Appendix 1

Standards for the Infrastructure for Spatial Information in Europe
(INSPIRE)
and
Global Spatial Data Infrastructure
(GSDI)

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Abstract

The purpose of this paper is to provide an introduction to standards and an overview of the standardization process in terms of the development, implementation, and deployment of international standards for spatial data infrastructures (SDIs) such as INSPIRE and the GSDI.

The introduction identifies the multiple functions of standards. Within the context of the International Organization for Standardization (ISO) Technical Committee 211, Geographic Information / Geomatics, this introduction describes the functionality of ISO standards beyond being just technical solutions. These functions include: standards serving as compromises, as forms of technology transfer, as democratic and as research mechanisms. It also discusses the consensus process and its implications for standardization. GIS standards, the relationship between the GIS standards infrastructure and spatial data infrastructures are also discussed.

The overview describes the standardization process in its progressive stages. The development of technical specifications, in accordance with the consensus process, to its final approval as a national, regional, or international standard characterizes the formal development of standards. Depending upon whether approved standards are accepted, it may or may not be followed by the equally important stages of implementation and deployment. Some standards never progress beyond formal development and approval.

The implementation stage is driven by the technical requirements of the particular standard. Some standards require complex software integration and vendor acceptance to incorporate or generate industry interfaces that achieve the highest levels and scope of interoperability. There may be geographic data standards that require national or regional acceptance to define, describe, collect, manage, access, and disseminate geographic information in a common and coherent manner. Some international standards development and implementation result from the need of various international organizations that require specific standards for their community of users, such as the military, aviation or maritime communities.

Traditionally, deployment of standards is somewhat passive, unless a specific community of users is actively promoting the development and implementation of the standards. The deployment of international standards at the regional and national levels is defined by implementation differences in languages and requirements, resulting in profiles of standards. These profiles may involve specific or combinations of subsets or extensions of the standards. The implementation of an international standard without any profiles would be ideal, but, not realistic or practical. Deployment of international standards within and among regional and international organizations requires a deliberate effort to institutionalize standards as part of a long-term solution that includes management support, policy, education, training and outreach.

This paper concludes with a brief review of the status ISO/TC 211 standards and the activities of its Advisory Group on Outreach.

Introduction

Standards are often deceptive because they serve different functions. Generally, standards are perceived as consensus accepted technical solutions. Within the International Organization for Standardization (ISO), consensus does not necessarily imply unanimity or approval by majority. The notion of consensus, within this context, refers to the absence of sustained objection. Closer scrutiny reveals that standards are more likely to be political compromises that may have significant roles and implications in the management, policy, and financial considerations of governments, industry, and user communities. In this regard, the approved standard is less than likely to be a superior technical solution. Standards frequently serve as forms of technology transfer between advanced and emerging countries. The traditional technology lag existing between developed and emerging countries is disappearing because emerging countries are now joining technical committees within standardization organizations as participating members or as observers. Within ISO, observers have all the privileges of participating member, however, observers are not required to vote. In reality, many national bodies participate as observers because this is an excellent low cost way, with a minimal commitment of technical resources, to update and manage many new and emerging technical developments. Standards also serve as democratic mechanisms to level the playing field for all players, large or small, in a competitive technological / GIS environment. Smaller companies usually do not have the resources that a larger company has to address significant technical issues. When such issues are resolved by a standard, this shifts the focus of competition between companies to other products and services. This democratic principle also applies to the standardization process: the International Organization for Standardization intentionally uses the ISO acronym rather than IOS to signify and to strive for the equality of nations in the standardization process and voluntary adoption of ISO standards.

Highly important but often overlooked is the role of research in the process of standardization. Such research begins with the basic / pure academic research that establishes the theoretical / conceptual basis for the development of standards. Equally important is the applied research necessary for the implementation and deployment of standards. Applied research for the implementation of standards may occur in the governmental, private, and commercial sectors. Some of this applied research has resulted in implementations of various drafts of the ISO Metadata standard. For this particular standard, there are implementations by governments, the private sector, as well as, commercially within industry. Ultimately, the true essence of standardization remains with the deployment of standards among its users.

High quality research can result in achieving higher levels of technical content and attaining the ever important objective of interoperability, the basic / applied research accomplished before, during, and after the standardization process can also minimize the amount of time and associated effort necessary to progress through the development, implementation, and deployment phases of standardization. Naturally, the emphasis should be on the basic research that can be accomplished “before” it is needed for the purposes of standardization. The more complete and widely accepted research, including concepts and theory, would certainly preclude much of the research that might be needed during the standards development phase, thereby reducing the length of this phase considerably.

Surprisingly, the development of standards for geographic information can oddly begin with the total absence of any real theory or conceptual basis. This results in the development of just enough “theory on the fly” to produce a standard with little or no technical sustainability or long-term viability. The problem is further complicated by the need for the conceptual and technical integration with other related standards for geographic information. This is further exacerbated by the need to consider the allowances for numerous disciplines that use geographic information as well as the within the pervasive presence of the information technology environment.

The role of academics in the standardization of geographic information has been limited to contributions by individuals as experts and members of national delegations. Basic / applied research to the various phases of standardization by academics as a group / organization would be new and welcomed contributions to the standardization process. The standards research agenda needs to be established, prioritized, and debated. Research, supporting the establishment of theoretical / conceptual foundations for use in standards development, remains one of the most neglected and needed aspects within the standardization of geographic information.

As research can define the theoretical foundations of standards, research may also influence spatial data infrastructures. Standards constitute one of the four basic components of spatial data infrastructures. These four common components: standards, technology, data policy, and institutional framework are mutually inclusive and form the foundation of a spatial data infrastructure.

List 1 ISO/TC 211 External Liaisons

CEOS, Committee on Earth Observation Satellites
DGIWG, Digital Geographic Information Working Group
EPSG, European Petroleum Survey Group
FIG, International Federation of Surveyors
GSDI, Global Spatial Data Infrastructure
IAG, International Association of Geodesy
ICA, International Cartographic Association
ICAO, International Civil Aviation Organization
IEEE Geoscience and Remote Sensing Society
IHB, International Hydrographic Bureau
ISCGM, International Steering Committee for Global Mapping
ISPRS, International Society for Photogrammetry and Remote Sensing
JRC, Joint Research Centre, European Commission
OGC, Open GIS Consortium, Incorporated
PCGIAP, Permanent Committee on GIS Infrastructure for Asia and the Pacific
UN Economic Commission for Europe, Statistical Division
UN Food and Agriculture Organization
UNGEGN, United Nations Group of Experts on Geographical Names
UNGIWG, United Nations Geographic Information Working Group
WMO, World Meteorological Organization
PC IDEA, Permanent Committee on Spatial Data Infrastructure for the Americas
SCAR, Scientific Committee on Antarctic Research
CEN/TC 287, Geographic information

One viewpoint most commonly associated with standards is that they are just to slow in their availability to be of any use or value. The development, approval, implementation, and deployment phases of standardization can be time consuming individually and collectively. Standards that are ambiguous in their technical specifications can be difficult or nearly impossible to implement and to deploy. International standards rely on the consensus approval of nations, which translates to broad consideration and a lengthy coordination of the national position, while always maintaining the legitimacy of due process.

The global user community for geographic information standards consists of nations, non-governmental organizations such as the United Nations and multi-lateral banks, and international initiatives and programmes, e.g., GSDI and INSPIRE. List 1 enumerates the External Liaisons of ISO/TC 211, most of these organizations constitute the ISO/TC 211 user community. Major national, regional, global initiatives such as INSPIRE and the GSDI have only identified and endorsed standards and specifications. This only answers the question of what, the question of how various implementations will be deployed among and between the user communities also requires planning, coordination, and cooperation.

Increasingly, the viability of standards are judged from their capacity to support the criterion established by governmental and non-governmental organizations, at the national, regional, and global levels, to achieve the integration and interoperability of geographic information and systems; and within existing and emerging information technology environments. This overall interoperability with generic information technology provides the ability to extend the benefits of geographic information / technology for incorporation within

other technologies and applications and from specific user domains to those of mass-market consumers. These are, in large measure, major and common objectives for INSPIRE and the Global Spatial Data Infrastructure. Consequently, it is why standards deserve the institutional advocacy and strategic support of such organizations.

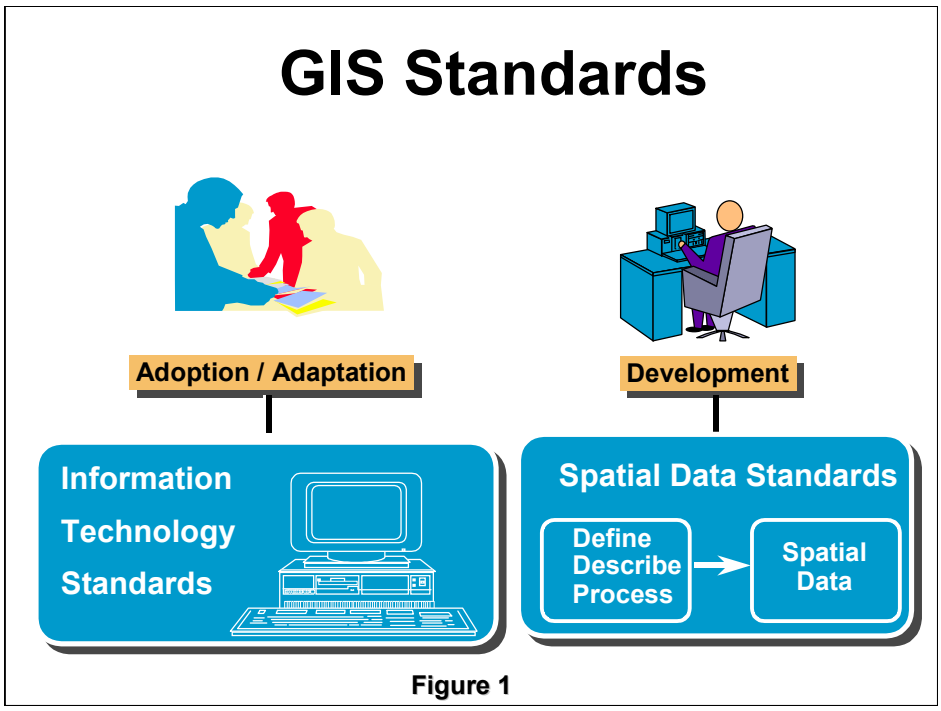

Figure 1

GIS Standards

GIS standards generally refer to information technology standards and/or spatial data standards (Figure 1). A GIS standard may result from the adoption or adaptation of an information technology standard for GIS applications. The use of the Structured Query Language (SQL) is an example of the adoption of an information technology standard. The modification of the SQL with a GIS extension represents an adaptation of an information technology standard. A GIS standard may also be a spatial data standard. Spatial data standards are standards developed for defining, describing, and processing spatial data. The ISO Metadata standard is an example of spatial data standard and one that is content oriented.

In standards development, a common practice is to first consider the adoption or adaptation of an existing standard. Developing a standard is usually a last resort, since the time for developing and approving standards is a lengthy process. Standards should be available when needed, so standards development needs to be anticipatory rather than reactive. Integrating other standards during the development process ensures the interoperability of these standards, while conformance testing of standards provides confidence in their implementations.

GIS Standards Infrastructure

Standards Organization	Standards Scope	User / Industry Organizations
US Federal Geographic Data Committee (FGDC)	Government	US Government agencies
American National Standards Institute INCITS L1 GIS	National	US Federal, state, county, city agencies
European Committee for Standardization (CEN)	Regional	Digital Geographic Information Working Group (DGIWG) Infrastructure for Spatial Information in Europe (INSPIRE) Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP)
International Organization for Standardization (ISO) Open GIS Consortium (OGC)	International	International Cartographic Assoc. (ICA) International Hydrographic Bureau (IHB), etc

Figure 2

GIS Standards Infrastructure

Globally, the development of GIS standards is occurring at government, national, regional and international levels. This development is not confined to just standards organizations which formally develop and approve standards. Substantial efforts are also being made in various user/applications communities. Some user/applications communities may develop standards, while others endorse and/or adopt GIS standards. These communities are, in fact, the user community for GIS standards. Collectively, these standards and user organizations along with their standardization efforts form the GIS standards infrastructure (Figure 2).

The GIS standards infrastructure, a specific subset of the global standards infrastructure, provides an institutional structure and process for coordinating and integrating the development of GIS standards. The GIS standards infrastructure is comprised of government, national, regional, and international levels. At each level are organizations that develop standards. These groups are classified as formal standards development organizations or user/industry organizations, which develop standards to fulfill their own needs because such standards have not or will not be developed by formal standards organizations.

The strategy for standardization reflects the evolution of the relationship between the GIS standards infrastructure and spatial data infrastructures. Standards as a major component of the global spatial data infrastructure, closely couples the GIS standards infrastructure with the Global Spatial Data Infrastructure (GSDI). The integration of both these infrastructures is greatly enhanced because they share common operating levels of jurisdiction and applications. As a subset of the global information infrastructure, spatial data infrastructures are also aligned and highly leveraged with the advances of information technology and transfer these advances to its various levels.

The establishment of spatial data infrastructures at the national, regional, and global levels is the international response to the challenges of organizing and using geographic information. Spatial data infrastructures (SDI) at the national and regional levels are collectively stimulating the emergence of the global spatial data infrastructure. A spatial data infrastructure for a country is considered the national spatial data infrastructure (NSDI), which can vary by country. A regional spatial data infrastructure (RSDI)

is comprised of several NSDIs and/or by a number of countries, within which a NSDI may or may not be present. Countries that cannot currently establish their own NSDI can be part of and benefit as a member of a regional spatial data infrastructure. This may be the case for some developing countries in Europe and why the European Spatial Data Infrastructure (ESDI) may assume a role more significant than had been planned or anticipated; and more so among the 55 countries that constitute the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). For Africa, while there are some NSDIs being established, a regional spatial data infrastructure may be the most sensible and appropriate solution available. Accordingly, the global spatial data infrastructure (GSDI) is formed by the linking of regional spatial data infrastructures, established by the linking of national spatial data infrastructures.

National Spatial Data Infrastructure (NSDI)

A national spatial data infrastructure formalizes the structure and process for organizing, using and sharing spatial data common to a broad spectrum of applications and users within a country. The concept of a spatial data infrastructure is not new. The need was recognized several years ago. Countries such as the United Kingdom, Australia, New Zealand, Japan, Korea, and Canada have also established their own NSDI and approximately 60 other countries are also establishing their own NSDI.

Regional Spatial Data Infrastructure (RSDI)

Currently, there are three emerging regional spatial data infrastructures (RSDI). The European, Asia and the Pacific, and Americas regions are actively engaged in coordinating the development of an RSDI in their own region. The establishment of regional spatial data infrastructures in Africa and the Middle East would complete the global spatial data infrastructure.

The European community, under the leadership of the Infrastructure for Spatial information in Europe (INSPIRE), is currently establishing the European Spatial Data Infrastructure (ESDI). This infrastructure is intended to deliver spatial information services to its users. Such services allow users to identify and access geographic information from a wide range of sources, from the local level to the global level, in an interoperable way for a variety of uses. The INSPIRE initiative supports the availability of spatial information for the formulation, implementation and evaluation of European Union polices.

The Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) is developing the Asia and the Pacific Spatial Data Infrastructure (APSDI). The Permanent Committee has made significant progress in establishing a regional geodetic network and has become a model for the Latin American region resulting in the formation of the Permanent Committee on GIS Infrastructure for the Americas (PCIDEA).

Spatial Data Infrastructure Components

Data policy, institutional framework, technology, and standards are emerging as the four major components of a spatial data infrastructure, common to each level of the global spatial data infrastructure. For data policy: many policies need to be developed, with an international viewpoint, regarding all aspects of data. For institutional framework: agreements must be ratified to establish a national spatial data infrastructure, for coordinating the formation of regional spatial data infrastructures and for linking them to form the global spatial data infrastructure. For technology: there is acknowledgment that GIS technology is founded upon generic information technology, which accentuates the need for GIS technology to be fully integrated with the emerging Global Information Infrastructure (GII). For standards: GIS standards are also based on information technology standards and that the GIS standards infrastructure needs to be understood, adopted, and utilized within spatial data infrastructures. Standards constitute the link between the GIS standards infrastructure and the spatial data infrastructures that form the global spatial data infrastructure.

Another important aspect of the global spatial data infrastructure is the concept of framework data. Framework data are those basic datasets upon which most other datasets could be built. Some of the basic datasets identified include: geodetic, cadastral, hydrography, transportation, boundaries, elevation, and digital ortho-imagery datasets. It is recognized that the underlying dataset for framework data is the

geodetic network, which provides consistent global geo-referencing for spatial datasets that are created or derived.

The GIS Standards Infrastructure and Spatial Data Infrastructures

The correspondence of levels between the GIS standards infrastructure and those of the global spatial data infrastructure facilitates the integration of spatial data. GIS standards can integrate horizontally across a spatial data infrastructure level and vertically integrate between various levels. GIS standards provide the horizontal integration of spatial data at each of the federal government, municipal, county, and state levels and provide the vertical integration of these levels to form the national spatial data infrastructure. Similarly, GIS standards also provide the horizontal integration of spatial data across each of the national and regional levels, while providing the vertical integration of these levels to form the global spatial data infrastructure. Equally significant, the global spatial data infrastructure serves a major role in the development, implementation, and deployment of international GIS standards. The success of standards, in turn, determines the viability of the global spatial data infrastructure.

As envisioned, the global spatial data infrastructure has four components to enable its realization: standards, technology, data policy, and institutional framework. With standards as a major component, the GIS standards infrastructure is established with a well-defined structure and process. Incorporating the GIS standards infrastructure within the global spatial data infrastructure provides much of the needed integration for the successful realization of the global spatial data infrastructure.

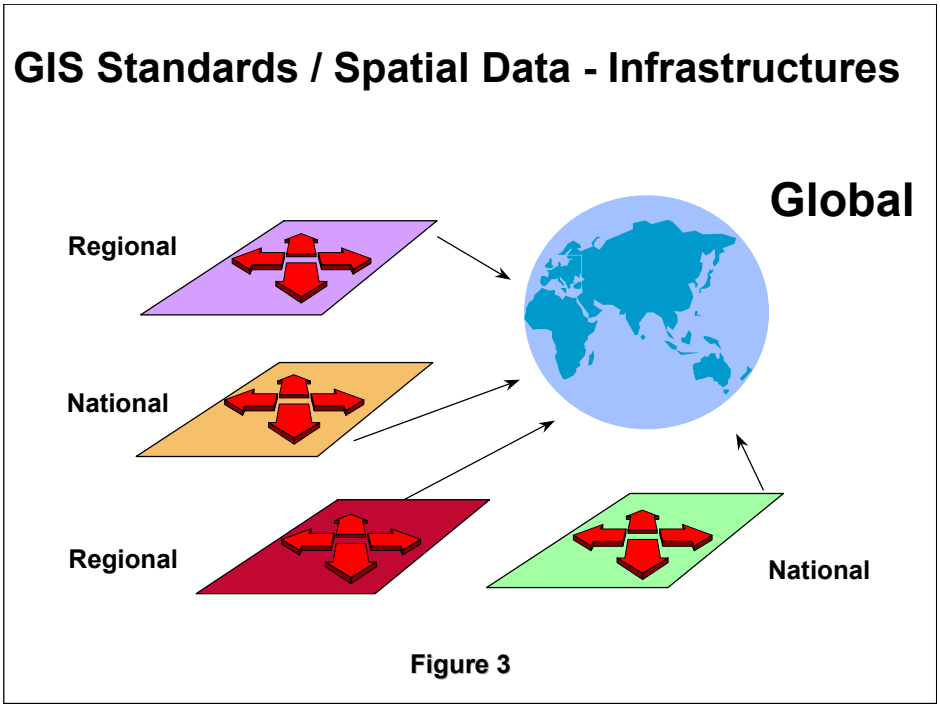

Figure 3

Standardization Process

The process of standardization consists of the phase of: development, approval, implementation, and deployment. While there may be room for research to improve the approval phase of the process, there are already well-developed technical and procedural directives to ensure the orderly development and approval of standards, at least there are in the ISO environment. Within the ISO standardization process, there are

only two phases, i.e., development and approval. The ISO process seems to end with the official publication of the standard. ISO, as an organization, has little to do with the implementation or deployment of ISO standards. In recent years, ISO is challenged to maintain its relevancy and to preserve its viability within the global market at large.

Development Phase

Within ISO, the standards development phase begins with a new work item proposal (NWIP). The NWIP is sent out for a letter ballot within the ISO technical committee. Upon approval, it must have at least five national bodies committed to working on this NWIP. The NWIP generally begins with a clearly defined scope of work and national bodies nominate experts to form the project team that will develop the technical specification. In some case, the NWIP may also include draft technical specifications. If sufficiently developed, the technical specification may be accepted a committee draft (CD). Normally, the project team meets two to three times a year to develop the working draft (WD) and then on to a CD. Both the WD & CD may require multiple drafts, evolving to a draft international standard (DIS) and on to a final draft international standard (FDIS) and ultimately to international standard (IS). An international standard may take at least three years or more to be completed within ISO/TC 211. The lengthy technical specification development phase is further extended by the approval process, which requires editing committees to respond to comments and make decisions that are in effect, compromises.

Unlike previous ISO technical committees, ISO/TC 211 has the unique distinction of beginning a programme of work that focused on the concurrent development of an integrated set of standards for geographic information. While the development of a singular or stand-alone ISO standard occurs at a faster rate, the carefully developed ISO/TC 211 set of integrated standards advances the interoperability of its family of standards. The ISO standardization process may be slower because it requires the formal consensus and approval of standards by many nations, however, the widespread acceptance of ISO standards internationally, by legal statutes and regulatory mandate in many countries, is recognized as much more preferable to any national, regional, commercial or de facto standards.

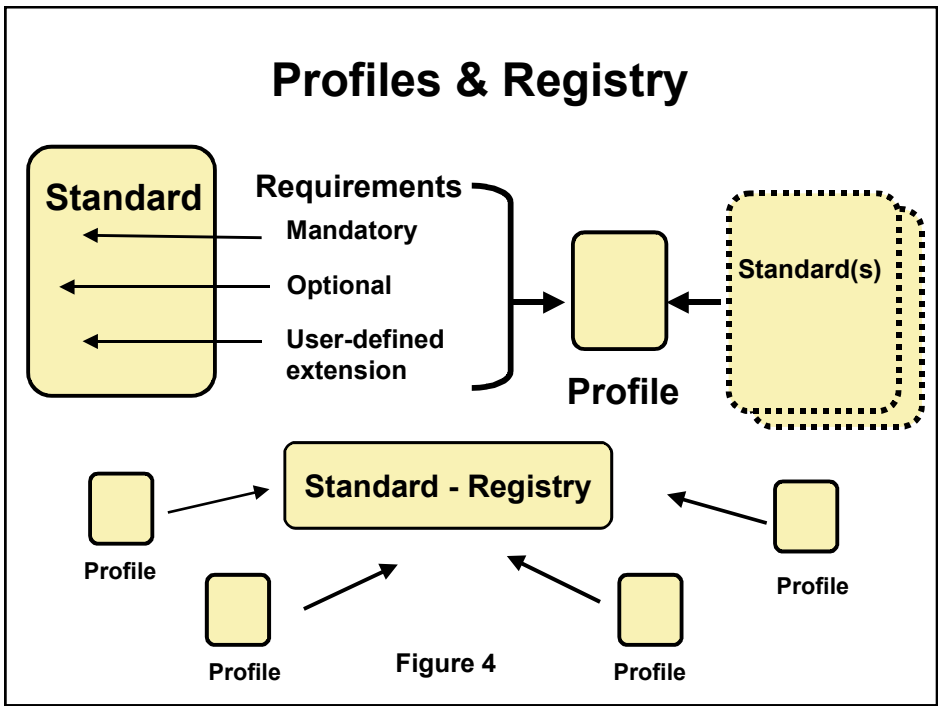

Figure 4

Implementation Phase

The Open GIS Consortium (OGC) was also established in 1994. Its vision is the integration of geospatial data and geospatial processing into mainstream computing. The OGC has an agreement to work cooperatively with ISO/TC 211. This is resulting in the introduction of OGC specifications such as the Web Mapping Server Interface for processing as an ISO standard. The OGC has adopted a number of the ISO/TC 211 draft standards as OGC Abstract Specifications. These include the ISO/TC 211 standards for spatial schema, coverage geometry, services, conceptual schema language, and rules for application schema. As such, the OGC recognizes the theoretical basis provided by the ISO/TC 211 standards.

In recent years, the OGC has enjoyed success with the Interoperability Testbed Program. This is a bottom up effort where OGC members work together to solve a particular set of interoperability issues and result in a working prototype and technical specification within a very short time. The top down approach of defining an initial technical specification for implementation was followed by ISO/TC 211 and by OGC initially. The resulting testbed specifications are then submitted to the OGC revision process for incorporation into the OGC technical specifications program.

ISO standards are usually broad in scope and technically comprehensive. Generally, ISO standards are implemented as profiles of the standard to specifically address requirements of a country, regional, or user community. The specific selection of mandatory and optional requirements of a comprehensive ISO standard form a particular subset known as a profile. The standard may even contain a part that allows for a user-defined extension that was not part of the standard. Profiles can be comprised of subsets, extensions, and even incorporate other standards in part or in total. As the proliferation of profiles for a standard are established, a registry for the standard may be necessary to maintain order and provide users with the technical information necessary to develop cross-walks and equivalency tables to relate various profiles of the same standard. (Figure 4)

Deployment Phase

The forthcoming deployment of standards and specifications for the GSDI and its regional spatial data infrastructures such the INSPIRE provide opportunities to plan this deployment properly. While the identified standards and specifications may be the same, their implementation will vary according to the constituent parts and subparts of the national bodies that comprise INSPIRE.

The deployment of ISO geographic information standards is rapidly approaching. In 1994, the International Organization for Standardization (ISO) established Technical Committee 211, Geographic information / Geomatics to develop standards for geographic information [http://www.isotc211.org]. Consequently, standardization emerged to be a visible and prominent part of the international geographic agenda The value of initial standardization efforts in the early 1990's was to gain the international recognition and acceptance by the cartographic and geographic communities of the need and value of geographic standardization. The widespread and prolific establishment of spatial data infrastructures will be a major factor in the acceptance and institutionalization of ISO geographic information standards.

Figure 5 shows the ISO/TC 211 standards applicable to spatial data infrastructure that are data or content oriented. It also shows that ISO/Technical Report 19122 – Qualifications and certification of personnel is certainly appropriate for the purposes of education and for organizational staffing. These standards also provide a foundation for when common documentation of geographic information is required.

Figure 6 shows ISO/TC 211 standards applicable to spatial data infrastructures that facilitate the access to geographic information and to services within geospatial and information technology environments. It also indicates those standards that can be used by organizations to understand and plan the implementation of standards.

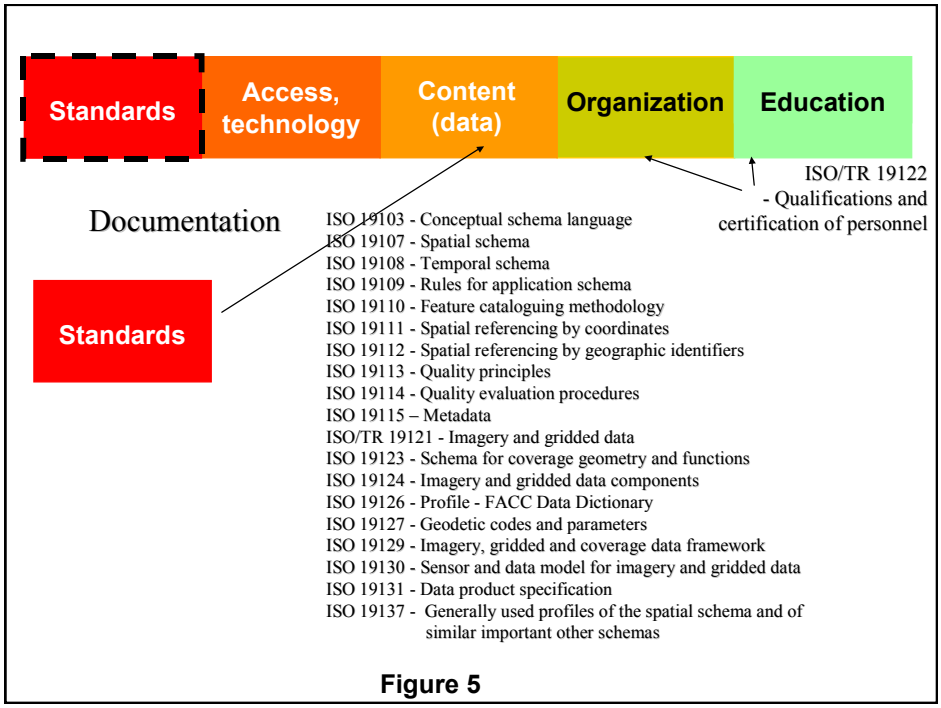

Figure 5

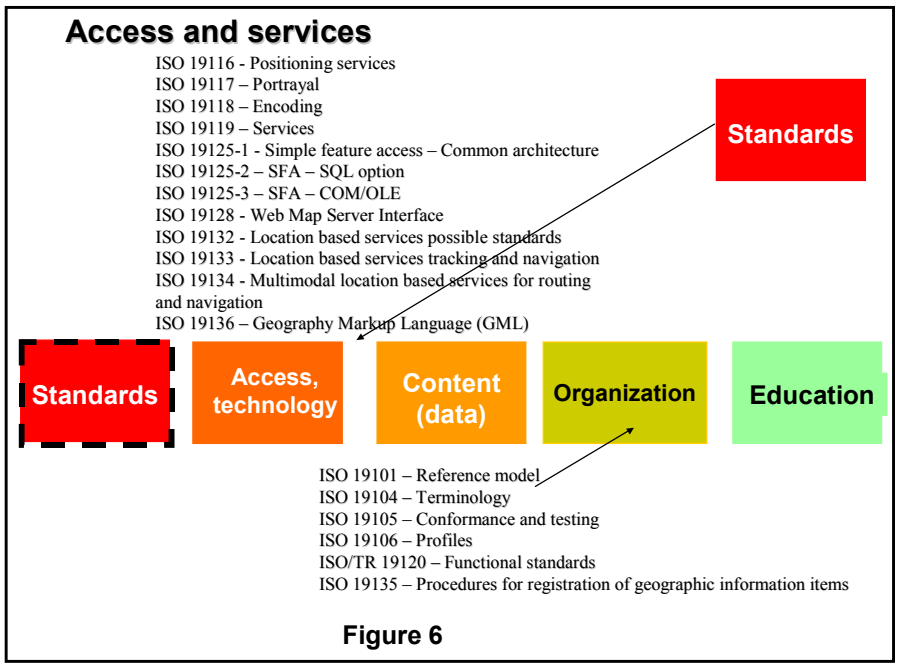

Figure 6

Both Figure 5 and Figure 6 are taken from the current ISO/TC 211 presentation on the ISP/TC 211 website.

All but three of the 20 work items within the original programme of work of ISO/TC 211 have been completed as international standards and technical reports. The introduction of an additional 17 work items represent the second generation of ISO/TC 211 standards.

Recently, ISO/TC 211 established an Advisory Group on Outreach to promote the awareness, adoption, and advocacy of ISO/TC 211 standards in user communities. Its terms of reference include:

- Create awareness
- Enable education and training
- Facilitate adoption and implementation
- Capture user requirements and feedback
- Generate outreach resources
- Maintain the ISO/TC 211 Business Plan

The ISO/TC 211 Advisory Group on Outreach is actively seeking to enter into joint outreach efforts with international organizations interested in applying ISO geographic information standards. Facilitate adoption and implementation and the capture user requirements and feedback provide the basis for research and contributions to the ISO/TC 211 standardization process. The intent is to institutionalize ISO/TC 211 standards in large international initiatives and programmes such as the GSDI and INSPIRE.

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