KSA Geospatial Standards Overview

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Revision history

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<td>1.0</td>
<td>published</td>
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<td>02-07-2018</td>
</tr>
</tbody>
</table>
Table of contents

1 Introduction 8
   1.1 Context 8
   1.2 Purpose of this Document 8
   1.3 Scope of this Document 8
   1.4 Reference Documents 8

2 General Introduction to Standards 9
   2.1 Introduction 9
   2.2 Standards Explained 9
      2.2.1 What is a Standard 9
      2.2.2 Importance of Standards 9
      2.2.3 Open versus Proprietary (De-Facto) Standards 9
      2.2.4 Standards Development 10
      2.2.5 Geospatial Standards 10
      2.2.6 Benefits of Geospatial Standards 10
   2.3 International Standards Organizations 11
      2.3.1 International Organization for Standardization (ISO) 11
      2.3.2 World Wide Web Consortium (W3C) 11
      2.3.3 Organization for the Advancement of Structured Information Standards (OASIS) 12
      2.3.4 Object Management Group (OMG) 12
      2.3.5 Internet Engineering Task Force (IETF) 13
      2.3.6 International Electrotechnical Commission (IEC) 13
   2.4 International Geospatial Standards Organizations 13
      2.4.1 ISO Technical Committee 211 Geographic information/Geomatics (ISO TC211) 14
      2.4.2 Open Geospatial Consortium (OGC) 14
      2.4.3 Defence Geospatial Information Working Group (DGIWG) 15
   2.5 International Geospatial Domain Specific Content Standards Organizations 16
      2.5.1 International Hydrographic Organization (IHO) 16
      2.5.2 International Civil Aviation Organization (ICAO) 17
      2.5.3 International Earth Rotation Service (IERS) 17

3 Governance of Geospatial Standards in KSA 19
   3.1 Introduction 19
   3.2 KSA Standards Governance Organizations 19
      3.2.1 Saudi Standards, Metrology and Quality Organization (SASO) 19
      3.2.2 General Commission for Survey (GCS) 19
   3.4 SASO Standards Adoption Process 20
   3.5 GCS Adoption Process For International Geospatial Standards 20
      3.5.1 GCS Standards Adoption Criteria 20
   3.6 Evolution of National SDI Standards 21

4 Use of Geospatial Standards in KSA 22

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Date 02-07-2018

Version 1.0
# KSA Geospatial Standards Overview

## 4.1 Introduction

## 4.2 Use of Geospatial Standards

### 4.2.1 Use of Standards in the NGIC Charter Initiatives

### 4.2.2 Use of Standards in the Data Governance and Dissemination Initiatives

## 4.3 Enforcement of Standards

### 4.3.1 Procurement Language in Tenders, RFQs and RFPs

#### 4.3.1.1 General Procurement Language

#### 4.3.1.2 More Specific Procurement Language

#### 4.3.1.3 Very Specific Procurement Language

### 4.3.2 Comply or Explain Policy for Standards

## 4.4 Standards Compliance

### 4.4.1 Metadata Validator

### 4.4.2 Data Validator

### 4.4.3 Service Standards

## 5. List of KSA Geospatial Standards

### 5.1 Introduction

### 5.2 Standards Classifications

### 5.3 Overview of Official KSA Geospatial Standards

#### 5.3.1 National Standards

#### 5.3.2 International Standards

### 5.4 Detailed Explanation of Selected Standards

#### 5.4.1 OGC Geography Markup Language (GML) - ISO 19136

#### 5.4.2 OGC Web Feature Service (WFS) - ISO 19142

#### 5.4.3 OGC Web Map Service (WMS) - ISO 19128

##### 5.4.3.1 OGC Feature Portrayal Service (FPS)

### 5.5 Dependencies between Standards
# List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRS</td>
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</tr>
<tr>
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<td>Catalog Service for the Web</td>
</tr>
<tr>
<td>CSW-ebRIM</td>
<td>e-Business Registry Information Model profile of OGC CSW</td>
</tr>
<tr>
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<td>ISO profile of OGC Catalogue Service for the Web</td>
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<td>Internet Engineering Task Force</td>
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<td>International Hydrographic Organization</td>
</tr>
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</tr>
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<td>Organization for the Advancement of Structured Information Standards</td>
</tr>
<tr>
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</tr>
<tr>
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</tr>
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<tr>
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<td>Extensible Stylesheet Language Transformation</td>
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1 Introduction

1.1 Context
As part of NSDI implementation in Saudi Arabia, awareness, use, as well as the enforcement of the use of geospatial standards in the country is important. Through the use of standards, interoperability can be achieved, which enables easy connection of systems and the exchange of data, leading to significant efficiency and economies of scale.

The National Spatial Data Infrastructure (NSDI) is “the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data.” The NSDI is very useful for facilitating seamless data development, information sharing, and collaborative decision making across multiple sectors of the economy.

1.2 Purpose of this Document
The purpose of this document is to describe in general terms which international standards for geospatial data creation and data interoperability are important for Saudi Arabia. It also describes the process of creation of national standards for the country, and how these standards can be used, improving data creation and exchange amongst and between governmental agencies and private sector companies.

1.3 Scope of this Document
This document is limited to the description of the establishment and use of geospatial standards in the National context of Saudi Arabia.

1.4 Reference Documents
The following reference documents have been used.

2. NGIC, January 2018, Standards Initiative Charter NGIC-CH-04
2 General Introduction to Standards

2.1 Introduction
This chapter provides a general introduction on Standards. Text is based on the United Nations GGIM Guide to the Role of Standards in Geospatial Information Management [UN, 2015].

2.2 Standards Explained

2.2.1 What is a Standard
There are many definitions but all incorporate the following central elements:

A standard is a documented agreement between providers and consumers, established by consensus, that provides rules, guidelines, or characteristics ensuring materials, products, and services are fit for purpose.

2.2.2 Importance of Standards
Behind the scenes, standards enable interoperability in everyday life. They may establish size or shape or capacity of a product, service, process or system. They can specify performance of products or personnel. They also can define terms so that there is no misunderstanding among those using the standard. As general examples, standards help assure that:

- A light bulb fits a socket;
- Individuals can withdraw money from their bank accounts through any Automated Teller Machine anywhere in the world;
- Mobile phones work across multiple countries around the world;
- Latitude and Longitude provide a standard reference system for the Earth;
- GPS coordinates are always provided in the same format;
- Etcetera.

2.2.3 Open versus Proprietary (De-Facto) Standards
The term “open standard” is often used. What does this term mean? The following are the essential characteristics of an open standard:

- Publicly available; Unencumbered by patents and other intellectual property;
- Anyone can download and use the standard (non-discriminatory);
- No license fees;
- Vendor neutral;
- Data neutral;
- Officially sanctioned and governed by a standards body;
- Agreed to in a consensus decision making process;
- No single entity controls the standard.

A proprietary standard is a specification that is controlled by a singly company or entity. When a proprietary standard is very widely used, it becomes a "de facto" standard even though it is not governed by a standards organization. Different governments and enterprises may choose to use geospatial information and software applications which do not rely on open standards and depend solely on proprietary (de-facto) standards. The most immediate drawback of such an approach is
that the organization would create an information and technology silo that presents users with many hidden challenges such as delays and costs of expanding or adapting data and software tools to work with other resources, software or organizations. In an ever changing world, open standards help assure that organizations can more quickly take advantage of new geospatial information sources and new technology tools. Open standards are a central element in the growing trend to open government.

A goal of open standards is to ensure that "interoperability" (the ability to integrate datasets and related services of different types and from different sources) will minimize such costs and problems. Further, the open process of developing and maintaining standards offers governments, universities, research organizations, and business enterprises the opportunity to have a voice in building and learning about the standards.

2.2.4 Standards Development
The majority of international standards are developed in Standards Development Organizations (SDOs) that use a consensus process guided by documented, repeatable and well proven policies and procedures (see also paragraphs 2.3 and 2.4). Typically, any organization can join an SDO and participate in the standards development process. This helps ensure that the standards developed meet the needs of all users and that they are primarily "demand" rather than "supply" driven.

2.2.5 Geospatial Standards
There are two key types of geospatial standards discussed in this document: information (or content) standards and technology (interface, API) standards. The following modified definitions of these two key types of standards are from the GeoConnections website of the Government of Canada.

"Geospatial information standards provide digital coding to locate and describe features on, above or below the Earth’s surface. Geographically-related features can be naturally occurring (for example: rivers, rock formations, coastlines), man-made (for example: dams, buildings, radio towers, roads) or intrinsic, implied and transient information (for example: political boundaries, electoral districts, weather systems, distribution of population ethnicity). Technology standards allow different systems and services to work together through standard interfaces. Ideally, when the standards are implemented in products or online services independently, the resulting components ‘plug-and-play’, that is, they work together seamlessly".

2.2.6 Benefits of Geospatial Standards
Spatial Data Infrastructure (SDI) initiatives worldwide are implementing a common set of international standards for geospatial data. These standards encapsulate geospatial data development, production, management, discovery, access, sharing, visualization, and analysis. As organizations and jurisdictions develop and agree on a common set of open standards, the ability to share geospatial information is enhanced, reducing costs, improving service provision, and facilitating new economic opportunities. Geospatial information, technologies and standards help to enable and improve the sharing, integration and application of geospatial information for decision
making. However, even with these tools in place, the decision to share information effectively between organizations and governments often depends on proactive policy. These policy choices must be made in all jurisdictions and enterprises at many levels, but particularly at the level of national governments. A multi-national response to a regional disaster is one example where having clear policy on the sharing of geospatial information is critically important. The shaping of appropriate geospatial policy is beyond the mandate of this guide but it must be addressed. For without a suitable policy framework the standards-based approaches described in this guide will be of limited value.

2.3 International Standards Organizations
Some of the key International Standards Development Organizations that develop and maintain encoding and technology standards are described in this section.

2.3.1 International Organization for Standardization¹ (ISO)

ISO (International Organization for Standardization) is the world’s largest developer of voluntary International Standards and has published 22,102 International Standards covering almost all aspects of technology and business. Because 'International Organization for Standardization' would have different acronyms in different languages (IOS in English, OIN in French for Organisation internationale de normalisation), the founders (in 1947) decided to give it the short form ISO. ISO is derived from the Greek isos, meaning equal. ISO is an independent, non-governmental international organization with a membership of 161 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges.

2.3.2 World Wide Web Consortium² (W3C)

W3C’s primary activity is to develop protocols and guidelines that ensure long-term growth for the Web. W3C’s standards define key parts of what makes the World Wide Web work. W3C standards define an Open Web Platform for application development that has the unprecedented potential to enable developers to build rich interactive experiences, powered by vast data stores, that are available on any device. W3C develops these technical specifications and guidelines through a process designed to maximize consensus about the content of a technical report, to ensure high technical and editorial quality, and to earn endorsement by W3C and the broader community.

¹ Source https://www.iso.org
² Source https://www.w3.org
2.3.3 Organization for the Advancement of Structured Information Standards\(^3\) (OASIS)

OASIS is a nonprofit consortium that drives the development, convergence and adoption of open standards for the global information society. OASIS promotes industry consensus and produces worldwide standards for security, Internet of Things, cloud computing, energy, content technologies, emergency management, and other areas. OASIS open standards offer the potential to lower cost, stimulate innovation, grow global markets, and protect the right of free choice of technology.

OASIS members broadly represent the marketplace of public and private sector technology leaders, users and influencers. The consortium has more than 5,000 participants representing over 600 organizations and individual members in more than 65 countries. OASIS is distinguished by its transparent governance and operating procedures. Members themselves set the OASIS technical agenda, using a lightweight process expressly designed to promote industry consensus and unite disparate efforts. Completed work is ratified by open ballot. Governance is accountable and unrestricted. Officers of both the OASIS Board of Directors and Technical Advisory Board are chosen by democratic election to serve two-year terms. Consortium leadership is based on individual merit and is not tied to financial contribution, corporate standing, or special appointment.

2.3.4 Object Management Group\(^4\) (OMG)

The Object Management Group® (OMG®) is an international, open membership, not-for-profit technology standards consortium, founded in 1989. OMG standards are driven by vendors, end-users, academic institutions and government agencies. OMG Task Forces develop enterprise integration standards for a wide range of technologies and an even wider range of industries. OMG members include hundreds of organizations including software end-users in over two dozen vertical markets (from finance to healthcare and automotive to insurance) and virtually every large organization in the technology industry. OMG’s one organization-one vote policy ensures that every member organization, whether large or small, has an effective voice in our voting process. At OMG, specification adoption is the starting point rather than the end of the process, with a “No Shelf-ware” policy that bars all proposed specifications that do not have an implementation plan from being adopted by OMG. This guarantees that all OMG specifications are immediately usable. Many OMG specifications have also been adopted in their entirety by ISO as ISO standards.

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\(^3\) Source [https://www.oasis-open.org](https://www.oasis-open.org)

\(^4\) Source [https://www.omg.org](https://www.omg.org)
2.3.5 Internet Engineering Task Force\(^5\) (IETF)

The IETF is the premier Internet standards organization. It follows open and well-documented processes for setting these standards.

The Internet, a loosely-organized international collaboration of autonomous, interconnected networks, supports communication through voluntary adherence to open protocols and procedures defined by Internet Standards. From its inception, the Internet has been, and is expected to remain, an evolving system whose participants regularly factor new requirements and technology into its design and implementation. Therefore, improving existing standards and creating, implementing, and deploying new standards is an ongoing effort. Users of the Internet and providers of the equipment, software, and services that support it should anticipate and embrace this evolution as a major tenet of Internet philosophy.

The IETF's mission is produce high quality, relevant technical documents that describe these voluntary standards.

2.3.6 International Electrotechnical Commission\(^6\) (IEC)

The IEC is the world leading organization for the preparation and publication of International Standards for all electrical, electronic and related technologies. IEC provides a platform to companies, industries and governments for meeting, discussing and developing the International Standards they require. The standards work of the Commission is carried out through technical committees and subcommittees, composed of representatives of the Full Member National Committees, each dealing with a particular subject. Technical committees are created or disbanded by the Standardization Management Board (SMB). They may delegate part of their scopes to subcommittees, in accordance with the Directives. Each technical committee has a chairman and a secretariat, both appointed by the SMB amongst representatives of Full Member National Committees. All IEC International Standards are fully consensus-based and represent the needs of key stakeholders of every nation participating in IEC work. Every member country, no matter how large or small, has one vote and a say in what goes into an IEC International Standard.

2.4 International Geospatial Standards Organizations

There are three key international organizations which have the objective of developing standards for geospatial information. These international standards organizations (described in subparagraphs below in more detail) have representative members from government, industry,

\(^5\) Source [https://www.ietf.org](https://www.ietf.org)
\(^6\) Source [http://www.iec.ch](http://www.iec.ch)
research, and academia who arrive at decisions through a consensus process. The organizations develop, maintain and make publicly available open standards that enable the ability to publish, discover, access, manage and use geospatial information across a range of applications, systems and business enterprises.

2.4.1 ISO Technical Committee 211 Geographic information/Geomatics7 (ISO TC211)

ISO/TC 211 Geographic information/Geomatics is responsible for the ISO geographic information series of standards. Many bodies are actively engaged in the work of ISO/TC 211. These include national standardization bodies, the OpenGIS Consortium (OGC), international professional bodies (such as FIG and ICA), UN agencies, and sectoral bodies (such as DGIWG and ICAO).

The scope of ISO/TC 211 is standardization in the field of digital geographic information.

- The work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations;
- The work links to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.

2.4.2 Open Geospatial Consortium8 (OGC)

The Open Geospatial Consortium (OGC) is an international not for profit organization committed to making quality open standards for the global geospatial community. These standards are made through a consensus process and are freely available for anyone to use to improve sharing of the world's geospatial data. OGC standards are used in a wide variety of domains including Environment, Defense, Health, Agriculture, Meteorology, Sustainable Development and many more. OGC members come from government, commercial organizations, NGOs, academic and research organizations.

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7 Source http://www.isotc211.org
8 Source http://www.opengeospatial.org
The OGC works closely together with other international standards organizations to develop geospatial standards, as illustrated in the following figure.

2.4.3 Defence Geospatial Information Working Group⁹ (DGIWG)

DGIWG is the multi-national body responsible for geospatial standardization for the defence organizations of member nations. DGIWG has been established under a memorandum of understanding between member nations, and addresses the requirements for these nations to have access to compatible geospatial information for joint operations. It supports the requirements of NATO and the other alliances that its member nations participate in, including UN sanctioned peacekeeping. The requirements have been identified to address a specific set of operational scenarios.

The DGIWG geospatial standards are built upon the generic and abstract standards for geographic information defined by the International Organization for Standardization (ISO TC/211). DGIWG makes use of the service specifications endorsed by the Open Geospatial Consortium (OGC). DGIWG defines information components for use in the development of product specifications and application schemas for military geospatial data. DGIWG also establishes service specifications, encoding formats and testing methodologies to meet military geospatial intelligence requirements. DGIWG also maintains an extensive Knowledge Base of documents related to geospatial

⁹ Source https://www.dgiwg.org/dgiwg
standardization, and historical documents such as previous versions of the DGIWG DIGEST exchange standard.

2.5 International Geospatial Domain Specific Content Standards Organizations
Some of the key Geospatial Domain Specific Content Standards Organizations that develop and maintain encoding and technology standards are described in this section.

2.5.1 International Hydrographic Organization\(^\text{(IHO)}\)

The International Hydrographic Organization is an intergovernmental consultative and technical organization that was established in 1921 to support safety of navigation and the protection of the marine environment.

The object of the Organization is to bring about

1. The coordination of the activities of national hydrographic offices
2. The greatest possible uniformity in nautical charts and documents
3. The adoption of reliable and efficient methods of carrying out and exploiting hydrographic surveys
4. The development of the sciences in the field of hydrography and the techniques employed in descriptive oceanography

A principal Aim of the IHO is to ensure that all the world's seas, oceans and navigable waters are surveyed and charted. The Mission of the IHO is to create a global environment in which States provide adequate and timely hydrographic data, products and services and ensure their widest possible use. The Vision of the IHO is to be the authoritative worldwide hydrographic body which actively engages all coastal and interested States to advance maritime safety and efficiency and which supports the protection and sustainable use of the marine environment.

\(^{10}\) Source [www.iho.int](http://www.iho.int)
2.5.2 International Civil Aviation Organization\textsuperscript{11} (ICAO)

The International Civil Aviation Organization (ICAO) is a UN specialized agency, established by States in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention).

ICAO works with the Convention’s 192 Member States and industry groups to reach consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector. These SARPs and policies are used by ICAO Member States to ensure that their local civil aviation operations and regulations conform to global norms, which in turn permits more than 100,000 daily flights in aviation’s global network to operate safely and reliably in every region of the world.

2.5.3 International Earth Rotation Service\textsuperscript{12} (IERS)

The International Earth Rotation and Reference Systems Service (IERS) is the body responsible for maintaining global time and reference frame standards, notably through its Earth Orientation Parameter (EOP) and International Celestial Reference System (ICRS) groups. The IERS was established as the International Earth Rotation Service in 1987 by the International Astronomical Union and the International Union of Geodesy and Geophysics and it began operation on 1 January 1988. In 2003 it was renamed to International Earth Rotation and Reference Systems Service.

The primary objectives of the IERS are to serve the astronomical, geodetic and geophysical communities by providing the following:

- The International Celestial Reference System (ICRS) and its realization, the International Celestial Reference Frame (ICRF).

\textsuperscript{11} Source \url{https://www.icao.int}
\textsuperscript{12} Source \url{https://www.iers.org}
● The International Terrestrial Reference System (ITRS) and its realization, the International Terrestrial Reference Frame (ITRF).
● Earth orientation parameters required to study earth orientation variations and to transform between the ICRF and the ITRF.
● Geophysical data to interpret time/space variations in the ICRF, ITRF or earth orientation parameters, and model such variations.
● Standards, constants and models (i.e., conventions) encouraging international adherence.
3 Governance of Geospatial Standards in KSA

3.1 Introduction
This chapter describes the governance of geospatial standards in KSA, the organizations involved and the process of creating national standards in Saudi Arabia.

3.2 KSA Standards Governance Organizations

3.2.1 Saudi Standards, Metrology and Quality Organization\(^\text{13}\) (SASO)

SASO was established pursuant to the Royal Decree No. M/10 dated 03/03/1392 H as a body of judicial personality and of an independent budget. A board of directors, headed by his Excellency the Minister of Commerce and Investment and comprised of representatives of the major sectors concerned with standardization in the Kingdom, outlines the general policy of SASO.

SASO works to achieve the following strategic goals:
1. Maintaining the safety of consumers through preparing and adopting suitable standards for goods and services.
2. Contributing to the development of national economy through the implementation of suitable Saudi standards on goods, products and services to improve the competitive capability of national products.
3. Adjusting tools and procedures of measurement and calibration in the Kingdom to match international measurements and calibration.
4. Disseminating the quality culture in all industrial and service activities, both public and private, and raising awareness of the benefits of adopting quality standards.

3.2.2 General Commission for Survey (GCS)

The General Commission for Survey (GCS) in KSA is envisioned to be mandated as the organizing body for the National Geospatial Information Sector in Saudi Arabia. In this role, GCS is a formal member of ISO TC 211 on Geographic information / Geomatics.

\(^{13}\) Source [www.saso.gov.sa](http://www.saso.gov.sa)
3.4 SASO Standards Adoption Process

The SASO adoption process for international standards starts from national technical committee suggestions or initiatives. The national technical committee consists of different stakeholders in the private, public, and academic sectors. The national technical committee selects the international standards appropriate for adoption in Saudi Arabia and then the technical committee experts study the candidate standards and, if necessary, impose additional national requirements. A final draft of the selected standards are then circulated for a 60 day review period between all stakeholders in Saudi Arabia. Any comments received on the final draft are addressed from the review period and then submitted for approval by the board of directors of SASO. The adoption process also requires submitters to specify the ‘degree of correspondence’ (identical, modified, not-equivalent) with the international standard as defined by ISO/IEC GUIDE 21-1:2005(E) Adoption of International Standards. The adoption of international standards will be submitted with ‘identical’ degree of correspondence with the source international standard if there is any national requirement added, and the adoption of national standards (e.g. the national ISO metadata profile) will be submitted with a ‘modified’ degree of correspondence with the source international standard. There are two categories of approval for the adoption of international standards: optional and mandatory depend on the decision of the national technical committee. In the meantime, if there is any suggestion from any entities for adoption international standards to be national standards, the SASO online submission form will be used and then the national technical committee will study the suggestion and validate its importance.

3.5 GCS Adoption Process For International Geospatial Standards

With an established geospatial standards adoption criteria, a technical working group at GCS can proceed to evaluate the standards in the candidate list and document the rationale for recommendation of a standards suite for national adoption. Both the adoption criteria and the candidate standards list may evolve as the recommendation process progresses.

3.5.1 GCS Standards Adoption Criteria

The evaluation criteria for the adoption of KSA standards should include the following considerations:

1. Relevance of the standard to the NGIC charters
   - Consult the charter initiative documents for relevance
     - e.g. Standards, Data Governance, Dissemination, Technical Platform, Organization

2. Maturity of the standard
   - Is the candidate standard actively maintained by a governance body?
     - e.g. ISO, OGC, W3C, OASIS, DGIWG, IHO, ICAO
   - Is the candidate standard widely adopted?
     - Consult the survey of ‘Standards by Adoption’ analysis in the spreadsheet provided in NGIC-SD-02 Initiative Reference Documents
   - Is there evidence of implementation of the candidate standard?
     - Some Standards Development Organisations require that there be evidence of implementation as part of the organization’s standardisation approval criteria (e.g. OGC Implementation Standards)

15 Source [https://www.saso.gov.sa/ar/standards/Pages/SubmitSuggestion.aspx](https://www.saso.gov.sa/ar/standards/Pages/SubmitSuggestion.aspx)
3.6 Evolution of National SDI Standards

Standards maintained by the different governance organizations (e.g. ISO, OGC, W3C, OASIS) are continually being revised by technical committees and advisory groups, based on feedback captured from lessons learned by implementers as the standard is used. In this way, standards mature over time and are published as new revisions as part of the standards release cycle of the governance organization.

One of the life cycle management decisions that a national standards working group has to make is if and when to adopt a new revision of a standard. This decision is closely linked to the life cycle management of SDI applications that have some dependency on the standard. Factors that need to be considered include the added value of the new standard, return on investment, and the ability to enhance SDI applications in a timely manner. Adoption of new standards in an SDI needs to add enough value to justify upgrading an SDI application, service or portal, and so the adoption of a new version of an SDI standard needs to be predictable and coordinated.

Backward compatibility is a key requirement for preserving customer investments in the overall technology. Minor revisions of standards (e.g. 3.1 to 3.2) tend to be backwards compatible and so are easier to accommodate by the SDI standards adoption process. On the other hand, major revisions of standards (e.g. 3.0 to 4.0) tend not to be backwards compatible and may be more of a burden to integrate into the life cycle management of dependent SDI applications. However exceptions to backward compatibility may be tolerated if the new functionality has enough value to fully compensate the investments in change management.

16 Source http://www.opengeospatial.org/resource/products/compliant
4 Use of Geospatial Standards in KSA

4.1 Introduction
This chapter describes the use, enforcement, and the compliance of geospatial standards in KSA.

4.2 Use of Geospatial Standards

4.2.1 Use of Standards in the NGIC Charter Initiatives
The NGIC Standards Initiative\(^\text{17}\) describes in general how standards and best practices are to be utilized in the other NGIC initiatives including data governance, dissemination, and technology platform.

4.2.2 Use of Standards in the Data Governance and Dissemination Initiatives
The use of standards in the Data Governance and Dissemination Initiatives for the development and dissemination of data and metadata is illustrated in the following figure. The blue boxes illustrate the standards that are to be applied at the various stages of the Data Governance initiative and the green boxes illustrate the standards that are to be used in the stages of the Dissemination initiative.

\(^{17}\) Source: NGIC-CH-04 Standards Initiative document

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Date 02-07-2018
Version 1.0
4.3 Enforcement of Standards

Deploying standards-based SDI applications and portals do not just happen. Stakeholder organizations must agree and commit to the use of standards in the SDI infrastructure. Clear statements must be made regarding the commitment to using standards and this commitment should be documented in procurement policy to maximize the value of investments. Organizations should use procurement language as suggested in the following section 4.3.1 in tenders, Requests For Quotes (RFQs) and Requests For Proposals (RFPs) that requires vendors to offer solutions and products that are standards based and to provide evidence of compliance as described in section 4.4 Standards Compliance with the relevant standards. Ideally a specific standard will be available to meet every interoperability need. However, compliance tests are not available for every standard. Requiring or favoring an ‘implementing’ product may be the most the purchaser can hope for in cases where no compliance test for the standard exists.

4.3.1 Procurement Language in Tenders, RFQs and RFPs

The procurement language used in tenders, RFQs and RFPs should clearly explain the purchaser’s interoperability needs for standard-compliant offerings in general, and in particular include any requirements for compliance with specific standards (e.g. data, process, or service standards).

4.3.1.1 General Procurement Language

General sample text that can be included in procurement documents in situations where compliance with national standards is recommended

- Contractors must implement or comply with the relevant KSA National Standards (https://www.saso.gov.sa/en/standards/Pages/default.aspx), as required by the project specifications.
Sample text that can be included in procurement documents in situations where compliance is not required but is one of the evaluation criteria being considered. The standards list should be provided to only include those standards required to satisfy the requirements of the desired system.

- **Evaluation Criterion 1.1: Standards compliance**
Purchaser seeks geospatial data and products (data, services, or systems) that provide maximum interoperability with purchaser’s and data sharing partner’s systems. To accomplish this, the purchaser seeks to make maximum use of open geospatial standards provided by the International Organization for Standardization (ISO), the Open Geospatial Consortium (OGC) and [list of other standards, profiles or recommendations]. **Products that can provide evidence of compliance with the standards listed below will score more favorably on this evaluation criterion.**

### 4.3.1.2 More Specific Procurement Language

Sample text that can be included in procurement documents in situations where compliance with GCS geospatial standards is required

- Contractors must provide full documentation as follows: complete source code, in the agreed formats appropriate for the platforms being used in the project; accompanying documents outlining overall functionality and implementation issues; and **for geospatial data products and services, evidence of compliance with the relevant GCS Geospatial Standards.**

### 4.3.1.3 Very Specific Procurement Language

Sample text that can be included in procurement documents in situations where compliance with a specific standard is required

- For the data capture of `<Fundamental Dataset X at scale Y>`, **contractors must comply with the national data capture standard:**
  

### 4.3.2 Comply or Explain Policy for Standards

One way to enforce the use of standards is to implement a ‘comply or explain’ policy as employed in the Netherlands. Under this policy, large technical projects must comply with a list of standards relevant to the project or explain why these standards cannot be used (e.g. in rare cases where the requirement is for very specialized (niche) software, for which no standards are applicable). The national open standards maintained by the Netherlands Standardization Forum\(^\text{18}\) are divided into two categories: the mandatory list\(^\text{19}\) and the recommended list\(^\text{20}\) of standards. The mandatory list of standards are applicable to the ‘comply or explain’ policy and must be requested in procurements by government organizations when purchasing Information and Communication Technology (ICT) products or services of € 50,000 or more.

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\(^{18}\) Source [https://www.forumstandaardisatie.nl/open-standaarden](https://www.forumstandaardisatie.nl/open-standaarden)

\(^{19}\) Source [https://www.forumstandaardisatie.nl/open-standaarden/lijst/verplicht](https://www.forumstandaardisatie.nl/open-standaarden/lijst/verplicht)

\(^{20}\) Source [https://www.forumstandaardisatie.nl/open-standaarden/lijst/aanbevolen](https://www.forumstandaardisatie.nl/open-standaarden/lijst/aanbevolen)
4.4 Standards Compliance

The main purpose of the standards compliance is to increase system interoperability while reducing technology risks. Buyers gain confidence that a compliant product will work with another compliant product based on the same standard, regardless of which company developed the product. Vendors gain confidence that they are providing a product compliant with standards, which will be easier to integrate and easier to market. Examples of standards compliance tools are described in the following sections.

4.4.1 Metadata Validator

Metadata validator tools are available for both online and stand-alone use. An online ISO metadata validator allows a user to reference or paste an ISO 19139 metadata instance in the online interface to be validated against a specific metadata profile. The following figure illustrates the Inspire Metadata Validator Tool\(^\text{21}\), which validates against the Inspire metadata profile of ISO 19115.

![Inspire ISO Metadata Editor](http://inspire-geoportal.ec.europa.eu/validator2/)

The Inspire ISO Metadata Editor\(^\text{22}\) also validates metadata as it is entered into the tool against the Inspire metadata profile. The following figure illustrates the Inspire metadata editor.

4.4.2 Data Validator

A data validator tool would enable the validation of fundamental datasets (GML) against the GML application schemas developed in the Data Governance Initiative and published in the data model catalog. Many schema validators are available both commercially (Oxygen, Altova, Saxon, etc) and as free open source (e.g. Apache Xerces). Schema validators are available for both online and stand-alone use. The following figure illustrates an online GML Validator\(^\text{23}\) hosted by OGC.

\(^{23}\) Source [http://cite.opengeospatial.org/test_engine/gml/2.1.2/validator/](http://cite.opengeospatial.org/test_engine/gml/2.1.2/validator/)
GML Instance Validator

Validate a GML instance document against its schema.

Instructions: You may provide a URL to the instance document or paste the contents below. In both cases, the schemaLocation must be specified as a valid URL.

Instance URL

or

Instance document

Validate instance
4.4.3 Service Standards
The OGC Compliance Program provides a free online testing facility, a process for certification of compliant products, and coordination of a vibrant community of developers. The OGC testing facility allows users to test the compliance of web service standards as well as a number of data encoding standards. The various service and data standards available for compliance testing by the OGC Test Engine\(^\text{24}\) is illustrated in the following figure.

### Available Test Suites

<table>
<thead>
<tr>
<th>Specification</th>
<th>Version</th>
<th>Test Suite Revision</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalogue Service - Web (CSW)</td>
<td>2.0.2</td>
<td>1.16</td>
<td>Final</td>
</tr>
<tr>
<td>Catalogue Service - Web (CSW)</td>
<td>3.0.0</td>
<td>1.0</td>
<td>Beta</td>
</tr>
<tr>
<td>GeoPackage</td>
<td>1.0</td>
<td>1.0</td>
<td>Beta</td>
</tr>
<tr>
<td>Geography Markup Language (GML)</td>
<td>3.2.1</td>
<td>1.25</td>
<td>Final</td>
</tr>
<tr>
<td>OGC KML</td>
<td>2.2</td>
<td>1.12</td>
<td>Final</td>
</tr>
<tr>
<td>Sensor Observation Service (SOS)</td>
<td>1.0.0</td>
<td>1.13</td>
<td>Final</td>
</tr>
<tr>
<td>Sensor Observation Service (SOS)</td>
<td>2.0</td>
<td>1.13</td>
<td>Final</td>
</tr>
<tr>
<td>Sensor Planning Service (SPS)</td>
<td>1.0</td>
<td>1.7</td>
<td>Final</td>
</tr>
<tr>
<td>Sensor Planning Service (SPS)</td>
<td>2.0</td>
<td>1.10</td>
<td>Final</td>
</tr>
<tr>
<td>SensorThings API</td>
<td>1.0</td>
<td>1.0</td>
<td>Beta</td>
</tr>
<tr>
<td>Simple Feature Access - SQL (SFS)</td>
<td>1.1</td>
<td>1.6</td>
<td>Final</td>
</tr>
<tr>
<td>Simple Feature Access - SQL (SFS)</td>
<td>1.2.1</td>
<td>1.4</td>
<td>Final</td>
</tr>
<tr>
<td>Web Coverage Service (WCS)</td>
<td>1.0.0</td>
<td>1.13</td>
<td>Final</td>
</tr>
<tr>
<td>Web Coverage Service (WCS)</td>
<td>1.1.1</td>
<td>1.12</td>
<td>Final</td>
</tr>
<tr>
<td>Web Coverage Service (WCS)</td>
<td>2.0.1</td>
<td>1.12</td>
<td>Final</td>
</tr>
<tr>
<td>Web Feature Service (WFS)</td>
<td>1.0.0</td>
<td>1.11</td>
<td>Final</td>
</tr>
<tr>
<td>Web Feature Service (WFS)</td>
<td>1.1.0</td>
<td>1.29</td>
<td>Final</td>
</tr>
<tr>
<td>Web Feature Service (WFS)</td>
<td>2.0</td>
<td>1.26</td>
<td>Final</td>
</tr>
<tr>
<td>Web Map Service (WMS)</td>
<td>1.1.1</td>
<td>1.15</td>
<td>Final</td>
</tr>
<tr>
<td>Web Map Service (WMS)</td>
<td>1.3.0</td>
<td>1.22</td>
<td>Final</td>
</tr>
<tr>
<td>Web Map Service (WMS) - Client</td>
<td>1.3.0</td>
<td>1.2</td>
<td>Final</td>
</tr>
<tr>
<td>Web Map Tile Service (WMTS)</td>
<td>1.0.0</td>
<td>1.0</td>
<td>Beta</td>
</tr>
</tbody>
</table>

\(^{24}\) Source [http://cite.opengeospatial.org/teamengine/](http://cite.opengeospatial.org/teamengine/)
5 List of KSA Geospatial Standards

5.1 Introduction
This chapter describes the candidate list of standards being proposed for national adoption in KSA and the various ways that these standards can be classified. The candidate list of standards described here are all relevant to horizon 1 of the master implementation plan.

5.2 Standards Classifications
There are several ways to classify geospatial standards and these classifications can be used to aid searching in browsing in standard registers. Some relevant classifications of standards are listed as follows:

- ISO TC 211 Classification
  - INFRASTRUCTURE STANDARDS
  - DATA MODEL STANDARDS
  - GEOGRAPHIC INFORMATION MANAGEMENT STANDARDS
  - GEOGRAPHIC INFORMATION SERVICES STANDARDS
  - GEOGRAPHIC INFORMATION ENCODING STANDARDS
  - STANDARDS FOR SPECIFIC THEMATIC AREAS

- OGC Reference Model classification
  - Geospatial Information
  - Geospatial Services

- Classification by Standards Organization
  - ISO
  - OGC
  - W3C
  - OASIS
  - OMG
  - IETF
  - WS-I

- UN GGIM Tier classification
  - Tier 1 - Share Maps over the Web
    - Visualization and Portrayal
    - Catalogue and Discovery
    - Data content and management
  - Tier 2 - Partnerships - Share, Integrate and Use Geospatial Data from different Providers
    - Distributed Maintenance and Use
    - Domain Data Model Standards
    - Additional Implementation standards
  - Tier 3 - Spatially Enabling the Nation
    - Geospatial Processing
    - Mobile Devices

Source 26  http://www.opengeospatial.org/standards/orm
5.3 Overview of Official KSA Geospatial Standards

5.3.1 National Standards
The following table contains an initial set of proposed standards that when completed will be recommended for national adoption in Saudi Arabia with ‘modified’ (not identical) degree of correspondence as defined by ISO/IEC GUIDE 21-1:2005(E) Adoption of International Standards.

<table>
<thead>
<tr>
<th>#</th>
<th>Standard Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISO Metadata Profile for KSA</td>
<td>Metadata for Datasets (ISO 19115-1), imagery (ISO 19115-2) and Services (ISO 19119) for KSA</td>
</tr>
<tr>
<td>2</td>
<td>GML Profile for KSA</td>
<td>ISO 19136 Geography Markup Language Profile</td>
</tr>
<tr>
<td>3</td>
<td>Feature Concept Dictionary for KSA</td>
<td>ISO 19126 Feature Concept Dictionary</td>
</tr>
<tr>
<td>4</td>
<td>Feature Catalogues for KSA</td>
<td>ISO 19110 Feature Catalogues</td>
</tr>
<tr>
<td>5</td>
<td>Data QA/QC Processing Standards</td>
<td>Standardized methodology for data QA/QC processes as developed by the NGIC in collaboration with data production stakeholders</td>
</tr>
<tr>
<td>6</td>
<td>Data Capture Standards</td>
<td>Standardized methodology for data capture for each Fundamental Dataset and per scale as developed by the NGIC in collaboration with data production stakeholders</td>
</tr>
<tr>
<td>7</td>
<td>KSA Coordinate Reference Systems and supporting geodetic components</td>
<td>New Coordinate Reference Systems and supporting components such as datums, ellipsoids, prime meridians, and other parameters that are specific to Saudi Arabia</td>
</tr>
</tbody>
</table>
### 5.3.2 International Standards

The following table contains an initial set of international standards recommended for national adoption in Saudi Arabia with ‘identical’ (unmodified) degree of correspondence as defined by ISO/IEC GUIDE 21-1:2005(E) Adoption of International Standards.

<table>
<thead>
<tr>
<th>#</th>
<th>Standard Name</th>
<th>Organisation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19101 Geographic information -- Reference model</td>
<td>ISO</td>
<td>Defines the framework for standardization in the field of geographic information and sets forth the basic principles by which this standardization takes place. This is an abstract specification and is the basis for most of the ISO TC211 specifications listed here.</td>
</tr>
<tr>
<td>2</td>
<td>19103 Conceptual schema language</td>
<td>ISO</td>
<td>Rules and guidelines for the use of a conceptual schema language. This provides the framework for the use of other standards and standards components including data dictionary, feature catalogue and schemas, including the use of UML.</td>
</tr>
<tr>
<td>3</td>
<td>19107 Spatial Schema (under review, will be replaced by ISO/DIS 19107)</td>
<td>ISO</td>
<td>Specifies conceptual schemas for describing the spatial characteristics of geographic features, and a set of spatial operations consistent with these schemas. This is an abstract specification that defines geometry classes and operations. Used as a foundation for implementation specifications like GML.</td>
</tr>
<tr>
<td>4</td>
<td>19108 Temporal Schema</td>
<td>ISO</td>
<td>Defines concepts for describing temporal characteristics of geographic information. This is an abstract specification that defines times, dates, time intervals etc. Used as a foundation for implementation specifications like GML.</td>
</tr>
<tr>
<td>5</td>
<td>19109 Rules for application schema</td>
<td>ISO</td>
<td>Defines rules for creating and documenting application schemas, including principles for the definition of features. This is an abstract specification that defines feature concepts in the context of application schemas, which are used as a foundation for implementation specifications like GML (ISO 19136).</td>
</tr>
<tr>
<td>6</td>
<td>19110 Feature Catalogue</td>
<td>ISO</td>
<td>Defines the methodology for cataloguing feature types and specifies how the classification of feature types is organized into a feature catalogue and presented to the users of a set of geographic data. This is an abstract specification but is important with respect to the deployment of feature catalogues using implementation specifications such as OGC CSW-ebRIM, and use of application schemas (e.g. in Oracle or GML (ISO 19136)).</td>
</tr>
<tr>
<td></td>
<td>Standard Number</td>
<td>Organization</td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-----------------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>7</td>
<td>19111 Spatial Referencing by Coordinates</td>
<td>ISO</td>
<td>Defines the conceptual schema for the description of spatial referencing by coordinates, optionally extended to spatio-temporal referencing. This is an abstract specification that defines coordinate reference systems and supporting components such as datums and earth models. Used as a foundation for implementation specifications like GML (ISO 19136)</td>
</tr>
<tr>
<td>9</td>
<td>19115-2 Metadata (Imagery)</td>
<td>ISO</td>
<td>Extends ISO 19115:2003/Cor 1:2006 (currently withdrawn) by defining metadata elements required to describe digital geospatial imagery and gridded data. It provides information about the properties of the measuring equipment used to acquire the data, the geometry of the measuring process employed by the equipment, and the production process used to digitize the raw data. Will be replaced by ISO/FDIS 19115-2</td>
</tr>
<tr>
<td>10</td>
<td>19118 Encoding</td>
<td>ISO</td>
<td>Specifies the requirements for defining encoding rules to be used for interchange of geographic data within the ISO 19100 series of International Standards. Concrete encoding specifications such as ISO 19136 (GML) and ISO 19139 (metadata) are consistent with ISO 19118.</td>
</tr>
<tr>
<td>11</td>
<td>19119 Services</td>
<td>ISO</td>
<td>ISO 19119:2016 defines requirements for how platform neutral and platform specific specification of services shall be created, in order to allow for one service to be specified independently of one or more underlying distributed computing platforms. Identifies and defines the architecture patterns for service interfaces used for geographic information, defines its relationship to the Open Systems Environment model, presents a geographic services taxonomy and a list of example geographic services placed in the services taxonomy. This standard replaces the previous standards: ISO 19119:2005 and ISO 19119:2005/Amd 1:2008</td>
</tr>
<tr>
<td>12</td>
<td>19126 Feature concept dictionaries and registers</td>
<td>ISO</td>
<td>Specifies a schema for feature concept dictionaries to be established and managed as registers. This is an abstract specification relevant to deployment of a feature concept dictionary</td>
</tr>
<tr>
<td>13</td>
<td>19128 Web Map Service</td>
<td>ISO, OGC</td>
<td>Defines an interface for rendering spatial data and producing geo-registered map images. A map is defined as the “portrayal of geographic information as a digital image file suitable for display on a computer screen.” This is a key specification for the sharing of digital maps.</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>Organization</td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>ISO 19131 Data product specifications</td>
<td>ISO</td>
<td>Specifies requirements for the specification of geographic data products, based upon the concepts of other ISO 19100 International Standards. This is an abstract specification and can be used for the specification of data products. A data product is a package of data, usually with some form of presentation, and can be media specific. A Data Product can include paper maps as well as geographic data sets distributed on electronic media.</td>
</tr>
<tr>
<td>15</td>
<td>ISO 19136 Geography Markup Language</td>
<td>ISO, OGC</td>
<td>An XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modeled in accordance with the conceptual modeling framework used in the ISO 19100 series of International Standards and including both the spatial and non-spatial properties of geographic features.</td>
</tr>
<tr>
<td>16</td>
<td>ISO 19139 Metadata -- XML schema implementation</td>
<td>ISO</td>
<td>Defines an XML grammar for representing geospatial metadata in conformance with the abstract content model specified in ISO 19115. The XML schemas are freely available from ISO. This is a critical standard for the sharing of metadata.</td>
</tr>
<tr>
<td>17</td>
<td>ISO 19142 Web Feature Service</td>
<td>ISO, OGC</td>
<td>Specifies the behaviour of a web service that provides transactions on and access to geographic features in a manner independent of the underlying data store. This is a critical specification for the sharing of geospatial information. This specification enables data to be requested or updated across the Internet.</td>
</tr>
<tr>
<td>18</td>
<td>ISO 3166 Country codes</td>
<td>ISO</td>
<td>Defines the country names. Likely to be used within a metadata record.</td>
</tr>
<tr>
<td>19</td>
<td>ISO 639 Language Codes</td>
<td>ISO</td>
<td>Codes for the representation of names of languages. Likely to be used within a metadata record. Avoids errors due to different and conflicting language encodings.</td>
</tr>
</tbody>
</table>

ISO 639 is composed of five different parts:
- Part 1 (ISO 639-1:2002) provides a 2 letter code that has been designed to represent most of the major languages of the world.
- Part 3 (ISO 639-3:2007) provides a 3 letter code and aims to give as complete a listing of languages as possible, including living, extinct and ancient languages.
<table>
<thead>
<tr>
<th></th>
<th>8601 Date times</th>
<th>ISO</th>
<th>Representation of dates and times. Likely to be used within a metadata record. Avoids errors due to different and conflicting data and time encodings be different groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Catalogue Service</td>
<td>OGC</td>
<td>Supports the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. This is an abstract specification and must be profiled to be implemented, e.g. the ISO profile (CSW-ISO) or the ebRIM profile (CSW-ebRIM).</td>
</tr>
<tr>
<td>22</td>
<td>Catalogue Services Specification 2.0.2 - ISO Metadata Application Profile: Corrigendum</td>
<td>OGC</td>
<td>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.</td>
</tr>
<tr>
<td>23</td>
<td>KML</td>
<td>OGC</td>
<td>An XML grammar used to encode and transport representations of geographic data for display in an earth browser, such as a 3D virtual globe, 2D web browser application, or 2D mobile application. A KML instance is processed in much the same way that HTML (and XML) documents are processed by web browsers. Like HTML, KML has a tag-based structure with names and attributes used for specific display purposes.</td>
</tr>
<tr>
<td>24</td>
<td>OGC Reference model</td>
<td>OGC</td>
<td>Provides an overarching concept for the application of standards</td>
</tr>
<tr>
<td>25</td>
<td>RFC 3986 URI</td>
<td>IETF</td>
<td>A Uniform Resource Identifier (URI) is a compact sequence of characters that identifies an abstract or physical resource (URI): Generic Syntax. This is a key companion specification for the W3C XML specification.</td>
</tr>
<tr>
<td>26</td>
<td>Rule based validation - Schematron</td>
<td>ISO</td>
<td>Schematron is a rule-based validation language for making assertions about the presence or absence of patterns in XML trees. It is a structural schema language expressed in XML using a small number of elements and XPath.</td>
</tr>
<tr>
<td>27</td>
<td>S-4</td>
<td>IHO</td>
<td>The publication S-4 (previously M-4) ‘Regulations of the IHO for International (INT) Charts and Chart Specifications of the IHO, includes: • 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’ The three Parts of S-4 are further subdivided into Sections dealing with specific topics. Regulations and</td>
</tr>
</tbody>
</table>
Specifications relating to particular topics may be found either by their subject matter in the Contents page at the beginning of each Section, or by reference to column 5 of INT 1 for Part B and the index for Part C. Cross referencing draws attention to related Regulations, Technical Resolutions and Specifications.

| 28 | S-52 | IHO | These Specifications for Chart Content and Display Aspects of ECDIS are intended to contribute to the safe operation of ECDIS by:  
- ensuring a base and supplementary levels of display for ENC data; standards of symbols, colours and their standardized assignment to features; scale limitations of data presentation; and appropriate compatibility with paper chart symbols as standardized in the Chart Specifications of the IHO.  
- ensuring the display is clear and unambiguous,  
- ensuring that there is no uncertainty over the meaning of colours and symbols on the display,  
- establishing an accepted pattern for ECDIS presentation that becomes familiar to mariners and so can be recognized instantly without confusion. |
| 29 | S-57 | IHO | A 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. For example, this standard is intended to be used for the supply of data for ECDIS. This transfer and distribution has to take place in such a way that none of the meaning of the data is lost. |
| 30 | S-65 | IHO | This document provides a high level guide to the production, maintenance and distribution of Electronic Navigational Charts (ENCs). It offers a framework to inform hydrographic offices of the processes and requirements necessary to produce, maintain and distribute ENCs. It provides references to documentation which can support each stage of the process. It is not intended to serve as a technical reference manual but to enable hydrographic offices to gain an overview of ENC production processes, and the requirements and procedures that need to be in place to set up an ENC production facility. |
| 31 | S100 | IHO | An IHO standard to facilitate better marine and hydrographic information exchange than is available with the S-57 standard. Essentially, S-100 extends the functionality of the S-57 hydrographic data transfer |
standard by creating a more flexible and richer data framework. The standard was developed by the IHO Transfer Standards Maintenance and Applications Development (TSMAD) Working Group with active participation from hydrographic offices, industry and academia. Concrete advantages cited by the IHO for S-100 have included alignment with internationally accepted geographic standards (ISO 19100), provision of images, gridded data types, enhanced metadata, and multiple encoding formats. This would, among other things, allow for presentation of real-time data, such as tidal changes. While S-57 was designed primarily to present nautical chart data, S-100 is meant to enable the organization, transfer, and presentation of data for multiple hydrographic application domains.

<table>
<thead>
<tr>
<th>Number</th>
<th>Standard</th>
<th>Organization</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>SAML</td>
<td>OASIS</td>
<td>XML-based framework for creating and exchanging security information between online partners.</td>
</tr>
<tr>
<td>33</td>
<td>Scalable Vector Graphics (SVG)</td>
<td>W3C</td>
<td>Modularized language for describing two-dimensional vector and mixed vector/raster graphics in XML. This specification could be a potential map encoding returned by an OGC WMS (ISO 19128). With HTML 5.0, SVG is again becoming more important.</td>
</tr>
<tr>
<td>34</td>
<td>Styled Layer Descriptor (SLD)</td>
<td>OGC</td>
<td>Defines an encoding that extends the WMS standard to allow user-defined symbolization and coloring of geographic feature and coverage data. This can be considered a key partner to the WMS (ISO 19128) specification. It is related to, but not a direct implementation of ISO 19117.</td>
</tr>
<tr>
<td>35</td>
<td>Unified Modeling Language (UML)</td>
<td>OMG, ISO</td>
<td>Graphical language for visualizing, specifying, constructing and documenting the artefacts of a software-intensive system. This may be used in GCS as a uniform approach to conceptual data modeling in support of feature/coverage types etc.</td>
</tr>
<tr>
<td>36</td>
<td>Web Services Common</td>
<td>OGC</td>
<td>Specifies many of the aspects that are, or should be, common to all or multiple OGC Web Service interface implementation standards. It is a component for other OGC standards.</td>
</tr>
<tr>
<td>37</td>
<td>XACML</td>
<td>OASIS</td>
<td>Core XML schema for representing authorization and entitlement policies, employed to support data security.</td>
</tr>
<tr>
<td>38</td>
<td>XLink</td>
<td>W3C</td>
<td>Language which allows elements to be inserted into XML documents in order to create and describe links between resources. A companion to the XML specification. Used by ISO 19136 and other OGC specifications.</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>Acronym</td>
<td>Organization</td>
</tr>
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</tr>
<tr>
<td>39</td>
<td>XMI</td>
<td>OMG, ISO</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>XML 1.0</td>
<td>W3C</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>XML namespaces</td>
<td>W3C</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>XML Schema</td>
<td>W3C</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>XPath</td>
<td>W3C</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>XPointer</td>
<td>W3C</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>XSLT</td>
<td>W3C</td>
<td></td>
</tr>
</tbody>
</table>

5.4 Detailed Explanation of Selected Standards

5.4.1 OGC Geography Markup Language (GML) - ISO 19136

GML is an XML grammar that is used to describe geographic objects in the world around us. By building upon broader Internet standards from W3C, GML expresses geographic information that can be readily shared over the Web. In GML, real world objects are called features which can be concrete and tangible such as rivers, roads, and land parcels; or abstract and conceptual, such as political boundaries or distributions of quantities over geographical areas (coverages). In contrast to legacy GIS approaches, a GML feature is not defined primarily as a geometric object, but rather a meaningful object that is an abstraction of real world phenomena that may have multiple geometric properties and other non-spatial properties such as: name, description, colour, height, and density.

As it is impossible to describe all features and predict their usage beforehand, the GML core schemas do not contain definitions of concrete features. Rather, concrete features must be defined...
in GML Application Schemas, which are created by user communities or organizations. For example a feature type Bridge may be created in an application schema with the properties: identifier, name, description, span, and location.

GML application schemas import the common geographic constructs in GML such as the abstract feature model, geometry, units, coordinate reference systems, etc. In turn, GML imports the common data types and constructs from W3C such as XML data types (strings, dates, etc.)

GML data is encoded in XML and GML application schemas are encoded as XML Schema (XSD), making it amenable to a wide range of existing XML tools and technologies to validate, parse, link, and transform.
5.4.2 OGC Web Feature Service (WFS) - ISO 19142
The WFS specifies the web service interface that provides transactions on and access to GML features in a manner independent of the underlying data store. The WFS standard defines operations that enable clients to:

- Discover which feature collections are available (GetCapabilities)
- Describe the properties of GML features (DescribeFeatureType)
- Query features using a filter on the property values (GetFeature)
- Add, edit or delete features (Transaction)

All WFSs support requests and responses in GML. Some WFSs also support other encodings, such as GeoRSS or shapefiles. Users typically interact with WFSs through browser or desktop clients, which allow them to access GML feature data from one or more external agencies over the web.

5.4.3 OGC Web Map Service (WMS) - ISO 19128
The WFS defines a web interface for rendering geospatial data and producing geo-registered map images. A map is defined as the portrayal of geographic information as a digital image file suitable for display on a computer screen. The WMS standard defines three operations:

- GetCapabilities (required): Obtain service-level metadata, which is a machine-readable (and human-readable) description of the WMS’s information content and acceptable request parameters.
- GetMap (required): Obtain a map image whose geospatial and dimensional parameters are well defined.
- GetFeatureInfo (optional): Ask for information about particular features shown on a map.

The WMS standard is implemented in hundreds of products, many of which are registered at the OGC (http://www.opengeospatial.org/resource/products/compliant).
5.4.3.1 OGC Feature Portrayal Service (FPS)
The Feature Portrayal Service (FPS) is a specialized case of a WMS. The FPS is a Component Web Map Service that supports SLD and SE. A Component WMS is loosely coupled and work with any combination of WFSs. For example, a Component WMS can symbolize feature data from one or more WFSs to which it is directed. The FPS applies styles typically encoded as Styled Layered Descriptor (SLD) to GML features to produce a map image. Both the styles and the source WFS components must be specified by the client in the GetMap request.

5.5 Dependencies between Standards
GML depends on standards from ISO, W3C, and IETF and other standards such as FPS, SLD, SE, WFS, and Filter depend directly or indirectly on GML. GML depends on the following W3C technology standards.

- XML 1.0 - Technology for encoding documents
- XML Schema (XSD) Parts 1 and 2 - Technology for data modeling expression
- XPointer/XPath - Technology for Selecting & Pointing
- XLink - Technology for Linking and Associating

The GML information model is also based on the OGC Abstract Specification and the conceptual modeling framework of the ISO 19100 series of International Standards including:

- ISO/TS 19103:2005, Geographic information — Conceptual schema language
- ISO 19107:2003, Geographic information — Spatial schema
- ISO 19108:2002, Geographic information — Temporal schema
- ISO 19109:2005, Geographic information — Rules for application schema
- ISO 19111:2007, Geographic information — Spatial referencing by coordinates
- ISO 19115:2003, Geographic information — Metadata
- ISO 19118:2005, Geographic information — Encoding
- ISO 19123:2005, Geographic information — Schema for coverage geometry and functions
- ISO/TS 19139, Geographic information — Metadata — XML schema implementation