Kingdom of Saudi Arabia
General Authority for Survey and Geospatial Information

KSA Geospatial Standards Overview

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List of Acronyms

Acronym	Description
CRS	Coordinate Reference System
CSW	Catalog Service for the Web
CSW-ebRIM	e-Business Registry Information Model profile of OGC CSW
CSW-ISO	ISO profile of OGC Catalogue Service for the Web
DGIWG	Digital Geographic Information Working Group
FGDC	US Federal Geographic Data Committee
FPS	Feature Portrayal Service
GASGI	General Authority for Survey and Geospatial Information
GIS	Geographic Information System
GML	Geography Markup Language
IETF	Internet Engineering Task Force
IHO	International Hydrographic Organization
ISO	International Organization for Standardization
JPEG	Joint Photographic Experts Group
KSA	Kingdom of Saudi Arabia
NGC	National Geospatial Center
NSDI	National Spatial Data Infrastructure
NSG	US National System for Geospatial Intelligence
OASIS	Organization for the Advancement of Structured Information Standards
OGC	Open Geospatial Consortium
OMG	Object Management Group
QA	Quality Assurance
QC	Quality Control
RFC	Request For Comment
SAML	Security Assertion Markup Language
SASO	Saudi Standards, Metrology and Quality Organization
SDI	Spatial Data Infrastructure
SE	Symbology Encoding
SLD	Styled Layer Descriptor
UML	Unified Modeling Language

URI	Uniform Resource Identifier
W3C	World Wide Web Consortium
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service
WPS	Web Processing Service
WS-I	Web Services-Interoperability Organization
XACML	Extensible Access Control Markup Language
XML	Extensible Markup Language
XSD	XML Schema Definition
XSLT	Extensible Stylesheet Language Transformation

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 and national 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 References

The following references have been used.

1. United Nations GGIM, August 2015, A Guide to the Role of Standards in Geospatial Information Management - Prepared cooperatively by the Open Geospatial Consortium (OGC), The International Organization for Standards (ISO) Technical Committee 211 Geographic information/Geomatics, and the International Hydrographic Organization (IHO)
2. NGC-CH-04 Standards Initiative v1.0, September 2018, Standards Initiative charter document
3. ISO Technical Committee (TC 211) Geographic information/Geomatics: https://committee.iso.org/home/tc211
4. Open Geospatial Consortium: http://www.opengeospatial.org/

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.[1]

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

[1] United Nations GGIM, August 2015, A Guide to the Role of Standards in Geospatial Information Management

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 Standardization[2] (ISO)

ISO (International Organization for Standardization) is the world's largest developer of voluntary International Standards and has published over 24 thousand 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 over 165 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 Consortium[3] (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.

[2] Source https://www.iso.org
[3] Source https://www.w3.org

2.3.3 Organization for the Advancement of Structured Information Standards[4] (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[5] (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 the 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.

[4] Source https://www.oasis-open.org
[5] Source https://www.omg.org

2.3.5 Internet Engineering Task Force[6] (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[7] (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,

[6] Source https://www.ietf.org
[7] Source 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/Geomatics[8] (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 Consortium[9] (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.

[8] Source http://www.isotc211.org
[9] Source http://www.opengeospatial.org

The OGC works closely together with other international standards organizations to develop geospatial standards, as illustrated in Figure 2.1.

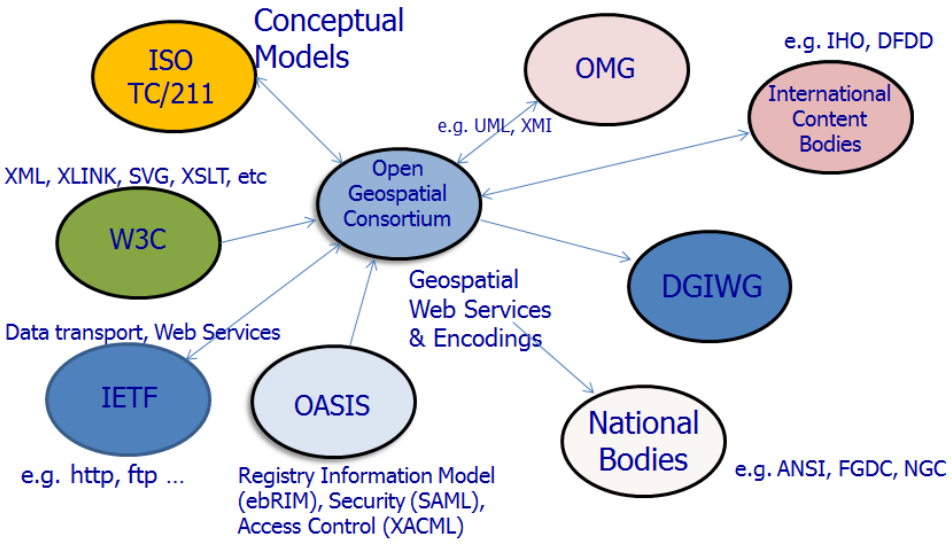

Figure 2.1 - OGC Relationships with other International Standards Organizations

2.4.3 Defence Geospatial Information Working Group[10] (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

[10] 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[11] (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.

[11] Source www.iho.int

2.5.2 International Civil Aviation Organization[12] (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[13] (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).

[12] Source https://www.icao.int
[13] Source 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[14] (SASO)

SASO was established pursuant to the Royal Decree No. M/10 dated 03/03/1392 H (17/4/1972 G) as a body of judicial personality and of an independent budget and obtained ISO membership the same year. 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.

[14] Source www.saso.gov.sa

3.2.2 General Authority for Survey and Geospatial Information (GASGI)

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

3.3 SASO Standards Adoption Process

The SASO adoption process for international standards starts from National Technical Team suggestions or initiatives. The National Technical Team consists of different stakeholders in the private, public and academic sectors. The National Technical Team selects the international standards appropriate for adoption in Saudi Arabia and then the Technical Team Working Groups 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*[15]. 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 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[16] will be used and then the national technical committee will study the suggestion and validate its importance.

3.4 GASGI Adoption Process For International Geospatial Standards

With an established geospatial standards adoption criteria, a Technical Team Working Group at GASGI 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.

[15] Source https://www.iso.org/standard/39799.html (document pdf freely available for download here)
[16] Source https://www.saso.gov.sa/ar/standards/Pages/SubmitSuggestion.aspx

3.4.1 GASGI Standards Adoption Criteria

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

1. 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 *NGC-RG-03 Standards Register*
    - 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)
        - Some Standards Development Organisations register certified compliant product implementations of standards (e.g. see OGC Product Compliance[17])

3.5 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 the National Technical Team 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.

[17] 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 NGC

The NGC Standards Initiative[18] describes in general how standards and best practices are to be utilized in the other NGC initiatives including Data Governance, Dissemination, and Technology Platform as illustrated in Figure 4.1.

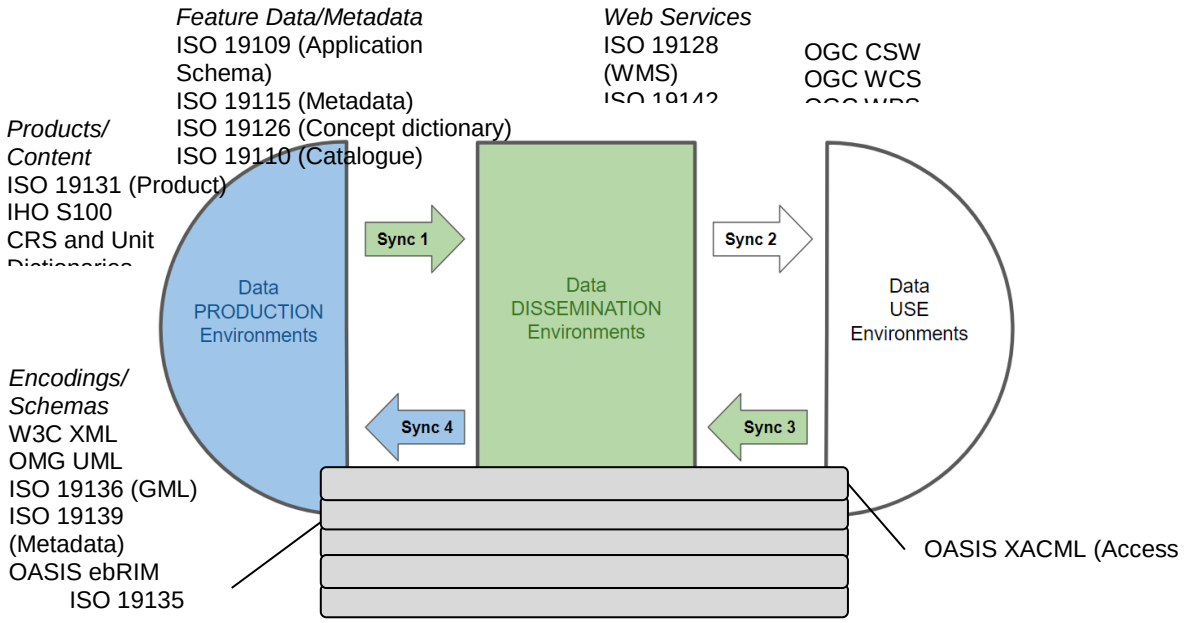

Figure 4.1 - Standards Organized by NGC Charter Initiative

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 Figure 4.1. 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.

[18] Source: NGC-CH-04 Standards Initiative document

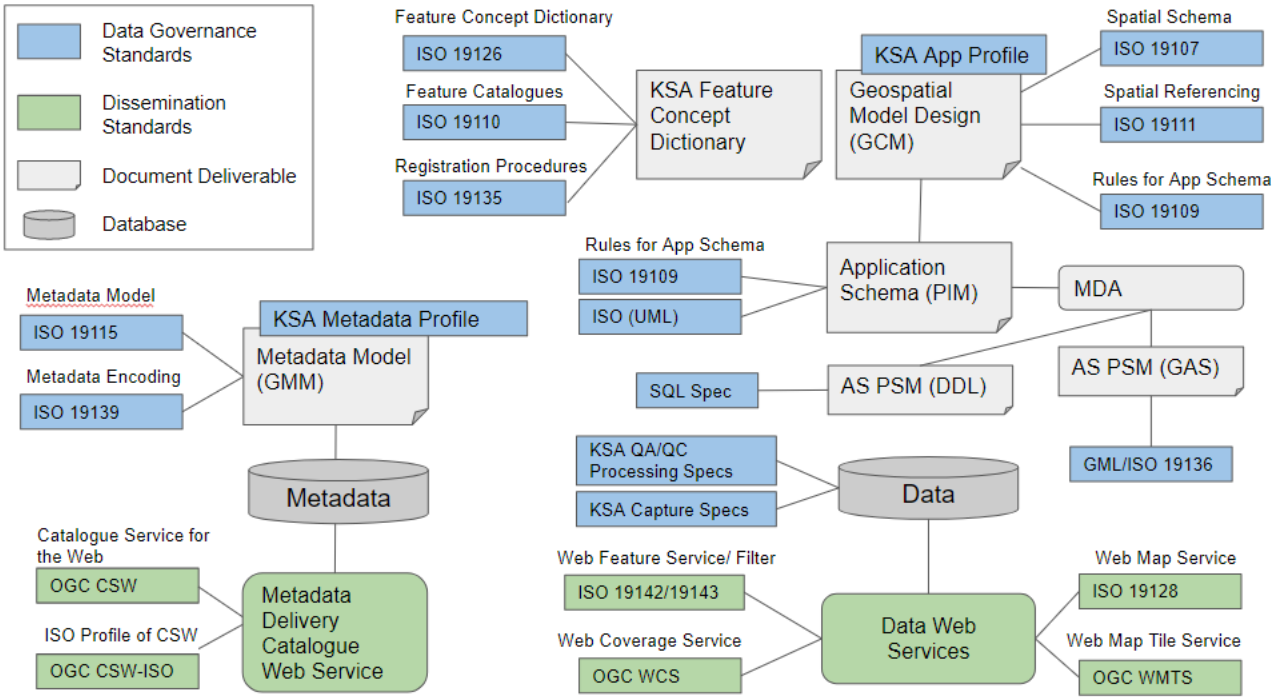

Figure 4.2 - Use of Standards in the Data Governance and Dissemination Initiatives

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 GASGI 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 GASGI 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: https://wasif.saso.gov.sa/Pages/User/SearchResults.aspx?searchkey=xyz.**

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[19] are divided into two categories: the mandatory list[20] and the recommended list[21] 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.

[19] Source https://www.forumstandaardisatie.nl/open-standaarden
[20] Source https://www.forumstandaardisatie.nl/open-standaarden/lijst/verplicht
[21] Source 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. Figure 4.3 illustrates the Inspire Metadata Validator Tool[22], which validates against the Inspire metadata profile of ISO 19115.

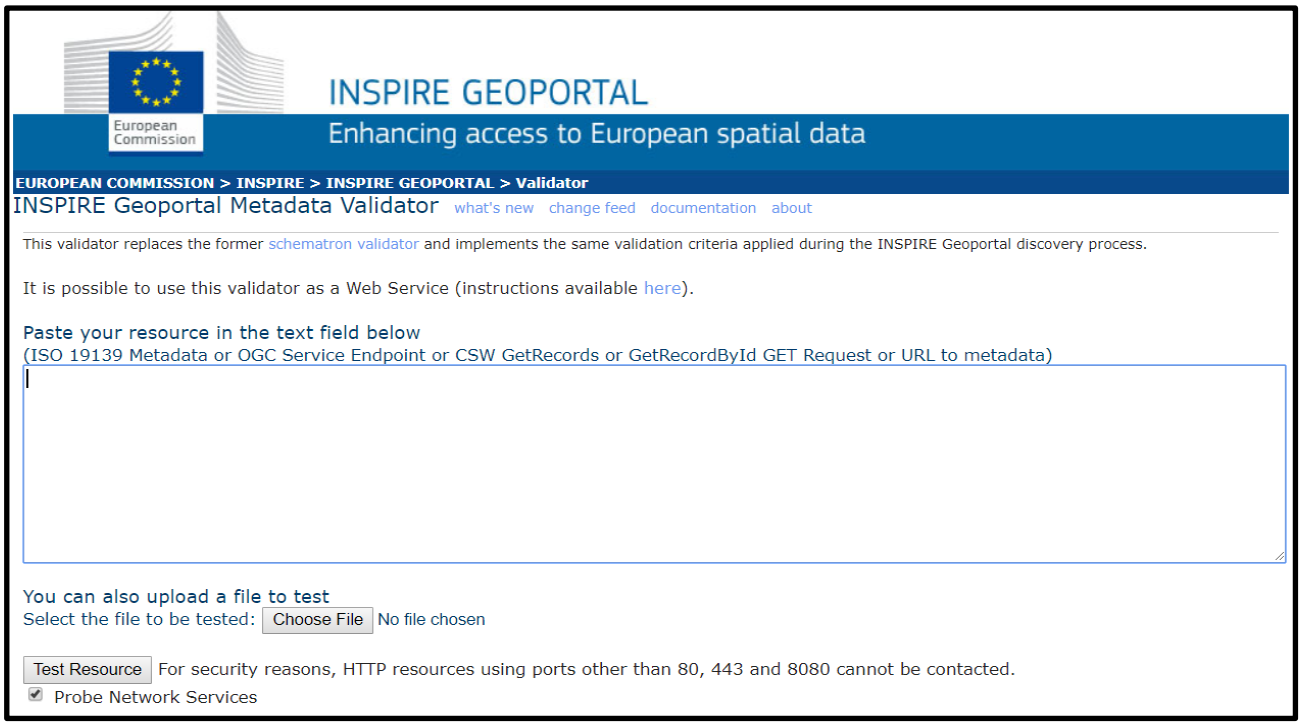

Figure 4.3 - Inspire Metadata Validator Tool

The Inspire ISO Metadata Editor[23] also validates metadata as it is entered into the tool against the Inspire metadata profile. The following Figure 4.4 illustrates the Inspire metadata editor.

[22] Source http://inspire-geoportal.ec.europa.eu/validator2/
[23] Source http://inspire-geoportal.ec.europa.eu/editor/

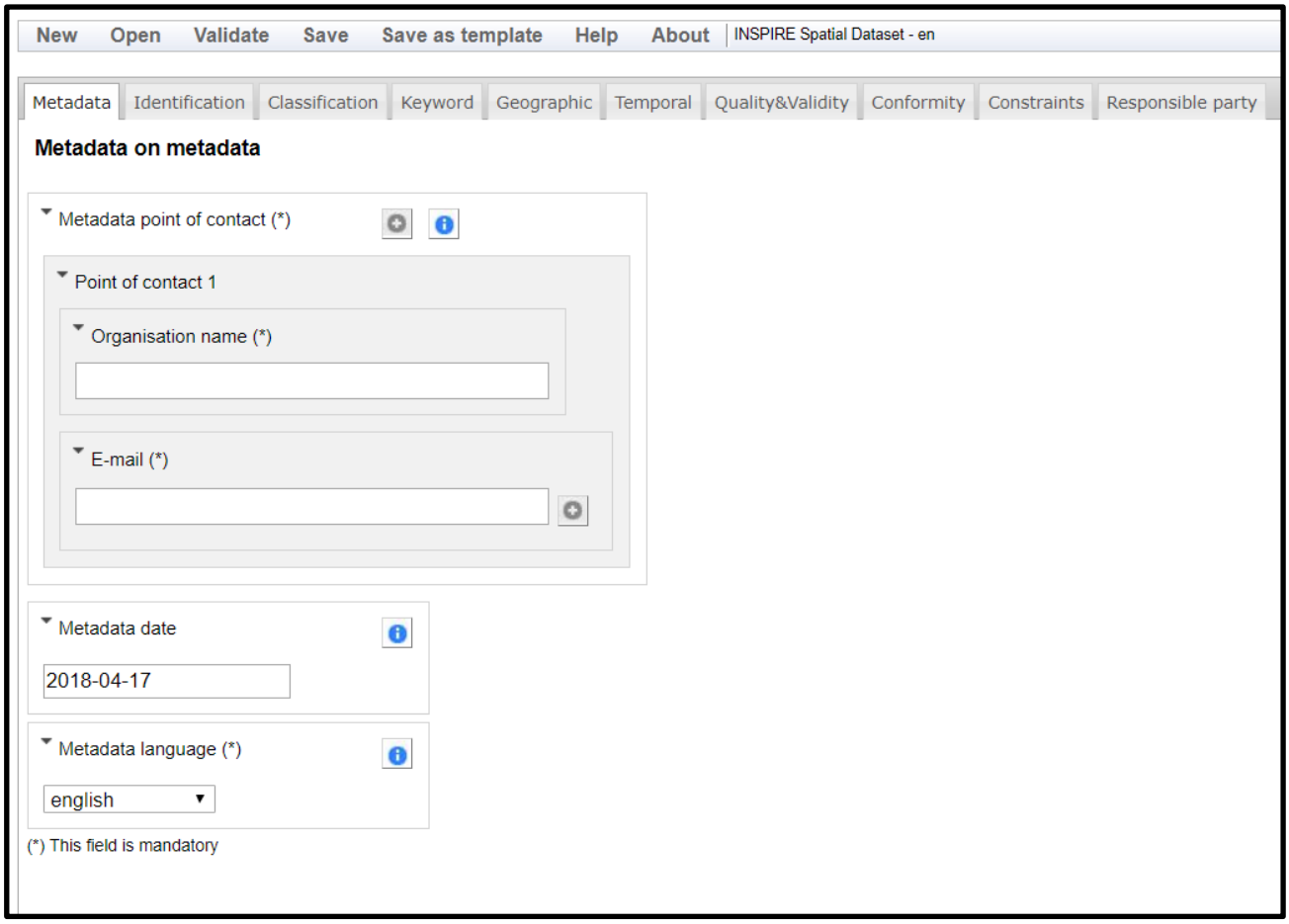

Figure 4.4 - Inspire ISO Metadata Editor

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 4.5 illustrates an online GML Validator[24] hosted by OGC.

[24] Source http://cite.opengeospatial.org/test_engine/gml/2.1.2/validator/

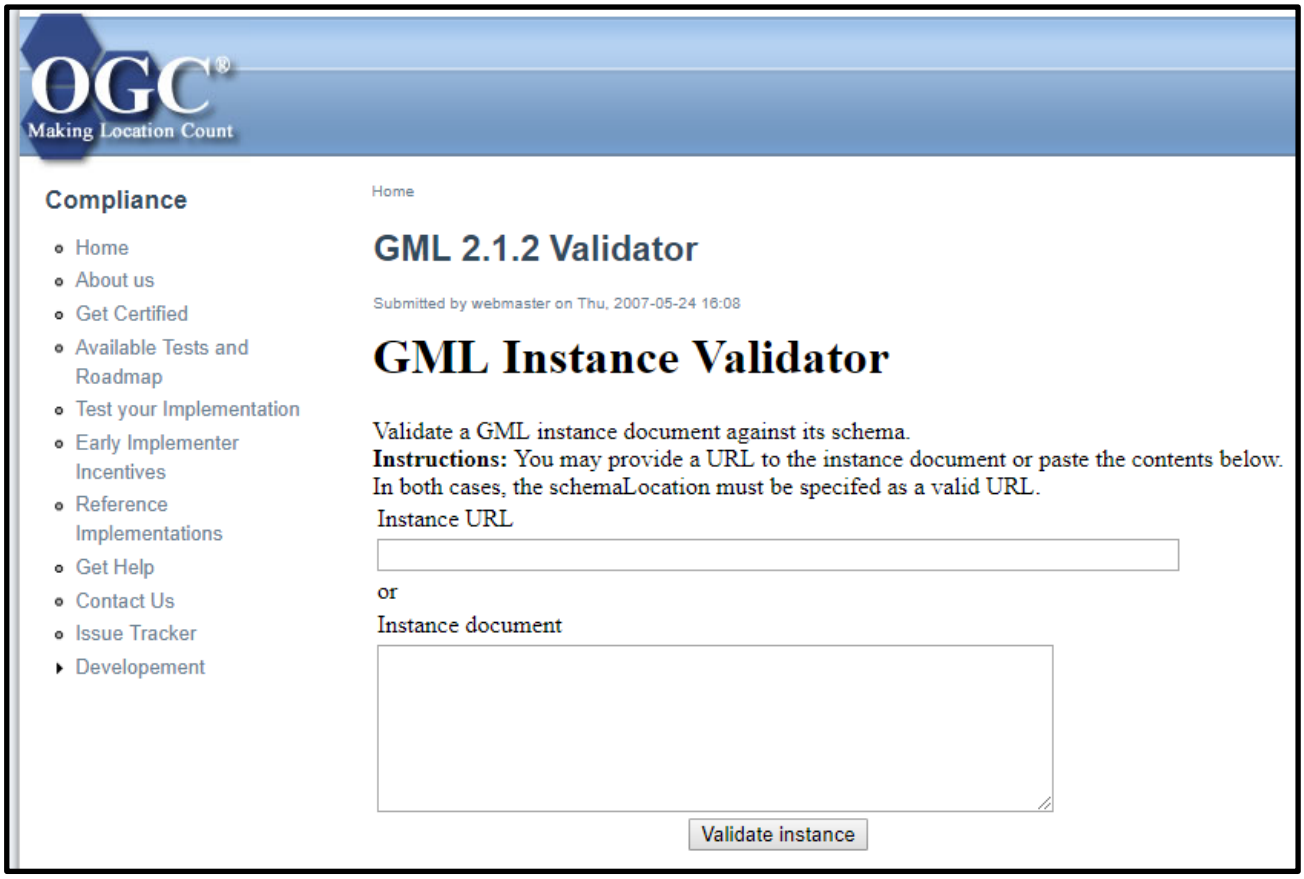

Figure 4.5 - OGC GML Validator

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[25] is illustrated in the following Figure 4.6.

Available Test Suites

OGC

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

Figure 4.6 - Test Suites Available in the OGC Test Engine

[25] Source 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[26]
    - 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[27] classification
    - Geospatial Information
    - Geospatial Services
- Classification by Standards Organization
    - ISO
    - OGC
    - W3C
    - OASIS
    - OMG
    - IETF
    - WS-I
    - FGDC
    - NSG
    - IHO
- UN GGIM[28] 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

[26] Source http://www.isotc211.org/Outreach/ISO_TC_211_Standards_Guide.pdf
[27] Source http://www.opengeospatial.org/standards/orm
[28] Source A Guide to the Role of Standards in Geospatial Information Management Companion document: http://ggim.un.org/documents/Standards%20Companion%20Document%20UN-GGIM%20-%20Final.pdf

        - Additional Implementation standards
    - Tier 3 - Spatially Enabling the Nation
        - Geospatial Processing
        - Mobile Devices
        - Real time
        - GeoSemantics
    - Tier 4 - Towards a Spatially Enabled Web of Data - Emerging Standards, Best Practices and Trends
    - Foundational Standards
        - General IT and Internet Standards
        - General Geospatial Information Standards
- Classification by NGC charter initiatives
    - Data Governance
    - Dissemination
    - Technical Platform
    - Organization
    - Outreach
    - Research
    - Applications and Services

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*.

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

		that are specific to Saudi Arabia

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*.

#	Standard Name	Doc Number/ version	Description
1	ebRIM (also ISO 15000-3:2004)	ISO 15000-3:2004 OASIS ebRIM v3.0	Provides an extensible meta-model for capturing a wide variety of digital resources (information items). These resources may include: dataset descriptions, schemas, feature catalogues, data dictionaries, service metadata, coordinate reference system definitions, symbol libraries, portrayal rules
2	19101-1 Reference model -- Part 1: Fundamentals	ISO 19101-1:2014	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
3	19103 Conceptual schema language	ISO 19103:2015	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
4	19104 Terminology	ISO 19104:2016	Provides the guidelines for collection and maintenance of terminology in the field of geographic information. The NGIC should play an active role within the Saudi national body that participates in ISO, and contribute terms in Arabic
5	19106 Geographic information profiles	ISO 19106:2004	Defines the concept of a profile of the ISO geographic information standards developed by ISO/TC 211 and to provide guidance for the creation of such profiles
6	19107 Spatial Schema (under review, will be replaced by ISO/DIS 19107)	ISO 19107:2003	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

7	19108 Temporal Schema	ISO 19108:2002/Cor 1:2006	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
8	19109 Rules for application schema	ISO 19109:2015	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)
9	19110 Feature Catalogue	ISO 19110:2016	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))
10	19111 Referencing by coordinates	ISO 19111:2019	Defines the conceptual schema for the description of referencing by coordinates and describes the minimum data required to define coordinate reference systems. 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)
11	19112 Spatial referencing by geographic identifiers	ISO 19112:2019	Defines the conceptual schema for spatial references based on geographic identifiers. It establishes a general model for spatial referencing using geographic identifiers and defines the components of a spatial reference system. It also specifies a conceptual scheme for a gazetteer. Spatial referencing by coordinates is addressed in ISO 19111. However, a mechanism for recording complementary coordinate references is included in this document.
12	19113:2002 Quality principles	ISO 19113:2002	Establishes the principles for describing the quality of geographic data and specifies components for reporting quality information. It also provides an approach to organizing information about data quality. This standard is applicable to data producers providing quality information to describe and assess how well a dataset meets its mapping

			of the universe of discourse as specified in the 19131 data product specification, and to data users attempting to determine whether or not specific geographic data is of sufficient quality for their particular application. This International Standard should be considered by organizations involved in data acquisition and purchase, in such a way that it makes it possible to fulfil the intentions of the product specification. ISO 19113 does not attempt to define a minimum acceptable level of quality for geographic data
13	19114 Quality Evaluation Procedures	ISO 19114:2003	Provides a framework of procedures for determining and evaluating quality that is applicable to digital geographic datasets, consistent with the data quality principles defined in ISO 19113. It also establishes a framework for evaluating and reporting data quality results, either as part of data quality metadata only, or also as a quality evaluation report. ISO 19114:2003 is applicable to data producers when providing quality information on how well a dataset conforms to the product specification, and to data users attempting to determine whether or not the dataset contains data of sufficient quality to be fit for use in their particular applications
14	19115-1 Metadata	ISO 19115-1:2014	Metadata content standard that specifies an information schema for describing geographic data sets. It provides information about the identification, extent, quality, spatial and temporal characteristics, spatial reference, and distribution of digital geographic data. Replaces ISO 19115:2003 (withdrawn) and ISO 19115:2003/Cor 1:2006 (withdrawn)
15	19115-2 Metadata -- Part 2: Extensions for acquisition and processing	ISO 19115-2: 2018	This document extends ISO 19115-1:2014 by defining the schema required for an enhanced description of the acquisition and processing of geographic information, including imagery. Included are the properties of measuring systems and the numerical methods and computational procedures used to derive geographic information from the data acquired by them. This document also provides the XML encoding for acquisition and processing metadata thereby extending the XML schemas defined in ISO/TS 19115-3.
16	19117 Geographic information -- Portrayal	ISO 19117:2012	An abstract specification that describes a conceptual model for feature data portrayal. In particular, ISO 19117 includes a methodology for describing symbols and how to map the schema to

			an application schema, but it does not address the standardization of carto-graphic symbols or their geometric and functional description. A portrayal rule set may be associated with either a feature type or a feature instance, which allows for both generic portrayal rules and specific customizations
17	19118 Encoding	ISO 19118:2011	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.
18	19119 Services	ISO 19119:2016	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
19	19123 Coverages (under review, will be replaced by ISO/NP 19123-1)	ISO 19123:2005	Defines a conceptual schema for the spatial characteristics of coverages. Coverages include items like images, including aerial and spacecraft images, bathymetric and terrain surfaces, sea surface temperature etc. It is an abstract specification and is the foundation for concrete specifications including ISO 19136 (GML).
20	Simple feature access - Part 1: Common architecture	ISO 19125-1:2004 OGC 06-103r4 (v1.21)	Describes the common architecture for simple feature geometry. The simple feature geometry object model is Distributed Computing Platform neutral and uses UML notation. The base Geometry class has subclasses for Point, Curve, Surface and GeometryCollection. Each geometric object is associated with a Spatial Reference System, which describes the coordinate space in which the geometric object is defined
21	Simple feature access -- Part 2: SQL option	ISO 19125-2:2004 OGC 06-104r4 (v1.21)	Specifies an SQL schema that supports storage, retrieval, query and update of simple geospatial feature collections via the SQL Call Level Interface (SQL/CLI) and establishes an architecture for the implementation of feature tables.

22	19126 Feature concept dictionaries and registers	ISO 19126:2009	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
23	19128 Web Map Service	ISO 19128:2005 OGC 06-042 (v1.3)	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.
24	19131 Data product specifications	ISO 19131:2007	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.
25	19132 Location Based Services RM	ISO 19132:2007	Defines a reference model and a conceptual framework for location-based services (LBS), and describes the basic principles by which LBS applications may interoperate.
26	19133 Location Based Services Tracking & Navigation	ISO 19133:2005	Describes the data types, and operations associated with those types, for the implementation of tracking and navigation services.
27	19134 Location Based Services - Multimodal routing and navigation	ISO 19134:2007	Specifies the data types and their associated operations for the implementation of multimodal location-based services for routing and navigation.
28	19135-1 Procedures for item registration -- Part 1: Fundamentals	ISO 19135-1:2015	Specifies procedures to be followed in establishing, maintaining and publishing registers of unique, unambiguous and permanent identifiers, and meanings that are assigned to items of geographic information. This specification is an abstract specification and is relevant to governance of data and metadata items.
29	19136 Geography Markup Language	ISO 19136:2007 OGC 07-036 (v3.2.1)	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.

30	19137 Geographic information – Core profile of the spatial schema	ISO 19137:2007	Defines a core profile of the spatial schema specified in ISO 19107 that specifies, in accordance with ISO 19106, a minimal set of geometric elements necessary for the efficient creation of application schemata.
31	19138 Data quality measures	ISO 19138:2013	Defines a set of data quality measures. This specification may be used in conjunction with ISO 19115 to define data quality metadata. This standard has been replaced/revised by ISO 19157:2013
32	19141 Schema for moving feature	ISO 19141:2008	Defines a method to describe the geometry of a feature that moves as a rigid body.
33	19142 Web Feature Service	ISO 19142:2010 OGC 09-025r2 (v2.0.2)	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.
34	19143 Filter Encoding	ISO 19143:2010 OGC 09-026r2 (v2.0.2)	Describes an XML and KVP encoding of a system neutral syntax for expressing projections, selection and sorting clauses collectively called a query expression. This is a critical specification for the sharing of geospatial information. It is used by the WFS (ISO 19142) and OGC CSW-ebRIM specifications.
35	19144 Classification Systems	ISO 19144-2:2012	Establishes the structure of a geographic information classification system, together with the mechanism for defining and registering the classifiers for such a system.
36	19146 Cross-domain vocabularies	ISO 19146:2018	A framework specification that establishes a methodology for cross-mapping vocabularies. It also specifies an implementation of ISO 19135-1:2015 for the purpose of registering cross-mapped vocabulary entries. This may be relevant to information integration across themes of importance.
37	Observations and measurements	ISO 19156:2011	Defines a conceptual schema for observations, and for features involved in sampling when making observations. These provide models for the exchange of information describing observation acts and their results, both within and between different scientific and technical communities.
38	19157 Data Quality	ISO 19157:2013	ISO 19157:2013 establishes the principles for describing the quality of geographic data. It

			- defines components for describing data quality; - specifies components and content structure of a register for data quality measures; - describes general procedures for evaluating the quality of geographic data; - establishes principles for reporting data quality. ISO 19157:2013 also defines a set of data quality measures for use in evaluating and reporting data quality. It is applicable to data producers providing quality information to describe and assess how well a data set conforms to its product specification and to data users attempting to determine whether or not specific geographic data are of sufficient quality for their particular application
39	3166 Country codes	ISO 3166-1:2013	Defines the country names. Likely to be used within a metadata record
40	Sustainable development of communities – indicators for city services and Quality of Life standard	ISO 37120:2018	Defines and establishes methodologies for a set of indicators to steer and measure the performance of city services and quality of life. This standard belongs to the following ISO standard category:13.020.20 - Environmental economics. Sustainability
41	639 Language Codes	ISO 639-1:2002 ISO 639-2:1998 ISO 639-3:2007 ISO 639-4:2010 ISO 639-5:2008	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. 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 2 (ISO 639-2:1998) provides a 3 letter code, which gives more possible combinations, so ISO 639-2:1998 can cover more languages. 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. Part 4 (ISO 639-4:2010) gives the general principles of language coding and lays down guidelines for the use of ISO 639. Part 5 (ISO 639-5:2008) provides a 3 letter code for language families and groups (living and extinct).
42	6709 Geographic point by coordinates	ISO 6709:2008	Standard representation of latitude, longitude, and altitude for geographic point locations

43	8601 Date times	ISO/DIS 8601-1	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
44	10646 Universal Coded Character Set (UCS)	ISO/IEC 10646:2011	Specifies the Universal Coded Character Set (UCS), which is applicable to the representation, transmission, interchange, processing, storage, input and presentation of the written form of the languages of the world as well as additional symbols. It covers over 109,000 characters from the world's scripts.
45	XMI	ISO/IEC 19503:2005 OMG XML v2.5.1	Enables easy interchange of metadata between application development lifecycle tools (such as modeling tools based on the Unified Modeling Language (UML), ISO/IEC 19501, and metadata repositories/frameworks based on the Meta Object Facility (MOF), ISO/IEC 19502) in distributed heterogeneous environments. This may play a key role in exchange UML models.
46	Unified Modeling Language (UML) ISO/IEC 19505-2	ISO/IEC 19505-2:2012 UML v2.5	Graphical language for visualizing, specifying, constructing and documenting the artefacts of a software-intensive system. This may be used in GASGI as a uniform approach to conceptual data modeling in support of feature/coverage types etc.
47	Rule based validation - Schematron	ISO/IEC 19757-3 (2nd Ed,)	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.
48	Presentation of ISO 42010	ISO/IEC/IEEE 42010	ISO/IEC/IEEE 42010 is based upon a conceptual model – or “meta model” – of the terms and concepts pertaining to Architecture Description. Provides a standard basis for modelling the NGIC/NSDI
49	Systems and software engineering -- Architecture description	ISO/IEC/IEEE 42010	Provides a standard basis for modelling the NGIC/NSDI
50	19115-3 XML schema implementation for fundamental concepts (was 19139)	ISO/TS 19115-3:2016	ISO/TS 19115-3:2016 defines an integrated XML implementation of ISO 19115- 1, ISO 19115- 2, and concepts from ISO/TS 19139 by defining the following: a) a set of XML schema required to validate metadata instance documents conforming to conceptual model elements defined in ISO

			19115- 1, ISO 19115- 2, and ISO/TS 19139; b) a set of ISO/IEC 19757- 3 (Schematron) rules that implement validation constraints in the ISO 19115- 1 and ISO 19115- 2 UML models that are not validated by the XML schema; c) an Extensible Stylesheet Language Transformation (XSLT) for transforming ISO 19115-1 metadata encoded using the ISO/TS 19139 XML schema and ISO 19115- 2 metadata encoded using the ISO/TS 19139- 2 XML schema into an equivalent document that is valid against the XML schema defined in this document.
51	19127 Geodetic codes and parameters	ISO/TS 19127:2005	Defines rules for the population and maintenance of registers of geodetic codes and parameters and identifies the data elements, in compliance with ISO 19135 and ISO 19111, required within these registers. This standard is relevant for the deployment of a CRS register.
52	19129 Imagery & Coverages	ISO/TS 19129:2009	Specifies a general content model for imagery, gridded and coverage data. It provides a basis for developing application schemas that are independent of interchange formats or portrayal details. The overall intent is to define a common data framework which can then be adapted to different encoding mechanisms and exchange formats. The frame-work makes extensive use of other ISO geomatics standards.
53	19139 Metadata -- XML schema implementation	ISO/TS 19139:2007	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.
54	19158 Quality assurance of data supply	ISO/TS 19158:2012	ISO/TS 19158:2012 provides a framework for quality assurance specific to geographic information. It is based upon the quality principles and quality evaluation procedures of geographic information identified in ISO 19157 and the general quality management principles defined in ISO 9000.

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.

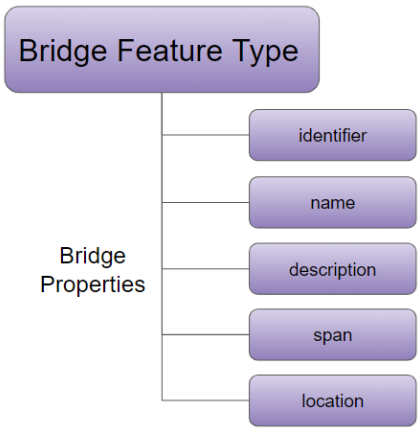

Figure 5.1 - Bridge Feature Example

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.)

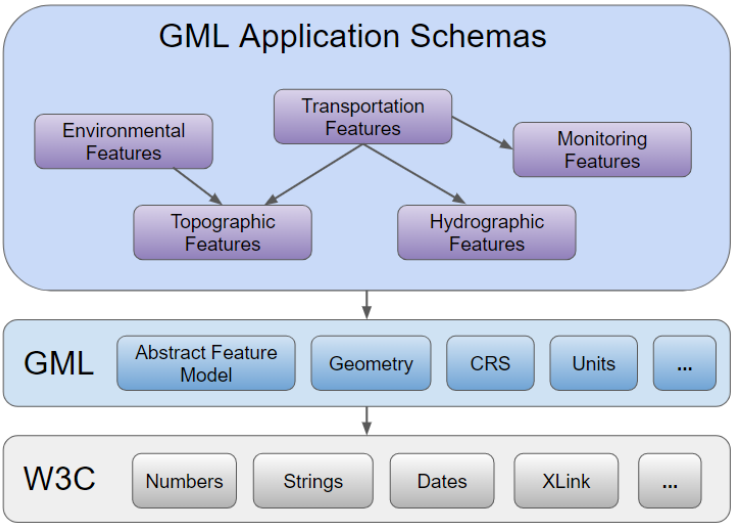

Figure 5.2 - GML Application Schema Imports

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.

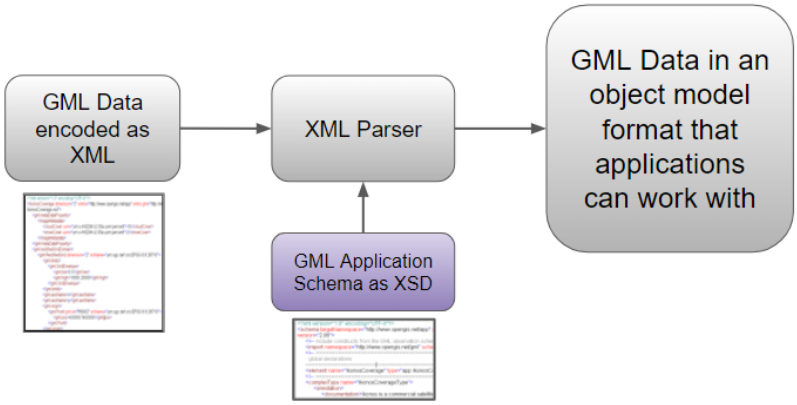

Figure 5.3 - XML Tools Used to Process GML

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.

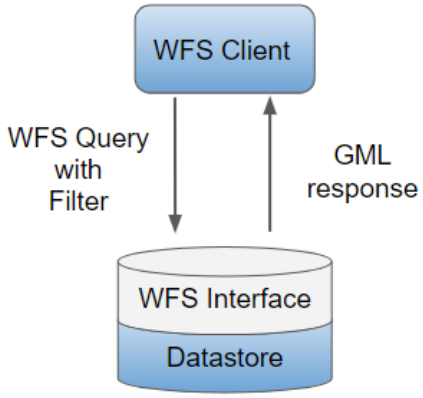

Figure 5.4 - WFS Requests and Responses in GML

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).

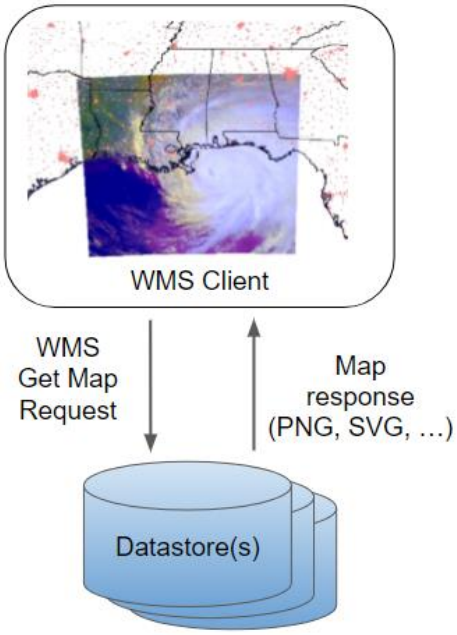

Figure 5.5 - WMS Requests and Responses

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 works 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.

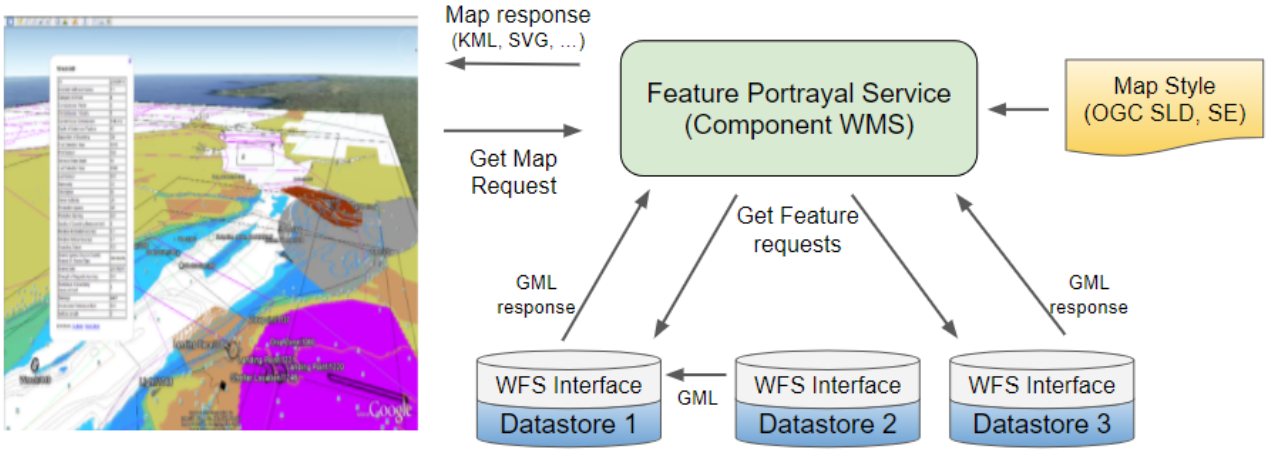

Figure 5.6 - FPS Requests and Responses

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

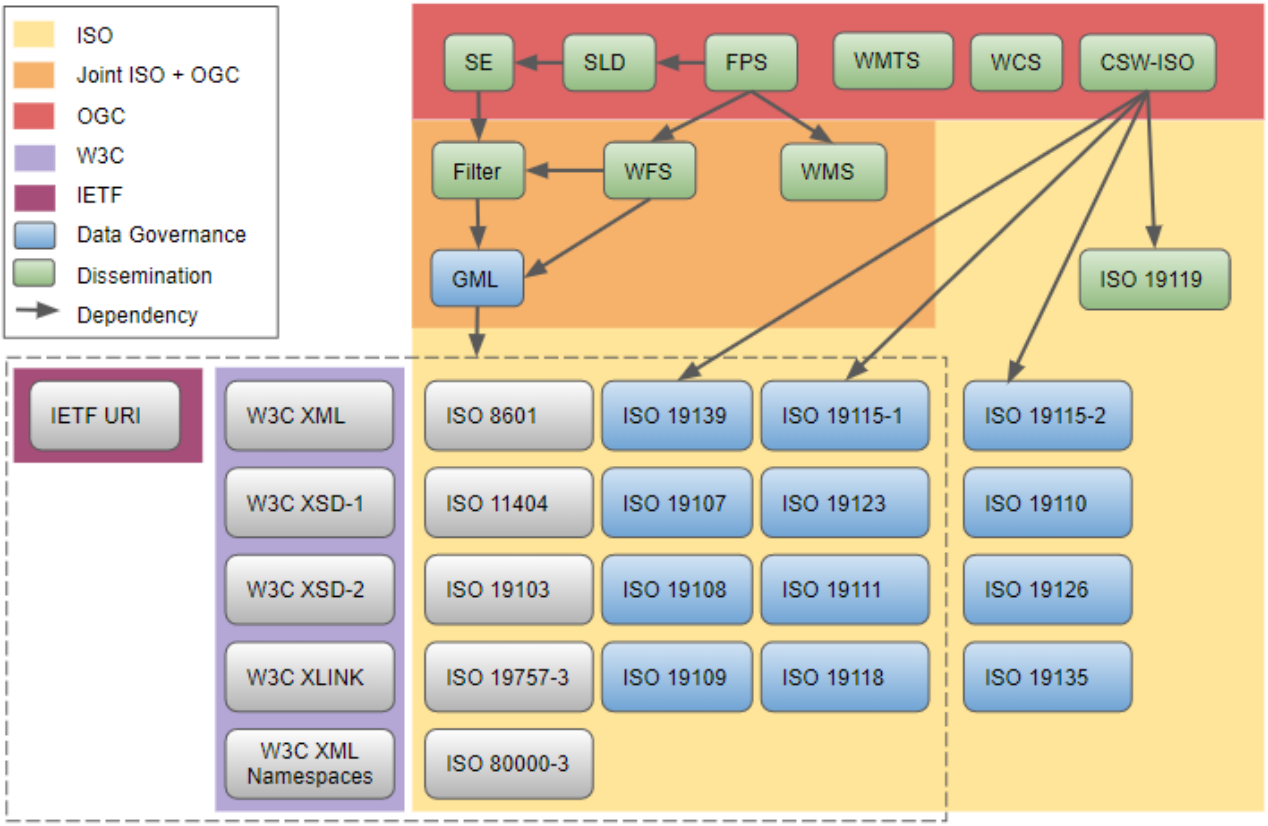

Figure 5.7 - Dependencies Between Standards