SPATIAL DATA STANDARDS

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Summary

As societies have developed over the past few thousand years, problems have invariably arisen due to the different ways that people may interpret the signs, language, and actions of others. To avoid this confusion (and sometimes more serious social, economic, or political consequences), it often becomes necessary for people to reach agreement over the meaning of concepts that are important to them, and the way that certain activities are to be undertaken. While this is not important when humans choose to live their lives in isolation from others, it becomes increasingly significant as people group together to form villages, towns, cities, regions, nations, and ultimately a global community. In essence, this practice of agreeing to willingly define and use common concepts and actions is the process of achieving standardization and producing standards.

With the evolution of the "information age" over the past 40 years, standards have also been required for the effective and efficient dissemination and application of information and information technology—and the needs of spatial information have been no exception. At first, standards were developed that would enable geographic information systems (GIS) technology to function correctly—for example in user interfaces, computer operating systems, database query languages, and network communications—but generally these standards did not apply directly to spatial data. However, this soon changed as users sought to share the digital spatial datasets they had developed in order to reduce data duplication, minimize data collection costs, and implement integrated data applications. Because of the differences in spatial data models and structures, particular attention was paid to developing and adopting spatial

data transfer standards. Since that work in the 1980s and 1990s, the Internet has evolved and with it have come the formation of complex spatial data infrastructures and new applications areas such as location-based services. Accordingly, fresh standards have been needed to facilitate the search and discovery of spatial data via the Internet and its transfer to users' GIS and other technologies. This article aims to provide readers with an introductory understanding of why spatial data standards have evolved, the areas in which they are being applied, and the organizations and procedures associated in their development.

1. Introduction

In the previous era of paper-based (or analogue) cartography, information often needed to be shared because of the expense of the data collection process. In those times, data sharing involved the transfer of maps, but spatial data are now recorded and stored using digital techniques that require completely different mechanisms for data sharing. Furthermore, spatial data users now obtain their data from many different sources, and combine them to form entirely new datasets to meet their individual application requirements. To make this transfer of spatial data as easy as possible, a variety of technical standards are needed in order to permit the flow of data to occur without requiring cumbersome programming tasks each time a transfer is necessary between two or more systems. As such, appropriate standards have become one of the fundamental conditions for optimizing the advantages to be obtained from sharing digital geographic or spatial data. See also ***GIS Interoperability: From Problems to Solutions.***

At the same time, now that digital spatial data have become available from a wide variety of sources, it has also become necessary to define systems that can inform potential data users as to what datasets are available and what is contained within them. Until relatively recently, no systems of this type existed for the dissemination of spatial data, and users had to depend on their own knowledge of what datasets might be used for their purposes. However, the use of the Internet as a means of data delivery has been responsible for the occurrence of an entirely new upsurge in data sharing—one which has been fuelled by the rapid growth of available digital data for both public and commercial purposes. Thus, a new form of infrastructure has evolved that relates to spatial data—called the spatial data infrastructure (or SDI)—which many observers believe will soon become as essential to modern societies as our existing transportation and telecommunication networks. Clearly, common standards relating to a variety of spatial data-related issues will be critical in ensuring its success and future growth.

At this stage it is worth noting that the broad industry relating to spatial data is known by several different names. For instance, in Europe it is popularly known as either the geo-information industry or the geo-information and communication technology (Geo-ICT) industry, while in the United States and Australia the terms geospatial and spatial are currently preferred respectively. However, regardless of the different terminology employed, it is considered that they generally mean the same thing and may be used interchangeably.

Accordingly this article aims to introduce readers to the topic of spatial data standards and is organized as follows. After these introductory remarks, it will provide a brief background to standards in general, focusing upon their history, their aims, and some of the terminology in use. The article then examines standards specifically relating to spatial data, and in doing so identifies the links between standards and spatial data infrastructures, the organization of spatial data standards, their content, and some of current initiatives being undertaken in this field. Next, the article discusses the major spatial data standards relating to metadata description for inventory purposes and spatial data transfer. Finally, there is a discussion of future work in the standardization field and some closing remarks.

2. A Background to Standards

2.1. A Brief History of Standardization

Standardization is as old as humankind itself, and it was through the communication between people that gestures and signs became the first implicit forms of standards. Later when formal language developed, the grammatical rules that gradually evolved can also be considered as types of standards, since grammatical rules must be followed to give the correct meaning when speaking or writing in any language. In fact, in the use of language, people agree to its common usage of their own free will, so these are two important aspects of standardization—"consensus" and "willingness." Of course, language is not only a subject for standardization but also a means of achieving it, since standards are written down in document form so they can become available to all users who understand the language.

Early examples of standards can be found in ancient buildings and other structures. For example the Egyptians (ca. 1500 BC) paved the corridors in their houses with tiles of a fixed format and the Phoenicians (ca. 1000 BC) built ships of fixed sizes, while later in Europe it was Charlemagne (ca. 800) who introduced a standardized form of handwriting—the Carolingian script—which is similar to our contemporary block letters. Another example of standardization is the definition of a suitable unit of length (the meter), which until its introduction and adoption had been a topic of considerable debate throughout the centuries. Indeed, the replacement of many alternative units of length in different European countries by the meter is considered one of the greatest successes achieved in standardization. More recent examples of important standardization practices can be found in the telecommunications industry.

However, it was the Industrial Revolution some two centuries ago that provided the greatest impetus to achieve greater standardization for technological and political purposes. Then, around 1900, technical standardization as it is now known came into being and almost every country now has some form of national standardization institute. The earliest examples of the formation of these organizations are:

- the British Standardization Institute (BSI) in 1901,
- the Deutsches Institut für Normung (DIN) in Germany in 1917,
- the American National Standards Institute (ANSI) in 1918,
- the Standards Australia International Ltd (SAI) in 1922,

- the State Committee on Standardization and Metrology, based on the Soviet Law on Standardization in 1933, and
- the Japanese Industrial Standards Committee (JISC) in 1949, as a successor to the Japanese Engineering Standards Committee of 1921.

So within a relatively short period the issue of standardization had progressed beyond the confines of particular applications and national boundaries. In due course, in 1946 in London the International Organisation for Standardisation (ISO) was established. Then soon after, in 1961, a European regional standardization body was created (known as the Comité Européen de Normalization, or CEN), followed shortly by the African Regional Standards Organization (ARSO).

Already, it can be seen that much use is made of abbreviations in standardization, and therefore readers are referred to Table 1 for some of the most commonly employed standards-related abbreviations.

Abbreviation	**Full name/term**
CEN	Comité Européen de Normalisation
CERCO	Comité Européen des Responsables de la Cartographie Officielle
DCMI	Dublin Core Metadata Initiative
DGIWG	Digital Geographic Information Working Group
DIS	Draft International Standard
EC/EU	European Commission/European Union
ENv	European experimental standards
GML	Geographic Markup Language
IHO	International Hydrographic Organisation
IS	International Standard
ISO	International Organisation for Standardisation
OGC	OpenGIS Consortium
SDI	Spatial Data Infrastructure
SDTS	Spatial Data Transfer Standard
W3C	World Wide Web Consortium
WAP	Wireless Application Protocol
XML	Extensible Markup Language

Table 1. A list of some common abbreviations that apply to the field of standardization (including those applying to spatial data)

2.2. The Aims and Terminology of Standardization

A formal definition of "standardization" can be given as "the process of obtaining and applying a set of rules and agreements with as many potential users as possible, in order to create clarity and unity in areas where diversity is unwanted." Following on from this, the definition of a "standard" is that it is "a documented technical and procedural agreement that is agreed upon by its potential users." Accordingly, the standardization process has several fundamental aims as shown below (with their particular connection to spatial data shown in brackets):

- efficiency (standards lead to improved data sharing due to easier data transfer, thereby avoiding costly and time-consuming duplication of data collection and processing);
- avoidance of information loss (the use of common standards helps minimize the loss of data that usually occurs when transforming data from one system into another);
- portability of applications (often specialized application software will be developed for spatial data, which should be able to be shared by users of different software and hardware platforms);
- ease of learning and increased productivity (shared application software means that other users can benefit from using those applications without having to develop their own software, thus saving time and money);
- quality improvement (standards make it possible to provide clear and well-defined quality concepts); and
- knowledge transfer (standards help clarify aspects of data usage and help different users transferring spatial data from one to another system to better understand the requirements of other users).

Standardization is a general term used for many different aspects and in many different processes, for example in classification, data transfer, and interconnection between systems. Although the words "standardization" and "standards" are used in the English language, in other languages the words "normalization" and "norms" are also commonly used as equivalent terms, although they can describe slightly different concepts. Another terminology issue occurs with the phrases "data transfer" and "data exchange." While the former term implies data going one-way from a sender to a recipient, the latter implies data going both ways between the two parties. Some spatial data users believe these two terms are interchangeable, but this is incorrect, and so for clarity "data exchange" should be instead referred to as a bi-directional transfer.

As for the implementation of standards, in general it is difficult to determine the best time to introduce a new standard. Obviously standards are required whenever users feel they have a need for one, but they can take a number of years to develop and while this work is proceeding the intended user community will often continue with their own research and development to overcome the particular problem posed by the lack of a standard. Then, when the new standard eventually evolves, it can sometimes be considered annoying by experienced users who believe it has come too late to assist them. In addition, new users may not always understand why the standard needed to be developed or applied, and may therefore fail to fully embrace it. Nevertheless, it should be realized that standards can create many new opportunities when seen from a general point of view, and from past experience this is particularly the case in the arena of spatial data standards.

Standardization is applied at three levels and for each level more detailed documentation tends to be developed. These levels are:

- national and international levels, for generic agreements between parties dealing with the same type of data;
- sector level, for agreements between institutions with a specific common field of application and data; and
- institutional levels, where internal processes are aligned through data and procedure definitions. These are commonly referred to as in-house standards.

The subdivision of the standardization process into these three levels becomes important in relation to standardization at a national and international level, especially now that data are becoming available through digital channels for users who want to apply them in different types of environments.

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Wyoming Geographic Information Science Center (2001). Wyoming Natural resources Data Clearinghouse: <http://www.sdvc.uwyo.edu/clearinghouse/>. [An excellent example of a spatial data clearinghouse that provides users with the online ability to browse, view, query, and download free spatial data.]

Biographical Sketches

Henri Aalders graduated from the Delft University of Technology as a geodetic engineer in 1969. Since then, he has worked in photogrammetry in the Survey Department of the Dutch Ministry of Transport, Traffic, and Water Control; at ITC as a lecturer in digital Cartography; and in the Dutch Cadastre as Head of Research and project leader for the development of a Dutch digital cadastre. Since 1998 he has been an associate professor in the Delft University of Technology in GIS technology. In 1995 he was appointed as a part-time professor in the Katholieke Universiteit Leuven in Belgium in the field of Geodesy. Henri Aalders was the designer of the national standard for geographic information in the Netherlands (NEN 1878). He also participated in the development of CEN standards in the 1990s, acting as chairperson for the Working Group on Fundamentals including the overview, conceptual schema language, terminology, and reference model, and was a member of the Working Group on Modeling, developing conceptual models for metadata, geometry, and quality principles. At present, Henri Aalders is a member of the ICA commission on Spatial Data Standards, of the Ravi project group on standardization, and the Dutch commission on standardization of the Netherlands Normalization Institute dealing with ISO standardization. With his present employer being a member of the OpenGIS Consortium, he is also involved in the OGC standardization process.

Gary J. Hunter came to academia in 1988 after 17 years in industry, and his experience includes engineering construction, cadastral and topographic mapping projects in Australia, Indonesia, and Papua New Guinea. In 1990 he was the first lecturer appointed in Geographic Information Systems at the University of Melbourne, and is now an Associate Professor and Reader in the Department of Geomatics. In 1994 he gained his Ph.D. from the University of Melbourne on the subject of managing uncertainty in spatial databases. He is a regional/section editor of *Transactions in GIS* and the *URISA Journal*, and serves on the editorial boards of the *International Journal of Geographical Information Science* and *GeoInformatica*. In 1996 he served as President of the Australasian Urban and Regional Information Systems Association (AURISA), and was appointed a Life Member of AURISA in 1999.