

Geographic information — Standards, specifications, technical reports and guidelines, required to implement Spatial Data Infrastructure

ICS 07.040; 35.240.70

National foreword

This Published Document was published by BSI. It is the UK implementation of CEN/TR 15449:2006.

The UK participation in its preparation was entrusted to Technical Committee IST/36, Geographic information.

A list of organizations represented on IST/36 can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2006

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ISBN 0 580 49490 X

Amendments issued since publication

Amd. No.	Date	Comments

ICS 07.040; 35.240.70

English Version

Geographic information - Standards, specifications, technical reports and guidelines, required to implement Spatial Data Infrastructure

Information géographique - Normes, spécifications, rapports techniques et lignes directrices, nécessaires à la mise en oeuvre d'une infrastructure d'information spatiale

Geoinformation - Normen, Spezifikationen, technische Berichte und Leitfäden zur Einführung von Geodateninfrastrukturen

This Technical Report was approved by CEN on 24 June 2006. It has been drawn up by the Technical Committee CEN/TC 287.

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Foreword

This Technical Report (CEN/TR 15449:2006) has been prepared by Technical Committee CEN/TC 287 “Geographic information”, the secretariat of which is held by NEN.

Introduction

Spatial Data Infrastructures (SDIs)

The proposal of the European Commission for a Directive establishing a spatial data infrastructure for Europe (INSPIRE) (European Commission 2004) defines a SDI as the metadata, spatial data sets and spatial data services; network services and technologies; agreements on sharing, access and use; and coordination and monitoring mechanisms, processes and procedures, established, operated or made available in an interoperable manner.

This Technical Report focuses on the technical aspects of a SDI, thereby limiting the term SDI to mean a platform- and implementation-neutral technological infrastructure for geospatial data and services, based upon standards and specifications. This report does not consider a SDI as a carefully designed and dedicated information system; rather, it is viewed as a collaborative framework of disparate information systems that contain resources that stakeholders desire to share. The common denominator of SDI resources, which can be data or services, is their spatial nature. It is understood that the framework is in constant evolution, and that therefore the requirements for standards and specifications supporting SDI implementations evolve.

Intended readership

The intended readership of this report are those people who are responsible for creating frameworks for SDI, experts contributing to INSPIRE, experts in information and communication technologies and e-government that have to familiarize themselves with geographic information and SDI concepts, and standards developers and writers.

Aim of the report

The aims of this report are three-fold:

- to identify the standards, specifications, technical reports and guidelines, required to implement a SDI in Europe;
- to give recommendations as to whether any of these items should become EN, and to propose a roadmap for future work items;
- to provide recommendations for measures to be taken in order to support implementation and maintenance of a SDI.

Structure of the report

Existing material about SDIs abounds. This report structures and refers to this existing material. The criteria used for determining if a given standard or specification is referred to in this report are:

- the publication is non- proprietary of nature, and
- the publication addresses an aspect of the SDI.

Based on the above considerations, and based on discussion within CEN/TC 287 Working Group SDI, the following reports have been taken into account:

- documents produced by ISO/TC 211 (ISO/TC 211, 2005);

- documents produced by the Open Geospatial Consortium (OGC), including the OpenGIS Reference Model (ORM) (OGC, 2003);
- INSPIRE Architecture and Standards Position Paper (Smits, 2002);
- Geospatial Interoperability Reference Model (GIRM) (Evans, 2003);
- internal report of CEN/TC 287/WG5 Spatial Data Infrastructure on the use of standards in SDI projects (August 2004);
- existing national guidelines based on the (EN) ISO 19100 series of standards.

Clauses 1 to 5 are introductory of nature, with the first four focusing on the scope, the considered standardization initiatives, the terms and definitions, and the symbols and abbreviated terms, respectively. Clause 5 explains what a SDI is.

The subsequent clauses cover the main concerns of a SDI in Europe. Clauses 6 and 7 give a data-centric and a service-centric view on SDI. The data- and service-centric views are brought together in the Reference Model for a SDI (Clause 8). Clause 9 addresses concerns related to multi-lingual and cultural adaptability, followed by a clause dedicated to geo-portals (Clause 10). Clause 11 provides considerations that are relevant for the implementation of SDI. Clause 12 identifies SDI aspects currently not covered by standards.

Management summary

In order for standards and specifications to be useful for implementing a SDI in Europe, it needs to be straightforward to identify which standards are relevant in a particular situation, and the interpretation of standards should be unambiguous. This Technical Report provides a framework for the identification of standards, and gives a number of recommendations with the aim to enhance interoperability between information systems that provide data and services in support of a SDI. The following paragraphs summarize the recommendations of this Technical Report.

Recommended standards and documents

Standards and documents that are recommended for use within SDIs in Europe appear underlined in the Reference Model (Clause 8). Standards that are not underlined are standards that are used or could be very useful in some communities, but are not considered as a main component in a European SDI.

This Technical Report encourages the geographic information software industry to support standards for the creation and management of geographic information and to implement appropriate interface specifications in their products. At the same token, it is recommended that relevant standards be used in public procurement, and that any findings related to the implementation of standards are fed back to the relevant standardization bodies.

Registries

For the realisation of SDI in Europe, it is recommended to establish one or more registration authorities.

A SDI needs, like any other distributed information system, a reference frame. A reference frame is the aggregation of the data needed by different components of the information systems. In a SDI context, the reference frame concerns:

- the units of measures;
- the coordinate reference systems;
- the codelist definitions;
- the feature data dictionaries (see ISO 19126);

- the feature catalogues (see ISO 19110);
- the portrayal catalogues and related symbology registers.

It is recommended that registries are established for the above-listed information elements and geographical items, and for:

- cultural and linguistic adaptability of metadata elements;
- European common data models;
- national data which are of interest in a cross border community or in a multilingual community.

Appropriate standards for registries for information elements and geographical items would need to be identified or developed. Registries should be conformant to ISO 19135, *Geographic information — Procedures for registration of geographic information items*.

In order to enable the cultural and linguistic adaptability (CLA) of metadata and common data models, it is recommended to use unique names and codes for the information elements and the geographical items (e.g. feature type). A number of practical suggestions related to CLA are given in Clause 9.

Data

- The model-driven approach is promoted for ESDI.
- Unique identifiers for use in a European SDI should be composed of a namespace and a Universally Unique Identifier (UUID).
- ISO 19109 and referred standards are promoted as ESDI rules for specifying data structures and semantics.
- UML class diagrams used according to ISO/TS 19103 is promoted as an ESDI conceptual schema language.
- ISO 19136 (GML) is promoted as the ESDI encoding method when transferring geographic data.
- ISO 19139 is promoted as the ESDI encoding method when transferring information related to geographic data such as metadata, feature catalogues, data dictionaries, ...

Services

This Technical Report recommends that all services be categorized according to the ISO 19119 taxonomy.

This Technical Report recommends applying the Web Service Architecture (WSA), including WSDL, SOAP, UDDI and XML when the following issues are considered to be important:

- components of information systems run on different platforms;
- the system consists of components from different vendors;
- the service is to be published and available on the internet;
- wrapping of existing services where these are exposed as web services;
- make existing services available for other applications on other platforms.

It is inappropriate to apply WSA when transferring large datasets.

Conceptual Schema Languages

This Technical Report encourages the use of UML.

If an information community applies a Conceptual Schema Language other than UML, it is the responsibility of that information community to map the ISO general feature model to the meta-model of the Conceptual Schema Language of choice, and to maintain the mapping rules, following the ISO/TS 19103 conformance statement:

Non-UML schemas shall be considered conformant if there is a well-defined mapping from a model in the source language into an equivalent model in UML and that this model in UML is conformant.

In order to provide a GML application schema, an application schema should be made by applying a conceptual schema language, and the GML application schema should be derived from that conceptual model, applying the rules for mapping from UML as described in Annex E of ISO 19136.

Conformance testing

It is recommended to establish a conformance authority charged with the conformance testing of implementations of SDI elements in Europe.

Roadmap for new work

It is recommended that CEN/TC 287, in collaboration with ISO/TC 211 and OGC, start new work on the following items:

- catalogue server;
- XML encoding of portrayal;
- quality aspects of services;
- standards for registries for geographical items, depending on the progress on ISO 19126;
- Digital Rights Management;
- the use of web services for the transfer of large datasets.

It is further recommended that before a given standard or specification be made mandatory in a European or national legislation, the standard be implemented and tested.

Practical experience with the implementation of a given standard may reveal that a European profile thereof is needed.

For example, based on interoperability experiments, CEN/TC 287 has identified that European profiles of EN ISO 19115 (metadata) and ISO 19128 (Web Map Server interface) are needed in order to enhance interoperability in Europe and started new work on these topics.

1 Scope

This Technical Report identifies the standards, technical specifications, technical reports and guidelines, required to implement a Spatial Data Infrastructure (SDI) in Europe. It gives recommendations as to whether any of these items should become EN, and proposes a roadmap for future work items. It further provides recommendations for measures to be taken in order to support implementation and maintenance of a SDI. In so doing, the report addresses a range of topics, including:

- multi-lingual aspects,
- consistent identification of geographical items,
- conformance testing,
- geographic information metadata including catalogue service profile and guidelines, and
- WMS and WFS profiles and guidelines.

2 Considered standardisation initiatives

Being embedded in information and communication technology with a strong focus on geographic information, a SDI will rely on a variety of standards (Figure 1). This Technical Report considers primarily material produced by the following organisations and initiatives:

- International Organization for Standardization (ISO), including but not limited to ISO/TC 211 Geographic Information / Geomatics;
- European Committee for Standardization (CEN), including CEN/TC 287 Geographic Information;
- Open Geospatial Consortium (OGC);
- World Wide Web Consortium (W3C).

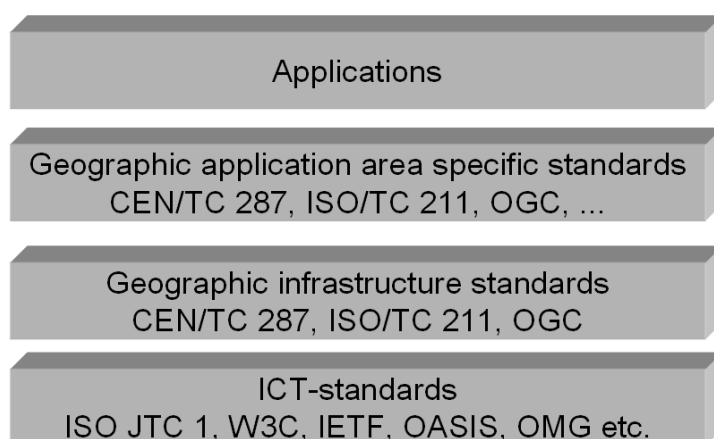


Figure 1 – The stack of standards in support of SDIs

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

conceptual formalism

set of modelling concepts used to describe a conceptual model

[EN ISO 19101:2005]

EXAMPLE UML meta model, EXPRESS meta model.

NOTE One conceptual formalism can be expressed in several conceptual schema languages.

3.2

conceptual model

model that defines concepts of a universe of discourse

[EN ISO 19101:2005]

3.3

conceptual schema

formal description of a conceptual model

[EN ISO 19101:2005]

3.4

conceptual schema language

formal language based on a conceptual formalism for the purpose of representing conceptual schemas

[EN ISO 19101:2005]

EXAMPLE UML, EXPRESS, IDEF1X.

NOTE A conceptual schema language may be lexical or graphical. Several conceptual schema languages can be based on the same conceptual formalism.

3.5

conformance

fulfilment of specified requirements

[EN ISO 19113:2005]

3.6

component

physical, replaceable part of a system that packages implementation and provides the realization of a set of interfaces

[ISO/TS 19103:2005]

3.7

identifier

linguistically independent sequence of characters capable of uniquely and permanently identifying that with which it is associated

[ISO/IEC 11179-3:2003]

3.8**interoperability**

capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units

[ISO/IEC 2382-1:1993]

3.9**reference frame**

aggregation of the data needed by different components of an information system

3.10**resource**

asset or means that fulfils a requirement

[EN ISO 19115:2005]

3.11**Spatial Data Infrastructure (SDI)**

metadata, spatial data sets and spatial data services; network services and technologies; agreements on sharing, access and use; coordination and monitoring mechanisms, processes and procedures, established, operated or made available in an interoperable manner

NOTE In the context of this report the term SDI is restricted to a platform- and implementation-neutral technological infrastructure for geospatial data and services, based upon standards and specifications.

3.12**Use Case**

specification of a sequence of actions, including variants, that a system (or other entity) can perform, interacting with actors of the system

[OMG UML Specification]

4 Abbreviated terms

API	Application Programming Interface
CLA	cultural and linguistic adaptability
CORBA	Common Object Request Broker Architecture
DCE	Distributed Computing Environment
DRM	Digital Rights Management
ebXML	Electronic Business using eXtensible Markup Language
EOSE	Extended Open System Environment
EN	European Standard (CEN deliverable)
ESDI	European Spatial Data Infrastructure
INSPIRE	Infrastructure for Spatial Information in Europe
GI	Geographic information

GIRM	Geospatial Interoperability Reference Model
GML	Geography Markup Language
ISO	International Organization for Standardization
IT	Information Technology
NSDI	National Spatial Data Infrastructure
OASIS	Organization for the Advancement of Structured Information Standards
OCL	Object Constraint Language
ODP	Open Distributed Processing
OGC	Open Geospatial Consortium
OLE/COM	Object linking and embedding/ Component Object Model
OMG	Object Management Group
ORM	OpenGIS Reference Model
RM-ODP	Reference Model of Open Distributed Processing
SDI	Spatial Data Infrastructure
SLD	Styled Layer Descriptor
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
UDDI	Universal Description, Discovery and Integration
UML	Unified Modelling Language
UUID	Universally Unique Identifier
WCS	Web Coverage Service interface specification
WFS	Web Feature Service interface specification
WMS	Web Map Service interface specification
WRS	Web Registry Server
WSA	Web Service Architecture
WSDL	Web Service Description Language
W3C	World Wide Web Consortium
XMI	eXtensible Markup Interface
XML	eXtensible Markup Language

5 Spatial Data Infrastructure as an implementation-neutral framework

5.1 Management summary

A SDI relies on standards and specifications in the field of geographic information and information technology. This report systematically identifies standards that are of particular relevance to SDI development and implementation. A *conditio sine qua non* for the successful establishment of a SDI is that the software industry supports relevant standards in commercial products. At the same time, public authorities are to request the support of standards in public procurement processes.

5.2 Standards and interoperability

The users of a SDI are considered to be those individuals or organisations that, in the context of their business processes, need to share and access geo-resources in a meaningful and sustainable way. Based on platform- and vendor-neutral standards and specifications, a SDI aims at assisting organisations and individuals in publishing, finding, delivering, and eventually, using geographic information and services over the internet across borders of information communities in a more cost-effective manner than would be possible without the SDI in place.

A SDI relies on standards and specifications in the field of geographic information and information technology, many of which are already available. There is, however, a need to systematically identify these standards and to determine whether or not these standards are sufficiently precise and unambiguous so that their implementation guarantees interoperability and fulfils requirements of a SDI in Europe.

Interoperability is the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units. Standardization of geographic information can best be served by a set of standards that integrates a detailed description of geographic information concepts with the concepts of information technology. A goal of the GI standardization efforts is to facilitate interoperability of geographic information systems, including interoperability in distributed computing environments. Interoperability provides the freedom to mix and match information system components without compromising overall success (OGC, 2003), and is a basis for the successful implementation of a SDI in Europe. A SDI in Europe will allow one to:

- a) find information and processing tools, when they are needed, independent of physical location;
- b) understand and employ the discovered information and tools, no matter what platform supports them; whether local or remote;
- c) integrate and combine easier and more cost-effective data originating from heterogeneous sources;
- d) support policies in Europe;
- e) control the evolution of a SDI.

It is anticipated that the current lack of interoperability in the field of geographic information will be resolved by the support and implementation of international standards by software providers. This will greatly increase the efficiency of the use of geographic information in the future.

Recommendation:

This Technical Report encourages the software industry to support standards for the creation and management of geographic information and to implement appropriate interface specifications in their products. It also recommends public authorities to reference relevant GI standards in public procurement processes that are to support SDI implementations.

5.3 Generic architecture model

Figure 2 shows a generic architecture model that allows one to describe a SDI. This model is based on the Geospatial Interoperability Reference Model (Evans, 2003). It is introduced to provide a common understanding of the technical aspects of spatial data infrastructures. In this model, a distinction is made between four major groups of components. In this context, the term component refers to a group of technically similar functionalities within the architecture. The four groups of components are:

- user applications;
- geo-processing and catalogue services;
- content repositories;
- catalogues.

User applications comprise the software usually seen by users; they include general purpose interfaces for query and viewing, a tool for database administrators, and analytical applications tailored to the information needs of the user.

Geo-processing and catalogue services may process user queries, draw maps from data, regulate access, perform payment operations, and extract and send data to a user application.

Content repositories provide data.

Finally, the catalogues allow clients and services to find out what repositories or services are available and appropriate for their use. The catalogues, together with the catalogue services, are a fundamental part of any SDI.

In addition, security, authentication and digital rights management (DRM) components are required

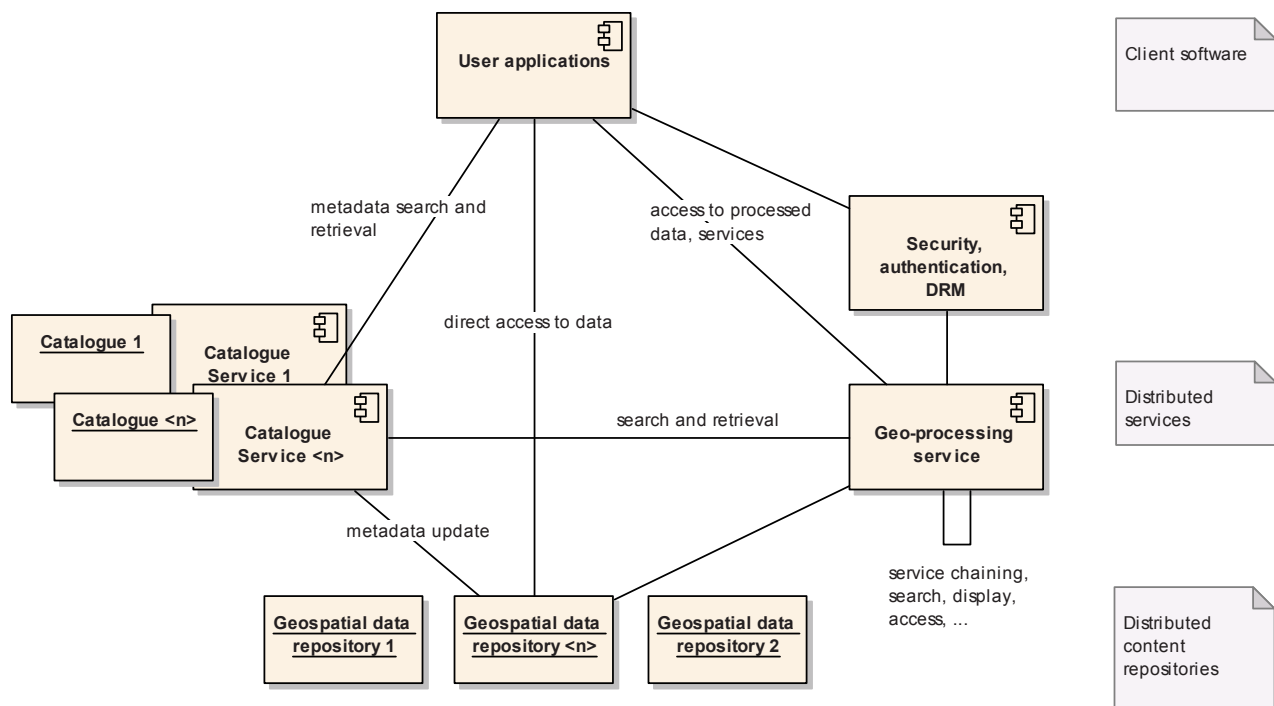


Figure 2 — A generic architecture of spatial data infrastructures

5.4 Data-centric vs service-centric

In the context of this report, two possible views on a SDI are considered: the *data-centric* view, and the *service-centric* view. These two views are discussed in detail in Clauses 6 and 7, respectively.

The data-centric view primarily addresses concerns related to the data, which includes application schemas and metadata.

The service-centric view includes the taxonomy of services, concepts of interoperability, service architecture, service catalogue, the underlying IT standards, and more.

5.5 SDI as a dynamic framework

A SDI should not be considered as a static framework that will offer solutions for a fixed set of requirements. Rather, it is a dynamic framework that satisfies current requirements while at the same time generating new needs and solutions. It also permits creation of new services and applications, and stimulates the creation of new standards and specifications. Once a SDI is in place, there are four interesting use cases: specification and standardisation, development, deployment and invocation. In each activity there are standards of interest. With this in mind, a SDI can be described in terms of a set of high-level activities that reflect the evolutionary character of a SDI.

These activities are: establish the core SDI, create new specifications, develop new services and applications, deploy services and applications, and invoke application instances. These activities are described in Table 1. The activity diagram in Figure 3 suggests how the SDI activities interact, thus driving the evolution of SDIs.

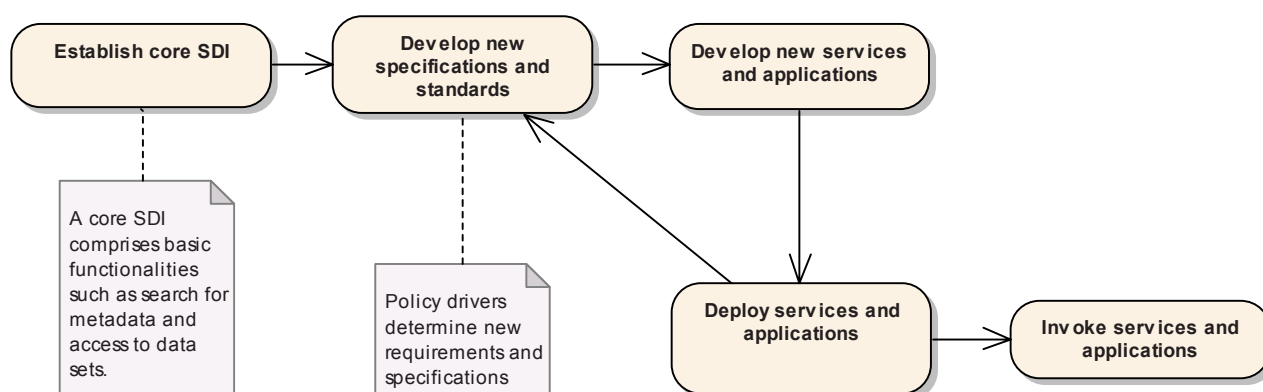


Figure 3 — Generic SDI activity diagram

Table 1 —SDI Activities

	Activity	Description	Example
1	Establish the "core" SDI	Certain basic services, paramount for the SDI, have to be developed and launched according to standards and specifications. Pre-condition: standards for metadata content (services and data). Post condition: human-readable catalogues.	Data, metadata content, metadata catalogues, service catalogues.
2	Develop new specifications	Service interfaces are specified and published by <i>interface providers</i> .	Standards required for description of features and coverage: modelling language, spatial representation etc. standards for description of presentation aspects, portrayal.
3	Develop new services and applications	Based on published interface specifications, services (for example a WFS for roads) and applications (for example an application for goods delivery) are built by <i>service providers</i> and <i>application providers</i> .	Standards for certain servers: WMS, WFS, gazetteer, transformation etc. Standards for encoding. Standards for finding services. Standards for security.
4	Deploy service and application instances	The services are published by the service providers. The applications are provided to the <i>users</i> and installed. Standards for describing and publishing services.	
5	Invoke application instances by users	The user uses the application that finds and calls appropriate services.	Standards for evaluation.

6 Data-centric view on SDI

6.1 Management summary

- The model-driven approach is promoted for ESDI.
- Unique identifiers for use in a European SDI should consist of a namespace and a UUID.
- ISO 19109 and referred standards are promoted as ESDI rules for specifying data structures and semantics.

- UML class diagrams used according to ISO/TS 19103 is promoted as an ESDI conceptual schema language.
- ISO 19136 (GML) is promoted as the ESDI encoding method when transferring geographic data.
- ISO 19139 is promoted as the ESDI encoding method when transferring information related to geographic data such as metadata, feature catalogues and data dictionaries.

6.2 Development

6.2.1 The model-driven approach

The model-driven approach follows the concepts developed in the model-driven architecture defined by OMG (OMG, 2003).

The lifetime of a technical implementation is shorter than the lifetime of the information it handles. This makes it necessary to describe the information in a way that allows for new techniques and implementation environments to be applied.

The (EN) ISO 19100 series of standards provide a model-driven approach: The information is described by a formal, implementation-independent schema. Implementations for various techniques (e.g. XML file transfer, web services, relational database) and implementation environments (e.g. J2EE, .Net) can be derived from the schema in a more or less automatic way. Changes in information requirements are applied to the schema; never directly to the implementation. Figure 4 depicts these principles.

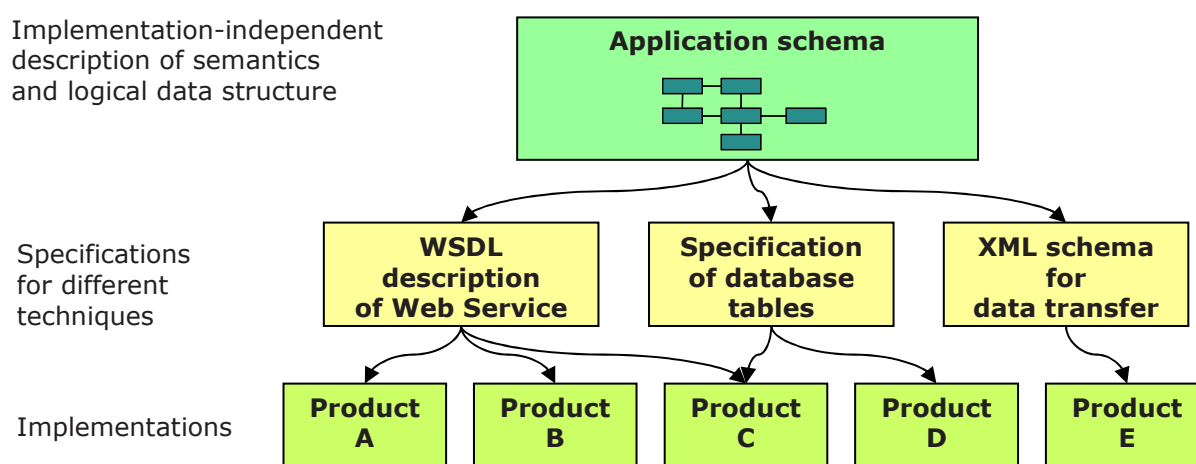


Figure 4 — The model-driven approach is promoted for ESDI

6.2.2 Semantics

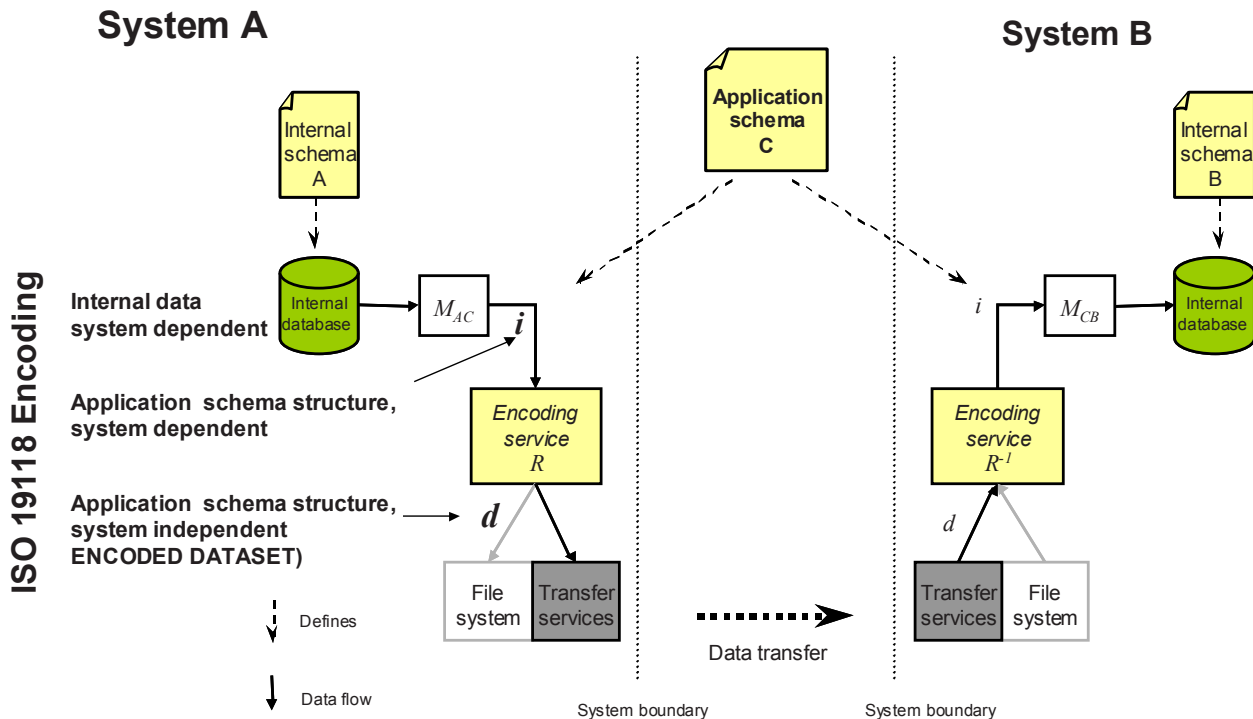


Figure 5 — Preserving semantics between systems

In Figure 5, system B has to be able to use data from system A. Data in the data transfer is structured according to the application schema C and encoded/decoded according to a standard. M_{AC} and M_{CB} are data mappings. If the data structure of system A or B is different from that of C, such mappings may be difficult to achieve. However, if the semantics of system A or B are different from that of C, such mappings may be even impossible to achieve. This makes semantics a very important issue.

6.2.3 Application schema

Formal schemas are in (EN) ISO 19100 named application schemas. They contain semantics for data interpretation as well as data structures for generation of, for example, XML-schemas.

According to ISO 19109, the development of an application schema for a specific domain has to follow certain rules. For example, spatial aspects have to be expressed according to a standard (EN ISO 19107). Figure 6 shows the main steps for implementing a schema derived from a set of specifications.

Recommendation:

ISO 19109 and referred standards are promoted as ESDI rules for specifying data structures and semantics.

The Editing Committee of ISO/CD 19126, considering the comments submitted by ISO/TC 211 members during the review period, has come to the conclusion that:

- on the one hand, a conceptual schema expressing the concept of data dictionary was needed;
- on the other hand, ISO 19110 could be simplified in order to define a conceptual schema dedicated to feature catalogues.

Due to procedural reasons, the activity related to ISO 19126 has been cancelled by the ISO Central Secretariat.

In October 2005, a workshop on Conceptual Schema Languages and Tools was organized by the Joint Research Centre of the European Commission, EuroSDR and CEN/TC 287 WG SDI. One of the findings of the workshop was that the ISO 19100 standards were not defining clearly the roles of applications schemas, feature catalogues and data dictionaries.

In addition, ISO/TC 211 has resolved to establish a two part standard (ISO 19144-1 and -2) related to classification systems (see also Annex A). This new work item is still at a preliminary stage. Both the establishment of an amendment of ISO 19110 and the reactivation of ISO 19126 are still expected. And, ISO/TC 211 resolved during its 22nd plenary to promote the establishment of a draft a new work item proposal for a stage 00.60 project investigating how ontology and semantic web approaches can benefit ISO/TC 211 objectives.

Recommendation:

The role of feature catalogues (ISO 19110) and data dictionaries (ISO 19126) and their relations with application schemas need further clarification.

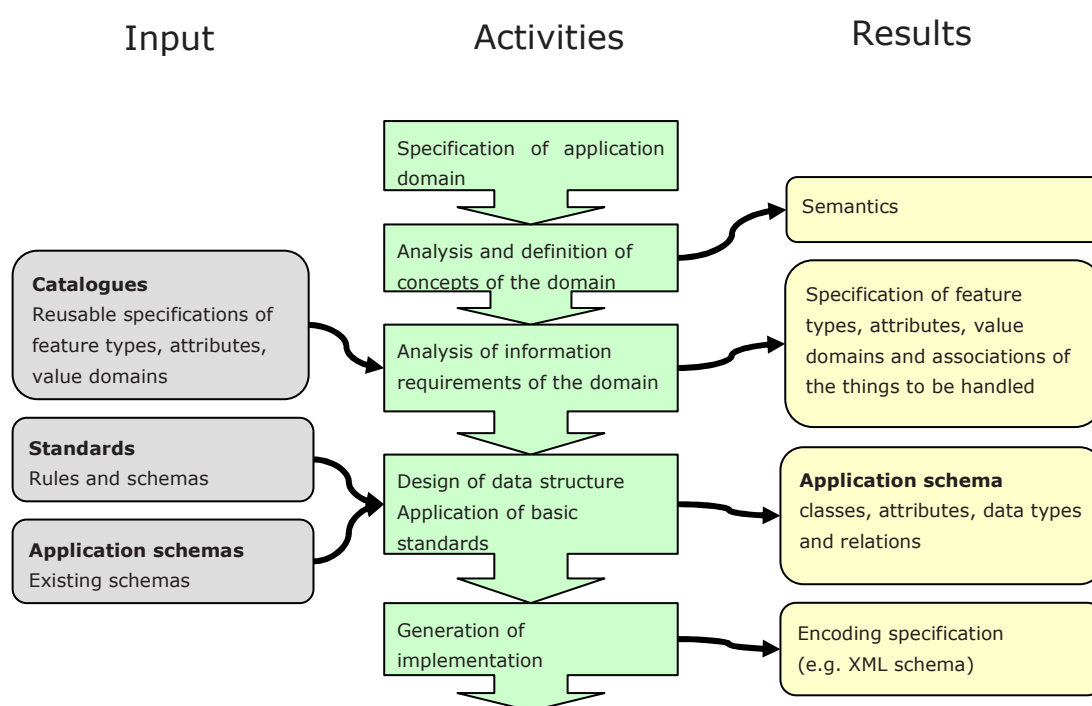


Figure 6 — From specification to application

6.2.4 Conceptual schema language

Application schemas are documented by using a conceptual schema language. Such a language may have a well defined graphical notation (such as UML for class diagrams) but also a machine-readable format (such as XMI). The ISO/TS 19103 specifies the requirements for conceptual schema languages. In practice ISO/TC 211 has adopted the Unified Modelling Language (UML) as the conceptual schema language to be used.

Recommendation:

The use of UML according to ISO/TS 19103 is promoted as an ESDI conceptual schema language.

In order to define requirements and apply constraints to a UML model, the Object Constraint Language (OCL) has been developed. Examples of OCL constraints are:

- the area of a building is at least 25 square meters (context Building; geometry()->area() > 25);
- the startTime of a feature shall be before the endTime (context Feature; FeatureStartTime < FeatureEndTime).

6.2.5 Encoding

Extensible Markup Language (XML) is selected as the basis for an implementation-neutral exchange format. The transition from UML to a common XML format should be well defined, and should preferably be done by automatic code generation. ISO 19118 describes rules and transitions for how to generate XML schema.

Geography Markup Language (GML) was developed to provide a common XML encoding for spatial data. Its core XML Schemas have not been established using a model-driven approach, but it is fully consistent to establish the GML encoding of application schemas applying a model driven approach. GML 3.2 is jointly developed by ISO/TC 211 and OGC for publication as ISO 19136. It defines a set of encoding rules between UML and XML. Those encoding rules are applicable to classes having the <<feature type>> stereotype, their properties and types (recursively).

Recommendation:

ISO 19136 (GML) is promoted as the ESDI encoding method when transferring geographic data.

ISO 19139 was developed to provide a common XML encoding for EN ISO 19115 conceptual schemas and the part of the ISO/TC 211 conceptual schemas used in EN ISO 19115. It was designed for the model driven approach providing encoding rules for a well defined set of stereotypes excluding the <<feature type>> stereotype. ISO 19139 encoding rules can more generally be applied to any conceptual schemas of information related to geographic data.

Even based on a model driven approach, the ISO 19139 method for encoding information related to geographic data allow manual encoding designs addressing the following requirements:

- part or the whole conceptual schema may take advantage of existing XML implementation. ISO 19139 reuse the encoding of EN ISO 19107 and EN ISO 19108 defined by ISO 19136. The XML encoding of portrayal catalogues (ISO 19117) would certainly be based on the OGC SLD.;
- some classes may require a custom implementation designed for efficiency or simplicity.

The specification of these manual encoding designs needs to be formalised in a (standard) specification. The XML Schema implementation of feature catalogues and data dictionaries will be addressed respectively in an amendment of ISO 19110 and in ISO 19126.

Recommendation:

ISO 19139 is promoted as the ESDI encoding method when transferring information related to geographic data such as metadata, feature catalogues and data dictionaries.

6.2.6 Relevant standards

6.2.6.1 Design rules

ISO/TS 19103, *Geographic information — Conceptual schema language*;

ISO 19109, *Geographic information — Rules for application schema*.

6.2.6.2 Standard schemas

EN ISO 19107, *Geographic information — Spatial schema*;

EN ISO 19108, *Geographic information — Temporal schema*;

ISO 19110, *Geographic information — Methodology for feature cataloguing*;

EN ISO 19115, *Geographic information — Metadata*;

ISO 19126, *Geographic information — Profile — FACC Data Dictionary*.

6.2.6.3 Encoding rules

ISO 19118, *Geographic information — Encoding*;

ISO 19136, *Geographic information — Geometric Markup Language (GML)*.

6.2.6.4 Registration rules

ISO 19135, *Geographic information — Procedures for registration of geographic information items*.

6.3 Data management

6.3.1 Metadata

6.3.1.1 Discovery metadata

Metadata provides information about data on different levels: from complete datasets to data of single features.

Metadata may be stored in a catalogue referring to a dataset (e.g. for discovery), as a separate entity together with the dataset (e.g. for quality evaluation) or integrated in the dataset (e.g. for positional accuracy for a certain measurement).

EN ISO 19115 specifies a schema to be used in all cases. However, in practice there are different requirements in the different use cases.

Recommendation:

The "European core metadata for discovery" currently under development (WI 00287033) is promoted as the ESDI metadata standard for discovery.

Data discovery will, in addition to a common metadata set, require services to register and search for datasets.

6.3.1.2 Feature level metadata

ISO 19109 defines the rules for application schema and is comprised of two categories of models that are related to metadata:

- **a General Feature Model** that determines the particular way metadata and quality elements relate to geographic features;
- **two interchange models**: the traditional data transfer model and the interoperability model; each of them implying an interrelation of the metadata with its resources.

With regards to the General Feature Model as described in ISO 19109, the following specific types of attributes can be defined for a feature type:

- metadata attributes (as instances of `GF_MetadataAttributeType`) whose data type is `MD_Metadata` or one of its subclasses;

- quality attributes (as instances of `GF_QualityAttributeType`) whose data type is `DQ_Element` or one of its subclasses.

The ISO 19109 rules are promoted as the ESDI method for metadata on feature level.

6.3.1.3 Dataset metadata

With regards to the ISO 19109 interchange models, the *interoperability* model is based on data interchange by transactions and is designed for a large number of transactions involving simple interchanges. In contrast, the *transfer model* is designed for a lesser number of transactions with large amounts of well-organised data. In both cases, the interchanged data are organised in datasets having possibly their own metadata. The organisation of the datasets and their metadata is application dependent and is called the metadata application information (see 6.2 of EN ISO 19115:2005).

The transfer model may imply quite complex metadata application information and the variety of metadata application information model used by the past has been until now a curb on interoperable interchange of geospatial information. Interoperable interchanges by transfer needs to go further in terms of standardization. This is the purpose of the “Extensions for metadata based transfers of geospatial information” presented in ISO 19139.

Recommendation:

The extensions for metadata based transfers of geospatial information defined in ISO 19139 is promoted for interchange by transfer of geospatial datasets.

6.3.2 Accessing data

Accessing data should not be based on data storage, but only on services on the web. It is up to the service to provide data transfer.

Recommendation:

This Technical Report promotes a transparent access to data through services on the web for SDIs in Europe.

Direct access to relational databases is not regarded as a part of a SDI. A relation database is regarded as a system's internal schema, and is an implementation based upon an implementation- and vendor- independent application schemas, and therefore outside the scope of a SDI.

6.3.3 Legacy datasets

Legacy datasets are datasets that are not conformant with the standards and specifications identified for a SDI in Europe. However, they are still representing great value.

Recommendation:

Metadata catalogues have to be able to store metadata of legacy datasets.

6.3.4 Consistent identification of geographical items

The consistent identification of geographical items is paramount in SDI implementation. It allows efficient discovery, access, management, and supply of data; it provides a mechanism for referencing thematic information to reference data etc.

It has to be guaranteed that identifiers are distinct when processed or used within the same application. Application may use on-the-fly identification whenever necessary. Volatile identifiers can be built through chained services having a life-time equal to the request/response time. Some identifiers have a local application but in many cases a Universally Unique Identifier (UUID) is required. A UUID is an identifier that is not specific for an environment, feature type or application domain.

Within a distributed computing environment, UUIDs are 128 bit numbers assigned to any object cell which is guaranteed to be unique. There are various mechanisms used to guarantee that UUIDs are unique: time and node based, name based, random number based etc. Common practice is that the creation of a UUID is done through combinations of hardware addresses, time stamps and random seeds:

- there is a reference in the UUID to the hardware address of the first network card on the host which generated the UUID - this reference is intended to ensure the UUID will be unique in space as the MAC address of every network card is assigned by a single global authority and is guaranteed to be unique. (Alternate addresses might be a problem here, but the author has not tested creating a UUID on a machine with an alternate address set.)
- the next component is a timestamp which, as DCE always moves clocks forward, will be unique in time;
- just in case some part of the above goes wrong, there is a random component placed into the UUID as a catch-all for uniqueness. (The timestamp component though is one of the reasons why DCE does not react well to clocks going backwards).

Using time and node-based UUIDs means the identifier is strongly correlated with the hardware (network card) when it has been computed. The generation of UUIDs does not require a registration authority for each single identifier (The Open Group, 1997).

In general, any responsible party of the data (or feature) should be part of the metadata. But in a community where geographic information is distributed in the same way as music files, metadata is not always supplied, and the only possibility to really trace an instance of a feature is a UUID within a namespace registered in a registry. If tracing is not a concern, a general UUID without any namespace should be sufficient.

In this Technical Report it is maintained that in a European SDI a UUID should allow to trace the metadata of an instance of a feature or of the collection of which the feature is part.

Recommendation:

Unique identifiers for use in a European SDI should consist of a namespace and an identifier which is unique within its namespace.

EXAMPLE 1

The ID for a feature in The Netherlands exists of three parts:

1. Landcode conform ISO 3166-1
2. Sectorcode
3. UUID

Example: NL.TOP10NL.UUID

Annex A of the standard ISO/CIE 11578:1996, *Information Technology — Open Systems Interconnection — Remote Procedure Call (RPC)* specifies how to generate such UUIDs. They are generated from hardware identities, current time and random giving a 128 bit value often represented as a 32 character string.

EXAMPLE 2

An example of a German identifier, expressed in GML, is the following:

```
<parcel gml:id="DENWK123aaaaaaa">
  <!-- ... -->
  <hasOwner xlink:href="urn:adv:DENWK124bbbbbbbb">
    <!-- ... -->
  </hasOwner>
</parcel>
```

6.3.5 Thematic identifiers

Many thematic datasets (e.g. cadastral parcel numbers) have been in existence for several decades and have their own identification method which is not likely to be changed now. Such cases need to be supported and included in any cross referencing. There should be some sort of structure in the identifiers that gives the possibility to find the object/feature in a net of servers. It is recommended to establish so called "lookup-service", which takes as an input the identifier and gives a URL of the WFS-server back, where the feature can be found.

7 Service-centric view on SDI

7.1 Management summary

The service-centric view includes the taxonomy of services, concepts of interoperability, service architecture, service catalogue, the underlying IT standards, and more.

When appropriate data (or services) are identified the access to these is essential. This access may be enabled by online access to a dataset in a standardised format, or by standardized interfaces to be applied directly from other applications. This part of the report describes the service-centric view of the SDI, and provides recommendations related to this view.

7.2 Registries as the SDI glue

A register is a set of files containing **identifiers** assigned to items with descriptions of the associated items [adapted from Annex E of the ISO/IEC JTC 1 Procedures].

ISO 19135, *Geographic information — Procedures for registration of geographic information items* 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. In order to accomplish this purpose, the standard specifies elements of information that are necessary to provide identification and meaning to the registered items and to manage the registration of these items.

A SDI needs, like any other information system, a reference frame. A reference frame is the aggregation of the data needed by different components of the information systems. In a SDI context, the reference frame concerns:

- the units of measures;
- the coordinate reference systems;
- the codelist definitions;
- the feature data dictionaries (see ISO 19126);
- the feature catalogues (see ISO 19110);
- the portrayal catalogues and related symbology registers.

Registries should be established for the above-listed information elements and geographical items, and for:

- cultural and linguistic adaptability of metadata elements;
- European common data models;
- national data which are of interest in a cross border community or in a multilingual community.