The Role of Geospatial Information Standards for Sustainable Development

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The purpose of this chapter is to illustrate how standards for geospatial information facilitate the implementation of United Nations Sustainable Development Goals (SDGs).

14.1 Introduction

The UN Millennium Development Goals Report from 2015 states under the heading “Geospatial data can support monitoring” the following phrase:

“Knowing where people and things are and their relationship to each other is essential for informed decision making. Comprehensive location-based information is helping Governments to develop strategic priorities, make decisions, and measure and monitor outcomes. Once the geospatial data are created, they can be used many times to support a multiplicity of applications.”

The notion of this sentence is not to be challenged but raises the very practical question: How exactly can this multitude of data uses be technically enabled? The obvious answer is standardization, more precisely, a standardization which enjoys universal acceptance and application. Section 14.2 explains why standardization is inseparably associated with the age of digitization. In section 14.3, background on international standardization for geospatial information is provided. Section 14.4 presents the ecosystem of international standards. In section 14.5, several case studies are briefly presented to demonstrate how suitable geospatial information based on common standards supports the overarching aspiration of sustainability.

It should be noted that in 2015 the OGC, ISO/TC211 and IHO presented the first version of the Guide to the role of standards in Geospatial Information Management and its companion document to the UN Global Geospatial Information Management Committee of Experts. This chapter on geospatial standards for the SDGs should be considered in relation to the fundamental principles and best practice guidance in these documents. The authors strongly recommend that anyone embarking on work that utilizes geospatial data for the SDGs should ensure they have familiarized themselves with this document.

Excerpt from the decisions of the Fifth Session of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM). Held from 3-7 August 2015 at the United Nations Headquarters in New York.

5/108 Implementation and adoption of standards for the global geospatial information community The Committee of Experts:

- (a) Welcomed the report by the Open Geospatial Consortium (OGC), Technical Committee 211 of the International Organization for Standardization (ISO/TC 211) and the International Hydrographic Organization (IHO), and thanked them and their many experts for their collaborative efforts in producing and finalising the Standards Guide and Companion Document.
- (b) Adopted the final published “Guide to the Role of Standards in Geospatial Information Management” and the “Technical Compendium” as the

international geospatial standards best practice for spatial data infrastructure, and encouraged all Member States to adopt and implement the recommended standards appropriate to their countries' level of spatial data infrastructure (SDI) maturity.

- (c) Encouraged Member States to continue to work in cooperation with the international standards bodies, including participation, as appropriate, in the work programmes of the OGC, ISO/TC211 and the IHO, and requested the standards organisations to consider mechanisms to facilitate wider training programmes and to ensure the access to standards on reasonable terms, especially for developing countries.

14.2 Digitization Forces Standardization

With regard to standardization the age of digitization evolves tremendous changes along the whole chain of information processing. Starting with the acquisition and storage of so far unseen massive data amounts, continuing with the processing to normalize and interpret the gathered information through correlation and quality assessment up to the visual presentation and treatment through artificial intelligence procedures. Digital standardization has become the elementary requirement for all modern data appliances. Compared with the analogue treatment of information in the past, the digital handling of information as data enables the combining of information originally delivered from different knowledge domains. The phrase coined for this capability is “interoperability” and can be effectively achieved in a digital environment only. Interoperability is based in the first place on a consistent abstraction about a set of associated entities by means of attributed objects and their interrelations applicable across domains -the data modelling. Consequently, data modelling itself is a relevant subject of standardization- known as semantic standards.

Once such universal data model exists, a standardized form of digital encoding of the semantic information associated with the modelled entity can be applied. The result are machine readable data sets describing a situation generically. Encoding schemes does not need to be identical for all data sets as long as they are based on the same modelling paradigm, however, broad use of the same encoding eases the processing of the resulting data sets enormously and led to the dominance of a small number of such schemes. Well known ones are XML and its derivation for geospatial information named GML. These standards belong to the world of technical standards.

The semantic and technical standardization deliver ample foundation to create consistent data sets assumed there is prescriptive coding guidance to assign the raw information to a designated object and to form a inter object

relations. Again, authoritative standardization is required here -at least within the knowledge domain to result in consistent data sets of the same theme but from different producers.

Once produced, the data sets have to be streamed to their users. Internet communication standards are ready to provide this carriage for geospatial information. There are basically two well-known concepts: the client-server architecture or the transfer of a copy of a data set toward the user to replicate the originating data base locally in parts or completely.

Today digital geospatial data sets mainly contain pure information only, which means that different interpretations can be applied to. The most popular interpretation is visual presentation. Based on a consistent data model and universal encoding standards, customized presentation rules can be applied to the data set. End users software, commonly named *Geo Information Systems - GIS* - provide additional functionality to generate varying presentations of the same information content but customized to the task at hand. Like the data modelling and the encoding, presentation rules are subject to standardization as well since this supports identical interpretation through the user.

The visual presentation is still the most popular human-machine-interface for the provision of geospatial information. However, natural voice command and response gain more and more acceptance. The machine “reads and tells” the user the facts on his/hers vocal request. Even here standards in vocabulary and pronunciation are the prerequisite. But procedural interpretation of the transmitted information with little or without human intervention is about to become the mightiest tool to treat complex geospatial information-familiar to anybody who ever planned a route to drive by means of car navigation.

Semantic Standards and Technical Standards Combined

Over the last two decades, many information communities have learned the importance of data coordination and have learned how to do it. Information communities who depend on sharing information often put in place data coordination committees and processes for creating and maintaining standard data models and metadata content standards. The data model used by an information community is their standard way of describing spatial information. It provides a data dictionary and related details necessary for the sharing, aggregation and comparison of data within the community. Metadata associated with a data set includes the data model along with other data about the data - date of collection, person or organization responsible for the collection, etc. Data model development proceeds as a part of an information community's metadata standards development effort. Such standards are often referred to as “semantic standards”. Because of these standards, different information systems used within the community can “speak the same language”. Different data sets that use the same data model can be aggregated or compared. Semantic standards also facilitate communication between information communities: When each community's data model is published and

relatively stable, translation between different data models is easier and more precise, despite some inevitable loss of information.

Data models necessarily evolve as information communities evolve, and so this data coordination process within and between domains is an ongoing activity. Data modelers working with other data modelers are key standards developers for the Anthropocene. Geospatial standards are important for environmental work because virtually everything in our environment has a spatial component and because interactions between environmental features and phenomena depend on proximity. In the geospatial world, an “information community” is an industry, profession, academic discipline or other domain that shares a set of spatial information communication requirements. Because the geospatial element is so important, many data coordination efforts have begun in efforts to create “spatial data infrastructures”.

14.3 The Framework of International Standardization for Geospatial Information

There are three key international organizations with the objective of developing open standards for geospatial information.

ISO/TC 211, Geographic information/Geomatics, is a technical committee of the International Organization for Standardization (ISO). It works towards 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. The Open Geospatial Consortium (OGC) is an international not for profit standards organization. The focus of OGC work is to define, document and test implementation standards for use with geospatial content and services. The International Hydrographic Organization (IHO) is an inter-governmental 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 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).

Members of the international standards organizations represent government, industry, research, and academia, and develop standards through consensus. Together the standards developed by these organizations form an integrated ecosystem, e.g. OGC and IHO standards leverage the abstract standards defined by ISO/TC 211. This ecosystem facilitates the publication, discovery, access, maintenance and use of geospatial information across a range of applications, systems and business enterprises.

FIGURE 14.1
O Ostensen, D McKenzie & R Ward - Standards Report to UN-GGIM 2015

DGIWG	Defence Geospatial Information Working Group
WMO	World Meteorological Organization
ICAO	International Civil Aviation Organization
W3C	World Wide Web Consortium
OASIS	Organization for the Advancement of Structured Information Standards
IETF	Internet Engineering Task Force
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Commission
OMG	Object Management Group
ISO/IEC JTC 1	ISO/IEC Joint Technical Committee 1-Information Technology

To achieve interoperability, standardization in the field of geospatial information covers system heterogeneity (hardware, operating systems, communication systems, etc.), syntactic heterogeneity (physical representation of information), structural heterogeneity (concepts and the relationships between them) and semantic heterogeneity (meaning of concepts). In addition, service standards define interfaces for geospatial information functionality provided by a server, and procedural standards provide specifications for accomplishing a particular task.

Geospatial information standards rely heavily on general purpose information communication and technology (ICT) standards. Similarly, domain-

specific geospatial information standards rely on generic geospatial information standards, as depicted below.

14.3.1 Technical Standards Link Environmental Standards to IT Innovations

Over the last two decades, the members of this integrated standardization ecosystem have developed policies and procedures for working together to develop consensus-based open interface and encoding standards that provide a way for any two computer systems to request and return any kind of spatial data. These “technical standards” are broadly useful within all spatial data information communities. They support inter-community communication and they are also essential for convergence and integration of different kinds of spatial technologies, such as 2D/3D/4D imaging, vector GIS, surveying, CAD, tracking, etc.

14.3.2 Standardization Driven by Innovation and Technical Evolution

Standardization has always an aspect of consolidation, i.e. freezes technical progress for a distinct duration in favor of uniformity. Modern concepts of digital standards try to overcome this paradigm. The ISO 19200 series for geospatial information standards introduced the registry concept which means that adaptations and new model items can be applied to a web based register at any time. This register is basically open to the interested public but administered by designated and acknowledged institutions. Once registered, the enhanced model items can be exported to form the basis for the future coding of a data product. The data product “hooks up” its most recent model for implementation at the user's device after delivery. This mechanism guaranties the application of the most recent data model at any time.

Like semantic standards, technical standards evolve. The fundamental domain-neutral spatial technology standards framework is now in place, but rapid advances in technology require that this foundation needs continual attention. Such industry-wide advances force revision and rethinking of established technical standards. Discussions about revision invariably run into the issue of backwards compatibility, a standard's lifetime of usefulness, and the importance of stability to both technology providers and technology users who have made investments based on the standard. These are difficult but important issues. Mature standards development organizations and their long-term members have experience in negotiating these issues. They also have a keen awareness of the costs and risks associated with letting market leaders establish proprietary standards outside of an open consensus process. Industry market leaders work in standards organizations because they, like their competitors and despite their natural desire to “lock in” customers, have business reasons to implement and help develop open standards. Technical standards

are in place that can provide access control, security and certain privacy protections, but development also needs to address other issues such as geospatial data rights management and data quality. Much work remains in the broad area of technical standards for geospatial interoperability, despite the fact that a mature domain-neutral open spatial technology standards framework is already largely in place.

14.3.3 New Information Communities Emerge

One reason work remains is that technology is advancing so rapidly. Another reason is that new information communities keep appearing.

In climate science, as in many domains, new disciplines arise, and they are new information communities. Their data models differ, but they need to share data and communicate. Communities in relationship need interoperability. The OGC Geography Markup Language (GML) Encoding Standard and other OGC standards can be used to develop international domain-specific encoding standards that bring semantic standards and technical standards together. This is a key cyber infrastructure innovation for environmental science, business and policymaking. A domain that develops a domain-specific data encoding standard based on OGC standards and on the domain's semantic standards gives domain participants much fuller access to developments in the mainstream digital technology world: Web searches, chained computer models, full use of cloud infrastructures, Big Data, data analytics, data fusion, management tools for open data, heterogeneous sensor webs and much more.

14.4 Case Studies

Each of the case studies in this section identifies geospatial information standards from the ecosystem and describes how they contributed or can contribute to achieving one or more SDGs.

Traditionally, addresses were used for delivery to individuals and organizations. Today, there are many more possibilities. Addresses are widely used as a locational reference for all kinds of information, such as information about people, buildings, organizations and services [2]. This makes it possible to spatially analyze and visualize the different pieces of information on a single map in support of planning, management and decision-making.

Addresses are a key element for delivering policies at national and international levels in support of the sustainable development goals (SDGs), specifically “with regard to governance, rule of law, poverty reduction, disease prevention and the provision of basic services such as electricity, sanitation and water”. Also, without an address, an individual does not have a legal

identity, does not have equal opportunities to finding employment and is not socially integrated [6]. There are thus direct links to at least 9 of the 17 SDGs and others are supported more indirectly through the linking of information to addresses.

A variety of address standards and/or specifications are in use around the world. They are typically well integrated into various operational processes and, in some cases, legally enforced. At the same time, some countries are rationalizing their addressing system or creating a new one. Addresses are also increasingly used to reference new geographic objects (e.g. road furniture) and are integrated in new technologies, such as in-vehicle navigation, for which digital interoperability is essential. The ISO 19160 series of standards on addressing facilitates the entire address lifecycle, from planning and assignment of addresses to using, changing and retiring addresses. The case studies from Australia, New Zealand and South Africa exemplify some of the benefits of standardized addresses.

14.4.1 Australia

Addresses in Australia are managed under the National Address Management Framework underpinned by two standards: the Australian/New Zealand Standard (AS/NZS) 4819 *Geographic information – Rural and Urban Addressing* for address creation and the Australian Standard (AS) 4590 *Interchange of client information* [1]. AS 4590 contains the data element requirements for digital address collection, interchange and storage. This standard references ISO 19160-1. Both standards are published through the Standards Australia IT-004 Committee, which mirrors the ISO TC-211.

Addresses in Australia are first created by the (537) local governments in Australia using AS/NZS 4819, which are maintained by a cross-jurisdictional Permanent Committee on Addressing ¹. This address information is aggregated by each state and territory governments and then contributed to a standardised, authoritative, national product - the Geocoded National Address File, or G-NAF®, which is made publicly available through the Commonwealth Government's open data portal ² [5]. G-NAF is produced and maintained by PSMA Australia Ltd, an independent and self-funded company that is owned by the nine governments of Australia [4].

Standardised address data underpins Australian governments' services to its citizens. For example:

- The national addressing system, as described above, is central to the Australian national statistical process that is maintained and implemented by the Australian Bureau of Statistics (ABS). The ABS maintains an internal Address Register sourced from G-NAF® and internal address

¹icsm.gov.au/what-we-do/permanent-committee-addressing

²data.gov.au

datasets. The Statistical Spatial Framework and National Address Management Framework (NAMF) [see [Figure 14.1](#)] provide the framework for the Address Register, which contains information on all addresses (e.g. their location, residential/non-residential status, etc.) and is processed to create residential dwelling frames for the five yearly Australian National Census of Housing & Population and most ABS social surveys.

Accurate census and survey information underpins key national population statistics. These statistics are critical to enabling governments to meet public health and educational outcomes, as well as providing the infrastructure that supports economic growth and sustainable communities.

FIGURE 14.2
Australian Bureau of Statistics Statistical Spatial Framework

- The Australian Electoral Commission uses the G-NAF® to deliver an impartial and independent electoral system through active electoral roll management and maintaining equitable electoral boundaries. This underpins Australia's democratic process and stable governance through a transparent representation process.
- Geoscience Australia uses address information to inform the National Exposure Information System (NEXIS), which provides comprehensive and nationally-consistent exposure information that enables users to understand the elements at risk. Resident, Population, Commercial, Agricultural, Infrastructure etc exposure information is produced by sourcing the best publicly available information, statistics, spatial and survey data

about buildings, demographics, community infrastructure and agricultural commodities.

This standardised and well governed structure for addresses in Australia has enabled a trial Linked Data API for delivery of the national address file [3]. The hope is that Linked Data will allow new applications of data presentation, access, mining and sharing that improve outcomes for Australians. The API allows users to request G-NAF® data mapped to any number of different ‘alternate views’, including one modelled on a profile of ISO 19160-1:2015–Addressing, Part 1: Conceptual model.

14.4.2 New Zealand

Land Information New Zealand and Statistics New Zealand implemented new systems for managing address data. These two systems, based on ISO 19160-1 and the associated New Zealand profile, manage the addresses used to support New Zealand's electoral system and the collection of official statistics. A standards based approach has made it easier for these two agencies to work together in the collection of up-to-date, authoritative, and accessible address data in New Zealand. ISO 19160 provides a shared understanding of the fundamentals of an address, for both the people involved and also for system interoperability.

FIGURE 14.3
Example of a property that has multiple addresses

Standardised address data underpins New Zealand's electoral system. For example, electoral boundaries are dependent on accurately locating voters by address. To deliver sustainable development goals, a country relies upon stable governance that is perceived to be fair and representative. Standardised address data also enables critical linking of addresses to other property infor-

mation, allowing delivery of reliable property-focused data that agencies can use to ensure the right services are delivered to the right citizens (see [Figure 14.3](#)). This includes government agencies providing critical social services and others working in fields directly related to the sustainable development goals relevant to address data.

Accurately sampling and capturing statistics requires standardised addresses. These statistics include census, household, economic, and social surveys. Analytics based on these statistics directly contributes to policy that supports citizens' wellbeing and allows outcomes to be measured against sustainable development goals. A standards-based approach to addressing has directly supported the development of New Zealand's Statistical Spatial Framework (see [Figure 14.4](#)) and contributions to the UN-GGIM Global Statistical Geospatial Framework.

FIGURE 14.4
Statistical Spatial Framework

14.4.3 South Africa

South Africa is a diverse country with many challenges. Thanks to the guide of standards, the subject of addresses now has a solution and firm way forward.

AfriGIS is a private GIS company based in Pretoria, South Africa. 2019 marks our 22nd year of existence. The focus of AfriGIS is to provide actionable answers through location insights to improve decision making. The foundation of the insights lies in the quality of the data and information. At AfriGIS we identified a need for quality information that is accurate and maintained. The spatial data we base our decisions on should be reflective of the world we live

in. In 2002, AfriGIS started building and maintaining a host of datasets to assist both private sector and government.

When the United Nations (UN) released the 14 Global Fundamental Geospatial Data Themes, AfriGIS could tick off at least eight of the boxes. We have maintained spatial data layers for South Africa in terms of:

- Geographical Names
- Addresses
- Buildings and Settlements
- Land Parcels
- Transport Networks
- Population Distribution
- Land cover and Land use
- Physical Infrastructure

Addressing is a complex item and challenge in South Africa. The various components that build up an address are divided between different custodians and entities. In order to create a national address dictionary, an estimated 250 different custodians from National and Provincial (9) and Municipal (226) level provide data. AfriGIS rose to the challenge.

SANS 1883-1:2009 was the first Address Standard AfriGIS ever implemented. The data sourced from the different entities are not standardised in any way. Several projects are in progress to ensure that best practices as prescribed in the conceptual model are adhered to.

AfriGIS became involved with ISO/TC211 to guarantee that our data and address offering to our clients remain world standard. Private sector companies have a multinational footprint and have to ensure that data shared across boundaries share the same profile. ISO 19160-1:2015 allowed AfriGIS to map our data to the South African profile as described in SANS 1883-1:2009.

The practical benefits to the company and our clients have been enormous. The following examples would not have been as successful without the foundation of a standard as a beacon in the dark.

Logistics

Ecommerce is one of the greatest emerging markets, not only in South Africa but also in the world. Accurate delivery address is crucial to make the model work. It empowers better delivery time, effective planning and accurate billing. The process works as the point of capture is accurate. The advantage of having a confidence level ensures that drivers have a clear view of the expectation with each delivery.

Emergency Services

In South Africa one of the first private companies to implement SANS 1883-1 is a prominent security firm. They have applied their own business rules to only accept confidence level 1 and 2 addresses. In their business the accuracy, or rather inaccuracy of the address could have life threatening consequences.

Financial Services

Through a host of services an address provides a vast amount of information about an area, a person and the potential of risk. In terms of the financial institutions the risk, the potential and the business profile of an organisation is dependent on the quality of the addresses in their database.

AfriGIS Search

These are just a few small high level examples. How did AfriGIS succeed to bring a Standards compliant address database to clients?

We have developed an API that serves the addresses. AfriGIS Search is an address verification, capture and geocoding tool. It contains intelligence to simplify the complex addressing system of South Africa.

There are six active address types (classes) incorporated into the solution:

- Street Addresses
- Building Addresses
- Farm Addresses
- Site Addresses
- Landmark Addresses
- Intersection Addresses

Informal addresses have been excluded in the product as there are currently no legal custodianship in place to maintain and verify an informal address.

AfriGIS Search gives clients up to 50 million searchable address combinations for South Africa. The reason the number appears to be so high is due to the fact that a single land parcel in South Africa can have multiple addresses; all relevant and legal. The API allows for all components of an address and its history to be maintained and captured.

AfriGIS Search provides a client with the tool to access an address with all the components required to understand the accuracy, maintenance, history and type.

Additional information available contains the land administration information with regards to deeds, ownership and contact information. All the additional information that provide a view of the address can be found within the AfriGIS Search API.

Addresses are a challenge in South Africa. We have multiple address

types. We have unconfirmed assigning methodologies. We have numerous role players.

The standard was used as a road map to determine the important pieces of information. To order it within the boundaries of logic and accessibility. It guides us in terms of requirements and possibilities. It made the data sharable and interoperable.

The true test of the benefits of standards were when we took the ISO 19160-1 compliant datasets from different countries. Based on the methodology, the data had to be easily compatible. The results of the combination of the three southern hemisphere address datasets is a story of triumph. The tri-nations may be fiercely competitive on a rugby field. Our addresses work together beautifully. In terms of addressing the conceptual model proved to be successful.

14.5 Case Studies of Relevant Standards for Specific Goals

14.5.1 New Zealand Government Use of WaterML and SOS

Relevant to Goals - 6 Clean Water and Sanitation, Goal 14 Life Under Water

The OGC WaterML 2.0 standard, developed in a working group organised jointly between OGC and the World Meteorological Organisation (WMO). To support requirements for monitoring laid out in the New Zealand Resource Management Act 1991 multiple New Zealand agencies. Monitoring Standards and Technologies for the compilation and reporting of water quality data across New Zealand is underpinned by the WaterML 2.0 and unifies data across regional agencies.

14.5.2 Urban Environment - Multiple Urban Implementations Including UK, Singapore, Germany, Finland, Australia, USA, Canada. Key Standards in Use Include CityGML, SensorWebs, SensorThingsAPI and Others

Relevant to goals: 7 - Affordable and Clean Energy, 11 Sustainable Cities and Communities, 13 Climate Action Two sources of excellent guidance on the

broad range of use cases include the OGC's Future Cities Pilot³.

The second source is the OGC's Smart Cities Domain Working Group list of use cases. These include topics such as waste management, planning,

³www.opengeospatial.org/projects/initiatives/fcp1

FIGURE 14.5
OGC Future Cities Pilot

disaster management, transport and others. Many of the use cases indicate which SDGs are relevant ⁴.

14.5.3 Arctic SDP

This project is an international exemplar in the efforts to share data across multiple nations and is perfect example of the vital role that geospatial standards play in striving towards Goal 17 - Partnerships for the goals.

The ArcticSDP proved the capacity of the international standards to achieve interoperability across all the Arctic nations in order to share environmental data vital to understand climate changes and animal migration and behaviour.

Further information on this project can be found at:
<http://www.opengeospatial.org/pub/ArcticSDP/index.html>

IHO and marine SDGs Goal 14

Standardization forces collaboration - a maritime use case

The maritime sector definitely holds the longest tradition in international

⁴external.opengeospatial.org/twiki_public/SmartCitiesDWG/UseCaseList

FIGURE 14.6

The S-100 Universal Hydrographic Data Model

The S-100 Standard is a framework document that is intended for the development of digital products and services for hydrographic, maritime and GIS communities. It comprises multiple parts that are based on the geospatial standards developed by the International Organization for Standardization, Technical Committee 211 (ISO/TC211).

standardization of geospatial information. It was the 23rd President of United States, Benjamin Harrison who called for the first International Marine Conference in Washington D.C. in 1889. In order to facility safety of navigation the attending 28 nations agreed – among a good amount of ship's related issues - to improve the regular update of nautical charts and to start the harmonization of the publication of nautical warnings. It was then in 1919 there first International Hydrographic Conference in London agreed to develop firm standards how to technically conduct sea survey and nautical cartography and confirmed the installation of a coordinating intergovernmental body - the International Hydrographic Bureau - later the International Hydrographic Organization (IHO) in Monaco. Since then the IHO has adopted the leading role in global standardization of nautical charting - or in more modern words - to enable the provision of marine geospatial information interpreted and customized for surface navigation in a globally unified manner. Though nautical charts are mainly individually produced by the affected coastal state they all adhere to the same paradigm of information encoding and presentation thanks to the applying technical IHO standards. The late eighties saw the uptake of digital means for navigation and IHO standards for nautical cartography were

turned into the digital domain too. Even thanks to Electronic Navigational Charts (ENC) shipping is comparably safe today but there is one significant change of the scenery: The application of nautical information is not limited to the purpose of surface navigation anymore. It likewise has to provide support for efficient and in particular resource saving navigation. Optimised route planning and tracking in terms of distance and speed can generate great savings in fuel burned for propulsion; the surveillance of proper fishery is based on precise charts and the preservation of habitats can be serviced much better if all available information is technically amalgamated. The response of the IHO to this is the installation of a modern standardization ecosystem - the IHO S-100 framework - which is not limited to means for surface navigation but utilizes a common model platform for all maritime geospatial information.

FIGURE 14.7
S-100 Geospatial Information Registry

S-100 basically adopts the fundamental mechanisms of the ISO 19200 series of standards for geospatial information and delivers the most important application of this suite.

The IMO as special UN Organization for the maritime sector has adopted the modelling part of S-100 as its “universal hydrographic data model”. In order to achieve interoperability between all data sets relevant for likewise safe and sustainable ship's operation all maritime data providers are called to develop data product specifications based on this model. To facilitate this the IHO runs the web based IHO Geospatial Information Registry which administers objects, attributes and presentation rules ⁵.

The IHO GI registry interfaces to tools supporting the generation of machine readable catalogues for customized modelling and presentation. The IHO

⁵<http://s100.iho.int/S100/>

GI registry itself is not limited to the hydrographic domain. Instead altogether nine domains owned and administered by other international and intergovernmental organizations active in geospatial information standardization, e.g. the World Meteorological Organization WMO and the International Association of Lighthouse Authorities IALA are already hosted and the IHO GI Registry is subject for grow further. The ambition is to consolidate comparable standardization activities in the domain of ocean sciences to eventually address all relevant maritime geospatial information in interoperable data product specifications.

Bibliography

- [1] ANZLIK. Australian national address management framework, 2019.
- [2] Serena Coetzee and Judith Bishop. Address databases for national sdi: Comparing the novel data grid approach to data harvesting and federated databases. *International Journal of Geographical Information Science*, 23(9):1179–1209, 2009.
- [3] PSMA Australia Ltd. G-naf ldapi.
- [4] PSMA Australia Ltd. G-naf, the foundation geocoded address database for australian businesses and governments.
- [5] PSMA Australia Ltd. G-naf view.
- [6] Universal Postal Union. Addressing the world—an address for everyone. *White Paper*, 2012.