Committee of Experts on
Global Geospatial Information Management

Background document [1]
Available in English only

Third session
Cambridge, United Kingdom of Great Britain and Northern Ireland
24-26 July 2013

Item 8 of the provisional agenda

Establishment and implementation of standards for the global geospatial information community

The UN-GGIM inventory of issues
and
geographic information standardization

Background Document Prepared jointly by the International Organization for Standardization (ISO/TC211), the Open Geospatial Consortium (OGC) and the International Hydrographic Organization (IHO)

The Secretariat acknowledges with thanks the contributions of Gilles Bessero, Jean Brodeur, Serena Coetzee, Olaf Østensen, Anthony Pharaoh and Carl Reed

[1] [1] The designations used and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. The term "country" as used in this publication also refers, as appropriate, to territories and areas.

The UN-GGIM inventory of issues and geographic information standardization

Prepared by

ISO/TC 211, *Geographic information/Geomatics*,

in cooperation with the

Open Geospatial Consortium (OGC)

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6 June 2013

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1. Introduction

In the sixties geographic information in digital form and geographic information systems (GIS) were first introduced for land inventory and management (Coppock et Rhind 1991). Since that time, we have witnessed a constant evolution, not only of the technology, but also the science of geographic information. GIS, geographic information databases, spatial data infrastructures and geospatial web services now provide geolocated information in support of decision making at the global, regional, and local scale. They are applied in diverse areas, including the environment, ecology, agriculture, transport, humanitarian problems, disasters, security and global warming. Geographic information is now widely accessible, shared and reused in many contexts. This is possible because geographic information, systems, and services are interoperable.

Standardization in the realm of geographic information has contributed significantly to the development of interoperability of geographic information (McKee and Buehler 1998; ISO/DIS 19101-1 2012). This complex task addresses multiple facets beginning with the definition of interoperability of geographic information. Then, topics such as fundamental data types for spatial and temporal information, conceptual modelling rules, semantics of real world phenomena, metadata, services, encoding, etc. are developed into standards to set the foundation and building blocks that enable interoperability of geographic information. Standards in geographic information are the underpinning for the development of a spatial data infrastructure (SDI).

There are a number of international organizations with the primary objective of developing standards for geographic information. This is the case for ISO/TC 211, *Geographic information/Geomatics* (ISO/TC 211), the Open Geospatial Consortium (OGC), and the International Hydrographic Organization (IHO).

The **International Organization for Standardization**[2] (ISO) is the world's largest developer of voluntary International Standards. International Standards provide state of the art specifications for products, services and good practice, helping to make industry more efficient and effective. Developed through global consensus, they help to break down barriers to international trade. ISO was founded in 1947, and since then has published more than 19,000 International Standards covering almost all aspects of technology and business, from food safety to computers, and agriculture to healthcare, impacting on people's daily lives. ISO aims to be as inclusive as possible when it comes to its membership. Three member categories, each with a different level of access and influence over the ISO system, allow countries with limited resources or without a fully developed national standards system to still observe and keep up to date with international standardization in ISO. Three quarters of the 163 ISO members are from developing countries.

ISO/TC 211, *Geographic information/Geomatics*[3], is the ISO technical committee responsible for the standardization of geographic information. Its work aims at establishing a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. More specifically, it covers semantic, syntactic and service issues, as well as procedural standards, at various levels of abstraction (e.g. geographic feature definition, spatial and temporal objects, coordinate reference systems, metadata, quality, web services, etc.).

The **Open Geospatial Consortium**[4] (OGC) is a voluntary consensus standards organization. 'Voluntary consensus standards bodies' are domestic or international organizations, which plan, develop, establish or coordinate voluntary consensus standards using agreed-upon procedures. The focus of OGC work is to define, document and test implementation standards for use with geospatial content and services. OGC standards leverage the abstract standards defined by ISO/TC 211. The work of the OGC is driven by member organization requirements, staff analysis of market trends and OGC Board of Directors guidance. In all cases, the mission is the integration of geospatial content and services into applications for the benefit of mankind. Key new OGC standards focus areas have a definite orientation on accessibility, sustainability and capacity.

[2] www.iso.org
[3] www.isotc211.org
[4] www.opengeospatial.org

The **International Hydrographic Organization**[5] (IHO) is an intergovernmental consultative and technical organization established in 1921 to support safety of navigation and the protection of the marine environment. Among its main objectives, IHO is to bring about the greatest possible uniformity in nautical charts and documents (i.e. standardization). The establishment and maintenance of hydrographic standards rests with the IHO Programme 'Hydrographic Services and Standards', under the responsibility of the IHO Hydrographic Services and Standards Committee (HSSC). The provision of hydrographic and nautical chart services is one of the obligations of coastal State signatories to the International Convention for the Safety of Life at Sea (SOLAS) under the responsibility of the International Maritime Organization (IMO). The SOLAS Convention (IMO 2009) stipulates that 'Contracting Governments undertake to ensure the greatest possible uniformity in charts and nautical publications and to take into account, whenever possible, the appropriate resolutions and recommendations adopted by the International Hydrographic Organization'.

The **United Nations initiative on Global Geospatial Information Management**[6] (UN-GGIM) aims to play a leading role in setting the agenda for the development of global geospatial information and to promote its use to address key global challenges. Interoperability and standardization in geographic information are essential elements for the development of global geospatial information. Geospatial information exits in many countries and organizations. Access to and reuse of such information can speed up the establishment of global geospatial information. By complying with standards for geographic information, existing geospatial information can be aggregated, arranged and made available more easily to achieve the UN-GGIM aims and objectives. In this context, the inventory of issues to be addressed by the United Nation Committee of Experts on Global Geospatial Information Management has been collated and consolidated within the following nine thematic groups (ECOSOC 2012):

(a) Developing a national, regional and global strategic framework for geospatial information;

(b) Establishing institutional arrangements and legal and common frameworks;

(c) Building capability and capacity, especially in developing countries;

(d) Assuring the quality of geospatial information;

(e) Promoting data sharing, accessibility and dissemination;

(f) Embracing trends in information technology;

(g) Promoting geospatial advocacy and awareness;

(h) Working in partnership with civil society and the private sector;

(i) Linking geospatial information to statistics.

At the second session of the UN Committee of Experts on GGIM (UNCE GGIM) in August 2012, in New York City, ISO/TC 211 in cooperation with the OGC and IHO proposed to the committee to develop a report addressing issues related to geographic information standards setting in the international community.

This report is the ISO/TC 211 response, in cooperation with the OGC and the IHO, and intends to provide recommendations regarding standards setting in the global geospatial community to the UNCE GGIM in support of its aims and objectives. It presents an analysis of the standardization needs relevant to the above UN-GGIM issues and currently available standards baselines from ISO/TC 211, the OGC and the IHO.

The remainder of the report is structured as follows: Section 2 describes how ISO/TC 211, the OGC and the IHO operate and cooperate on standardization of geographic information. Section 3 provides a summary of the detailed analysis in the Annexes. Section 4 contains recommendations for consideration by UNCE GGIM.

Annex A and B provide a tabular overview of Annexes C to K in which the contributions from relevant standards to each of the UN-GGIM issues, as well as additional areas of geographic information standardization that could contribute to UN-GGIM issues in future, are described (there is an Annex for each UN-GGIM issue). Annex L provides a subset of ISO terms and definitions used in this document.

[5] www.iho.int
[6] http://ggim.un.org/

Annex M provides a bibliography of references where the reader can find additional information about the geographic information standards and activities described in this report.

2. Standardization of geographic information

2.1 ISO/TC 211 standardization processes and procedures

ISO technical work is carried out under the overall management of the Technical Management Board (TMB). The TMB reports to the ISO Council and its role is defined in the statutes of the organization. TMB tasks include setting up technical committees, appointing chairs and monitoring the progress of technical work (ISO 2013). The ISO/IEC Directives (ISO/IEC 2011, ISO/IEC 2012) are essentially the rules for the development of International Standards and deal with matters of strategic planning, coordination, performance and monitoring of technical committee activities, as well as rules for the structure and drafting of standards.

ISO standards are developed by groups of experts within technical committees (ISO/TCs). ISO/TCs are made up of representatives of industry, NGOs, governments, academia and other stakeholders, who are put forward by ISO's members. Each TC deals with a different subject. ISO/TC 211[7] is the ISO technical committee responsible for standardization of geographic information. ISO/TC 211 currently has 35 participating members, 31 observing members and liaison relationships with more than 30 international organizations and more than 15 other ISO/TCs. The Vienna agreement (1991) ensures technical cooperation with the European Committee for Standardization (CEN). The European Committee for Standardization (CEN) Technical Committee for geographic information, CEN/TC 287, is the mirror committee to ISO/TC 211, adopts their standards in order to make them mandatory within the European Union and produces technical guidance and best practice for spatial data infrastructures.

Once the need for a standard has been established, experts meet face-to-face or through online mechanisms to discuss and negotiate a draft standard. As soon as a draft has been developed, it is shared with ISO's members who are asked to comment and vote on it. If consensus is reached, the draft becomes an ISO standard, if not, it goes back to the technical committee for further edits. Key principles for the development of standards are that ISO responds to standardization needs in the market (rather than deciding itself when to develop a new standard); ISO standards are based on global expert opinion; ISO standards are developed through a multi-stakeholder process; and ISO standards are based on consensus.

An ISO International Standard embodies the essential principles of global openness and transparency, consensus and technical coherence safeguarded through its development in a technical committee, representative of all interested parties, and supported by a public comment phase (the ISO Technical Enquiry). Other ISO deliverables include the ISO Technical Specification (ISO/TS), the ISO Public Available Specification (ISO/PAS) and the ISO Technical Report (ISO/TR) with lower levels of consensus and therefore not the same status as an International Standard. An Industry Technical Agreement (ITA) aims to bridge the gap between the activities of consortia and the formal process of standardization represented by ISO and its national members. An important distinction is that the ITA is developed by ISO workshops and fora, comprising only participants with direct interest, and is therefore not accorded the status of an International Standard.

2.2 OGC standardization processes and procedures

Founded in 1994 as a 501 (c) (6) not for profit membership based consensus standards organization[8], the vision and mission of the OGC is to enable the use and integration of geospatial content and services in any system or application regardless of whether the system or application is single purpose for a given organization or is an enterprise portal application accessible on an international basis. The OGC currently has 480+ Member organizations representing Government, the private sector, universities, NGOs, research communities, and the open source community. The work of the OGC is guided by Member approved Policies and Procedures (P&Ps). These P&Ps are living documents that evolve based on Member and market requirements. However, the fundamental requirement of a collaborative, consensus standards development and maintenance process has remained since 1994.

[7] www.isotc211.org

[8] OGC is a tax-exempt "membership corporation," as defined in section 501(c)(6) of the US tax code

The standards work in the OGC occurs primarily in two major activities: the Interoperability Program and the Standards Program. The Interoperability Program provides a facilitated, rapid engineering (agile) lifecycle approach to capturing interoperability requirements and then using those requirements and use cases to prototype applications (software) that either test existing OGC standards against those requirements, often providing change requests to existing standards; or develop new candidate standards or extensions to existing standards. The work of an interoperability initiative then feeds directly into the standards program.

The Standards Program (SP) is where work on candidate standards and revisions to existing standards occurs. The SP is an open forum for discussion of requirements, use cases, and issues. The SP is also a forum for Members to present on implementations of OGC standards and lessons learned. The SP is comprised of Domain and Standards Working Groups. Domain Working Groups are open to any Member as well as the public (non-Members). Standards Working Groups (SWGs) are for Members only and their work is guided by the OGC P&P and the OGC Intellectual Property policies. SWGs are the working groups in which standards documents are maintained. Candidate standards are submitted by three or more Member organizations. Candidate standards may have been developed outside the OGC (such as KML), developed by the SWG, or submitted as a result of an interoperability initiative. The OGC standards track is well documented in the OGC P&Ps.

All OGC standards, when approved, are freely and publicly available on a Royalty Free, non-discriminatory basis (RAND-RF).

2.3 IHO standardization processes and procedures

The current membership of the IHO is composed of 81 coastal States. The official representatives of Member Governments within the IHO are normally the national Hydrographer, or Director of Hydrography, who, together with their technical staff, meet in Monaco at the International Hydrographic Conference (IHC). The IHC holds ordinary sessions at five-year intervals and extraordinary sessions in the interim period as required. All decisions of the Organization are made by the Member States, during IHC sessions or by postal voting during the inter-sessionary period. Each Member State has one vote in ordinary decision making.

The principles and procedures for developing IHO standards are laid out in a specific resolution[9] which was initially approved by IHO Member States in 2007. This resolution applies to "standards" and "guides" as defined by ISO[10]. The development, consultation and approval process ranges from a very comprehensive regime for *new publications* and significant changes to existing publications (*new editions* or *revisions)*, requiring formal approval by a majority of the Member States, to approval at the level of a subordinate body (committee, sub-committee, working group) for simple *clarifications*.

Proposals to develop a *new publication*, a *new edition* or a *revision* are considered by the relevant IHO Committee, generally the Hydrographic Services and Standards Committee (HSSC) but not exclusively. When assessing the proposal, the Committee concerned considers the impact on relevant stakeholders, including a risk and feasibility analysis and an estimate of the resources needed for the development and the implementation of the new or revised standard. After the Committee has endorsed proposals and established a work priority, the relevant tasks are incorporated in the IHO work programme. Relevant stakeholders are notified of the timetable for new work items and invited to comment and participate as appropriate. At the successful completion of the development and testing phases for new standards and proposed changes to existing standards, the Committee reviews the work done in terms of its impact on relevant stakeholders and whether the appropriate non-IHO stakeholder consultation process has been achieved. After endorsement by the Committee, the new or changed standard is submitted to the approval of Member States (simple majority).

Clarifications to standards and associated references are assessed and authorised by the relevant subordinate body, subject to seeking input from relevant stakeholders.

The IHO Secretariat maintains an on-line register of IHO stakeholders used to inform and seek input from stakeholders. Stakeholders include other international organizations, maritime administrations, equipment manufacturers, data distributors, users and professional organizations.

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[9] IHO Resolution 2/2007 (as amended) - *Principles and procedures for making changes to IHO technical standards and specifications*, IHO Publication M-3, 2nd Edition 2010, updated to January 2013.

[10] ISO/IEC Directives, Part 2 - *Principles to structure and draft documents intended to become International Standards, Technical Specifications or Publicly Available Specifications*, 6th Edition, 2011.

2.4 Cooperation between the IHO, ISO/TC 211 and the OGC

The OGC and the IHO are category A liaisons of ISO/TC 211. Category A liaisons are organizations that make an effective contribution to the work of the technical committee for questions dealt with by the technical committee. Such organizations are given access to all relevant documentation and are invited to meetings. They may nominate experts to participate on the development of standards in working groups (ISO/IEC Directives, Part 1 2012).

The OGC and ISO/TC 211 have a long history of collaboration and development of joint standards documents, the submission of OGC standards to ISO/TC 211 for consideration for approval as International Standards, and the use of ISO/TC 211 developed standards as part of the OGC Abstract Specification, the conceptual foundation for most OGC specification development activities. Open interfaces and protocols are built and referenced against the Abstract Specification, thus enabling interoperability between different brands and different kinds of spatial processing systems.

OGC develops standards that can be directly implemented. Many of these implementation standards are based on the conceptual (or abstract) models defined by ISO or jointly by the OGC and ISO. Therefore, the OGC maintains a Class A Liaison relationship with ISO/TC 211. The terms of the agreement[11] are:

- The OGC wishes to obtain ISO International Standard status for its Industry Implementation Standards.
- ISO/TC 211 wishes to adopt appropriate Industry Implementation Specifications as ISO International Standards or other ISO deliverables.
- The OGC wishes, while retaining its market responsiveness, to align with ISO/TC 211 on working practices.
- ISO/TC 211 wishes, within the constraints of the ISO Directives, to co-operate with OGC in assisting the alignment of life cycle working practices.
- The OGC and ISO/TC 211 wish to harmonize and agree their respective work programmes and to set up a group to handle issues under this agreement.
- The OGC and ISO/TC 211 wish to achieve mutual benefit from sharing the expertise of domain experts of the two organisations and they welcome cross-project participation.

The current OGC standards baseline and their relationship to the ISO 19100 series of standards is documented in the OGC Reference Model (ORM). The OGC Reference Model (ORM) describes the OGC Standards Baseline focusing on relationships between the baseline documents. The OGC Standards Baseline (SB) consists of the approved OGC Abstract and Implementation Standards (Interface, Encoding, Profile, and Application Schema – normative documents) and OGC Best Practice documents (informative documents).

The cooperation between IHO and ISO/TC 211 has been driven by the development of standards for digital hydrographic information and products. The IHO recognized the benefits of developing standards based on some or all of the parts of the ISO 19100 series or other related standards and both organizations agreed to formalize their cooperation through a Memorandum of Understanding[12] in order to strengthen the joint development of international standards and to avoid duplication of work on standards related to hydrography and nautical charting and related data, products and services.

As a category A liaison organization to ISO/TC 211, IHO members, IHO technical staff, and IHO nominated experts attend ISO/TC 211 working groups and plenary meetings and participate in the work in a non-voting capacity. IHO liaison to ISO/TC 211 provides overall co-ordination of this activity within IHO.

As an accredited Non Governmental International Organization, ISO/TC 211 representatives participate as non-voting liaison members in the IHO committees and working groups so that reciprocal liaison is achieved.

Reports on the work of the IHO are given at each relevant ISO/TC 211 plenary or working group meeting; reciprocally, and conversely, reports on the work of ISO/TC 211 are given at each relevant IHO meeting.

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[11] http://www.isotc211.org/Agreements/Agreement_OGC.pdf

[12] http://www.iho.int/mtg_docs/International_Organizations/MOU/IHOISO.pdf

3. Summary of the analysis

This section provides a summary of the detailed analysis in Annexes C to K of this report. Section 3.1 provides an overview of existing IHO, ISO and OGC geographic information standards and their contribution to UN-GGIM issues. Section 3.2 presents an overview of identified future areas of geographic information standardization, indicating for each one to which UN-GGIM issues they could potentially contribute.

3.1 Existing geographic information standards

Table 1 and Figure 1 provide an overview of existing geographic information standards contributing to UN-GGIM issues. The contributions are described in detail in Annexes C to K. A short summary is provided at the end of this section

Table 1. Existing geographic information standards and the UN-GGIM issues

	UN-GGIM issue	**Number of standards**		
		ISO	OGC	IHO
(a)	Developing a national, regional and global strategic framework for geospatial information	6	5	1
(b)	Establishing institutional arrangements and legal and common frameworks	5	2	7
(c)	Building capability and capacity, especially in developing countries	5	2	2
(d)	Assuring the quality of geospatial information	7	6	8
(e)	Promoting data sharing, accessibility and dissemination	63	24	15
(f)	Embracing trends in information technology	20	18	3
(g)	Promoting geospatial advocacy and awareness	-	4	2
(h)	Working in partnership with civil society and the private sector	-	-	-
(i)	Linking geospatial information to statistics	7	6	-

The IHO, ISO and OGC standards address all the UN-GGIM identified issues, although naturally the primary focus is on issue *(e) Promoting data sharing, accessibility and dissemination*. It is important to note the comparatively high number of standards contributing to issue *(f) Embracing trends in information technology*, which confirms that in the geospatial community, similar to other communities, standards are increasingly used as a tool to facilitate innovation. The number of standards on quality contributing to *(d) Assuring the quality of geospatial information* is low in comparison to (e) and (f), but one has to keep in mind that implementing standards *per se*, e.g. standards counted under (e) and (f), also contributes to the quality of geographic information. While there are no standards contributing to *(h) Working in partnership with civil society and the private sector*, consensus based standards development in the IHO, ISO and OGC, with representatives from the private and public sector, research institutes, academia and other stakeholders, is an example of a collaborative effort with civil society and the private sector.

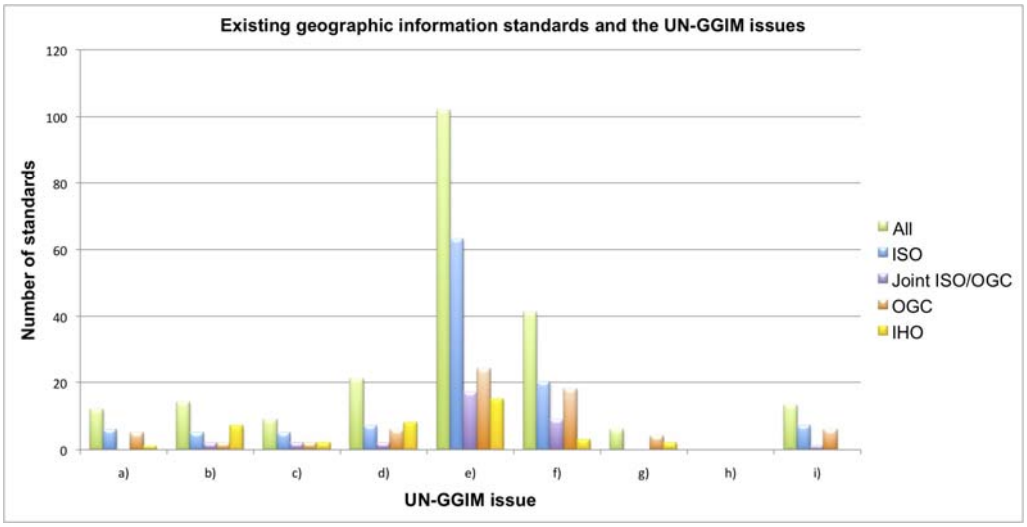

Figure 1. Existing geographic information standards and the UN-GGIM issues

(a) Developing a national, regional and global strategic framework for geospatial information

IHO recommendations address strategic frameworks relevant to geographic information in two areas: the provision of a Worldwide Electronic Navigational chart Database (WEND) and the development of Maritime Spatial Data Infrastructures (MSDI). A number of ISO standards, such as the reference model, the conceptual schema language and terminology, provide the foundations for standardization in geographic information. The SDI Cookbook published by the Global Spatial Data Infrastructure Association is an implementation guide (or 'cookbook') for spatial data infrastructures (SDI). The SDI Cookbook provides geographic information providers and users with the background information to evaluate and implement existing components of SDI, including standards.

(b) Establishing institutional arrangements and legal and common frameworks

The institutional framework for the provision of hydrographic and nautical chart services follows from the IMO SOLAS Convention (IMO 2009). Neither the OGC nor ISO has specific standards for establishing institutional arrangements and/or legal and common frameworks. However, both organizations have processes (policies and procedures) that can be used to develop consensus based, domain based, institutional agreements on domain specific models and encodings for sharing specific themes (or layers) of geographic information.

(c) Building capability and capacity, especially in developing countries

Standardized terminology is essential for unambiguous communication in professional activities, as well as in education and training. The terminology defined in IHO, ISO and OGC standards thus supports capability and capacity building. Standards exist for cross-mapping vocabularies of geographic information science and statistics, as well as vocabularies used among the multiple disciplines involved in sustainability science. The IHO, ISO and the OGC have measures in place to ensure that developing countries can participate or observe in standardization. Finally, outreach activities of the three organizations inform the geospatial community of geographic information standards.

(d) Assuring the quality of geospatial information

ISO standards for measuring quality and quality assurance of geographic information have been developed by ISO/TC 211 and the OGC, while most IHO standards related to hydrographic data and products include quality considerations. The ISO quality standards for geographic information are based on the general quality management principles defined in ISO 9000. As noted above, following standards *per se* already contributes to the quality of geographic information.

(e) Promoting data sharing, accessibility and dissemination

Standards play a prominent role in this issue. There are standards for the geospatial standardization infrastructure; data models, encodings and web services for geographic information; the management

of geographic information; tightly coupled access to geographic information; portrayal of geographic information; the digital rights management of geographic information; geodetic products; and the calibration and validation of sensors. Standards in specific domains of interest, such as addressing, land administration and climate change are emerging, while there are a considerable number of standards for hydrographic and nautical chart services. Some of these standards are jointly developed between the IHO, ISO and/or OGC. Standards are implemented in thousands of services, portals, and other applications. Content from existing OGC standards are now also included as elements in standards from other standards organizations, such as the Internet Engineering Task Force (IETF) and Organization for the Advancement of Structured Information Standards (OASIS).

(f) Embracing trends in information technology

A variety of ongoing standards development activities in the IHO, ISO and the OGC are related to facilitating interoperability in new and/or emerging technology areas, such as augmented reality, location-based services, the semantic web, sensor web enablement and e-navigation. Resulting standards have the potential to enhance the ability to provide access to geographic data and resources to many more organizations and citizens on a global scale.

(g) Promoting geospatial advocacy and awareness

Outreach activities in the three organizations are relevant here. The IHO has published two standards contributing to the promotion of geospatial advocacy and awareness.

(h) Working in partnership with civil society and the private sector

There are no specific standards for this issue, but consensus based standards development with representatives from the private and public sector, research institutes, academia and other stakeholders, is a collaborative effort with civil society and the private sector.

(j) Linking geospatial information to statistics

This issue is concerned with linking or combining different metadata conventions and systems for geospatial and statistical information, as well as combining statistical databases with geoportals containing spatial datasets. ISO metadata standards for geographic information are implemented in many geoportals and thus relevant here. The OGC has developed a standard for linking geospatial data, such as census boundaries, with corresponding statistical data.

The level of harmonization and interoperability of hydrographic and nautical chart services on a world-wide basis can be considered as satisfactory. What is far from satisfactory is the limited capacity to collect hydrographic data on a worldwide basis and the number of coastal States that do not have relevant arrangements in place to provide adequate hydrographic surveying and nautical chart services. This not only impacts directly on risks to safety of lives at sea and the protection of the marine environment, but also impedes the sustainable exploitation of the resources of the seas and the oceans - the development of the so-called Blue Economy.

Over the last 30 years the numbers of surveying vessels operated by IHO Member State governments has declined by 34% for offshore vessels and 35% for coastal vessels. This reduction in numbers of vessels has not been offset by either the use of more efficient technology, such as LiDAR or multibeam sensors or through governments opting for commercial survey contracts. An examination of IHO Publication C-55 - *Status of Hydrographic Surveying and Nautical Charting Worldwide* shows that progress in the amount of sea area surveyed in most States is slow or non-existent. For many coastal States there are very large areas of their waters for which there is little or no hydrographic data.

In spite of recurring resolutions of the UN General Assembly and decisions of the IMO Council urging coastal States to fulfill their obligations, progress is slow as governments of developing countries face more pressing needs in a context of increasing national budgetary constraints and reduced international aid. Out of 151 States in the world with significant coastlines, only 81 have so far become Members of the IHO.

3.2 Future areas of standardization

An active IHO work programme is in place that addresses new requirements and future trends, notably with the development of the ISO-based S-100 series of hydrographic geospatial standards. Progress is subject to continued active involvement on a voluntary basis of Member States and expert contributors from industry and academia. This involvement needs to be encouraged and valued in order to counter continuing pressure to reduce or discontinue activities with no obvious short term return on investment.

ISO responds to standardization needs in the market, rather than deciding itself when to develop a new standard. The ISO/TC 211 Programme Maintenance Committee (PMG) monitors the ISO 19100 series of published standards and standards under development to ensure harmonization and consistency. The PMG also monitors changing requirements and technological developments to ensure that the TCs programme of work is aligned to these.

For this report a number of future areas of standardization were identified. This is not a comprehensive list, but gives an idea of standardization that could contribute to resolving UN-GGIM issues in future. Table 2 presents a statistical overview of the identified areas of standardization. A short summary of the future areas of standardization described in Annexes C to K is provided at the end of this section.

Table 2. Future areas of geographic information standardization and the UN-GGIM issues

	UN-GGIM issue	Future areas of standardization
(a)	Developing a national, regional and global strategic framework for geospatial information	1
(b)	Establishing institutional arrangements and legal and common frameworks	2
(c)	Building capability and capacity, especially in developing countries	6
(d)	Assuring the quality of geospatial information	2
(e)	Promoting data sharing, accessibility and dissemination	16
(f)	Embracing trends in information technology	12
(g)	Promoting geospatial advocacy and awareness	6
(h)	Working in partnership with civil society and the private sector	-
(i)	Linking geospatial information to statistics	2

(a) Developing a national, regional and global strategic framework for geospatial information

UN member countries should be encouraged to leverage and build upon existing geospatial standardization initiatives in the IHO, ISO and the OGC.

(b) Establishing institutional arrangements and legal and common frameworks

Various frameworks for the standardization of geographic information exist and these need to be described and developed into best practices so that communities can take informed decisions when deciding on a framework to suit their needs. Management system standards describe processes and procedures to ensure that an organization fulfils tasks required to achieve set objectives. Such standards would not only contribute to establishing frameworks, but also to build capacity and capability, assuring the quality of information and to promote geospatial advocacy and awareness.

(c) Building capability and capacity, especially in developing countries

Terminology, standards and training material need to be translated into many more languages. Standardized descriptions of geospatial knowledge, skills and competencies are required for capacity building so that, amongst others, qualifications can be compared and training material can be developed accordingly. Additional cross-mappings between vocabularies of multiple disciplines are required. Collaboration on outreach activities between IHO, ISO, the OGC and UN-GGIM would be beneficial to all. See also management system standards under (b) above.

(d) Assuring the quality of geospatial information

There is a need to quantify and qualify the provenance of crowd sourced content. Quality standards tailored for crowd sourced information could contribute to this need. See also management system standards under (b) above.

(e) Promoting data sharing, accessibility and dissemination

While standards for generic geospatial information exist, the need for geospatial standards in specific domains of interest is emerging. Work on addressing (together with the Universal Postal Union) and land administration data models has started, work in the climate change domain is under discussion. Work on ontologies to enable the geospatial semantic web, ubiquitous public access to geographic

information and the calibration and validation of sensors has been initiated. Other future areas of standardization are in the field of license agreements for geographic information, geodetic references and LiDAR. See also translations, outreach, cross-mappings and standardized descriptions of knowledge, skills and competencies under (e) above, as well as an ISO standard for administrative boundaries in (j) below.

(f) Embracing trends in information technology

Standard development activities in new and emerging technology described earlier are also relevant here. Amongst others, augmented reality, location-based services, the semantic web, sensor web enablement and e-navigation are included.

(g) Promoting geospatial advocacy and awareness

See under (b) above. See also translations, outreach and standardized descriptions of knowledge, skills and competencies under (e) above

(h) Working in partnership with civil society and the private sector

n/a

(j) Linking geospatial information to statistics

The development of an ISO standard for the second administrative level boundaries (http://www.unsalb.org/) dataset developed by the UN Geographic Information Working Group (UN GIWG) was identified. See also cross-mappings under (e) above.

4. Recommendations

The IHO, ISO and the OGC welcome input on requirements, use cases, issues, change requests and any other form of community input from the UNCE GGIM or UN member nations to make standards better and as relevant as possible to UN-GGIM issues. Active engagement from the UNCE GGIM at a strategic and/or technical level is encouraged to assist in crafting and evolving the respective standards baseline to match UN-GGIM requirements. With this in mind, **ISO/TC 211 invites the UNCE GGIM to become an ISO/TC 211 Category A liaison** in order to influence and benefit from the ISO/TC 211 work.

Consistent policy (similar to INSPIRE in EUROPE) and best practices for standards implementation advocated by the UNCE GGIM is needed to facilitate the interoperability of standards implemented in one region or country with those from another region or country.

Continued outreach and education is essential and the three organizations recommend UN-GGIM collaboration with existing activities. With the increasing emergence of mobile based applications, the outreach and education is not with the end user but with the organizations that maintain the infrastructure and develop the applications the end users access.

Noting that 71% of the surface of the planet is occupied by seas and oceans it is **recommended that UN-GGIM acknowledges that the UN initiative on Global Geospatial Information Management includes the maritime dimension** and welcomes the contribution of the International Hydrographic Organization (IHO) to the provision and development of standards, information, products and services related to hydrography and nautical charting.

Noting that recurring resolutions of the UN General Assembly encouraging States to work with IHO to increase the coverage of hydrographic information on a global basis have had little or no impact on States that have not yet become members of the IHO and that current IHO Member States are tempted to reduce their involvement for short term savings, it is **recommended that UN-GGIM urges States to address as a matter of priority the critical need to improve hydrographic services and the production of nautical charts and coordinate their activities within the framework of the IHO**.

Annex A. Tabular overview: Existing geographic information standards and the UN-GGIM issues

Table 3 lists ISO, OGC and IHO standards alphabetically, indicating to which UN-GGIM issue each contributes. This is a summary of the contributions described in Annexes C to K. There is an Annex for each issue. For each 'X' in the table below, the corresponding contribution is described in the relevant Annex.

Table 2. Existing geographic information standards and the UN-GGIM issues

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
CEN/TR 15449-1:2012, *Geographic information - Spatial data infrastructures - Part 1: Reference model. European Committee for Standardization (CEN), CEN/TC 287, Geographic information*	X		X						
CEN/TR 15449-2:2012, *Geographic information - Spatial data infrastructures - Part 2: Best practices. European Committee for Standardization (CEN), CEN/TC 287, Geographic information*	X		X						
CEN/TR 15449-3:2012, *Geographic information - Spatial data infrastructures - Part 3: Data centric view. European Committee for Standardization (CEN), CEN/TC 287, Geographic*	X		X						
IHO B-6 - *Standardization of Undersea Feature Names*		X			X				
IHO C-17 - *Spatial Data Infrastructures: "The Marine Dimension" - Guidance for Hydrographic Offices*	X	X					X		
IHO C-51 - *A Manual on Technical Aspects of The United Nations Convention on the Law of The Sea - 1982*		X							
IHO S-4 - *Regulations for International (INT) Charts and Chart Specifications of the IHO*				X	X				
IHO S-5 - *Standards of Competence for Hydrographic Surveyors*			X						
IHO S-8 - *Standards of Competence for Nautical Cartographers*			X						
IHO S-11 - Part A - *Guidance for the Preparation and Maintenance of INT Chart schemes*		X							
IHO S-12 - *Standardization of List of Lights and Fog Signals*					X				
IHO S-23 - *Limits of Oceans and Seas*					X				
IHO S-32 - *Hydrographic Dictionary*					X				

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
IHO S-44 - *Standards for Hydrographic Surveys*				X					
IHO S-49 - *Standardization of Mariners' Routeing Guides*					X				
IHO S-52 - *Specifications for Chart Content and Display Aspects of ECDIS*					X				
IHO S-53 - *Joint IMO/IHO/WMO Manual on Maritime Safety Information*		X							
IHO S-57 - *Transfer Standard for Digital Hydrographic Data*				X	X				
IHO S-58 - *Recommended ENC Validation Checks*				X					
IHO S-60 - *Users Handbook on Datum Transformations involving WGS 84*					X				
IHO S-61 - *Product Specifications for Raster Navigational Charts (RNC)*					X				
IHO S-63 - *Data Protection Scheme*					X				
IHO S-64 - *Test Data Sets for ECDIS*				X					
IHO S-65 - *ENC Production Guidance*		X		X	X				
IHO S-66 - *Facts about Electronic Charting and Carriage Requirements*							X		
IHO S-99 - *Operational Procedures for the Organization and Management of the IHO Geospatial Information Registry*		X							
IHO S-100 - *Universal Hydrographic Data Model*					X	X			
IHO S-101 - *ENC Product Specification* (in development)				X	X	X			
IHO S-102 - *Bathymetric Surface Product Specification*				X	X	X			
ISO/DIS 19101-1, *Geographic information -- Reference model -- Part 1: Fundamentals*	X				X				
ISO 19101-2:2008, *Geographic information -- Reference model -- Part 2: Imagery*	X				X				
ISO/TS 19103, *Geographic information -- Conceptual schema language*	X				X				
ISO/TS 19104:2008, *Geographic information -- Terminology*	X		X		X				
ISO 19105:2000, *Geographic information -- Conformance and testing*	X				X				
ISO 19106:2004, *Geographic information -- Profiles*	X	X			X				

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
ISO 19107:2003, *Geographic information -- Spatial schema (*approved by OGC Members as a topic volume in the OGC Abstract Specification)					X				
ISO 19108:2002, *Geographic information -- Temporal schema*					X				
ISO 19109:2005, *Geographic information -- Rules for application schema*					X				
ISO 19110:2005, *Geographic information -- Methodology for feature cataloguing*					X				
ISO 19111:2007, *Geographic information -- Spatial referencing by coordinates* (approved by OGC Members as a topic volume in the OGC Abstract Specification)					X				
ISO 19111-2:2009, *Geographic information -- Spatial referencing by coordinates -- Part 2: Extension for parametric value (joint ISO/OGC document)*				X	X	X			
ISO 19112:2003, *Geographic information -- Spatial referencing by geographic identifiers*					X				
ISO 19115:2003, *Geographic information -- Metadata* (approved by OGC Members as a topic volume in the OGC Abstract Specification)				X	X	X			X
ISO 19115-1, *Geographic information -- Metadata -- Part 1: Fundamentals*				X	X	X			X
ISO 19115-2:2009, *Geographic information -- Metadata -- Part 2: Extensions for imagery and gridded data*				X	X	X			X
ISO 19115-3, *Geographic information -- Metadata -- Part 3: XML schema implementation of metadata fundamentals*				X	X	X			X
ISO 19116:2004, *Geographic information -- Positioning services*					X	X			
ISO 19117:2012, *Geographic information -- Portrayal*					X				
ISO 19118:2011, *Geographic information -- Encoding*					X				
ISO 19119:2005, *Geographic information -- Services.* (approved by OGC Members as a topic volume in the OGC Abstract Specification)					X				
ISO/TR 19122:2004, *Geographic information/ Geomatics -- Qualification and certification of personnel*			X						
ISO 19123:2005, *Geographic information -- Schema for coverage geometry and functions*					X				
ISO 19125-1:2004, *Geographic information -- Simple feature access -- Part 1: Common architecture* (OGC standard submitted to ISO/TC 211)					X	X			

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
ISO 19125-2:2004, *Geographic information -- Simple feature access -- Part 2: SQL option* (OGC standard submitted to ISO/TC 211)					X	X			
ISO 19126:2009, *Geographic information -- Feature concept dictionaries and registers*					X				
ISO/TS 19127:2005, *Geographic information -- Geodetic codes and parameters*		X			X				
ISO 19128:2005, *Geographic information -- Web Map Server interface* (OGC standard submitted to ISO/TC 211)					X	X			
ISO/TS 19129:2005, *Geographic information -- Imagery, gridded and coverage data framework*					X				
ISO/TS 19130:2010, *Geographic information -- Imagery sensor models for geopositioning*					X				
ISO/TS 19130-2, *Geographic information -- Imagery sensor models for geopositioning -- Part 2: SAR, InSAR, Lidar and sonar*					X				
ISO 19131:2007, *Geographic information -- Data product specifications*					X				
ISO 19132:2007, *Geographic information -- Location-based services – Reference model*					X	X			
ISO 19133:2005, *Geographic information -- Location-based services -- Tracking and navigation*					X	X			
ISO 19134:2007, *Geographic information -- Location-based services -- Multimodal routing and navigation*					X	X			
ISO 19135:2005, *Geographic information -- Procedures for item registration*					X				
ISO/TS 19135-2:2012, *Geographic information -- Procedures for item registration -- Part 2: XML Schema Implementation*					X				
ISO 19136:2007, *Geographic information -- Geography Markup Language (GML)* (OGC standard submitted to ISO/TC 211)					X	X			
ISO 19136-2, *Geographic information -- Geography Markup Language (GML) -- Part 2: Extended schemas and encoding rules* (OGC standard submitted to ISO/TC 211)					X	X			
ISO 19137:2007, *Geographic information -- Core profile of the spatial schema*					X				
ISO/TS 19139, *Geographic information -- Metadata -- XML schema implementation*					X				X

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
ISO/TS 19139-2:2012, *Geographic information -- Metadata -- XML Schema Implementation -- Part 2 : Extensions for imagery and gridded data*					X				X
ISO 19141:2008, *Geographic information -- Schema for moving features*					X				
ISO 19142:2010, *Geographic information -- Web Feature Service* (OGC standard submitted to ISO/TC 211*)*					X	X			
ISO 19143: 2010, *Geographic information -- Filter encoding* (OGC standard submitted to ISO/TC 211)					X	X			
ISO 19144-1:2009, *Geographic information -- Classification systems -- Part 1: Classification system structure*					X				
ISO 19144-2:2012, *Geographic information -- Classification systems -- Part 2: Land Cover Meta Language (LCML)*					X				
ISO 19145, *Geographic information -- Registry of representations of geographic point locations*					X				
ISO 19146:2010, *Geographic information -- Cross-domain vocabularies*			X		X				X
ISO 19147, *Geographic information -- Transfer Nodes*					X				
ISO 19148:2012, *Geographic information -- Linear Referencing*. (approved by OGC Members as a topic volume of the OGC Abstract Specification)					X				
ISO 19149:2011, *Geographic information -- Rights expression language for geographic information – GeoREL* (OGC standard submitted to ISO/TC 211)		X	X		X				
ISO 19150-1, *Geographic information -- Ontology -- Part 1: Framework*					X	X			
ISO 19150-2, *Geographic information -- Ontology -- Part 2: Rules for developing ontologies in the Web Ontology Language (OWL)*					X	X			
ISO 19152:2012, *Geographic information -- Land Administration Domain Model (LADM)*					X				
ISO 19153, *Geospatial Digital Rights Management Reference Model (GeoDRM RM)* (OGC standard submitted to ISO/TC 211)		X	X		X				
ISO 19155:2012, *Geographic information -- Place Identifier (PI) Architecture*					X	X			
ISO 19156:2011, *Geographic information -- Observations and measurements.* (OGC standard submitted to ISO/TC 211)					X				
ISO 19157, *Geographic information -- Data quality*				X					

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
ISO/TS 19158:2012, *Geographic information -- Quality assurance of data supply*				X					
ISO 19159-1, *Geographic information -- Calibration and validation of remote sensing imagery sensors -- Part 1: Optical sensors*					X				
ISO 19160-1, *Addressing -- Part 1: Conceptual model*					X				
ISO 19161, *Geodetic references* (preliminary stage)		X			X				
ISO 19162, *Geographic information -- Well known text representation of coordinate reference systems* (Joint OGC-ISO/TC 211 project)					X	X			
ISO 19163, *Geographic information -- Content components and encoding rules for imagery and gridded data*					X				
ISO 6709:2008, *Standard representation of geographic point location by coordinates*					X				
OGC Catalogue Service Interface Standard	X	X		X	X	X			X
OGC CityGML 2.0 Encoding Standard	X			X	X	X	X		
OGC GeoAPI					X	X			
OGC GeoSPARQL Encoding Standard					X	X			
OGC GeoXACML Encoding Standard					X	X			
OGC GML in JPEG 2000 Encoding Standard					X				
OGC KML 2.2 Encoding standard	X		X		X	X	X		
OGC Open GeoSMS Encoding Standard (submitted to the ITU for consideration as an International Standard)	X				X	X	X		
OGC OpenLS Interface Standard					X	X			
OGC Ordering Service Interface Standard					X				
OGC OWS Common					X				
OGC PUCK protocol standard					X				
OGC SensorML Encoding Standard. Being submitted to JTC 1 WG7 for consideration as an International Standard				X	X	X			X
OGC Sensor Observation Service Interface Standard. Being submitted to JTC 1 WG7 for consideration as an International Standard				X	X	X			X
OGC Sensor Planning Service. Being submitted to JTC 1 WG7 for consideration as an International Standard				X	X	X			
OGC Style Layer Descriptor Encoding Standard					X				

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
OGC SWE Common Data Model. Being submitted to JTC 1 WG7 for consideration as an International Standard					X	X			
OGC SWE Service Model. Being submitted to JTC 1 WG7 for consideration as an International Standard					X	X			
OGC Table Joining Service Interface Standard					X				X
OGC WaterML 2.0 Encoding Standard. Being submitted to WMO for consideration as a WMO international standard	X	X	X	X	X	X	X		X
OGC Web Coverage Service Interface Standard					X	X			
OGC Web Map Context Encoding Standard					X	X			
OGC Web Map Tile Service Interface Standard					X	X			
OGC Web Processing Service Interface Standard					X	X			X

Annex B. Tabular overview: Identified future areas of geographic information standardization and the UN-GGIM issues

Table 4 lists identified areas of standardization that could contribute to resolving UN-GGIM issues in future. This is a summary of the standardization areas identified and described in Annexes C to K. There is an Annex for each issue. For each 'X' in the table below, the corresponding standardization area and its potential contribution to the UN-GGIM issue is described in the relevant Annex.

Table 4. Identified future areas of geographic information standardization and the UN-GGIM issues

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
Leverage and build upon existing geospatial standardization initiatives	X								
Guidelines for frameworks conducive to standards.		X					X		
Management system standards.		X	X	X			X		
Translations of the terminology in the field of geographic information.			X		X		X		
Standardized descriptions of knowledge, skills and competencies in geographic information science (GISc).			X		X		X		
Cross-mapping among vocabularies used in multiple disciplines.			X		X				X
Outreach activities to promote awareness and use of standards.			X		X		X		
Multi-lingual standards outreach, education and training.			X		X		X		
Quality assurance for crowdsourced data**.**				X					
ISO 19150-3, Geographic information – Ontology -- Semantic operators					X				
ISO 19150-4, Geographic information – Ontology -- Service ontology					X				
Ontologies for national geographic information									
Standardized license agreements.					X				
Standardization requirements to be identified by the ISO 19161, *Geodetic references.*					X				
Standards for the calibration and validation for additional types of remote sensing imagery sensors: LIDAR, SAR/InSAR and microwave radiometers (RADAR) and SONAR.					X	X			

	(a) Develop strategic framework	(b) Establish institutional arrangements	(c) Building capacity and capability	(d) Quality assurance	(e) Sharing, access, dissemination	(f) Embracing trends	(g) Geospatial advocacy and awareness	(h) Civil society & private sector	(i) Linking to statistics
Standardization requirements identified by the ISO 19160, *Addresses*: ISO 19160-2, *Good practices for address assignment schemes.*					X				
Standardization requirements identified by the ISO 19160, *Addresses*: ISO 19160-3, *Quality management for address data.*					X				
Standardization requirements identified by the ISO 19160, *Addresses*: ISO 19160-5, *Address rendering for purposes other than mail.*					X				
Standardization of essential climate variables.				X	X				
Standardization requirements identified by the review summary report of ISO 19154.					X	X			
ISO standardized representation of boundaries to which statistical data is linked.					X				X
Emerging trends described in Annex H.						X			

Annex C. Developing a national, regional and global strategic framework for geospatial information

While there are no specific ISO/TC 211 or OGC standards for defining strategic frameworks for geographic information, the SDI Cookbook published by the Global Spatial Data Infrastructure Association[13] is an implementation guide (or 'cookbook') for spatial data infrastructures (SDI). Through the support of the global GSDI community, the SDI Cookbook provides geographic information providers and users with the background information to evaluate and implement existing components of SDI, including standards:

> 'To enable builders of SDI to make use of and build on existing SDI components in a way which makes their endeavors compatible with the efforts of other SDI builders, this GSDI Cookbook identifies:
>
> - existing and emerging standards,
> - open-source and commercial standards-based software solutions,
> - supportive organisational strategies and policies and
> - best practices.
>
> Working within a common framework of standards and tools based on these standards also makes it possible to maximize the impact of the total available resources for SDI creation through future co-operation -- e.g. we develop this, you develop that, and then we share. Although proprietary or project-based solutions for information sharing continue to exist, the adoption of consistent geospatial data sharing principles will in general provide a better solution for information dissemination, through publishing geospatial data using the Internet and computer media. In an increasingly "global community", there is a need to ensure that transnational implementations and common knowledge bases are available. Ultimately, these SDI activities should improve collaboration within the geospatial data industry and make the benefits derived from the use of geographic information part of everyday life for all.' (GSDI 2012)

Chapter 10 of the SDI Cookbook (recently updated) focuses on the identification of compatible, mature geospatial standards that allow maximum technical interoperability based on general evaluation criteria. This chapter defines an SDI standards baseline of mature, widely implemented standards. This baseline is intended for all SDI communities interested in providing and accessing geospatial data over the Internet. The baseline of standards is comprised of key standards from the World Wide Web Consortium (W3C), ISO/TC 211 and the OGC.

The SDI Cookbook also touches on legal issues and economic policy (chapter 8), access and delivery (chapter 6), outreach and building capacity (chapter 9), and other issue areas of concern to the UN-GGIM community.

IHO recommendations address strategic frameworks relevant to geographic information in two areas: the provision of a Worldwide Electronic Navigational chart Database (WEND) and the development of Maritime Spatial Data Infrastructures (MSDI).

The purpose of WEND is to ensure a world-wide consistent level of high-quality, updated official Electronic Navigational Charts (ENC) through integrated services that support chart carriage requirements defined in Chapter V of the Convention for Safety of Life at Sea (SOLAS) of the International Maritime Organization (IMO) and the requirements of the IMO Performance Standards for Electronic Chart Display and Information Systems (ECDIS). IHO Resolutions 1/1997 (as amended) - *Principles of the Worldwide Electronic Navigational chart Database (WEND)* and 2/2012 - *Reaffirmation of the IHO's commitment to full ENC coverage*[14] set out the relevant strategic principles and guidelines to be implemented by Member States.

IHO Publication C-17 - *Spatial Data Infrastructures: "The Marine Dimension" - Guidance for Hydrographic Offices*, listed in Annex B, provides background information and guidance for

[13] www.gsdi.org

[14] IHO Publication M-3, 2nd Edition 2010, updated to January 2013.

developing the maritime component of SDI. It seeks to explain the way in which Hydrographic Offices (HO) might promote, support and participate in SDI through practical advice, simple step by step processes, useful links to reference material and examples of best practice. The options considered include having, or seeking to take on, a leading role in SDI development, seeking to support an existing SDI initiative or working with others to develop an SDI. In all cases, HOs should be seen as the competent authority concerning the provision of hydrographic and related data under any national and/or regional SDI. Working in an SDI environment as described in this document can provide a useful template to developing an SDI capability within individual HOs. An HO could choose to participate at the national or regional level in order to enjoy the shared benefits such an association might bring.

Finally, the UNCE GGIM should be encouraged to leverage and build on existing geospatial standardization initiatives in the IHO, ISO and the OGC.

Annex D. Establishing institutional arrangements and legal and common frameworks

D.1 Overview

Neither the OGC nor ISO has specific standards for establishing institutional arrangements and/or legal and common frameworks. However, both organizations have processes (policies and procedures) that can be used to develop consensus based, domain based, institutional agreements on domain specific models and encodings for sharing specific themes (or layers) of geographic information.

Many of the ISO and OGC standards can be used to institutionalize or guide such arrangements as codified in standards, best practice use, policy statements or rights management for geographic information and related services. Particularly relevant standards are described in section D.2 but many of the other standards described in the subsequent annexes can obviously also be used. This approach suggests that any organization, country or region first needs to specify policies related to sharing geographic information and services. Such policies would need to consider intellectual property, copyright, open data, data for fee structures, service access, and so forth.

Once policies and governance are in place, then activities such as defining reference architectures (common framework) and access control can be defined. There are numerous national or trans-national examples of this approach. For example, the Canada Geospatial Data Infrastructure (CGDI), the Catalonian SDI, and INSPIRE (Infrastructure for Spatial Information in Europe) are examples of how a country or a region can define institutional arrangements and common architectures and frameworks that are codified in policy and expressed in the best use practices for a standards baseline.

The OGC staff and Members have developed a number of reference architectures for spatial data infrastructures. These reference architectures provide patterns for defining a framework of technical governance, policy development, and specific implementation architectures. Examples of such reference architectures are publicly available and have been used to develop and document national and regional policy and standards and SDI governance in a number of countries and regions. Examples include:

- Spatial Interoperability Demonstration Project (SIDP), Australia, 2003[15]
- Sensors Anywhere Architecture Guidance (tied to INSPIRE directives), Europe, 2010[16]
- Reference Model for the ORCHESTRA Architecture (tied to INSPIRE), Europe, 2011[17]

Most recently the OGC released the Reference Architecture Profiler (RAP)[18]. The RAP Advisor is a web based application that recommends OGC Standards and ORM Sections that are relevant to system development, such that a community of interest can derive and build a profile of suitable OGC standards to meet their specific needs. Such a tool helps meet requirements related to many of the key UN-GGIM issues. Another source of information is provided by the technical reports (CEN/TR 15449-1:2012, CEN/TR 15449-2:2012, CEN/TR 15449-3:2012) published by CEN/TC 287, *Geographic information*, describing, amongst others, a reference model and best practice for spatial data infrastructures.

Also relevant here is the Spatial Legal subcommittee of the OGC Board of Directors, which is to address "spatial law and policy issues" that will influence development requirements of the Consortium's technology process.

The institutional framework for the provision of hydrographic and nautical chart services proceeds from the IMO SOLAS Convention (IMO 2009). Namely, SOLAS Chapter V, Regulation 9, requires Contracting Governments to ensure that hydrographic data are available in a suitable and standardized manner in order to satisfy the needs of safe navigation. It requires also that they cooperate and co-

[15] portal.opengeospatial.org/files/?artifact_id=10687
[16] http://www.tatoo-fp7.eu/tatooweb/biblio/sany-open-service-architecture-sensor-networks
[17] http://portal.opengeospatial.org/files/?artifact_id=23286
[18] http://rap.opengeospatial.org/

ordinate their activities to the greatest possible degree, in order to ensure that hydrographic and nautical information are made available on a world-wide scale.

In addition to the standards mentioned in section D.2, the following IHO documents are relevant to establishing institutional arrangements and legal and common frameworks for geographic information:

- IHO Publication B-7 - *GEBCO Guidelines* (under revision) describes the framework and procedures for collecting bathymetric data and mapping the Earth's oceans under the GEBCO project. GEBCO (General Bathymetric Chart of the Oceans) is currently a joint project of the IHO and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Its objective is to provide the most authoritative, publicly-available bathymetry data sets for the world's oceans through the efforts of an international collaborating community of scientists and hydrographers with the support of their parent organizations.
- IHO Publication C-55 - *Status of Hydrographic Surveying and Nautical Charting Worldwide* describes the worldwide coverage of surveys and nautical charts and the extent of effective organisations for the timely promulgation of navigational safety information.
- IHO Publication M-2 - *The Need for National Hydrographic Services* explains the rationale for supporting and investing in hydrography and nautical charting at a national level. It describes the benefits to national development. It also provides suggestions (Chapter 2 - The National Hydrographic Framework) about how a national Hydrographic Service can be established, how to define individual national requirements, and how to decide upon an appropriate level of involvement. It is written for all those that have an interest in the safe and efficient navigation of ships, protection of the marine environment and more generally to the improvement of the global economy through improving the wealth and prosperity of individual States.
- IHO Resolutions 7/1919 (as amended) - *Hydrographic Office Arrangements for the exchange and reproduction of nautical products* and 1/1997 (as amended) - *Principles of the Worldwide Electronic Navigational chart Database (WEND)*[19] set out the general principles on which arrangements related to cooperation and exchange of data and products between Hydrographic Offices should be based.

D.2 Existing standards

IHO Publication B-6 - ***Standardization of Undersea Feature Names*** is a joint publication of the IHO and of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. It includes recommendations for National authorities naming undersea features.

IHO Publication C-17 - ***Spatial Data Infrastructures: "The Marine Dimension" - Guidance for Hydrographic Offices,*** defines in its part 3 (SDI - Make it happen) the minimum requirements in terms of data management that Hydrographic Offices need to consider to operate an MSDI. They include inputs such as policy and plans necessary to deliver metadata, data sharing and exchange mechanisms, levels of data interoperability, network services including "discovery", "view", "download", "invoke" and "transform" and other plans necessary to ensure compliance with SDI requirements (e.g. data licensing, digital rights management, pricing).

IHO Publication C-51 - ***A Manual on Technical Aspects of The United Nations Convention on the Law of The Sea – 1982*** provides the technical geodetic and hydrographic framework relevant to the understanding and implementation of the United Nations Convention on the Law of the Sea of 1982, notably to determine and chart baselines and maritime limits and boundaries. This publication is maintained by the Advisory Board on the Law of the Sea (ABLOS) of the IHO and the International Association of Geodesy (IAG)

IHO Publication S-11 - Part A - ***Guidance for the Preparation and Maintenance of INT Chart schemes*** describes the principles and procedures for developing and maintaining regional chart schemes of paper nautical charts in order to obtain an optimized world coverage of international charts at medium and large scales for all of the world's main shipping routes, ports and port approaches.

[19] IHO Publication M-3, op cit.

IHO Publication S-53 - *Joint IMO/IHO/WMO Manual on Maritime Safety Information* provides a practical guide for anyone who is concerned with the issuance of navigational warnings or meteorological forecasts and warnings under the Global Maritime Distress and Safety System (GMDSS). Maritime Safety Information (MSI) is promulgated in accordance with the requirements of IMO resolution A.705(17), as amended. Navigational warnings are issued under the auspices of the IMO/IHO World-Wide Navigational Warning Service (WWNWS) in accordance with the requirements of IMO resolution A.706(17), as amended. Meteorological forecasts and warnings are issued under the patronage of the World Meteorological Organization (WMO).

IHO Publication S-65 - *ENC Production Guidance* describes the responsibilities that Hydrographic Offices (HOs) are expected to fulfil in relation with the production and distribution of Electronic Navigational Charts (ENCs).

IHO Publication S-99 - *Operational Procedures for the Organization and Management of the IHO Geospatial Information Registry* describes the roles, responsibilities and procedures for operating and managing the Geospatial Information Registry and its component Registers which underpin S-100, the IHO framework geospatial standard for hydrographic and related data. S-99 is based on ISO 19135.

ISO 19106:2004, *Geographic information -- Profiles* provides guidelines on how an ISO standard with many options and provisions can be converted into a profile (a specialized version of the general standard), so that the profile remains interoperable with the ISO standard (and therefore with other profiles). It is not always possible to have a single international standard to which all countries conform, but a general international standard with profiles for specific countries enables interoperability at a global scale. The representation of address information and land administration information are examples. This standard also provides guidance for establishing, managing, and standardizing at the national level.

ISO 19149:2011, *Geographic information -- Rights expression language for geographic information - GeoREL* defines a XML-based vocabulary or language to express rights for geographic information in order that digital licenses may be created for such information and related services. This language, an extension of the rights expression language in ISO/IEC 21000-5, is to be used to compose digital licenses. Each digital license will unambiguously express those particular rights that the owners (or their agent) of a digital geographic resource extend to the holders of that license. The digital rights management system in which these licenses are used can then offer ex ante (before the fact) protection for all such resources. ISO 19149:2011 is a joint ISO/TC 211 and OGC document. It was prepared and submitted by the OGC to ISO/TC 211.

ISO 19153, *Geospatial Digital Rights Management Reference Model (GeoDRM RM)* (publication expected in May 2013) is a reference model for digital rights management (DRM) functionality for geospatial resources (GeoDRM). As such, it is connected to the general DRM market in that geospatial resources must be treated as nearly as possible like other resources, such as music, text, or services. It is not the intention to reinvent a market nor the existing technology that already exists and is thriving, but to make sure that a larger market has access to geospatial resources through a mechanism that it understands and that is similar to and consistent with the ones already in use. ISO 19153 was prepared and submitted by the OGC to ISO/TC 211.

ISO/TC 211 control body for a geodetic registry network. The ISO/TC 211 control body for a geodetic registry network has started drafting requirements for an international registry of geodetic codes. ISO/TS 19127, *Geographic information -- Geodetic codes and parameters*, applies the principles of ISO 19111, *Geographic information -- Spatial referencing by coordinates*, and ISO 19135, *Geographic information -- Procedures for item registration*, to establish rules for the population and maintenance of registers of geodetic codes and parameters. The registry consists of an information system available on the Internet (i.e. a database with a user interface and associated web services for access), a registration authority (i.e. an organization hosting the register and taking care of the daily operations), and a control body (i.e. an international committee responsible for authorizing the content of the ISO register of the geodetic registry network) (ISO/TC 211 2011a). See also the work on standardizing geodetic products and corresponding standardization needs described in Annex G, section G.10.

OGC GeoXACML Encoding standard defines a geo-specific extension to the XACML Policy Language, as defined by the OASIS standard 'eXtensible Access Control Markup Language (XACML), Version 2.0'. Due to the similarity of XACML version 2.0 to its predecessor versions (e.g. 1.0 or 1.1), the extension described in this document also represents a valid extension for earlier XACML versions. As being an extension to OASIS eXtensible Access Control Markup Language

(XACML), GeoXACML provides support for spatial data types and spatial authorization decision functions. Those data types and functions can be used to define additional spatial constraints for XACML based policies.

D.3 Identified future areas of standardization

D.3.1. Guidelines for frameworks conducive to standards

Various frameworks for the standardization of geographic information exist. For example, the INfrastructure for SPatial InfoRmation in Europe (INSPIRE) is a legally enforced top-down approach, AuScope (http://www.auscope.org.au/) and the National Collaborative Research Infrastructure Strategy (NCRIS) where limited financial support facilitates broader uptake of mainly existing technologies, while Geoscience Markup Language (GeoSciML) is driven entirely by enthusiasts in a bottom-up approach. Pros and cons and best practices should be described, basically, a narrative version of the business-case analysis, so that countries and regions can take informed decisions when deciding on a framework to suit their needs. The framework directly impacts on the promotion of standards for data sharing, accessibility and dissemination.

D.3.2. Management system standards

Management system standards describe processes and procedures used to ensure that an organization fulfils tasks required to achieve set objectives. The need for management system standards comes from outside information communities to adopt and integrate geographic information into their management systems (e.g. INSPIRE, governments and global organisations). The ISO/TC 211 ad hoc group on management system standards recommended preliminary work on the topic. ISO/TC 211 has sent out an invitation to submit a new work item proposal on this (ISO/TC 211 2011b). It was recommended that this work include policies and management, governance, guidance for the use of geographic information, licensing and release of geographic data. Such standards would not only contribute to establishing frameworks, but also to build capacity and capability, assuring the quality of information and to promote geospatial advocacy and awareness.

Annex E. Building capability and capacity, especially in developing countries

E.1 Overview

The use of standardized terminology is needed for unambiguous communication. Such terminology is also essential for education and training and therefore related to capacity building. The terminology defined in ISO and OGC standards supports one aspect of the UN-GGIM identified need for building capability and capacity.

Standardized descriptions of geospatial knowledge, skills and competencies are required for capacity building, for example, so that education and training courses can be developed accordingly.

Cross-mapping vocabularies of geographic information science and statistics, as well as vocabularies used among the multiple disciplines involved in sustainability science, will improve understanding and communication related to the objectives of the UN-GGIM.

Finally, outreach activities to inform the geospatial community of geographic information standards and related work are relevant here.

Relevant existing standards and activities are listed in section E.2.

E.2 Existing standards and activities

ISO/TS 19104:2008, *Geographic information -- Terminology* provides guidelines for the collection and maintenance of terminology in the field of geographic information. A multi-lingual glossary of terms is available at http://www.isotc211.org/Terminology.htm in Arabic, Chinese, Danish, Dutch, English, Finnish, French, German, Japanese, Korean, Polish, Russian, Spanish and Swedish. In some languages only a subset of the terminology has been translated. These terms provide the basis for communication in the field of geographic information in different languages and are therefore essential for communication about geospatial information management at the global level.

ISO/TR 19122:2004, *Geographic information -- Qualification and certification of personnel,* is a report (not a standard) that describes the situation regarding qualification and certification in some member countries and the ongoing activities of some relevant international professional associations.

ISO 19146:2010, *Geographic information -- Cross-domain vocabulary* defines a methodology for cross-mapping technical vocabularies that have been adopted by industry-specific geospatial communities. The standard is relevant for communication and interoperability in any multi-disciplinary endeavour, e.g. geoinformatics and/or sustainability science.

The **ISO/TC 211 Advisory Group on Outreach** compiles a fact sheet on each published standard and also compiled the ISO/TC 211 Standards Guide (ISO/TC 211 2009c). Workshops and presentations at conferences are arranged from time to time.

The OGC has a long and well-documented history of **standards work related to cross community collaboration and the related technology known as semantic mediation**. There are numerous examples of the use of OGC standards to enable cross community, cross jurisdiction, and/or cross-domain interoperability, including cross mapping of vocabularies. The initial semantic mediation and related schema mapping interoperability testbeds, pilots and experiments occurred in the early 2000's. This work was driven by transportation and emergency response use cases. More recently, the OGC has been facilitating sophisticated testbed activities focused on cross community interoperability (CCI).

The **OGC's program of outreach and communication** (aka marketing) promotes the use of OGC and related ISO standards to the global community. In this regard, the OGC:

- uses social media (LinkedIn, Twitter, etc) to engage as broad a community as possible;
- interacts with 30+ other standards and best practices organizations, such as the Internet Engineering Task Force (IETF), Organization for the Advancement of Structured Information Systems (OASIS), World Wide Web Consortium (W3C), World Meteorological Organisation

(WMO), International Union of Geological Sciences (IUGS)[20], GSDI, and International Environmental Modeling and Software (IEMS)[21] to ensure the consistent and effective modelling and communication of geographic information and services;

- has an OGC blog where any OGC Member can post items of interest about the implementation of OGC and related standards;
- has a Business Value Working Group focusing on the business and technical value of participating in standards development processes, in implementing standards, and in setting policy and governance for the best practice use of standards;
- supports OGCNetwork, a publicly accessible resource for sharing information on the use OGC and related OGC standards; and
- has participation and presentation by OGC staff in dozens of workshops, conferences, and seminars; and
- works with a number of Members on translating OGC standards into Chinese, French and Spanish.

There are 151 States in the world with significant coastlines, but only 81 have so far become Members of the IHO. Therefore, capacity building is one of the priorities of the IHO. As early as 1972, IHO Resolution 2/1972 (as amended) - *Technical assistance and cooperation in the field of hydrography*[22] outlined how the IHO Secretariat should assist developing countries in establishing or strengthening their hydrographic capabilities. A specific subordinate body, currently the IHO Capacity Building Sub-committee (CBSC), was set up to support the implementation of the IHO capacity building strategy.

Besides IHO Publication M-2 - *The Need for National Hydrographic Services* which provides the rationale and framework for developing hydrographic capabilities (see Annex D), two IHO standards relate to capacity building:

IHO Publication S-5 - *Standards of Competence for Hydrographic Surveyors* specifies the minimum degree of knowledge and experience considered necessary for hydrographic surveyors in government and industry, and provide a set of programme outlines against which the FIG[23]-IHO-ICA[24] International Board on Standards of Competence may evaluate programmes submitted for recognition.

IHO Publication S-8 - *Standards of Competence for Nautical Cartographers* is the equivalent for the profession of nautical cartographers.

The latest editions of both publications address the recognition of schemes that maintain the competency of individuals beyond their formal training and education.

E.3 Identified future areas of standardization

E.3.1. Translations of the terminology in the field of geographic information

Terminology in the field of geographic information needs to be translated into many more languages. For some languages not all terms were translated and there is also a need to complete these. Terminology translations are essential for the communication about geographic information and are therefore important for building capacity and capability at a local (country) level.

[20] IUGS: International Union of Geological Sciences
[21] IEMS: International Environmental Modeling and Software
[22] IHO Publication M-3, ibid.
[23] FIG: International Federation of Surveyors.
[24] ICA: International Cartographic Association.

E.3.2. Standardized descriptions of knowledge, skills and competencies in geographic information science (GISc)

While the responsibility for qualification and certification of professionals lies with education institutions, national statutory bodies and/or professional associations, standardized descriptions of knowledge, skills and competencies in GISc contribute towards building capacity and capability in various ways:

- assessing and comparing GISc education and training capacity;
- assessing and comparing GISc human resource capacity;
- preparing GISc education and training material;
- comparing GISc qualifications from different institutions; and
- creating GISc job descriptions for posts needed in support of the issues identified by the UN-GGIM.

A body of knowledge has been prepared in the US (UCGIS 2006). See also du Plessis & Van Niekerk (2012) for a comparison of competency requirements in geographic information science.

E.3.3. Management system standards

See D.3.2 for a description of the need for management system standards. Such standards will support this UN-GGIM issue by providing a means of assessing geospatial capacity and also by being best practice guidelines for building capacity.

E.3.4. Cross-mapping among vocabularies used in multiple disciplines

Cross-mapping vocabularies of geographic information science and statistics, as well as vocabularies used among the multiple disciplines involved in sustainability science, will improve understanding and communication related to the objectives of the UN-GGIM. Additional cross-mappings are required.

E.3.5. Outreach activities to promote awareness and use of standards

There is a need to continuously inform the geospatial community about the value and benefits of standards. Collaboration between ISO, the OGC and UN-GGIM on outreach would be to the benefit of all.

E.3.6. Multi-lingual standards outreach, education and training

ISO/TC 211 standards are prepared in English and translated into French and Russian by the ISO Central Secretariat. Within the OGC community, a number of OGC standards have been translated into Chinese and Spanish. However, additional translations are required to ensure proper uptake and use of OGC and related ISO standards in all parts of the world.

Standards are written with conformance testing in mind. Complementary material is required to understand their application and implementation. Within ISO/TC 211, the fact sheets (ISO/TC 211 2012a) and Standards Guide (ISO/TC 211 2009c) provide some of this information. The technical reports published by CEN/TC 287, *Geographic information*, (CEN/TR 15449-1:2012, CEN/TR 15449-2:2012, CEN/TR 15449-3:2012) provide further complementary material. Additional material, as well as translations of existing material into additional languages, is required.

OGC staff now has the ability to present and perform training in multiple languages including Spanish, German, Arabic, Dutch, French, Greek, and English. Through Member partnerships, education and training are also available in other languages (Korean, Chinese, Italian, etc).

Annex F. Assuring the quality of geospatial information

F.1 Overview

ISO standards for measuring quality and quality assurance of geographic information have been developed by ISO/TC 211 and the OGC. These standards are based upon the general quality management principles defined in ISO 9000. Most IHO standards related to hydrographic data and products include quality considerations.

Relevant standards and activities are reviewed in section F.2.

F.2 Existing standards and activities

IHO Resolution 1/1997 (as amended) - ***Principles of the Worldwide Electronic Navigational chart Database (WEND)*** invite ENC producers to consider implementing a quality management system conforming to a suitable recognised standard such as ISO 9001:2008 (as amended).

The IHO has instituted a Data Quality Working Group, under the aegis of HSSC, with the primary objective to develop appropriate methods of classifying and depicting the quality of digital hydrographic data. The following IHO standards include specifications related to the quality of geospatial information:

IHO Publication S-4 - ***Regulations for International (INT) Charts and Chart Specifications of the IHO*** addresses the depiction of the quality of source data on nautical charts.

IHO Publication S-44 - ***Standards for Hydrographic Surveys*** addresses quality control procedures in conducting and rendering hydrographic surveys.

IHO Publication S-57 - ***Transfer Standard for Digital Hydrographic Data*** specifies data quality encoding and addresses the depiction of quality of source data on Electronic Navigational Charts (ENC).

IHO Publication S-58 - ***Recommended ENC Validation Checks*** specifies the checks that, at a minimum, producers of ENC validation tools should include in their validation software. This software will be used by hydrographic offices to help ensure that their ENC data are compliant with the S-57.

IHO Publication S-64 - ***Test Data Sets for ECDIS*** provides the standardized data sets that are necessary to accomplish all testing requirements specified by the International Electrotechnical Commission (IEC) standard for testing Electronic Chart Display and Information Systems (ECDIS). The IEC standard[25] is intended for use by type approval authorities in view of ECDIS certification as well as by ECDIS manufacturers in the frame of ECDIS design and production.

IHO Publication S-65 - ***ENC Production Guidance*** requires that ENC producers set up a quality management system for ENC production and distribution, in accordance with IHO Resolution 1/997 (as amended).

IHO Publication S-101 - ***ENC Product Specification*** (in development) addresses the depiction of quality of source data on ENC.

IHO Publication S-102 - ***Bathymetric Surface Product Specification*** specifies data quality encoding for bathymetric surface products.

ISO/DIS 19157, *Geographic information -- Data quality* (publication expected in April 2014, to replace ISO 19113:2002, ISO 19114:2003 and ISO/TS 19138:2006) establishes the principles for describing quality of geographic data. Requirements for a data quality evaluation process, data quality metadata, a standalone quality report and data quality measures are specified. This standard is related to the metadata standards described in G.4.2.

[25] IEC 61174: Electronic chart display and information system (ECDIS) - Operational and performance requirements, methods of testing and required test results, Edition 3.0, 2008-09.

ISO/TS 19158:2012, ***Geographic information -- Quality assurance of data supply*** provides a framework for quality assurance specific to geographic information. It is based upon the quality principles and quality evaluation procedures of geographic information identified in ISO 19157 and the general quality management principles defined in ISO 9000.

OGC Data Quality Domain Working Group. The OGC has an active Data Quality Domain Working group. The OGC also has a number of documents and standards that detail encoding of a variety of uncertainty and data quality metadata. For example, SensorML allows the application to encode all metadata for a specific sensor, including quality and provenance information. The OGC is also becoming more involved in a variety of activities related to data provenance, such as participation in the W3C Data Provenance activity and including more data provenance in our testbed activities. Finally, the OGC just published a new discussion paper related to Uncertainty and the encoding of multi-dimensional scientific data.

OGC work in quality assurance for crowd sourced data. The OGC is involved in a EU FP 7 project titled "COBWEB". The infrastructure developed will exploit technological developments in ubiquitous mobile devices, crowd-sourcing of geographic information and the operationalising of standards based SDI such as the UK Location Information Infrastructure. It will enable citizens living within Biosphere Reserves to collect environmental information on a range of parameters including species distribution, flooding and land cover/use. A main driver will be the opportunity to participate in environmental governance.

Data quality issues will be addressed by using networks of people as sensors and by analysing observations and measurements in real-time combination with authoritative models and datasets. The citizens observatory framework will integrate with evolving INSPIRE compliant national SDIs and allow the fusion of citizen sourced data with reference data from public authorities in support of policy objectives.

To maximise impact, COBWEB will work within the processes of the standards defining organisations. Specifically, it aims to improve the usability of Sensor Web Enablement standards with mobile devices, develop widespread acceptance of the data quality measures and maximise the commercial appeal of COBWEB outputs.

F.3 Identified future areas of standardization

F.3.1. Management system standards

Refer to D.3.2 for a description of management system standards, which complement quality assurance.

F.3.2. Quality assurance for crowd sourced data

There is a recognition that moving forward, an increasing volume of geospatial data and sensor observations will be provided by volunteered and crowd sourced frameworks. Refer also to existing work in F.2 in which OGC is involved. Thus, there will be a need to quality assure applications and a need for the ability to quantify and qualify provenance and quality of crowd sourced content. ISO/TS 19158:2012 provides a framework for quality assurance for non-crowdsourced geographic information. However, more work is needed to make this applicable to crowdsourced data.

Annex G. Promoting data sharing, accessibility and dissemination

G.1 Overview

Standards play a prominent role in this UN-GGIM issue. As a result the list of relevant standards is quite long. To provide some structure, this section has sub-sections similar (but not identical) to the categories described in the ISO/TC 211 Standards Guide (ISO/TC 211 2009c).

G.2 Standardizing the geospatial standardization infrastructure

The first set of standards provides the infrastructure for geospatial standardization. They are relevant to the UN-GGIM inventory of issues because they are related to all other ISO/TC 211 and OGC standards.

A reference architecture is critical to the proper use and definition of what standards to be used and what profiles or application schemas of those standards are most beneficial to the organization or enterprise. Developing a reference architecture requires an organization or enterprise to discuss and document requirements, use cases, and business processes. Simply implementing a standard does not guarantee success! There are numerous, publicly available documents that describe reference architectures for SDIs. See also Chapter 10 in the GSDI Cookbook (2012).

Relevant standards are described below.

ISO/DIS 19101-1, ***Geographic information -- Reference model -- Part 1: Fundamentals*** (revision of ISO 19101:2002, publication expected in June 2013) provides a mechanism to structure the scope of the standardization activity in geographic information.

ISO/TS 19101-2, ***Geographic information -- Reference model -- Part 2: Imagery*** extends the first part of ISO 19101 to specify a reference model for standardization in the field of geographic imagery processing.

ISO/TS 19103:2005, ***Geographic information -- Conceptual schema language*** (currently under revision, revised publication expected in March 2015) specifies how the Unified Modeling Language (UML) is to be used as conceptual schema language in the ISO 19100 series of standards.

ISO/TS 19104:2008, ***Geographic information -- Terminology.*** See description in Annex E, section E.2.

ISO 19105:2005, ***Geographic information -- Conformance and testing*** provides the framework, concepts and methodology for testing and criteria to be achieved to claim conformance to ISO/TC 211 family of standards. It needs to be revised to include the latest developments on modularizing standards.

ISO 19106:2004, ***Geographic information -- Profiles.*** See description in Annex D, section D.2.

ISO 19146:2010, ***Geographic information -- Cross domain vocabulary.*** See description in Annex E, section E.2.

G.3 Standardizing the data models for geographic information

These standards describe data models for geographic information. They provide the 'tools' for representing individual features in geographic information required by the UN-GGIM.

Many of these ISO standards provide the abstract framework or models from which content models and implementation standards can be defined and implemented. For example, ISO 19107 provides a model for specifying geometry, topology, and features and the underlying relationships. It is the foundation for how geometry (points, lines, polygons, curves, etc) are specified in implementation standards such as the OGC Geography Markup Language (GML). Standards such as GML are then the

basis for encoding specific domain content models such as CityGML (3D city models), WXXM (weather information), AIXM (aeronautical information), and so forth.

Content models (and the encodings) in specific domains of interest are based firstly on specific domain requirements and vocabularies (semantics) and secondly on the geometry and other models as defined in the ISO standards described in this section.

Relevant standards are described in the sub-sections that follow.

G.3.1. Geographic point location by coordinates

ISO 6709:2008, ***Standardised representation of geographic point location by coordinates*** specifies the representation of coordinates used to describe point locations. The standard is primarily intended for data interchange between computer systems. An informative annex summarizing the different requirements at the human interface is included.

G.3.2. Schemas for features

ISO 19107:2003, ***Geographic information -- Spatial schema*** specifies UML classes for representing the spatial characteristics of features as composites of geometric and/or topological primitives. ISO 19107:2003 is approved by OGC Members as a topic volume in the OGC Abstract Specification.

ISO 19108:2002, ***Geographic information -- Temporal schema*** does the same as ISO 19107 for the temporal characteristics of features and also specifies classes for describing relevant temporal reference systems.

ISO 19109:2005, ***Geographic information -- Rules for application schema*** (currently under revision, revised publication expected in April 2015) defines rules for creating and documenting application schemas (conceptual schemas for data required by one or more applications), including principles for the definition of features. It defines the General Feature Model (GFM), a model of the concepts required to classify a view of the real world.

ISO 19123:2005, ***Geographic information -- Schema for coverage geometry and functions*** provides a schema for an alternative representation of spatial information as a coverage, in which non-spatial attributes are assigned directly to geometric objects rather than to features composed of such objects.

ISO 19137:2007, ***Geographic information -- Core profile of a spatial schema*** is a profile (subset) of ISO 19107 that is limited to describing features as simple geometric primitives of 0, 1, or 2 dimensions.

ISO 19141:2008, ***Geographic information -- Schema for moving features*** extends ISO 19107 to support the description of moving geometric objects.

G.3.3. Schemas for imagery

ISO/TS 19129:2009, ***Geographic information -- Imagery, gridded and coverage data framework*** defines the framework for imagery, gridded and coverage data: a content model for the content type imagery and for other specific content types that can be represented as coverage data. These content models are represented as a set of generic UML patterns for application schemas.

ISO/TS 19130:2010, ***Geographic information -- Imagery sensor models for Geopositioning*** identifies the information required to determine the relationship between the position of a remotely sensed pixel in image coordinates and its geoposition. It also defines the metadata to be distributed with the image to enable user determination of geographic position from the observations.

ISO/TS 19130-2:2012, ***Geographic information -- Imagery sensor models for geopositioning – Part 2: SAR, InSAR, Lidar and sonar*** extends ISO 19130 with a set of metadata elements required for geolocation by providing physical sensor models for LIght Detection And Ranging (LIDAR) and SOund Navigation And Ranging (SONAR), and a more detailed set of elements for Synthetic Aperture Radar (SAR). It also provides a schema for all of these metadata elements.

G.4 Standardizing the management of geographic information

This sub-section deals with standards for the management of geographic information. In contrast to the data model standards, which are focused on individual features and their characteristics, these standards are focused on the description of data sets containing information about one or, typically, many feature instances. These standards provide the 'tools' for managing geographic information required by the UN-GGIM.

G.4.1. Specifications for referencing

The ability to provide consistent vocabularies and encodings of reference information, such as coordinate reference systems, is critical to sharing geospatial data locally, regionally, and globally. There are a variety of ISO and OGC standards related to referencing. OGC standards implement the ISO standards for spatial referencing in order to provide a consistent, well known way to encode and communicate reference information/metadata. Further, the OGC provides a common and consistent set of implementation standards for expressing referencing information as Well Known Text (WKT), uniform resource identifiers (uris), or http uris (aka URLs). The OGC also provides best practices statements for using the OGP EPSG database as a normative reference for coordinate referenced system parameters and metadata. Finally, the OGC is considering how to provide a publicly accessible CRS registry.

Relevant standards are described below.

ISO 19111:2007, *Geographic information -- Spatial referencing by coordinates* specifies a schema for coordinate based reference systems, which is necessary for geographic information to be shared between applications. The schema is of value to developers of geographic information systems and other applications requiring data based upon coordinate reference systems. Producers and users use the standard to specify and identify coordinate reference systems of geographic data. ISO 19111:2007 is a joint ISO/TC 211 and OGC document and approved by OGC Members as a topic volume in the OGC Abstract Specification.

ISO 19111-2:2009, *Geographic information -- Spatial referencing by coordinates – Part 2: Extension for parametric values* specifies the conceptual schema for the description of spatial referencing using parametric values or functions. It applies the schema of ISO 19111 to combine a position referenced by coordinates with a parametric value to form a spatio-parametric coordinate reference system (CRS). The standard is applicable to producers and users of environmental information. ISO 19111-2:2009 is a joint ISO/TC 211 and OGC document

ISO 19112:2003, *Geographic information -- Spatial referencing by geographic identifiers.* Spatial reference may be provided by using geographic identifiers (e.g. place names) instead of coordinates. This standard specifies the conceptual schema to define and describe systems for spatial referencing by geographic identifiers, which enables gazetteers to be constructed in a consistent manner.

ISO 19148:2012, *Geographic information -- Linear Referencing* specifies a conceptual schema for locations relative to a one-dimensional object as measurement along (and optionally offset from) that object. It defines a description of the data and operations required to use and support linear referencing. It is applicable to transportation, utilities, location-based services and other applications, which define locations relative to linear objects (ISO 19148:2012). ISO 19148:2012 is approved by OGC Members as a topic volume in the OGC Abstract Specification.

G.4.2. Metadata and data product specifications

The ability to discover what geodata and geospatial resources are available is a critical aspect of an operational SDI. The use of catalogues and registries provides the online ability to enter and maintain metadata, discover resources, and federate discovery across organizations. In turn, standards are required that provide a common and consistent vocabulary for defining metadata and a standard catalogue service interface to discover and access geospatial resources. In the vernacular of web services, this is the ability to publish metadata about resources and data, to find these resources, and to bind to these resources.

ISO/TC 211 and the OGC provide a number of standards that enable the implementation of online catalogues, described in the next section. The key OGC standard is the OGC Catalogue Interface Standard (Web). This standard has been implemented using a variety of application profiles, including one for ISO 19115:2003, *Geographic information -- Metadata*. This particular profile is widely implemented in both vendor products as well as any number of online SDI portal applications.

Some of the metadata standards and their corresponding XML implementations are currently under revision. This will result in two editions of the standards being available. The second generation standards should be used to develop new products and services, but the first generation standards continue to be available for backward compatibility. Table 5 below shows which standards should be used together.

Table 5. First and second generation metadata standards

Generation	Conceptual schema	Corresponding XML implementation
First	ISO 19115:2003	ISO/TS 19139:2007
	ISO 19115-2:2008	ISO/TS 19139-2:2012
Second	ISO 19115-1 (publication expected June 2013)	ISO 19115-3 (publication expected May 2015)
	ISO 19115-2 (revision to be initiated)	ISO 19115-4 (to be initiated)

Relevant standards are described below.

ISO 19115:2003, ***Geographic information -- Metadata*** provides a conceptual schema for the description of geographic datasets, which enables users to determine whether the dataset is of use to them and how to access it. The common set of metadata terminology, definitions and extension procedures defined in this standard promotes the proper use and effective retrieval of geographic data. ISO 19115:2003 is approved by OGC Members as a topic volume in the OGC Abstract Specification.

ISO/DIS 19115-1, ***Geographic information -- Metadata -- Part 1: Fundamentals*** (revision of ISO 19115:2003, publication expected in June 2013) is a revised edition of ISO 19115:2003.

ISO 19115-2:2008, ***Geographic information -- Metadata -- Part 2: Extensions for imagery and gridded data*** extends ISO 19115:2003, adding 138 additional metadata elements for describing imagery datasets.

ISO 19115-3:2009, ***Geographic information -- Metadata -- Part 3: XML schema implementation of metadata fundamentals*** (publication expected in May 2015) provides the XML schema implementation for ISO/DIS 19115-1.

ISO 19115-4:2009, ***Geographic information -- Metadata -- Part 4: XML schema implementation of extensions for imagery and gridded data*** (to be initiated) provides the XML schema implementation for ISO 19115-3.

ISO/TS 19139:2007, ***Geographic information -- Metadata -- XML schema implementation*** provides the XML schema implementation for ISO 19115:2003.

ISO/TS 19139-2:2012, ***Geographic information -- Metadata -- XML Schema Implementation -- Part 2: Extensions for imagery and gridded*** data provides the XML schema implementation for ISO 19115-2:2008.

ISO 19131:2007, ***Geographic information -- Data product specifications*** makes use of the metadata terminology defined in ISO 19115:2003 to describe the requirements for specifying the characteristics expected of a geographic data product.

OGC Catalogue Interface Standard (2.0.2). This document specifies the interfaces between clients and catalogue services, through the presentation of abstract and implementation-specific models. Catalogue services support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Metadata in catalogues represent resource characteristics that can be queried and presented for evaluation and further processing by both humans and software. Catalogue services are required to support the discovery and binding to registered information resources within an information community.

OGC Catalogue Interface Standard is a profile of ISO 19115:2003. This document explains how Catalogue Services based on the ISO19115/ISO19119 Application Profile for the OGC Catalogue Services Specification v 2.0.2 [OGC 07-006] are organized and implemented for the discovery, retrieval and management of data metadata, services metadata and application metadata.

G.4.3. Standards for registries

ISO 19135:2005, ***Geographic information -- Procedures for item registration*** (currently under revision, publication expected in November 2014) specifies procedures for establishing and maintaining registers of identifiers and meanings assigned to items of geographic information.

ISO/TS 19135-2:2012, ***Geographic information -- Procedures for item registration -- Part 2: XML Schema Implementation*** defines an XML encoding for the storage and exchange of ISO 19135-compliant registers and register items.

ISO 19145, ***Geographic information -- Registry of representations of geographic point locations*** (publication expected in April 2013) defines the structure of a register for the descriptions of geographic point location representation. A registry of representations of geographic point locations gives access to description of the format in which a geographic point location is encoded and also identifies conversion services to transform the representation of the geographic point location to another representation.

G.4.4. Feature catalogues and concept dictionaries

ISO 19110:2005, ***Geographic information -- Methodology for feature cataloguing schema*** (currently under revision, revised publication expected in January 2015). Feature catalogues define the types of features represented in geographic data and enable the dissemination, sharing and use of geographic data through a better understanding of the contents and meaning of the data. The standard provides a standard framework for organizing and reporting the classification of features. . This standard describes the features, attributes, operations and relationships among features and is therefore related to the metadata standards described in G.4.2 because it also describes geographic information.

ISO 19126:2009, ***Geographic information -- Feature concept dictionaries and registers*** specifies a schema for geographic feature concept dictionaries managed as registers. A feature concept dictionary provides basic definitions and related information about a set of concepts that may be used to describe geographic features and shared across multiple application areas. It provides a complete textual specification of a set of feature types and their properties and relationships. The standard includes a profile of the standard for Defense Geospatial Information Working Group (DGIWG).

G.4.5. Classification

ISO 19144-1:2009, ***Geographic information -- Classification systems -- Part 1: Classification system structure*** establishes the structure of a geographic information classification system, together with the mechanism for defining and registering the classifiers for such a system. It specifies the use of discrete coverages to represent the result of applying the classification system to a particular area and defines the technical structure of a register of classifiers in accordance with ISO 19135. The structure can be used to develop specific classification systems that address particular application areas, specified in other parts of ISO 19144.

ISO 19144-2:2012, ***Geographic information -- Classification systems -- Part 2: Land Cover Meta Language (LCML)*** specifies a Land Cover Meta Language (LCML) expressed as a UML metamodel that allows different land cover classification systems to be described based on physiognomic aspects. It also specifies the detailed structure of a register for the extension of LCML but does not specify the maintenance of the register. This International Standard recognizes that there exist a number of land cover classification systems. It provides a common reference structure for the comparison and integration of data for any generic land cover classification system, but is not intended to replace those classification systems.

G.5 Standardizing the encoding of geographic information

This sub-section deals with encodings for geographic information, including those required in a geospatial semantic web.

G.5.1. Encoding rules

ISO 19118:2011, *Geographic information -- Encoding* provides a model for rule-based encoding of data that conforms to an application schema.

ISO 19163, *Geographic information -- Content components and encoding rules for imagery and gridded data* (initiated in 2012, schedule to be agreed) classifies imagery and regularly-spaced gridded thematic data into types based on attribute property, sensor type, and spatial property, and defines an encoding-neutral content model for the required components for each type of data. It also specifies logical data structures and the rules for encoding the content components in the structures. It provides examples on how to bind the logical data structures into selected commonly-used physical data formats. It does not define any new physical data formats.

G.5.2. Vendor and content model neutral XML encodings

A key requirement for a global geographic information management infrastructure is the ability to encode and share any geographic content in a vendor neutral encoding. Further, there is the need for the ability to encode any geographic content model, regardless of domain, in a common, well known encoding such as XML. Finally, there is the requirement to be able to capture and encode not just geometry but also features and their related semantics. The standard that provides such a capability is the Geography Markup Language (GML).

Relevant standards are described below.

ISO 19136:2007, *Geographic information -- Geography Markup Language (GML)* specifies ISO 19118 compliant XML encodings of a number of the conceptual classes defined in the ISO 19100 series of standards. ISO 19136:2007 is a joint ISO/TC 211 and OGC document. It was originally developed in the OGC in the late 1990s as part of the OGC Web Mapping testbed. It has matured significantly since then and is now widely implemented in numerous information communities and applications. GML was submitted to ISO/TC 211 in the mid-2000s and published as an ISO Standard in 2007. There is a current ISO/TC 211 new work item proposal related to the latest revision of GML as provided by the OGC.

ISO 19136-2, *Geographic information -- Geography Markup Language (GML) -- Part 2: Extended schemas and encoding rules* (publication expected February 2014) builds on GML 3.2, published as ISO 19136:2007, and extends it with additional schema components and requirements. The OGC recently submitted ISO 19136-2 as a new work item proposal (NWIP) to ISO/TC 211. This NWIP is related to the latest revision of GML (GML 3.3).

G.5.3. Well known text (WKT) encodings

ISO 19162, *Geographic information -- Well known text representation of coordinate reference systems* (initiated in 2012, schedule to be agreed) defines a simple string implementation of the abstract model for coordinate reference systems described in ISO 19111:2007. ISO 19162 is a joint ISO/TC 211 and OGC project currently under development.

G.5.4. Ontologies

The sub-section deals with standards specifying ontological representations of geographic information. These standards are relevant to the emerging semantic web. Preliminary stage work in ISO/TC 211 identified how the concept of ontology and the Semantic Web can support and facilitate the work of ISO/TC 211, as well as how ISO/TC 211 may contribute to the Semantic Web in the perspective of

improving the interoperability of geographic information. From this work, it was recommended that four standards be developed (ISO/TC 211 2009b). Work on the first two parts has started; the other two parts are included in G.5.5.

Relevant standards are described below.

ISO/TS 19150-1, *Geographic information -- Ontology -- Part 1: Framework* (publication expected January 2013) defines the framework for semantic interoperability of geographic information. This framework defines a high level model of the components required to handle semantics in the ISO geographic information standards with the use of ontologies.

ISO 19150-2, *Geographic information -- Ontology -- Part 2: Rules for developing ontologies in the Web Ontology Language (OWL)* (publication expected January 2015) specifies rules and guidelines for the development of ontologies of geographic information in support of interoperability over the Semantic Web. The Web Ontology Language (OWL) is the language adopted for ontologies. The standard specifies how UML static view modelling elements in ISO standards are to be converted into OWL. It further defines conversion rules for describing application schemas based on the General Feature Model defined in ISO 19109 into OWL.

G.5.5. Identified future areas of standardization

G.5.5.1 ISO 19150-3, *Geographic information -- Ontology -- Semantic operators*

Definitions of semantic proximity operators between concepts associated with geometric and temporal representations. These operators should complement the current suites of geometric and temporal operators defined in ISO/TC 211 standards (ISO/TC 211 2009b).

G.5.5.2 ISO 19150-4, *Geographic information -- Ontology -- Service ontology*

Provide specifications for enhanced service metadata in order to support discovery of web services on the Semantic Web. Such a standard should specify the preferable description language for ISO/TC 211 web services: OWL-S, WSML, or another (ISO/TC 211 2009b).

G.5.5.3 Ontologies for national geographic information.

Consideration should be given to the existence of thematic data on many topics in the various national mapping agencies or jurisdictions. Standardizing and harmonizing such thematic data in compliance with a common data model would be a tremendous task which might not be conceivable since it would require data transformation to comply with the standard. However, developing high level ontologies that would serve as a semantic bridge to connect existing thematic data from the different origins would contribute to their interoperability and should also contribute to the UN-GGIM in achieving its mandate. The development of ISO and OGC standards on high level ontologies may be considered by ISO/TC 211 to support UN-GGIM and facilitate the reuse of national geographic information.

G.6 Standardizing tightly coupled access to geographic information

The sub-section deals with standards that describe a tightly coupled access interface to geographic information. These standards were originally developed in the OGC and then submitted to ISO/TC 211. They are broadly implemented in the marketplace and are supported in most proprietary and open source geospatial database products.

Relevant standards are described below.

ISO 19125-1:2004, *Geographic information -- Simple feature access -- Part 1: Common architecture* (currently under revision in the OGC) describes a common architecture for providing access to information about features with simple geometry. ISO 19125-1:2004 is a joint ISO/TC 211 and OGC document. It was prepared and submitted by the OGC to ISO/TC 211. The corresponding OGC document is currently under revision in the OGC. The standard describes the common architecture for simple feature geometry, a distributed computing platform neutral model represented in UML. The base Geometry class has subclasses for Point, Curve, Surface and GeometryCollection. Each geometric object is associated with a Spatial Reference System, which describes the coordinate

space in which the geometric object is defined. The extended Geometry model has specialized 0, 1 and 2-dimensional collection classes named MultiPoint, MultiLineString and MultiPolygon for modeling geometries corresponding to collections of Points, LineStrings and Polygons, respectively. MultiCurve and MultiSurface are introduced as abstract superclasses that generalize the collection interfaces to handle Curves and Surfaces.

ISO 19125-2:2004, *Geographic information -- Simple feature access -- Part 2: SQL option* (currently under revision in the OGC) specifies a Structured Query Language (SQL) implementation of ISO 19125-1. ISO 19125-2:2004 is a joint ISO/TC 211 and OGC document. It was prepared and submitted by the OGC to ISO/TC 211. The corresponding OGC document is currently under revision in the OGC.

G.7 Standardizing portrayal of geographic information

This sub-section deals with standards about the presentation of geographic information on maps.

Relevant standards are described below.

ISO 19117:2012, *Geographic information -- Portrayal* provides a schema for specifying symbols and mapping them to an application schema.

The **OpenGIS® Styled Layer Descriptor (SLD)** is a profile of the OpenGIS® Web Map Service (WMS) Encoding Standard and defines an encoding that extends the WMS standard to allow user-defined symbolization and colouring of geographic feature and coverage data. SLD addresses the need for users and software to be able to control the visual portrayal of geospatial data over the web.

The **OpenGIS® Symbology Encoding Standard (SE)** provides the ability to define styling rules through a styling language that the client and server can both understand. The SLD profile of WMS enables application of SE to WMS layers using extensions of WMS operations. Additionally, SLD defines an operation for standardized access to legend symbols.

G.8 Standardizing web services for geographic information

The sub-section deals with standards that describe web services for accessing geographic information over the web. These standards are relevant to internet GIS applications in general and in spatial data infrastructures in particular.

Relevant standards are described below.

ISO 19119:2005, *Geographic information -- Services* (currently under revision, publication expected in May 2015) identifies and defines the architecture patterns for service interfaces used for geographic information and definition of the relationships to the Open Systems Environment model. It includes a geographic services taxonomy and a list of example geographic services placed in the services taxonomy. It describes how to create a platform-neutral service specification, and how to derive platform-specific service specifications that are conformant with this. ISO 19119:2005 is approved by OGC Members as a topic volume in the OGC Abstract Specification.

ISO 19128:2005, *Geographic information -- Web Map Server interface* (currently under revision in the OGC) specifies a set of interfaces for producing spatially referenced maps from geographic information available through the web. ISO 19128-2:2005 is a joint ISO/TC 211 and OGC document. It was prepared and submitted by the OGC to ISO/TC 211. The corresponding OGC document is currently under revision in the OGC.

ISO 19142:2010, *Geographic information -- Web Feature Service* (currently under revision in the the OGC) specifies direct fine-grained web service access to geographic information at the feature and feature property level. The web service allows a web client to retrieve or modify specified data, instead of retrieving a file containing the data (and possibly more). ISO 19142:2010 is a joint ISO/TC 211 and OGC document. It was prepared and submitted by the OGC to ISO/TC 211. The corresponding OGC document is currently under revision in the OGC.

ISO 19143:2010, *Geographic information -- Filter encoding* (currently under revision in the OGC) specifies an XML and KVP (key-value pair) encoding of a system-neutral syntax for expressing projections, selection and sorting clauses collectively called a query expression. Some of the components defined in this standard are used in ISO 19142:2010. ISO 19143:2010 is a joint ISO/TC

211 and OGC document. It was prepared and submitted by the OGC to ISO/TC 211. The corresponding OGC document is currently under revision in the OGC.

G.9 Standardizing digital rights management for geographic information

This sub-section deals with standards for expressing digital rights of geographic datasets, similar to the way it is done for other resources, such as music, text, or services.

G.9.1. Existing standards

Relevant standards are described below.

ISO 19149:2011, ***Geographic information -- Rights expression language for geographic information – GeoREL.*** See description in Annex D, section D.2.

ISO 19153, ***Geospatial Digital Rights Management Reference Model (GeoDRM RM)*** (publication expected in May 2013). See description in Annex D, section D.2. This standard was developed in the OGC and submitted to ISO/TC 211.

G.9.2. Identified future areas of standardization

G.9.2.1 Standardized license agreements

If license agreements of source data sets differ, it becomes a challenge to negotiate a license agreement for an integrated dataset. Research results have proposed different approaches to the standardization of license agreements. One approach proposes the standardization of license agreements, similar to the Creative Commons License (Welle Donker et al 2010), which will simplify the integration of data from a variety of sources. There are also other approaches. Standardized license agreements will also simplify the flow of data among SDI stakeholders and between different SDIs.

G.10 Standardizing geodetic products

The standards in this sub-section deal with georeferencing information, managing this information and other geodetic products. The standards in this sub-section contribute to the development of and growing demand for a global geodetic reference system for all geospatial information, identified by UN-GGIM (ECOSOC 2012a).

G.10.1. Existing standards

Relevant standards are described below.

ISO 19111:2007, ***Geographic information -- Spatial referencing by coordinates.*** Refer to the description in section G.4.1. Amongst others, the standard provides required standardized geodetic terminology.

ISO 19111-2:2009, ***Geographic information -- Spatial referencing by coordinates – Part 2: Extension for parametric values***. Refer to the description in section G.4.1.Amongst others, the standard provides required standardized geodetic terminology.

ISO/TS 19127:2005, ***Geographic information -- Geodetic codes and parameters*** applies the principles of ISO 19111 and ISO 19135 to establish rules for the population and maintenance of registers of geodetic codes and parameter.

ISO 19161, ***Geodetic References*** is a project at the preliminary stage, i.e. no target date is set for the project and the main aim is to plan work in this area of standardization. The ISO 19161 project team investigates standardization requirements related to all geodetic products used for any scientific or societal activity, such as surveying, mapping, navigation, geo-referencing. Main items are:

- Geodetic datums
- Terrestrial reference systems and frames
- Geodetic ellipsoids
- Coordinate systems used for geo-referencing
- Map projections
- Gravity and geoïd (gravity models, geoidal models..)
- Vertical reference systems
- Geodetic networks and related metadata

Measurements, instruments, observing system or data analysis techniques used in geodesy are not included. The project aims firstly to determine the interest of standards for interoperability; the role of a validated basic terminology for common understanding between the various communities of practice; and the role of ISO/TC 211 for those aspects. Secondly, the aim is to discuss the added value of standards describing some of the fundamental geodetic references, such as a global terrestrial reference system (ITRS vs WGS84), a global vertical reference system (including the hydrographic aspects), or a universal identification system of space geodetic stations (including GNSS).

G.10.2. Identified future areas of standardization

G.10.2.1 Standardization requirements to be identified by ISO 19161, *Geodetic references*.

These requirements will be relevant to the UN-GGIM inventory of issues because they affect the collection and sharing of geographic information globally. Formal ISO standards could assist countries in realizing the ITRS. They support the development of a global geodetic reference system for all geospatial information, described by UN-GGIM (ECOSOC 2012a).

G.11 Standardizing the interface for positioning instruments and devices

ISO 19116:2004*, Geographic information -- Positioning services,* defines a standard interface for use between positioning devices and geographic information application systems. Modern electronic positioning technology is making available a wide range of positioning instruments and devices that can measure the coordinates of a location on or near the Earth dynamically with great speed and accuracy. A variety of geographic information system applications make use of these facilities including surveying, navigation and intelligent transport systems. The application of these devices will be taken up more readily with a standard interface.

G.12 Standardizing calibration and validation of sensors

This sub-section deals with standards for the calibration and valuation of sensors. Imaging sensors are one of the major data sources for geographic information. Typical spatial outcomes of the production process are vector maps, digital elevation models (DEMs), and 3-dimensional city models. The spectral analysis of images usually leads to image segmentation and a subsequent classification of the found segments. In each of these cases the quality of the end products fully depends on the quality of the measuring instruments that originally sensed the data. The quality of measuring instruments is determined and documented by calibration defined in these standards.

G.12.1. Existing standards

There are three relevant standards.

ISO/TS 19159-1, *Geographic information -- Calibration and validation of remote sensing imagery sensors -- Part 1: Optical sensors* (publication expected October 2013) defines the calibration and validation of airborne and space borne remote sensing imagery sensors. It also addresses the associated metadata related to calibration and validation that has not been defined in other ISO standards. This part is for optical sensors of the type frame cameras and line cameras (2D CCD scanners).

OGC SensorML 2.0 specifies standard models and XML Schema for describing sensors systems and processes and provides information needed for discovery of sensors, location of sensor observations, processing of low-level sensor observations, and listing of taskable properties.

OGC PUCK defines a protocol for RS232 and Ethernet connected instruments. PUCK addresses installation and configuration challenges for sensors by defining a standard instrument protocol to store and automatically retrieve metadata and other information from the instrument device itself.

G.12.2. Identified future areas of standardization

G.12.2.1 Standards for the calibration and validation for additional types of remote sensing imagery sensors: LIDAR, SAR/InSAR and microwave radiometers (RADAR) and SONAR.

These are relevant to UN-GGIM because these types of sensors are increasingly used in all kinds of applications, including LIDAR and satellite derived bathymetry, climate change monitoring and disaster management.

G.13 Standardizing in specific domains of interest

Most of the ISO/TC 211 above (in previous subsections) are generic and describe any type of geospatial data. Domain specific standards, described in this section, focus on the data itself and are needed to develop domain specific data interoperability.

Traditionally, each group or country or region defined and used their own content models and encodings. In today's world in which issues require cross-nation, regional, or even global collaboration, information sharing on a global basis is more important than ever. There is an increasing amount of activity related to domain content models and related encodings in both ISO and the OGC. For example, the ISO 19152:2012, *Geographic information – Land administration domain model*, and ISO 19160, *Addressing*, OGC Hydrology, Aviation, Meteorology, and Land Development working groups are working a variety of content models and encodings for sharing specific geographic content, such as weather information and ground water information. This works includes cross community interoperability, semantic mediation, and model mapping.

G.13.1. Addressing

The sub-section deals with standards for addressing. Addresses are one of the most common ways used to find a location and are therefore important for global geospatial information. As a result addressing is a key data theme in any spatial data infrastructure and a key location element used in many other application areas. A review summary report by the preliminary stage work in ISO 19160, *Addressing*, was concluded in 2011 (ISO/TC 211 2011c) and identified five standardization requirements (listed below). A project on the first requirement was approved in 2012 and a work item proposal for the fourth requirement is expected. It was recommended that these standards be developed in ISO/TC 211, *Geographic information/Geomatics*, possibly as joint projects together with the Universal Postal Union (UPU) and other standards organizations.

G.13.1.1 Current activities

Relevant standards are described below.

ISO 19160-1, *Addressing -- Part 1: Conceptual model* (publication expected June 2015) defines a conceptual model for address information (address model), together with the terms and definitions that describe the concepts in the model. The model provides a common representation of address information, independent of actual addressing implementations. It is not intended to replace conceptual models proposed in other specifications, but provides a means to cross-map between different conceptual models for address information and enables the conversion of address information between specifications. The model provides a basis for developing address specifications by individual countries or communities.

ISO 19160-4, *Addressing -- Part 4: International postal address components and templates.* The fourth recommendation is that UPU S42, *International postal address components and templates*, be adopted as part of this suite of international addressing standards to support interoperability of address rendering rules. The modifications should be aligned with the terminology and conceptual model in ISO 19160-1 and support additional requirements, such as vertical writing. The preparation on a new work item proposal for this work has been initiated by the UPU.

G.13.1.2 Identified future areas of standardization

ISO 19160-2, *Addressing -- Part 2: Good practices for address assignment schemes*

The second recommendation is to develop a good practice document for address assignment schemes. This includes general principles for the maintenance of address data sets. This report could be used as guidance for countries that want to develop a new addressing system, or want to evaluate or improve an existing addressing system. In addition, the report will provide guidance for developers of software and information systems in support of such addressing systems.

ISO 19160-3, *Addressing -- Part 3:* Quality management for address data

The third recommendation is to develop standards for address management that ensure address data quality. This should include measures to assess and communicate the quality of the address data, such as attribute (thematic) accuracy, logical consistency, completeness, positional accuracy and temporal accuracy. Existing standards on quality management in general should be taken into consideration. Quality standards for addresses will ensure that countries developing or maintaining address data have consistent guidelines to measure and report on the quality and integrity of the data.

ISO 19160-5, *Addressing -- Part 5: Address rendering for purposes other than mail*

The fifth recommendation is to investigate how addresses are rendered for purposes other than mail, such as in maps (cartographic portrayal) on the Web and on graphic displays of handheld devices and mobile phones. For example, this could be a conceptual model or specification for the rendering of addresses. It is recommended that a stage zero project reviews this issue and identify the standardization requirements. The standard will provide assistance to developers of software for the display of addresses on digital output and in user interfaces.

G.13.2. Climate change

Reliable assessments of global and regional environmental changes - both natural and human-induced - require systematic, consistent and well-documented observations. Since data for the terrestrial environment are obtained by national agencies and given that the existing national data gathering systems developed in the absence of a consistent international framework, the fulfilment of this requirement presents a special challenge.

G.13.2.1 Identified future area of standardization

Standardization terrestrial essential climate variables is needed to monitor climate change consistently. A report on progress on the development of standards for terrestrial essential climate variables was submitted to ISO (ISO/TC 211 2009a). However, no work item proposal has been received to date. Related information is available at http://www.isotc211.org/Climate_change/Climate_change.htm.

G.13.3. Geology

GeoSciML recently submitted to the OGC, is a content model and corresponding GML encoding for sharing borehole, geological structure, and other geology information.

G.13.4. Land administration

ISO 19152:2012, *Geographic information -- Land Administration Domain Model (LADM)* provides an abstract, conceptual model of basic information-related components of land administration (including those over water and land, and elements above and below the surface of the earth); provides terminology for land administration; is a basis for national and regional profiles; and enables the combining of land administration information from different sources in a coherent manner.

G.13.5. Transportation

ISO/DIS 19147, *Geographic information -- Transfer Nodes* (publication expected in December 2014) specifies the data types and code lists associated with the implementation of transfer nodes and their services in transport modelling and location based services. It is applicable for transportation infrastructure owners and operators when defining and/or describing their infrastructure and for transport related service providers when providing information to travellers and others.

G.13.6. Urban and building information

CityGML 2.0 is an OGC content model and corresponding GML encoding for sharing 3d urban and building information. It was recently approved as a national standard in the Netherlands. The standard includes semantics.

G.13.7. Hydrographic and nautical chart services

The standardization of hydrographic information and products, including nautical charts, is one of the core objectives of the IHO. A number of IHO resolutions adopted from 1919 onwards set out provisions related to units, symbols and abbreviations, measurements, datums, terminology, geographical names, contents of nautical publications, data formats and security, etc.[26]

The following IHO standards are relevant to promoting data sharing, accessibility and dissemination:

IHO Publication B-6 - *Standardization of Undersea Feature Names* is a joint publication of the IHO and of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. It includes guidelines for the standardization of undersea feature names outside territorial waters (principles and procedures), name proposal forms and a list of undersea feature terms and definitions.

IHO Publication S-4 - *Regulations for International (INT) Charts and Chart Specifications of the IHO* addresses the standardization of paper nautical charts. It includes three parts:

- Part A: Regulations of the IHO for International (INT) Charts,
- Part B: Chart Specifications of the IHO for Medium- and Large-scale National and International (INT) Charts,
- Part C: Chart Specifications of the IHO for Small-Scale International (INT) Charts.

IHO Publication S-12 - *Standardization of List of Lights and Fog Signals* provides a standardized structure for the publication of List of Lights and Fog Signals.

IHO Publication S-23 - *Limits of Oceans and Seas* describes the limits of oceans, seas and their subdivisions. The list is intended to ensure that all nautical publications (Sailing Directions, Notices to Mariners, etc.) headed with the name of an ocean or sea will deal with the same area.

IHO Publication S-32 - *Hydrographic Dictionary* contains terms and definitions in the two official IHO languages (English and French) and in Spanish. The definitions are intended to give concise explanations of terms, without necessarily considering specific applications or interpretations as, for example, for legal matters.

IHO Publication S-49 - *Standardization of Mariners' Routeing Guides* provides a standardized structure for the preparation and publication of Mariners' Routeing Guides.

[26] IHO Publication M-3, op cit.

IHO Publication S-52 - *Specifications for Chart Content and Display Aspects of ECDIS* consists of the following components:

- the Specifications for Chart Content and Display Aspects of ECDIS, which describes the requirements and methods in relatively general terms;
- Annex A, the Presentation Library, which gives full details of colours, symbols, symbolization instructions, etc. together with guidance on how an ENC should be displayed;
- Annex B, which specifies procedures for initial colour calibration of displays and the verification of that calibration;
- Annex C, which specifies a procedure for maintaining the calibration of displays;
- Appendix 1, Guidance on Updating the Electronic Navigational Chart.

IHO Publication S-57 - *Transfer Standard for Digital Hydrographic Data* describes the standard to be used for the exchange of digital hydrographic data between national hydrographic offices and for its distribution to manufacturers, mariners and other data users. It consists of the following components:

- Part 1 provides a general introduction including a list of references and definitions of terms used in the rest of the Standard;
- Part 2 describes the theoretical data model on which the entire Standard is based;
- Part 3 defines the data structure or format that is used to implement the data model and defines the general rules for encoding data into that format;
- Appendix A is the Object Catalogue which provides the official, IHO approved data schema that can be used within an exchange set to describe entities in the real world;
- Appendix B contains the IHO approved Product Specifications which describe additional sets of rules applicable to specific applications. It includes the current Electronic Navigational Chart (ENC) Product Specification.

IHO Publication S-60 - *Users Handbook on Datum Transformations involving WGS 84* ontains transformation constants and formulas to relate local/regional geodetic datums to WGS-84.

IHO Publication S-61 - *Product Specifications for Raster Navigational Charts (RNC)* defines the minimum requirements a Raster Navigational Chart (RNC) must have to satisfy the IMO performance standard for an ECDIS operating in Raster Chart Display System (RCDS) mode in the absence of ENC.

IHO Publication S-63 - *Data Protection Scheme* describes the recommended standard for the protection of ENC information. It defines security constructs and operating procedures that must be followed to ensure that the data protection scheme is operated correctly and to provide specifications that allow participants to build compliant systems.

IHO Publication S-65 - *ENC Production Guidance* provides a framework to inform hydrographic offices of the processes and requirements necessary to produce, maintain and distribute ENCs.

IHO Publication S-100 - *Universal Hydrographic Data Model* comprises a set of geospatial hydrographic standards which specify, for hydrographic and related information, methods and tools for data management, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. S-100 conforms as far as is reasonably possible to the ISO/TC 211 19000 series of geographical information standards, and where necessary has been tailored to suit hydrographic requirements. S-100 specifies the procedures to be followed for:

- establishing and maintaining registers of hydrographic and related information;
- creating product specifications, feature catalogues and a definition of the general feature model;
- using spatial, imagery and gridded data, and metadata specifically aimed at fulfilling hydrographic requirements.

IHO Publication S-101 - *ENC Product Specification* (in development) describes an S-100 compliant product specification for ENC. This product specification includes the content model, the encoding, the feature catalogue, portrayal catalogue and metadata.

IHO Publication S-102 - *Bathymetric Surface Product Specification* describes an S-100 compliant product specification for a Bathymetric Surface Product. It defines a content model and an exchange file format for the exchange of bathymetric coverage data.

G.13.8. Hydrology

OGC WaterML 2.0 is a content model and GML encoding for sharing hydrological and hydrogeological observation time series information. The standard is developed jointly with the World Meteorological Organisation (WMO).

G.13.9. Other

Other domains of interest in OGC are:

- 3d Information Management (CAD-GIS-BIM), jointly with ISO/TC 211
- Aviation
- Meteorology and Oceanography
- Emergency and Disaster Management
- Land Development
- Law Enforcement and Public Safety
- Earth Systems Science
- Energy and Utilities

Annex H. Embracing trends in information technology

The IHO, OGC and ISO/TC 211 have a variety of ongoing standards development activities related to providing interoperability in new and/or emerging technology areas that have the potential to enhance the ability to provide access to geographic data and resources to many more organizations and citizens on a global scale.

Currently relevant topics, amongst others, are described in more detail in the following sections.

H.1 Augmented reality

Augmented Reality Markup Language (ARML) became a Standards Working Group based on participation in the AR Standards Community meetings. The meetings have also been the venue for initial development of an AR Reference Model which has been taken up by ISO/IEC JTC 1 and which OGC anticipates to publish once it is approved.

The OGC participates in a multi-standards collaboration as part of an effort to insure consistency and harmonization of the numerous augmented reality (AR) standards (existing and emerging) that comprise the AR stack.

More specifically, the OGC has an active AR Markup Language activity. The ultimate goal of ARML 2.0 is to provide an extensible standard and framework for AR applications to serve the AR use cases currently used or developed. With AR, many different standards and computational areas developed in different working groups come together. ARML 2.0 needs to be flexible enough to tie into other standards without actually having to adopt them, thus creating an AR-specific standard with connecting points to other widely used and AR-relevant standards.

H.2 Indoor modelling and navigation

OGC Members are heavily involved in modelling indoor and outdoor space. A key current activity is titled “InDoorGML”. The aim of IndoorGML is to represent and exchange the geoinformation that is required to build and operate indoor navigation systems. IndoorGML will provide the essential model and data for important applications like building evacuation, disaster management, personal indoor navigation, indoor robot navigation, indoor spatial awareness, indoor location based services, and the support for tracking of people and goods. IndoorGML provides a framework for the flexible integration of different localization technologies and allows the ad-hoc selection of the appropriate navigation data according to the capabilities of the mobile device and the offered localization technologies of a building.

Indoor navigation comprises route planning, localization, and tracking of subjects (i.e. people) and objects (e.g. robots or other indoor vehicles). IndoorGML will support these activities in different modes of locomotion, i.e. walking, driving, and flying as well as navigation in virtual environments. Since there is no unique localization technology like GPS available indoors, many different types of indoor positioning techniques are used today, often in combination with each other. This makes it necessary to provide geospatial data about the different senders, receivers, and sensors and their respective signal ranges.

In 2012, OGC has become increasingly known in the commercial mobile domain in particular regarding IndoorGML. Based on activity in late 2012, awareness of OGCs relevance is increasing the mobile areas of Indoor Maps and Indoor Location (i.e., position determination). High-level visibility for OGC is afforded by appointment of staff to the European Commission Future Internet – Public Private Partnership (FI-PPP) Advisory Board.

H.3 Internet of Things

A series of workshops on the Internet of Things (IoT) led by the OGC identified the most important topic to be sensor webs. The IoT is an important focus area for OGC standards activity because for

millions of potential users, sensor data will be accessible from a variety of network accessible sensors. Real time sensor information is critical to a large number of time sensitive decision support applications (such as where to find affordable clean water or available hospital beds) to life saving emergency alert services, such as for tsunamis.

Based on recommendations from the IoT Workshops, OGC formed a Sensor Web for IoT (SWIOT) Standards Working Group in 2012. The initial scope of the SWIOT SWG seeks to make observations captured by IoT devices easily available to applications and users through data aggregation portals. The OGC also has participated in the ITU Joint Coordination Activity on Internet of Things (JCA-IoT). This collaboration will continue.

H.4 Location-based services

ISO 19132:2007*, Geographic information -- Location-based services – Reference model* provides a reference model and a framework for location base services.

ISO 19133:2005*, Geographic information -- Location-based services – Tracking and navigation* provides a schema for describing the data and services needed to support tracking and navigation applications for mobile clients.

ISO 19134:2007*, Geographic information -- Location-based services – Multimodal routing and navigation* extends ISO 19133 to support mobile clients using two or more transportation modes to reach a destination.

ISO 19155:2012*, Geographic information -- Place Identifier (PI) Architecture* specifies an architecture that defines a reference model with an encoding method for an identifier of a place in the real world and places in the virtual world. These places are identified using coordinate identifiers, geographic identifiers, or virtual world identifiers such as URI. A mechanism to match multiple place identifiers to the same place is provided, as well as a data structure and the definition of a set of service interfaces. The standard is applicable to location-based services, emergency management services and other application domains that require a common architecture, across specific domains, for the representation of place descriptions using coordinate, geographic, or virtual world identifiers.

H.5 Mobile Internet

The OGC Mobile Internet focus area represents the intersection of multiple OGC activities and continued to produce results in 2012. The OGC feels that this is a very important standards work activity due to the fact that mobile, location enabled devices will be the primary client interface for millions of potential users of geospatial content and services. This is especially true in developing nations and regions in which desktop computers and other traditional mechanisms for accessing geo-enabled applications simply do not exist – nor will they exist in the future.

H.6 Positioning instruments and devices (e.g. GPS)

ISO 19116:2004*, Geographic information – Positioning services.* See description in Annex G, section G.11.

H.7 Semantic Web

ISO/TS 19150-1, Geographic information -- Ontology -- Part 1: Framework (publication expected January 2013). See description in Annex G, section G.5.4.

ISO 19150-2, Geographic information -- Ontology -- Part 2: Rules for developing ontologies in the Web Ontology Language (OWL) (publication expected January 2015). See description in Annex G, section G.5.4.

H.8 Sensor Web Enablement (SWE)

This subsection describes the ISO/TC 211 and OGC Sensor Web Enablement (SWE) standards baseline. The SWE standards have significant relevance in hundreds of applications ranging from warning and alerting systems to in-building environmental monitoring sensor networks. The baseline consists of:

- Three data model standards: Observations and Measurements, SWE Common Data Model Encoding Standard and SensorML.
- Three standard web service interfaces: SWE Service Model Implementation Standard, Sensor Observation Service (SOS) and Sensor Planning Service (SPS).
- One hardware/software interface protocol: PUCK.

ISO 19156:2011, ***Geographic information -- Observations and measurements*** defines a conceptual schema for observations, and for features involved in sampling when making observations, which can be used for the exchange of information describing observation acts and their results, both within and between different scientific and technical communities (ISO 19156:2011). The standard establishes a high-level framework for representing observations, measurements, procedures and metadata of sensor systems and is required by the Sensor Observation Service for implementation of SWE-enabled architectures, and for general support for standards compliant systems dealing in technical measurements in science and engineering. ISO 19156:2011 is a joint ISO/TC 211 and OGC document. It was prepared and submitted by the OGC to ISO/TC 211.

The OGC **SWE Common Data Model Encoding Standard** defines low level data models for exchanging sensor related data between nodes of the OGC Sensor Web Enablement (SWE) framework. These models allow applications and/or servers to structure, encode and transmit sensor datasets in a self-describing and semantically enabled way.

The **OGC Sensor Model Language (SensorML)** is an OGC adopted standard that defines standard models and XML schema for describing sensors systems and processes; provides information needed for discovery of sensors, location of sensor observations, processing of low-level sensor observations, and listing of taskable properties.

The OGC **SWE Service Model Implementation Standard** standard currently defines eight packages with data types for common use across OGC Sensor Web Enablement (SWE) services. Five of these packages define operation request and response types. These packages use data types specified in other standards.

The **OGC Sensor Observations Service (SOS)** is an OGC adopted standard that specifies a standard web service interface for requesting, filtering, and retrieving observations and sensor system information. This is the intermediary between a client and an observation repository or near real-time sensor channel.

The **OGC Sensor Planning Service (SPS)** is an OGC adopted standard that specifies standard web service interface for requesting user-driven acquisitions and observations. This is the intermediary between a client and a sensor collection management environment.

The **OGC PUCK Protocol Standard** defines a protocol for RS232 and Ethernet connected instruments. PUCK addresses installation and configuration challenges for sensors by defining a standard instrument protocol to store and automatically retrieve metadata and other information from the instrument device itself. PUCK is the newest addition to the OGC's SWE standards suite.

The **OGC Sensor Alert Service (SAS)** is an OGC discussion paper describing a web service interface for publishing and subscribing to alerts from sensors.

The **OGC Web Notification Services (WNS)** is an OGC standard web service interface for asynchronous delivery of messages or alerts from SAS and SPS web services and other elements of service workflows.

H.9 Ubiquitous public access

H.10 Existing standards

ISO 19155:2012, *Geographic information -- Place Identifier (PI) Architecture.* See description in Annex H, section H.4.

H.10.1. Identified future area of standardization

H.10.1.1 Standardization requirements identified by ISO 19154 review summary report

Preliminary stage work identified a number of issues in current ISO/TC 211 standards that need to be addressed so that the standards are suitable for ubiquitous public access (UPA), including amongst others: data models for streaming data from sensors, data models for multiple levels of detail, global identifiers for geographic features and geographic context awareness.

H.11 E-Navigation

The e-Navigation concept under development by the International Maritime Organization (IMO) is defined as "The harmonized collection, integration, exchange, presentation and analysis of marine information on-board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment." It requires easy access to standardized high quality digital geographic information describing the marine environment.

The IMO strategy for the development and implementation of e-Navigation has identified the need for "an internationally agreed common data structure" that allows information to be exchanged, read and interpreted by ship-borne and shore-based ICT systems. It is foreseen that the development of the so-called "Common Maritime Data Structure" (CMDS) will be an incremental process driven by user requirements. In that context, the e-Navigation doctrine under development by IMO has agreed that S-100 (see Annex G, section G.13.7) is an appropriate baseline standard for creating a framework for e-Navigation data access and services under the scope of SOLAS. To support this, the IMO has agreed the establishment of an IMO/IHO Harmonization Group on Data Modelling to lead future work in that direction.

S-100 based Product Specifications being developed in that context include:

- product specification for maritime boundaries data, developed by the United Nations Division for Ocean Affairs and the Law of the Sea;
- product specification for sea ice, developed by the Expert Team on Sea Ice of the Joint Technical Commission for Oceanography and Marine Meteorology of IOC and WMO (JCOMM);
- product specification for ocean forecasts, developed by the Expert Team on Maritime Safety Services of JCOMM.

Besides the IHO and JCOMM, two other organizations are currently involved in maintaining domains within the S-100 Registry:

- the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) for the domains related to aids-to-navigation and associated services; IALA has developed guidance documents on domain management procedures and product specifications preparation and is developing S-100 product specifications for e-Navigation.
- the Inland ENC Harmonization Group (IEHG) for the Inland ENC domain; that group is following the development of S-101, and intends to align the product specification for Inland ENCs with S-101.

H.12 Other

OGC standards activities currently in progress in support of emerging trends are:

- **GeoPackage**: payload encoding for sharing and updating geographic information in the mobile world but with consideration of issues related to limited or no connectivity.
- **Geosynchronization**: Best practices and a standard governance model for synchronizing geographic information collected by a mobile workforce, volunteered geographic information, emergency responders, and so forth.
- **Moving Features**: Recent submission to the OGC. Developed in Japan in support of disaster and emergency response requirements.

Annex I. Promoting geospatial advocacy and awareness

Refer to Annex E where outreach is described. Also relevant are the needs for guidelines for frameworks conducive to standards and for management system standards, both described in Annex D, section D.3.

IHO Publications S-66 - *Facts about Electronic Charting and Carriage Requirements* and C-17 - *Spatial Data Infrastructures: "The Marine Dimension" - Guidance for Hydrographic Offices* contribute to promoting geospatial advocacy and awareness.

Annex J. Working in partnership with civil society and the private sector

Both ISO and the OGC are voluntary consensus standards organizations that ensure collaboration and partnership between government organizations, the private sector, universities, NGOs and scientific research organizations. This commitment to a working partnership of all constituents creates a strong consensus environment. In OGC this environment enables specifying interoperability requirements, testing alternative approaches to solving a specific interoperability requirement, and developing the best implementation standards possible. This partnership also ensures that technology users and technology providers collaborate to create standards that meet user and organizational requirements.

As indicated in section 2.3, the IHO works with a wide spectrum of international organizations, industry stakeholders and other important associated communities. IHO Resolution 5/1957 (as amended) - *IHO relations with other organizations*[27] describes the framework of relations with other organizations, whose activities are likely to be of interest to the IHO. When appropriate, bilateral relations are fixed by a specific arrangement which may include the formation of inter-organizational bodies. Observer status may be granted to non-governmental international organizations.

Provision is made in IHO Resolution 2/2007 (as amended) - *Principles and procedures for making changes to IHO technical standards and specifications*[28] to assess impact on the stakeholders concerned and seek input from them.

The IHO Work Programme provides for conducting biennial IHO stakeholders' forums.

[27] IHO Publication M-3, ibid.
[28] IHO Publication M-3, ibid.

Annex K. Linking geospatial information to statistics

K.1 Overview

For this issue, it is necessary to determine effective ways of linking or combining the different metadata conventions and systems for geospatial and statistical information as well as other types of data and to explore ways of combining statistical databases and geoportals hosting spatial datasets in terms of creation, presentation and use of the information (ECOSOC 2012b).

However, linking geographic information could go beyond the requirements of statistical data such as facilities and critical infrastructure to assist public safety, emergency, rescue, disaster management, support to responsible resource development and sustainable development, economic development, and the knowledge and management of hydrography and oceans. Standardization of high level thematic data definitions through common data models or ontologies can also be considered to support linking geospatial information to other types of data, refer to Annex G, section G.5.4 for ontology standards.

K.2 Existing standards

Many geoportals implement or are based on the geographic information metadata standards described in Annex G, section G.4.2 and are therefore relevant:

- ISO 19115:2003, *Geographic information – Metadata*
- ISO 19115-1, *Geographic information -- Metadata – Part 1: Fundamentals* (replaces ISO 19115:2003, publication expected in June 2013)
- ISO 19115-2:2008, *Geographic information – Metadata – Part 2: Extensions for imagery and gridded data*
- ISO 19115-3, *Geographic information -- Metadata – Part 3: XML schema implementation of metadata fundamentals* (publication expected in May 2015)
- ISO/TS 19139:2007, *Geographic information -- Metadata -- XML schema implementation*
- ISO/TS 19139-2:2012, *Geographic information -- Metadata -- XML Schema Implementation -- Part 2: Extensions for imagery and gridded data*

The **OGC Table Join Service Interface Standard** is specifically focused on the requirement to allow an application to link geospatial data, such as census boundaries, with corresponding statistical data. This standard was originally developed by the Canadian SDI community to address the geospatial to statistical linking requirement.

The **OGC Web Processing Service (WPS)** has also been used successfully to link geospatial data with statistical data and processes. WPS provides rules for standardizing inputs and outputs (requests and responses) for geospatial processing services, e.g. a WPS can be used to specify any analytic operation that has inputs and outputs. The standard also defines how a client can request the execution of a process, and how the output from the process is handled. Therefore, a WPS instance (also known as a profile) could specify the operations necessary to link census tracks with census data and then perform some analysis.

Both of these OGC standards are technology, data, and vendor neutral and as such can be implemented within any technology environment. Further, the OGC members are working on mechanisms for developing and maintaining profiles and registries of these standards. This work is based on ISO related standards for profiles and registries.

K.3 Identified future areas of standardization

K.3.1. ISO standard for the representation of boundaries to which statistical data is linked

For example, the second administrative level boundaries (http://www.unsalb.org/) dataset was developed by the UN Geographic Information Working Group (UN GIWG) and is used for the collection, management, visualization and sharing of sub national data and information in a seamless way from the national to the global level. An ISO standard for these boundaries would assist in the maintenance of the dataset but would also make the specifications of the dataset available to the general public.

Refer also to Annex E, section E.3.4 for the cross-mapping of vocabularies between statistics and geographic information science, which contributes to this UN-GGIM issue of linking of geospatial information to statistics.

Annex L. Selected terms and definitions from ISO standards

Table 6 shows a subset of ISO terms and definitions used in this document. The full list of terminology defined in the ISO 19100 series of standards is available at http://www.isotc211.org/Terminology.htm. ISO terms and definitions are available in the ISO concept dictionary at cdb.iso.org.

Table 6. Subset of ISO terms and definitions

Term	Definition
application schema	conceptual schema for data required by one or more applications [ISO 19101:2002]
classification	abstract representation of real world phenomena using classifiers [ISO 19144-1:2009]
conceptual schema	formal description of a conceptual model [ISO 19101:2002]
content model	information view of an application schemas [ISO/TS 19109:2009]
encoding	conversion of data into a series of codes [ISO 19118:2005]
encoding rule	identifiable collection of conversion rules that define the encoding for a particular data structure [ISO 19118:2005]
feature	abstraction of real world phenomena [ISO 19101:2002]
feature catalogue	catalogue containing definitions and descriptions of the feature types, feature attributes, and feature relationships occurring in one or more sets of geographic data, together with any feature operations that may be applied [ISO 19101:2002]
feature concept dictionary	dictionary that contains definitions of, and related descriptive information about, concepts that may be specified in detail in a feature catalogue [ISO 19126:2009]
geographic information	information concerning phenomena implicitly or explicitly associated with a location relative to the Earth [ISO 19101:2001]
linear reference system	reference system that identifies a location by reference to a segment of a linear geographic feature and distance along that segment from a given point [ISO 19116:2004]
portrayal	presentation of information to humans [ISO 19117:2012]
quality	degree to which a set of inherent characteristics fulfils requirements [ISO 9000:2005]
registry	information system on which a register is maintained [adapted from ISO/IEC 11179-3:2003]
schema	formal description of a model [ISO 19101:2002]
spatial reference	description of position in the real world [ISO 19111:2007]
spatial reference system	system for identifying position in the real world [ISO 19112:2003]
technical report (TR)	document published by ISO or IEC containing collected data of a different kind from that normally published as an International Standard or Technical Specification [ISO/IEC Directives Part 2]
technical specification (TS)	document published by ISO or IEC for which there is the future possibility of agreement on an International Standard, but for which at present
standard	document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context

Annex M. Bibliography

The first section of the bibliography provides information and a list of references to sources with information about the geographic information standards and activities described in this report. The second section lists references cited in the text of this report.

M.1 References to information about geographic information standardization

The reader should note that the GSDI Cookbook provides an excellent reference in regard to the content of this document and the identified needs of the UN-GGIM community. Another excellent reference is the OGC Reference Model (ORM)[29]. The ORM describes the OGC and ISO Standards Baseline focusing on relationships between the baseline documents. The OGC Standards Baseline (SB) consists of the approved OGC Abstract and Implementation Standards (Interface, Encoding, Profile, and Application Schema – normative documents) and OGC Best Practice documents (informative documents).

Below a list of references with information about the geographic information standards and activities described in this report

CEN/TR 15449-1:2012, *Geographic information - Spatial data infrastructures - Part 1: Reference model*. European Committee for Standardization (CEN), CEN/TC 287, Geographic information.

CEN/TR 15449-2:2012, *Geographic information - Spatial data infrastructures - Part 2: Best practices*. European Committee for Standardization (CEN), CEN/TC 287, Geographic information.

CEN/TR 15449-3:2012, *Geographic information - Spatial data infrastructures - Part 3: Data centric view*. European Committee for Standardization (CEN), CEN/TC 287, Geographic information.

Global Spatial Data Infrastructure Association (GSDI) (2012). *SDI Cookbook*. Available at http://www.gsdidocs.org/GSDIWiki/.

International Hydrographic Organization (IHO) (2013). *IHO Website*. Available at http://www.iho.int.

International Hydrographic Organization (IHO) (2011), *The Need for National Hydrographic Services*. International Hydrographic Organization (IHO), Publication M-2, Version 3.0.1. Available at http://www.iho.int/iho_pubs/misc/M-2_3.0.1_E_19OCT2011_TheneedforNHS.pdf.

International Organization for Standardization (ISO) (2013). *ISO website*. Available at www.iso.org.

ISO/IEC (2012). *ISO/IEC Directives, Part 1 – Procedures for the technical work*. ISO/IEC, Geneva, Switzerland. Available at http://www.iso.org/iso/home/standards_development/resources-for-technical-work/iso_iec_directives_and_iso_supplement.htm.

ISO/IEC (2011). *ISO/IEC Directives, Part 2 – Rules for the structure and drafting of International Standards*. ISO/IEC, Geneva, Switzerland. Available at http://www.iso.org/iso/home/standards_development/resources-for-technical-work/iso_iec_directives_and_iso_supplement.htm.

ISO/TC 211 Geographic information/Geomatics (2009a). *A Framework for Terrestrial Climate-Related Observations and the Development of Standards for the Terrestrial Essential Climate Variables - Report to the 30th session of the Subsidiary Body for Scientific and Technological Advice (N2721)*. Liaison Report.

ISO/TC 211 *Geographic information/Geomatics* (2012a). *ISO/TC 211 Fact sheets.* Available at http://www.isotc211.org/Outreach/Overview/Overview.htm.

ISO/TC 211 *Geographic information/Geomatics* (2012b). *ISO/TC 211 Multi-Lingual Glossary of Terms.* Available at http://www.isotc211.org/Terminology.htm in Arabic, Chinese, Danish,

[29] http://www.opengeospatial.org/standards/orm

Dutch, English, Finnish, French, German, Japanese, Korean, Polish, Russian, Spanish and Swedish.

ISO/TC 211 *Geographic information/Geomatics* (2009c). *ISO/TC 211 Standards Guide*. Available at http://www.isotc211.org/Outreach/Standards_Guide.htm in Arabic, Chinese, English, Japanese, Russian and Spanish.

ISO/TC 211 *Geographic information/Geomatics* (2013). *ISO/TC 211 Website*. Available at http://www.isotc211.org.

Kresse W and Fadaie K (2004). *ISO standards for geographic information.* ISBN 978-3540201304, Springer, Germany.

Peng Z and Tsou M (2003). Internet GIS: Distributed Geographic Information Services for the Internet and Wireless Network. ISBN 978-0471359234, Wiley, Hoboken, New Jersey, USA.

Open Geospatial Consortium (OGC) (2011). *OGC Reference Model*. Reference number: OGC 08-062r7, Version: 2.1. Available at http://www.opengeospatial.org/standards/orm.

Open Geospatial Consortium (OGC) (2013). *OGC website*. Available at www.opengeospatial.org.

M.2 References cited in the report

CEN/TR 15449-1:2012, *Geographic information - Spatial data infrastructures - Part 1: Reference model*. European Committee for Standardization (CEN), CEN/TC 287, Geographic information.

CEN/TR 15449-2:2012, *Geographic information - Spatial data infrastructures - Part 2: Best practices*. European Committee for Standardization (CEN), CEN/TC 287, Geographic information.

CEN/TR 15449-3:2012, *Geographic information - Spatial data infrastructures - Part 3: Data centric view*. European Committee for Standardization (CEN), CEN/TC 287, Geographic information.

Coppock, J T, et D W Rhind 1991 The History of GIS. In D J Maguire, M F Goodchild, and D W Rhind (eds) Geographical Information Systems. New York, Longman Scientific and Technical: 21-43.

Du Plessis H and Van Niekerk H (2012). *A comparison of geographical information science competency requirements*, GISSA Ukubuzana 2012, Ekurhuleni, South Africa, 2-4 October 2012.

ECOSOC, 2012. Inventory of issues to be addressed by the Committee of Experts on Global Geospatial Information Management, Committee of Experts on Global Geospatial Information Management, Second session, E/C.20/2012/5/Add.1, New York, 13-15 August 2012, http://ggim.un.org/2nd Session/E-C20-2012-5 Inventory of Issues 5 July.pdf.

Global Spatial Data Infrastructure Association (GSDI) (2012). *SDI Cookbook*. Available at http://www.gsdidocs.org/GSDIWiki/.

International Hydrographic Organization (IHO) (2011), *The Need for National Hydrographic Services*. International Hydrographic Organization (IHO), Publication M-2, Version 3.0.1. Available at http://www.iho.int/iho_pubs/misc/M-2_3.0.1_E_19OCT2011_TheneedforNHS.pdf.

International Maritime Organization (IMO) (2009). *Convention for Safety of Life at Sea* (*SOLAS)*. Consolidated Edition.

International Organization for Standardization (ISO) and European Committee for Standardization (CEN) (1991). *Agreement on technical cooperation between ISO and CEN (Vieanna agreement).* Available at http://isotc.iso.org/livelink/livelink/fetch/2000/2122/3146825/4229629/4230450/4230458/01_Agreement_on_Technical_Cooperation_between_ISO_and_CEN_(Vienna_Agreement).pdf?nodeid=4230688&vernum=-2

ISO/DIS 19101-1:2012, *Geographic Information — Reference model — Part 1: Fundamentals.*

ISO/IEC (2012). *ISO/IEC Directives, Part 1 – Procedures for the technical work*. ISO/IEC, Geneva, Switzerland. Available at http://www.iso.org/iso/home/standards_development/resources-for-technical-work/iso_iec_directives_and_iso_supplement.htm.

ISO/IEC (2011). *ISO/IEC Directives, Part 2 – Rules for the structure and drafting of International Standards*. ISO/IEC, Geneva, Switzerland. Available at http://www.iso.org/iso/home/standards_development/resources-for-technical-work/iso_iec_directives_and_iso_supplement.htm.

ISO/TC 211 Geographic information/Geomatics (2009a). *A Framework for Terrestrial Climate-Related Observations and the Development of Standards for the Terrestrial Essential Climate Variables - Report to the 30th session of the Subsidiary Body for Scientific and Technological Advice (N2721)*. Liaison Report.

ISO/TC 211 *Geographic information/Geomatics* (2011a). *Terms of Reference for the Control body for the ISO geodetic registry network* (N3153).

ISO/TC 211 *Geographic information/Geomatics* (2012a). *ISO/TC 211 Fact sheets.* Available at http://www.isotc211.org/Outreach/Overview/Overview.htm.

ISO/TC 211 *Geographic information/Geomatics* (2012b). *ISO/TC 211 Multi-Lingual Glossary of Terms.* Available at http://www.isotc211.org/Terminology.htm in Arabic, Chinese, Danish, Dutch, English, Finnish, French, German, Japanese, Korean, Polish, Russian, Spanish and Swedish.

ISO/TC 211 Geographic information/Geomatics (2011b). *Invitation to submit a New Work Item Proposal for a stage 0 project on management system standards* (N3164).

ISO/TC 211 *Geographic information/Geomatics* (2009b). *Report from stage 0 Project 19150 Geographic information - Ontology* (N2750).

ISO/TC 211 *Geographic information/Geomatics* (2010). *Review summary of ISO 19154, Ubiquitous public access* (N2862).

ISO/TC 211 *Geographic information/Geomatics* (2011c). *Review summary of ISO 19160, Addressing* (N3188). Available online at http://www.isotc211.org/address/iso19160.htm.

ISO/TC 211 *Geographic information/Geomatics* (2009c). *ISO/TC 211 Standards Guide.* Available at http://www.isotc211.org/Outreach/Standards_Guide.htm in Arabic, Chinese, English, Japanese, Russian and Spanish.

Kresse W and Fadaie K (2004). *ISO standards for geographic information.* ISBN 978-3540201304, Springer, Germany.

McKee L and Buehler K (eds) (1998). *The OpenGIS Guide*. Wayland, Massachusetts, OpenGIS Consortium Inc.

Peng Z and Tsou M (2003). *Internet GIS: Distributed Geographic Information Services for the Internet and Wireless Network.* ISBN 978-0471359234, Wiley, Hoboken, New Jersey, USA.

University Consortium for Geographic Information Science (UCGIS) 2006, *Geographic Information Science and Technology Body of Knowledge 2006*. USA

United Nations (2003). *Oceans and the law of the sea*. United Nations, General Assembly, Resolution A/RES/58/240. Available at http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/58/240&Lang=E.

United Nations (2012). *Oceans and the law of the sea*. United Nations, General Assembly, Resolution A/RES/66/231. Available at http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/66/231.

United Nations Economic and Social Council (ECOSOC) (2012a). *Global Geodetic Reference System.* Note by the Secretary-General (E/C.20/2012/9/Add.1), New York, USA, 2 July 2012.

United Nations Economic and Social Council (ECOSOC) (2012b). *Inventory of issues to be addressed by the Committee of Experts on Global Geospatial Information Management.* Report to the Secretary-General (E/C.20/2012/5/Add.1), New York, USA, 2 July 2012.

Welle Donker F, Van Loenen B, Zevenbergen J (2010) Geo Shared licences: a base for better access to public sector geoinformation for value-added resellers in Europe. *Environment and Planning B: Planning and Design*, 37(1): 326-343