50

National and international data standards

F SALGÉ

The history of standardisation in the GI field extends over 25 years and initially focused on data transfer mechanisms. This chapter demonstrates the importance of standards and how the GI ones relate to those being created in the Information and Communication Technology fields. It draws a distinction between *de jure* and *de facto* standards, describes the main 'actors' involved and summarises the work and achievements of national, professional, and commercial groups thus far in defining one kind or other of these standards. The timetable for likely final definition of standards produced by the different actors is anticipated, along with the interactions between the resulting standards. Finally, it is pointed out that there is something of a hegemony of American commercial interests in the commercial standard-setters, prompting the fear that this may impact on the fairness of information trading in years to come: standards can affect the wealth and economic health of nations, enterprises, and individuals.

1 WHY DO WE NEED STANDARDS?

'I like standards, there are so many to choose from.'

This often-quoted sentence begs the question: what is a standard? Standards can be *de jure* – that is, endorsed by an official standardisation body whether national, such as AFNOR in France, BSI in the United Kingdom, or DIN in Germany; or international such as ISO or CEN in Europe. In French, the word 'normes' is used to qualify *de jure* standards. But standards can also be *de facto* – that is, promoted by their usage either by the industry, such as some IT standards that the market selects as being the unavoidable reference, or by a professional sector at a global or regional level such as the one promoted by NATO for military purposes (STANAG: Standard Agreements). It happens often that *de facto* standards are upgraded to the level of *de jure* standards when there is a general agreement that it is worthwhile. Structured query language (SQL: Worboys, Chapter 26) is an example of such a situation where the International Graphic Exchange Standard (IGES) did not succeed in becoming an ISO standard because of its weaknesses in some areas. Irrespective of whether they come about by the *de jure* or *de facto* route, standards are justified for economic or strategic reasons.

In the field of geographical information, standardisation began more than 25 years ago. First to emerge was the requirement for transferring data from one system to another with a static perspective: Lang (1970) was perhaps the first of many proponents. Later came the requirements for interoperability.

What are today's requirements for standardisation in this field of activity? Understanding how the market, in its wider sense, is organised nationally, regionally, or globally is key to the answer. The geographical area in which the actors operate influences their requirements for standards. For example, international organisations with concerns in Europe such as the European Commission, the United Nations, and the Organisation for Economic Cooperation and Development (OECD) are potential customers of geographical information for their own purposes of simulating, determining, and managing their various policies in agriculture, transport, etc. Their requirements include transnational harmonised datasets, together with efficient updates from data gathered at national or local levels. The requirements of multinational organisations such as retailing companies, the automotive industry, and banking and insurance include geographical information for display and analysis of their in-house statistics on consumers in order to optimise their cost effectiveness. At the other end of the spectrum, local governments and utilities are less concerned with harmonisation of datasets in a wider context than with those pertaining to their local areas, yet they still need interoperability between the heterogeneous information systems owned by the local actors (see Sondheim et al, Chapter 24).

Other market sectors with different requirements may also be added to this list. One of them is the general public market for use of geographical information with personal computers, either professionally or privately. For this mass market, geographical information is just another commodity as with, for example, digital encyclopaedias which include a number of maps describing the world (see Elshaw Thrall and Thrall, Chapter 23). In other applications, the geographical dimension of the information may be used to a greater extent, such as in route-finding and tourism-related services (Waters, Chapter 59). Standards in this area are at the software level at which text processors, spreadsheets, multimedia, Internet products, and suchlike need to communicate with GIS for better integration of various available tools.

University users for education and research are themselves a second specific market. This category refers not only to geography as a discipline but also includes socioeconomic, environmental, and medical uses in which the geographical dimension of information is absolutely critical to integrate different data and models, to develop and assess scenarios, and to formulate policy. Requirements for standards thus encompass spatial analysis tools and modelling techniques (see the various contributions to Section 1(c)).

The requirements for standards vary between different market sectors. It is thus important for all the 'actors' in the geographical information arena to recognise that, at a certain point in time and space, different standards may be required. Various authors have described two concepts for standardisation: the *data-centric* approach and the *process-centric* approach. In the first approach, the standards can be expected to achieve data portability between systems. The concept is epitomised by the work of CEN/TC 287. This approach addresses today's (and yesterday's) most urgent needs. In this approach, conceptual models, data quality, metadata, transfer, query, and update are key items for standardisation.

The general information (GI) market is now considering a newer approach to standardisation, often called process-centric, which arises out of the increased interest in information highways. The GI market will continue to lag unless it also adapts to this trend by adopting open operability standards which support distributed data management ideas. ISO/TC 211 focuses on this approach. Even if the goal of completely open systems for GI is discounted as unrealistic and unattainable in the short term, the process-centric concept must remain the longer-term goal. Nevertheless, this is not even generally apparent as yet because initiatives such as the European and global GI infrastructure proposals (see Rhind, Chapter 56) tend to concentrate on basic data-related priorities for making information more accessible.

Five questions underlie the contents of this chapter:

- Why are the current information communication and technology (ICT) standards insufficient to meet the requirements for standards in the GI field?
- What makes GI special, requiring its own specific standards?
- What are the concepts and elements of the ongoing standardisation efforts?
- What has been achieved and what is already operational?
- What seems likely to happen and why is it important to GIS users?

No unique answer is provided to each question but the various sections that follow give information in such a way that the reader will be able to establish his or her own convictions on the future of GI-related standards.

2 SETTING THE SCENE: THE MAIN ACTORS

Standardisation in the field of GI inherits concepts, models, practices, procedures, and terminology from four main technological streams, as shown in Figure 1. Three of these belong to the general purpose ICT industry. The fourth stream comes from the GI sector practices, and these have necessarily been developed over a long period because the unique features of GI have previously defied the possibilities of general purpose systems.

Among the ICT streams, that from Computer Aided Design (CAD/CAM) provides computer graphics tools such as the Standard for the Exchange of Product Model Data (STEP) which may be useful for the geometric aspects of GI. The Information System (IS) stream is relevant to GI for many reasons, notably because it initiated the study of specific extensions to SQL in order to handle GI from an information system perspective. Finally the electronic data interchange (EDI) stream recognises the requirements for exchanging GI for administrative purposes and thus has studied possible GI messages within the electronic document interchange (EDIFACT) context.

As far as standards are concerned, GI actors first grouped themselves either on a national or a professional basis, as shown in Figure 2. Thus national groups gave birth to national *de jure* standards such as National Transfer Format (NTF) in the UK, EDIGéO in France (see section 3.1). Spatial data transfer Standard (SDTS), in the USA and (Spatial Archive and Interchange Format: SAIF) in Canada. Subsequently, however, professionals organised themselves into international groups, such as the Digital Geographic Information Exchange Standard (DIGEST) for the Ministry of Defence of the NATO countries or the International Hydrographic Organisation (IHO) and created application-oriented international *de facto* standards such as DIGEST or S57. The automotive industry also developed a geographic data file (GDF) as its own European standard.

CEN/TC 287 is the technical committee of the European standardisation committee (Comité Européen de Normalisation) in the field of GI. It predated ISO/TC 211, the technical committee of the international organisation for standards (ISO) in the field of GI–geomatics. When these two international bodies were created, the national standardisation bodies – each backed by its national GI community – became involved, along with the international groupings which acted as observers on the committees. Observer status was also granted to them on other technical committees of CEN and ISO, in order to ensure that ongoing activities on relevant standards were taken into account.

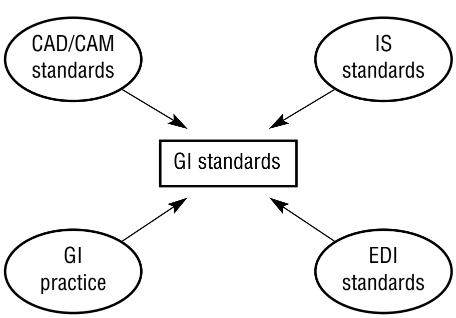

Fig 1. Streams of standardisation.

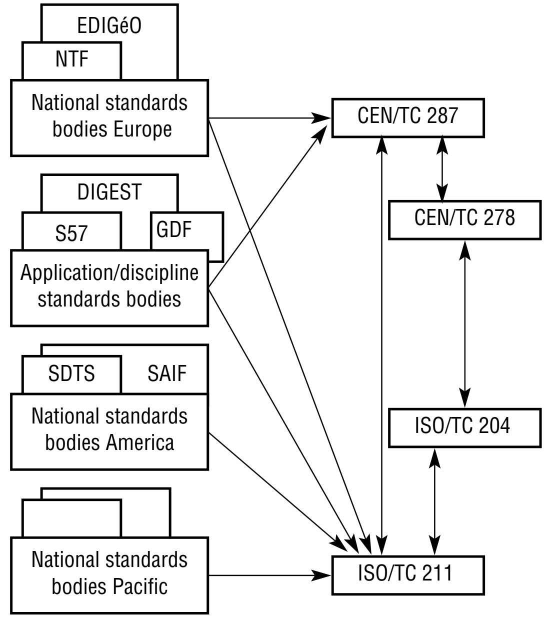

Fig 2. Actors involved in standardisation, some of the standards created to date, and the international standards working parties.

3 GI SECTOR PRACTICES: THE HISTORY OF THE CREATION OF GI STANDARDS

3.1 National efforts

From an historical point of view, the US was first to develop the concept of a national transfer standard. In 1980, the US National Bureau of Standard (later renamed the US National Institute of Standards and Technology or NIST) signed a memorandum of understanding with the US Geological Survey (USGS) which assigned leadership to USGS in developing, defining, and maintaining earth science data elements and their representation standards for use by the US Federal Government agencies (Moellering 1991). After a long gestation period, during which all the actors of the GI domain in the USA gradually became involved, the SDTS achieved official status in 1994 as a Federal Information Processing Standard (FIPS 173–1: Moellering 1994). Use of this standard is mandatory for transfer of data between federal agencies unless both parties agree otherwise. In principle, this therefore necessitates that all GI software used by these agencies must be capable of coping with SDTS.

Backed by routine experience in transferring map data in the UK during the late 1970s (indeed, the first UK transfer standard had been proposed as early as 1969), in 1983 the House of Lords Select Committee on Science and Technology recommended that 'standards for the exchange of digital maps should now be established and consultation to that end should be pressed forward between the British Standard Institution (BSI), the Ordnance Survey (OS), and the other interested bodies' (Rhind 1986). The work took account of the ongoing activities in the other countries, notably that in the USA. In 1986 the first draft was of the National Transfer Format (NFT) prepared for public review. Attaining official status in 1992, the British standard, BS 7567 NTF, also exemplifies the way standardisation was perceived in the mid 1980s (Moellering 1991).

The production of a French exchange standard for digital geographical data began in 1988 under the aegis of the Comité National de l'Information Géographique (CNIG). Strategic constraints were defined, such as the recycling of the 'best' available solution already in use and the quest for the French contribution to become the basis of a European standard to be accepted in 1995 (Moellering 1991: 85–98). Derived from the DIGEST draft available at that time, EDIGéO (processing of digital geographical information: Electronic Data Interchange in the field of GI) was adopted as an experimental official standard (AFNOR: Z13-150) in August 1994 (Moellering and Wortman 1994). More information on other initiatives worldwide is given in Table 1.

3.2 Application-orientated efforts

Experience shows that standardisation through data is carried out foremost by motivated groups of users. The benefits of data-centric approaches are the first to be perceived and can be more directly addressed. In parallel, therefore, with the national initiatives, organisations having common interests in a given application domain grouped themselves at a multi-national level to create *de facto* standards for their

Table 1 A brief overview of national standard. *Source*: Moellering and Wortman 1994

Country	*Name of the standard (derived from)*	*de jure*	*Official status granted*
Australia	Australian Spatial Data Transfer Standard (US-SDTS)		Jan. 1994
Austria	Interface for Digital Exchange of Geographic-Geometric data	✓	ÖNORM A2260 July 1990
Canada	Spatial Archive and Interchange Format	✓	CGSB-171.1-M92 Oct. 1993
Finland	The Finnish Geographical Data Interchange Standards	✓	JHS 116-119 1993
France	Echange de Données Informatisé dans le domaine de l'IG (EDIGéO)	✓	AFNOR Z13-150 Aug. 1992
Germany	Einheitliche Datenbankschnittstelle (EDBS) für die Automatisierte Liegenschaftskarte (ALK) und das Amtliche Topographisch-Kartographische Informationssystem (ATKIS)		Jan. 1993
Hungary	Data interchange standard for cadastral mapping		1989
Israel	Israel Exchange Format		Nov. 1992
Japan	Standard Procedure and Data Format for Digital Mapping		March 1988
Netherlands	Interchange format for data of object related to the Earth's surface	✓	NEN-1878 1994
Norway	Coordinated Approach to Spatial Information	✓	ISBN 82-90408-72 Aug. 1993
Russia	Digital and Electronic Maps Transfer Standards		
South Africa	Standard for the Exchange of Digital Georeferenced Information		April 1993
Spain	Norma de Intercambio de Cartografia Catastral		Jan. 1991
Switzerland	INTERLIS, data exchange mechanism for LIS		June 1992
UK	Electronic Transfer of Geographic Information	✓	BS 7567 1992
USA	Spatial Data Transfer Standard	✓	FIPS 173-1 June 1994

respective disciplines. This is exemplified by the military field (but see Swann, Chapter 63), the hydrographic field (nautical charts), and the automotive industry.

The DGIWG was formed in 1983 in response to the growing demands for geographical defence data. DGIWG consists of representatives of several NATO countries but is not itself a NATO body. Although originally created to meet defence needs, the DGIWG has been greatly influenced by civilian efforts since its foundation, because many defence-mapping agencies rely on data gathered by the National Mapping Agencies (Moellering 1991: 223–33). Its DIGEST is a family of standards. It is designed to establish a uniform method for the exchange of digital geographical information based upon a common logical organisation for any geographical dataset. Consequently, DIGEST not only provides clear definitions of data models, data organisation, and data structure but also includes sections on data quality, feature coding, recording standards, and the necessary supporting information (Moellering and Wortman 1994: 95). Work was carried out to make DIGEST a profile (or subset) of SDTS.

The IHO has long experience of information exchange. Since the early 1920s, IHO has been setting standards for nautical charts in order to provide a uniform mapping of seas in the world. The introduction of computer-based on-board navigation systems demanded standards. The IHO transfer standard for digital hydrographic data (DX-90/S57) is intended for the exchange of data between National Hydrographic Offices and for its distribution to manufacturers, mariners, and other data users including uses for ECDIS (electronic chart display) purposes. It contains a catalogue of descriptions of features and the coding schema to be used, the description of the actual data format, and the description of the conventions to be observed when converting analogue source data into machine-readable form (Moellering and Wortman 1994: 83). Work is now going on to harmonise S57 with DIGEST.

The development of GDF has largely been funded by the European Union within its research and development framework programme for the improvement of the transport system in Europe and the consequential reduction of transport pressures on the environment and on society. It is of relevance to all professionals and organisations involved in the creation, supply, update, and use of locationally-referenced, structured road network data derived from large and medium scale mapping sources (Moellering and Wortman 1994: 96). The work in this area started in the late 1980s and the GDF standard was largely derived from earlier versions of NTF. In later versions, harmonisation with the principles underlying DIGEST was achieved.

Figure 3 indicates how national and application-oriented efforts have influenced each other. It is noticeable that the national transfer standards have been aimed at providing general purpose exchange mechanisms, whilst application-oriented standards have complemented this work through the creation of catalogues of objects, attributes, and relationships.

At a multi-national level the existence of DIGEST, DX–90/S57 and GDF as *de facto* standards ensures that ongoing *de jure* activities must take them into account. If they do not, standards will eventually diverge and application-specific standards will not be compatible with generic ones. This would make the reuse of application-dependent data more difficult. How can the strategic interest of consistency across domains be met if the characteristics of application domains are ignored?

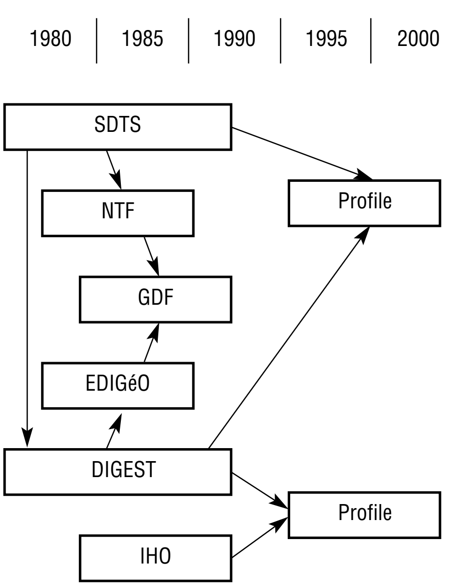

Fig 3. Some national and international application-orientated initiatives.

3.3 Multi-national standardisation efforts

The natural forum for discussing *de jure* standards in Europe is the European committee for standards, the Comité Européen de Normalisation. This is an association of the official national standardisation bodies of European countries. Initially composed of European Union and European Free Trade Association countries, it is progressively expanding its remit to include Eastern and Central European countries. CEN Standards, called EN (for European Standards in German), replace national standards when formally adopted. Therefore the work undertaken at CEN level supersedes national works, although the use of European or national standards is not mandatory in many cases (Brand et al 1993).

In October 1991, CEN officially created CEN/TC 287, a working party responsible for standards in the field of geographical information. This developed a structured set of standards specifying a methodology to define, describe, and transfer representations of the real world. Members of CEN/TC 287 are delegates from 22 countries and observers from DGIWG, Comité Européen des Responsables de la Cartographie Officielle (CERCO), and IHO. From the beginning there has been a consensus to follow a general approach taking account of national efforts and benefiting from existing results such as SQL, IRDS, or the STEP family of standards.

ISO is composed of the national standardisation bodies from almost all the countries of the world. Unlike the situation in CEN, ISO standards may be made national according to decisions taken at a national level. An IS does not bear the same level of constraints upon national bodies from Europe as does an EN. ISO/TC 211, geographic information – geomatics, was established in November 1994 with a wider scope than CEN/TC 287:

'the work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analysing, accessing, presenting, and transferring such data in digital/electronic form between different users, systems and locations.'

Members of ISO/TC 211 come from 24 countries (including ten CEN members) and observers from 12 (including six CEN members). CEN/TC 287 has a specific cooperation agreement and liaisons are established with international organisations, including DGIWG, IHO, International Cartographic Association (ICA), and International Society for Photogrammetry and Remote Sensing (ISPRS). Internal liaison with ISO technical committees is also organised, allowing the relevant stream of ICT standardisation to be brought to the attention of ISO/TC 211.

Another CEN committee termed CEN/TC 278 is concerned with standardisation in the field of road transport and traffic telematics. It identified several work area including digital road maps and databases. CEN/TC 278 is the standardisation body in which GDF was adopted as an ENV (ENV 14825). Similarly, ISO/TC 204 also addresses geographical standards in this area and GDF is considered to be a draft international standard (DIS) seeking for approval in the ISO environment. Fortunately, relationships exist between these technical committees of CEN and ISO.

3.4 The *de facto* newcomers

The Open GIS Consortium, Inc. is a non-profit trade association founded in 1994 including industrial and public sector members, largely originating from the USA. It is dedicated to the promotion of new technical and commercial approaches to interoperable geoprocessing. One of many consortia and fora created by the industry it may eventually create *de facto* standards. The Open GIS Consortium was created 'in response to the recognition of the problem of non-interoperability and its many negative ramifications for industry, government and academia' (Buehler and McKee 1996:12). (See also Sondheim et al, Chapter 24.)

Open GIS Consortium members share a vision of a national and global infrastructure in which geodata and geoprocessing resources move freely and are fully integrated with the latest distributed computing technologies. This may allow everyone to undertake geoprocessing without the need for lengthy education and training (see Forer and Unwin, Chapter 54). The Open GIS Consortium members see all aspects of geographical information technologies as entering an era of closer integration never previously achieved. The Open Geodata Interoperability Specifications (OGIS) are claimed to be sufficiently abstract to be implementable in various distributed computing platforms such as the Common Object Request Broker Architecture (CORBA), or the Object Linking and Embedding/Common Object Model (OLE/COM).

OGIS is a comprehensive set of specifications of a software framework for distributed access to geodata and geoprocessing resources. It will have three parts: an Open Geodata Model (OGM) as a common means of digitally representing the Earth and related phenomena; an OGIS services model (OSM) as a common specification model for implementing services for geodata access, management, manipulation, representation and sharing between information communities; and an Information Communities Model as a framework for using the OGM and the OSM to solve not only the technical non-interoperability problem but also their institutional counterparts.

The Open GIS Consortium has a liaison status to ISO/TC 211 and several members of their Working Groups participate in the relevant ISO working groups. OGIS's strategy is clearly stated thus (Buehler and McKee 1996: 13):

'Prior to OGIS becoming a *de jure* standard, vendors and OGIS participants will have implemented it widely in commercial software products, commercial integration projects, government data centres, and academic research settings, making OGIS a *de facto* standard for interoperable geoprocessing. Because it addresses geoprocessing transactions and geodata sharing in a comprehensive and basic fashion, it is likely that OGIS will be the basis for interoperable geoprocessing for a very long time into the future.'

4 INFORMATION TECHNOLOGY STANDARDS AND THEIR APPLICABILITY TO GEOGRAPHICAL INFORMATION

Information technology is currently reshaping itself as new technology brings possibilities hitherto unimagined (see Batty, Chapter 21). We are used to considering CAD/CAM, ISs, and EDI as parts of the computer sciences with little in common. However, with the advent of multimedia, Internet, and PC technology, these divisions begin to blur. The advent of the information society will generate a major modification of future standards. The following sections briefly review some ICT standards relevant to the GI community.

4.1 Standards arising from computer science

CAD/CAM-oriented standards have often been seen as inapplicable to geographical information whose characteristics are such that they have often been too challenging for standards designed for much simpler geometric data. For example, there is no integrated vehicle for the transfer of graphics and non-graphic-related attributes in the CAD/CAM world. Current graphic standards development focuses on image data. Nonetheless recent work in ISO has led to STEP (IS 10303). Some ten years' effort has led to creation of an international standard for the computer-interpretable representation and exchange of product data. The objective has been to provide a neutral mechanism capable of describing product data throughout the life-cycle of a manufactured product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

IS 10303 (ISO 1993) includes several parts. Two of them – Part 11 'Description methods: the EXPRESS language reference manual' and Part 42 'Integrated generic resources: geometric and topological representation' – may be useful to the geographical information community. After evaluation of existing description languages, EXPRESS was selected by CEN/TC 287 as the description method used in all of its proposed standards. However there has been no deep evaluation of the other parts of STEP for its applicability of geographical information.

In a different information technology development, the joint technical committee, ISO/IEC (International Electrotechnical Commission) JTC1 has prepared an extension to the draft international standard SQL. The purpose of this extension is to define multimedia and application-specific objects and their associated methods using object-oriented features. Its Part 3 deals with spatial information and provides some concepts of topological operators and abstract data types for the spatio-temporal data used in spatial databases. The proposed standard provides a limited view of geographical information and, although it is comprehensive in listing all data types that may be encountered in spatial databases, it lacks a conceptual model providing flexibility and extensibility. In general, the authors seem to have underestimated the complexity of geographical information.

More generally, ICT standardisation is an area in which the geographical information community has not yet become deeply involved. Yet many emerging standards increasingly include issues related to geographical information in their agenda. So far, little information exists on substantive investigations into their appropriateness to geographical information.

4.2 Global Information Infrastructure: a new family?

Discussions about the information society have increased over the past few years, and have often been formulated in terms of a second industrial revolution. This debate has received added impetus from US Vice-President Al Gore, the G7 Group, Jacques Delor's White Paper on 'Croissance, Compétitivité et Emploi', the Bangemann report, and the European Commission itself. This has resulted in the translation of words into action to create what is widely recognised as the Global Information Society or 'GIS' (abbreviated to GISo here for obvious reasons!) This GISo is more than just the latest fashionable acronym. Rather, it provides a focal point for society's exploitation of new developments in the ICT industries and a source of political support.

A distinction is made between the two terms Global Information Society (GISo) and the Global Information Infrastructure (GII). An article in the October 1995 issue of the ISO bulletin defined the GII by saying that it 'provides the vital services and capabilities required for the information society to prosper'. Another definition often used is that the GII is the enabler for achieving the objective of the GISo.

Standardisation has a specific role to play in achieving the potential of the GISo and its supporting GII. Standardisation bodies are already responsible for providing the standards in key IT application areas which have been identified as necessary for the realisation of the GISo. Other partners have equal concerns for areas such as telecommunications infrastructure and applications, digital video and broadcasting, and multimedia content provision.

Standardisation bodies identify their responsibility as being towards sector-specific applications, and these in turn may be separated into two groups: intersectoral (i.e. involving definition of 'intermediate' tools such as smart cards, character sets, and bar coding); and sectoral (i.e. the application of ICT by specific industrial sectors such as road transport, health care or geographical information).

Will this concern bring new *de jure* standards that will need to be taken into account, or will it define new ways of assembling existing standards?

4.3 The *de jure/de facto* dilemma

Information technology has evolved from stand-alone or closed systems to mass-market products. The ability of products from different manufacturers to work with others (interoperability) is important in the deployment of many ICT products and services. Standardisation is generally a voluntary process and reflects the dynamics of the market. For products with short life-cycles which provide immediate economic profits, the market will tend to adopt technical specifications through the framework of consortia or will use *de facto* standards. In other cases, the market may prefer to adopt formal standards, for instance where large scale investment is required. Since ICT product cycle times are already short and are becoming shorter, standards adopted following traditional procedures often prove inappropriate because of the lengthy procedures involved in their elaboration. Both the scope and procedures of formal standardisation are therefore currently under review.

Major questions related to standardisation must be addressed. Will the necessary standards be available either as *de jure* or *de facto*? Will they encourage fragmentation or help convergence of markets? Will they be used to confirm or create dominant positions of *de facto* monopolies in ICT? How is it possible through standardisation to enable citizens and enterprises to take full advantage of the possibilities offered by the GISo? How will the formal procedure of the *de jure* standardisation be flexible enough to allow for competition to be as open as possible?

In 1995 standardisation bodies in the ICT field started a process of fundamental reassessment of the aims and methodologies of standardisation. CEN had already anticipated much of the philosophy underlying this reassessment since its technical board had started to apply management principles to the TCs. Proper justification of new work items in line with market requirements and regular standard reporting formats were developed to increase the efficiency and responsiveness of the ICT standards.

In November 1994, at a workshop organised by the European Commission to look on ICT standardisation policy, it was clear that the standardisation process needed to have more direct links with interested parties, that it should be more accountable to ensure that the market had the standards needed when they were required, and that scarce resources were not wasted on standards that were not required. In order to achieve this, a number of models have been proposed and are still under discussion. These include a model where a consortium or forum would develop *de facto* standards then ask for *de jure* recognition when stabilisation by the market is achieved. This leads to the concept of the Publicly Available Specification (PAS) that should be granted official status whenever required. PAS means free accessibility to all concerned, i.e. not limited to consortium members only. Each of the models involves an increased direct participation of the interested parties or stakeholders at every level of the process. Crucially, the justification and the strategy of the standards projects has to be defined at the outset in such a way that it is possible to identify the best delivery mechanisms.

The measure of success for a standard can be established on three levels: the availability of systems which conform to its specification, the degree to which a standard is regularly employed in commercial applications, and the establishment of a common perceptual framework for further activities (e.g. the concept of programmer portability as well as actual information interchange). Key factors for ensuring a standard's success include: its formal specification; availability of rigorous conformance tests; previous agreement amongst users on the need for a standard in a particular application domain; possibilities for increased openness and the prospect of market advantage to product developers; and existence of application profiles for particular market sectors.

It is now evident to all that the process of standards development needs to be accelerated in order to catch and improve incipient *de facto* standards. However, taken to its logical conclusion, this results in a paradoxical situation since it implies recognition that current practice is no longer timely yet anticipates that predicting future practice is error prone.

Because of ambiguities in the drafting of standards, people not directly involved with their development may interpret them differently. As standards become more complex, so the danger of misinterpretation becomes greater. There is thus a need for harmonisation of data modelling languages such as EXPRESS. However, it is recognised that formal methods often lead to impenetrable documents requiring specialist interpretation. Formal methods must be accessible to the widest possible user group.

Finally, better dissemination of information is a contributory factor to the development of successful standards. In particular, communication between standards bodies, software vendors, data providers, and end-users must improve. Increased collaboration might include the formation of user interest groups, subsidised attendance at standards meetings, and greater publicity about the work of the standards developers which emphasises their relevance to commercial success.

5 SETTING A VISION

5.1 Towards a definition of requirements for GI standards

Interoperability in the geographical information field can be viewed from diverse perspectives. On the one hand, the degree of interconnectivity needs to be addressed: this ranges from stand-alone systems (which are still viewed as such in certain circumstances), to systems embedded in the global network (specifically the Internet), via the intermediate situation of Intranets, i.e. networks set up internally within enterprises. The levels in the software 'layer' in which interoperability is considered add another perspective: the system viewpoint (i.e. the application as opposed to the operating system and environment), the application view (i.e. the professional field), the production line view (i.e. the scheduling of treatment of data or spatial analysis tools), and finally the data view. These four viewpoints, together with the three degrees of interconnectivity, create different requirements for interoperability.

Local, transnational, pan-European, and global interoperability of GIS is an oft-quoted requirement. But what do such statements really mean? As an example, interoperability at a local level may imply the ability for GIS operated by different organisations to share the same territory for their activities, allowing information to be shared in order to ensure the necessary level of coordination. At the other end of the spectrum, global interoperability may imply the ability to surf the Web in order to identify the data which exist, to search the conditions of use, and eventually to get the data into the local system for immediate use.

From a data perspective, interoperability – as a key issue for the future – serves several objectives. These are reusability of GI in different applications (both in a system viewpoint and as a discipline), combining GI from various sources to obtain added value, merging GI from various countries (although this requirement is presently marginal), and as a means of increasing the interest of international institutions.

5.2 A vision of the GI future

Can we forecast the GI market organising itself as a virtual geographical database from which every user will be able to acquire the information he or she requires, when it is needed, in a suitable format, and in a 'liberal context' (i.e. without political restrictions)? In the future, will a virtual networked GIS exist which enables users to access functions in a distributed environment, i.e. permitting the reuse of methods and tools for spatial analysis? This implies a growth of the GI market driven by economic forces enabling investors in systems, data, or services to make reasonable profits and users to answer their spatially-oriented concerns at sensible costs. In that vision of the future and from a standardisation point of view, the appropriate level of standards should enable the move of geographical information, data, and related processes from A to B. This is the basic concept of open GIS.

Such a vision requires the availability of services which enable geographical information and data to be:

- described;
- searched;
- queried;
- evaluated;
- ordered;
- accessed;
- paid for;
- updated;
- transformed;
- processed.

Similarly, such a vision requires the availability of geographical information and data which enable systems to provide the basic GIS functions:

- acquisition;
- handling;
- spatial analysis;
- presentation.

Because geographical information must be seen as part of general information, strategic geographical templates must be available to enable georeferencing and provide appropriate geographical identifiers – serving as 'hooks' for other 'potentially located data' – to be effectively linked to coordinates for spatial analysis. This would permit the future of GIS to be based on the linkage and the sharing of information/data and processes.

6 SETTING THE REQUIREMENTS FOR STANDARDS IN THE GI FIELD

6.1 The concept of a reference model

A reference model is a framework defining the important concepts, views, layers, components, and their relationships. Its purpose is to explain and provide a unified generic vision, key ideas, and scope of what is considered to be of mutual interest. In the standards arena, a reference model is often used as a broad 'map' on which more specific standards or missing standards can be positioned and compared. Reference models may be descriptive or prescriptive. They may serve different purposes, ranging from a very abstract view of the problem area to a rather exact specification of different components and their relationships. For example, the CEN/TC 287 reference model describes and clarifies the field of GI, relationships and differences between GI and aspatial information, and identifies and defines components which can be standardised and the interfaces and relationships between components. It provides a safeguard against duplication of effort and thus avoids the creation of new standards where others already exist or are under consideration. And it makes possible new components being adopted as new standards and technology develop.

Reference models, then, serve as a foundation for the development of standards in a given field. CEN/TC 287 and ISO/TC 211 developed slightly different models because the requirements of CEN are data-oriented as Europe is confronted with the problem of exchanging data between partners. Those in ISO are technology-oriented, focusing on integration of information and geoprocessing.

However, putting aside the accidents of history, is there really only one reference model which can be applicable to all environments – for CEN, ISO, OGIS, and for application domains (general public or professional, thematic dependant)? Or should we consider a series of compatible reference models with each targeting a specific market segment?

6.2 Core standards, domain-specific standards, and standards for strategic data

Core standards, or generic standards, should be *de jure* and should aim at providing generic concepts which can be used regardless of the discipline, market segment, or geographical area. Domain-specific standards (profiles) should be drawn where vested interests exist for specific disciplines, market segments, or groups of countries. Standards for strategic data should be defined and made available to allow operational GIS to incorporate them and the users to concentrate on their actual field of expertise (see Figure 4). In this sense, strategic data are those which are common to many applications, notably the so-called framework or core data (Estes and Loveland, Chapter 48; Smith and Rhind, Chapter 47). Some people consider that the provision of strategic geographical data is part of the universal service that governments should provide for their own citizens. These data may even be considered as a sign of sovereignty and their provision at present is often the exclusive role of public institutions. However, such data can also be viewed as profit-making and

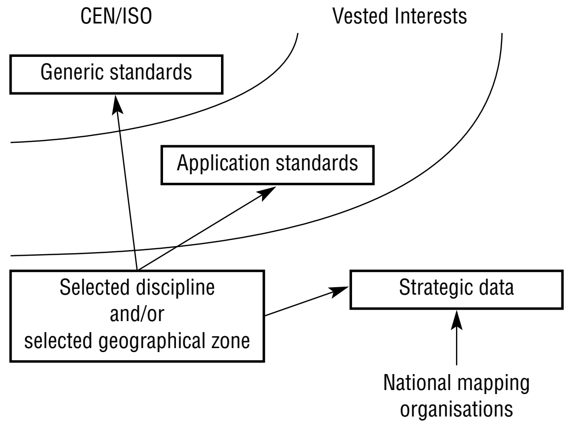

Fig 4. The emergence of standards and their application.

they can create business opportunities for the private sector. Regardless of the type of producer, standards for strategic data should be created to which domain-specific data can be registered.

Generic standards are system-independent and provide a platform on which applications or disciplines may develop their own profiles. Figure 5 provides an extended view of the relationships between generic and application standards, and identifies the essential components. The reference model as previously defined answers

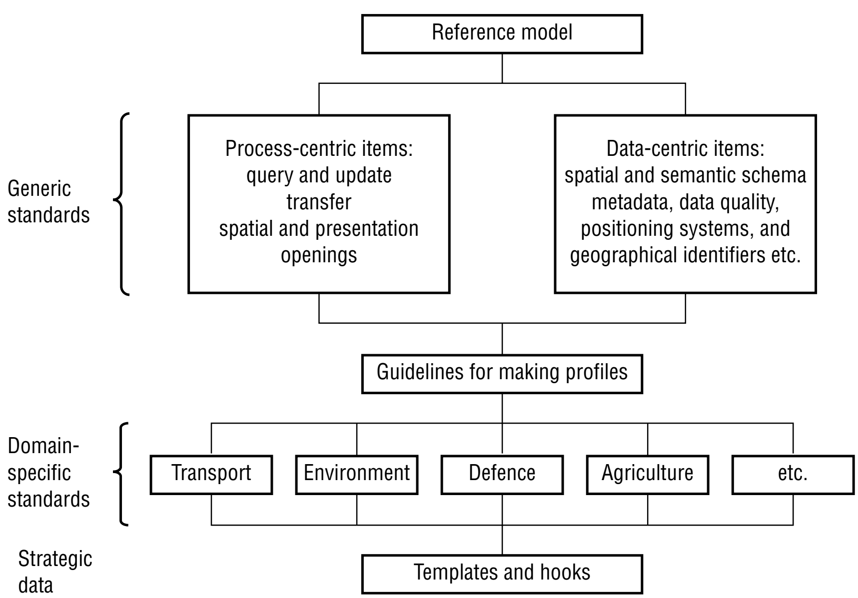

Fig 5. An extended view of generic application standards.

the question ‘what are the items to be standardised?’ The core standards are the ones commonly identified (semantic and spatial conceptual schema, metadata, data quality, positioning systems, geographical identifiers for the data side, query and update, transfer, spatial and presentation operators for the process side). They answer the question ‘how are the items to be standardised turned into standards?’ Core standards are versatile. This flexibility allows them to suit virtually any application. Groups of users may, however, prefer to define profiles where only specific options are possible. That will enable the core standards to be more efficient. Nonetheless, guidelines for using the core standards are required in order to ensure a minimum of interoperability between groups of users; this answers the question ‘how should we use the family of standards?’

7 WHAT IS OPERATIONAL AND WHAT WILL HAPPEN?

Today, as described above, many countries and several multinational disciplines have defined transfer standards for geographical information and many software vendors provide tools enabling import and export of data consistent with common transfer standards. In each country, considerable effort has been made to facilitate the effective adoption of national standards; this has included many awareness-raising meetings, training sessions, and the provision of basic tools. Certification is the key to raising confidence in the interface provided by the vendors and in the data delivered by the providers. ICT interoperability standards already exist although very few GIS implement them. The link between ICT standards and geographical information, therefore, still needs to be made operational.

European standards are being adopted at least as experimental standards (ENV). At the time of writing, the Reference Model (ENV 12009, 1997) and the spatial sub-schema (ENV 12160) have successfully completed the formal vote procedure. Six other standards – for data quality (prEN 12656), metadata (prEN 12657), transfer (prEN 12658), position (prEN 12662), geographical identifiers (prEN 12661), and query-and-update (prEN 12660) – completed a six-month formal review in summer 1997 (the CEN enquiry) with possible adoption by early 1998. If all proceeds to this timetable, it will have taken four and a half years to adopt these European standards. From the formal adoption of the standards to their use by the industry, months are required. As far as the European standards are concerned, it will be up to the ‘umbrella organisations’ for geographical information, not only in each country but also at the European level (EUROGI 1994) in order to foster the use of the standards.

International standards are also on their way. Among the items identified in the ISO/TC211 work programme, several had reached the status of a working group draft by the end of 1996. Those whose scope overlaps the CEN/TC 287 work are largely based on the European efforts. If the latter suit the requirements of the international community, ISO standards will upgrade the ENs. The ISO/TC211 timetable will be respected and international standards in the field of GI will be adopted by 1998. Publication and implementation is scheduled for 1999. However, if substantial modifications are necessary, it is likely that more time will be required. In such circumstances, the new strict ISO internal regulation which stipulates that no more than three and a half years must be spent on the creation of an IS may ensure that no international *de jure* standard will be defined for geographical information. A variety of intermediate scenarios is obviously possible.

Meanwhile, the Open GIS Consortium may be successful in bringing the GIS vendors together. Their timetable is quite impressive. They forecast the creation of internal specifications and test-beds to be finalised by the end of 1996 and a first version of the specification set to be made available by mid 1997. Second and third iterations were planned for later in 1997, leading to availability of a third version of the final specification by mid 1998. *De facto* interoperability standards may then be available and used in the main GIS.

The information society will provide new ways for the information market to develop and appropriate standards will enable information highways to be interoperable in an effective manner. The timetable for development of the GISo is not yet clarified but the high level political support makes it likely that the interoperability landscape will have changed considerably by the beginning of the 21st century.

8 CONCLUSIONS: GI STANDARDS AND THE THREAT TO NATIONAL WELL-BEING

Thus far, standards have been treated as technical necessities. But there is also a wider view of them which relates to international and national wealth.

Managers consider standards as an economic weapon. If this is so, international standards are the key to allow the global market to be more open. Despite this, private sector bodies have typically been reluctant to make significant investments in standards unless there is a clear and short-term strategic benefit. It has hitherto been left to national governments and regional bodies such as the European Commission to invest in standards because they see long-term benefits from encouraging standards to emerge. This is particularly relevant in the geographical information domain where public sector organisations are dominant. But the main market sector is formed by local governments for whom investing in the standardisation process is a non-core function. National mapping and cadastre agencies (NMCA) are therefore key for GI standards development and are largely involved in the process, often taking a leading role. NMCAs are, nonetheless, only part of the data-providing community as – in most cases – they deal only with map data. It is now agreed that GI is not limited to map data and encompasses any information which can be related to the Earth.

The realities of funding and public sector rules conspire to make difficult public and private sector partnerships in standards development. NMCA and most similar bodies are, because of their public sector origin, able to justify their involvement in the *de jure* standardisation process but can hardly join, at least in Europe, private sector-driven consortia. Software vendors, together with the consultancy industry, need to be involved in the standardisation process. In the ICT sector, they have often considered the *de jure* standardisation process too expensive and prefer the consortium route to standards.

Despite these complications, it is essential that the private and public sectors cooperate in standardisation within the geographical information sector. As the ICT requires rapid standard-making, the only possible way is through publicly available specifications. Therefore consortia must allow their standards to be as open as possible and ensure that their processes take into account the requirements of and constraints on the public sector as much as possible. The interoperability consortia operating at present originate from, and are based in, the USA, although there have been some attempts to secure 'legitimisation' from non-US bodies.

If these consortia are to succeed in developing the *de facto* standards they are considering and if public sector interests and those of other countries in the world are not taken into account in the process, will national industries survive or will only one country come to dominate the world geographical information market? Will the GI sector experience the same unbalanced competition as in the movies market? Will GI of foreign origin invade each national market (see Estes and Loveland, Chapter 48, for a discussion with respect to remote sensing data management)? Will there be a renunciation of sovereignty for countries unable to master and protect the production of knowledge over their own territory?

Which 'cars' will circulate on the information highways? The European Commission foresees a threat where the traffic will largely comprise non-European 'cars'. Its INFO 2000 programme, with an emphasis on the development of information content (and its specific geographical information component), exemplifies this concern. Two major questions remain: will geographical datasets be widely available so that geographical 'fuel' will allow 'GIS cars' to operate on the information highways? and will European information manufacturers have their fair share of the geographical information market? Answers to these questions are partly about standards. It is essential that the standards which are defined and used lead to the creation of a GI market which protects the investments, including data resources, of the actors and enable an economy to develop in a fair global environment.

References

Brand M, Burrough P, Salgé F, Schüller K 1993 *Report of the committee for investigating the feasibility of creating a European Umbrella Organisation for Geographic Information – Phase II. Proposals for setting up EUROGI*. Luxembourg, Commission of the European Communities DG XIII-E2 (Information Technology)

Buehler K, McKee L 1996 *The OpenGIS guide: introduction to interoperable geoprocessing – part 1 of the Open Geodata Interoperability Specification (OGIS)*. OGIS TC Document 96–001

ENV 12009 1997 *Geographic information – reference model*. Paris, AFNOR (French Standardisation Organisation)

ENV 12160 1997 *Geographic Information – spatial schema*. Paris, AFNOR

EUROGI 1994 EUROGI's work programme for standardisation; paper presented at the first General Assembly of EUROGI

GI2000 1996 *Towards a European policy framework for geographic information*. Luxembourg, European Commission – DG XIII

ISO 1993 *Industrial automation systems – product data representation and exchange STEP*. Draft International Standard ISO/DIS 10303

Lang T 1970 *Computer programs for mapping*. London, Architectural Press

Masser I, Morais Arnaud A, Salgé F, Scholten H 1993 to 1996 *GISDATA Research Programme – newsletter numbers 1 to 4*. Strasbourg, European Science Foundation

Moellering H (ed.) 1991a *Spatial database transfer standards: current international status*. Oxford and New York, Elsevier Science on behalf of the International Cartographic Association: 191–215

Moellering H 1996 *Spatial database transfer standards 2: characteristics for assessing standards for the transfer of spatial data and full descriptions of the national and international standards in the world*. Oxford, Elsevier Science on behalf of the International Cartographic Association: 80

Moellering H, Wortman K 1994 *Technical characteristics for assessing standards for the transfer of spatial data and brief international descriptions*. ICA technical report

Rhind D W 1996b Remote sensing, digital mapping, and geographical information systems: the creation of national policy in the United Kingdom. *Environment and Planning C: Government and Policy* 4: 91–102

Salgé F 1994 Geographic information: the challenge for Europe. In Shand P J, Ireland P J (eds) *The 1994 European GIS Yearbook*. London, Blenheim

Salgé F 1996a *From an understanding of the European GI economic activity to the reality of a European dataset*. GISDATA specialist meeting, Buoux, May

Salgé F 1996 Spatial data handling keynote address: twelve years' impact of spatial data handling research on the GIS community. *Proceedings, Spatial Data Handling*