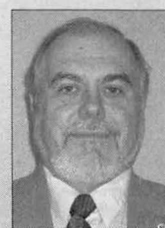

Hydrographic Data Standards and Standards-based Geospatial Data Infrastructures

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The global leadership shown by the International Hydrographic Organization (IHO) in leading the development and implementation of international standards for the paper navigational chart has been successfully carried over into the digital domain. This has been demonstrated by the acceptance and use of the S57 and S52 data standards for Electronic Navigational Charts (ENCs). The IHO has also been careful to ensure that S57 and S52 retain upward compatibility with other emerging international standards for geospatial data. The first part of the paper reviews the position and status of S57 in relation to this new standards environment. The second part of the paper considers the influence of the Internet which is having a major influence on the emerging geospatial data infrastructures that are being built in a number of countries and impacting the distribution and use of geospatial data, and will also provide opportunities for, and have an effect on the provision of data by hydrographic offices.

Introduction

The IHO's S57 data transfer standard was developed under the leadership of the international hydrographic community. This community long ago realized the importance of standardized information, and founded the IHO with a primary goal being the development of nautical chart standards, particularly with respect to the content and the presentation of the information on nautical charts. Although standardisation of the paper chart was a lengthy, difficult, and costly task, the motivation to increase the safety of marine navigation was very strong and the task was accomplished and benefited all those associated with the marine world. However, by the time the standards for the paper chart had stabilised, the hydrographic community was already studying the potential benefits of computers and digital products, and by the time the electronic chart had been successfully demonstrated the IHO had embarked on another round of standards development.

In 1982 the Canadian and US Charting Agencies met to develop a draft standard for the exchange of hydrographic data, but before that this task could be completed the participation was broadened to include more than a dozen countries that refocused upon developing a consensual specification for a data transfer standard for electronic chart products. This resulted in the S57 standard, the first version of which was available in 1992. Initially this standard was intended for the exchange of chart information between hydrographic offices, but over time the standard was enhanced to support the definition of an electronic chart product. S-57 Version 3.0 containing an ENC product specification, was formally approved in 1996 and has led to the commitment by a number of hydrographic offices to implement the infrastructure for providing digital navigational products; a trend that will accelerate.

The initial work on the S-57 exchange standard was based on the exchange of data files. Since the IHO developed S57 and the related presentations standard - S52, the world has seen a dramatic growth in the use of the Internet. The Internet forces users to implement a certain level of data standardisation and is providing a foundation for the development of a number of national infrastructures for not only finding, accessing, displaying and distributing geospatial data through the Web but also to provide the capabilities to quickly integrate data from multiple sources. These activities are also providing the foundations for national and international data infrastructures that are expected to affect the IHO collectively, and member states individually, and it is in this context that this paper describes the emergence of standards-based geospatial infrastructures.

Evolution of Geospatial Standards

Geospatial data is a valuable commodity, and as such there are major markets for it, but the market can only survive if the geospatial data can be found and used by the recipient. To be usable, it has to be compatible. Incompatibility can result from market forces that lock users to particular manufacturers' systems, or information community systems and can be a barrier to the sharing of information outside that community.

Computer and information technology was first applied to assist in cartography, hydrography, and other geographically related application areas over 20 years ago. At first individual organisations developed their own unique computer based systems to assist them in their existing procedures, primarily the production of paper maps and charts. Standards were narrowly defined by each organisation for its own use. For example the Canadian Hydrographic Service developed its own NTX standard that served its own needs but differed from that of other organisations.

Over time the commonality between the tasks being performed in different organisations was recognised and manufacturers developed systems that were flexible to satisfy many organisations different needs, since the same equipment could be used for many purposes or by many businesses. But different manufacturers were still often incompatible. Organisations also developed standards that addressed their own 'Information Community' but required unique implementations. For example, IHO S-57, a standard limited in scope and implementation which also provides important compatibility for data sharing in the hydrographic information community, and which has spawned the ENC, a worldwide standard.

There is no shortage of standards. Many agencies and companies have developed their own proprietary standards. Some are in wide use, whereas others have very narrow applicability.
Standards limited to particular application domains are actually barriers rather than aids in fostering interchange. They create 'islands of incompatibility'.

Application area-specific standards create an isolationism, which discourages the reuse of data and in some ways the success of narrowly focused standards hinders broader standardisation.
The compatibility that exists within a user community is a market barrier for other systems. Fortunately some manufacturers have developed tools that can convert between hundreds of the different formats currently in use, either on one computer or through a Web-based service.

Up until recently there has been no common perception of exactly what standards are needed. Data producers, application developers, manufacturers, database suppliers, operators and users have seen standards in different ways. However, due to the widespread acceptance of the Web for searching and accessing information, the requirements for the standards to support geospatial applications are now much clearer and very important progress has been made.

Users need data to apply within their application area, but they also want to be able to utilise different data sources, available from other application areas. They also want common tools for integrating, viewing and using this data. This calls for a *separation of the information content* specific to an application area such as hydrographic charting, *from the Information Technology (IT) standards and general geographic information standards used to support it.*

As the field of geographic information matures, broader and more generic standards are emerging. Application areas that once were isolated will become part of the national and international data infrastructures. The principle advantage is the reduction of cost for production equipment and the increase in the number of potential users of the data. The natural order of evolution with respect to standards is to develop standards for particular application areas and then to gradually evolve into broader and more comprehensive standards. This evolutionary path is not always smooth and it can be very difficult to retain backward compatibility with existing and legacy systems.

The navigation of ships is a very special application area that is somewhat out of the mainstream of Geographic Information Systems (GIS). This has been both an advantage and a disadvantage. The advantage of relative isolation from other geographic information standards has been that a well controlled, highly functional data product exchange specification has been developed, well focused on the needs of hydrography and the support of ship navigation. The disadvantage has been the barriers to implementation that have added both costs and delays to implementing S-57 based systems. These barriers still exist today.

S-57 and S-52 satisfy the technical requirements for ECDIS. However, a limited number of implementations and production tools, and a disincentive to pay higher costs to produce S-57 compatible data have been constraints. Alignment with broader public domain standards such as ISO standards has the potential to reduce costs and increase the number of implementations and increasing the acceptance of ECDIS. The work has begun with the development of S57 Edition 4.0.

The field of Geographic Information Systems is poised for an explosion of growth. Almost everything in some way relates to a geospatial reference. Further, conventional database technology has improved and now incorporates

International Standards Status
The following organisations are developing public domain standards internationally

- **ISO TC211** suite of standards consists of a series of base standards. The first 20 of these standards have reached the Draft International Standard (DIS) stage, and will be completed by Jan 2002
- **ISO TC204** is developing the **Geographic Data Files (GDF)** for Transportation Information Control Systems. The standard has reached a mature Working Draft stage by November 1999 and is proceeding to DIS
- **ISO JTC1/SC24** has developed the **Basic Image Interchange Format (BIIF)** (ISO/IEC IS 12087-5) in 1998. BIFF is based on the US work on the Imagery Transmission Format Standard (NITFS)
- **ISO JTC1/SC32** has developed the **SQL/MM Spatia**l standard for handling of geospatial information in SQL databases in 1998
- **DGIWG DIGEST** has been available since June 1991. Edition 2.0 was released in December 1996. Edition 3.0 is under development, in line with ISO TC211. DGIWG is redesigning DIGEST based on TC211 standards just like IHO is doing with S-57. This will bring the technical standards closer together. Further, the work on registering feature catalogues, and especially a shift in DGIWG to accept the IHO feature definitions for the hydrographic features 'for which IHO is the authority' will bring the feature catalogues into alignment [Harbaugh, M., 2001]
- **IHO S-57** has been available since 1992. Edition 3.0 was released in 1996, and 3.1 in 2001. It is referenced by the IMO for safe navigation at sea. Edition 4.0 is under development, in line with ISO TC211
- **OGC – The Open GIS Consortium:** An international industry consortium of more than 220 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications

spatial referencing. Everything from accounting systems to word processors are including 'Map' type data. Location Based services are gaining in importance with increased GPS and cell phone use. By 2004 cell phones in the US will be required to include a method of determining location to support the 911 emergency services. While this capability has its privacy implications, it will bring in a number of new potential application areas based on the user of a cell phone equipped with Web access to query data based on the user's current location.

This growth in geospatial data use will cause a tremendous drop in the cost of GIS systems. Low cost 'shrink wrapped' software is beginning to emerge and if this software is standards based, then it will erode the market for the higher priced GIS systems. There is currently a market shift occurring that is similar to the shift from mainframe computing to personal and networked computers. This will be accompanied by a similar economic shift and potential growth.

There will be a very large impact on specialised application areas such as ship navigation using S-57 ENC data. No longer will this be an isolated specialised 'Location Based Service'. The economic base upon which ENC data is sold will shift dramatically. This could be very beneficial to the IHO's main goal of safety of navigation at sea, and to the economic well being of companies and agencies producing electronic chart systems and ENC products. However these benefits can only be realised by compatibility with public domain, particularly ISO standards.

IHO Uniqueness and S57

Even with a major change in the GIS marketplace, the position of IHO is unique. This is due to the legal framework in which nautical chart data is made available, and the fact that it is dynamically updated. Thus there is no threat to the overall position of S-57. However, some aspects of S-57 must change dramatically if the IHO is to take advantage of the expected major drops in the cost and wider availability of systems.
The information content in a geographic information data set is the part of value. The content model represents the data that can be converted into many different formats. As long as these formats are capable of carrying all of the content, then the essential information is carried. Defining information in terms of a content models and components is preferable to defining complete exchange standards. Every set of data, whether it is temporary, or persistent and standardised, has a content model. This content model can be expressed in terms of a modeling language, and basic components can be shared. This increases the commonality between systems, since systems can be developed to support many different content models.

Parts of S-57

- A geographic information data standard consists of several components that require separate standardisation
- The four principal components of the standard are:
  - an object or feature catalogue
  - a data model
  - a list of information about the information (i.e.metadata)
  - an encapsulation and coding into bits and bytes

IHO and ISO TC211[1]

The IHO has been a liaison member and active participant of the ISO Technical Committee on Geographic Information/Geomatics since it was formed about a decade ago and that has resulted in compatibility between S57 and the ISO specification. The ISO TC211 efforts are summarised in the following table.

[1] Information on how the TC211 standards are being implemented by software vendors can be found at the following website: http://www.ccrs.nrcan.gc.ca/ccrs/data/standards/welcom_e.html

The TC211 outputs are grouped into four categories shown in Table 1.

Guidance - High-level abstract documents that define the ISO world of geospatial data standardisation:
19101 Reference model

19103 Conceptual schema language
19104 Terminology
19105 Conformance and testing
19106 Profiles

Components – Documents covering the discrete parts of the geospatial data:
19107 Spatial schema
19108 Temporal schema
19111 Spatial referencing by coordinates
19112 Spatial referencing by geographic identifiers
19113 Quality principles
19115 Metadata
19123 Schema for coverage geometry & functions
19125 Simple Feature Access - SQL& COM/OLE
19127 Geodetic Codes and Parameters
19129 Imagery, Gridded and Coverage framework
19130 Sensor Models
19133 Location based services tracking and navigation
19134 Multimodal location based services for routing and navigation

Rules - for developing standards for very specific areas:
19109 Rules for application schema
19110 Feature cataloguing methodology
19114 Quality evaluation procedures
19116 Positioning services
19117 Portrayal
19118 Encoding
19119 Services
19126 Profile - FACC
19128 Services
19135 Registries
19131 Product Specifications

Reports – Areas of standardisation under development:
19120 Functional standards
19121 Imagery and gridded data
19122 Qualifications/certification of personnel
19124 Imagery & gridded data components
19132 Location based services standards

Table 1: ISO TC211 Work items

CHRIS[2] Decision and Impact on ENCs and S57, and the Object Catalogue

Based on discussions of TSMAD[3] it will be proposed to CHRIS to freeze the current ENC product specification and current S-57 edition 3.1 indefinitely. This freezing allows producers to continue producing the current ENC data product for as long as there remains market for the product.

The ENC Product Specification effectively defines a content model which can be expressed using the more mainstream ISO standards. By developing the next edition of S57 based on the ISO standards, S-57 will be able to satisfy other areas of hydrographic data standardisation, and it is intended to add a Raster Matrix component to S-57 in alignment with TC211, as well as a 3D and time dimension also in alignment with TC211.

CHRIS is also considering organising the S-57 Object Catalogue as a Register in alignment with TC211 and other organisations. This relates to the proposal for authoritative referencing in ISO SC24, another ISO committee which focuses upon areas of standardisation for general information technology.

The current ENC product specification remains valid indefinitely providing the stability required for implementation in the international maritime community. However, the ENC product specification can also be expressed as a model using the standard modeling language (UML) used by ISO TC211and TC211 model components. This makes ENC compatible with emerging GIS tools and geospatial database software and eliminates most of the production side tools based barriers. The ENC product specification should therefore be viewed as a Content Model for the hydrographic Information Community for navigation.

[2] CHRIS - Committee - Hydrographic Requirements for Information Systems
[3] TSMAD – (S57) Transfer Standard Maintenance and Application Development Working Group

The S-57 standard can be extended to cover raster, 3D, time and other capabilities by building on existing standards developed internationally thus providing for broader acceptance and implementation. The S-57 object catalogue can be established as a registry under IHO's authority, but compatible with other registers. This facilitates maintenance.

ISO JTC1 SC24 is proposing a system of registers linked by authoritative references. An external catalogue would link to the IHO catalogue for the definition of those objects and attributes that are considered to be in the domain of IHO.

ISO TC211 Impact on S52 and Updating

TC 211 has already developed a portrayal standard (ISO 19117) based on the S-52 concept of presentation rules linked to a feature and attribute. This was done based on input from IHO members to ISO TC211. Systems that implement ISO 19117 and other of the TC211 components, especially the spatial schema (ISO 19107), which is compatible with S-57, can more easily become ECDIS compliant. This may reduce the barrier to acceptance of the presentation side of ECDIS.

ISO TC211 has also adopted a generic updating structure based on S-57's transaction oriented updating using unique identifiers. The ISO work is at a very high level but it may guide the establishment of a generic updating structure that can used by other applications and be implemented using different communications methodologies.

Thus the evolution of S-57/S-52 toward mainstream geographic information and information technology standards may reduce some of the barriers that have limited acceptance and growth of ECDIS.

The Power of Standards

Surowiecki [2002] provides an impressive story of William Sellers' role in getting America to adopt a standard for machine threads which created a mass market for standardised screws, and which then had a major impact on the American economy. Prior to this period every craftsman and machine shop had their

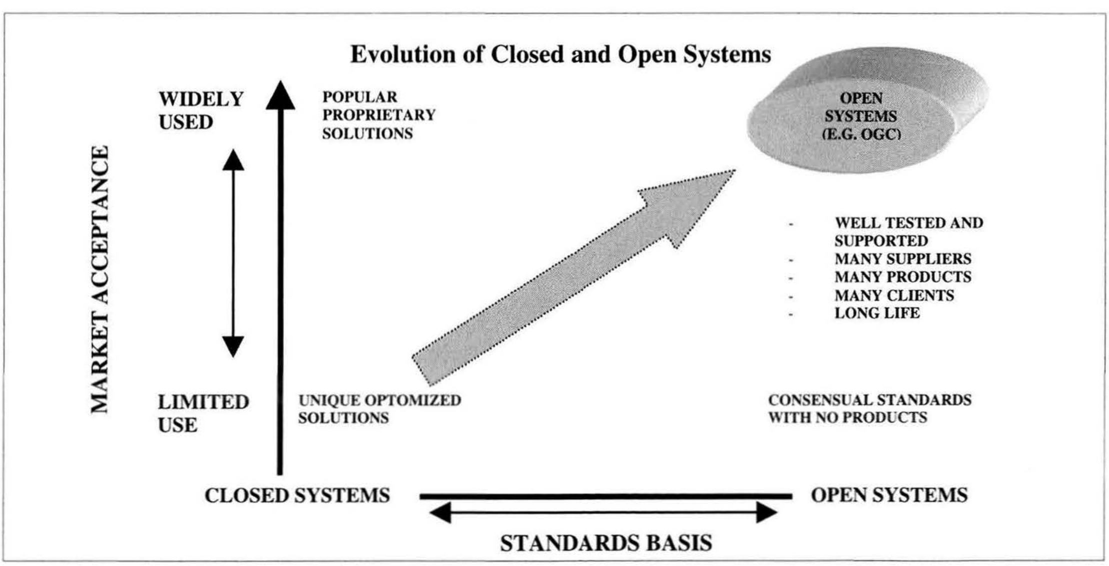

Figure 1: Market acceptance of closed and open systems

own thread design and interchangeability with the products of others was impossible, a situation not too dissimilar to the current situation for geospatial data.

In the GIS world data standards are something of a joke with just about every vendor, institution, and discipline tending to have their own 'standard'. This democratic state has been a major and costly barrier for anyone trying to integrate and use data from multiple sources. Although some help is available from certain products which convert among the hundreds of formats currently in use this is often at the cost of the loss of some of the data content. Although the struggle of dealing with many standards still exists, the efforts of the Open GIS Consortium (OGC) in providing leadership for open geospatial specification is having a very positive and practical impact as illustrated in Figure 1.

The Open GIS Consortium and Its Impact on Geospatial Data Infrastructures

The pressure on manufacturers to provide for more geospatial data interoperability had very little effect until the OGC was established. OGC is an international industrial consortium which is focusing upon providing specifications that support the delivery of practical systems or components of systems that can work together and facilitate a wide variety of functions for finding, accessing, integrating and sharing of data; that is, they provide for data interoperability. Further these systems are being developed for the sharing and handling of data over the Internet, thus laying the foundation for networks of interoperable systems. The Open GIS Consortium is composed of over 220 organisation of companies, government agencies, and universities.

Open Systems

- Open systems provide a 'building block' environment for manufacturers and system integrators
  - Allows smaller innovative companies to participate
  - Components from different supplies can be used to optimise the systems
  - Supports the implementation of interoperable systems

The Open GIS Consortium (OGC) is a broadly based organisation dedicated to open systems geoprocessing, primarily from an application point of view. Open interfaces and protocols defined by OGC specifications provide for interoperable solutions that 'geo-enable' the Web, wireless and location-based services, as well as mainstream IT, and empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications. OGC produces implementation specifications based on an open process. Further, OGC has an agreement with ISO TC211 to provide harmonized solutions and is currently introducing several of its specifications to ISO TC211 to be processed as standards. In addition OGC has also adopted several ISO TC211 standards as abstract specifications. Table 2 lists current OGC specifications.

OpenGIS® Simple Features Specification	Version 1.1
OpenGIS® Catalog Interface Implementation Specification	Version 1.0
OpenGIS® Grid Coverages Implementation Specification	Version 1.0
OpenGIS® Coordinate Transformation Services Implementation Specification	Version 1.0
OpenGIS® Web Map Server Interfaces Implementation Specification	Version 1.1.1
OpenGIS® Geography Markup Language (GML) Implementation Specification	Version 2.0

Table 2: Current OGC Specifications[4]

[4] http://fgdc.er.usgs.gov/nsdi/nsdi.html

The Birth of National Geospatial Data Infrastructures

Monahan, et al [2001] describes the revolution that mapping and charting has undergone over the past two decades. This world is on the threshold of another revolution which will have an even greater impact on those organisations that provide geospatial data as well as having major impacts upon the users of such data. The change from analogue to digital products may only be a prelude to the next phase where computers, communication (including the Internet and wireless links), computer graphics, and implementable world standards combine to lay the foundations for standards-based information infrastructures for the collection, maintenance, management, sharing, reuse and dissemination of geospatial data. The critical part that makes these infrastructures possible is the open international standards now becoming available.

The Importance of ISO Standards:

- Participation is open to all nations and professional organisation like the IHO
- Well organised approach that lead to consensual solutions
- Many countries have national processes in place to adopt ISO specifications as national standards

The Importance of OGC Standards:

- Provide for the implementation for key ISO TC211 standards such as features, coverages, metadata, temporal and spatial schemas, services, and reference systems
- Defines standards for Web-based geospatial services including data discovery, data access, processing and visualisation
- Standards are driven and developed by vendors. The standard will be part of the commercial products
- Participation includes the major geospatial data producers and the database and software suppliers
- The standards define a 'service-based' infrastructure

Although the ISO TC211 efforts are providing specifications for standardising geospatial data the ISO specifications tend to be at a higher, more abstract level of detail and additional levels of effort are usually required for practical implementation. When computers were initially used to produce maps and charts, commercial systems were not available and governments often developed their own highly proprietary systems. This practice has largely disappeared over the past decade as governments turned to the commercial, but still proprietary systems that became available. This solution created a new set of problems as the data bases developed for various institutions could not be readily shared and a tremendous amount of duplication of data was created to support the multitude of proprietary and incompatible systems. The costs for users wishing to incorporate data from multiple sources also became unreasonable as up to 85 per cent of the resources for such project were needed for data conversions. Although many organisations recognised these problems [IACG, 1996], they also realised that there was little to be done individually, but by working together they could establish and fund new initiatives to overcome these barriers. This led to the establishment of new programmes to begin creating standards-based geospatial data infrastructures. The basic requirements for the geospatial data infrastructures are:

- Universal Access – anywhere, anytime
- Remote access through a distributed architecture
- Integration of disparate geospatial data and services
- Seamless chaining of applications, data and services
- Catalogues and registries for finding and accessing data
- Collaborative data update and exchange
- Common Framework data
- Sharing semantics
- Interoperability through common open standards
- Facilitates partnerships across governments

In the United States the establishment of the National Spatial Data Infrastructure (NSDI)[5] is an important development sanctioned by the highest political level. The NSDI is defined as the technologies, policies, standards, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and non-profit sectors, and the academic community. It provides a base or structure of practices and relationships among data producers and users that facilitates data sharing and use.

In 1997, Canada established the Canadian Geospatial Data Infrastructure (CGDI) programme whose mission is to make Canada's geospatial data available on the Internet. Led by Natural Resources Canada, CGDI is founded upon the following five basic thrusts:

- Client centered **access** to government information
- Which is built on a national **data framework**
- Using international **standards**
- Collected by agencies in cost-efficient **partnerships**
- Provided seamlessly to users within a supportive **policy** environment

According to Coleman and MacLaughlin [1998], '(geo)spatial data infrastructure' encompasses all of the data sources, systems, network linkages, standards and institutional policies required to deliver geospatial data and information from many different sources to the widest possible group of potential users.

Table 3 shows a partial list of many other nations that are also building or planning to build data infrastructures similar to the ones underway in Canada and the USA. Over the next decade this will have a major impact on how geospatial data will be found, managed and delivered. In general the goals of these Infrastructures are to reduce duplication of effort among agencies, improve quality and reduce costs related to geographic information, to make geographic data more accessible to the public, to increase the benefits of using available data, and to establish key partnerships with provinces and states, municipalities, first nations, academia, and the private sector to increase data availability.

- Australia: ASDI/ALIC	- Indonesia NGIS
- United Kingdom NGDF	- Malaysia NALIS
- European Geographic Information Infrastructure	- Korea NGIS
- Qatar NGIS/NCGIS	- South Africa NSIF
- Portugal SNIG/CNIG	- Africa SDI
- Netherlands NGII/RAVI	
- Japan NSDI	

Table 3: Some National/Regional Geospatial Data Infrastructures under Construction

The Internet is seen as the 'vehicle' that could unite disparate efforts and also make it possible for all to have more readable access to geospatial data. The Internet is based upon common standards and is the main force in uniting many isolated data communities.

According to Gillespie [2000] good IT infrastructure is based upon the following five key characteristics:
- Built upon common standards for interoperability (seamless databases and systems). The IHO had led in this area through its efforts with electronic charts
- Wide area networking which ensures that the infrastructure reaches a broad audience. Telecommunication and information technology for networked distribution is highly evolved and provides the backbone for virtually instantaneous access to data and information, if it can be found
- Enabling of simple third party access –required if the infrastructure is to be useful and be used. Making existing geospatial databases available on the Internet does not make them usable for the

[5] http://fgdc.er.usgs.gov/nsdi/nsdi.html

non-expert and additional effort is required to make the complexities transparent to the users
- It is invisible to the user – telecommunications is a good example of a complex infrastructure that works well and is invisible
- It is affordable – by serving a broad base of users the infrastructure becomes affordable. Efforts are required to overcome the existing policy and price barriers to geospatial data

Global Initiatives

- **GSDI:**[6] The Global Spatial Data Infrastructure supports global access to geographic information. This is achieved through the co-ordinated actions of nations and organisations that promote awareness and implementation of complimentary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes
- **Digital Earth:**[7] A vision and meta-system connecting existing systems into a coherent, interoperable vehicle. This has been supported by the former US Vice-President

Closed versus Open Standards-based Infrastructures

The Internet provides a wonderful channel for publishing information and many institutions are busy linking their proprietary geospatial systems to the internet. Although these solutions help get results published on the Web, they do not help to reduce the barriers to sharing and using geospatial data from distributed sources. As indicated in Figure 2, in these proprietary systems, data of interest is converted and integrated, often at substantial cost and effort. Further, as this is being done in many different disciplines it is leading to the widespread duplication of effort and data, and to future difficulties in expanding and updating of the data. Developers of these 'closed' systems should be encouraged to review the work done by OGC which could open these systems up, provide more capabilities and reduce the need and cost of conversion, maintenance of the integrated data sets, as well as reducing the duplication of data.

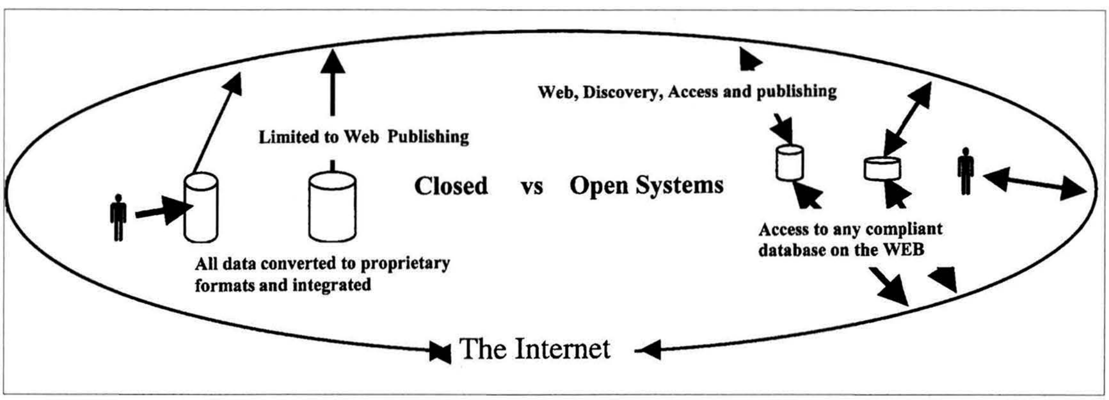

Figure 2: Closed vs open geospatial data infrastructures

Conclusions

The future of the earth and all those who live on it will depend more and more upon society being able to make informed decisions. To make these decisions, information based upon a wide range of reliable data that has been brought together will become more and more important. It is clear that the open standards-based geospatial data infrastructures can have a crucial role in satisfying this need for information.

6 http:www.gsdi.org/
7 http://www.digitalearth.gov/vision.html

As pointed out by Monahan et al [2001] hydrographic data plays important role in a wide variety of applications beyond that of marine navigation. Gillespie [2001] notes that Canada has created a special focus on the marine component of the Canadian Geospatial Data Infrastructure to ensure that the technical barriers to marine data are eliminated. Similar activities are either occurring in other countries or they will begin soon, and it is recommended that IHO consider the impact and opportunities that are becoming available for member nations. A seminar hosted by the IHO on Geospatial Data Infrastructure would be useful to bring key players together as well as providing a forum for other HO's to learn what is happening and discuss strategies for dealing with this new information era.

Further, the progress of the Open GIS Consortium depends upon volunteers to develop appropriate specifications. As the first round of work in TC211 approaches a level of completion, the OGIS work has grown in importance and it now depends upon national and international leadership and support if it is to complete its work.

IHO may need to develop cooperative agreements with ISO TC211 (with respect to abstract and general geospatial standards), ISO SC24 (with respect to authoritative referencing between object catalogues), and OGC (with respect to implementation specifications).

It is felt that opening discussion on geospatial data infrastructures does not make any threat to the position of S-57. However, some aspects of S-57 must evolve if HOs are to take advantage of the growth in new applications of their data and of the lower costs of managing and distributing their data as more and more open-standard tools and services become available.

References

CGDI Architecture Working Group, 2001. *Target Vision - Canadian Geospatial Data Infrastructure*, Version: 1. Ottawa

Coleman, D.J., MacLaughlin, J.D., and Nicols, S.E., 1997. *Building a Spatial Data Infrastructure.* Proceeding of the 64th Permanent Congress Meeting of the Federation des Geometres (FIG), Singapore

Fadaie, K., 2001. *Standards in Action in Canada: The Building Blocks for Infrastructure.* ISO TC211 Presentation, Kuala Lumpur, Malaysia

Gillespie R., Butler, M Anderson, N. Kucera, H, and LeBlanc, C., 2000. *MGDI: An Information Infrastructure to Support Integrated Coastal management.* GeoCoast Vol.1, No. 1, http://www.theukcoastalzone.com/

Harbaugh, M., 2001. *Liaison report from the Digital Geographic Information Working Group (DGIWG) to the 13th ISO/TC 211 Plenary.* ISO/TC 211 N 1179

IACG (Inter-Agency Committee on Geomatics) 1996. *Barriers to the Use of Geomatics Data.* Unpublished paper, Ottawa

Monahan, D., Hecht, H., Wells, D. Kenny, M.R., Campos, A. 2001. *Challenges and Opportunities for Hydrography in the New Century.* The International Hydrographic Review, December, Vol. 2, No 3, pp.56-67

Nebert, D.D., Editor. 2001, *GSDI Cookbook.* Version 1.1. May. http://www.gsdi.org/

Surowiecki, J. 2002. *Turn of the Century. Wired,* December, pp. 85-89

Biographies

Timothy V. Evangelatos retired from the Canadian Hydrographic Service in 1996 after three decades of involvement in developing hydrographic data processing systems, nautical chart production systems, geospatial standards, and electronic charts infrastructure. Now President of Terraqueous Technologies he has been active in establishing the national programme to build the Canadian Geospatial Data Infrastructure (CGDI).

C. Douglas O'Brien, President of IDON Technologies Inc., has been involved in the development of international geospatial standards for over 18 years. He has been involved in the development of S-57 and the current effort to align it with ISO standards. He is also an international convenor for one of the working groups of the ISO TC211 committee on geographic information standards.

Michel J. Casey is a/Director of Marine Cartography, Canadian Hydrographic Service. He has been involved in electronic chart activities for over 10 years.

Don Vachon, Chief, Engineering Development, Canadian Hydrographic Service, has been involved with the development of GIS and geospatial databases for over 23 years and is currently implementing OGC-based services in his department through the GeoPortal Project. He also chairs the Working Group on S57 extensions for Edition 4.0 which will integrate several of the TC211 components.

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