

ENSURING STANDARDS IN GEOSPATIAL DATA

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Abstract

Since evolution of modern civilization, land surveyors solely were legally entrusted with the task of geographic data collection for planning and development of any nation. Presently, society has become very complex and so has the high demand of geo-data facing the surveyor. In response to this, technological development of new sensors and ICT revolution - GPS, digital photogrammetry, DGPS, RTK (GPS), high-resolution satellite imagery, laser altimetry, radar (IFSAR, InSAR), GIS, computer technology, telecommunication, EDM, Internet, etc have been evolved to facilitate data acquisition to meet this challenge. This has resulted in unprecedented increase in generation of data in the history of surveying and mapping. Non-surveyors are now involved in data collection due to user-oriented application nature of these instruments. The implication of these scenarios was therefore examined and it was found out that there is the need for establishment of standards to harmonize the geodata issue; and that about three organizations already exist for this purpose, viz: International Organization for Standardization (ISO), International Federation of Surveyors (FIG), and the Open Geospatial Consortium (OGC). The roles and functions of these organizations were also examined, and it was discovered that membership of nations or companies is voluntary, instead of mandatory. This constitutes a clog to the implementation of resolutions as they lack the power to sanction for non-compliance. Accuracy of data is often quoted by data providers or manufacturers without provision of methods for checking such claims. Non-standardization of data leads to data bastardization and it is becoming a big challenge to surveyors as they face unhealthy competition by quacks. It also poses security risk to national governance. It was further discovered that data acquisition, processing and dissemination, which hitherto used to be statutorily the exclusive preserve of surveyors is now being seriously jeopardized and compromised. A case was therefore made for the establishment of a strong and enforceable legislation to govern geo-data issues as obtained in cadastral surveying

Keywords: Geo-data, Information acquisition, Standards organizations and Legislation.

Introduction

There is growing demand for access to geospatial data and information for decision making processes on local, regional, national and international levels. This is premised on the notion that better resourced, informed communities can more effectively address their issues of critical social, environmental and economic importance. Hence, this has led to geodata liberalization, whereby most governments which were initially custodians of geodata are now allowing private companies and communities to procure and process their own data to facilitate development.

According to Lemmens (2003), geodata plays a key role in our increasingly information-intensive, networked society. About 80 percent of all public sector information has a geospatial component, either referenced by address or by coordinates. Facilitating variety of needs, he observed, requires simulation of the use of geo-information in both public and private sectors, as well as individuals. This has led to geospatial democracy which can facilitate the discovery, acquisition, exploitation and sharing of geographic information vital to decision-making at both local and regional level (Nwadiolor, 2007).

It can be stated that relinquishing governments' monopoly of geodata will imply degrading of standards in the processes of data acquisition, processing and dissemination, since a great multitude of standards can be used without regulation or specification. Burmanje and Van der

Molen (2005) have defined that one can think of standards as a way to meet expectations both at technical and human level, and it is hard to imagine that open standards do not improve the world. FIG (2006) observed that standards are of great interest to surveyors, both as professionals and as business people. Knoop and Pachelski (2005) revealed that standards are set within Europe as a result of voluntary agreements between the 28 member countries via the European Committee for Standardization (CEN). Organizations need to share information throughout an enterprise. Many suffer the problem of "islands of automation": proprietary or custom systems separated by incompatibilities (Kennedy-Smith, 2005). This results in duplication of effort, manual processes and interface engineering costs, causing undue expense and delay, Sumrada (2005) pointed out that modelling is a well-proven and widely accepted engineering technique for controlling complex reality. Unified Modelling Language (UML) is a general-purpose aid for geographical modelling. In another development, Xie and Shibasaki (2006) intimated that Coordinated Enhanced Observation Period (CEOP) is currently working on an integrated global water and energy cycle observation system for scientific and civilian use. One challenge is the creation of a satellite-data integration system able to combine a multitude of data stemming from a diversity of distributed systems. Data retrieval and combination requires high-performance distributed data-management and archiving systems. But the key is specification of metadata, for which international standards are indispensable (Shibasaki Group, 2006). Trinder (2000), has earlier pointed out that standards for, and validation of, the information derived from remotely sensed data will be essential to ensure credibility of the derived results. With the possibility of fusion of data from different sensors the need for accurate geometric and radiometric calibration has become increasingly important. Use of data as supplementary and complementary information originating from the current large number of available sensors calls for standardization in specifying sensor parameters and their evaluation methodology, so as to allow spatial, spectral and radiometric comparisons. In related issue on standards, ISO (1996) and Vaughn (1999), revealed that turning digital precision to geographical resolution by truncation is an optimization challenge because it may induce topological problems. This implies that negligent dropping of digits during image processing may cause topological faults and violation of specifications.

In addition, some international, regional and national organizations, including individual researchers have contributed to various aspects of studies on standards. These include ISO/TC211, OGC, Burmanje and Molen (2005), Ploeg (2005), Blom (2003), Lemmen and Oosterom (2003), Graybill (2000), Reed (2000), Takino (2000), Levine (2003), Lewis (2003), Simonis and Wytzisk (2003), van Loenen and Ploeger (2005), Haydn and Volk (2005), Morales (2006), Cromptoets et al (2005), Buchroithner and Schenkel (1999), Petek (1999), Lemmens and Kurm (2005), Li et al (2005) and van der Molen et al (2005).

The aim and objectives of this study, therefore, are to examine the implications of the rapid increase in the rate of geospatial data acquisition, processing and presentation on data standards-occasioned by proliferation of technological tools (hardware/software), and liberalization of policies and programmes in surveying and mapping.

The Issue of Geospatial Data Acquisition

Planning and development rely on spatial data. A prerequisite for the beneficial use of spatial data is the availability of large spatial information systems with data acquired by geomatics techniques (Sausen and Rivett, 2002). In the past, geodata was acquired by the conventional techniques of surveying (e.g. levelling, traversing, trilateration, triangulation, photogrammetry, etc.) using compasses, tapes, levels, theodolites, EDM, aircraft and camera sensors.

However, nowadays, among methods of gathering geospatial data, the use of satellites (remote sensing, earth observation) is a particularly innovating one in view of its global coverage. In addition users-friendly, highly automated instruments are in use. Fritz (1999) has observed that the authorization for the ownership and operation of Earth observing satellite,

virtually without restriction, has stimulated unprecedented competition among large aerospace companies to create new geospatial products and services aimed at markets never before considered. Traditionally, satellite remote sensing systems have been used for global, regional and national programmes to support government activities.

The Principles Relating to Remote Sensing of the Earth from space adopted by the United Nations on 3 December, 1986 have proven to be judicious for guidance of the commercialization of remote sensing. The principles have minimized the extent of legal issues regarding Earth observation, including open skies accessibility, and enhanced opportunities for international co-operation in Earth observation from space. These principles were formulated and established during the height of the Cold War, when governments were the sole operators of remote sensing satellites and most nations had 10 to 50 metre resolution restrictions for civil Earth observation satellites. Hence, what was once the privileged domain of a few defence and intelligence agencies is now becoming available for civil and commercial applications. For example, when the United States government licensed the state's private industry to build and operate commercial high resolution satellite, it did so with very few restrictions, that is; shutter control for national security instances and limitations on technology export for national technology and economic competitiveness, as well as for national security and honouring international obligations.

Table 1: Classification of the spatial resolutions of satellite imagery

Very Low	$\geq 300m$
Low	$\geq 30 > 300m$
Medium	$\geq 3 < 30m$
High	$\geq 0.5 < 3m$
Very High	$< 0.5m$

Source (Fritz, 1999)

Nwadior (2007), has noticed that now, new geospatial markets are available from some geospatial data provider companies, viz. Space Imaging/Lockheed-Martin, E-Systems, Earth Watch/Ball Aerospace Corp., Orblmage/Orbital Sciences Corp., Aircraft Ind. Corp., GEROS/GER Corp., XSTAR/Matra-Marconi Space, Resource 21/Boeing, GDE, etc. Some of these companies focus on receiving, processing and distributing data from satellite constellations of the commercially available Earth observation (EO) satellites.

Some software vendors, such as Bentley, Autodesk, Geodan, ESRI, Intergraph (geonedia), eQte (reseller of FME), Snowflake (GO Loader), Oracle (Oracle Spatial), Laser-Scan (Radius Topology), etc, on the other hand, have made some claims of competencies to the effect that their specializations lie in geo-data, software, Information Systems (IS) and geo-information management consulting. They design and develop specialized software solutions for the processing of geo-information - e.g. a number of tailor- made software packages have been claimed to have been developed as stand alone and customized applications.

Others claim they have been involved in the development and application of thematic image enhancement and semi-automated image data analysis for land and coastal applications; set production lines for large-scale ortho-image generation, mosaic, topographic and thematic feature extraction among others.

To get remote sensing work as a spatial data source for various applications, GIS are indispensable and crucial to most projects. Furthermore, they claim we design and implement GIS/Data Base solutions from cradle to maturity. Typically, services comprise a detailed application, data-base and GIS application programming, database generation, prototyping and benchmarking; and model integration - all these are executed according to international and software development standards. Customer portfolio includes: companies, public institutions, government departments and supranational organizations, telecommunication companies, oil

and gas mining firms, etc. These are some of the myriads of claims made by government owned companies, professionals and geospatial providers companies.

This development, though, very beneficial to consumers of geo-data, in the sense that there are availability of data of different sorts and specifications, calls for standardization to avoid data bastardization and misuse since data acquisition, processing and dissemination need to be harmonized. Greenway (2006) opined that standards are of great interest to surveyors, both as professionals and as business people. Early and active engagement with the process of standardization by professional bodies such as the International Federation of Surveyors (FIG) should ensure more workable and timely standards that meet the needs of practitioners, their customers and the wider community.

Definition of Standards

The Collins English Dictionary offers among its nineteen definitions of the word standardization the following: “of the usual, regularized, medium or accepted size”; “denoted, or characterized by idiom, vocabulary etc, that is regarded as correct and acceptable by educated native speakers”; “an accepted or approved example of something against which others are judged or measured”; and “a level of excellence or quality”.

The International Organization for Standardization (ISO) offers the followings: “standards are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines or definitions of characteristics, to ensure that materials, products processes and services are fit for their purpose”. This takes the dictionary definition of the word ‘standard’ and creates a process, purpose and measurement for it. From these two sources, it can be distinguished, perhaps, between “standards” and “Standards”. The former are “norms” against which items can be compared for “acceptability”; the latter are formal, often legal, documents which define more closely what is deemed acceptable for a particular purpose and what is not. Both are of consequence to surveyors and other geoscientists in their dual role as professionals and business people. Furthermore, Martin and Gatta (2006), and Martin (2007) stated that standard is a rule or requirement determined by user consensus and prescribes the accepted and (theoretically) the best criteria for a product, process, test or procedure. As a result, he emphasized that the benefits of a standard are safety, quality, inter-changeability of parts or system and consistency across international borders.

THE IMPLICATION FOR ADOPTION OF STANDARDS

The format, for instance, of telephone and banking cards, quality management, environmental management, but also the international freight container; paper sizes and universal system of measurement known as SI are all examples of standardization.

Standards provide economic benefits, bringing confidence that things will work and will fit together. These increases in importance with key changes in the world, including:

- globalization on trade: more and more businesses and consumers require confidence that trade can flow between countries and continent
- competition laws: the need to prove that equal opportunities and standards are applied to equivalent transactions
- growing consumer requirements, whereby products and services need to be guaranteed to meet certain criteria
- technological development to a point at which most equipment users, whether in business or social arenas, will not be in a position to understand the detailed working of the equipment and thus to make unaided appropriate adjustment to results
- increasing intertwining of industries and professions, such that professionals are expected to have a level of understanding beyond the discipline within which they are trained.

All of these trends point to the need for a common bench-mark of expectations; and standards are designed to provide this vision and the necessary translation service. With the benefits to the United Kingdom and United States, for example, in addition to the benefit of the German economy from standardization amounting to more than 15 billion dollar per year, the importance of standards cannot be overemphasized. Luckily, some standardization bodies exist and there is need to examine their roles in ensuring standards.

Strategies in Ensuring Standards in Geospatial Data

There are "standardization bodies" existing at the national, regional and international levels. Those of the international would be the focus of this study. They are the Open GIS Consortium (OGC) now known as Open Geospatial Consortium, International Federation of Surveyors, and International Organization for Standardization (ISO).

OpenGiS Specifications

OGC is an organization with many members of standards organizations. According to Reichardt (2002) since OGC began in 1994, its members have made steady steps toward a difficult goal which include: creation of interoperability across the world's diverse geo-processing systems; interoperability across technology platforms, application domains and classes of products. That is to do what is necessary to enable geo-processing software systems from differing vendors to communicate directly across networks and also make it possible for users to work easily among different types of geo-processing systems. These include (US, as well as earth imaging, facilities management, automated mapping, location based- services and other systems such as data-base programmes, CAD, etc.

The vision and reach of OGC is global, it having approximately 230 members worldwide in 2002, from 24 countries and across five continents. There are 57 European members from 16 European countries and 45 Asia Pacific members. OGC has built strong co-operative tie with *de jure* standards organizations, particularly ISO TC 211 and TC 204, which is a Technical Committee set up to standardize Geographic information/Geomatics. Their new location services mission has brought them into synergistic relationships with major commercial standards groups, such as IETF (Internet), I3GPP (mobile) and W3C (Web). It took OGC several years to produce the first consensus- approved OpenGiS Specifications for open interfaces and protocols. After modest gains in 1996 and 1997, the rate of specification output and the rate of adoption by vendors accelerated rapidly. The OGC list of products that implement OpenGiS Specifications (see <http://www.opengis.org/cgi-bin/Implement.pl>) provides a place for developers to advertise their capabilities and for users to find products that "plug and play". More than twenty five vendors now offer 104 software products that implement OpenGIS Specifications, while rapid increase is envisaged in future years. These members grow weekly, as the user community demands greater interoperability - and just as the value of every Web node increases with the number of Web servers and Web clients online, the real value of every online geo-data and geo-processing server and every browser increases as the "spatial Web1" grows. With GML (the OGC Geography Markup Language, a world standard XML encoding system for spatial data and spatial processing), every ordinary Web browser becomes a client for these servers.

The OGC has a diversity of membership. Major institutions come to it with their interoperability requirements: the United Nations, the European Commission, the German state of Northrhine Westphalia, Geoconnections Canada, CSIRO of Australia, US Federal agencies and major commercial companies are Sponsoring OGC Interoperability Initiatives. These test-beds, pilots, and other projects drive new OpenGIS Specification development, test vendor interoperating products and teach technology providers and technology users how to thrive in the new environment of interoperable geo-processing. OGC has also established cooperation with the ISO and FIG. It is an organization with a diverse membership and broad-ranging agenda.

FIG Standards Network

The International Federation of Surveyors (FIG) is the only international body that represents all surveying disciplines, and is a UN-recognized Non-Government Organization (NOD). It is a non profit organization which has many functions, including the specifications of the standards of surveying. This is in view of the fact that standards are of great interest to surveyors, both as professionals and as business people. Early and active engagement with the process of standardization by professional bodies such as FIG should ensure more workable and timely standards that meet the needs of practitioners, their customers and the wider community.

Thus, recognizing the increasing importance of standards in the work of surveyors and the key role of professional bodies, especially at the international level, in articulating requirements increased its focus on standards in the late 1990s. FIG set up a Task Force on Standards in late 1997 to focus and to coordinate its efforts. At its 2002 Congress, FIG decided to set up Standards Network whose mandate currently includes, according to Greenway (2006) the following:

- Maintaining information on the work of the different commissions as relevant to standardization.
- Strengthening links with other NGOs.
- Building further on FIG's relationship with the International Valuation Standards Committee (IVSC). FIG is currently reviewing its formal relationship with IVSC, recognizing the important role FIG. particularly Commission 9, Valuation and Management of Real Estate' can play in developing valuation standards.
- Input to ISO work on standards for survey instruments. FIG Commission 5 has been involved for some years in the ISO work of refining standards for survey instruments. The goal is a single, usable set of standards for field surveyors, and not just for calibration laboratories. Some of these standards are now published; Commission 5 will ensure that FIG continues to work in this field, with a particular current focus being a proposed standard on testing the repeatability of Real Time GPS measurements.
- Input to ISO work on Geographic Information standards. The work of ISO Technical Committee (TC) 211 will have a profound impact on large numbers of surveyors. Many of its first generation standards are conceptual models, TC 211, however, has now moved into the more detailed area, including the development of registries. Location Based Services is a particular focus. Another is geodetic codes and parameters, where FIG has been asked to assist in compiling a library of the definitive transformations required to move between different coordinates reference systems. TC 211 is also becoming the place where the geographic information committee meets; the liaison members of the Committee include Open Geospatial Consortium, the Global Spatial Data Infrastructure (GSDI) and FIG. FIG has played an active role, but has recognized that it can't be involved in everything.
- Promoting the development of best practice and standards in areas of construction economies (Commission 10, working with the International Cost Engineering Council) and Spatial Planning (Commission 8), areas not to date covered to any extent by official standards. Another area of interest to FIG is the further development of international hydrographic standards.
- Maintaining and building links with the ISO Central Secretariat.
- Maintaining a profile for the Network through articles, papers, etc.
- On the other hand, it is to be noted that FIG has limited human and cash resources. Therefore efforts should be focused on those areas central to its members' interests and where FIG can add value. Key benefits of FIG involvement include:

- improved two-way linkages between standards developers and practising surveyors, ensuring that developers are aware of user requirements and of what already exists and that practitioners are aware of standardization work and its consequences for them.
- improved standards, both in terms of workability and timeliness.
- improved survey practice, with higher levels of performance and quality, thus responding to customers' growing expectations.
- improved bottom line for both surveyors and their customers.

Cadastral Domain

One area not currently subject to international *de jure* standardization is that of the cadastre. FIG some years ago submitted the statement of the cadastre for fast-tracking to become an international standard, but this was not taken forward by ISO due to concerns over interrelationship with national laws generally governing any cadastre. However, in a world of global trade, and with secure title to land being a key issue in human development, many stakeholders are demanding more communality within the cadastral domain to provide the required security. FIG has long been acknowledged and respected as one of the leading international sources of expertise on the cadastre.

A detailed, prescriptive specification on the content of cadastre would be inappropriate given the very different legal and cultural frameworks within which national cadastres operate. ISO/TC 211 has used a model-based approach to describing and specifying relevant matters, supported by a concept of registers to list instances that conform to the models. The route taken by FIG Commission 7, cadastre and land management, over the last few years has mirrored this approach.

Agreement within the FIG community on a core cadastral domain model is a very important step but does not provide the quasi-legal statement of that model required by many key international stakeholders. The FIG Standards Network and the links and performance record it has built within ISO therefore bridges FIG work and the ISO arena.

However, despite all these efforts by FIG on standards, there is still a long way to go before all its members are aware of the standardization issues relevant to them and are providing appropriate input to the standards development process. The FIG Standards Network should facilitate increased mutual understanding between surveyors and standards developers.

The ISO Initiatives on Standards

The ISO can be described as the highest organization of standardization bodies. A second standardization body of relevance to surveyors, among others is the International Valuation Standards Committee (IVSC). Others include

- national standardization bodies, which are increasingly adopting international standards
- regional standardization bodies, including groups such as NATO
- governments: all laws can be seen as setting standards
- companies: the larger of which can create *de facto* standards, such as those surrounding the Microsoft operating system.

Recognizing wider interests, a variety of international organizations are registered by ISO as Liaison Bodies. These vary from Visa International, European Committee for Standardization (CEN) to FIG. They may be involved in the standardization process to the full extent of the national bodies, with the sole exception that they do not have a vote.

The work of ISO started in the arena of manufacturing. Service industries have become a focus for it far more recently. Hence, it has been observed that land and engineering surveying is more standardized than spatial planning. The ISO standards that existed for survey

instruments, such as theodolites and total stations were a case illustrating how standardization can lose touch with reality. That reality is often a muddy building-site in the rain, whereas ISO standards required calibration standard facilities. In addition to this, two different non-correlated standards covered similar ground.

In recent years FIG, particularly its Commission 5 'Positioning and Measurement', has worked with the relevant ISO technical committees to harmonize requirements, and a number of new standards in the series ISO 17123 have been published. These incorporate two levels of tests: periodic calibration and regulation field-testing (Greenway, 2006, FIG, 2002).

Geographic Information Standards

Apart from ISO standards for capturing of geospatial data, using survey instruments, a more recent area for its attention involves Geographic Information (GI). An European initiative in the early to mid- 1990s had resulted in some provisional GI standards, but ISO is now in the process of publishing over forty standards in the ISO 191 x x series, and European Standardization work within the area has recently been recommenced (Swann, 2000). They cover aspects from terminology to coordinate reference systems, including crucial areas such as interoperability.

This is in line with an industry move to open systems standards, and GIS manufacturers are key players in the ISO work. So are a number of professional surveying bodies of which FIG, probably, is the most active. This work is underpinning the government and industry moves towards interoperability of geographic data and systems between data providers and across national borders (NASA, 2005, DIN, 1999). The INSPIRE initiative to create an European Environmental Spatial Data Infrastructure, for example, plans to rely on ISO and CEN standards (www.ec-gis.org/inspire).

The Well-known Standards of ISO

The ISO has many technical committees for standardization of geospatial data capture, processing and dissemination. The most prominent, is the ISO/TC 211 which is a technical committee on standardization of geographic information.

According to Tom (2005a), ISO/TC 211 comprises fifty national bodies, liaisons with 25 major international professional organizations and twelve other standards committees and organizations. Its work is concentrated on developing geographic data standards. ISO/TC 211 has a Joint Advisory Group (JAP) with the Open Geospatial Consortium (OGC) that develops open geospatial software interfaces (www.isotc211.org).

Some aspects of this ISO/TC 211 Committee's work aim to establish a structured set of standards for information concerning objects and phenomena directly or indirectly associated with a location relative to the Earth (www.opengeospatial.org). These standards specify for geographic information methods, tools and services for data management, including definition and description, acquisition, processing, analysis, access, presentation and transference of such data in digital and electronic form between different users, systems and locations. The work shall, where possible link in with appropriate standards for information technology and data, and provide a framework for the development of sector- specific applications using geographic data.

The Liaison Perspectives of the ISO

The ISO/TC 211 has internal and external links to other standardization organizations. Internal links comprise liaisons with other ISO technical committees doing related work that may be relevant; external links are with standardization organizations outside ISO. The relationships between ISO technical committees are defined by ISO directives and may impact technical work programmes, perhaps involving the scope of the technical committee and new work item proposals. ISO/TC 211 also maintains very important external liaisons with various standards organizations, outside of the realm of its standardization efforts as shown in Table 2.

Table 2. ISO/TC 211 External Liaisons

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

Source (Tom. 2005b)

Benefits of Open Standards Adoption

A growing number of organizations have adopted or are planning to adopt open standards developed by internet, government, industry, and international organizations. Organizations dependent on geospatial information are making similar transitions to standards developed by the ISO and Open Geospatial Consortium (OGC).

Several European organizations have provided leadership in standards adoption, often ahead of their counterparts in the US: The Czech Republic Land Survey, which publishes using the OGC Web Map Service (WMS); Ordnance Survey Great Britain, an early adopter of GML standards and future publisher of WMS and Web Feature Service (WFS); in Germany, the Runder Tisch GIS, a WMS and WFS enterprise development integrating data from regional and local government, and military and commercial inputs (Kennedy-Smith, 2005). The proven maturity of open standards reduces any risk associated with adoption.

Organizations need to share information throughout an enterprise. Many suffer the problem of "islands of automation": proprietary or custom systems separated by incompatibilities. This results in duplication of effort, manual processes and interface engineering costs, causing undue expense and delays. To realize the value and benefits of data, many organizations are moving to Web-based, data-base centric architectures enabling more timely and responsive information sharing and exploitation. Another factor is cost. Architectures based on "islands of automation" must maintain expensive proprietary interfaces. By comparison, architectures based on open systems deliver the benefits of competitive procurement. The existence of a rich set of consistent open interfaces and schemas provides "plug and play" integration between diverse components, enabling new components to become integrated and operational within greatly reduced time-frames. Open standards enable organizations to be more agile. Organizations can respond to change, reduce the risk of 'stranded' technologies, and deliver new capabilities and benefits in months rather than years.

It is important to note that the growth in open standards continues throughout the world, and many new and exciting capabilities are in the pipeline. The adoption of open standards is an enabler for innovation, allowing organizations and individuals to realize the potential of existing and emergent technologies. Location based services can be easily integrated with other geospatial capabilities through standard interfaces. The fusion of multiple sources of geospatially referenced data such as images, reports and video can be accomplished through the use of WMS and other standards. In addition, new standards and encoding for the OGC Web Terrain Service, Sensor Web Enablement, semantic translation and other capabilities are maturing and moving forward in the consensus process.

This is related to Lemmens (2005) statement, to the effect that, within the geo-IT domain, Unified Modelling Language (UML) is gaining momentum because it supports the interoperability of geo-information. This is important for dissemination of geo-information within the framework of establishing a national Geo-information Infrastructure. Today most standards are even written in UML. So, the system developer who represents his design in accordance with UML syntax is developing along standardized lines, which is in itself a sound selling point.

In another related development, Tom (2005) has pointed out that the global user community for geographic information standards also consists of nations, non-governmental organizations, multilateral banks, vendor community, international initiatives and programmes. The viability of standards are increasingly judged on their capacity to support criterion established by these communities at national, regional and global level to achieve the integration and interoperability of geographic information and systems within existing and emerging information technology environments.

This overall interoperability using generic information technology provides the ability to extend the benefits of geographic information/technology and its incorporation within other technologies and applications, and from specific user domains to those of mass-market consumers. These are, in large measure, the major and common objectives for the international geospatial community. That is why standards deserve their institutional advocacy and strategic support.

Analysis of the Standardization Efforts

The efforts initiated by the International Organization for Standardization, and other organizations at regional and national levels, to standardize geospatial data capture, transfer and interoperability, is a welcome development in spatial planning and management. However, a critical analysis needs to be made here, to assess the viability or sustainability of this effort by the ISO and its associated counterparts.

Geographic information standards generally refer to geographic data standards and / or software interface specifications for geographic information. Geographic data standards are developed for defining, describing and processing geographic data. The ISO Metadata Standard is an example of a geographic data standard, and one that is primarily content-oriented. Software interface specifications allow different software to interact and be interoperable whilst maintaining its proprietary nature. Such specifications may also result from the adoption or adaptation of an existing information technology standard for geographic information applications. The use of the Extensible Markup Language (XML) is an example of such; modification of the XML with a geographic information extension, Geographic Markup Language (GML) is a good example of adaptation.

One of the benefits of standards is technology transfer. Standards frequently serve as forms of technology transfer between advanced and emerging countries. The traditional technology lag between developed and emergent countries is disappearing as these later join technical committees within standardization organization, either as participating members or as observers.

Standards also serve as democratic mechanisms to level the playing field for all players, large or small, in a competitive technological/GIS environment (Delphi Group, 2003; Tom,

2005b). The benefits of standards as stated above, notwithstanding, it is to be noted that standards are generally perceived as technical solutions accepted by consensus. Secondary, within ISO, 'consensus' does not, however, necessarily imply unanimity or approval by majority. The notion of consensus within this context refers rather to the absence of sustained objection. Closer scrutiny reveals that standards are more likely to be political compromises that may have significant roles and implications in the management, policy and financial considerations of governments, industry and user communities. In this regard the approved standard is less than likely to be a superior technical solution. In addition, the ISO standardization process may be slower because it requires formal consensus and approval of standards by many nations. This would lead to bastardization of data going on unchecked.

However, it may be argued that while the development of a singular or stand-alone ISO standard occurs faster, the recently carefully developed sets of integrated standards in the ISO/TC 211 ensure interoperability. Moreover, there is a widespread notion of international acceptance of the ISO standards by legal statute and regulatory mandate by many countries as being far preferable to any national, regional, commercial or *de facto* standards.

Conclusion and Recommendations

It is the view of this paper that standards can further be improved by the establishment of "Spatial Data Infrastructure for Standards" at national and global levels. The quality and reliability and of information services delivered by a geo-information provider determine their success and patronage on the market. So geographic information business should not be limited to acquiring, storing and publishing data, but should also add value, integrate and develop such information services. This is as a result of the ever-changing requirements of users, which invariably demand system reconfiguration and commensurate standards.

Standards as generator of quality and reliability require that processes, data, operations and applications are put together in a service chain. Static implementation of such a service chain would suffice if the requirements remain constant during its life cycle. This is usually not the case because users want to influence products in many ways; competition has intensified and new technology offers many opportunities. Hence, the design of geo-information provision systems that cope with dynamically changing requirements can become rather complex, as well as the standards to be met.

The three main phases of a spatial data value-chain are generation, communication and use. This is the role of the Spatial Data Infrastructure (SDI) in geo-information services; which also needs to be standardized for effectiveness and efficiency. Although, SDI tries to play a significant role in communication by facilitating discovery and access to data, the "use" phase, however, has mostly been largely neglected. This passive approach has led to data being collected and advertised but never used to its full potential.

Increase in data use requires a proactive strategy, which is enabled by the development of information services; but this carries its own problems. To be useful a service has to fit user requirements, which mostly depend on the way data is perceived, expected and used, and on the current forms of projects, markets and technology. A flexible approach can be achieved, for instance, by identifying core (atomic) services that may be combined. This is in consonance with the definition of a geo-information as a non-persistent collection of elements organized so that they have value for a user.

The traditional role of the SDI for standards need to change from being a data discovery and retrieval facility to an integrated system suited for the provision of customized information and services. Services are seen as the contribution of a system, or part thereof, to its surrounding environment. This contribution can be defined in terms of data, operations, processes, resources, value-added products, or any combination of these. Normally, providers of Geographic information (GI) address services by stringing together groups of functions in an *ad hoc* manner. This may satisfy a single need, but continually and separately providing in this way for different services hampers reusability. Moreover, lack of descriptions of the solutions obtained makes it hard to aggregate them to support some elaborate tasks. This suggests the

need for research on the development of mechanisms to manage independent collections of core services so that their combinations improve reusability and flexibility while maintaining correctness and standards of the compositions.

The provision of tailored UI-services should allow the user to be given added-valued geo-information products as opposed to raw data, as is often the case. Approaches to design systems for the integration of disparate GI-resources to form Geo-information Service Infrastructure (OSI) enable providers to cope with the ever-changing requirements of geo-information users. But achieving this requires an evaluation of the security and legal aspects of gathering geo-data in space. This will form the basis for extension of this work; as it will aim to elaborate on the suggestion here that the already existing conceptual and institutional framework on standards, be backed up by strong and enforceable legislations, making it mandatory, instead of voluntary, for every nation to be a member of the standards organizations, and be held liable for any breach of the laws on geo-data issues.

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