



BSI Standards Publication

Intelligent transport systems — Geographic Data Files (GDF) GDF5.1

Part 1: Application independent map data shared between multiple sources

National foreword

This British Standard is the UK implementation of EN ISO 20524-1:2022. It is identical to ISO 20524-1:2020. It supersedes BS EN ISO 14825:2011 and BS ISO 20524-1:2020, which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/278, Intelligent transport systems.

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English Version

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(GDF) GDF5.1 - Part 1: Application independent map data
shared between multiple sources (ISO 20524-1:2020)

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(GDF) - GDF5.1 - Teil 1: Anwendungsunabhängige
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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

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This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2023, and conflicting national standards shall be withdrawn at the latest by June 2023.

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The text of ISO 20524-1:2020 has been approved by CEN as EN ISO 20524-1:2022 without any modification.

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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.

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

A list of all parts in the ISO 20524 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

GDF5.1 (the ISO 20524 series) is an evolution of GDF5.0 that introduces the concept of Sharable Features, takes cooperative ITS (Cooperative ITS) needs into account and is harmonized with the European public transportation standard EN 12896:2012 (TRANSMODEL). This last harmonization was made in the framework of the European Opticities project.

GDF5.1 consists of two parts:

- GDF5.1 Part 1 (this document) contains GDF5.0 specification except Public Transport Theme specification which has been revised and is now described in Part 2.
- GDF5.1 Part 2 (ISO 20524-2) is dedicated to Sharable Features, Cooperative ITS and Public Transport.

This document presents the specification for GDF5.1 Part 1. GDF5.0 entities are unchanged but Public Transport Theme entities have been removed and corresponding sections and figures are deprecated and refer to GDF5.1 Part 2 (ISO 20524-2). In order to ensure the consistency between GDF5.0 and GDF5.1 Part 1 (this document), the numbering of common figures in both versions has been conserved. GDF5.1 Part 1 (this document) is divided into several parts.

After the introductory clauses, the overall conceptual data model is specified. In it, the basic building blocks of GDF and their interrelations are explained. It contains a specification of the different types of topology supported by this document. It furthermore describes how database representations of real world objects, referred to as Features, are defined. It describes the characteristics of Features, called Attributes, and the topological and non-topological interrelations between Features. Finally, it describes the organization of the Features in GDF. Semantically, Features are organized in different Feature Themes. Logically and physically, Features are organized in Sections by area or in Layers by contents.

In the Feature Catalogue, the different Features supported by this document are defined. A special case is the Features from the Services Feature Theme. Because the requirements for this Feature Theme are highly market-oriented, the Services Feature Theme does not contain any normative Features, but contains an annex comprising an informative list of service definitions to assist users of this document (see Annex C).

In the Attribute Catalogue, the different characteristics of Features, called Attributes, are defined. A usage matrix outlines applicability of Attributes per Feature Theme and per Relationship.

In the Relationship Catalogue, the different non-topological (i.e. semantic) Relationships which Features have been defined. Relationships may relate Features of different Feature Themes, or those from the same or different Section and/or Layer.

In the Feature representation rules, the possible geometrical ways in which the individual Features may be represented are specified for each topology type. This document supports zero-, one- and two-dimensional primitives and up to four-dimensional coordinates.

The specification of Features, Attributes and Relationships by no means dictates mandatory inclusion. The actual contents of GDF, apart from a minimum set of metadata elements as specified in the delivery formats, is not specified by this document since this is considered to be an issue between clients and vendors. This document allows the introduction of user-defined Features, Attributes and Relationships.

In certain cases, different alternative ways of modelling and representation are offered. Representing Features in different geographical areas also may require the use of different basic representation mechanisms, e.g. character sets, projection systems. It is important that all of these individual choices associated with GDF are specified. Furthermore, GDF should essentially be self-contained and be readable without any external specification. In order to make this possible, this document specifies ways of describing GDF by means of metadata, captured by the Metadata Catalogue.

Apart from providing a standard for the definition of geographic road databases, this document also specifies mechanisms for data exchange and delivery. In order to facilitate the definition and exchange of data, a logical view of the data organization is important. This logical view is presented in the Logical Data Structures. The data structures are specified using the data description language ESN.

Two physical implementations for data exchange and delivery are specified: the Media Record Specifications (ASCII flat file) and the XML schema specifications. These physical implementations are limited to the data specification present in GDF5.1 Part 1 (this document).

These specifications support the explicit registration of updated information, thereby allowing map databases to continue to reflect ground truth over time.

Features, Attributes and Relationships appear in the physical GDF as codes. These codes are specified in Annex A. Codes used in the metadata are given in Annex B, which is an informative part of this document. In order to access the most up-to-date information, the user is referred to the original source organization. Annex C contains the specification of Features of the theme Services as an informative part of this document. In Annex D, the syntax for specifying temporal aspects of geographic information is described. The specific rules for organizing GDF in different spatial subdivisions (Sections) is described in Annex E. As informative parts of this document, guidelines for the formation of Level 2 Features from the Feature Theme Roads and Ferries are given in Annex F. A list of local Administrative Area names in different countries is provided in Annex G, as well as illustrative examples for the description of the (non-hierarchical) geopolitical structures and their components in a number of countries. Finally, the use of notation and phonetic Attributes for character strings are illustrated in the informative Annex H. Annex H provides a range of examples showing how the different notation- and phoneme-related Attribute properties may be used to qualify name strings, in both their written and their pronounced form.

Intelligent transport systems — Geographic Data Files (GDF) GDF5.1 —

Part 1:

Application independent map data shared between multiple sources

1 Scope

This document specifies the conceptual and logical data model and physical encoding formats for geographic databases for Intelligent Transport Systems (ITS) applications and services. It includes a specification of potential contents of such databases (data dictionaries for Features, Attributes and Relationships), a specification of how these contents shall be represented, and of how relevant information about the database itself may be specified (metadata).

The focus of this document is on ITS applications and services and it emphasizes road and road-related information. ITS applications and services, however, also require information in addition to road and road-related information.

EXAMPLE 1 ITS applications and services need information about addressing systems in order to specify locations and/or destinations. Consequently, information about the administrative and postal subdivisions of an area is essential.

EXAMPLE 2 Map display is an important component of ITS applications and services. For proper map display, the inclusion of contextual information such as land and water cover is essential.

EXAMPLE 3 Point-of-Interest (POI) or service information is a key feature of traveller information. It adds value to end-user ITS applications and services.

Typical ITS applications and services targeted by this document are in-vehicle or portable navigation systems, traffic management centres, or services linked with road management systems, including public transport systems.

The Conceptual Data Model has a broader focus than ITS applications and services. It is application independent, allowing for future harmonization of this document with other geographic database standards.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 690, *Information and documentation — Guidelines for bibliographic references and citations to information resources*

ISO 639-2, *Codes for the representation of names of languages — Part 2: Alpha-3 code*

NOTE 1 Codes are available at <http://www.loc.gov/standards/iso639-2/>

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

NOTE 2 Codes are available at <https://www.iso.org/obp/ui>

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 General terms

3.1.1

cartographic primitive

atomic construction element in a cartographic representation

EXAMPLES Node, Edge and Face.

3.1.2

data file

collection of related data records having a homogeneous structure

Note 1 to entry See Reference [1].

3.1.3

data record

record containing Feature-related data

3.1.4

global record

record that logically precedes the data records and contains control parameters, data definition and documentation necessary to interpret companion data records

Note 1 to entry See Reference [2].

3.1.5

Medium Unit

object for data storage that may be considered as a physically undivided whole

EXAMPLE One floppy disk, one magnetic tape, a CD, or a DVD.

3.1.6

multi-media

any kind of data other than conventional data

EXAMPLE Graphical, audio or visual data.

3.1.7**Multi-media Object**

piece of multi-media to be processed by an application

EXAMPLE A picture, a text, a movie, or a sound.

3.1.8**repeating Attribute Type**

Attribute Type that may have multiple values associated to one and the same instance of a particular Feature Class

3.1.9**Spatial Domain**

description of the limits of a geographical area to which a particular set of data belongs spatially

3.1.10**source material**

origin of data in analogue or digital representation, stored on any kind of data medium

3.1.11**topology**

field of mathematics that deals with characteristics of geometric structures that are preserved after continual variation

Note 1 to entry See Reference [3].

3.1.12**transcription**

rendering of geographic names from a non-alphabetic script into an alphabetic one or vice versa

Note 1 to entry See Reference [4].

Note 2 to entry The term is also applied to initial recording in script of hitherto unwritten names.

3.2 Mathematical terms**3.2.1****Area Feature**

two-dimensional Feature, defined by one or more Faces

3.2.2**Edge**

directed sequence of non-intersecting Line Segments with Nodes at each end

Note 1 to entry See Reference [1].

3.2.3**enclave**

small part of an area enclosed by another area, seen from the area to which that part belongs

3.2.4**exclave**

small part of an area enclosed by another area, seen from the enclosing area

3.2.5

Face

two-dimensional element bounded by a closed sequence of Edges and by zero or more sets of non-intersecting closed sequences of Edges within the first sequence of Edges

Note 1 to entry The Face is the atomic two-dimensional element.

3.2.6

graph

set of points and a set of arrows, with each arrow joining one point to another, whereby the points are called Nodes of the graph, and the arrows are called the Edges of the graph

Note 1 to entry See Reference [1].

3.2.7

Intermediate Point

point, other than a Node, that defines the shape of an Edge

3.2.8

Line Feature

one-dimensional Feature defined as a sequence of one or more Edges

3.2.9

Node

zero-dimensional element that is a topological junction of two or more Edges, or an end point of an Edge

Note 1 to entry See Reference [1].

3.2.10

non-planar graph

graph which may not be embedded in a plane

3.2.11

planar graph

graph which may be embedded in a plane, i.e. it may be drawn on the plane so that Edges intersect only at a Node mutually incident with them

3.2.12

point

zero-dimensional element that specifies geometric location specified by one coordinate pair or triplet

Note 1 to entry See Reference [1].

3.2.13

Line Segment

Segment

direct connection between two Intermediate Points, two Nodes or a Node and an Intermediate Point

3.2.14

valency

degree

number of Edges which are incident with a particular Node

3.3 Geodetical terms

3.3.1

control point

point having known coordinates in the real world, identifiable with a corresponding point in a map or an aerial photograph or satellite image

3.3.2

ellipsoidal height

distance between a point and the reference ellipsoid, measured along the ellipsoidal normal

3.3.3

geodetic datum

mathematical surface that approximates a portion of the earth's surface

3.3.4

geoid

model of the figure of the earth that coincides with the mean sea level over the oceans and continues in continental areas as an imaginary sea level surface, defined by spirit level

Note 1 to entry At every place, geoid level/surface is perpendicular to the pull of gravity. The shape is irregular but may, for most purposes, be approximated by an oblate ellipsoid.

3.3.5

Geoid Undulation

difference between the orthometric height and the ellipsoidal height, measured along the ellipsoid normal

3.3.6

height

elevation

(vertical) distance between a point and the reference height level or the reference ellipsoid

Note 1 to entry On land maps, the reference level is commonly the mean sea level.

3.3.7

horizontal reference system

reference system for positions

3.3.8

magnetic declination

angle between Magnetic North and True North

Note 1 to entry See Reference [4].

3.3.9

map projection

transformation method used to represent the curved earth surface on a plane

3.3.10

offset

pair of values subtracted from all coordinate values in order to shorten these coordinate values

3.3.11

orthometric height

distance between a point and the geoid, measured along the perpendicular line

3.3.12

reference ellipsoid

oblate ellipsoid of revolution that is used to approximate the figure of the geoid

Note 1 to entry It is specified by two parameters: a semi-major axis a (equatorial radius of the earth) and a semi-minor axis b (polar radius). The flattening f is defined as: $f = (a - b)/a$.

3.3.13

reference height level

level to which all terrestrial heights are referred

Note 1 to entry It changes from country to country and it forms part of the national coordinate system for surveying and mapping.

3.3.14

reference system

coordinate system on which a national survey is based

Note 1 to entry See Reference [4].

3.3.15

vertical reference system

reference system for elevations

3.3.16

world geodetic system

WGS

set of standard reference ellipsoids that define latitude, longitude and height for every point on the earth

3.4 GDF terms

NOTE All Feature Classes mentioned below are defined in the Feature Catalogue.

3.4.1

Album

collection of related Datasets (logical sub-division) and, if applicable, Volumes (physical sub-division)

3.4.2

Attribute

characteristic of a Feature which is independent of other Features

Note 1 to entry See Reference [1].

3.4.3

Attribute Code

alphanumeric identifier for an Attribute Type

Note 1 to entry See Reference [5].

3.4.4**Attribute Name**

name associated to an Attribute Type

Note 1 to entry See Reference [5].

3.4.5**Attribute Type**

defined characteristic of a Feature, which is independent of the other Features

3.4.6**Attribute Value**

specific quality or quantity assigned to an Attribute

Note 1 to entry See Reference [1].

3.4.7**Dataset**

sub-division of Album, which in turn may be sub-divided into Sections

Note 1 to entry A large set of data covering a particular geographic area may be considered a Dataset.

3.4.8**District**

area regarded as a geographical unit, which is defined by the delivery of a specific public or private sector service

3.4.9**Feature**

database representation of a real-world object

3.4.10**Feature Category**

type of representation of a Feature, including Point, Line, Area and Complex Feature

3.4.11**Feature Class**

categorization of a Feature

3.4.12**Feature Class Code**

alphanumeric identifier for a Feature Class

Note 1 to entry See Reference [5].

3.4.13**Feature Name**

name associated with a Feature Class

Note 1 to entry See Reference [1].

3.4.14**Feature Theme**

specified group of related Features

3.4.15

field

set of characters representing one unit of data

3.4.16

Layer

certain subset of a Dataset based upon information contents

3.4.17

Manoeuvre

ordered sequence of a Road Element, a Junction and one or more Road Elements, and optionally associated with a Traffic Sign

3.4.18

Place

administrative area of the types: Order-i Area, Country, Supra-National Area, Administrative Place A-Z or Named Area Feature of the types: Built-up Area, Named Area, District

3.4.19

Property

combination of Attribute and Relationship values which pertain to a Feature and which together define a certain characteristic of the Feature

3.4.20

Relationship Code

alphanumeric identifier for a Relationship

3.4.21

Relationship name

name associated with a Relationship Type

Note 1 to entry See Reference [1].

3.4.22

Relationship Type

defined characteristic of a Feature which is dependent on other Features

3.4.23

Semantic Relationship

Relationship

characteristic of a Feature involving other Features

3.4.24

Section

spatial subset of a Dataset

Note 1 to entry The coverage area of a map sheet, confined by geographic coordinates, may be considered a Section.

3.4.25

Transportation Element

Road Element, Pathway, Railway Element, Path, Ferry Connection, Water Body, Water Boundary Element, Junction, Railway Element Junction or Water Boundary Junction

3.4.26**turn**

ordered sequence of a Road Element, a Junction and a Road Element

Note 1 to entry A turn is a special case of a Manoeuvre, relating exactly two Road Elements.

3.4.27**Volume**

smallest physical unit of a medium

Note 1 to entry A single Volume may contain one or more GDF Datasets depending on Dataset size.

EXAMPLE A magnetic tape, a floppy disk.

4 Symbolization and notation elements

Many of the basic concepts of GDF are best expressed diagrammatically in data models. The Unified Modeling Language (UML) [6] has been adopted as the conceptual modeling language for GDF.

Annex I provides a summary of the UML Class Diagram notation conventions used in this document.

5 Overall conceptual data model**5.1 Conceptual data models in GDF**

The general data model of GDF is presented in Figure 1 and Figure 2, Figure 4 through Figure 8, and Figure 10 through Figure 18. Detailed sub-schemas are presented in the respective clauses. The data model diagrams convey a range of dedicated terms describing concepts of the GDF model; according to UML practise, these terms are spelled using "CamelCase" notation. Textual descriptions complementing the graphical descriptions use initial capitals for each constituent word of a given GDF term.

The general data model—serving as meta-model for the respective semantic models of the individual Feature classes (see Feature Catalogue), of the individual Attribute types (see Attribute Catalogue), and of the individual Relationship Types (see Relationship Catalogue)—are presented and explained in detail in the remainder of this clause. Each Feature class, Attribute type, and Relationship Type may be considered an instance of the generic UML classes for Feature class, Attribute type, and Relationship Type, respectively, in the meta-model. This two-level notion is implemented using UML class sub-typing.

While IDs are usually not part of a conceptual model, it has been decided to explicitly include them here due to their conceptual relevance. This refers to the fact that they provide a means of unique identification of elements regardless of a particular physical realization of the GDF conceptual model. This, despite the fact that certain physical realizations may not require the use of physical IDs. Consequently, transition between different physical realizations will not result in loss of information.

5.2 The general data model of GDF**5.2.1 The Feature model**

In the centre of the model in Figure 1 resides the “Feature” which is a database representation of a real world geographic object. Examples of real world geographic objects are roads or buildings. Note that in this diagram “Feature” has the meaning of Feature instance, i.e. an individual occurrence of a geographic object, such as the Eiffel Tower in Paris.

Figure 1 shows that each Feature shall belong to exactly one Feature Class and exactly one Feature Theme. The diagram also shows that Feature Classes and Feature Themes are uniquely referenced by a name and a code.

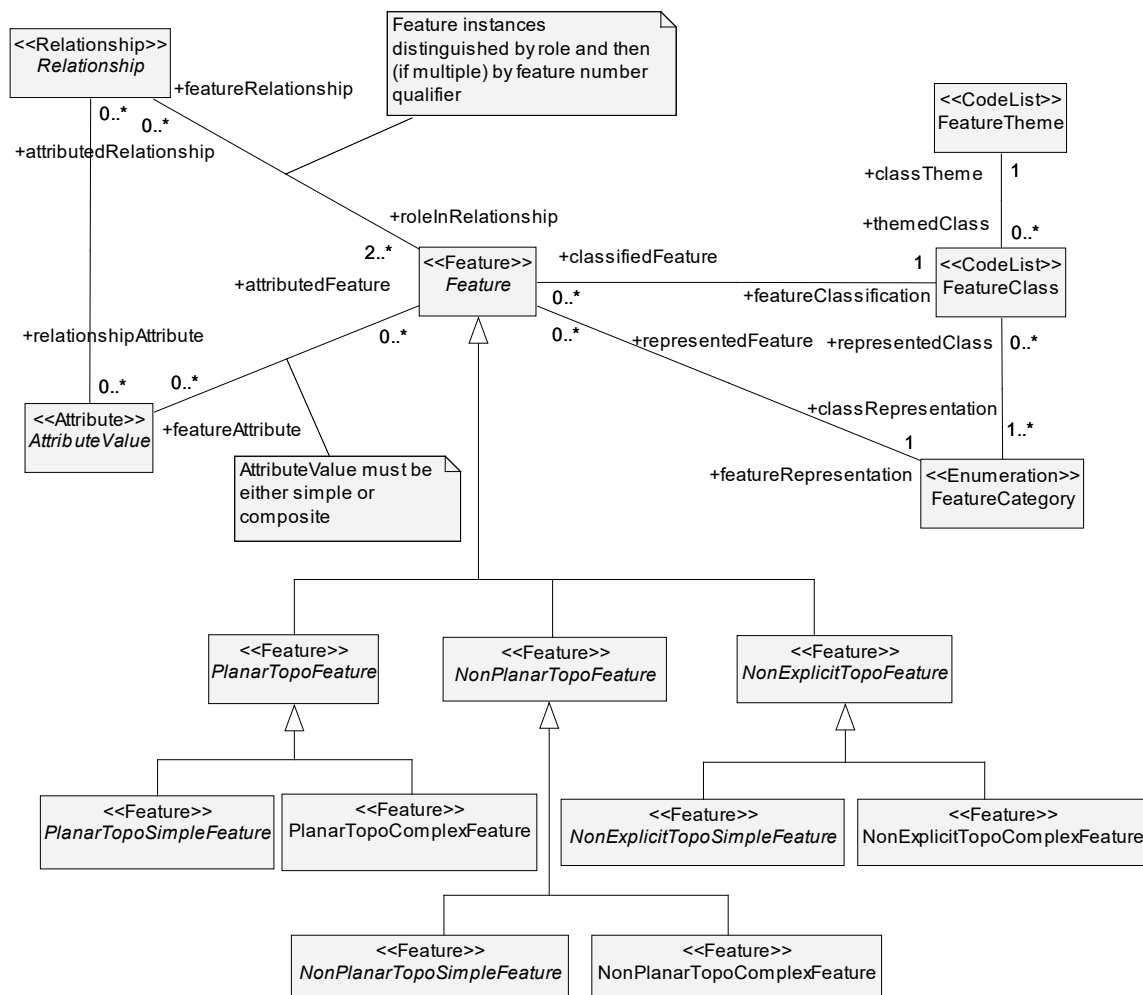


Figure 1 — Overall Conceptual Data Model

Each Feature belongs to exactly one Feature Class. This constraint is indicated in Figure 1 by the depiction of Feature Class with a multiplicity of 1 in the association between classes Feature and Feature Class. Thus, neither classless Features (Features belonging to no Feature Class) nor hybrid Features (Features belonging to multiple Feature Classes) are allowed in a GDF.

A Feature may have zero or more Attributes. Attributes serve to represent characteristics of a Feature that are independent of other Features.

A Relationship is used to associate two or more Features together. However, a Feature is not required to participate in a Relationship. A Relationship may have zero or more Attributes.

Each Feature is of exactly one Feature Category. A Feature Category is uniquely referenced by a Name and a Code. GDF defines four Feature Categories – Point, Line, Area and Complex. Collectively, Point, Line, and Area Features are referred to as Simple Features. Complex Features are aggregations of other Features, either Simple, Complex or in combination.

5.2.2 Graph topology

The first subdivision of Features relates to the topology of the underlying graph with which the Features are defined. The GDF supports three different types of graph topologies: Planar topology, Non-planar topology and Non-explicit topology:

- Non-explicit topology: No topological relations between objects are explicitly defined. That is, topological relations are only defined via coordinate values.
- Non-planar topology: Topological relations are explicitly defined; objects may fully or partially coincide, or intersect or overlap each other.
- Planar topology: Topological relations are explicitly defined; objects shall not fully or partially coincide, and shall not intersect or overlap each other. Intersecting objects or overlapping objects are broken-up into object fragments, whereby common parts (such as a street coinciding with a boundary) are present only once.

In exceptional cases this document also supports the explicit definition of topology on the Feature level²⁾.

Non-explicit topology gives the possibility to define and process data, for which topological relations are less relevant (e.g. map display data) in a very efficient way. Non-planar topology gives the possibility to perform network operations efficiently. Planar topology gives also the possibility to efficiently integrate area information in network operations.

In the GDF model, the rendering method chosen for planar topology is the full integration method, and for non-planar topology the connectivity method. Both methods are further described below.

Obviously since planar topology is a special case of non-planar topology it is quite possible to have utilized the "connectivity" approach to render the planar topology case. However, it is even conceivable (although less likely) to make use of the full integration method to render non-planar topology. It is important not to confuse the rendering choice with the topology choice.

In planar topology, the zero- and one-dimensional basic building blocks, Nodes and Edges, form a graph. In special cases where in reality two Point Features are located above each other, a single Node is being defined (possibly connected by a vertical Edge (of "length" zero) representing a Line Feature, e.g. an lift between different building levels). Furthermore, in the GDF model of topological planarity, a fully topologically integrated representation is provided for Area Features. Area Features are defined by referencing the two-dimensional building blocks, Faces, which make up that Area Feature (Figure 2).

2) This document allows the following additional explicit definitions of topology:

The start and end Point Feature of a Line Feature.

The start and end Complex Feature of a Complex Feature.

Through the use of Relationships (See below: The Relationship Model).

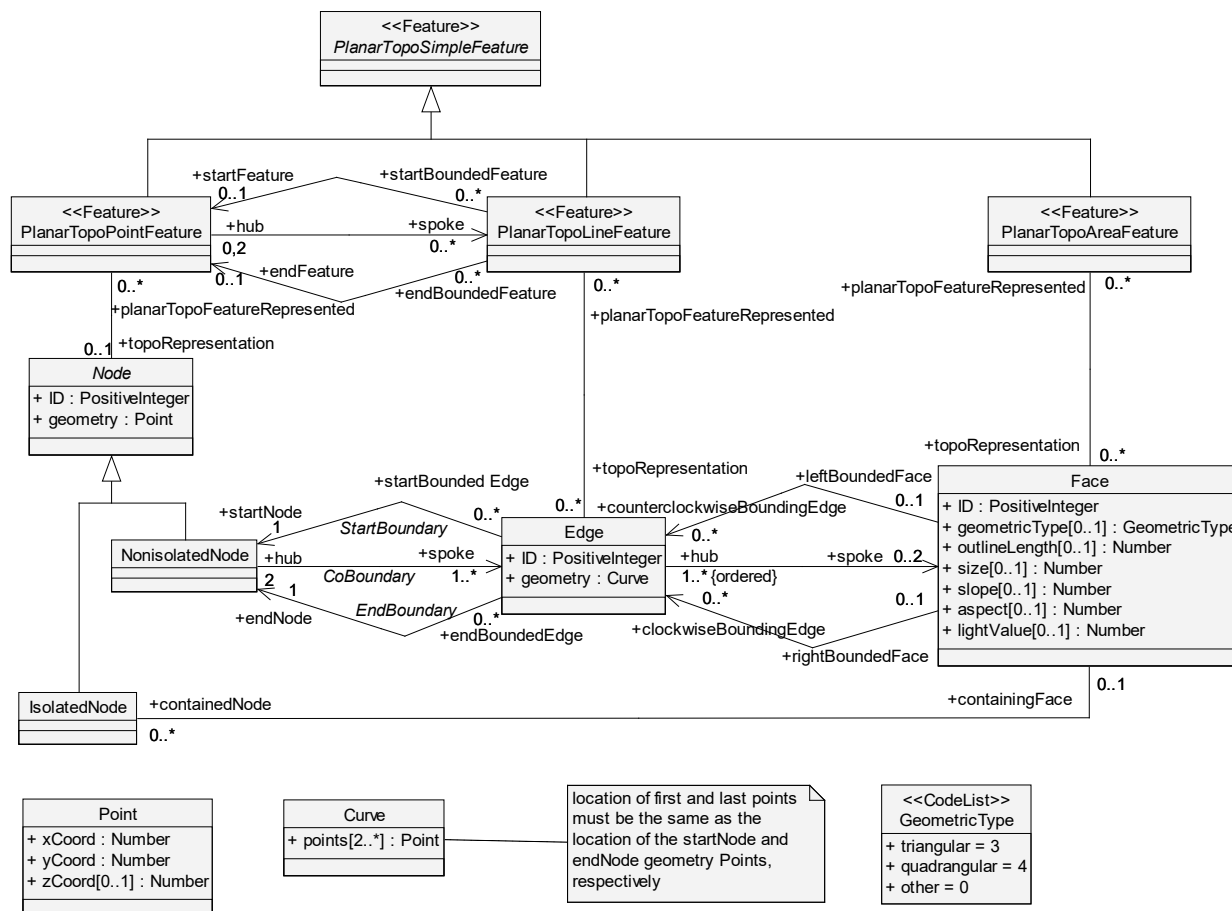


Figure 2 — Conceptual data model of Planar Topological Simple Features

Here, an Area Feature shall have at least one Face and a Face at least one Edge. This constraint is depicted in Figure 2 by the hub and spoke association between Face and Edge. The relation between a Face and its composing Edges is determined by the location of the Face relative to the Edge (left or right) relative to the direction of an Edge or, when approached from the Face, by the orientation of the Edge (clockwise or counter clockwise) when seen from the inside or the outside of the Face. This means that an Edge which bounds two Faces will have a clockwise orientation in the definition of one Face and a counter-clockwise orientation in the definition of the other Face (See Figure 3).

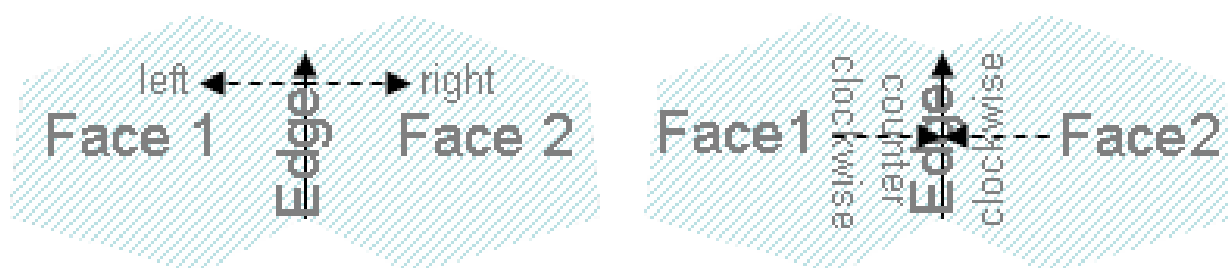


Figure 3 — Relation between Faces and bounding Edges

In non planar topology the Nodes and Edges together form a non-planar graph. That is, where in reality two Line Features cross at different levels (e.g. two roads crossing via a bridge), the Edges which represent these Line Features cross without forming a Node on the point of crossing. Also, in special cases where in reality two Point Features are located above each other, two Nodes are being defined (possibly

connected by a vertical Edge representing a Line Feature, e.g. an lift between different building levels). In the GDF model of topological non-planarity, Faces do not exist, i.e. only topological connectivity is represented. Two dimensional Features are defined by referencing the Edges making up this boundary (Figure 4).

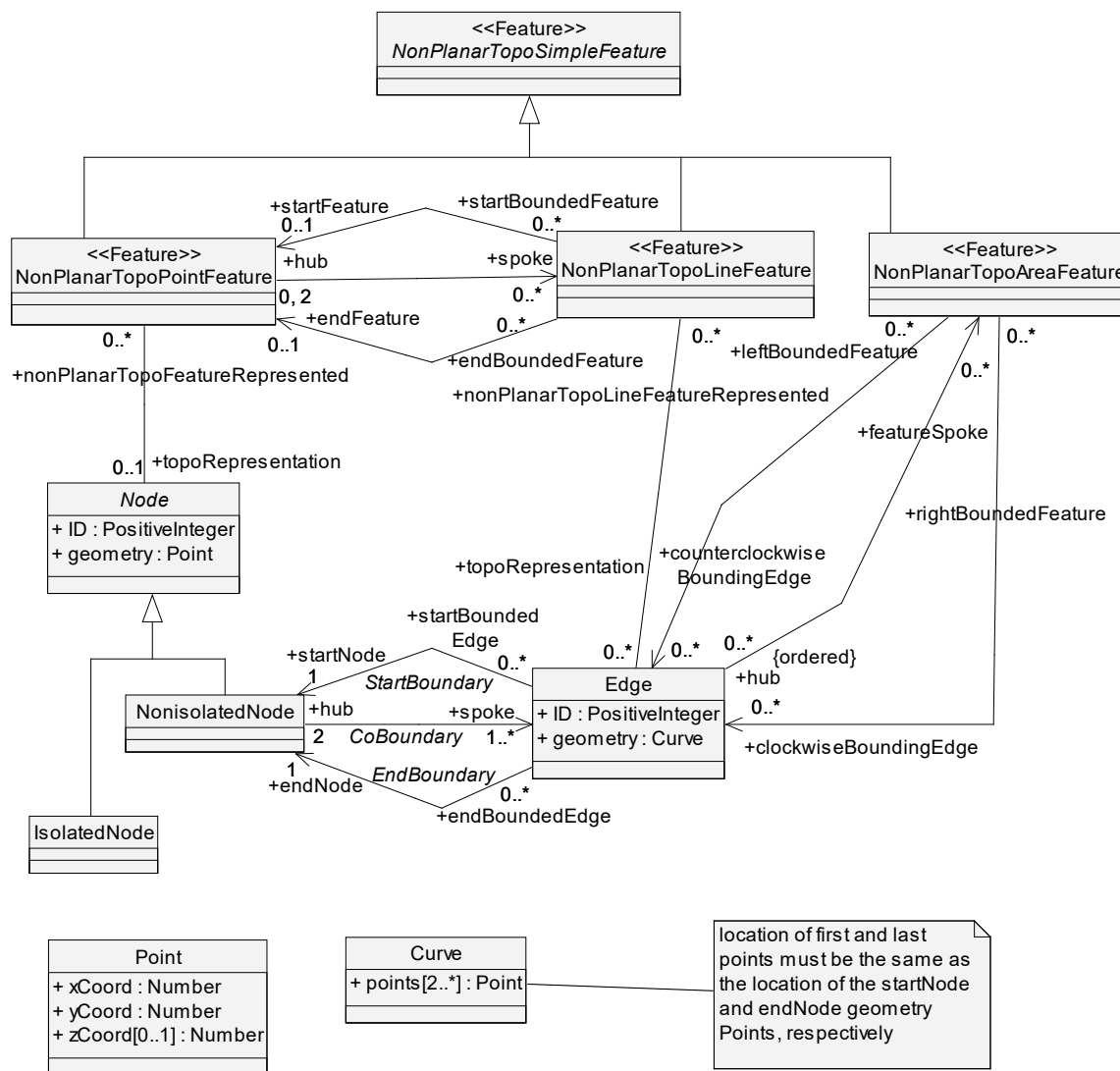


Figure 4 — Conceptual data model of Non-planar Topological Simple Features

As is stated above, in planar topology, the basic graph represents objects in a single plane. Reality however is not planar. Roads for instance may cross each other at different grades. This non-planarity shall be introduced on the Feature level³⁾.

In non-explicit topology the basic building blocks of zero-, one- and two- dimensional Features are Dots (zero dimensional), Polylines (one dimensional) and Polygons (two dimensional). Dots, Polylines and Polygons are defined without explicit topological relations.

In the remainder of this chapter, the planar topology and the non-planar topology will be both referred to as “topology” and the corresponding Features as topological Features, while the non-explicit

3) In addition to this, this document allows the definition of the height level of Edges (See 10.2.4.5).

topological way will be referred to as the non-explicit topology or NET way and its corresponding Features as “non-explicit topological or NET Features”.

In topology, Features are defined by the basic building blocks Nodes, Edges and Faces. Figure 2 and Figure 4 show that a topological Point Feature is always represented by exactly one Node, a topological Line Feature by one or more Edges and a topological Area Feature either by one or more Faces or by one or more Edges forming one or more closed boundaries. The lowest part of each Figure illustrates how the basic building blocks Node, Edge and Face (Face in planar topology only) are mutually related in each of the supported topologies. Within the conceptual model Nodes may be broken down into two types. Isolated Nodes are Nodes which do not coincide with other geometry. Otherwise a Node is considered a non-isolated Node which means it is connected to one or more Edges.

In non-explicit topology, Features are defined by the basic building blocks Dots, Polylines and Polygons. Figure 5 shows that a NET Point Feature is always represented by exactly one Dot, a NET Line Feature by exactly one Polyline and a NET Area Feature by exactly one Polygon. As may be seen, no relations are defined between these basic building blocks, thus signifying their non-explicit topological nature. An important distinction here is that in contrast with topology there is no reuse within the building blocks--neither a Polyline reuses (references) Dots, nor a Polygon reuses Polylines. Thus, shared geometry never occurs and overlapping Features need to have their building blocks replicated. In non-explicit topology reuse may occur in the definition of Complex Features.

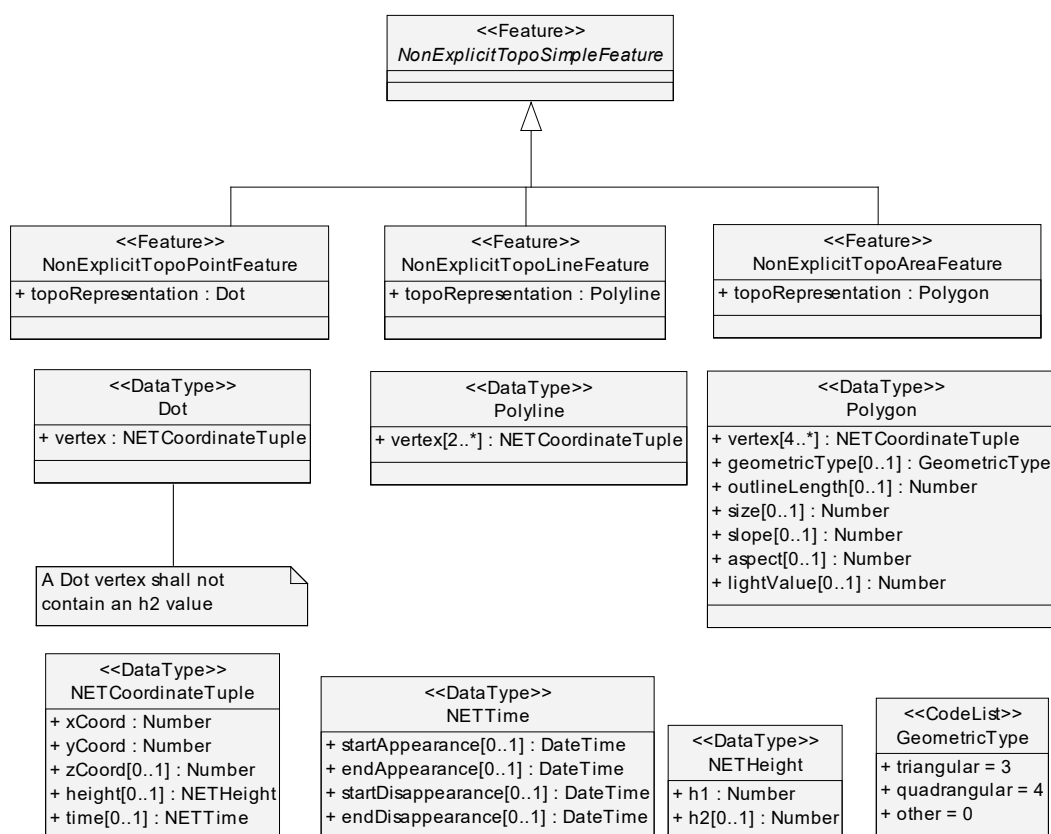


Figure 5 — Conceptual data model of NET Simple Features

It is not allowed to mix the use of topologies, i.e. a GDF Layer may only contain data from one type of topology (See Figure 14 and Figure 15).

One should note that the multiplicity of classes representing the basic geometric building blocks (Nodes, Edges and Faces) in the associations with the classes representing Features with the different Feature

Categories (Point, Line and Area) in planar and non-planar topology have zero as begin value. This indicates that geometry-less Features are allowed. I.e. this document allows the definition of Features for which the geometry is not defined.

5.2.3 Levels in GDF

The different objects together making up a GDF are conceptually divided over three different levels, Level-0, Level-1 and Level-2. The topological primitive building blocks, Node, Edge, and Face, reside on Level-0. The Simple Features, as referred to in the previous paragraph and in the data models there together make up Level-1. Simple Features may form aggregated Features which are called Complex Features. Complex Features comprise Level-2. Figure 6, Figure 7 and Figure 8 give the data model of Complex Features for the three different types of topologies. As may be seen in these figures, Complex Features may only consist of Features defined with the same topology.

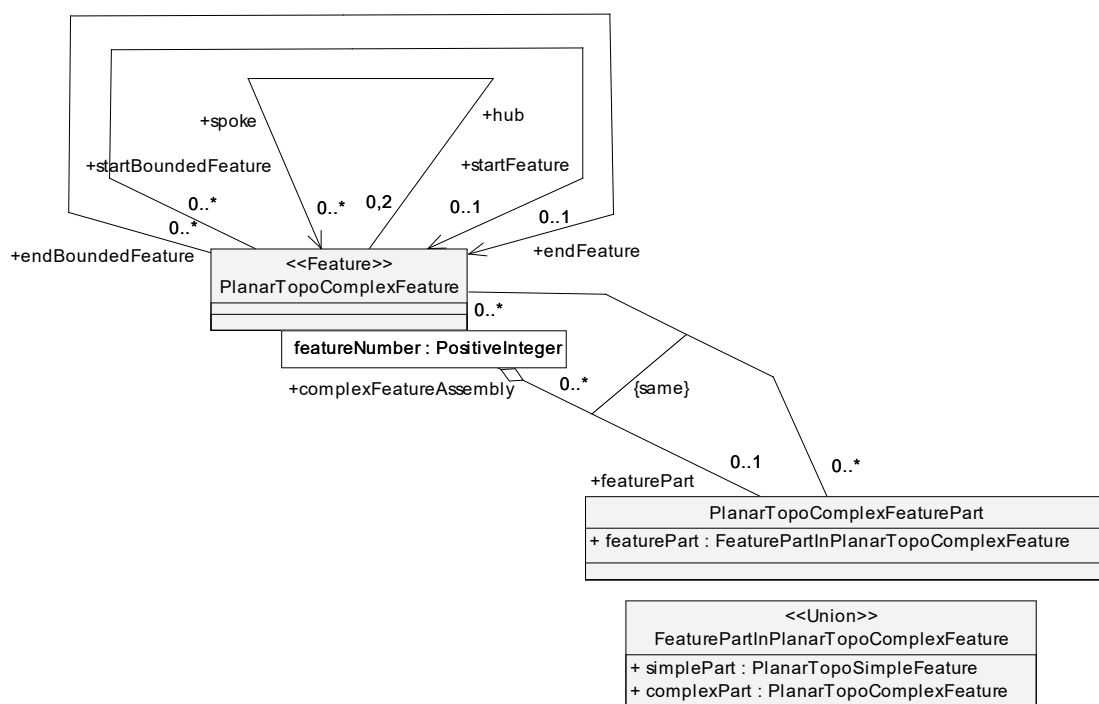


Figure 6 — Conceptual data model of Planar Topology Complex Features

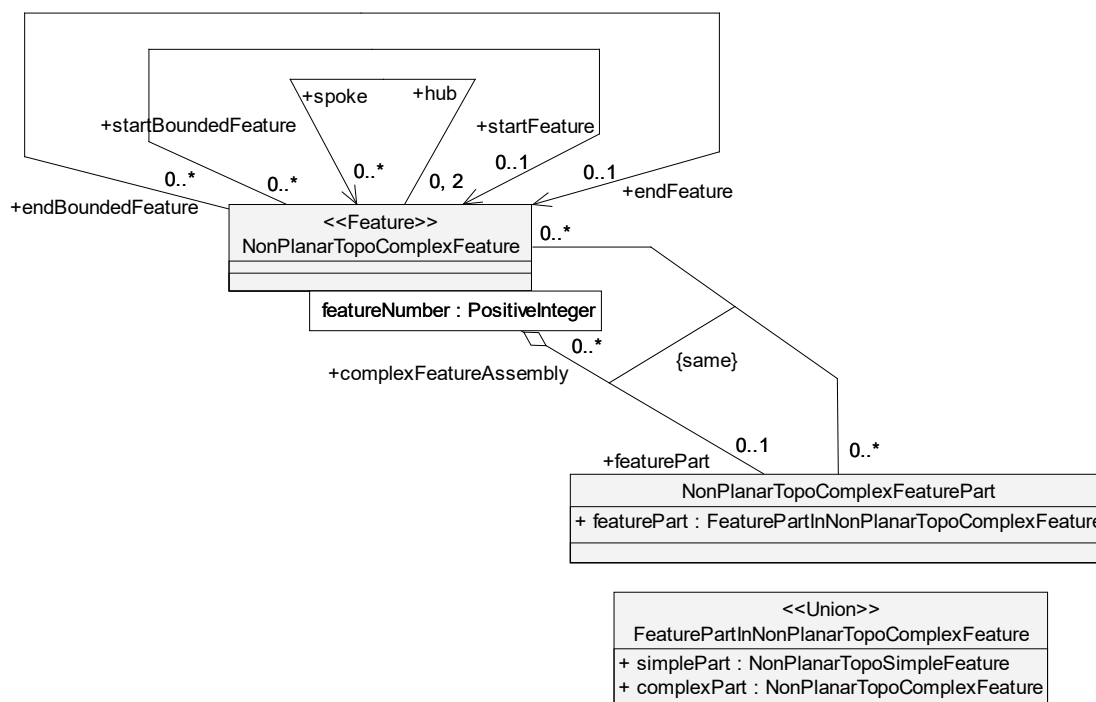


Figure 7 — Conceptual data model of Non-planar Topology Complex Features

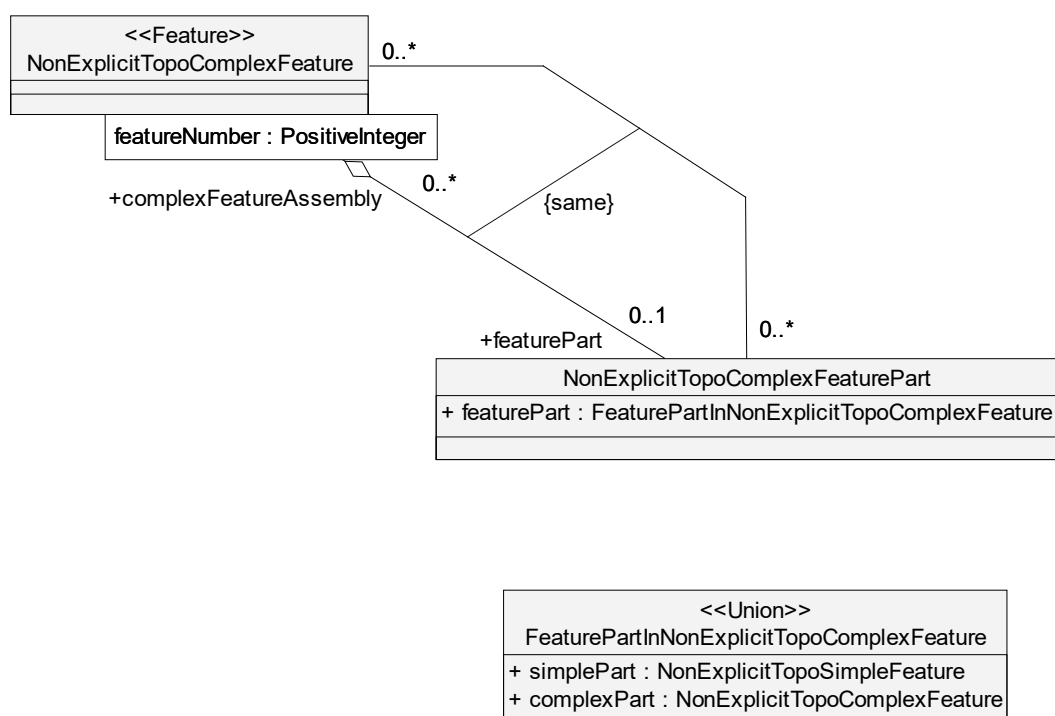


Figure 8 — Conceptual data model of Non-Explicit Topology Complex Features

5.2.4 Height modelling and time modelling

So far, the different types of topology have been described in terms of their ability to define two dimensional objects. This document however supports various levels of 3-dimensional modelling and also includes the possibility to model objects in a space-time continuum.

All different types of topology assume a two-dimensional plane to which the different Features are referred to. This document also supports the definition of elevation above this plane in the sense that all geometries defined (by Nodes, Edges, Faces, Dots, Polylines or Polygons) may be given an elevation value representing terrain height.

In addition to this, non-explicit topology supports the 3-dimensional representation of Features. Next to their horizontal and elevation geometrical definition, Features are represented 3 dimensionally by a specification for each horizontal position of their minimum height and their maximum height above the terrain. In most cases the minimum height will be zero representing a Feature which extends from the ground a certain height vertically. This refers for instance to the case in which a normal building, located on the terrain with a certain height is represented. In certain cases however a Feature will extend from a certain height above the ground a certain height vertically. This refers for instance to arch shaped buildings which have a certain part starting a certain height above the ground and extending further upward (See Figure 9).

In non-planar and planar topology 3-dimensional aspects may be modelled via an Attribute solution. If a given Non-Explicit Topology Feature is subject to both 3-dimensional representation models (namely 3-dimensional characteristics on Feature level as well as 3-dimensional characteristics of Attributes of the Feature in question), the 3-dimensional characteristics on Feature level shall be given priority over the 3-dimensional characteristics on Attribute level.

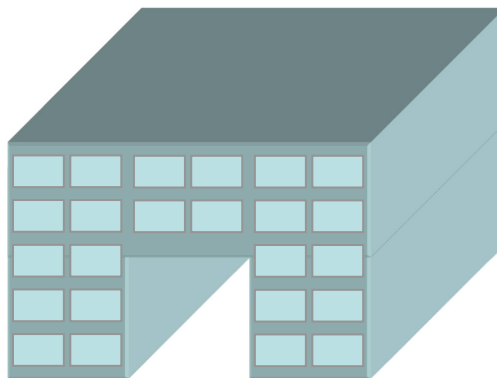


Figure 9 — Example of an arch shaped building

This document also supports terrain modelling in which a 3-dimensional representation of the terrain may be defined. Four different methods are offered for this which include support for Triangular Irregular Networks (TIN's), contour lines and point grids. For the TIN support Faces and Polygons have been extended with enhanced geometric properties such as triangle size and slope. Contour Lines and Point Grids are modelled as Features and Attributes.

This document also supports the representation of temporal characteristics of Features. This is supported for Non-Explicit Topology Features. This is done by extending each horizontal position of a Feature with four temporal definitions. These definitions stand for the moment of start of appearance (construction start), the moment of end appearance (opening), the moment of start of disappearance (closure) and the end of disappearance (demolition end). In this way the existence of a Feature over time may be represented. In non-planar and planar topology temporal aspects may be modelled via an

Attribute solution. Here the Time Domain Model of GDF (See also 5.7) is applied whereby the start time and the duration of a certain construction status may be defined.

If a given Non-Explicit Topology Feature is subject to both time models (namely temporal characteristics on Feature level as well as temporal characteristics of Attributes of the Feature in question), the temporal characteristics on Feature level shall be given priority over the temporal characteristics on Attribute level.

5.3 Attribute model

Characteristics of Features which are independent of other Features are modelled as Attributes. Attributes are of a certain Attribute Type identified by a name and code. The value of an Attribute instance is called an Attribute Value. Attribute data types include among others a code, text, an ID or number. This document defines Attributes relevant for ITS applications and specifies which Attributes may be used in combination with which Features. For Complex Features, Attributes may be defined for a Complex Feature as a whole (assembly) or for a particular Feature part on an instance by instance basis.

In certain cases, Attribute Values are defined within the GDF itself. In other cases only, the domain of the Attribute Value is specified. This is the case when the Attribute Value is a measure (e.g. Average Speed) or is defined by a string of characters (e.g. Official Street Name Text). Another case relates to user-defined Attributes. User-defined Attributes are defined by the user within the context of a particular GDF. Certain Attributes that have been defined in the GDF do not have their Attribute Values defined. For example, the Attribute Value of Multimedia File Attachment is the reference to external files rendered in binary, XML, or other physical encodings.

The Attribute Catalogue defines a set of Attribute Types and corresponding reference names and codes. It also defines the Feature Class and/or the Relationship Type to which a particular Attribute Type may be attached. Figure 10 and Figure 11 give the conceptual data model for this. The diagram shows that an Attribute may be an aggregation of other Attributes. Such an Attribute is called a Composite Attribute, as opposed to a normal (non-aggregated) or Simple Attribute. A Composite Attribute consists of a number of Sub-Attributes. Semantically, a Composite Attribute specifies an aggregated value, which is composed of a number of values, specified by the value of the respective Sub-Attribute. Their appearance in a Composite Attribute specifies the fact that they represent partial information and that the complete information may be found in the other Sub-Attributes of the Composite Attribute.

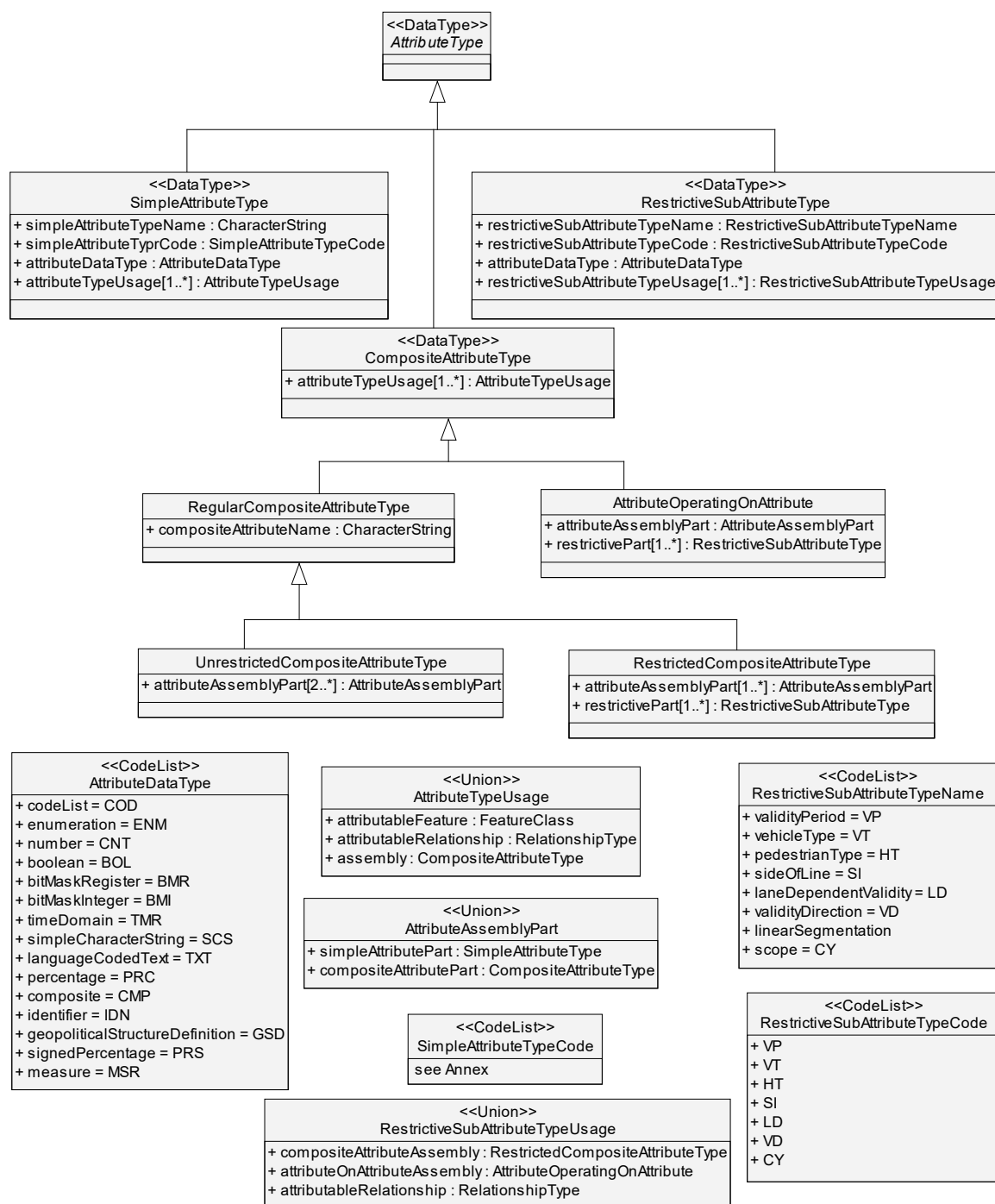


Figure 10 — Conceptual data model for Attribute Types

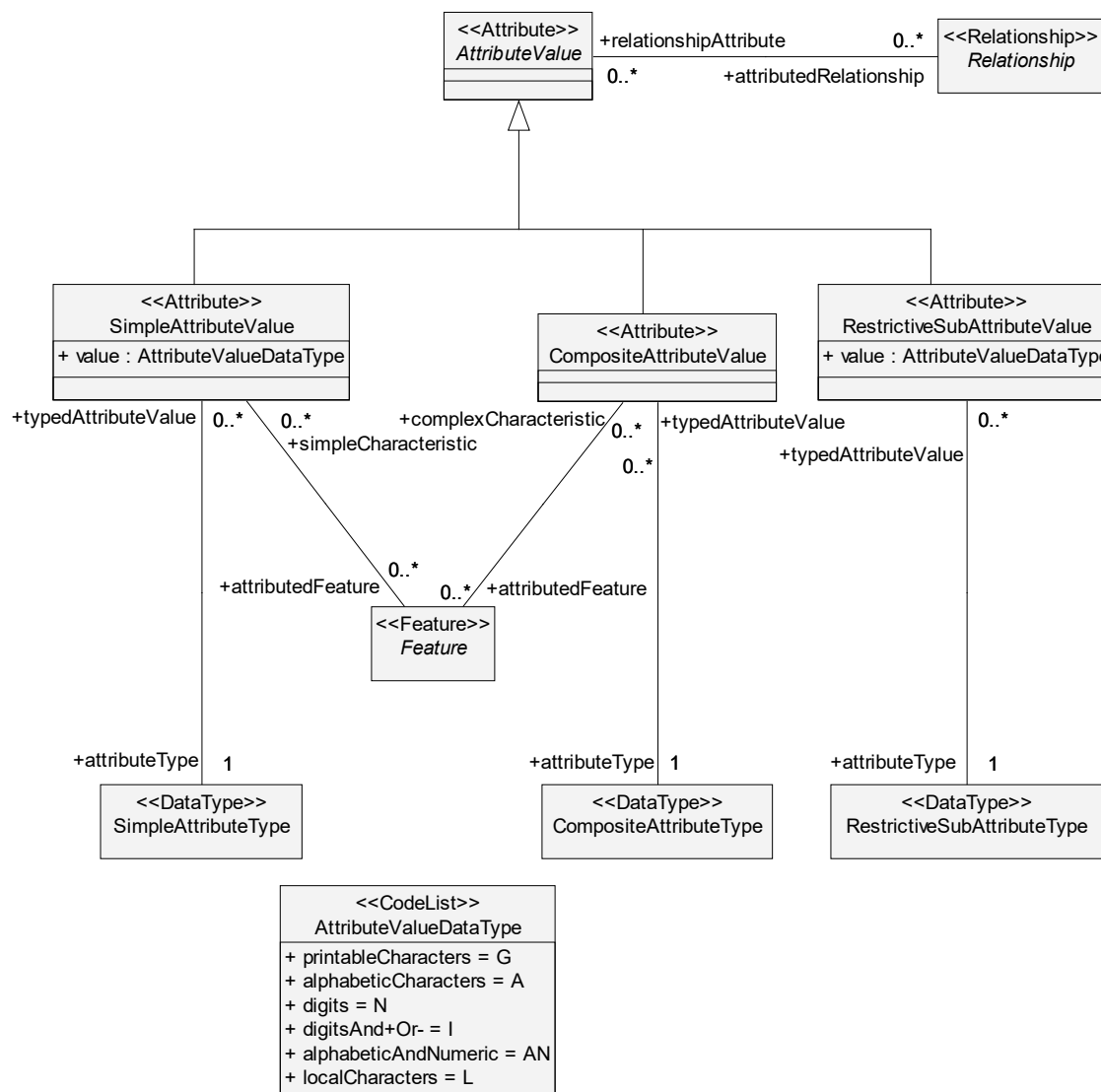


Figure 11 — Conceptual data model for Attribute Values

In most cases, like values of normal Attributes, Sub-Attributes values are independent. Cases where Sub-Attribute Values are not independent are cases where an Attribute (Simple or Composite) are combined with a so-called Restrictive Sub-Attribute operating in said Attribute. In these cases, the validity of the Attribute is restricted to the value specified in the Restrictive Sub-Attribute. Restrictive Sub-Attributes values may never be attached to a Feature individually. They shall always appear in combination with the Attribute they restrict. Restrictive Sub-Attribute Values may be attached individually to Relationship. In these cases, they restrict validity of the Relationship.

Each Sub-Attribute of a Composite Attribute is either a Simple Attribute, a Composite Attribute, or a Restrictive Sub-Attribute. Any Sub-Attribute being a Composite Attribute recursively builds a hierarchical tree of Sub-Attribute sets at different hierarchical scope level. In case a Restrictive Sub-Attribute operates on a (Simple or Composite) Attribute, it implies representing a different scope level than said Attribute.