Framework of geospatial data standards for The Netherlands

Geonovum guidance

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Content

Version control

Version	Date	Status	Dutch profiles
4.0	June 2023	Current	Current version with various updates with references to normative and informative references, guidelines, explorations and context (geospatial data standards in coherence).
3.0	March 2015	Lapsed	Standard reference version posted on www.geonovum.nl
2.3	January 2014	Lapsed	Update, and small extensions for recommended standards such as GeoJSON, ATOM feeds and linked data.
2.2	March 2012	Lapsed	An update and minor updates such as implementation tools, 3D, StUF, etc.
2.1	March 2010	Lapsed	Version 2.1 has been adapted to current developments such as tiling, INSPIRE, ISO/TC 211 and OGC adjustments and updated to the Dutch situation. This version is also a deepening document referred to from NORA 3.0.
2.0	October 2007	Lapsed	Version 2.0 has become a direct effect on NORA 2.0 for the Geo standards, and updates and changes have been made based on user needs and latest information INSPIRE.
1.1	June 2006	Lapsed	This version has been attributed to the Dutch GII by a wider group of authors and reviewers.
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Colophon

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Summary

When designing and developing a geographic information infrastructure, the challenge is always to choose the right set of geospatial data standards. This Framework of geospatial data standards helps with this. It sets out the international and national standards that apply to the Netherlands within the geospatial domain for connection with other domains. The Framework takes into account the connection to the European geographic information infrastructure and ensures the integration of the geographic information domain into the Dutch digital government.

1. Introduction

When designing and developing a geographic information infrastructure, the challenge is always to choose the right set of standards. The Geospatial data standards Framework of geospatial data standards helps with this. It sets out the international and national standards that apply to the Netherlands within the geospatial domain for connection with other domains. The framework takes into account the connection to the European geographic information infrastructure and ensures the integration of the geographic information domain into the Dutch digital government.

1.1 Purpose and target group of the framework

The Framework of geospatial data standards is written for anyone who captures, exchanges, and manages geospatial data and for anyone who creates information policies. The purpose of the Framework of Geospatial data standards is to choose the right set from the wide variety of standards: those standards that are needed to make geodata findable, accessible, interchangeable and reusable. We base the choices for standards in the Framework on the following principles:

- International connection,
- Maturity and openness of these geospatial data standards ; and
- Widespread adoption and use.

Applying the geospatial data standards included in this framework contributes to a solid geographic information infrastructure, in line with international developments and in line with national digital government.

1.2 Status of the framework

The framework of geospatial data standards provides guidance for the use of standards within the Dutch geographic information infrastructure. For Dutch government organizations, it is therefore the guideline for geospatial data standards to be applied. The Framework is anchored within the government through the Geographic information Council. The Framework is aligned with the basic list of open standards of the Forum Standardization and forms the in-depth chapter on geo within the Dutch Government Reference Architecture (NORA). With regard to coordinate reference systems, the Framework follows the recommendations of the Dutch Geodetic Infrastructure Cooperation (NSGI). The NEN standardization committee for Geographic information maintains relations with the NEN, CEN and ISO standardization organizations. In addition, the geospatial data standards mentioned in the Framework are in line with the geospatial data standards of the European geographic information infrastructure according to the INSPIRE Directive. The status of the framework of geospatial data standards cannot be seen separately from these organizations and/or frameworks. Below is a brief explanation of their relationship with the Framework of geospatial data standards .

Geographic information Council

Given the importance of geographic information for public tasks, the Dutch government has set up a Geographic information Council – in short the GI Council – to direct the establishment and maintenance of the national geographic information infrastructure.
The GI Council is an official advisory board for the Minister for Housing and Spatial Planning (placed in the Ministry of Interior), which in the Netherlands is responsible for the policy and maintenance of the national geographic information infrastructure. The GI Council was established on 2 June 2006 and the institution decision was published in the Staatscourant. The GI Council includes representatives from: the Ministry of Agriculture, Nature and Food Quality, the Ministry of Economic Affairs, the Ministry of the Interior, the Ministry of Defense, the Interprovincial

Organization (IPO), the Association of Dutch Municipalities (VNG), the Union of Water Boards (UvW), The Netherlands' Cadastre, Land Registry and Mapping Agency and Geological Survey of the Netherlands, Rijkswaterstaat (executive agency of the Ministry of Infrastructure and Water Management), the Central Bureau for Statistics (CBS) and Geonovum.

The tasks of the GI Council are of a strategic nature, with the GI Council advising the Minister for Housing and Spatial Planning in the form of a strategic agenda on the issues that will be addressed in the field of national and European geographic information infrastructure in the coming years. The GI Council established the Framework of geospatial data standards as a mandatory Framework for the organizations representing the participants of the GI Council.

Netherlands Standardization Forum
The Netherlands Standardization Forum advises the Dutch government on the use of open standards. The Netherlands Standardization Forum manages two lists, namely the list of mandatory open standards under the "comply or explain" regime and a list of recommended open standards.
For the standards on the 'apply or explain' list of open standards, (semi-) public organizations must follow the 'apply or explain' principle. A number of geospatial data standards from the Geospatial data standards Framework of geospatial data standards are listed on the "comply or explain" list of the Netherlands Standardization Forum.

NEN Standard Committee Geographic information
At NEN, the Royal Netherlands Standardization Institute , agreements are established through national and/or international standards committees in standards and guidelines. The Standards Committee Geographic information falls within the standardization structure of NEN under the Policy Committee on Construction. The work in this standard subcommittee is related to national, European and global laws and regulations. At European and global level, the Standards Committee monitors the standard developments from the CEN and ISO committees. These national (NEN), European (CEN) and global (ISO) standards, which are related to the Geographic information Standards Committee, are:

- Basic model geographic information: NEN 3610;
- Geographical information: CEN/TC 287; and
- Geographic information/Geomatics: ISO/TC 211.

Dutch Cooperation Geodetic Infrastructure (NSGI)
The Netherlands' Cadastre, Land Registry and Mapping Agency, Rijkswaterstaat (executive agency of the Ministry of Infrastructure and Water Management) and the Hydrographic Service of the Royal Netherlands Navy work together in the Dutch Geodetic Infrastructure Cooperation (NSGI). They establish, maintain and publish elements of the geodetic infrastructure in which the agreements and standards for the coordinate reference systems are established and managed. The Framework of Geospatial data standards follows the recommendations of the Dutch Geodetic Infrastructure Cooperation (NSGI) regarding coordinate reference systems.

Dutch Government Reference Architecture (NORA)
The Dutch Government Reference Architecture (NORA) is the interoperability framework for the Dutch government, translating legislation, policies and standards into architectural principles, descriptions and models. It is a description of the starting points for setting up the information management of the Dutch government. NORA is relevant to the performance of all public tasks by public and private organizations. The geospatial data standards must also fit within the Dutch Government Reference Architecture, the architecture of all government organizations in the Netherlands. Principles such as findability, accessibility and transparency are also important in

NORA as well as for the national geographic information infrastructure. NORA also requires the 'comply or explain' list of the Netherlands Standardization Forum. The listing on this list contributes to the 'enhancing' of geospatial data standards and geographic information infrastructure in the national digital administration. The framework of geospatial data standards complements and deepens the NORA theme GEO.

INSPIRE Directive

Since 15 May 2007, the European framework directive INSPIRE has been in force. This Directive has led to the realization of the European geographic information infrastructure. The introduction of INSPIRE has been enshrined in the Dutch INSPIRE Act with an implementation law since 2009. In a nutshell, the law obliges European Member States to provide geographic information (datasets) on 34 geospatial and environmental themes with metadata and the datasets 'as is' and to make European harmonized data availability via network services (discovery, view and download services). All this according to delivery conditions that do not unnecessarily impede the use. The European framework directive INSPIRE has been elaborated in detail in implementing rules, and includes technical directives. These introduction rules and technical guidelines have led to European profiles for geospatial data standards . Where possible, these profiles are also processed in Dutch profiles for metadata, various data specifications (information models) and associated network services (APIs). The European geo-standard profiles mentioned in the Framework follow the line of the European geographic information infrastructure according to INSPIRE.

1.3 Standards of documentation

In order to get and keep a system or system as a national geographic information infrastructure functioning, an interplay of agreements is required. At its core, the work is aimed at achieving coherent agreements on geospatial data standards and connecting supply and demand. Managing and maintaining this well is essential and a continuous, cyclical process.
More concretely, the following tasks can be distinguished in this cycle:

- Explore and innovate geospatial data standards ;
- Developing and managing geospatial data standards ;
- Advise on applying and implementing geospatial data standards .

In this Framework of geospatial data standards , we therefore also use different types of documentation. We list them below, with their meaning.

Standard

A standard is housed at an official standardization institute and contains binding agreements.

Information Model

A standard in which using the term information model indicates that it constitutes an abstraction (the model) of reality as described within a particular sector/domain. Information models are a semantic interpretation of standards for sectors such as spatial planning, cables and pipes, water, etc..

Practical Guidelines

A practical guideline is a product that provide information, often of a technical nature, which is necessary for the application of standards. A practical guideline is always part of a standard or standard.

Guide

Self -contained documentation that aims to be a tool, not mandatory but supportive.

Working arrangement
Explains how legislation should be applied in case of ambiguities, discrepancies or errors in the standards.

Management documentation
Documentation related to the management process of the standard. This documentation does not concern a standard or part thereof, such as a manual or working arrangement. This can be internally targeted documentation for capturing steps in the day-to-day work process, planning or how the helpdesk works. This can also be a management plan or manual.

1.4 Reading guide

Compared to the previous version, the framework of geospatial data standards has been reduced to a comprehensive form, in which the coherence of the geospatial data standards has been identified and the geospatial data standards are included as an international standard and where applicable with the European and national application profiles.
This first chapter provides background information about the document. Chapter 2 describes some context and the geospatial data standards in coherence.

As in previous versions of this framework, the geospatial data standards are divided into six categories:

- Geospatial data standards for information models;
- Geospatial data standards for visualization;
- Geospatial data standards for Application Programming Interfaces (APIs);
- Geospatial data standards for exchange formats;
- Geospatial data standards for metadata; and
- Geospatial data standards for coordinate reference systems.

Chapters 3 to 8 include geospatial data standards for these six categories of geospatial data standards (to a hierarchy of international, European and national geospatial data standards) and cover aspects of the quality of the geospatial data standards and possible explorations carried out.

Finally, all normative references – the references to the official standards documentation – are included (in [] square brackets).

2. Geospatial data standards in coherence

There are various standards for finding, accessible, interchangeable and reusable geographic information. The purpose of the Framework of Geospatial data standards is to choose from the wide variety of geographic information standards, those geospatial data standards that fit the situation, context and set goals. Each standard plays its own role and applied in a coherent way, they ensure interoperability in a geographic information infrastructure.

This chapter describes important contexts for the use of geospatial data standards , as well as the coherence between the geospatial data standards . The national geographic information infrastructure provides insight into the world of international standards, which guide the Dutch geospatial data standards . The national geographic information infrastructure also complies with the FAIR principles, which should not be ignored here. The Dutch geospatial data standards are part of Dutch architecture (NORA) and are managed according to the management and development model for Open Standards in the Netherlands (BOMOS in Dutch for short).

2.1 National geographic information infrastructure

In recent years, the Netherlands has been working on a National Geographic information Infrastructure (NGII) to unlock geographic information as easily as possible. The NGII as a concept is the whole of datasets (geographic information sources), data services, metadata, standards, facilities, organization and agreements for the efficient exchange of and access to geographic information.
The NGII develops from an infrastructure that offers low-threshold access to individual data sources, to an infrastructure of data that you can access in coherence. The importance of both semantic and technical interoperability is increasing for this reason. The Whitepaper ‘Vision on upgrade Dutch Geographic information Infrastructure‘ describes the development of the NGII towards a demand-driven infrastructure: “Data is an essential raw material for decision making. In the Netherlands, we believe it is important that decision making processes are transparent. Citizens should be able to monitor public policies and actively contribute to it with new initiatives or alternatives. Openness, authenticity, traceability are therefore important points of attention when developing the infrastructure.”
The Dutch geographic information Infrastructure is in need of an upgrade. How can the NGII be upgraded to a demand-driven infrastructure, which makes the power of geographic information accessible for the major societal challenges? What (new) standards play a role in this? How do all kinds of separate developments actually relate to each other? And how do these developments relate to European developments around data and digitalization?

2.2 Fair principles

Work together in an unambiguous way to better exchange geographic information and make it accessible to everyone. That is how open geospatial data standards promote cooperation between government, business and citizens. The FAIR Principles are a tool in this: the aim of the principles is to enable the reuse of valuable data. The FAIR Principles do not enforce standards, but encourage data and services to be found, accessible, interoperable and reusable.

The geospatial data standards create geographic information FAIR and provide the connecting power of standardization in findable, accessible, interchangeable and reusable geographic information:

- **Findable** (findable). The first step in (re)using data is to find the data. Metadata and data should be easy to find for both people and computers. Machine-readable metadata is essential for finding data;

- **Accessible** (accessibility). Once the user has found the necessary data, the user must know how to access it, including access (authentication and authorization);
- **Interoperable** (interoperable). The data usually needs to be integrated with other data. In addition, the data must work with applications or workflows for analysis, storage and processing;
- **Reusable** (reusable). The ultimate goal of FAIR is to optimize the reuse of data. To achieve this, metadata and data must be properly described so that they can be replicated and/or combined in different situations.

2.3 International standards

For the national geospatial data standards , these have been developed on the basis of international standards, supplemented by the specific requirements applicable to the Netherlands. When a national standard (called an application profile) has been developed, a national standard is leading. If there is no national standard, the European standard applies and if there is no European standard, an international, global standard applies.
Internationally, the geospatial data standards come from standardization organizations ISO/TC 211 Geographic information/Geomatics, the Open Geospatial Consortium (OGC) and the World Wide Web Consortium (W3C). ISO/TC211 and the OGC make technical geospatial data standards , which the Netherlands fulfils semantic and technical. These geospatial data standards organizations have liaisons with general ICT and Internet standardization organizations such as the W3C. Geonovum actively participates on behalf of the Netherlands in these three international standardization organizations.

International and national regulations also have an impact on the choice of standards. From Europe, among other things, the standards covered by the European INSPIRE Framework Directive are relevant. This Directive sets out technical arrangements that allow for the exchange of geographic information on 34 themes relating to the geospatial and environmental domain. The INSPIRE Directive applies specifically to public organizations (the public authorities) of the European Member States. The INSPIRE standards are based on international geospatial data standards for finding, viewing and downloading data. The INSPIRE data specifications for the themes have a clear relationship with the information models for different domains and sectors in the Netherlands.
Over the past few years, the European Commission (EC) has also put forward several legislative proposals on digitalization and data that will take shape in the coming years. Together they form the geopolitical positioning of the European Union with regard to digitization and data. At the heart of this proposition is the exploitation of the social value of digitization and data, while at the same time strengthening and protecting the individual rights of citizens. The published factual information on the content of the proposals, the activities of the EC, and the known timelines for implementation are shared in the EU's Digital and Data Strategy Information Guide (in Dutch).

Finally, national laws and regulations also affect the application of geospatial data standards , such as the Dutch key registrations and the environmental law. These Dutch profiles of standards are based on or aligned with the international and European profiles. The part of the Dutch geo-standard profiles that ensures the functioning of the national geographic information infrastructure has a separate position on the 'comply or explain' list of mandatory open standards of the Netherlands Standardization Forum of the Dutch digital government. These geospatial data standards are of primary importance in connecting geographic information to the digital government.

2.4 BOMOS

Geonovum has set up the management of all geospatial data standards along the lines of the Management and Development Model for Open Standards (in short BOMOS). BOMOS is managed by the Centre for Standards at Logius. Geonovum uses BOMOS for all the standards it manages to ensure that they are open according to the definition given by BOMOS. The application of BOMOS also ensures that standards that Geonovum manages and develops are eligible for inclusion on the mandatory standards list and on the list of recommended standards of the Netherlands Standardization Forum. The use of BOMOS for the management of geospatial data standards is described in management documentation for the geospatial data standards .

3. Information models

An information model lists agreements about concepts and definitions within a given domain. This simplifies the exchange and reuse of information. In this chapter, we describe the geospatial data standards that form the basis of the information models and descriptions of geographic information.

3.1 NEN 3610 – Basic model for information models

NEN 3610 is the basic model for geographic information models. Information models, also known as data specifications, specify the content of datasets or data services. NEN 3610 provides rules for the unambiguous description and exchange of geographic information within the geographic information infrastructure.
The focus of the NEN 3610 is on semantic interoperability. Semantic interoperability is achieved by harmonizing terms and definitions used by different sectors. This contributes to the interoperability of data across the borders of different sectors. In addition to semantics, NEN 3610 offers a common set of rules, concepts and modeling patterns through which you model geographic reality. NEN 3610 positions information models in the broader context of an open and accessible semantic architecture consisting of conceptual frameworks, information models, ontologies and registries designed for that purpose. The user of NEN 3610 is the information architect and information modeler, who design geographic information models.

3.2 Coherence of international and national standards

NEN 3610 is aligned with and related to international standards. Important to mention is that the structure and structure of NEN 3610 conforms to the ISO 19100 series. This ISO standard must comply with geographic information within the framework of European rules (INSPIRE). Due to the international alignment, the structure of the Dutch information models in accordance with NEN 3610 is similar to that of European standards. The European INSPIRE standards have been implemented on the basis of 34 content themes, for which 'data specifications' have been drawn up. Dutch datasets, which fall under INSPIRE, are made available to the European geographic information infrastructure in accordance with these European data specifications.

NEN 3610 also has a relationship with the NEN 2660:2022 which provides rules for information modelling of the built environment. Both are attuned to each other. Figure 3.1 below shows schematically the relationships between overarching standards, NEN 3610 and sectoral information models.

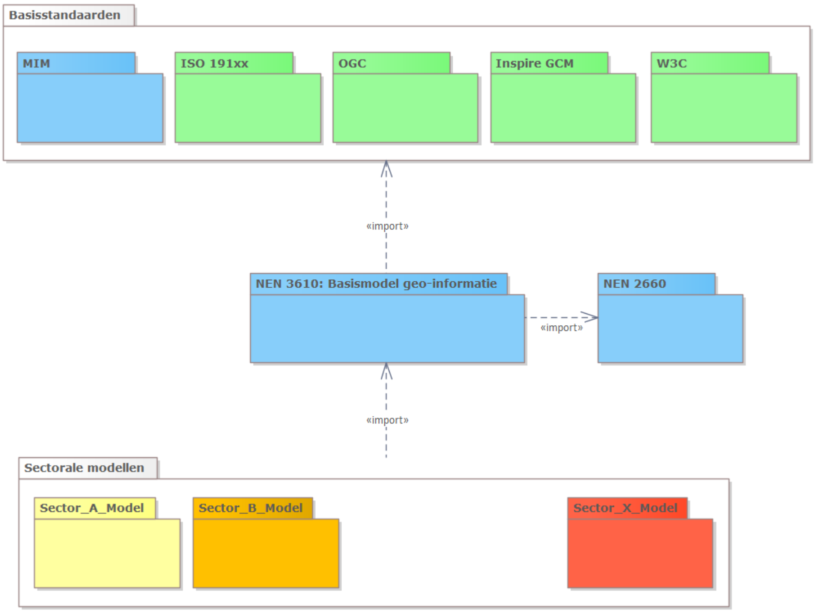

Figure 2.1 – UML Package diagram of relation between national, international standards – NEN 3610 – sectoral models

The 'import' statement means that there is a dependency between standards. For example, NEN 3610 uses the MIM metamodel, ISO 19103 agreements for the use of UML as a modeling language, the geometry model from ISO 19107, XML and linked data agreements from W3C, the network model from INSPIRE Generic Conceptual Model (GCM). Sectoral models re-use the NEN 3610 application. Figure 3.2 shows the relationship between the different frameworks of standards in the NEN 3610 pyramid with domain models (the sectoral information models).

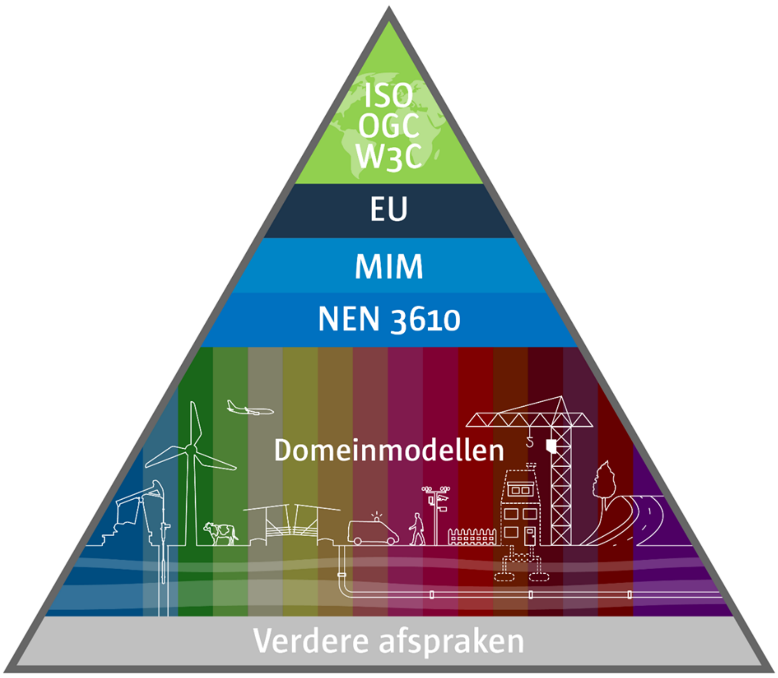

Figure 2.2 – Previous figure 1 shown in the 'NEN 3610 pyramid'

3.3 MIM – Metamodel for Information Modeling

The Metamodel for Information Modelling [MIM] is a standard that describes the meta-model by which information models – including for other than geographic information – are created. It describes the meta classes, meta structures and metadata that form the basis for an information model. The aim of MIM is to standardize the method of information modelling. This enables alignment between information models, comparability in publication and use of common tooling. Compliance with MIM facilitates the emergence of a broad system of comparable and coherent information models. The MIM metamodel is conceptually described and elaborated for use in UML and in Linked Data.

To make NEN 3610 information models interoperable in the context of the digital government, NEN 3610 uses the Dutch standard for meta-information modelling MIM as a meta model. NEN 3610 conforms to MIM.

3.4 Overview geospatial data standards information models

NEN 3610 is the basis from which various sectoral information models have been developed. For example, there are models for the application domains of water (IMWA), public space (IMBOR, IMSW), environment (IMG, IMAER), nature management (IMNA), traffic and transport (IMWV,) cables and pipes (IMKL) and public order and security (IMOOV, IMDBK, IMEV). Some national key registrations are also part of the NEN 3610 family, such as the key registrations addresses and buildings (BAG/IMBAG), large-scale topography (BGT/IMGeo), topography (BRT/IMTOP), cadastral plots, (BRK/IMKAD) and subsoil (BRO/IMBRO). Each of these information models acts as a standard for exchanging geographic information within that sector or domain (the application profiles). The documentation on the sector models based on NEN 3610 can be found at overview Geospatial data standards .

Table 3.1 – Standards and specifications relating to information models

International standards and specifications	European profiles	Dutch profiles
ISO 19101 Geographic Information – Reference model [iso19101]	INSPIRE: Generic Conceptual Model [inspire-gcm]	MIM – Metamodel Information Modelling [MIM]
ISO/TS 19103 Geographic Information – Conceptual schema language [iso19103]	INSPIRE: Methodology for the development of data specifications [inspire-mds]	NEN 3610:2022 Basic model Geographic information. [NEN3610]
ISO 19107 Geographic information – Spatial Schema [iso19107]		
ISO 19108 Geographic information – Temporal Schema [iso19108]		
ISO 19109 Geographic information – Rules for application schema [iso19109]		
ISO 19110 Geographic information – Methodology for feature cataloguing [iso19110]		
ISO 19118 Geographic Information – Encoding [iso19118]		
ISO 19131 Geographic Information – Data product specification [iso19131]		
ISO 19136 Geographic Information – Geography Markup Language (GML) [iso19136]		
OGC Observations, measurements and samples v3.0 [OMS3]		
OGC Observations and Measurements – XML Implementation 2.0 [OaMx2]		
OGC Timeseries Profile of Observations and Measurements 1.0 [OaMt1]		
OGC City Geography Markup Language (CityGML) Part 1: Conceptual Model Standard v3.0 [CityGML3]		
	INSPIRE Data specifications	Dutch application profiles

3.5 Alignment of conceptual frameworks

Alignment between conceptual frameworks increases the effectiveness of information provision. There are a number of mechanisms to steer this alignment:

- NEN 3610 has a semantic model that divides reality into generic concepts (or UML super classes) of real objects and the virtual space, with below it a distribution into, for example, soil, water, vegetation, functional space, legal space. Sectoral models are obliged to link their concepts to them;
- Information models publish their concepts in registers. Registers are accessed via the web. The NEN3610 Concept Library is an example of this;

- When developing sectoral models, look for cooperation and alignment between sectoral models;
- Knowledge graphs can help to connect conceptual frameworks.

3.6 Quality of information models

Information models are not yet data and can therefore only be assessed on a conceptual level for quality. There are a number of mechanisms to ensure quality:

- NEN 3610:2022 conformity. NEN 3610:2022 contains an abstract test suite for testing the conformity of an information model to NEN 3610. The rules and recommendations of NEN 3610 have been translated into conformity classes;
- A NEN 3610:2022 template is available for UML modeling in Enterprise Architect;
- Publication and implementation of a NEN 3610 model in implementation schedules is supported by tooling. The tooling includes a test for MIM conformity;
- A guide 'Geometry in model and GML' is available. This guideline describes the application of geometry in information modelling and its implementation in GML. It supports the application of the basic geographic information model (NEN 3610) and GML. The guide explains, among other things, which geometries there are, Simple Feature profiles and transformation rules for generating GML from UML.

4. Visualization

To present geographic information on a map, visualization rules are drawn up. Think of flatt fills, line styles, symbols, etc.. Various domains have defined a visualization standard for an information model. By following those rules, a certain type of data always looks the same in a visualization.

4.1 Overview of geospatial data standards for visualization

Standardizing visualization (flat fills, line styles, symbols, etc.) is becoming increasingly important. Many content domains consider formally capturing a standard visualization for their information model and look for a suitable standard to capture it. OGC offers various specifications for this purpose[1]:

- **Styled Layer Descriptor** (SLD) and **Symbology Encoding** (SE): These standards together describe the specification for describing visualizations for OGC services;
- **Web Map Context Documents** (XML syntax) allows you to record the status of a WMS client (viewer). Think of a combination of a number of WMS services, (subset) of a legend, layers (styles, formats), zoom scale, etc.. This situation can be stored on a client and exchanged to other WMS clients so that they have the same Web Map Context;
- **Mapbox Styles** is a de-facto standard from the market for web visualization of geographic information. The version management of this specification is not described and therefore this framework does not refer to a specific version but to the most up-to-date;
- **OGC API Styles** is a new OGC standard to retrieve, edit and validate styles and their metadata (visualization rules) through an API. The styles themselves can be expressed in SLD 1.0, SLD 1.1 or Mapbox Styles;
- **3D Tiles** is an approved OGC community standard for publishing 3D geographic information as tiles. This standard also includes 3D Tiles Styles, a way to describe declarative visualization specifications that you can apply to tilesets;
- **Indexed 3D Scene Layers** (i3S) is also an approved OGC community standard. It specifies a format, made up of standardized layers, for efficient 3D visualization on the web.

European visualization profiles are available in the form of visualization rules for data products and information models. These are described in SLD and SE for the European INSPIRE profiles; in chapters 11 of the INSPIRE data specifications, portrayal is defined according to **Styled Layer Descriptor** and **Symbology Encoding**. Visualization rules are also applied in Dutch profiles as in the Visualization Rules of the BGT (see below). The geospatial data standards for visualization are set out in Table 4.1.

[1] 3D visualization is becoming increasingly important. For this purpose, various desktop applications are available that for example CityGML, Google SketchUp and other formats can often use together for visualizations. OGC services for this have not yet been crystallized as standard(s), this is currently being worked on. In the meantime, de-facto standards are usually applied. Interesting developments from W3C are: XML3D and X3D which both aim for 3D services on the web without browser plug-ins (based on HTML5). Both come from W3C and it is still unclear which direction it is going. KML and Collada are also great for 3D visualization.

Table 4.1 – Standards and specifications for visualization

International standards and specifications	European profiles	Dutch profiles
ISO 19117 Geographic Information – Portrayal [iso19117]	Visualization rules for INSPIRE data specifications	Visualization rules for information models
OGC Styled Layer Descriptor Implementation Specification, version 1.1.0 [SLD11]		
OGC Symbology Encoding Implementation Specification, version 1.1.0 [SE11]		
OGC Web Map Context Documents Implementation Specification, version 1.1 [WMC11]		
Corrigendum for Implementation Standard Web Map Context Documents – Corrigendum 1, version 1.1.0 [WMCC11]		
Mapbox Styles [MBS]		
OGC API Styles 1.0.0 **Draft** [OAPISTYLES]		
3D Tiles 1.0 [3DTILES] chapter 11, Declarative styling specification		
OGC Indexed 3D Scene Layers v1.2 [I3S]		

4.2 Quality and visualization

Visualization rules data products and information models
A visualization is not part of an information model or data product, but is a separate aspect. Only the visualization of texts is mentioned in the information models if necessary. Visualization of objects and data products is described in visualization rules. These are laid down in an annex or in a handbook. Each visualization rule records the selection of objects for which this is the visualization (see example 1 below).

Example 1 – Visualization rules BGT

Seven presentations are available for the BGT/IMGeo. These are described in the Manual BGT\IMGeo Visualization Rules of 2028:

- **Standard visualization**: a visualization for the use of the BGT/IMGeo content as the main theme, which is in line with the visualization of the Key Registration Topography (BRT). In the standard visualization, only the point symbols for CADO, traffic threshold and barrier are used. For the sake of the visual hierarchy, it is strongly advised not to depict the icon visualization of IMGeo point objects in combination with the standard visualization;
- **Background visualization**: a visualization for the use of the BGT/IMGeo content as a background card, which is in line with the visualization of the BRT-Background map as realized for 'Public Services on the Map' (shortly PDOK in Dutch);

- **Icon Visualization**: a visualization of the point symbols for the use of the IMGeo content, which corresponds to the above-mentioned background visualization. For the sake of the visual hierarchy, it is strongly recommended that the icon visualization should not be depicted in combination with the standard visualization;
- **Line-based visualization**: a visualization for the use of the BGT/IMGeo content as the main theme, which is in line with the visualization of the Large-scale Basic Map Netherlands (GBKN). All individual objects with the same properties adjacent to each other are visualized contiguously. The boundaries between the individual objects fall away in order to achieve a calmer map image. For this purpose, a white flatt fill is given to the objects;
- **Circumference-oriented visualization**: a visualization for the use of the BGT/IMGeo content as the main theme, which is in line with the visualization of the Large-scale Basic Map Netherlands (GBKN). All individual objects are visualized separately. The boundaries between the individual objects are maintained;
- **Pastel visualization**: a visualization for the use of the BGT/IMGeo content as a background map, which is in line with the needs of civil engineering firms and the cable and piping chain to display information about its buildings, works of art and infrastructure on the BGT/IMGeo content;
- **Planning visualization**: a visualization for the use of the plan information content.

Map visualization for web applications
For developers of geographic web applications, the web cartography guide was developed in 2010. In the Guidelines ‘Web cartography’ [HRWC] guide you will find practical tips on how to provide geographic information – where possible – within the intents of accessibility requirements.

4.3 Accessibility and geographic information

Since 1 July 2018, the Temporary Decree ‘Digital accessibility government’ applies. As of that date, government websites must comply with accessibility requirements for people with disabilities. However, this decision explicitly states in Article 2(2)(d) that the decision does not apply to online maps. The decision follows the European directive on the accessibility of public sector bodies’ websites and mobile applications. Only exception is that in the case of maps for navigation applications, the essential information is also in a different way (read: route description in text) must be made accessible. In the manual ‘Digitally accessible location data’ [HRTOEG] and the Guidelines ‘Web cartography’ you will find practical tips on how to provide geographic information – where possible – within the meanings of the accessibility requirements. This document is the web version of a PDF document originally published in January 2015. It is based on Web Content Accessibility Guidelines (WCAG) 2.0 [WCAG20]. There have been renewed accessibility requirements and digital accessibility legislation for some time, based on WCAG version 2.1 [WCAG21]. This document has not yet been adapted to this.

5. Application Programming Interfaces

To be able to find, consult, and download geographic information on the Internet, Application Programming Interfaces (APIs) are in use. APIs play an important role on the Internet. An API serves as an interface between different software programs and ensures that an application automatically accesses the data.

5.1 Transition to a new generation of APIs

The international geospatial data standards for APIs often come from the Open Geospatial Consortium (OGC). The first generation API standards, then called "services", are based on XML and SOAP. These standards are still valid and in use, but are gradually being replaced by a new generation, based on general Web architecture, such as REST. The advantage of these new APIs is that geographic information becomes part of the Web ecosystem and is thus accessible to a much wider audience. The OGC plans to phase out the old generation of services standards slowly. The new OGC API standards are partly under development, partly already approved. It is advisable to apply the new OGC API standards as much as possible in new facilities. Existing facilities, which are based on the old 'services' standards, can be kept operational for a longer period of time. New OGC APIs can also be set up. It is also possible to make OGC APIs available as a layer on top of old generation "services". Software is available for this.

5.2 Overview geospatial data standards for APIs

In the overview of geospatial data standards for APIs, the standards per theme are included in tables:

- API standards for retrieving webmaps: OGC WMS and OGC API Maps (Table 5.1);
- API standards for querying (downloading) vector data: OGC WFS, OGC API Features and ATOM (Table 5.2);
- API standards and specifications for retrieving (downloading) grid data: OGC WCS and OGC API Coverages (Table 5.3);
- API Standards and specifications for retrieving (downloading) sensor data: OGC SOS, OGC SensorThings API and OGC API Environmental Data Retrieval (Table 5.4);
- API Standards and specifications for querying metadata catalogs: OGC CSW and OGC API Records (Table 5.5);
- API standards and specifications for card tile retrieval: OGC WMTS, OGC API Tiles, 3D Tiles (Table 5.6);
- API standards and specifications for linked data: GeoSPARQL (Table 5.7).

In the overview below are the new generation OGC API standards that have been approved, but also the OGC API standards that are still in development or draft. This is indicated for each standard.

5.3 Web mapping APIs

Table 5.1 – API standards and specifications for web mapping: OGC WMS and OGC API Maps

International standards and specifications	European profiles	Dutch profiles
Web Map Server (WMS) Implementation Specification, version 1.3.0 [WMS]	Technical Guidance for the implementation of INSPIRE View Service [INSTGVS]	English profile on ISO 19128 Geographic information – Web Map Server Interface version 1.0 [NLWMS]
ISO 19128 Geographic Information – Web Map Service (WMS) [iso-19128-2005]		
OGC API Maps Draft [OAPIMAPS]		

5.4 Vector Data APIs

Table 5.2 – API standards and specifications for vector data: OGC WFS, OGC API – Features and ATOM

International standards and specifications	European profiles	Dutch profiles
Web Feature Service (WFS) Implementation Specification, version 1.1.3 [WFS11]	Technical Guidance for the implementation of INSPIRE Download Services [INSTGDS]	English WFS Profile 1.0 on OGC WFS 1.1.0 [NLWFS]
ISO 19142, Geographic information – Web Feature Service (= WFS version 2.0) [iso-19142-2010], [WFS]		
OGC Filter Encoding 2.0 Encoding Standard – With Corrigendum [FE20]		
ISO 19143, Geographic information – Filter encoding [iso-19143-2010]		
OGC API – Features Part 1 Core [OAPIF1]	OGC API – Features as an INSPIRE download service [INSGPOAPIF]	API Design Rules Geomodule **Draft** [adr-mod-geo]
OGC API – Features Part 2 CRS by reference [OAPIF2]		API Design Rules Geomodule **Draft** [adr-mod-geo]
OGC API – Features Part 3 Filtering **Draft** [OAPIF3]		
OGC API – Features Part 3 Filtering **Draft** [OAPIF3]		
OGC API – Features Part 4 Create Replace Update and Delete **Draft** [OAPIF4]		
Atom [rfc4287]		

5.5 Raster Data APIs

Table 5.3 API standards and specifications for grid data: OGC WCS and OGC API – Coverages

International standards and specifications	European profiles	Dutch profiles
OGC Web Coverage Service (WCS), version 2.1 [WCS21]	Technical Guidance for the implementation of INSPIRE Download Services using Web Coverage Services (WCS)[INSTGDSWCS]	Same as the European profile
OGC API – Coverages – Part 1: Core, version 0.0.6 **Draft** [OAPIC]		

5.6 Sensor data APIs

Table 5.4 – API Standards and specifications for sensor data: OGC SOS, EDR API and SensorThings API

International standards and specifications	European profiles	Dutch profiles
OGC Sensor Observation Service Interface Standard Version 2.0 [SOS]	Technical Guidance for implementing download services using the OGC Sensor Observation Service and ISO 19143 Filter Encoding [INSTGDSSOS]	Same as the European profile
OGC SensorThings API part 1 Sensing, version 1.1 [STAS]	OGC SensorThings API as an INSPIRE download service (good practice) [INSGPSTA]	
OGC SensorThings API Part 2 Tasking Core, version 1.0 [STAT]		
OGC API – Environmental Data Retrieval Standard, version 1.0.1 [OAPIEDR]		

5.7 Metadata APIs

Table 5.5 – API Standards and specifications for metadata: OGC CSW and OGC API – Records

International standards and specifications	European profiles	Dutch profiles
OGC Catalogue Service for the Web (CSW) Implementation Specification, version 2.0.2 [CSW]	Technical Guidance for the implementation of INSPIRE Discovery Services [INSTGDIS]	Same as the European profile
CSW2 AP ISO, Catalogue Services Specification 2.0.2 – ISO Metadata Application Profile, Version 1.0.0, [CSWISOAP]		
OGC API – Records – Part 1: Core **Draft** [OAPIRECORDS1]		

5.8 Map tile APIs

Table 5.6 – API standards and specifications for folder tiles: OGC Web Map Tile Service (WMTS,) OGC API – Tiles, and 3D Tiles

International standards and specifications	European profiles	Dutch profiles
Web Map Tile Service Implementation Standard (WMTS) v1.0.0 [WMTS]	Technical Guidance for the implementation of INSPIRE View Service [INSTGVS]	Same as the European profile
OGC API – Tiles – Part 1: Core [OAPITILES1]		
OGC 3D Tiles 1.0 [3DTILES]		

Available practice guidelines

Practical guidelines for implementation:

- Practical Guideline Vector Tiling (2021);
- Practical Guideline Best practices Vector Tiling (2021).

5.9 Linked Data APIs

Table 5.7 – API standards and specifications for linked data: GeoSPARQL

International standards and specifications	European profiles	Dutch profiles
GeoSPARQL – A Geographic Query Language for RDF Data v1.0 [GeoSPARQL]		
GeoSPARQL – A Geographic Query Language for RDF Data v1.1 **Draft** [GEOSPARQL11]		

Available practical guidelines

Practical guideline for implementation: NEN 3610 – Linked Data [NLDP][2]

5.10 Quality of APIs

API Strategy Government (policy) and REST Design Rules

In the Dutch API strategy and Rest Design Rules various recommendations are made for the quality of APIs. The Dutch API Strategy [NLAPIS] consists of an informative section on policy, user requirements, architecture and a normative part with draft guidelines for APIs. These draft guidelines are registered for placement on the 'comply or explain' list of the Netherlands

[2] GeoSPARQL has an interaction part and a concise information model (ontology) for geodata. This guide is mainly about the information model. With this, this reference or note also has a relationship with the chapter on information models.

Standardization Forum. Both the API Strategy and the draft guidelines for APIs are actively being developed. The Rest Design Rules is a list of agreements that developers follow while building a REST API for the public sector. By using the rules, the API is predictable. And that's nice for other developers who want to use it. Thanks to these rules, it remains easy for organizations to exchange data with each other.

Agreements on quality of service

It is important to make agreements as a service provider with the service customers about the service. For example, to express the quality of a service, INSPIRE defines the three types of service quality standards (Table 5.8).

Table 5.8 – Example of quality standards for services

Quality standard	Explanations	Example
Reliability	Reliability refers to the amount of failed requests that a system may return at an agreed time.	For example, "10 %" is a failed request for a geo-service per week.
Availability	Availability measures the percentage of availability (uptime). The uptime percentage = uptime/(uptime + downtime).	For example, the geo-service should be available in 98 % of requests.
Performance/response time	Performance expressed in response time.	For example, an 800\600 pixels image with 8bit colors should have a response time of up to 5 seconds.

Validators

Validators are available to validate services (WMS and WFS). With the ETF validator, the quality of the WMS and WFS can be tested for the most part.

6. Exchange formats

Based on the information models, exchange formats are defined. Where an information model determines semantics, an exchange format describes the form or syntax in which geographic information is exchanged based on a particular information model. There are several ways to represent and exchange geographic information.

6.1 Overview geospatial data standards for exchange formats

In the overview of geospatial data standards for exchange formats, the topics are distinguished and included in the tables below:

- Exchange standards for the exchange of vector data;
- Exchange standards for exchanging raster data;
- Exchange standards for the exchange of sensor data;
- Exchange standards for the exchange of 3D data.

6.2 Vector data exchange standards

The vector representation is used for capturing discrete objects where the geometry is described using: point, line and plane (2D) or with full planes (3D). The vector representation is described in detail in the international standard [iso19107]. This standard also provides guidelines for explicitly recording interrelationships between geographical objects. The ISO standard is very extensive. For most applications, you can use the OGC subset from this standard: Simple Feature Access [iso-19125-1-2004][3].

The following standards exist for the exchange of vector data (Table 6.1).

[3] An exception applies to circular arches. If you want to describe geo-objects with circular arches, it is best to use the OGC Simple Features profile for GML [GMLSF] that applies the Simple Features subset of geometry types, with the additional addition of circular arches, to GML 3.2.1 [ISO19136].

Table 6.1 – Exchange formats standards and specifications related to vector data

International standards and specifications	European profiles	Dutch profiles
ISO 19107 Geographic information – Spatial Schema [ISO-19107-2003]	INSPIRE Guidelines for the encoding of spatial data [inspire-gen]	
ISO 19125 Simple Feature Access Part 1: Common Architecture, version 1.2.1 [iso-19125-1-2004]		
OGC Geography Markup Language (GML) Encoding standard, version 3.2.1 (=ISO 19136) [iso-19136-2007]		
OGC Geography Markup Language (GML) Encoding standard, version 3.3 [GML33]		
OGC Simple Features profile (OGC 10-100r3, version 2.0) at ISO 19136:2007 (GML 3.2.1) [GMLSF]		
OGC GeoPackage Encoding Standard, version 1.3.1 [GeoPackage]	GeoPackage encoding for INSPIRE datasets (INSPIRE good practice) [INSGPGeopackage]	
The GeoJSON Format [rfc7946]		
OGC JSON Features and Geometries, version 0.1 draft [JSON-FG]		
HTML5 [html5]		
Resource Description Framework (RDF): Concepts and Abstract Syntax. [rdf11-concepts]		

6.3 Raster data exchange standards

The raster representation is used to capture data where each point on the earth's surface is assigned a dynamic value. Examples are the air pressure above the Netherlands, values of a harmful substance, temperature or – as with a photo – reflection values. In OGC and ISO/TC 211 terms, this is called a "coverage". Such coverage is often implemented by laying a regular grid of points over the terrain (a raster) and recording a value for each point. For example, this value is a height indicator determined using laser altimetry, or the numerical coding of a color value included in a satellite image. There are several geospatial data standards for coverages or raster data (see Table 6.2), such as netCDF and HDF5. Also GeoTIFF (Geo Tagged Image File Format), where geographic reference is included as tags in the file. In addition, you can also see web standards listed here as JPEG2000 and PNG. The latter is mainly used in WMS.

Table 6.2 – Exchange formats standards and specifications related to raster data

International standards and specifications	European profiles	Dutch profiles
OGC Network Common Data Form (NetCDF) Core Encoding Standard version 1.0. [NETCDF]	INSPIRE Guidelines for the encoding of spatial data [inspire-gen]	
Hierarchical Data Format 1.0 [HDF5]		
HDF-EOS5 Data Model, File Format and Library (v1.1) [HDFEOS]		
OGC GeoTIFF Standard, version 1.1 [GeoTIFF]		
ISO/IEC 15444-1:2019 – JPEG 2000 image coding system [isoJPEG2000]		
ISO 19123-1: Coverage Fundamentals [iso-19123-2005]		
ISO 19123-2: Cover Implementation Schedule (CIS 1.0) [CIS10]		
GML for JPEG 2000 [GMLJPEG2000]		
ISO/IEC 15948:2004 – Portable Network Graphics [PNG]		
CoverageJSON 1.0 **Draft** [COVJSON]		

6.4 Sensor data exchange standards

Sensors are devices for measuring substances in water, soil compositions, groundwater, air pollution, etc. Sensors also have a position and the results of the measurements must be exchanged. For the exchange of these 'observations, measurements and samples', different exchange formats exist (Table 6.3).

Table 6.3 – Exchange formats standards and specifications related to sensor data

International standards and specifications	European profiles	Dutch profiles
OGC Observations and Measurements version 3.0 (ISO 19156) [OMS3]	INSPIRE Guidelines for the encoding of spatial data [inspire-gen]	Information model Measurements [IMMeasurements]
Observations and Measurements – XML Implementation 2.0 [OaMx2]		
W3C/OGC Semantic Sensor Network Ontology [vocab-ssn]		
OGC SensorML 2.1 [SensorML]		

6.5 3D data exchange standards

To exchange 3-dimensional data, i.e. data about objects and phenomena in the geographical space, in which the x-y and x-coordinate are recorded, you can use the following standards (Table 6.4).

Table 6.4 – standards and specifications for 3D data exchange formats

International standards and specifications	European profiles	Dutch profiles
OGC City Geography Markup Language (CityGML) Encoding Standard, version 2.0 [CityGML2]		
CityJSON Community Standard, version 1.1.2 [CityJSON]		

6.6 Quality and exchange formats

Validation
An important quality aspect of an exchange format is the possibility to validate it. This is preferably done with automated processes, or described procedures and validation rules. Validation helps to ensure that exchange formats comply with the geo-standard validation rules. Validation tools are available to assist in validation. The tools are intended as a tool to reduce errors in the application of geospatial data standards . There are two validators for the validation of GML (vector data):

- The GML3.2 Simple Features validator checks that a GML 3.2 file complies with the GML 3.2 Simple Feature profile, level 2;
- The GML 2D geometry Validator checks whether the 2D geometries in a GML 3.x file comply with ISO 19107 (Spatial Schema).

Guide 'Geometry in model and GML'
The guide 'Geometry in Model and GML' describes the application of geometry in information modelling and its implementation in GML. It is thus a support for the application of standard NEN 3610:2011 – Basic model geographic information [NEN3610]. NEN 3610 does not go beyond reference to the relevant geographic information (ISO) standards. ISO standards have been expanded. Geometry in model and GML is a practical, simplified introduction to the ISO standard. For the normative reference we refer to the original documents. The Guide can be read as an independent document.

Guide 'Light geometry formats'
For exchanging geographic information, you can choose from different exchange formats. What is the best format for an application depends on several aspects. In the information model associated with the data, these aspects can already emerge – for example the geometry types that are recorded, the modelling paradigm used, etc. But from one information model multiple implementations can also be derived in exchange formats – decisions in the model do not necessarily exclude this. Therefore, a choice aid has been made for light vector geometry formats [HRLFG]: in the light formats HTML, GML, JSON, GeoPackage and RDF. This also explains the application of the different versions of GML. The Guide provides handles for choosing the right exchange format for the right situation, and provides detailed information on how to exchange geometry in these light formats . This guide outlines the most important aspects and links them to common applications. The application determines what the requirements for the geometries are (are complex types necessary? Is high accuracy important?), and what obligations are involved in

the choice of light geometry standards. The answers to these questions can already give an indication of the suitability of the exchange formats. In addition, it is important to understand the needs of users: is support in certain tools/frameworks important? Should the files be readable for people and easy to find? How important is the semantics of the data? This Guide provides tools for choosing the right format for the right situation, and provides detailed information on how to exchange geometry in GML, HTML, JSON, GeoPackage and RDF in individual chapters.

7. Metadata

In order to make data findable and to be able to get a first impression of its applicability for use, the data must be described in the geographic information infrastructure. Characteristics of the data, such as the owner and topic, are recorded using metadata. Metadata ensures that geographic information can be found and used for purpose.

7.1 Overview geospatial data standards for metadata

There are different levels at which metadata is created. Metadata of data describes the dataset or dataset series (also dataset series). Metadata of services describes the "service" or API. In the Netherlands, the Dutch metadata profile for datasets and services is applied. This profile is based on ISO 19115 for data and ISO 19119 for services. It is an extension, but also further specification of the European INSPIRE metadata requirements and specific needs of users in the Netherlands. With the Dutch metadata profiles, the INSPIRE profiles for metadata are also met. The Dutch metadata profiles also include the connection to data.overheid.nl. Data.overheid.nl is a data catalog for all open data of the government. In order to search for datasets from different domains, datasets in data.overheid.nl are described with metadata in accordance with the standard DCAT. DCAT is a metadata standard of W3C for exchanging metadata between different data catalogs. The DCAT Application Profile for Data Portals in Europe (DCAT-AP) has been developed for European portals. DCAT-AP has an geospatial extension GeoDCAT-AP for describing geographic datasets, dataset series and services. This extension is also tailored to INSPIRE. The geospatial data standards for metadata are included in Table 7.1.

Table 7.1 – Standards and specifications related to metadata standards

International standards and specifications	European profiles	Dutch profiles
ISO 19115:2003, Geographic information – Metadata1 [ISO19115-2003]	Technical Guidance for the implementation of INSPIRE dataset and service metadata based on ISO/TS 19139:2007 [inspire-TG-metadata][4]	Dutch profile ISO 19115 for geography, version 2.1.0 [NLISO19115]
ISO 19115/Cor.1:2006, Geographic information – Metadata, Technical Corrigendum 1 [ISO19115-2006]		English profile ISO 19119 for services, version 2.1.0 [NLISO19119]
ISO 19115-2:2009, Geographic information – Metadata – Part 2: Extensions for imagery and gridded data [ISO19115-2009]		
ISO 19119:2005, Geographic information – Services [ISO19119-2005]		
ISO 19119:2005/Amd 1:2008, Extensions of the service metadata model [ISO19119-2008]		
ISO/TS 19139:2007, Geographic information – Metadata – XML Schema Implementation [ISO19139]		
Data Catalog Vocabulary (DCAT) version 2.0 [vocab-dcat-2]	DCAT-AP – An extension for the DCAT application profile for data portals in Europe version 2.1.1 [DCAT-AP-2.1.1]	
	GeoDCAT-AP – A geospatial extension for the DCAT application profile for data portals in Europe version 2.0.0 [GeoDCAT-ap]	

7.2 Quality of metadata

Guide 'Metadata quality'
The metadata quality policy is laid down in the guide 'metadata quality'. Using the manual, 26 elements described in the metadata standards can be used to assess the quality of metadata.

Validation
Validators are available for testing metadata validity. These validators check the correct application of the Dutch metadata profile for datasets and services. The validator Dutch metadata profile on ISO 19115 and ISO 19119] validates the metadata of datasets and services respectively in accordance with the Dutch profile. Metadata of datasets or services designated for INSPIRE is

[4] The [inspire-TG-metadata] is based on [ISO19115-2003]. This is why the NL profile is also based on [ISO19115-2003] and not on [ISO19115-2014].

subject to more specific requirements. In addition to the Dutch validator, use the European INSPIRE validator to validate metadata.

7.3 Exploratory study

Methods and techniques to search, find and unlock data do not stand still. At the end of 2021, an exploratory study of the future of metadata standards was done. In this 'Exploratory study of the future of metadata' draws a development towards more coherence and connection between different metadata standards. Connecting to generic standards, such as DCAT and establishing relationships between data, models, concepts and data catalogues is therefore important. Better connecting providers and users of data is also a focus area.

8. Coordinate reference systems

Geographic information is directly linked to a location on Earth. Through the coordinate reference system, we record coordinates of a location. For the Netherlands, several standards for coordinate reference systems are in use, especially Rd, ETRS89 and WGS 84 are well-known examples of coordinate reference systems applied for the Netherlands.

8.1 Overview geospatial data standards for coordinate reference systems

A coordinate reference system (CRS) is composed of a date and a coordinate system. The coordinate system defines how coordinates are expressed, e.g. cartesian or geographical. The date indicates the relationship of the coordinate system with the Earth. The coordinate reference systems used in the Netherlands for the storage and exchange of geographic information can be divided into different groups:

- **Geographic CRSs** give geographical coordinates in degrees (2D latitude and length) latitude and longitude) and for 3D also height relative to an ellipsoid model of the Earth's surface;
- **Projected CRSs** present geographic information on a flat plane in cartesian (x and y) coordinates. A projected CRS is a derivative of a geographical CRS, using a map projection for imagery in the flat plane;
- **Vertical CRSs** for the determination of height and depth relative to a reference plane. This reference plane is often based on the direction of gravity and normally does not coincide with the surface of an ellipsoid;
- **Compound CRSs** are composite CRSs, for example composed of a projected CRS and a vertical CRS.

ISO standard 19111 [iso19111] is available for the definition of CRSs. The [iso19111] standard describes the parameters that define the CRS. For specification and naming of a CRS, Name Type Specification (NTS), Uniform Resource Names (URN), or Uniform Resource Locators (URL) can be used, for example, which may include EPSG codes that refer to the parameters that define the CRS. For exchange under INSPIRE, the CRSs to be used and their specification are laid down in a specific directive. The relevant CRSs used in the Dutch geographic information infrastructure can also be classified according to their geographical scope:

- A **global CRS** is a CRS that, on average, fits the entire Earth as well as possible. Global CRSs are intended for small-scale or global applications, e.g. world maps, satellite navigation and describing processes such as sea currents and plate tectonics. Global CRSs are less suitable for accurate geographic information capture, as in a global CRS the coordinates are time-dependent due to plate tectonics;
- A **continental or regional CRS** is linked to a tectonic plate; as a result, coordinates in the CRS move along with the tectonic plate;
- A **national CRS** is often a projected CRS that has been chosen in such a way that the deformations in the flat plane are minimal. The systems used within the Netherlands and their corresponding EPSG code are included in Annex A of the Guide 'Use of coordinate reference systems in the exchange and visualization of geographic information' [HRCRS]. The following table 7.1 sets out the standards and specifications applicable to the CRS standards for the Netherlands.

Table 7.1 – Standards and specifications relating to CRSs

International standards and specifications	European profiles	Dutch profiles
Geographic Information – Spatial Referencing by Coordinates [iso19111] (equal to [OREFCO])	INSPIRE specification on Geographical Grid Systems – Guidelines [inspire-ggs]	Use coordinate reference systems in the exchange and visualization of geographic information [HRCRS]
ISO 6709 Standard representation of geographic location by coordinates [iso6709]	INSPIRE specification on Coordinate Reference Systems – Guidelines [inspire-crs]	
EPSG codes database & CRS Ids [EPSG]		
ISO/TS 19127 Geographic Information – Geodetic codes and parameters [isots19127]		

8.2 Quality and CRSs

CRS and themselves are not geographical data, the quality of geographical data falls or stands with the proper recording of the coordinate reference system used. Without information about the CRS used, coordinates are numbers without meaning, because it is not clear what the relationship of the numbers is with the earth. The guide 'Coordinate reference systems in exchange and visualization of geographic information' [HRCRS] from 2022 discusses backgrounds in CRSs and various issues of concern when dealing with CRSs, such as:

- CRS choice for information models;
- Providing information on CRS and in information models and metadata;
- Unambiguous naming of CRSs;
- Unambiguous coordinate transformations; and
- Support for CRSs and in exchange formats and software (libraries).

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