iho-wms.net/encat/>)

The purpose of the IHO Worldwide Electronic Navigational Chart Database (WEND) is to ensure a world-wide consistent level of high-quality, updated official ENC's through integrated services that support chart carriage requirements of SOLAS Chapter V, and the requirements of the IMO Performance Standards for ECDIS. The IHO worldwide ENC catalog compiles the information provided by the Regional ENC Coordinating Centres, ENC Producers and ENC Distributor Organizations. It shows ENC data limits worldwide for each of the 6 ENC usage bands defined by the IHO ENC Product Specification (IHO Publication S-57, Appendix B1).

4.3 Tier 3 Use Cases/examples

Canadian Geospatial Data Infrastructure (CGDI)²³: (<http://geodiscover.cgdi.ca/>). The GeoConnections Discovery Portal leverages Tier 1, Tier 2 and Tier 3 standards to support discovery and publishing of geospatial data, and to evaluate, access, visualize and publish Canadian geospatial and geoscience data products and Web services.

New Zealand SDI (<http://www.linz.govt.nz/> and www.geodata.govt.nz)

The New Zealand Geospatial Office has developed a comprehensive 2013 to 2015 Work Programme which takes a cross-system view of the implementation of a national Spatial Data Infrastructure (SDI).

All projects relate directly back to the New Zealand Geospatial Strategy and measures for achievement have been put in place. Two areas of focus on accelerating development of an SDI are supporting the Canterbury Earthquake recovery efforts, and the related national view from this work.

²³ Permanent Committee for Geospatial Data Infrastructure of the Americas (PC-IDEA) (2013). Spatial Data Infrastructure (SDI) manual for the Americas, Version 1, 203 p., http://unstats.un.org/unsd/geoinfo/RCC/docs/rcca10/E_Conf_103_14_PCIDEA_SDI%20Manual_ING_Final.pdf

SDI of France (www.geoportail.gouv.fr)

The French geoportal allows viewing not only maps and aerial photographs, but also many other geo data related to the environment, development, public service. This ability to display geographical information allows creating maps to discover, understand and analyze territory. An excellent presentation on the use of standards for cataloguing in the French geoportal can be found here: <http://www.ign.fr/institut/the-geoportail-gi-standards-approach>

Norway Digital – Norwegian Spatial Data Infrastructure (NO):

“Norway digital is the Norwegian government's initiative to build the national geographical infrastructure. It is a nation-wide program for co-operation on establishment, maintenance and distribution of digital geographic data. The aim is to enhance the availability and use of quality geographic information among a broad range of users, primarily in the public sector. A broad representation of Norwegian public bodies are participating: Ministries and their Directorates at national level, all Norwegian Municipalities and different regional public bodies at local and regional level.”

4.4 Future: Spatially enabled Web of data

UK Ordnance Survey linked data platform (<http://data.ordnancesurvey.co.uk/>)

Linked data constitutes a fast emerging trend leveraging a way to interconnect related data resident on the web, and deliver it in a more effective manner to increase its value for users. The resulting "Web of data" has recently started being populated with geospatial data. Ordnance Survey is the first national mapping agency that has made various kinds of geospatial data from Great Britain available as open linked data. OS OpenData is the opening up of Ordnance Survey data as part of the drive to increase innovation and support the "Making Public Data Public" initiative. As part of this initiative Ordnance Survey has published a number of its products as Linked Data.

5 Next steps

Deploying standards-based SDI applications and portals do not just happen. Stakeholder organizations must agree and commit to the use of standards in their SDI infrastructure. They must make clear statements regarding the commitment to using standards and if at all possible this commitment should be documented in procurement policy. To maximize the value of investments, organizations should use procurement language that requires vendors to offer standards-based solutions.

Before the Internet and the Web, a well-run organization would use in-house experts or consultants to provide interoperability among the geoprocessing systems used in various offices of the organization. Policies focused on standardizing on specific vendor solutions, standardizing on certain vendor-specific or domain-specific proprietary formats and encodings and providing custom or third party tools for connectivity between geospatial systems and between geospatial and non-geospatial systems.

Now, enterprise information and communication technology (ICT) has evolved dramatically and the model described above is outdated. Today, a well-run organization can best maximize the value of

geospatial processing systems and geospatial data by using the expanding framework of Internet and Web standards to enable interoperability both internally and universally.

Standardization is the reason for the success of the Internet, the World Wide Web, e-commerce, and the emerging wireless revolution. 'Communication' means 'transmitting or exchanging through a common system of symbols, signs or behavior', and 'standardization' means 'agreeing on a common system'. Thus we have much more communication today because we have much wider use of common ICT interfaces and encodings.

Yesterday, interoperability depended on tight coupling of systems under centralized control. Today interoperability depends on wide use of standard interfaces and encodings that enable loose coupling of countless systems that can exchange much more information, at much less cost, than was possible yesterday. Today, because open standards enable 'plug and play', much less expertise is required in integrating systems. Also, because Web standards such as HTML and XML make user interface design easier, and because widespread implementation of a small number of user interface design patterns has made millions of people familiar with those patterns, less expertise is required in using the systems.

Policy makers should also keep in mind that advances in technology inexorably change organizational structures, workflows and business models. Today's SDI is different from yesterday's SDI. SDI 2.0 allows distributed or centralized approaches to fit the needs of users. It is built on Web services and online catalogs, not file transfers and manual clearinghouses. It is more adaptable for place-based decision-making. The pace of change requires new thinking about national SDI roles and investments, and a commitment to interoperability based on open standards is essential in dealing with this transition.

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Resources for next steps

Cookbooks

Global Spatial Data Infrastructure Association, SDI Cookbook,
http://www.gsdi-docs.org/GSDIWiki/index.php/Main_Page

This SDI Implementation Guide or Cookbook, through the support of the Global Spatial Data Infrastructure community, provides geographic information providers and users with the necessary background information to evaluate and implement existing components of SDI. It also facilitates participation within a growing (digital) geographic information community known as the Global Spatial Data Infrastructure (GSDI).

IHO-IOC GEBCO Cook Book - IHO Publication B-1,
http://ibis.grdl.noaa.gov/SAT/GEBCO_Cookbook/index.php

Operational Policy

Principles of the Worldwide Electronic Navigational Chart Database (WEND) - IHO Resolution 1/1997 as amended (in IHO Publication M-3 - http://www.iho.int/iho_pubs/IHO_Download.htm#M-3)

Guides

Spatial Data Infrastructures: “The Marine Dimension” - Guidance for Hydrographic Offices, Edition 1.1.0, February 2011 (http://www.iho.int/iho_pubs/CB/C-17_e1.1.0_2011_EN.pdf)

Hydrographic Data Policy for SDI
(http://www.iho.int/mtg_docs/com_wg/MSDIWG/MSDIWG_Misc/Marine_SDI_Documents/SDI_Hydrographic_Data_Policy.pdf)

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