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Geographic information — Feature cataloguing methodology

Information géographique — Méthodologie de catalogage des entités

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 19110 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

This International Standard contains four annexes. Annexes A and B are normative; annexes C and D are informative.

Introduction

Geographic features are real world phenomena associated with a location relative to the Earth, about which data are collected, maintained, and disseminated. Feature catalogues defining the types of features, their operations, attributes, and relationships represented in geographic data are indispensable to turning the data into usable information. Such feature catalogues promote the dissemination, sharing, and use of geographic data through providing a better understanding of the content and meaning of the data. Unless suppliers and users of geographic data have a shared understanding of the kinds of real world phenomena represented by the data, users will be unable to judge whether the data supplied are fit for their purpose.

The availability of standard feature catalogues that can be used multiple times will reduce costs of data acquisition and simplify the process of product specification for geographic datasets.

This International Standard provides a standard framework for organizing and reporting the classification of real world phenomena in a set of geographic data. Any set of geographic data is a greatly simplified and reduced abstraction of a complex and diverse world. A catalogue of feature types can never capture the richness of geographic reality. However, such a feature catalogue should present the particular abstraction represented in a given dataset clearly, precisely, and in a form readily understandable and accessible to users of the data.

Geographic features occur at two levels: instances and types. At the instance level, a geographic feature is represented as a discrete phenomenon that is associated with its geographic and temporal coordinates and may be portrayed by a particular graphic symbol. These individual feature instances are grouped into classes with common characteristics — feature types. It is recognized that geographic information is subjectively perceived and that its content depends upon the needs of particular applications. The needs of particular applications determine the way instances are grouped into types within a particular classification scheme. ISO 19109, *Geographic information — Rules for application schema* specifies how data shall be organized to reflect the particular needs of applications with similar data requirements.

NOTE The full description of the contents and structure of a geographic dataset is given by the application schema developed in compliance with ISO 19109. The feature catalogue defines the meaning of the feature types and their associated feature attributes and feature relationships contained in the application schema.

The collection criteria used to identify individual real world phenomena and to represent them as feature instances in a dataset are not specified in this International Standard. Because they are not included in the standards, collection criteria must be included separately in the product specification for each dataset.

A standard way of organizing feature catalogue information will not automatically result in harmonization or interoperability between applications. In situations where classifications of features differ, this International Standard may at least serve to clarify the differences and thereby help to avoid the errors that would result from ignoring them. It may also be used as a standard framework within which to harmonize existing feature catalogues that have overlapping domains.

Geographic information — Feature cataloguing methodology

1 Scope

This International Standard defines the methodology for cataloguing feature types. This International Standard specifies how the classification of feature types is organized into a feature catalogue and presented to the users of a set of geographic data. This International Standard is applicable to creating catalogues of feature types in previously uncatalogued domains and to revising existing feature catalogues to comply with standard practice. This International Standard applies to the cataloguing of feature types that are represented in digital form. Its principles can be extended to the cataloguing of other forms of geographic data.

This International Standard is applicable to the definition of geographic features at the type level. This International Standard is not applicable to the representation of individual instances of each type and excludes schemas for spatial referencing, temporal referencing, and portrayal parameters which are specified in ISO 19107, ISO 19108, and ISO 19117. It also excludes collection criteria for feature instances.

This International Standard may be used as a basis for defining the universe of discourse being modelled in a particular application, or to standardize general aspects of real world features being modelled in more than one application.

2 Conformance

Any feature catalogue claiming conformance with this International Standard shall pass all the requirements described in the abstract test suite (annex A).

3 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3166-1, *Code for the representation of names of countries and their subdivisions — Part 1: Country codes*

ISO 19109:—[1)], *Geographic information — Rules for application schema*

4 Terms and definitions

For the purposes of this International Standard, the following definitions apply.

1) To be published.

4.1
feature
abstraction of real world phenomena with common properties

EXAMPLE The phenomenon 'Eiffel Tower' may be classified with other similar phenomena into a feature type 'tower'.

NOTE In a feature catalogue, the basic level of classification is the feature type.

4.2
feature association
relationship that links instances of one feature type with instances of the same or a different feature type [Adapted from ISO 11179–3]

4.3
feature attribute
characteristic of a feature

EXAMPLE 1 A feature attribute named 'colour' may have an attribute value 'green' which belongs to the data type 'text'.

EXAMPLE 2 A feature attribute named 'length' may have an attribute value '82.4' which belongs to the data type 'real'.

NOTE 1 A feature attribute has a name, a data type, and a value domain associated to it. A feature attribute for a feature instance also has an attribute value taken from the value domain.

NOTE 2 In a feature catalogue, a feature attribute may include a value domain but does not specify attribute values for feature instances.

4.4
feature catalogue
catalogue containing definitions and descriptions of the feature types, feature attributes, and feature associations occurring in one or more sets of geographic data, together with any feature operations that may be applied

4.5
feature operation
operation that every instance of a feature type may perform

EXAMPLE An operation upon a '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'.

NOTE Feature operations provide a basis for feature type definition.

4.6
functional language
programming language in which abstract data types are defined in terms of operations on the types, and in which algebraic axioms specify the results of each of the operations for each of the types

NOTE In a functional language, feature types may be represented as abstract data types.

5 Requirements

5.1 Feature catalogue

The feature catalogue shall present the abstraction of reality represented in one or more sets of geographic data as a defined classification of phenomena. The basic level of classification in the feature catalogue shall be the feature type. A feature catalogue shall be available in electronic form for any set of geographic data that contains feature types. A feature catalogue may also comply with the specifications of this International Standard independently of any existing set of geographic data.

5.2 Organization and presentation of feature catalogue information

5.2.1 General requirements

5.2.1.1 Feature catalogue completeness

A template for the recording and presentation of feature classification information is specified in annex B. A feature catalogue prepared according to this template shall document all of the feature types found in a given set of geographic data. The feature catalogue shall include identification information as specified in annex B. The feature catalogue shall include definitions and descriptions of all feature types contained in the data, including any feature attributes and feature associations contained in the data that are associated with each feature type, and optionally including feature operations that are supported by the data. To ensure predictability and comparability of feature catalogue content across different applications, it is recommended that the feature catalogue should include only the elements specified in annex B. To maximize the usefulness of a feature catalogue across different applications, the use of a conceptual schema language to model feature catalogue information is recommended.

NOTE Natural language definitions, feature type aliases, criteria for the birth and death of feature instances, and other semantic elements of the feature catalogue may be included in a conceptual schema as structured comments or as attributes.

5.2.1.2 Form of names

All feature types, feature operations, feature attributes, and feature associations included in the feature catalogue shall be identified by a name that is unique within the feature catalogue. If the name of a feature type, feature operation, feature attribute, or feature association appears more than once in the feature catalogue, the definition shall be the same for all occurrences.

5.2.1.3 Form of definitions

Definitions of feature types, feature attributes, and feature associations, and descriptions of feature operations shall be given in a natural language. Definitions of feature types, feature attributes, feature attribute values, feature associations, and codes for each of these, shall be included in the catalogue, unless the catalogue specifies a separate definition source. If the same term appears in both the definition source and the feature catalogue, the definition in the feature catalogue shall apply.

5.2.2 Requirements for feature types

Each feature type shall be identified by a name and defined in a natural language, and optionally defined in a functional language using scientific notation. Each feature type may also be identified by an alphanumeric code that is unique within the catalogue and by a list of aliases. The feature catalogue shall also include, for each feature type, its feature operations and associated feature attributes and feature associations, if any. The use of functional language specifications to help define feature types is recommended.

5.2.3 Requirements for feature operations

Feature operations, if any, shall be identified and defined for each feature type. Feature attributes shall be specified for each feature operation as well as any object feature types affected by the operation. The definition shall include a natural language definition and may be formally specified in a functional language.

5.2.4 Requirements for feature attributes

Feature attributes, if any, shall be identified and defined for each feature type. The definition shall include a natural language definition and a specified data type for values of the attribute. Each feature attribute may also be identified by an alphanumeric code that is unique within the catalogue.

5.2.5 Requirements for feature associations

Feature associations, if any, shall be identified and defined for each feature type. Each feature association may also be identified by an alphanumeric code that is unique within the catalogue. For each affected feature type, any feature attributes affected by the feature association shall be identified.

Annex A
(normative)

Abstract test suite

A.1 Introduction

This normative annex presents the abstract test suite for evaluating conformance to this International Standard. The abstract test suite contains two test cases and two test modules: a test case for the existence and form of catalogue information (A.2); a test module for the content of feature catalogue information (A.3); a test module for cross-referencing of feature catalogue information (A.4); and a test case for the uniqueness of feature catalogue identifiers (A.5). To check that a feature catalogue conforms to this International Standard, verify that all the requirements in A.2 – A.5 are satisfied.

A.2 Test case for existence and form of feature catalogue information

a) Test purpose: verify the existence and form of a feature catalogue

b) Test method: check whether the feature catalogue exists and can be obtained in electronic form, by obtaining a copy of the feature catalogue such as on a computer disk or through a file transfer

c) Reference: 5.1

d) Test type: basic

A.3 Test module for presence of required elements

A.3.1 Test case for feature catalogue identification

a) Test purpose: verify that identification information is included in the Feature Catalogue

b) Test method: check whether the Feature Catalogue information includes the Name, Scope, Version Number, Version Date, and Producer

c) Reference: Annex B, Table B.1: feature catalogue elements 01, 02, 04, 05, and 07

d) Test type: basic

A.3.2 Test case for feature type information

a) Test purpose: verify that feature type information is included in the Feature Catalogue

b) Test method: check whether the Feature Catalogue includes the name and definition of at least one feature type; then check whether a definition is given for every feature type in the feature catalogue; the definitions may be given in the Definition Source (element 06) or in the Feature Type information (element 12)

c) Reference: Annex B, Table B.1: elements 11 and 12 (or 11 and 06)

d) Test type: basic

A.3.3 Test case for feature operation information

a) Test purpose: verify that any required Feature Operation information is included in the Feature Catalogue

b) Test method: check whether the Feature Type information includes the names of one or more feature operations; if it does, check whether the Feature Operation information includes at least one Name, at least one Feature Attribute Name and at least one Definition; the definitions may be given in the Definition Source (element 06) or in the Feature Operation information (element 24)

c) Reference: Annex B, Table B.1: elements 15, 21, 22 and 24 (or 06)

d) Test type: basic

A.3.4 Test case for feature attribute information

a) Test purpose: verify that any required Feature Attribute information is included in the Feature Catalogue

b) Test method: check whether the Feature Type information includes the names of one or more feature attributes; if it does, check whether the Feature Attribute information includes at least one Name, at least one Definition, and at least one Value Data Type ; the definitions may be given in the Definition Source (element 06) or in the Feature Attribute information (element 32) ; the value data types may be given in the Definition Source (element 06) or in the Feature Attribute information (element 34)

c) Reference: Annex B, Table B.1: elements 16, 31, 32 (or 06), and 34 (or 06)

d) Test type: basic

A.3.5 Test case for feature association information

a) Test purpose: verify that any required Feature Association information is included in the Feature Catalogue

b) Test method: check whether the Feature Type information includes the names of one or more feature associations; if it does, check whether the Feature Association information includes at least one Name, at least one Definition, a list of one or more Feature Types Included, and at least one Order Indicator; the definitions may be given in the Definition Source (element 06) or in the Feature Association information (element 43)

c) Reference: Annex B, Table B.1: elements 17, 41, 43 (or 06), 45, and 46

d) Test type: basic

A.4 Test module for cross-referencing of feature catalogue information

A.4.1 Test case for cross-referencing of feature types and feature attributes

a) Test purpose: verify that cross-references exist between feature types and feature attributes included in the Feature Catalogue

b) Test method: for each Feature Type, check whether one or more names are listed in the Feature Attribute Names element; if so, check whether there is corresponding Feature Attribute information for each Feature Attribute Name; for each Name included in Feature Attribute information, check whether there is at least one Feature Type that includes the name of the attribute in the Feature Attribute Names element of the Feature Type information

c) Reference: Annex B, Table B.1: elements 16 and 31

d) Test type: basic

A.4.2 Test case for cross-referencing of feature types and feature associations

a) Test purpose: verify that cross-references exist between feature types and feature associations included in the Feature Catalogue

b) Test method: for each Feature Type, check whether one or more names are listed in the Feature Association Names element; if so, check whether there is corresponding Feature Association information for each Feature Association Name; for each Name included in Feature association information, check whether there is at least one Feature Type that includes the name of the relationship in the Feature Association Names element of the Feature Type information

c) Reference: Annex B, Table B.1: elements 17 and 41

d) Test type: basic

A.5 Test case for uniqueness of identifiers used in feature catalogue

a) Test purpose: verify the uniqueness of names and codes used within the feature catalogue

b) Test method: check each feature type name, feature operation name, feature attribute name, feature association name, feature type code, feature attribute code, and feature association code appearing in the feature catalogue; if any name or code appears more than once, verify that the element so named has precisely the same definition in each place where it is defined

c) Reference: 5.2.2, 5.2.4, and 5.2.5; Annex B, Table B.1: elements 06, 11, 12, 13, 21, 24, 31, 32, 33, 41, 43, and 44

d) Test type: basic

Annex B
(normative)

Feature catalogue template

This normative annex presents the template for the organization of feature catalogue information according to this International Standard. Table B.1 presents the template as a table of feature catalogue contents. In Table B.1, the sections of a feature catalogue are shaded. Feature catalogue elements and sections and the relationships among them are identified using the following notation for obligation and conditions:

M – The section or element is mandatory: it shall be included in the feature catalogue.

C – The section or element is conditional: the condition is stated as a question. If the answer to the question is yes, the section or element shall be included in the feature catalogue.

O – The section or element is optional: if a section is included in the feature catalogue, mandatory elements of the section shall also be included.

Following Table B.1, Figure B.1 illustrates the feature catalogue template in the form of a Unified Modeling Language (UML) package. Figures B.2 through B.4 illustrate how the structure of a standard feature catalogue conforms to the General Feature Model (ISO 19109, 7.3).

Table B.1 — Feature catalogue contents

	Feature Catalogue Element	Definition	Obligation/ Condition	Maximum occurrence	Data type	Domain
	Feature Catalogue	**Identification and contact information for feature catalogue**	**M**	**1**		
01	Name	Name for feature catalogue	M	1	text	free text
02	Scope	Subject domain(s) of feature types defined in feature catalogue	M	N	text	free text
03	Field of Application	Description of kind(s) of use to which the feature catalogue may be put	O	N	text	free text
04	Version Number	Version number of feature catalogue	M	1	text	free text
05	Version Date	Effective date of feature catalogue	M	1	date	free text
06	Definition Source	Bibliographic reference, including author, title, edition, publisher, place of publication, and date of publication, to a published external source of definitions for information included in feature catalogue	O	N	text	free text
07	Definition Type	Indicates the category of catalogue information to which each given definition source applies: feature type names, feature operation names, feature attribute names, feature attribute value labels, feature attribute value data types, feature association names, feature type codes, feature attribute codes, feature attribute value codes, and (or) feature association codes.	O	N	text	free text

Table B.1 *(continued)*

	Feature Catalogue Element	Definition	Obligation/ Condition	Maximum occurrence	Data type	Domain
08	Producer	Name, address, country, and telecommunications address of person or organization having primary responsibility for the intellectual content of the feature catalogue	M	1	text	free text (see ISO 3166-1 for country codes)
09	Functional Language	Notation system used for formal definition	C/ Feature operation formal definition occurs in feature catalogue?	1	text	free text
	Feature Type	**Class of real world phenomena with common properties**	**M**	**N**		
11	Name	Text string that uniquely identifies the feature type within the catalogue	M	1	text	free text
12	Definition	Definition of the feature type in a natural language	C/ Definition not provided by definition source?	1	text	free text
13	Code	Code that uniquely identifies the feature type within a catalogue	O	1	text	free text
14	Aliases	Name(s) of equivalent feature term(s)	O	N	text	free text
15	Feature Operation Names	Operations that every instance of this feature type may perform	O	N	text	free text
16	Feature Attribute Names	Characteristic(s) of the feature type	O	N	text	free text
17	Feature Association Names	Association(s) between instances of this feature type and instances of the same or a different feature type	O	N	text	free text
18	Subtype of	Identifies one or more feature types from which the subject feature type inherits all properties, including feature operations, feature attributes, and feature associations	O	N	text	free text
	Feature Operation	**Operation that every instance of a feature type may perform**	**C/ feature operation name occurs in 'feature operation names' list**	**N**		
21	Name	Text string uniquely identifying feature operation within the catalogue	M	1	text	free text
22	Feature Attribute Names	Name(s) of the feature attribute(s) participating in the feature operation	M	N	text	free text
23	Object Feature Type Names	Name(s) of other feature type(s) affected by the operation	C/ feature operation affects a different feature type?	N	text	free text
24	Definition	Describes how the subject and object feature types and attributes are used or affected by the operation	M	1	text	free text
25	Formal Definition	Signatures and equations for the feature operation, in scientific notation	O	1	symbols	symbols

Table B.1 *(continued)*

	Feature Catalogue Element	Definition	Obligation/ Condition	Maximum occurrence	Data type	Domain
	Feature Attribute	**Characteristic of the feature type**	**C/ feature attribute name occurs in 'feature attribute names' list?**	**N**		
31	Name	Text string uniquely identifying feature attribute within the catalogue	M	1	text	free text
32	Definition	Definition of the feature attribute in a natural language	C/ Definition not provided by definition source?	1	text	free text
33	Code	Code that uniquely identifies the feature attribute within the catalogue	O	1	text	free text
34	Value Data Type	Data type of attribute values	C/ Definition not provided by definition source?	1	text	free text
35	Value Measurement Unit	Measurement unit for attribute values	O	1	text	free text
36	Value Domain Type	Indicates whether or not domain for feature attribute values is enumerated (if omitted, domain is not specified)	O	1	integer	0 ="not enumerated" 1 ="enumerated"
37	Value Domain	Permissible values of feature attribute	C/ Feature attribute value domain type = 0 (not enumerated)	1	text	free text
	Feature Attribute Value	**Value for the enumerated feature attribute value domain**	**C/ Feature attribute value domain type =1 (enumerated) and labels not provided by definition source ?**	**N**		
38	Label	Descriptive label that uniquely identifies one value of this feature attribute	M	1	text	free text
39	Code	Code that uniquely identifies one value of this feature attribute	O	1	integer	integer
40	Definition	Definition of the attribute value in a natural language	O	1	text	free text
	Feature Association	**Relationship that links instances of the feature type with instances of the same or a different feature type**	**C/ Feature association name occurs in 'feature association names' list**	**N**		
41	Name	Text string uniquely identifying feature association within the catalogue	M	1	text	free text
42	Inverse Relationship	Text string identifying opposite or inverse of feature association	O	1	text	free text
43	Definition	Definition of the Feature association in a natural language	C/ Definition not provided by definition source?	1	text	free text
44	Code	Code that uniquely identifies the feature association within the catalogue	O	1	text	free text

Table B.1 *(continued)*

	Feature Catalogue Element	Definition	Obligation/ Condition	Maximum occurrence	Data type	Domain
45	Feature Types Included	Names of feature types participating in the association	M	N	text	free text
46	Order Indicator	Indicates whether the ordering of feature types is significant in the association	M	1	integer	0 ="not ordered" 1 ="ordered"
47	Cardinality	Possible cardinality of the association	O	1	text	1 :1 ="exactly one" 1 : ? ="one or more" 0 :1 ="zero or one" 0 : ? ="zero or more"
48	Constraints	Constraints on the feature association	O	N	text	free text
49	Role Name	Role played by the feature type included in the feature association	O	N	text	free text

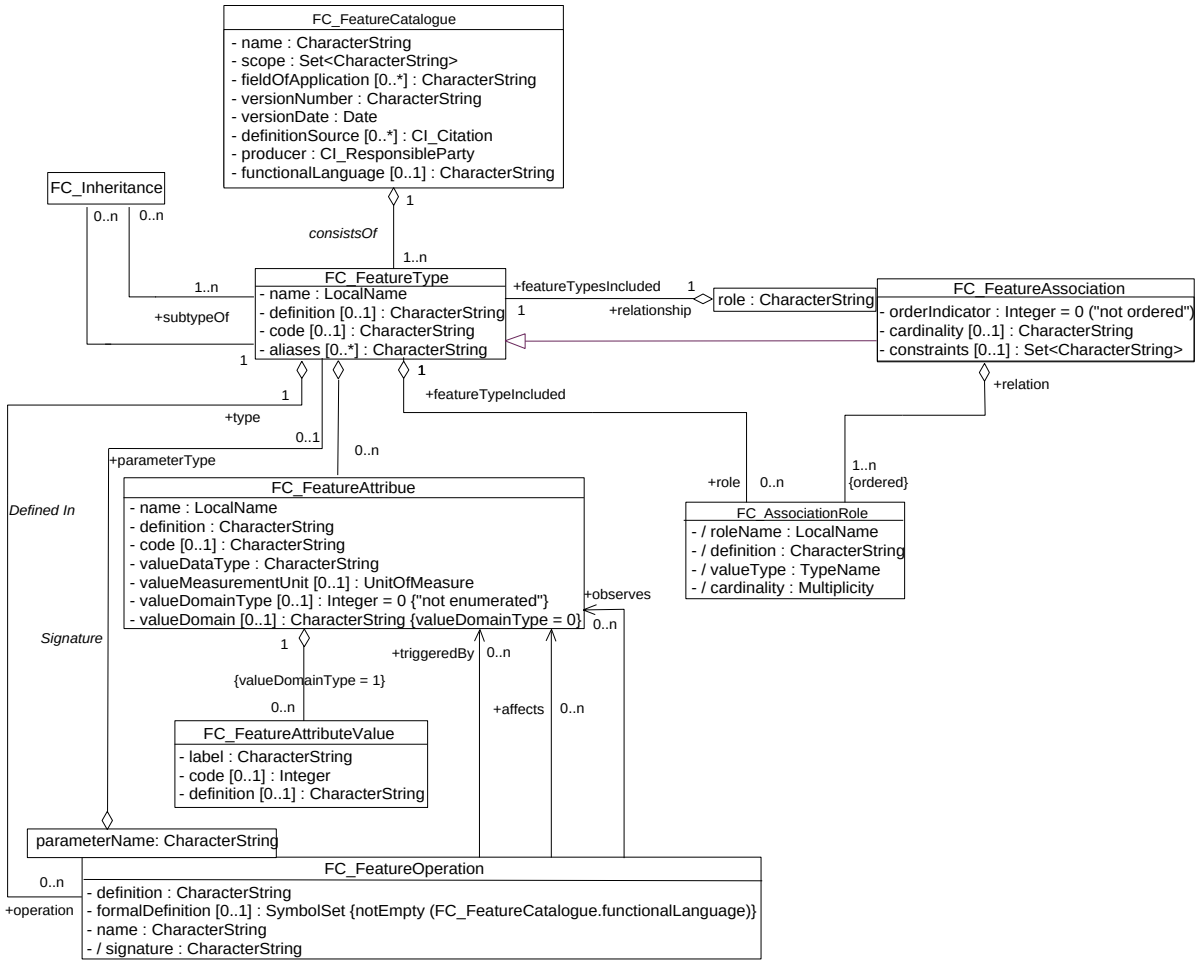

Figure B.1 — Conceptual model of feature catalogue

Figure B.2 includes the kernel of the General Feature Model (GFM; ISO 19109 Figure 5) and illustrates that the concepts in the feature catalogue are realizations of General Feature Model elements. Feature Type realizes the GFM metaclass *feature type*. Feature Attribute realizes the GFM metaclass *attribute type*. Feature Association realizes the GFM metaclass *association type*. Association Role realizes the GFM metaclass *association role*. The feature catalogue relation 'subtype of' realizes the 'specialization' role of the GFM class *inheritance relation*. Feature Operation realizes the GFM metaclass *operation*.

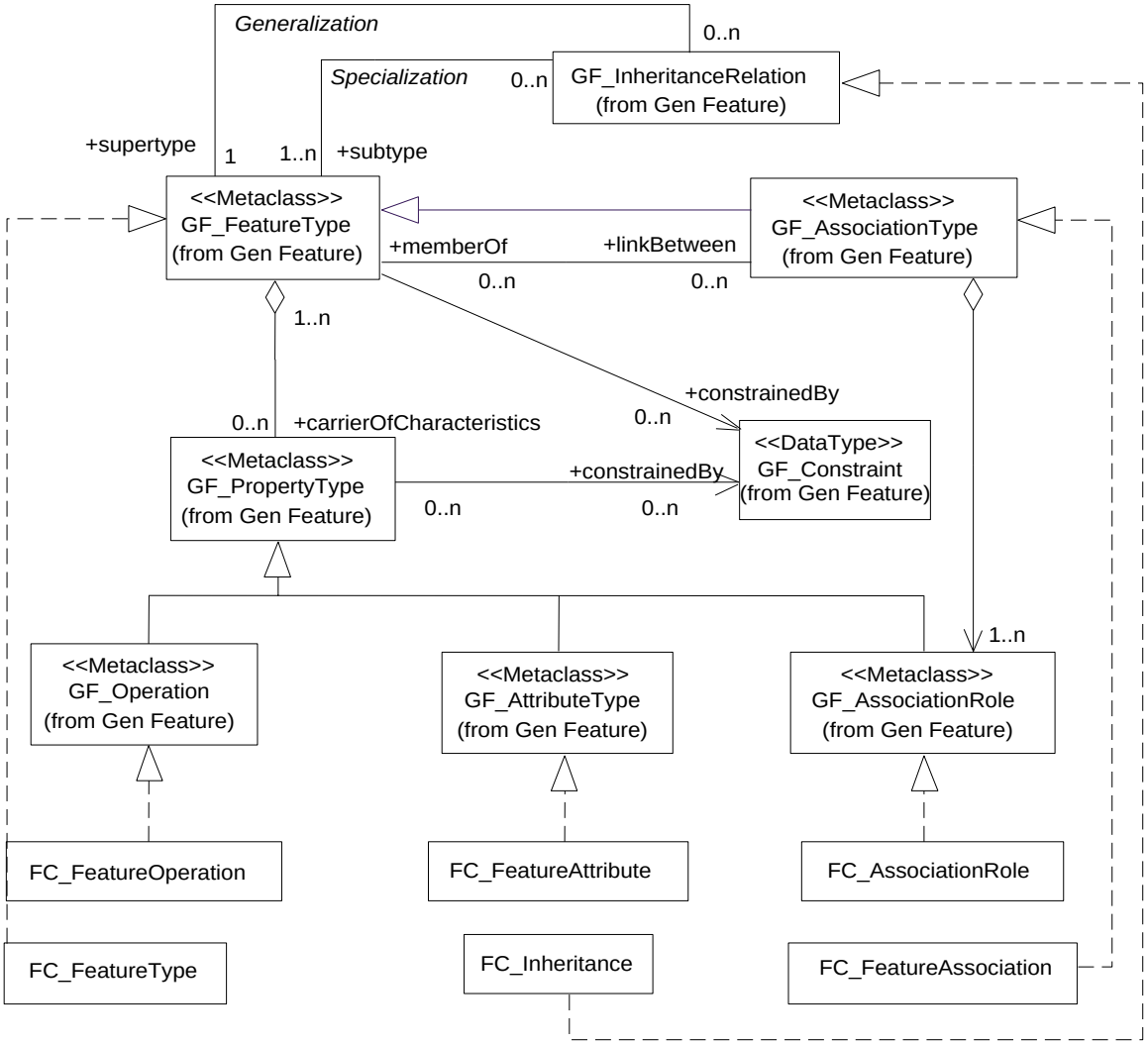

Figure B.2 — Feature cataloguing classes as realizations of General Feature Model metaclasses

Figure B.3 provides details of the derivation of feature catalogue classes Feature Type, Feature Attribute, Feature association, and Association Role from the corresponding General Feature Model metaclasses. In a conforming feature catalogue, Feature Type corresponds to the GFM *feature type*. Like the corresponding GFM metaclass, Feature Type has attributes 'name' and 'definition'. In addition, it has optional attributes 'code' and 'aliases'.

Feature Attribute corresponds to the GFM metaclass *attribute type*. Feature Attribute has attributes 'name' and 'definition' from the GFM metaclass *property type*, of which GFM metaclass *attribute type* is a subclass. Feature Attribute has 'value data type' and 'value domain type' corresponding to 'value type' and 'value domain' in the GFM. Feature Attribute also has optional attributes 'code', 'value measurement unit', and 'value domain', and optionally provides for defining individual values of attributes that have ‘enumerated’ value domains. Unlike GFM, the feature catalogue class Feature Attribute does not include a 'cardinality' attribute.

Annex C discusses the concept of Feature Relationship and shows that "generalization," "aggregation," "association," and any other user-defined relationships may all be considered forms of Feature Relationship. The GFM distinguishes *inheritance relations*, which are relationships between *feature types*, from *association types*, which can be aggregations, associations, or any other relationships between single or multiple *feature instances*. The corresponding concepts in the feature catalogue template are the relation 'subtype of' for *inheritance relations* and Feature Association for *association types*. Specifically, 'subtype of' in a feature catalogue realizes the 'specialization' role of *inheritance relation*. In order to simplify the design of feature catalogues, the inverse inheritance relation 'supertype of' is not included in the feature catalogue template, nor are the attributes of GFM *inheritance relation*: 'name', 'description', 'exhaustive', or 'unique instance'.

Besides the *inheritance relation* 'subtype of', any other feature associations are included in the feature catalogue template as realizations of the GFM *association type*. Consistently with GFM, Feature Association is considered a subtype of Feature Type and therefore has attributes 'name', 'definition', and 'code'. In addition, it has attributes 'order indicator', 'cardinality', and 'constraints'. Feature Association Role realizes the GFM *association role*. Feature Association Role has the attribute 'role name'. The 'feature types included' in the association shall be listed in the feature catalogue; if the list is ordered, role names may also be given in the feature catalogue for each feature type. The table elements 'feature types included' and 'role name' are shown in the diagram as opposite ends of the relation between Feature Type and Feature Association. GFM *association role* attributes 'value type' and 'cardinality' are not included in the feature catalogue template.

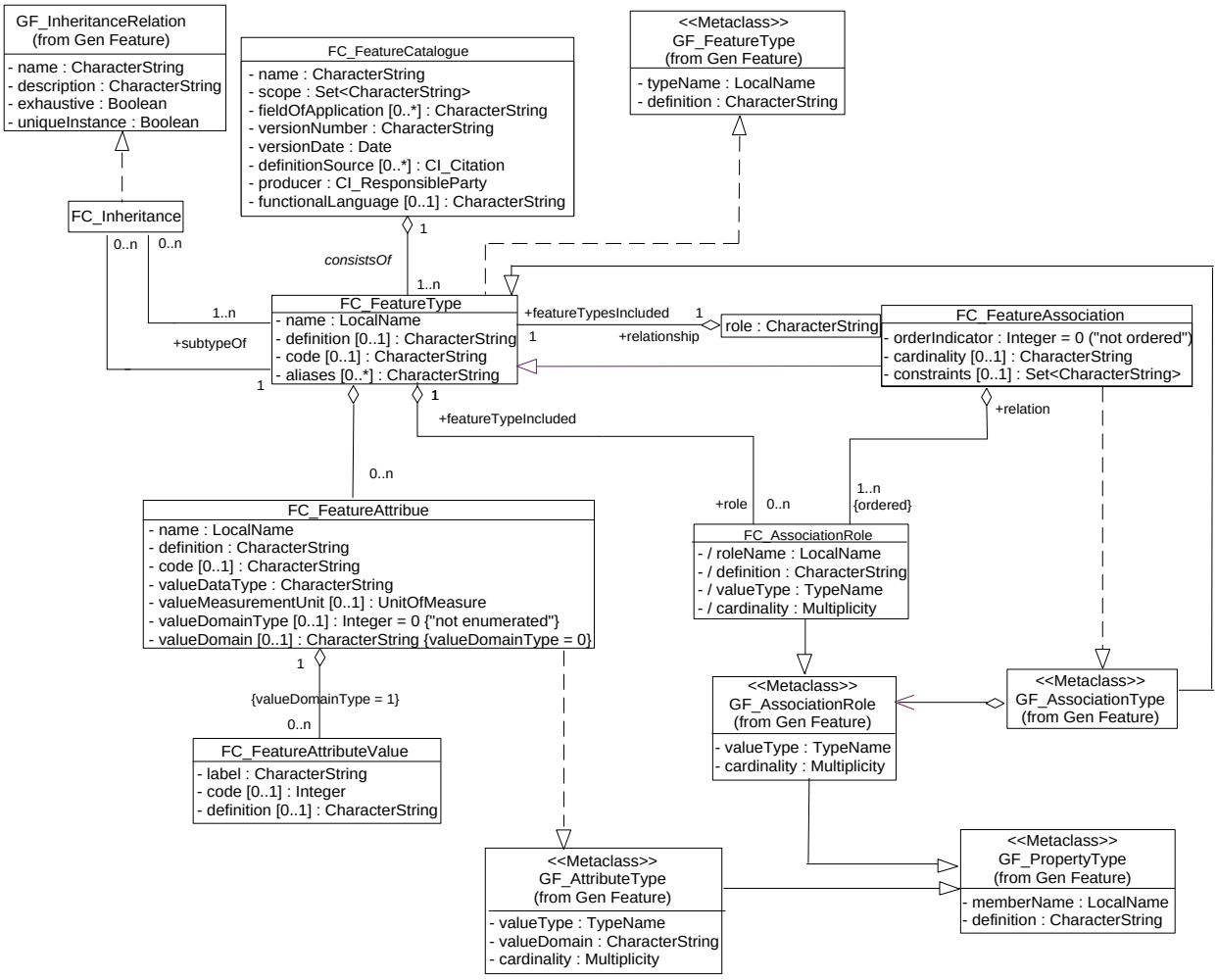

Figure B.3 — Derivation of FC_FeatureType, FC_FeatureAttribute, and FC_FeatureAssociation from GF Metaclasses

Figure B.4 provides details of the derivation of the feature catalogue class Feature Operation from the GFM metaclass *operation*. The 'signature' of a Feature Operation specifies the Feature Types involved in the operation (the Feature Type for which the Feature Operation is defined plus any other 'object feature types' that are affected by the operation) and the Feature Attributes with values that trigger, are observed by, or are affected by the Feature Operation. The feature catalogue template includes a list of the affected feature types (shown in Figure B.4 as 'parameter name') and the affected attributes. In addition to the signature specified in the GFM *operation*, the feature catalogue template also provides for a 'name', 'definition', and 'formal definition' of a Feature Operation. The formal definition includes both the signature and the equations governing the Feature Operation, expressed in a formal language. Therefore, the 'signature' in a Feature Catalogue is a derived attribute obtained as part of the formal definition.

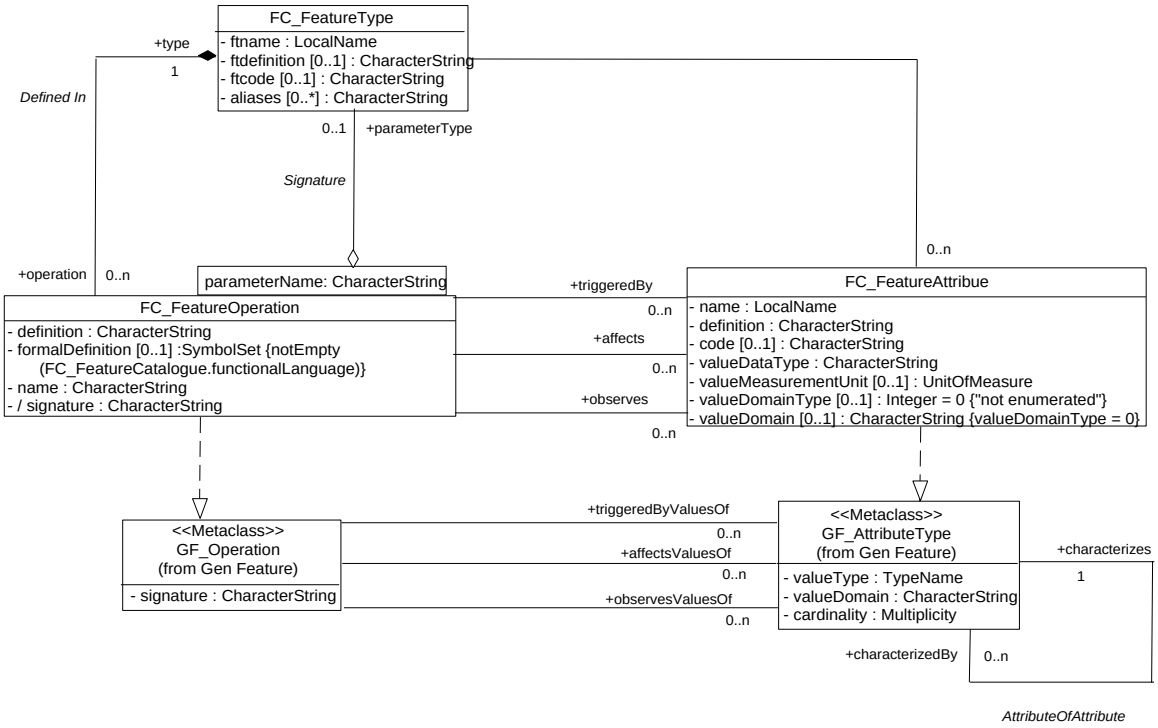

Figure B.4 — Derivation of FC_FeatureOperation from GF_Operation

Annex C
(informative)

Feature cataloguing concepts

C.1 Introduction

A feature catalogue forms a repository for a set of definitions to classify real world phenomena of significance to a particular universe of discourse. The catalogue provides a means for organizing the data that represent these phenomena into categories so that the resulting information is as unambiguous, comprehensible, and useful as possible.

In the past, it has been common practice to isolate and distinguish three separate aspects of geographic features: the definitions used to group them into types, the attributes associated with each type, and the relationships among the types. Within this general framework, the operations (also called 'behaviours' or 'functions') of the features have generally been included as part of the definitional criteria, and have been expressed only in terms of the natural language definitions. As the following examples will show, the attributes of features and the relationships among them have a much richer meaning when viewed in the context of how the features operate. Within this context, attributes provide measures of the state of a feature as it exhibits certain kinds of behaviour over time, not just static measures of the differences among features at a given instant in time. Relationships can also be seen in this active sense, that one phenomenon's behaviour or condition is affected by the operation of another one.

Although, for the purpose of this International Standard, feature operations are presented as a fourth major aspect of feature classification, they represent a difference in point of view as much as they do a difference in kind. In a functional specification, an operation is triggered by, returns or affects a value (i.e., a feature attribute value) for a given type of geographic feature. If values are observed or affected for more than one feature, the operation also specifies a relationship between them. By including feature operations as an additional dimension of classification, this International Standard seeks to support the anticipated transition from current practice to a future, more rigorously functional, approach.

When presented in the form of a conceptual schema language, a catalogue of feature types may provide additional specificity according to the syntax of the particular language. For example, a particular schema may distinguish mandatory from optional attributes and relationships, specify well-defined rules for relationships such as aggregation and association, provide cardinality information for attributes and relationships, provide consistency rules, and enable automatic syntax checking of a feature catalogue.

C.2 Feature operations

Feature operations are frequently included in the natural language definitions of the types. They are important for several reasons. First and foremost, they are the distinguishing characteristics that are embedded in the perceptions of the human beings who distinguish one type of geographic feature from another: they have psychological and behavioural significance to the people who use geographic information. Another reason is that computer systems are increasingly able to represent geographic phenomena, not just as a static set of maps, but as a dynamic representation of events occurring in geographic space in real time. Still another reason is that interoperability is an increasingly important goal in the design of geographic information systems. Functional equivalence of features is the key to interoperability of geographic information systems in the emerging open systems environment.

Feature operations are of two kinds: observer functions and constructor functions. Observer functions return the current values of attributes. Constructor functions include actions that change those values. For example, an

observer function may be used to find the height of a dam. Raising the dam is a constructor function that changes the height of the dam and also affects the attributes of the watercourse and the reservoir associated with the dam.

C.3 Feature attributes

Feature attributes are derived directly from feature operations. For example, the volume of traffic over the bridge is a measure of its behaviour. All bridges exhibit the operation of carrying traffic, making this property a part of the definition of the feature.

Other feature attributes may be indirectly derived for a feature. For example, the 'clearance' is an important attribute of a bridge because it limits the height of vessels that can pass under it. This attribute results from a different operation, the navigation of vessels in the water under the bridge. Therefore, in specifying the attributes for a feature it is important to consider the operations that are performed on it as well as those that are performed *by* it.

Finally, in a catalogue, there may be feature attributes included for a given feature that are unrelated to any operation specified in the catalogue. For example, the catalogue may define a feature 'mountain' that has no specified operations, but includes the attribute 'altitude'. There is an operation 'air navigation' that relies on observing the altitude of a mountain, even though air navigation is not a kind of behaviour engaged in by mountains nor specified elsewhere in the feature catalogue. The catalogue producers have included the attribute in response to perceived (but unspecified) external demands for information about mountains.

C.4 Feature relationships

C.4.1 Kinds of relationships

Feature relationships may be one of two kinds – generalization or association. Associations may include aggregations or other logical relationships. Feature operations, attributes, and associations are properties that are inherited through generalization relationships.

Note that the term 'superclass' is sometimes used ambiguously to refer to generalizations, aggregations, or other logical relationships, and 'subclass' to refer to the more specific features involved in these relationships. In this International Standard, a 'superclass' is simply another feature type, usually one with a more general membership.

C.4.2 Generalization

In generalization, the members of one feature type are automatically members of another feature type by definition. For example, a bridge is a transportation feature if a bridge is defined by the operation 'carries traffic' and a more general feature 'transportation feature' is also defined by the operation 'carries traffic'.

Generalization implies inheritance of properties, e.g., feature operations, feature attributes, and feature associations, from the more general to the more specific. The generalization of feature types may or may not result in a hierarchical organization. Many feature types have multiple operations and attributes; therefore, generalization may result in a pattern of multiple inheritance of properties. For example, the feature type 'bridge' may belong both to the general class of 'transportation feature' for road features and to the general class of 'hazards' for navigation features.

Generalization is thus an inheritance relation between feature types. It is supported in Table B.1 of annex B by the optional element ‘subtype of’ for feature types.

C.4.3 Aggregation

Instances of features are grouped into different types that have different properties. For example, a 'canal lock' is composed of walls, gates, and a portion of a canal. The operation of moving vessels around a dam or rapid is not performed by the walls or gates by themselves, but only when they are aggregated to form a lock. Similarly, a 'road network' has some properties that are not inherited by the individual roads composing the network.

The aggregation association does not imply a hierarchical organization of feature types unless all the members of each constituent feature also belong to the aggregate feature. For example, not all walls are part of canal locks. It is a potential relationship to which individual instances of a feature may or may not belong.

C.4.4 Other logical relationships

In the bridge example, there is a relationship between the watercourse and the bridge because of the operation of navigation on the watercourse which is affected by the clearance of the bridge. The association between the feature type 'watercourse' and the feature type 'bridge' is neither a generalization nor an aggregation. A logical relationship of 'transportation related' might be specified to include bridges, watercourses, roads, and the feature type 'signs'. The operation 'carries traffic' does not apply to signs so the association 'transportation related' is not a generalization. Again, the organization of other logical relationships is not necessarily hierarchical: for example, not all signs are transportation related.

C.5 Synonyms and included terms

In Part 2 of the Spatial Data Transfer Standard (U.S. Department of Commerce: 1992), there are many 'included terms' listed for some 'standard terms'. The included terms may be subtypes of a more general feature, or they may be synonyms or near synonyms that have overlapping definitions with a term selected as the 'standard term'. In Part 4 of the Digital Geographic Information Exchange Standard (Digital Geographic Information Working Group: n.d.), for each defined feature and code, there are equivalent terms listed in several languages. Where the features are different (with regard to operations, attributes, or associations), they should be included in the feature catalogue as distinct terms with their own definitions. Where an included term is a functionally equivalent synonym, it may be listed as an 'alias' after the definition of the main feature term.

Annex D illustrates several possibilities. For the feature 'building', many different functions of a building are listed as values of the attribute 'building use'. The features 'transportation' and 'water body' are defined to have an 'aggregation' association with other features. For other features, the aliases suggest terms from other catalogues that may be functionally equivalent to the feature named in the subject feature catalogue. Producers of the catalogue should take care to ensure that the meaning of alias terms is precisely equivalent (with regard to operations, attributes, and associations) for a given purpose. Functional specifications of the feature types provide an unambiguous method for evaluating equivalence.

C.6 Examples of feature operations

C.6.1 Feature types 'road' and 'watercourse'

In this International Standard, it is recommended that defining operations and associations explicitly will provide less ambiguous definitions of feature types. The first of the following examples, based on a specification for the feature type 'road' in Vector map - Level 1, will demonstrate this concept for a road catalogue entry. A second example is shown to illustrate the operation of navigation on the feature type 'watercourse'. The source of definitions for the first two examples is the Feature and Attribute Coding Catalog (FACC) of the Digital Geographic Information Working Group. A third example, derived from definitions in the Spatial Data Transfer Standard, illustrates the operations of the feature type 'dam' in relation to the feature types 'watercourse' and 'reservoir'. The third example uses the Gofer functional programming language (JONES 1993) to specify the feature operations of a dam.

C.6.2 Feature type 'road'

C.6.2.1 Enabling data type 'road vehicle'

In order to define the operations of the feature 'road' it is necessary to consider the related data type 'road vehicle'. By knowing the characteristics of the vehicle it is possible to determine whether or not the road is passable.

C.6.2.2 'Road vehicle' specification

NAME **ROADVEHICLE**

SYNTAX OF OPERATIONS:

VEHICLEWIDTH: V → i

VEHICLETRACKED: V → b

VEHICLEWHEELED: V → b

VEHICLELOADCLASS: V → i

VEHICLEHEIGHT: V → i

SEMANTICS OF OPERATIONS:

pre-VEHICLEWIDTH(v) ::= **true**

post-VEHICLEWIDTH(v;i) ::= i=*width_of_vehicle*

pre- VEHICLETRACKED(v) ::= **true**

post- VEHICLETRACKED(v;b) ::= **if** *vehicle_tracked* **then** b=**true**

else b=**false**

pre- VEHICLEWHEELED(v) ::= **true**

post- VEHICLEWHEELED(v;b) ::= **VEHICLETRACKED**(v,b);

b = **NOT** b

pre- VEHICLELOADCLASS(v) ::= **true**

post- VEHICLELOADCLASS(v;i) ::= i=*load_class_of_vehicle*

pre- VEHICLEHEIGHT(v) ::= **true**

post- VEHICLEHEIGHT(v;i) ::= i=*height_of_vehicle*

WHERE ...

b	The set consisting of Boolean values *true* and *false*.
i	The set of integers
V	The set of RoadVehicles.

C.6.2.3 'Road' specification

FEATURE TYPE NAME:	Road
FEATURE TYPE DEFINITION:	An openway for the passage of vehicles, persons or animals on land.
FEATURE TYPE CODE:	AP030
FEATURE ATTRIBUTES:	Existence Category, Minimum Travelled Way Width,
	Weather Type Category

FEATURE OPERATIONS: RoadPassable

FEATURE RELATIONSHIPS: GeneralisedAs

FEATURE ATTRIBUTES:

ATTRIBUTE NAME: Existence Category

ATTRIBUTE DEFINITION: See FACC

ATTRIBUTE CODE: EXS

ATTRIBUTE DOMAIN: Enumerated

LABEL	CODE	DEFINITION
Unknown		0
Under Construction		5
Operational		28

ATTRIBUTE NAME: Minimum Traveled Way Width

ATTRIBUTE DEFINITION: See FACC

ATTRIBUTE CODE: WD1

ATTRIBUTE DOMAIN: Integer

UNITS	RANGE
dm	>25

ATTRIBUTE NAME: Weather Type Category

ATTRIBUTE DEFINITION: See FACC

ATTRIBUTE CODE: WTC

ATTRIBUTE DOMAIN: Enumerated

LABEL	CODE	DEFINITION
Unknown		0
All Weather		1
Fair/Dry Weather		2
Winter Only		3

FEATURE OPERATIONS:

NAME RoadPassable

DEFINITION : Indicates whether a Road is passable by a given RoadVehicle. Takes into account WeatherTypeCategory, the ExistenceCategory of the Road and the MinimumTraveledWayWidth.

FEATURE OPERATION ATTRIBUTES:

WeatherTypeCategory, ExistenceCategory and MinimumTraveledWayWidth

OBJECT FEATURE TYPE: None

FORMAL DEFINITION :

SYNTAX OF OPERATIONS

ROADPASSABLE: R, V, SY, WT → b

SEMANTICS OF OPERATIONS

pre- ROADPASSABLE(r,v,sy,wt) ::= **true**

post- ROADPASSABLE(r,v,sy,wt;b) ::=

if (**GETROADEXISTENCECATEGORY**(r) = 28) **AND**

((sy = *winter* **AND GETROADWEATHERTYPECATEGORY**(r) = 3) **OR**

(**GETROADWEATHERTYPECATEGORY**(r) = 1) **OR**

(**GETROADWEATHERTYPECATEGORY**(r) = 2 **AND** wt = *Fair/Dry*))

AND (**VEHICLEWIDTH**(v)<= **GETROADMINIMUMTRAVELEDWAYWIDTH**(r))

b= **true**

else

b = **false**

WHERE ...

b The set consisting of Boolean values *true* and *false*.

i The set of integers.

R The set of road instances.

SY The set of seasons, consisting of *spring*, *summer*, *autumn* and *winter*.

V The set of RoadVehicles.

WT The set of weather conditions consisting of *Fair/Dry, Rain,* and *Snow/Ice.*

FEATURE RELATIONSHIPS:

NAME: GeneralisedAs

DEFINITION: Grouped into the super-feature of Transportation Features

$\forall w \in \mathbf{R}$ [$w \in \mathbf{T}$]

WHERE ...

R The set of Road Instances

T The set of TransportationElement Instances

FEATURE TYPES: Road, TransportationElement

C.6.3 Feature type 'watercourse'

C.6.3.1 Enabling data type 'inland water vehicle'

As with the feature type 'road', it is necessary to consider the related abstract data type 'inland water vehicle' in order to determine whether a watercourse is navigable.

C.6.3.2 'Inland water vehicle' specification

NAME **INLANDWATERVEHICLE**

SYNTAX OF OPERATIONS:

BARGEWIDTH: V $\rightarrow$ i

BARGETONNAGE: V $\rightarrow$ i

BARGEDRAFT: V $\rightarrow$ i

SEMANTICS OF OPERATIONS:

pre-BARGEWIDTH(v) ::= **true**

post-BARGEWIDTH(v;i) ::= i=*width_of_barge*

pre- BARGETONNAGE(v) ::= **true**

post- BARGETONNAGE(v;i) ::= i=*load_class_of_boat*

pre- BARGEDRAFT(v) ::= **true**

post- BARGEDRAFT(v;i) ::= i=*maximum_draft_of_boat*

WHERE ...

i The set of integers

V The set of InlandWaterVehicles.

C.6.3.3 'Watercourse' specification

FEATURE TYPE NAME: Watercourse

FEATURE TYPEDEFINITION: A way or course through which water may or does flow.

FEATURE TYPE CODE: BH020 | BH030 | BH140

FEATURE ATTRIBUTES: Existence Category, Width

FEATURE OPERATIONS: WatercourseNavigable

FEATURE RELATIONSHIPS: GeneralisedAs, AggregatedFrom

FEATURE ATTRIBUTES:

ATTRIBUTE NAME: Existence Category

ATTRIBUTE DEFINITION: See FACC

ATTRIBUTE CODE: EXS

ATTRIBUTE DOMAIN: Enumerated

LABEL	CODE	DEFINITION
Unknown	0	
Under Construction	5	
Abandoned/Disused	6	
Navigable	32	

ATTRIBUTE NAME: Width

ATTRIBUTE DEFINITION: See FACC

ATTRIBUTE CODE: WID

ATTRIBUTE DOMAIN: Integer

UNITS	RANGE
dm	>0

FEATURE OPERATIONS:

NAME Watercourse Navigable

DESCRIPTION : Indicates whether a Watercourse is navigable by a given InlandWaterVehicle. Takes into account Width and ExistenceCategory of the Watercourse.

FEATURE OPERATION ATTRIBUTES: ExistenceCategory, Width

OBJECT FEATURE TYPE: None

FORMAL DEFINITION :

SYNTAX OF OPERATIONS:

WATERCOURSENAVIGABLE: W,V → B

SEMANTICS OF OPERATIONS

pre- WATERCOURSENAVIGABLE(w,v) ::= **true**

post- WATERCOURSENAVIGABLE(w,v;b) ::=

if (**GETWATERCOURSEEXISTENCECATEGORY**(w) = 32) **AND**

AND (**BARGEWIDTH**(v)< **GETWATERCOURSEWIDTH**(w))

b= **true**

else

b = **false**

WHERE ...

B The set consisting of Boolean values *true* and *false*.

V The set of InlandWaterVehicles.

W The set of Watercourse instances.

FEATURE RELATIONSHIPS:

NAME: GeneralisedAs

DEFINITION: Grouped into the super-feature of Transportation Features

$\forall w \in \mathbf{W}\ [w \in \mathbf{T}]$

WHERE ...

W The set of Watercourse Instances

T The set of Transportation Instances

FEATURE TYPES: Watercourse, Transportation

NAME: AggregatedFrom

DEFINITION: Feature Watercourse formed from the union of the set of Canal, Ditch and River/Stream Features

$\mathbf{W} = \mathbf{C} \cup \mathbf{D} \cup \mathbf{R}$

WHERE ...

C The set of Canal Instances

D The set of Ditch Instances

R The set of River/Stream Instances

W The set of Watercourse Instances

FEATURE TYPES: Watercourse, Canal, Ditch, River/Stream

C.6.4 Feature type 'dam'

C.6.4.1 Before constructing a dam

The following example uses the Gofer functional programming language to specify the feature type *dam* algebraically. The definition for a dam given in the Spatial Data Transfer Standard is 'a barrier constructed across a watercourse to control the flow or raise the level of water' [implicitly: '...in a reservoir'].

Features can be defined in Gofer as 'abstract data types'. 'Operations' in Gofer correspond to *feature operations*. 'Axioms' in Gofer specify the results of each operation in terms of the attribute values of the types. 'Observer functions' simply return the current value of an existing attribute or one derived from others by mathematical

manipulation. 'Constructor functions' affect the values of one or more attributes of the subject feature or a related feature. Taken together, the 'abstract data types' and the 'operations' of a feature constitute the 'signature' of that feature. Such 'signatures' provide a formal basis for assessing the interoperability of feature definitions between applications and datasets.

In the example of a *dam*, we can take the natural-language definition and picture a series of operations as illustrated below. First, while the dam is only proposed, we have a single feature, the *watercourse*, with attributes of depth[2)] and flow. The situation can be represented algebraically in Gofer (Specification 1), with an abstract data type Watercourse, the only operations of which are to observe the depth and flow of the stream (operations *streamDepth* and *streamFlow)*.

Specification 1:

```
--abstract data type

data Watercourse          =  Stream (Int,Int)

--operations (observer functions)

streamDepth              ::  Watercourse -> Int
streamFlow               ::  Watercourse -> Int

--axioms

streamDepth (Stream(u,v)) =  u
streamFlow (Stream(u,v))  =  v
```

C.6.4.2 Constructing a dam

The first phrase in the definition of *dam* is, 'a barrier constructed across…' So, we have two conditions of dam, the one under construction and the one ready to operate. As a result of constructing the dam, several changes occur. Of course, there is a new dam where there was none before. The *watercourse* is now split into two parts that will behave differently, an upstream part and a downstream part. Also, a portion of the valley through which the watercourse flows is about to be flooded. This area will become a new *reservoir*.

The algebraic specification now involves the features *dam* and *reservoir* in addition to *watercourse*. The operations include constructing a dam and creating a new reservoir. We then observe that the new dam is (as yet) open, its height is zero, and its discharge is zero. The new reservoir is empty and its depth is also zero. The maximum height of the dam is set at the time of construction (Specification 2).

Specification 2:

```
--abstract data types

data Dam        = ConstructDam (Int) | Operate (Dam,Int,Int)
data Watercourse=Upstream(Int,Int)|Downstream(Watercourse,Int,Int)
data Reservoir  = NewReservoir (Int) | Fill (Reservoir, Int)

--operations (observer functions)

maxHeight       :: Dam -> Int
damHeight       :: Dam -> Int
damOpen         :: Dam -> Bool
streamDepth     :: Watercourse -> Int
streamFlow      :: Watercourse -> Int
reservoirDepth  :: Reservoir -> Int
reservoirEmpty  :: Reservoir -> Bool
```

2) To simplify the metrics of the problem, one can assume that the gradient of the watercourse and its cross-sectional area, taken together, result in a constant value for the attribute "stream depth" over the segments where the dam will be built. One can then use this attribute to operationalize the variable "water level" in the definition of dam.

```
--axioms

maxHeight (ConstructDam (k))    = k
damHeight (ConstructDam (k))    = 0
damOpen (ConstructDam (k))      = True
streamDepth (Upstream(u,v))     = u
streamDepth (Downstream(w,u,v)) = streamDepth (Upstream (u,v))
streamFlow (Upstream(u,v))      = v
streamFlow (Downstream(w,u,v))  = streamFlow (Upstream (u,v))
reservoirDepth (NewReservoir(m))          = 0
reservoirEmpty (NewReservoir(m))          = True
```

C.6.4.3 Raising a dam

The next operation is to raise the height of the dam and begin to fill the reservoir. We add the operation of raising the dam, which results in the dam being closed and stopping the flow of water downstream. We add a condition to the operation of raising the dam that prevents the dam from being raised higher than its maximum possible height (or lower than zero). The mutual interdependence of the features is reflected in more complex operations and equations (Specification 3).

Specification 3:

```
--abstract data types

data Dam        = ConstructDam (Int) | Operate (Dam,Int,Int)
data Watercourse= Upstream(Int,Int)|Downstream(Watercourse,Int,Int)
data Reservoir  = NewReservoir (Int) | Fill (Reservoir, Int)

--operations (damRaise is a constructor function)

damRaise       :: (Dam,Int) -> Dam
maxHeight      :: Dam -> Int
damHeight      :: Dam -> Int
discharge      :: Dam -> Int
damOpen        :: (Dam,Watercourse,Reservoir) -> Bool
damClose       :: (Dam,Watercourse,Reservoir) -> Bool
streamDepth    :: (Dam,Watercourse,Reservoir) -> Int
streamFlow     :: (Dam,Watercourse,Reservoir) -> Int
reservoirDepth :: (Dam,Watercourse,Reservoir) -> Int
reservoirEmpty :: (Dam,Watercourse,Reservoir) -> Bool

--axioms

maxHeight (ConstructDam(k)) = k
maxHeight (Operate (d,i,j)) = maxHeight (d)
damHeight (ConstructDam(k)) = 0
damHeight (Operate (d,i,j)) = i
discharge (ConstructDam(k)) = 0
discharge (Operate (d,i,j)) = j

streamDepth (d,Upstream(u,v),l) = u
streamDepth (d,Downstream(w,u,v),l)
| damClose (d,w,l) == True = 0
| damOpen (d,w,l) == True  = streamDepth (d,w,l)
    + reservoirDepth(d,w,l) - damHeight (d)
| otherwise                = streamDepth (d,Upstream(u,v),l)
streamFlow (d,Upstream(u,v),l)  = v
streamFlow (d,Downstream(w,u,v),l)
| damClose (d,w,l) == True = 0
| damOpen (d,w,l) == True = streamFlow (d,w,l)
   + discharge (d)
| otherwise              = streamFlow (d,Upstream(u,v),l)

damOpen (ConstructDam (k),w,l) = True
damOpen (Operate(d,k),w,l) = damHeight(d) < reservoirDepth (d,w,l)
```

```
reservoirEmpty (ConstructDam(d),w,l) = True
reservoirDepth (ConstructDam(d),w,l) = 0

damRaise (ConstructDam (d),h)         = error
    "Cannot raise height of a dam under construction"
damRaise (Operate (d,i,j),h)
        | (h>i) && (h < maxHeight(d)) = Operate (d,h,j)
        | otherwise = error "Illegal new height for dam"
damClose (d,w,l) = damHeight (d) > reservoirDepth(d,w,l)
```

C.6.4.4 Reservoir is full

The above state of affairs continues until the reservoir fills to the level of the dam. We add an observer function to indicate when the reservoir is full (Specification 4).

Specification 4:

```
--observer function reservoirFull

reservoirFull        :: (Dam,Watercourse,Reservoir) -> Bool
reservoirFull (d,w,l) = reservoirDepth (d,w,l) == damHeight (d)
```

When this occurs, the dam is neither 'open' (discharging extra water into the downstream segment of the watercourse) nor 'closed' (preventing any water from flowing downstream). The downstream segment of the watercourse returns to its normal upstream depth.

C.6.4.5 Lowering a dam (discharging)

An operation that has different consequences is lowering the dam. When this happens, there is a period of time when the height of the reservoir exceeds that of the dam. The downstream flow is increased relative to the upstream flow by the additional amount of discharge from the dam. The dam-lowering operation and its effects are shown in Specification 5.

Specification 5:

```
discharge :: (Dam, Watercourse, Reservoir) -> Int
discharge (ConstructDam (k),w,l) = 0
discharge (Operate (d,i,j),w,l)
 | damOpen (d,w,l) = (( reservoirDepth(d,w,l) - damHeight(d)) / streamDepth (d,w,l)) *
streamFlow (d,w,l)
 | otherwise = 0

--constructor function damLower

damLower  :: (Dam,Int) -> Dam
damLower (ConstructDam (k),h) = error "Cannot lower a new dam"
damLower (Operate (d,i,j),h)
        | (h<i) && (h >= 0) = Operate (d,h,j)
        | otherwise = error "Illegal new height for dam"
```

Eventually, the level of the reservoir falls to the height of the dam and the system is again in equilibrium (as observed by the operations 'dam not open', 'dam not closed', and 'reservoir full'). This condition was specified earlier. The only difference is that there are new values for the height of the dam and the depth of the reservoir.

Annex D
(informative)

Example feature catalogue

D.1 Introduction

A text version of an example feature catalogue is presented below (D.2). It complies with the specifications of this International Standard. The example is based on a selection of feature types from the Canadian National Topographic Data Base (NTDB), augmented with a few feature types from other catalogues. Feature operations have been formally defined for the road and dam feature types using the functional programming language Gofer (JONES 1993).

This example catalogue is not intended to satisfy the needs of any particular application, or to be complete or comprehensive in any other sense. It is intended merely to illustrate the format and content of an ISO-compliant feature catalogue.

The reader will note that the information in the catalogue body is organized alphabetically by feature type, with the feature operations, feature attributes, and feature associations placed immediately after each feature type description. The order of presentation is not prescribed by this International Standard. If there are many features that share the same attribute, for example, it may be more convenient to organize a printed catalogue into sections, with all features and their operations appearing first, all feature attributes appearing next, and so on. If the catalogue information is maintained in a database, the order of presentation will of course be independent of the storage structure.

In the following Example Catalogue, the names of feature catalogue sections and elements are presented in boldface or italics. The example feature catalogue content is shown in plain text.

D.2 Example Catalogue

FEATURE CATALOGUE

Name:	Example feature catalogue
Scope:	hydrographic, topographic
Field of Application:	Intended for illustrative purposes only, not for any particular application
Version Number:	1.4
Version Date:	2001-02-26
Definition Source:	none
Definition Type:	not applicable

Feature Catalogue Producer:

Robert D. Rugg, Project Leader
ISO 19110 Project Team
Virginia Commonwealth University
Richmond, Virginia 23284-2008
US
Voice telephone: +1 804 828 2489
Facsimile telephone: +1 804 828 6681
Electronic mail address: rugg@vcu.edu

Functional Language: Gofer

FEATURE TYPE

Name: Administrative boundary

Definition: Nonphysical line indicating the limit or extent of an officially designated division of an area or territory

Code: 2145

Aliases:

Feature Operation Names:

Feature Attribute Names: Administrative level

Feature Association Names:

Subtype of:

Feature Attribute

Name: Administrative level

Definition: Level of the administrative area enclosed by the boundary

Code: 145

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Country	1	
Province	2	
District	3	
County	4	
Other	9	

FEATURE TYPE

Name: Bridge

Definition: Raised structure built to support a road or railway and serving to span an obstacle such as a river, road, or railway

Code: 91

Aliases:

Feature Operation Names:

Feature Attribute Names: Bridge category, Bridge composition, Bridge structure, Name

Feature Association Names: Bridge share with

Subtype of:

Feature Attribute

Name: Bridge category

Definition: Type of transportation facility supported

Code: 911

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Railway	1	
Road	2	
Railway and Road	3	
Pedestrian	4	
Other	9	

Feature Attribute

Name: Bridge composition

Definition: Primary element or ingredient used in construction

Code: 912

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Steel	1	
Cement	2	
Brick	3	
Wood	4	
Iron Chain	5	
Stone	6	
Rattan	7	
Other	9	

Feature Attribute

Name: Bridge structure

Definition: Structural design characteristics of a bridge

Code: 913

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Covered	1	Has a building-like cover to protect the bridge deck
Moveable Surface	2	A section can be moved to allow passage of vessels.
Other	3	Other than Covered or Moveable Surface

Feature Attribute

Name: Name

Definition: Descriptive or official proper name

Code: 15941

Value Data Type: Character

Value Measurement Unit:

Value Domain Type:

Value Domain:

Feature Attribute Values:

Feature Association

Name: Bridge share with

Definition: Features are partially or totally contiguous or coincident

Code: 9101

Feature Type Included: Railway, Road

Order Indicator: 0 (“not ordered”)

Cardinality:

Constraints:

Role Name:

FEATURE TYPE

Name: Building

Definition: Permanent walled and roofed construction

Code: 105

Aliases:

Feature Operation Names: (see attribute Building use)

Feature Attribute Names: Building Use, Name

Feature Association Names: Building connect to

Subtype of:

Feature Attribute

Name: Building use

Definition: Use of a building

Code: 1051

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Arena	1	Enclosed, large surface used for sporting activities
Barn/Machinery Shed	3	Large utility building on a farm complex
Cabin	4	Building in a remote or wilderness area
Dome	10	Structure with a roof formed by grouped, rounded arches rising from a round base, normally used for storing salt or sand for road maintenance
Electric Power Station	11	Building where electricity is generated
Fire Station	12	Building housing fire-fighting equipment
Grain Elevator	14	Building used for the storage of grain, usually located along a railway
Hospital	17	Institution where sick or injured people receive medical care
Kiln (tobacco)	18	Permanent, heated enclosure used for drying tobacco
Museum	21	Public building set aside for the exhibition of natural, historic, artistic, or scientific objects
Observatory	22	Building equipped for astronomical observations
Railway Station	27	Building along a railway where the train stops to load and unload passengers or freight
Satellite Tracking Station	29	Building containing receiving devices to record information from satellites
Trading Post	33	Building, in a remote area, where goods are purchased or exchanged
Warden/Ranger Station	34	Building housing national/provincial park or forestry administrative offices

Feature Attribute

Name: Name

Definition: Descriptive or official proper name

Code: 15941

Value Data Type: Character

Value Measurement Unit:

Value Domain Type:

Value Domain:

Feature Attribute Values:

Feature Association

Name: Building connect to

Definition: When there is a geometric intersection of the features

Code: 1052

Feature Type Included: Railway, Road

Order Indicator: 0 (“not ordered”)

Cardinality:

Constraints:

Role Name: Applies only to Building Use value 27 (Railway Station)

FEATURE TYPE

Name: Coastline

Definition: Demarcation line between sea and land surface

Code: 456

Aliases: Coastal shoreline

Feature Operation Names:

Feature Attribute Names: Material composition category

Feature Association Names:

Subtype of:

Feature Attribute

Name: Material composition category

Definition: Primary element or ingredient

Code: 4561

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Boulders	8	

Clay	16
Gravel	46
Mud	65
Rock/Rocky	84
Sand	88
Shingle	98
Stone	108

FEATURE TYPE

Name:	Dam
Definition:	Barrier constructed across a watercourse to control the level or flow of water in the watercourse or the level of water in a reservoir
Code:	359
Aliases:	Barrage, Weir
Feature Operation Names:	Raise dam
Feature Attribute Names:	Dam height, Dam type, Maximum height, Name
Feature Association Names:	Dam connect to, Dam share with
Subtype of:	

Feature Operation

Name:	Raise dam
Attribute Names:	Maximum height, Dam height, Reservoir depth, Stream depth, Stream flow
Object Feature Type Names:	Watercourse, Reservoir
Definition:	The action of raising the dam causes changes in the discharge from the dam. The rate of discharge, in turn, affects the flow of water in the downstream segment of the watercourse and the depth of water in the reservoir behind the dam.

Formal definition:

```
--Feature Type Dam and related feature types

data Dam         = ConstructDam (Int) | Operate (Dam,Int,Int)
data Watercourse = Upstream (Int,Int) | Downstream (Watercourse,Int,Int)
data Reservoir   = NewReservoir (Int) | Fill (Reservoir, Int)

--Operations

maxHeight       :: Dam -> Int
damHeight       :: Dam -> Int
raiseDam        :: (Dam,Int) -> Dam
lowerDam        :: (Dam,Int) -> Dam
damOpen         :: (Dam,Watercourse,Reservoir) -> Bool
damClose        :: (Dam,Watercourse,Reservoir) -> Bool
discharge       :: (Dam,Watercourse,Reservoir) -> Int
```

```
streamDepth     :: (Dam,Watercourse,Reservoir) -> Int
streamFlow      :: (Dam,Watercourse,Reservoir) -> Int

reservoirEmpty       :: (Dam,Watercourse,Reservoir) -> Bool
reservoirFull        :: (Dam,Watercourse,Reservoir) -> Bool
reservoirDepth       :: (Dam,Watercourse,Reservoir) -> Int

--Axioms

maxHeight (ConstructDam(k)) = k
maxHeight (Operate(d,i,j)) = maxHeight(d)
damHeight (ConstructDam(k)) = 0
damHeight (Operate (d,i,j)) = i
raiseDam (ConstructDam (d), h) = error "Cannot raise height of dam under construction"
raiseDam (Operate (d,i,j),h)
        | (h>i) && (h< maxHeight(d)) = Operate (d,h,j)
        | otherwise = error "Illegal new height for dam"
lowerDam (ConstructDam (d),h) = error "Cannot lower a newly constructed dam"
lowerDam (Operate (d,i,j),h)
        | (h<i) && (h >= 0) = Operate (d,h,j)
        | otherwise = error "Illegal new height for dam"
damOpen (ConstructDam (k),w,l) = True
damOpen (Operate(d,i,j),w,l) = damHeight (d) < reservoirDepth (d,w,l)
damClose (d,w,l) = damHeight (d) > reservoirDepth(d,w,l)
discharge (ConstructDam(k),w,l) = 0
discharge (Operate (d,i,j),w,l)
        | damOpen (d,w,l) = (( reservoirDepth (d,w,l) - damHeight (d)) / streamDepth
(d,w,l)) * streamFlow (d,w,l)
        | otherwise = 0

streamDepth (d,Upstream(u,v),l) = u
streamDepth (d,Downstream(w,u,v),l)
        | damClose (d,w,l) == True = 0
        | damOpen (d,w,l) == True = streamDepth (d,w,l)
               + reservoirDepth(d,w,l) - damHeight (d)
        | otherwise = streamDepth (d,Upstream(u,v),l)
streamFlow (d,Upstream(u,v),l) = v
streamFlow (d,Downstream(w,u,v),l)
        | damClose (d,w,l) == True = 0
        | damOpen (d,w,l) == True = streamFlow (d,Upstream(u,v),l)
               + discharge (d,w,l)
        | otherwise = streamFlow (d,Upstream(u,v),l)

reservoirEmpty (ConstructDam(d),w,l) = True
reservoirEmpty (Operate (d,i,j),w,l) = reservoirDepth (d,w,l) == 0
reservoirEmpty (d,w,NewReservoir(m)) = True
reservoirEmpty (d,w,Fill(l,m)) = m == 0
reservoirFull (d,w,l) = reservoirDepth (d,w,l) == damHeight (d)
reservoirDepth (ConstructDam(d),w,l) = 0
reservoirDepth (Operate (d,i,j),w,l)
        | reservoirFull (d,w,l) = damHeight (d)
        | reservoirEmpty (d,w,l) = 0
reservoirDepth (d,w,NewReservoir(m)) = 0
reservoirDepth (d,w,Fill(l,m)) = m
```

Feature Attribute

Name:	Dam height
Definition:	Vertical distance from base of dam to level where water spills over
Code:	damHeight
Value Data Type:	numeric

Value Measurement Unit: meters

Value Domain Type: 0 (“not enumerated”)

Value Domain: positive real numbers

Feature Attribute Values:

Feature Attribute

Name: Dam type

Definition: Method used to control the flow of water

Code: 3591

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Other	1	All other than Sluice Gate
Sluice Gate	2	Device for regulating water through a sluice or irrigation canal

Feature Attribute

Name: Maximum height

Definition: highest possible dam height

Code: MaxHeight

Value Data Type: Numeric

Value Measurement Unit: meters

Value Domain Type: 0 (“not enumerated”)

Value Domain: positive real numbers

Feature Attribute Values:

Feature Attribute

Name: Name

Definition: Descriptive or official proper name

Code: 15941

Value Data Type:	Character
Value Measurement Unit:	
Value Domain Type:	
Value Domain:	
Feature Attribute Values:	

Feature Association

Name:	Dam connect to
Definition:	When there is a geometric intersection of the features
Code:	3592
Feature Type Included:	Railway, Road, Water Body, Watercourse
Order Indicator:	0 (“not ordered”)
Cardinality:	
Constraints:	
Role Name:	

Feature Association

Name:	Dam share with
Definition:	When features are partially or totally contiguous or coincident
Code:	3593
Feature Type Included:	Railway, Road, Water body, Watercourse
Order Indicator:	0 (“not ordered”)
Cardinality:	
Constraints:	
Role Name:	

FEATURE TYPE

Name:	Railway
Definition:	Roadbed with rails on which trains and other equipment can travel
Code:	934
Aliases:	Railroad
Feature Operation Names:	
Feature Attribute Names:	Railway gauge, Railway traction, Railway type, Relationship to the ground, Status

Feature Association Names: Railway connect to, Railway share with

Subtype of:

Feature Attribute

Name: Railway gauge

Definition: Size of gauge used

Code: 9341

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Narrow	1	Railway in which the rails are 0.967 m apart
Special	2	Railway-like feature, such as a subway or miniature railway
Standard	3	Railway in which the rails are 1.435 m apart

Feature Attribute

Name: Railway Traction

Definition: The form of locomotion

Code: 9342

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Electrified	1	Provides electric power for engines
Non-electrified	4	Does not provide electric power for engines

Feature Attribute

Name: Railway type

Definition: The type of railway on a single railroad bed

Code: 9343

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Multiple	1	More than one set of rails on the same roadbed
Side Track	2	Track connected to the main track such as a siding, passing track, spur, or wye
Single	3	Only one set of rails on the roadbed

Feature Attribute

Name: Relationship to the ground

Definition: Support on which the feature type is built

Code: 9344

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Ground Level	1	Built directly on the ground
Other	2	Built on a structure such as a bridge or dam, or in a tunnel

Feature Attribute

Name: Status

Definition: Operational status of a Feature Type

Code: 9345

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Abandoned	1	No longer suitable for traffic. A minimum of repair could restore it to limited service.
Operational	2	In use or full operation
Under Construction	3	Being built when surveyed in the field

Feature Association

Name: Railway connect to

Definition: When there is a geometric intersection of the features

Code: 9346

Feature Type Included: Dam, Railway, Road

Order Indicator: 0 (“not ordered”)

Cardinality:

Constraints:

Role Name:

Feature Association

Name: Railway share with

Definition: When features are partially or totally contiguous or coincident

Code: 9347

Feature Type Included: Bridge, Dam, Road

Order Indicator: 0 (“not ordered”)

Cardinality:

Constraints:

Role Name:

FEATURE TYPE

Name:	Reservoir
Definition:	Natural or artificial pond or lake used for the storage and regulation of water
Code:	765
Aliases:	Storage pond
Feature Operation Names:	
Feature Attribute Names:	Reservoir depth
Feature Association Names:	
Subtype of:	Water body

Feature Attribute

Name:	Reservoir depth
Definition:	Maximum vertical distance from the water surface to the bottom of the reservoir
Code:	7651
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0 (“not enumerated”)
Value Domain:	positive real numbers
Feature Attribute Values:	

FEATURE TYPE

Name:	Road
Definition:	Open way for the movement of motor vehicles on land
Code:	1594
Aliases:	
Feature Operation Names:	Road passable
Feature Attribute Names:	Name, Number of Lanes, Relationship to the Ground, Road Classification, Road Number, Road Surface, Road Weather Type, Road Width, Status
Feature Association Names:	Road connect to, Road share with
Subtype of:	

Feature Operation

Name: Road passable

Attribute Names: Status, Road weather type, Road width

Object Feature Type Names:

Definition: Road passable indicates whether or not a road is passable for a vehicle of a given width. The related abstract data type Vehicle is not a geographic feature.

Formal Definition:

```
--Feature Type Road and related abstract data type Vehicle

data Vehicle    = RoadVehicle (Int)
data Road       = BuildRoad (Bool) | TravelRoad (Road,Int,Int,Char)

--Operations

vehicleWidth    :: Vehicle -> Int
status          :: Road -> Bool
roadWeatherType :: Road -> Int
roadWidth       :: Road -> Int
name        :: Road -> Char

roadPassable    :: (Vehicle,Road) -> Bool

--Axioms

vehicleWidth (RoadVehicle (a)) = a

status (BuildRoad(e)) = e == True
roadWeatherType (TravelRoad (e,f,g,h)) = f
roadWidth (TravelRoad (e,f,g,h)) = g
name (TravelRoad (e,f,g,h)) = h

roadPassable (v,r) = status (r) &&
                        roadWeatherType (r) == 1 &&
                        (vehicleWidth (v) <= roadWidth (r))
```

Feature Attribute

Name: Name

Definition: Descriptive or official proper name

Code: 15941

Value Data Type: Character

Value Measurement Unit:

Value Domain Type:

Value Domain:

Feature Attribute Values:

Feature Attribute

Name: Number of lanes

Definition: Number of lanes of the road, including both directions

Code: 15942

Value Data Type: Integer

Value Measurement Unit: lanes

Value Domain Type: 0 (“not enumerated”)

Value Domain: 1 to 6

Feature Attribute Values:

Feature Attribute

Name: Relationship to the ground

Definition: Support on which the feature type is built

Code: 9344

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Ground Level	1	Built directly on the ground
Other	2	Built on a structure such as a bridge or dam, or in a tunnel

Feature Attribute

Name: Road classification

Definition: Classification of a road

Code: 15944

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Highway	1	Road for motor vehicles designed for high-speed travel, usually lacking rail or road intersections
Main	2	Numbered thoroughfare
Secondary	3	Local or rural road not assigned a number
Street	4	Public road in a residential or commercial area with buildings on one or both sides
Rapid Transit	5	Road restricted to vehicles of the public transportation system

Feature Attribute

Name: Road number

Definition: Number assigned to a road

Code: 15945

Value Data Type: Character

Value Measurement Unit:

Value Domain Type:

Value Domain: free text

Feature Attribute Values:

Feature Attribute

Name: Road surface

Definition: Composition of the road surface

Code: 15946

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine

Hard Surface	1	Surface made of concrete, asphalt, or gravel
Loose Surface	2	Surface other than concrete, asphalt, or gravel

Feature Attribute

Name: Road weather type

Definition: Weather conditions for which a road is maintained

Code: roadWeatherType

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
All Season	1	Maintained for use at all seasons of the year
Season	2	Maintained for seasonal use only

Feature Attribute

Name: Road width

Definition: Measurement of the extent from shoulder to shoulder

Code: RoadWidth

Value Data Type: Real

Value Measurement Unit: meters

Value Domain Type: 0 (“not enumerated”)

Value Domain: positive real numbers

Feature Attribute Values:

Feature Attribute

Name: Status

Definition: Operational status of a Feature Type

Code: 9345

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Abandoned	1	No longer suitable for traffic. A minimum of repair could restore it to limited service.
Operational	2	In use or full operation
Under Construction	3	Being built when surveyed in the field

Feature Association

Name: Road connect to

Definition: When there is a geometric intersection of the features

Code: 159410

Feature Type Included: Barrier/Gate, Dam, Railway, Road

Order Indicator: 0 (“not ordered”)

Cardinality:

Constraints:

Role Name:

Feature Association

Name: Road share with

Definition: When features are partially or totally contiguous or coincident

Code: 159411

Feature Type Included: Bridge, Dam, Railway

Order Indicator: 0 (“not ordered”)

Cardinality:

Constraints:

Role Name:

FEATURE TYPE

Name: Sounding

Definition: Measured depth of water at a specified location

Code: 936

Aliases:

Feature Operation Names:

Feature Attribute Names: Sounding depth

Feature Association Names:

Subtype of:

Feature Attribute

Name: Sounding depth

Definition: Vertical distance from the surface to the bottom of a water body

Code: 9361

Value Data Type: Real

Value Measurement Unit: meters

Value Domain Type: 0 (“not enumerated”)

Value Domain: positive real numbers

Feature Attribute Values:

FEATURE TYPE

Name: Transportation

Definition: Generic theme that aggregates features used to define a road network

Code: 9

Aliases:

Feature Operation Names:

Feature Attribute Names:

Feature Association Names: Transportation is composed of

Subtype of:

Feature Association

Name: Transportation is composed of

Definition: Features included in the theme transportation

Code: 901

Feature Type Included: Road, Bridge

Order Indicator: 0 (“not ordered”)

Cardinality:

Constraints:

Role Name:

FEATURE TYPE

Name:	Wall
Definition:	Vertical structure constructed to enclose or divide an area
Code:	1423
Aliases:	Fence
Feature Operation Names:	
Feature Attribute Names:	
Feature Association Names:	Wall connect to
Subtype of:	

Feature Association

Name:	Wall connect to
Definition:	When there is a geometric intersection of the features
Code:	14230
Feature Type Included:	Wall
Order Indicator:	0 (“not ordered”)
Cardinality:	
Constraints:	
Role Name:	

FEATURE TYPE

Name:	Water body
Definition:	Generalization of water feature types
Code:	1440
Aliases:	
Feature Operation Names:	
Feature Attribute Names:	Name, Water body type
Feature Association Names:	Water Body Connect To
Subtype of:	

Feature Attribute

Name: Name

Definition: Descriptive or official proper name

Code: 15941

Value Data Type: Character

Value Measurement Unit:

Value Domain Type:

Value Domain:

Feature Attribute Values:

Feature Attribute

Name: Water body type

Definition: Type of water body

Code: 14401

Value Data Type: Character

Value Measurement Unit:

Value Domain Type: 1 (“enumerated”)

Value Domain:

Feature Attribute Values:

Label	*Code*	*Definition*
Generic/Unknown	0	Value indicating that an attribute value is not applicable or that it is impossible to determine
Intermittent/Slough	1	Normally dry at some time of the year
Other	2	Other than Intermittent/Slough or Flooded Area
Flooded Area	3	Area always containing dead trees and not exploitable, permanently covered by water because the natural drainage has been interrupted

Feature Association

Name: Water body connect to

Definition: When there is a geometric intersection of the features

Code: 14402

Feature Type Included: Dam, Water Body

Order Indicator: 0 (“not ordered”)

Cardinality:

Constraints:

Role Name:

FEATURE TYPE

Name:	Watercourse
Definition:	Way or course through which water may or does flow
Code:	1470
Aliases:	Brook, Kill, River, Seaway, Stream
Feature Operation Names:	
Feature Attribute Names:	Stream depth, stream Flow
Feature Association Names:	
Subtype of:	Water body

Feature Attribute

Name:	Stream depth
Definition:	Maximum vertical distance from the water surface to the bottom
Code:	1471
Value Data Type:	Real
Value Measurement Unit:	Meters
Value Domain Type:	0 (“not enumerated”)
Value Domain:	positive real numbers
Feature Attribute Values:	

Feature Attribute

Name:	Stream flow
Definition:	Quantity of water flowing per unit of time
Code:	1472
Value Data Type:	Integer
Value Measurement Unit:	Cubic meters per second
Value Domain Type:	0 (“not enumerated”)
Value Domain:	positive integers
Feature Attribute Values:	

Bibliography

[1] ISO 19107:—[3] *Geographic information — Spatial schema*

[2] ISO 19108:—[3] *Geographic information — Temporal schema*

[3] ISO 19117:—[3] *Geographic information — Portrayal*

[4] ISO/IEC 11179 *Information Technology — Specification and Standardization of Data Elements; Part 3, Basic Attributes of Data Elements; Part 4, Rules and Guidelines for the Formulation of Data Elements; Part 5, Naming and Identification Principles for Data Elements*.

[5] Association Française de Normalisation (AFNOR, 1992). Échanges de données informatisées dans le domaine de l'informatique géographique — EDIGéO. Norme expérimentale française Z13-150. Section 6.2.2: pages 128-135.

[6] *Amtliches Topographisch Kartographisches Informationssystem* ATKIS (1989). Part A, Part C1, Part D0.

[7] Australian Spatial Data Exchange Centre (AUSDEC, 1993). *Guidelines for Creating a Spatial Feature Data Dictionary Suitable for the Spatial Data Transfer Standard*. Technical Report No. 3.

[8] Australian Spatial Data Exchange Centre (AUSDEC, 1992). *An Implementation Strategy for Creating an SDTS Data Dictionary*. Technical Report No. 1.

[9] Canada Department of Natural Resources, Geomatics Canada, Centre for Topographic Information (Sherbrooke) (1997). *National Topographic Database Data Dictionary*. Edition 3.1.

[10] *Catalogue for Classification and Coding Objects of Digital Topographic Map at Scales of 1:1,000,000. Part 1: The list of the objects and their codes*. *Part 2: The list of attributes. Part 3: "The list of attribute definitions.*"

[11] China State Bureau of Surveying and Mapping (1992). *Classify and Codes for National Land Information*.

[12] CNIG (1992). *Nomenclature d'échange du CNIG associée à la norme EDIGéO*.

[13] Digital Geographic Information Working Group (n.d.). *Digital Geographic Information Exchange Standard. Part 4: Feature and Attribute Coding Catalog*.

[14] Digital Geographic Information Working Group, DIGEST Technical Committee. *DIGEST/S-57 Harmonization Interface Control Document DRAFT Plan*.

[15] European Committee for Standardization, Technical Committee 278 (1995*). Geographic Data Files. Draft European Standard (GDF 3.0). Part 4: General Data Model*. Copyright reserved to CEN members.

[16] *European Territorial Data Base* (1991). Part C0.

[17] EVANGELATOS, Tim (1996). *Creating a Feature Dictionary: the CHS experience*. Submitted to the Project Team 1996-01-18.

[18] Federal Service of Geodesy and Cartography of Russia (1993). *Classifier of Topographical Information of Digital Map at the Scale of 1:1 000 000*. Roskartografia. Distribution restricted.

3) To be published.

[19] IAKOVLEVA, Raissa (1996). *Suggestions on the Methodology for Developing the Catalogue of Geographical Objects*. Moscow: Federal Service of Geodesy and Cartography, February 1996.

[20] ILLERT, Andreas (1996). *Report on ATKIS and ETDB*. Submitted to the Project Team 1996-01-30.

[21] IHO/DGIWG Harmonization Committee (1995a). *The Consolidated DIGEST and S-57 Data Model*. Information Paper to ISO/TC 211, November 1995.

[22] IHO/DGIWG Harmonization Committee (1995b). *Consolidated DIGEST and S-57 Feature/Object Catalogues*. Information Paper to ISO/TC 211, November 1995.

[23] International Hydrographic Bureau (1995). *Publication S-57, version 3.0. Object Catalogue*.

[24] International Organization for Standardization, Technical Committee for Geographic information/Geomatics, Ad Hoc Working Group 3 (1995). *Proposed Semantic Data Model for Geographic Data*.

[25] JIANG Jingtong (n.d.). *Technical Report in the Area of GIS Standardization in China*. Beijing: National Geomatics Center of China.

[26] JIANG Jingtong and LIU Ruomei (n.d.). *Research on the Data Classifying and Coding for the National Fundamental Geographic Information in China*. Beijing: National Geomatics Center of China.

[27] JONES, Mark P. (1993). *Gofer Functional Programming Environment, version 2.28*. Available on the World Wide Web at ftp://ftp.dcs.gla.ac.uk/pub/haskell/gofer/

[28] KUHN, Werner (1994). *Defining Semantics for Spatial Data Transfers*. Proceedings, Sixth International Symposium on Spatial Data Handling. Edinburgh: International Geographical Union.

[29] LAND, Nick (n.d.). *The Classification of Spatial Data: a proposal for a national standar*d.

[30] NUORA, Arto (1996). *Classification of Geographic Information in Finland*. Helsinki: the Association of Finnish Local Authorities.

[31] Rational Software Corporation (1998). *Rational Rose 98, Rose Enterprise Edition*. (Software used to generate Unified Modeling Language diagrams.)

[32] RUGG, Robert D. (1995). *Defining Standard Features for Land Use Applications*. *Cartography and Geographic Information Systems, 22:3.*

[33] RUGG, Robert D. (1994). *SDTS, FACC, and S-57: towards an international standard for geographic features*. Report prepared for the U.S. National Institute of Standards and Technology, September 7, 1994.

[34] RUGG, Robert D., Max J. EGENHOFER, and Werner KUHN (1997). *Formalizing Behavior of Geographic Features. Geographical Systems, 4 :2*

[35] Tri-Service CADD/GIS Technology Center (n.d.). *Tri-Service GIS Spatial Data Standards*, release 1.4.

[36] U.S. Department of Commerce (1992). *The Spatial Data Transfer Standard (SDTS). Federal Information Processing Standard (FIPS PUB) 173. Part 1, Annex A The Model of Spatial Features; Annex B Attribute Encoding Example; Part 2, Spatial Features*.

[37] U.S. Geological Survey (1990). *An Enhanced DLG Design. Methodology portion*.

[38] ZHDANOV, N.D., E.A. ZHALKOLVSKY, V.N. ALEXANDROV, and R.B. IAKOVLEVA (n.d.). *Establishment of Digital Database of 1:1,000,000 Scale Topographic Map for Russia*.