BS EN ISO 19109:2015

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Geographic information — Rules for application schema

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

A list of organizations represented on this committee can be obtained on request to its secretary.

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Geoinformation - Regeln zur Erstellung von Anwendungsschemata (ISO 19109:2015)

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European foreword

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This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2016, and conflicting national standards shall be withdrawn at the latest by June 2016.

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/TC 211, *Geographic information/Geomatics.*

This second edition cancels and replaces the first edition (ISO 19109:2005).

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Introduction

Any description of reality is always an abstraction, always partial, and always just one of many possible "views", depending on the application field.

The widespread application of computers and geographic information systems (GIS) has led to an increased use of geographic data within multiple disciplines. With current technology as an enabler, society's reliance on such data is growing. Geographic datasets are increasingly being shared and exchanged. They are also used for purposes other than those for which they were produced.

To ensure that data will be understood by both computer systems and users, the data structures for data access and exchange must be fully documented. The interfaces between systems, therefore, need to be defined with respect to data and operations, using the methods standardized in this International Standard. For the construction of internal software and data storage within proprietary systems, any method may be used that enables the standardized interfaces to be supported.

An application schema provides the formal description of the data structure and content required by one or more applications. An application schema contains the descriptions of both geographic data and other related data. A fundamental concept of geographic data is the feature.

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Geographic information — Rules for application schema

1 Scope

This International Standard defines rules for creating and documenting application schemas, including principles for the definition of features.

The scope of this International Standard includes the following:

— conceptual modelling of features and their properties from a universe of discourse;

— definition of application schemas;

— use of the conceptual schema language for application schemas;

— transition from the concepts in the conceptual model to the data types in the application schema;

— integration of standardized schemas from other ISO geographic information standards with the application schema.

The following are outside the scope:

— choice of one particular conceptual schema language for application schemas;

— definition of any particular application schema;

— representation of feature types and their properties in a feature catalogue;

— representation of metadata;

— rules for mapping one application schema to another;

— implementation of the application schema in a computer environment;

— computer system and application software design;

— programming.

2 Conformance

2.1 General

This International Standard defines 12 conformance classes shown in Tables 1 to 12, matching the 12 requirements classes described in Clauses 7 and 8. Any application schema claiming conformance to any requirements class in this International Standard shall pass all of the tests listed in the corresponding conformance class, which are described in detail in the abstract test suites in Annex A. Each test relates to one or more specific requirements, which are explicitly indicated in the description of the test.

2.2 Meta-model

Table 1 — Meta-model conformance class

Conformance class	/conf/general
Requirements	/req/general (Clause 7, Table 15)
Tests	All tests in A.2

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2.3 UML application schema

Table 2 — UML application schema conformance class

Conformance class	/conf/uml
Dependency	/conf/general (2.2)
Requirements	/req/uml (8.2, Table 16)
Tests	All tests in A.3

2.4 Profiling standard schema

Table 3 — Profiling standard schema conformance class

Conformance class	/conf/profile
Dependency	/conf/uml (2.3)
Requirements	/req/profile (8.3, Table 19)
Tests	All tests in A.4

2.5 Metadata

Table 4 — Metadata conformance class

Conformance class	/conf/metadata
Dependency	/conf/uml (2.3)
Requirements	/req/metadata (8.4, Table 20)
Tests	All tests in A.5

2.6 Quality

Table 5 — Quality conformance class

Conformance class	/conf/quality
Dependency	/conf/uml (2.3)
Requirements	/req/quality (8.5, Table 21)
Tests	All tests in A.6

2.7 Temporal

Table 6 — Temporal conformance class

Conformance class	/conf/temporal
Dependency	/conf/uml (2.3)
Requirements	/req/temporal (8.6, Table 23)
Tests	All tests in A.7

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2.8 Spatial

Table 7 — Spatial conformance class

Conformance class	/conf/spatial
Dependency	/conf/uml (2.3)
Requirements	/req/spatial (8.7, Table 25)
Tests	All tests in A.8

2.9 Coverages

Table 8 — Coverages conformance class

Conformance class	/conf/coverage
Dependency	/conf/uml (2.3)
Requirements	/req/coverage (8.8, Table 27)
Tests	All tests in A.9

2.10 Observations

Table 9 — Observations conformance class

Conformance class	/conf/observation
Dependency	/conf/uml (2.3)
Requirements	/req/observation (8.9, Table 29)
Tests	All tests in A.10

2.11 Spatial referencing by identifiers

Table 10 — Spatial referencing by identifiers conformance class

Conformance class	/conf/identifier
Dependency	/conf/uml (2.3)
Requirements	/req/identifier (8.10, Table 30)
Tests	All tests in A.11

2.12 Code list

Table 11 — Code list conformance class

Conformance class	/conf/codeList
Dependency	/conf/uml (2.3)
Requirements	/req/codeList (8.11, Table 31)
Tests	All tests in A.12

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2.13 Multi-lingual support

Table 12 — Multi-lingual support conformance class

Conformance class	/conf/multi-lingual
Dependency	/conf/uml (2.3)
Requirements	/req/multi-lingual (8.12, Table 32)
Tests	All tests in A.13

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IETF RFC 5646 (2009), *Tags for Identifying Languages, available at* <*https://www.rfc-editor.org/info/rfc5646*>

ISO 19103:2015, *Geographic information — Conceptual schema language*

ISO 19107:2003, *Geographic information — Spatial schema*

ISO 19108:2002, *Geographic information — Temporal schema*

ISO 19112:2003, *Geographic information — Spatial referencing by geographic identifiers*

ISO 19115-1:2014, *Geographic information — Metadata — Part 1: Fundamentals*

ISO 19115-2:2009, *Geographic information — Metadata — Part 2: Extensions for imagery and gridded data*

ISO 19123:2005, *Geographic information — Schema for coverage geometry and functions*

ISO 19156:2011, *Geographic information — Observations and measurements*

ISO 19157:2013, *Geographic information — Data quality*

ISO/IEC 19505-2:2012, *Information technology — Object Management Group Unified Modeling Language (OMG UML) — Part 2: Superstructure*

4 Terms and definitions

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

4.1
application
manipulation and processing of data in support of user requirements

[SOURCE: ISO 19101-1:2014, 4.1.1]

4.2
application schema
conceptual schema (4.5) for data required by one or more *applications* (4.1)

[SOURCE: ISO 19101-1:2014, 4.1.2]

4.3
complex feature
feature (4.9) composed of other features

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4.4
conceptual model
model (4.15) that defines concepts of a *universe of discourse* (4.19)

[SOURCE: ISO 19101-1:2014, 4.1.5]

4.5
conceptual schema
formal description of a *conceptual model* (4.4)

[SOURCE: ISO 19101-1:2014, 4.1.6]

4.6
coverage
feature (4.9) that acts as a function to return *values* (4.20) from its range for any direct position within its spatial, temporal or spatiotemporal *domain* (4.8)

[SOURCE: ISO 19123:2005, 4.1.7]

4.7
dataset
identifiable collection of data

[SOURCE: ISO 19115-1:2014, 4.3]

4.8
domain
well-defined set

Note 1 to entry: Well-defined means that the definition is both necessary and sufficient, as everything that satisfies the definition is in the set and everything that does not satisfy the definition is necessarily outside the set.

4.9
feature
abstraction of real-world phenomena

Note 1 to entry: A feature can occur as a type or an instance. Feature type or feature instance should be used when only one is meant.

[SOURCE: ISO 19101-1:2014, 4.1.11]

4.10
feature association
relationship that links instances of one *feature* (4.9) type with instances of the same or a different feature type

[SOURCE: ISO 19110:2005, 4.2]

4.11
feature attribute
characteristic of a *feature* (4.9)

Note 1 to entry: A feature attribute can occur as a type or an instance. Feature attribute type or feature attribute instance is used when only one is meant.

Note 2 to entry: A feature attribute type has a name, a data type and a *domain* (4.8) associated with it. A feature attribute instance has an attribute *value* (4.20) taken from the domain of the feature attribute type.

[SOURCE: ISO 19101-1:2014, 4.1.12, modified – Notes and examples in 19101-1 have been omitted and other notes have been added.]

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4.12
feature operation
operation that every instance of a *feature* (4.9) type may perform

EXAMPLE 1 A feature operation upon the feature type "dam" is to raise the dam. The results of this operation are to raise the height of the "dam" and the level of water in a "reservoir".

EXAMPLE 2 A feature operation by the feature type "dam" might be to block vessels from navigating along a watercourse.

[SOURCE: ISO 19110:2005, 4.5, modified - The note given in ISO 19110:2005 for this entry has been omitted. A second example has been added.]

4.13
geographic data
data with implicit or explicit reference to a location relative to the Earth

Note 1 to entry: Geographic information is also used as a term for information concerning phenomena implicitly or explicitly associated with a location relative to the Earth.

4.14
metadata
information about a resource

[SOURCE: ISO 19115-1:2014, 4.10]

4.15
model
abstraction of some aspects of reality

4.16
observation
act of measuring or otherwise determining the *value* (4.20) of a *property* (4.17)

[SOURCE: ISO 19156:2011, 4.11]

4.17
property
facet or attribute of an object referenced by a name

[SOURCE: ISO 19143:2010, 4.21]

4.18
quality
degree to which a set of inherent characteristics fulfils requirements

[SOURCE: ISO 9000:2005, 3.1.1]

4.19
universe of discourse
view of the real or hypothetical world that includes everything of interest

[SOURCE: ISO 19101-1:2014, 4.1.38]

4.20
value
element of a type *domain* (4.8)

[SOURCE: ISO/IEC 19501:2005, 0000_5]

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5 Presentation and abbreviations

5.1 Presentation

5.1.1 General

This International Standard describes how to create an application schema that integrates conceptual schemas defined in the ISO geographic information standards. In addition to stating the rules for creating application schemas, this International Standard provides guidance through examples.

5.1.2 Conformance class

Conformance to this International Standard is possible at a number of levels, specified by conformance classes (Clause 2). Each conformance class is summarized using the template shown as Table 13.

Table 13 — Conformance class template

Conformance class	/conf/{classM}
Dependency	[identifier for another conformance class]
Requirements	/req/{classA}
Tests	[reference to clause(s) containing tests]

All tests in a class must be passed, so dependencies are recorded with respect to other conformance classes rather than individual tests . Each conformance class tests conformance to a set of requirements packaged in a requirements class (Clauses 7 and 8).

5.1.3 Requirements class

Each normative statement (requirement or recommendation) in this International Standard is a member of a requirements class. In this International Standard each requirements class is described in a discrete clause or subclause, and summarized using the template shown as Table 14.

Table 14 — Requirements class template

Requirements class	/req/{classM}
Target type	[artefact or technology type]
Dependency	[identifier for another requirements class]
Requirement	/req/{classM}/{reqN}
Recommendation	/rec/{classM}/{recO}
Requirement	/req/{classM}/{reqP}
Requirement/Recommendation	[repeat as necessary]

All requirements in a class must be satisfied, so the requirements class is the unit of re-use and dependency, rather than individual requirements. Hence, the value of a Dependency requirement is another requirements class.

5.1.4 Rules

All rules are normative, and each rule is presented using the following template:

/re(c|q)/[classM]/[reqN]	[Normative statement]

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where /re(c|q)/[classM]/[reqN] identifies the requirement or recommendation. The use of this layout convention allows the normative provisions of this International Standard to be easily located by implementers.

5.1.5 Identifiers

Each requirements class, requirement and recommendation has an identifier in the form of a path or partial URI. The identifier supports cross-referencing of class membership, dependencies, and links from each conformance test to requirements tested. The identifier can be appended to a URI that identifies the standard as a whole in order to construct an absolute URI which identifies the requirements class, requirement or recommendation. For example, a URI scheme following the approach described in 2.8 of [IETF RFC 5141] would result in

— http://standards.iso.org/iso/19109/ed-2

Hence, the absolute URI for each requirements class would have the form

— http://standards.iso.org/iso/19109/ed-2/req/[classM]

and the absolute URI for each requirement or recommendation would have the form

— http://standards.iso.org/iso/19109/ed-2/req/[classM]/[reqN]

5.1.6 Conceptual schemas

Conceptual schemas in the normative part of this International Standard are presented in the Unified Modeling Language (UML) in conformance with ISO 19103. UML diagrams are presented in compliance with ISO/IEC 19505-2.

5.1.7 Descriptions of concepts

Concepts from UML are presented in all capitals – e.g. CLASS, PACKAGE, ROLE, ATTRIBUTE, ASSOCIATION.

5.2 Abbreviations

CSL Conceptual Schema Language

GFM General Feature Model

OCL Object Constraint Language

OWL Web Ontology Language

UML Unified Modeling Language

5.3 Package abbreviations

Concepts from schemas defined in some other International Standards are designated with names that start with two-letter codes as follow:

CV ISO 19123:2005 Schema for Coverage Geometry and Functions

DQ ISO 19157:2013 Data Quality

GM ISO 19107:2003 Spatial Schema

LI ISO 19115-2:2009 Metadata extensions for imagery

MD ISO 19115-1:2014 Metadata fundamentals

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MI ISO 19115-2:2009 Metadata extensions for imagery

OM ISO 19156:2011 Observations and Measurements

SF ISO 19156:2011 Observations and Measurements

SI ISO 19112:2003 Spatial referencing by geographic identifiers

TM ISO 19108:2002 Temporal Schema, Temporal Objects

TP ISO 19108:2002 Temporal Schema, Temporal Topology

6 Context

6.1 Purpose of an application schema

An application schema is a conceptual schema for data required by one or more applications. An application schema shall define

— the content and structure of data;

and may define

— operations for manipulating and processing data;

— constraints to ensure the integrity of the data.

The purpose of an application schema is twofold:

— to provide a computer-readable data description defining the data structure, which makes it possible to apply automated mechanisms for data management;

— to achieve a common and correct understanding of the data, by documenting the data content of the particular application field, thereby making it possible to unambiguously retrieve information from the data.

6.2 Rules for application schema

This International Standard does not standardize any application schemas; it only defines rules for creating application schemas in a consistent manner (including the consistent definition of features) to facilitate the acquiring, processing, analysing, accessing, presenting and transferring of geographic data between different users, systems and locations. The rules in this International Standard are, in the case of data transfer or interchange, used by suppliers and users of geographic data to

— build a transfer application schema for data interchange;

— interpret the semantics of the transferred dataset with respect to user's local data and content and structure of data;

— determine the necessary transformations between the two datasets.

The rules in this International Standard will assist the users of applications with similar data requirements in creating a common application schema for the interface between their systems and data. This includes an agreement about the elements from the universe of discourse. This is described in more detail in 6.3.

The mapping from one application schema to another application schema may be difficult and even impossible if the two schemas are too divergent. The mapping is facilitated if the application schema used within a system is designed considering also the requirements for the data interchange. The rules

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can also be used for building an application schema used within a system, although such application schemas are not within the scope of this International Standard.

The creation of an application schema is a process. The content of an application schema has to be settled according to the view of reality in the universe of discourse. This is modelled in terms of types of features and their properties. Clause 7 contains principles for consistently defining features.

The application schema defines the structure and content of data. It is expressed in a conceptual schema language (CSL). Clause 7 also includes a model expressed in a UML profile that defines the concepts required to describe types of features. Feature type definitions may be documented in feature catalogues (ISO 19110). Such definitions may be used in an application schema. Other ISO geographic information standards define reusable modules of conceptual schemas that may be integrated in an application schema. Clause 8 gives the main rules for integrating these predefined modules into a conceptual schema in UML.

NOTE ISO 19118, ISO 19136 and ISO/TS 19139 define how a dataset defined by an application schema in UML is encoded.

6.3 Application schema supporting data interchange

6.3.1 Introduction

Data interchange between information systems may take place in two ways:

— In the traditional data transfer model, the data supplier creates a dataset that is transferred to the user. The structure and the content of data are described in the application schema for the dataset. The dataset is sent in a transfer format;

— In the interoperability model, the user application communicates with the supplier application through a common communication protocol. In this scenario, the user invokes services that result in data being passed from the service provider to the user application. The application schema describes not only the structure and content of the exchanged data, but also the structure of the interfaces involved in the transaction.

There is a fundamental distinction between a data transfer and a data transaction. In data transfer, a data set is predefined in an application schema. The spatial extent and the rules for inclusion of feature instances are also predefined. The user requests and receives a copy of the dataset (or may receive it automatically through a long-term agreement for distribution of datasets). In a data transaction, a requester first specifies selection criteria, such as spatial extent and feature instance inclusion rules for the data from the producer's data store. Data meeting the selection criteria are then retrieved from the data store and provided to the user.

NOTE Conformance to the rules in this International Standard does not guarantee that data conforming to any given application schema can be transformed in a meaningful way to conform to any other application schema. At best, it allows the user to determine which elements are common to the two schemas and which could be transformed from one schema to another, as well as those that cannot be transformed. Complete interoperability can only occur when user and supplier have identical application schemas.

6.3.2 Data interchange by transfer

Figure 1 shows the traditional data transfer model for data suppliers and data users. The structure and content of the data provided by the supplier and received by the user are described in application schemas. To be able to transfer data, three conditions must be fulfilled.

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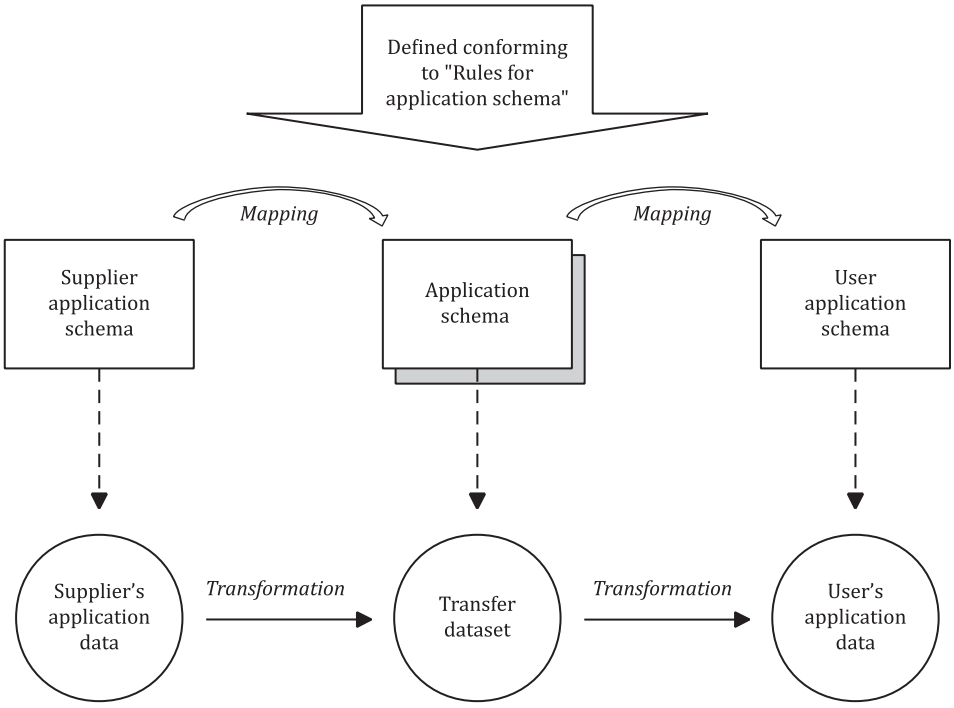

Figure 1 — Data interchange by transfer

First, the user and the supplier must agree on creating an application schema for the data being exchanged in accordance with this International Standard. In order to facilitate the transfer of data, the application schema is developed using the application schemas from the user and the supplier. One mapping will be made from the supplier's application schema to this application schema for the exchanged data, and a second mapping will be made from this application schema to the application schema of the user.

Second, the supplier must be able to transform the application data defined according to the supplier application schema into a transfer dataset defined according to the application schema for the exchanged data.

Third, the user must be able to transform the transfer dataset defined according to its application schema to the application data defined according to the user's application schema.

6.3.3 Data interchange by transactions

Figure 2 shows data interchange through transactions described in the interoperability model. The user application makes a request for data that is received by the supplier application. In response, the supplier application delivers a resulting dataset. Both the request and the resulting dataset are defined according to a common application schema. The supplier application is responsible for transforming the data in system A into the data in the exchanged dataset. After receipt, the user application is responsible for transforming the exchanged data into data in system B. Data interchange by transaction is provided by geospatial services as defined in ISO 19119. In particular, feature access services are defined in Geographic model/information management services.

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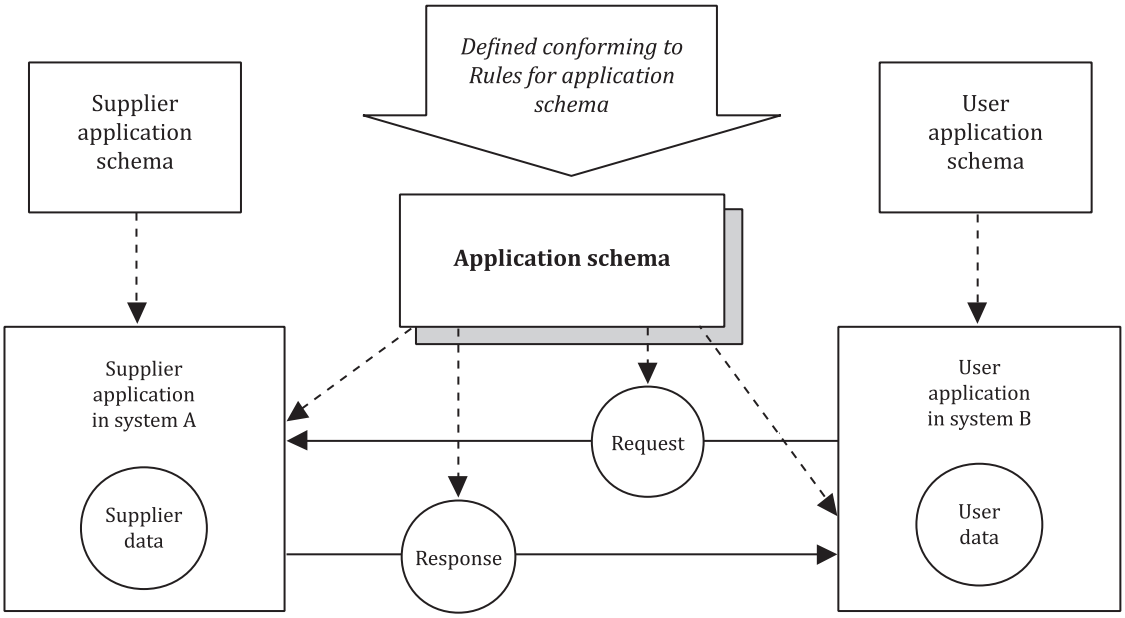

NOTE The unbroken lines show the flow of data. Broken lines denote the role of the application schema on the data interchange.

Figure 2 — Data interchange by transactions

7 Principles for defining features

7.1 General

This clause describes general rules for formalizing an application schema, independent of any specific conceptual schema language. The General Feature Model is the meta-model for application schemas, and the definition of the General Feature Model is part of the general rules. The rules comprise a requirements class summarized in Table 15.

Table 15 — Requirements class covering general requirements and the meta-model for application schemas

Requirements class	/req/general
Target type	Application schema
Requirement	/req/general/csl
Requirement	/req/general/integration
Requirement	/req/general/feature
Recommendation	/rec/general/property-name
Requirement	/req/general/attribute
Requirement	/req/general/operation
Requirement	/req/general/association-role
Requirement	/req/general/value-assignment
Requirement	/req/general/feature-association
Requirement	/req/general/inheritance
Recommendation	/rec/general/constraint

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7.2 Features, Coverages and Properties

7.2.1 Features

A fundamental unit of geographic information is called a feature. ISO 19110 provides a standard framework for organizing and reporting the classification of features.

This International Standard gives rules for creating application schemas, including the principles for the definition of features. The term "feature" is used in different contexts, and defined according to the four-layer architecture. Annex B describes the use of the term feature in the four-layer architecture.

This International Standard distinguishes four aspects of defining features: the definitions or description used to group them into types, the attributes associated with each type, the relationships among the types and the behaviour of the features.

EXAMPLE "Tower Bridge" is the abstraction of a certain real-world bridge in London. The term "bridge" is the abstraction of the collection of all real-world phenomena that is classified into the concept behind the term "bridge". Later in the document, the terms "feature type" and "feature instance" are used to separate the concept of "feature" describing the whole collection from the concept of describing a certain instance occurrence.

Figure 3 describes the most abstract level of defining and structuring geographic data. The classification of real-world phenomena as features depends on their significance to a particular universe of discourse.

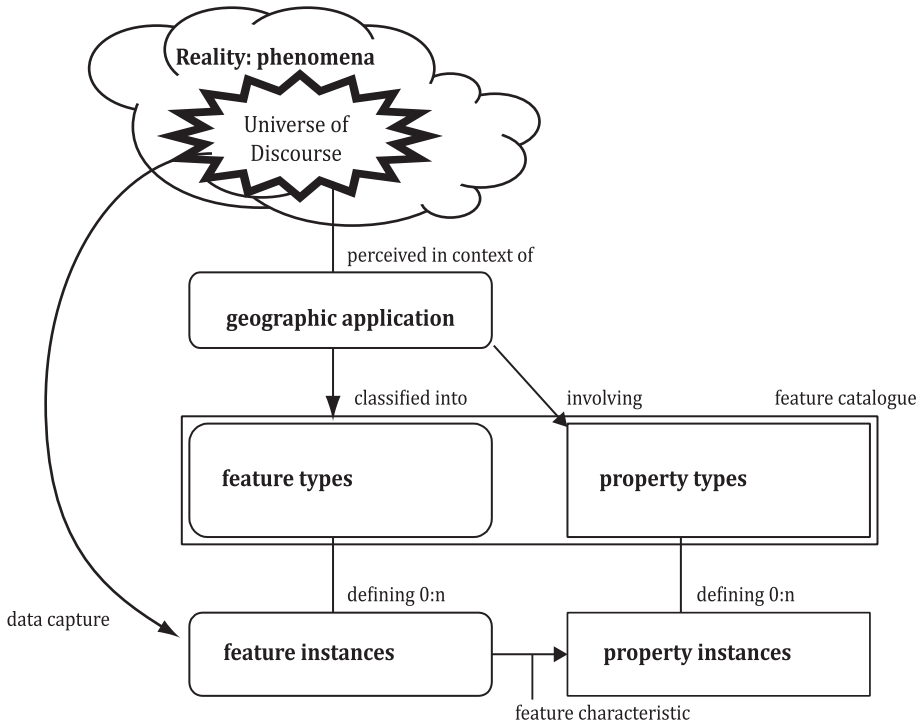

Figure 3 — The process from universe of discourse to data

7.2.2 Coverages

Many aspects of the real-world may be represented as features whose properties are single-valued and static. These conventional features provide a model of the world in terms of discrete objects located in it. However, in some applications it is more useful to use a model focussing on the variation of property values in space and time, formalized as coverages. Users of geographic information may utilize both viewpoints. While coverages are themselves strictly features as well, it is common to contrast coverages and non-coverage features when discussing the functionality provided by each viewpoint. In the following discussion the name 'feature' refers to non-coverage features.

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The feature and coverage representations may be related in several ways:

— signal processing to find and characterize features: signals in coverages may provide evidence for the existence, location and type of features, detected through modelling and interpretation;

EXAMPLE 1 Patterns of colour or other radiance bands within a remotely-sensed image may be used to infer the existence of specific objects or features on the ground.

EXAMPLE 2 Signals in a geophysical borehole log may be used to infer the presence of particular rock-units at underground locations.

— coverage-typed feature properties: feature properties whose value vary within the scope of a feature may be described as coverages whose domain extent is the geometry of the feature;

EXAMPLE 3 The variation of concentration of a particular ore-mineral within a mine may be described as a spatial function or coverage within the spatial limits of the mine.

— features sample a coverage: the values of a common property of a set of features provide a discrete sampling of a coverage, whose range type is the property, and whose domain is the aggregate geometry of the set of features.

EXAMPLE 4 The temperature at a set of weather stations may be compiled to show the spatial variation of temperature across the region where the stations are located.

A constraint in the latter two cases is that a property-type from a feature catalogue is the range-type of a coverage description in the same universe of discourse.

The case of features having property values that vary within the scope of the feature can be described using the general feature model (7.5.8).

While the coverage model is described in detail in ISO 19123, an application schema may include both feature- and coverage-types.

NOTE The feature and coverage viewpoints are related to (though not identical with) the so-called 'vector' and 'raster' approaches from traditional GIS implementations.

7.2.3 Properties and observations

Property values are associated with features and coverages. In the case of features, a property value is associated with a classified object. In the case of coverages, a property value is associated with a position in the domain.

Property values can be assigned in a number ways, such as through assertion by a competent authority, by inheritance from a parent feature or type, by derivation from more primitive properties, or by observation. In the latter case the value assigned is an estimate, with an error resulting from the observation procedure.

NOTE Following ISO 19156, 'observation' denotes the generalized case of an event using a procedure to generate the estimate. The procedure may involve a sensor, but may also be a computational or classification process.

The result of an observation is a property value that is assigned to its feature of interest. Where the feature property has a constant value, an associated observation result has a static value. Where the feature property varies with position, the result of an associated observation is a spatial function or coverage.

7.3 Features and the application schema

This International Standard supports the definition of feature types and coverages with respect to their representation in data structures defined by application schemas.

Figure 4 shows the process of structuring data from the universe of discourse to the geographic dataset. The definitions of the feature types and their properties, as perceived in context of an application field, will be derived from the universe of discourse. A feature catalogue documents the feature types.

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An application schema defines the logical structure of data and may define operations that can be performed on or with the data. An application schema addresses the logical organization, rather than the physical. An application schema is formalized using a Conceptual Schema Language.

/req/general/csl	An application schema shall be expressed in a conceptual schema language. It shall describe the structure and content of the dataset that represents a universe of discourse.

When creating an application schema, the concepts of the General Feature Model (GFM; see 7.4) are mapped to the concepts of the chosen conceptual schema language. For UML, these rules are described in Clause 8.

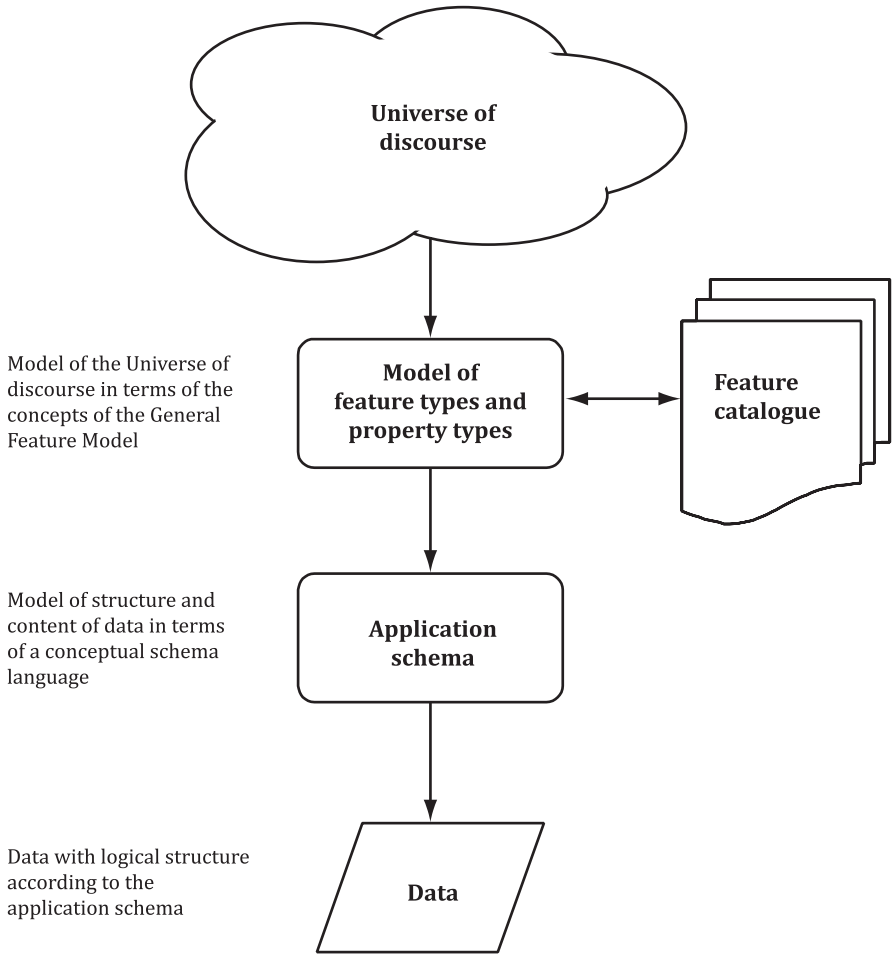

Figure 4 — From reality to geographic data

Use of definitions from existing feature catalogues or feature concept dictionaries can reduce the costs of data acquisition, allowing developers to use existing data, and simplify the process of developing the application schema. Dependencies are clearly recorded.

/req/general/integration	The developer of an application schema may use definitions from feature catalogues that already exist. Where an application schema integrates components from another schema, the dependencies shall be recorded explicitly using mechanisms provided by the conceptual schema language.

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7.4 The General Feature Model

7.4.1 Introduction

Concepts used to define features and how these concepts are related are identified and described in 7.4. The description is expressed in a conceptual model, also called the General Feature Model (GFM).

Annex B provides discussions regarding the purpose and design of the GFM.

NOTE The complete kernel of GFM is found in Annex B.3.

7.5 to 7.7 depict how different aspects of the properties of a feature are managed. 7.5 describes different aspects of attributes and 7.6 describes different aspects of relationships. 7.7 describes the concept of constraints.

7.4.2 The purpose of the GFM

The GFM is a model of the concepts required to classify a view of the real world. It is expressed in a CSL, which is UML in accordance with ISO 19103.

The things we want to classify are called features. Feature types have properties that are feature attributes, feature operations and feature association roles. The relations between feature types are feature associations and inheritance. All these concepts are expressed as metaclasses in the GFM. The GFM is a metamodel of feature types.

Feature types can be documented in feature catalogues. The GFM may serve as the conceptual model of the structure of a feature catalogue, but the feature catalogue has additional concepts for documenting feature types. There is a Feature Catalogue Model (FCM) that realizes the GFM concepts and adds more concepts (see ISO 19110). Some new concepts are, for example, a list of the feature attributes of each feature type, aliases of the feature type name, and codes for the feature type name. These additional concepts are not in conflict with the concepts from the GFM.

The GFM specifies the requirements for the classification of features, but is not a CSL. We have to use an existing CSL to define the application schema. Within the ISO geographic information standards, UML is used to define standard schemas. As we want to integrate standard schemas into our application schemas, it is convenient to also express the application schema in UML. This International Standard defines the main rules for mapping GFM concepts into UML. This may be done for other CSLs as well. As UML provides a general mechanism for classifications of any kind, it has to be profiled to be used as a basis for the classification of features. This profile is UML as specified in ISO 19103 and augmented in this International Standard and is summarized in 8.2.2.

The GFM defines the structure for classifying features that we need to keep in mind when we make our application schema in UML. However, the mapping from GFM to UML is a one-way mapping; it is not possible to map backwards. For example, the application schema has UML classes. Some of these classes are GFM feature types and some are the datatypes for feature attributes; it is not possible to keep these things apart. The GFM does not define feature-attribute values to the depth that is needed. That is not necessary to do as the GFM only specifies the structure and content of definition of features.

Hence, the GFM is a metamodel for definition of features that is also used to define the structure of feature catalogues. The chosen CSL (i.e. the UML profile as restricted by ISO 19103 and augmented in this International Standard) is the metamodel for an application schema.

7.4.3 The main structure of the GFM

Figure 5 shows the concepts used to define types of features. Besides a name and a description, a feature type is defined by its properties such as

— feature attributes,

— feature association roles characterizing the feature type, and

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— defined behaviour of the feature type.

Additional concepts are

— feature associations between the feature type and itself or other feature types,

— generalization and specialization relationships to other feature types, and

— constraints on the feature type.

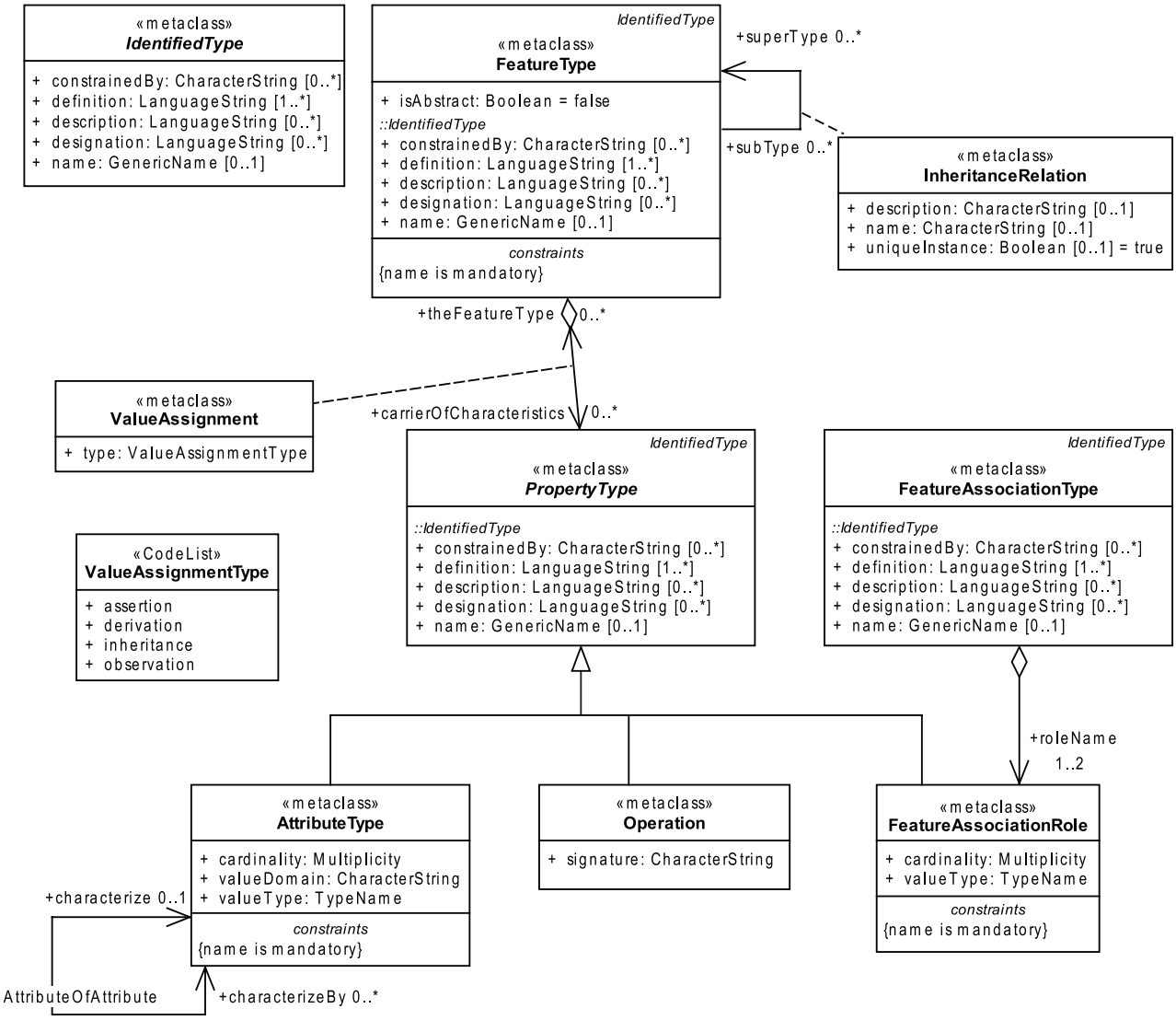

Figure 5 — The General Feature Model

NOTE 1 Earlier versions of this standard prefixed most class names with 'GF_'. That convention is no longer used.

NOTE 2 The types CharacterString, GenericName, LanguageString, LocalName, TypeName, are from ISO 19103.

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7.4.4 IdentifiedType

IdentifiedType is a metaclass from which the other key classes in the General Feature Model inherit some common identification and description attributes. IdentifiedType is the supertype of FeatureType, PropertyType and FeatureAssociationType.

— name

name of the element. Optional in general, but required on some specializations as indicated below. The type GenericName [ISO 19103] allows the namespace to be either explicit or implicit.

The CSL may constrain the scope and namespace of model elements. In UML the name of a class is scoped to the package, and the name of an attribute or role is scoped to a class, so when using UML as the CSL [Clause 8] the Application Schema provides the namespace for feature types, and the feature type provides the namespace for properties. In OWL the namespace for both classes and properties is usually but not necessarily provided by the ontology. When using OWL as the CSL [ISO 19150-2] classes will typically be scoped to the ontology or application schema, but property types may be scoped to a class, to the application schema, or to an external ontology or catalogue.

— definition

concise definition of the element. One definition is mandatory. Additional definitions can be provided in multiple languages if required.

— designation

natural language designator for the element to complement the **name**. Optional, with multiple designations allowed to support different languages.

— description

description of the element, including information beyond that required for concise definition but which may assist in understanding its scope and application. Optional, with multiple descriptions allowed to support different languages.

— constrainedBy

description of a constraint made on the IdentifiedType or specified on properties within a type. Also see 7.7.

7.4.5 FeatureType

A feature is an abstraction of real-world phenomena. FeatureType is a metaclass that is instantiated as classes that represent individual feature types. A certain feature type is the class for all instances of that feature type. The instances of a class that represents an individual feature type are feature instances.

/req/general/feature	Features shall be modelled as instances of the metaclass FeatureType, as defined in Figure 5 and in 7.4.5. Features shall not be modelled as specializations of GM_Object (ISO 19107:2003) or TM_Object (ISO 19108:2002). The feature shall have a name that is unique in the application schema.

NOTE 1 Feature types are equivalent to classes and feature instances are equivalent to objects, in object-oriented modelling.

NOTE 2 Geometry-, topology- and temporal-objects (GM_Object, TP_Object, TM_Object) are not abstractions of real-world phenomena. These types can provide types for feature properties, but cannot be specialized to features.

NOTE 3 Annex B provides a table on the use of the term “feature”.

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FeatureType inherits attributes for identification and description from the abstract metaclass IdentifiedType. The **name** is mandatory on a feature type, and is unique in an application schema.

FeatureType adds the following attributes and association ends:

— isAbstract

Boolean attribute (mandatory). If true, the feature type acts as an abstract supertype.

— carrierOfCharacteristics

association role to specify any feature operation, any feature attribute type and any feature association role that carries characteristics of a feature type. While strictly optional, it is unlikely for a feature type to be defined having no properties. Repeatable.

— superType

association role to specify a supertype (generalized type) of the feature type (optional, repeatable).

7.4.6 PropertyType

PropertyType is the abstract superclass for AttributeType, Operation and FeatureAssociationRole, which provide characteristics that may be associated with a feature type. PropertyType inherits attributes for identification and description from the abstract metaclass IdentifiedType. PropertyType adds no further attributes or associations.

Property types are specified independent of any specific feature type. A property instance and value occurs in the context of a feature, though in some cases the feature is very generic and might not be made explicit in the dataset. For example, the feature type or feature identity for an observed property might not be available because the necessary data interpretation has not yet been completed. Properties will often be described independent of features. It is therefore best if property type names are unique within an application.

/rec/general/property-name	The name of each property type should be unique within an application schema, or should have the same intention with respect to the CLASS owning the property as any other property with the same name in the Application Schema. A property type may be used by one or more feature types if the property type definition is the same in all contexts.

NOTE Decoupling property-types from feature-types is consistent with scientific and observational applications, where properties may be observed prior to feature detection, and where the same property may characterize more than one feature at different stages in a processing chain.

EXAMPLE 1 Physical properties like temperature, magnetic field, gravity vector, are present universally, and may be usefully measured and recorded independently from the feature or medium at any particular location.

EXAMPLE 2 Engineering properties like mass, width, height, distance, velocity, may be used in the same sense in the context of different feature-types.

7.4.7 AttributeType

AttributeType is the metaclass for attribute definitions of a feature type (see also 7.5).

/req/general/attribute	Feature attributes shall be modelled as instances of the metaclass AttributeType, as defined in Figure 5 and in 7.4.7, and further elaborated in 7.5.

AttributeType inherits attributes and associations from the abstract metaclass PropertyType, The **name** is mandatory for an attribute type.

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AttributeType adds the following attributes and association ends:

— valueType

data type of the attribute value (mandatory).

NOTE 1 ISO 19103 defines some data types that may be used for the valueType of a feature attribute, and other ISO geographic information standards define other object types that may be used.

EXAMPLE 1 Integer, CharacterString or GM_Object.

— valueDomain

description of a set of values (mandatory). In some cases the domain of values may be a set of concepts used as classifiers, organized in a vocabulary or lexicon.

EXAMPLE 2 Positive, from 3 to 7; GM_Object and all its subtypes as defined in ISO 19107; enumerated set.

NOTE 2 ISO 19103 provides for a class that defines a vocabulary to be stereotyped «enumeration» or «CodeList», where the members of the vocabulary are modelled as UML attributes. Conventionally a vocabulary was considered as a set of character string values. However, modern knowledge organization theory considers a *term* to be merely a label for a *concept* (ISO/TS 19104:2008; Miles & Bechhofer, 2009).

— cardinality

number of instances of the attribute that may be associated with a single instance of a feature type (mandatory).

— characterize

the attribute type that is described by this attribute type (in the case of an attribute of attribute) (optional).

— characterizeBy

an attribute type that describes this attribute type (in the case of an attribute of attribute) (optional, repeatable).

EXAMPLE 3 An attribute that carries the position of a feature may have another attribute that holds the positional accuracy (data value of QualityAttributeType) of this position.

A taxonomy of attribute types is described in 7.5.

7.4.8 Operation

The behaviour of features is described by operations that may be performed upon or by all instances of a feature type. An Operation represents the behaviour of a feature type as a function or a method. ISO 19110 provides a broader discussion on behaviour of feature types. Operation is the metaclass for describing behaviour of feature types in terms of operations.

/req/general/operation	Operations shall be modelled as instances of the metaclass Operation, as defined in Figure 5 and in 7.4.8.

NOTE 1 Operations only apply to the interoperability model and do not apply to the data transfer model as described in 6.3.

NOTE 2 Instances of Operation are of three kinds: observer operations, mutator operations and constructor operations. Observer operations return the current values of attributes. Mutator operations include actions that change those values. A constructor operation creates an instance of a class for which it is defined. For example, an observer operation may be used to find the height of a dam. Raising the dam is a mutator operation that changes the height of the dam and also affects the attributes of the watercourse and the reservoir associated with the dam. Values may be observed or affected for another feature instance if there is an association between the feature types involved.

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In addition to the attributes and associations inherited from the abstract metaclass PropertyType, Operation adds the following attributes:

— signature

description that indicates the name, the arguments and the return values of an operation (mandatory).

NOTE 3 In UML, the signature is expressed in the form *operation_name(input_parameter1, input_parameter2,...): output_value_type*, for example has_height(): real.

Properties of class operations are determined by application schema designers.

7.4.9 FeatureAssociationRole

FeatureAssociationRole is the metaclass for the classes of roles that are part of a FeatureAssociationType (7.4.11). FeatureAssociationRole indicates the role played by the feature type through the association. The instance of FeatureAssociationRole that gives the role for one feature type can also be seen as part of this feature type.

/req/general/association-role	Feature association roles shall be modelled as instances of the metaclass FeatureAssociationRole, as defined in Figure 5 and in 7.4.9.

FeatureAssociationRole inherits attributes and associations from the abstract metaclass PropertyType. The **name** is mandatory for an association role.

FeatureAssociationRole adds the following attributes:

— valueType

data type of the role value (mandatory).

— cardinality

number of instances of the feature type that can act in this role relative to a single instance of the feature type at the other end of the association (mandatory).

7.4.10 ValueAssignment

PropertyType is the metaclass for any class of property of a feature type that describes characteristics of the feature, the behaviour of a feature, or the association roles that the feature is in. PropertyType is the supertype of Operation, AttributeType and FeatureAssociationRole.

Values can be assigned to properties through a variety of methods. In many applications and for many properties the method is either not known, or is not of sufficient interest for it to be explicitly modelled. Nevertheless, in principle a value assignment process is associated with every property value. ValueAssignment is the association metaclass for any process by which values are assigned to a property, and when required, instances of this metaclass support auditing the evidence for assignment of a property value.

/req/general/value-assignment	A value-assignment process shall be modelled as an instance of the association class metaclass ValueAssignment, as defined in Figure 6 and in 7.4.10. In a value-assignment instance, the property for which a value is assigned shall be consistent with the feature-type that it is associated with.

The feature type OM_Observation (ISO 19156), and the classes LI_ProcessStep (ISO 19115-1) and MI_Event (ISO 19115-2) may be interpreted as instances of ValueAssignment (Figure 6). The description of a specific observation can provide an evaluation of the likely error in a property value.

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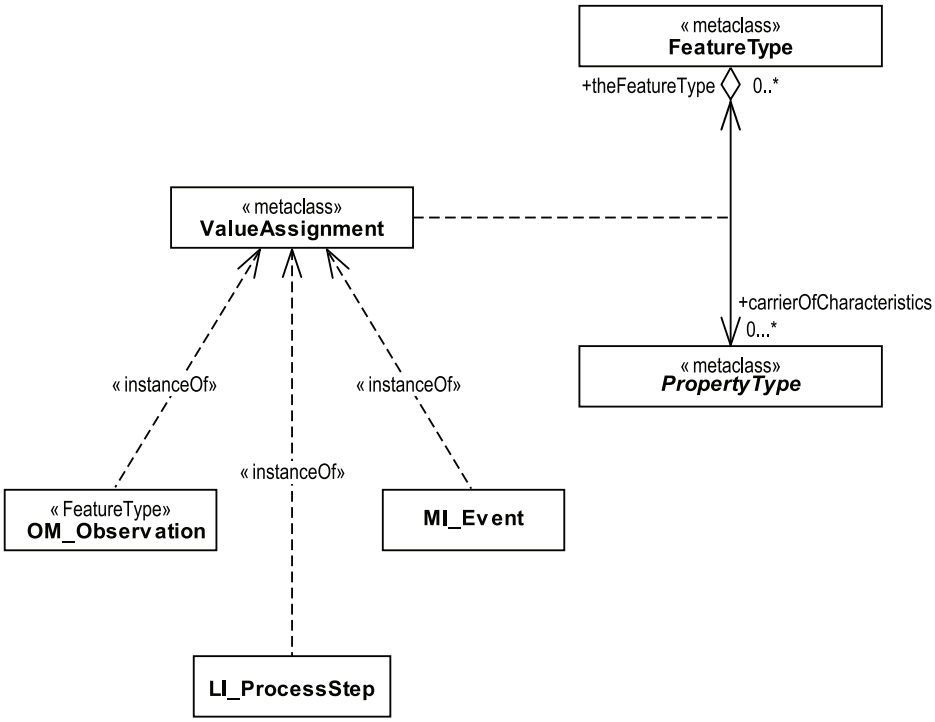

NOTE The OM_Observation class in ISO 19156 carries an explicit constraint that the feature-property combination is consistent.

Figure 6 — Example instances of ValueAssignment metaclass

Other examples of value assignment classes are:

— Assertion, in which a property value is assigned by a competent authority.

EXAMPLE 1 The owner of a land parcel or owner of a building is typically asserted by a land registration authority.

— Inheritance from a parent feature or type in which a property value is duplicated from a well defined source.

EXAMPLE 2 All instances of 'daffodil' have the property colour='yellow' inherited from their class definition.

— Derivation, in which a property value is derived from a number of input parameters based on a defined ruleset.

EXAMPLE 3 If a land area feature has a surface property that equals 'paved', a type property that equals 'road or track' and a make property that equals 'manmade', then the classification value 'road' is assigned.

EXAMPLE 4 Spatial analysis: The municipality a feature falls into given by a point location is automatically determined by spatial analysis against a municipal area dataset.

The ValueAssignment metaclass is shown with a single attribute to indicate the general class involved:

— type

class of value assignment (mandatory)

The set of value assignment classes described here is not exhaustive, and is therefore shown in Figure 5 as a «CodeList».

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