
Geographic Data Files (GDF)

Fichiers de données géographiques



Foreword

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The main task of technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 14825, which is a Technical Report of type 2, was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee ISO/TC 204, *Transport information and control* systems, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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Directives, 1995) as a “prospective standard for provisional application” in the field of transport information and control systems because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an “International Standard”. It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO/TC 204 Secretariat.

A review of this Technical Report (type 2) will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

INTRODUCTION

The Geographic Data Files (GDF) standard has been developed to meet the needs of professionals and organizations involved in the creation, update, supply and application of referenced and structured road network data.

It has been created in order to improve the efficiency of the capture, the production and handling of road related geographic information. This increase in efficiency is obtained by supplying a common reference model on which users can base their requirements and producers can base their product definition. In addition to this, the standard facilitates the exchange of information, defined according to this reference model. For this, it contains the definition of an exchange format which avoid compatibility problems at both the users and the producer's side of the information flow. In this respect, producers and users should not be viewed as two totally distinct groups. It is envisaged that an important application of the standard will be the combination of information present in already existing geographic information data bases, into one, more comprehensive source of road-related information.

To ensure maximum compatibility with these already existing sources and also to make use of the strengths of the structure in which these sources have been defined, the basic foundation of the standard is based on a general, non-application specific data model. On top of this data model, a road network specific application model has been built. Together they make up the GDF standard. Due to its general character, the data model also is able to support other types of applications, thus facilitating the future creation of a wide variety of geographic information sources which can be combined with maximum flexibility.

The standard consists of twelve chapters, of which six (chapter 5 to 10) together form the reference model. They each contain the elaboration and definition of one clearly identifiable aspect of road related information. Chapter 4 contains a more general description of the standard. It contains the definition of the general data model as well as the definition of the basic components of the standard, thus explaining the structure of the rest of the standard.

Chapter 11 describes the logical data structure by which the conceptual models as defined in the previous chapters can be represented.

Chapter 12 defines the exchange format by which the information can be exchanged.

1. SCOPE

This standard specifies a system for the interchange of digital road related geographic information. It takes into account all the requirements of applications in the road transport and traffic telematics (RTTT) field. Within this field, the standard is application independent. The standard contains the following detailed specifications :

- a) A reference model according to which the information covered by the standard shall be defined. The core of the reference model is formed by a data model and a data dictionary in which the individual information components and their interrelations are defined.
- b) A specification of ways of representation of the information components contained.
- c) The specification how to define meta information. An important aspect is the quality of the information defined according to the standard. This aspect is dealt with separately in the sense that the methodology is defined with which the quality of the information components contained can be measured.
- d) A specification for an exchange format reflecting the reference model.

2. REFERENCES

2.1 Normative References

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- 2] National Committee for Digital Cartographic Data Standards et al.; Spatial Data Transfer Standard; U.S. Geological Survey, National Mapping Division; Columbus, Ohio, USA; June 1990
- 3] International Federation of Library Associations and Institutions, Joint Working Group on the International Standard Bibliographic Description for Cartographic Materials; ISBD(CM): International Standard Bibliographic Description for Cartographic Materials; IFLA International Office for UBC; London, U.K.; 1977
- 4] Bibliographic Systems Office, Working Group on Bibliographic Codes; Revised List of Languages and Language Codes; Library of Congress, Bibliographic Systems Office; Washington D.C., U.S.A; 1977
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- 6] ISO; International Standard ISO 6709, Standard representation of latitude, longitude and altitude for geographic point locations; International Organisation for Standardisation; 1983
- 7] ISO; International Standard ISO 3166; Codes for the representation of names of countries.; International Organisation for Standardisation; 1993
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- 19] Nijssen G.M, Halpin T.A.; Conceptual Schema and Relational Database Design - A fact oriented approach; Prentice Hall, Sydney; 1989

3. DEFINITIONS

The numbers between square brackets refer to the reference documents mentioned in 2.

3.1 General terms

3.1.1 Accuracy

The closeness of results of observations, computations or estimates to the true values or the values as accepted as being true [2]

3.1.2 Cartography

The art, science and technology of making maps, together with their study as scientific documents and works of art[15]

3.1.3 Cartographic Primitive

Atomic construction element in a cartographic representation, i.e. Node, Edge and Face.

3.1.4 Data File

A collection of related data records.[2] The records shall have a homogeneous structure.

3.1.5 Data Record

A record containing feature related data

3.1.6 Data set

A large set of data covering a particular geographic area

3.1.7 Entity

A real world phenomenon that is not subdivided into phenomena of the same kind (e.g. a bridge) [2]

3.1.8 Error Rate

The percentage of falsehoods

3.1.9 Field

A specified part of a record containing a unit of data. The unit of data may be a data element or a data item [1]

3.1.10 Geodesy

Science of determination of the shape and gravity field of the earth and of survey and mapping of the physical surface of the earth [14]

3.1.11 Geography

Science of phenomena of the earth's surface, its being and growing and its manifold relations [16]

3.1.12 Geometry

Science of the characteristics of spatial figures [16]

3.1.13 Global Record

A record that logically precedes the data records and contains control parameters, data definition and documentation necessary to interpret companion data records [ISO 8211]

3.1.14 Information Unit

A collection of information that may be regarded as an undivided whole, e.g. 1 data set, 1 section, 1 layer

3.1.15 Logical Domain

The range of attribute values to which a meaning has been assigned.

3.1.16 Logical Unit

A collection of data that may be regarded as a logically undivided whole, e.g. 1 logical record.

3.1.17 Medium Unit

An object for data storage that can be considered as a physically undivided whole, e.g. 1 floppy disk, 1 magnetic tape etc.

3.1.18 Physical Unit

A unit of data storage that may be regarded as physically undividable.

3.1.19 Precision

The closeness of measurements of the same phenomenon repeated under exactly the same conditions and using the same techniques.

3.1.20 Primitive

Fundamental form from which all other forms can be derived [17]

3.1.21 Repeating Attribute Type

An attribute type that may have multiple values associated to one and the same instance of a particular feature type.

3.1.22 Resolution

The smallest unit which can be detected. It fixes a limit to precision and accuracy.

3.1.23 Spatial Domain

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

3.1.24 Source Material

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

3.1.25 Topography

The technical and conceptual registration of the terrain, its features and properties of the landscape [14].

3.1.26 Topology

The field of mathematics that deals with characteristics of geometric structures that keep preserved after continual variation [16]

3.1.27 Transcription

Rendering of geographic names from a non-alphabetic script into an alphabetic one or vice versa. The term is also applied to initial recording script of hitherto unwritten names [15]

3.1.28 Up-to-dateness

The closeness in time of the (geographic) data to the present reality.

3.2 Mathematical terms

3.2.1 Area Feature

A two dimensional feature. An area feature is defined by one or more faces.'

3.2.2 Edge

A directed sequence of non-intersecting line segments with nodes at each end [2]

3.2.3 Enclave

Small part of an area enclosed by another area seen from the area to which that part belongs [14]

3.2.4 Exclave

Small part of an area enclosed by another area seen from the enclosing area [14]

3.2.5 Face

A two-dimensional element bounded by a closed set of edges and zero or more non-intersection inner closed set of edges. The face is the atomic two dimensional element.

3.2.6 Graph

A set of points and a set of arrows, with each arrow joining one point to another. The points are called nodes of the graph, and the arrows are called the edges of the graph [18].

3.2.7 Intermediate

A Point, not being a Node, that bounds the line segments belonging to an Edge

3.2.8 Line Feature

A one-dimensional feature. A line feature is defined by one or more edges.

3.2.9 Loop

An edge which is bounded at both ends by one and the same node.

3.2.10 Node

A zero-dimensional element that is a topological junction of two or more edges, or an end point of an edge [2]

3.2.11 Non planar graph

A graph which is not planar

3.2.12 Path

A finite, alternating sequence of nodes and edges, such that every arc is immediately preceded and succeeded by the two vertices with which it is incident and in which no vertex is repeated, except (possibly) the first and the last one. [18]

3.2.13 Planar Graph

A graph G is planar if it can be embedded in a plane. That means that it can be drawn on the plane so that edges intersect only at a node mutually incident with them.

3.2.14 Plane Graph

A planar graph embedded in the plane

3.2.15 Point

A zero-dimensional element that specifies geometric location. One coordinate pair or triplet specifies the location [2]

3.2.16 Segment

The direct connection between exactly 2 Intermediate Points

3.2.17 Valency (or Degree)

The number of edges which are incident with a particular Node.

3.3 Geodetical terms

3.3.1 Control Points

Points in the real world that are identical with points in a map or aerial photograph.

3.3.2 Ellipsoidal Height

The distance between a point and the reference ellipsoid (measured along the ellipsoidal normal).

3.3.3 Geodetic datum

The position and orientation of a particular reference ellipsoid.

3.3.4 Geoid

A 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.

At every place it is perpendicular to the pull of gravity. The shape is irregular, but can for most purposes be approximated by an oblate ellipsoid.

3.3.5 Geoid Ondulation

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

3.3.6 Height

The (vertical) distance between a point and the reference height level or the reference ellipsoid. On land maps the reference level is commonly the mean sea level.

3.3.7 Horizontal Reference System

A reference system for positions

3.3.8 Magnetic Declination

Angle between Magnetic North and True North [14]

3.3.9 Map Projection

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

3.3.10 Offset

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

3.3.11 Orthometric Height

The distance between a point and the geoid (measured along the perpendicular line).

3.3.12 Reference Ellipsoid

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

The level to which all terrestrial heights are referred. It changes from country to country and it forms part of the national coordinate system for surveying and mapping.

3.3.14 Reference System

A coordinate system on which a national survey is based [14]

3.3.15 Vertical Reference System

A reference system for elevations

3.3.16 World Geodetic System (WGS)

A three-dimensional Cartesian coordinate system, its origin being the geocentre. WGS is related to a specified gravity model.

3.4 GDF Terms

Note: All feature classes mentioned below are defined in the Feature Catalogue (Chapter 5)

3.4.1 Album

A collection of related Volumes.

3.4.2 Attribute

A characteristic of a feature which is independent of other features[2]

3.4.3 Attribute Code

An alphanumeric identifier for an attribute type [1]

3.4.4 Attribute Name

A name associated to an attribute type [1]

3.4.5 Attribute Type

A defined characteristic of a Feature, which is independent of the other features.

3.4.6 Attribute Value

A specific quality or quantity assigned to an attribute [2]

3.4.7 Completeness

Extent to which all specified features are present.

3.4.8 Correctness

Indication of whether a data item is correctly recorded according to a specified data catalogue.

3.4.9 Data Set

A collection of related data files

3.4.10 Feature

A database representation of a real world object. (see feature catalogue)

3.4.11 Feature Category

Type of representation of a feature. I.e. Point, Line, Area or Complex Feature.

3.4.12 Feature Class

An alphanumeric identifier for a feature class..

3.4.13 Feature Code

An alphanumeric identifier for a feature class [1]

3.4.14 Feature Name

A name associated with a feature class [2]

3.4.15 Feature Theme

A specified group of related features.

3.4.16 Field

A set of characters representing one unit of data

3.4.17 Layer

A certain subset of a section based upon information contents. The collection of level-0 elements present in a layer together should form one planar graph.

3.4.18 Manoeuvre

An ordered sequence of a *Road Element*, a *Junction* and one or more *Road Elements*.

3.4.19 Record

An implementation dependent construct that consists of an identifiable collection of one or more related fields [2]

3.4.20 Semantic Relationship

A characteristic of a feature involving other features.

3.4.21 Section

A certain subset of a dataset based on geographical co-ordinates

3.4.22 Relationship

Semantic relationship

3.4.23 Relationship Code

An alphanumerical identifier for a (Semantic) Relationship.

3.4.24 Relationship Name

A name associated to a relationship type [2]

3.4.25 Relationship Type

A defined characteristic of a feature which is dependent of other features.

3.4.26 Transportation Element

A *Road Element*, *Railway Element*, *Water Boundary Element*, *Junction*, *Rail Junction* and *Water Boundary Junction*

3.4.27 Turn

An ordered sequence of a *Road Element*, a *Junction* and a *Road Element*.

3.4.28 Volume

The smallest physical unit of medium. For example a magnetic tape, a floppy disk etc. A single Volume may contain one or more GDF Datasets depending on Dataset size.

4. GENERAL DATA MODEL

4.1 GDF History

The first version of the draft GDF standard was released in October 1988 (Geographic Data Files Release 1.0; 1988-10-01). A product of the EUREKA project DEMETER, it was designed to specify the data content, means of data representation and structure of data supply for vehicle navigation systems. Based on a comprehensive data model (derived from the UK National Transfer Format [NTF] Model) the first draft standard was used extensively in the EUREKA project CARMINAT and in the DRIVE projects PANDORA and Task Force European Digital Road Map (EDRM). Both the DRIVE-1 projects put forward requests for changes to GDF 1.0.

GDF 2.0 has been developed under work package 3532 of the Task Force EDRM. The GDF 2.0 Working Group consisted of representatives of EDRM partners Daimler Benz (Prime Contractor), Bosch, Philips, Renault, Tele Atlas and Intergraph and MVA Systematica, a participant of the PANDORA project. The other PANDORA project partners were Philips, Bosch, Ordnance Survey and the Automobile Association.

In parallel with DRIVE projects, an informal working group of mapping organizations (both state and private), electronics and vehicle manufacturers, academics and other experts has been developing a conceptual data model upon which to standardize the exchange of geographical data in Europe. Termed the "European Transfer Format" (ETF) model, it diverges from the GDF 1.0 data model in certain key areas. The second release of GDF endorses the ETF conceptual data model, and is therefore the first exchange format to be compliant with the ETF model.

GDF 2.0 differs from GDF 1.0 both in its treatment of the architecture of certain data structures and in its use of terminology. It is also far more extensive in specification. It defines standards for the description, classification and encoding of features of the road environment, suitable to support a family of application areas. These include requirements for Vehicle Navigation Systems, Highway Maintenance Systems, Road Transport Informatics, and Advanced Road Transport Telematics (ATT). RTI and ATT are known in the US as Intelligent Vehicle Highway Systems (IVHS). Accommodation of other applications in the future is envisaged.

GDF 2.1 was released in October 1992 and consists of a revision of Volume 3, the Attribute Catalogue and Volume 9, the Media Record Specifications. The major differences with respect to 2.0 are the introduction of the Segmented Attribute concept and the Time Domain concept.

GDF 2.2 was released in November 1994. The Feature, Attribute and Relationship Catalogue have been considerably extended. The changes mainly consisted of the introduction of new information items. GDF 2.2 was at the time of release, officially submitted to CEN TC278 for approval as a prENV. For this, the CEN member countries reviewed the document during a three months period. The comments received were subsequently incorporated. The result of this was published in July 1995 as GDF 2.3.

GDF 2.3 was subject to a final editorial review in September 1995.

GDF 3.0 was the result of the incorporation of comments from this review and submitted to CEN TC278 for official approval as ENV in October 1995.

The work was undertaken by EDRM2 project partners and the members of CEN TC278 WG 7 with considerations given to the needs of highway authorities in the later stages.

4.2 Structure of GDF

GDF is divided into 12 chapters :

- 1,2,3 Scope, Normative References and Definitions
- 4. General Data Model
- 5. The GDF Feature Catalogue
- 6. The GDF Attribute Catalogue
- 7. The GDF Relationship Catalogue
- 8. The GDF Feature Representation Scheme
- 9. Quality Description Specifications
- 10. Global Data Catalogue
- 11. Logical Data Structures
- 12. Media Record Specifications

Throughout each chapter, *Italics* are used to indicate a reserved meaning.

4.3 Contents of GDF

The **Feature Catalogue** provides a definition of the “real world objects” such as Roads, Buildings, Administrative Areas and Settlements that have significance in the broad area of applications for this standard. They all relate to the road environment. Suppliers of data destined for Vehicle Navigation Systems, Highway Maintenance Systems and other applications will find a concise description and classification of features in this catalogue.

The **Attribute Catalogue** defines a number of characteristics of features and possibility of relationships. Some attributes are dedicated to one particular feature class. Other attributes may be more generally applied. Some attributes themselves describe a certain characteristic completely. Others have to be combined to reach this goal.

The **Relationship Catalogue** describes relations between features that may be used to convey information in a realistic manner. For example, a relationship may exist between Road Elements and Buildings such that a Building “is along” a Road Element. This serves to enrich the model to represent the real world.

In the **Feature Representation Scheme**, instruction is given on how to represent an object: as a Point, Line, Area or Complex Feature.

The **Quality Measuring Specifications** describe rules and methods on how to measure the quality of and validate a GDF dataset.

In the **Global Data Catalogue**, a description is given on how meta information such as geodetic references and data sources must be modelled. Data dictionary specifications are also provided in this catalogue so that GDF will be able to meet diverse needs in the future.

The Volume **Logical Data Structures** describe how the information modelled according to the rules described in the previous volumes, can be represented by a nested set of data types. This specification is independent of any particular media record specification.

Finally, information needed to supply GDF data as physical data records is provided in the **Media Record Specification**.

4.4 Data Models in GDF

Many of the concepts relevant to GDF are best expressed diagrammatically. Those concepts concerned with the data models of GDF are represented using a variant of Entity-Relation Modelling referred to as NIAM (see section 4.5).

Where required, detailed sub-schema's are given to reduce the complexity of the figures. The complete data model and views pertinent to each of the volumes are presented and explained in detail in 4.5.

4.5 Understanding the NIAM diagrams

Figure 4.2 gives a diagram of the Conceptual Data Model. The diagram has been constructed according to the conventions of NIAM modelling (Nijssens Information Analysis Method) [20].

Figure 4.1 provides the key to figure 4.2 and all other data models contained in this standard.

In the centre of the model resides "the feature" which is a geographic object that has a location, such as a road or a building. Note that in this diagram with "feature" is meant feature instance, i.e. an individual occurrence of a geographic object, such as the Eiffel Tower in Paris.

Each feature belongs to a certain feature class, i.e. a set of feature instances of the same class. Each feature belongs to not more than one feature class: hybrid features are not allowed. This constraint is indicated by the arrow above "belongs to". Each feature also must belong to a feature class: classless features are not allowed. This constraint is indicated by the black dot at the location where "belongs to" is attached to "feature".

The diagram shows furthermore that each feature may have zero, one or more attributes and may be related to one or more other features.

It can also be seen that each feature is of exactly one feature category (Point, Line, Area or Complex). The consequences of being of a particular category is illustrated in the lower part of the diagram. The single side arrows indicate a subtype constraint: a Point feature is a subtype of a Simple Feature, which in turn is a subtype of Feature.

The diagram shows that a Point feature is always represented by not more than one Node, a Line feature by one or more Edges and an Area feature by one or more Faces. The lowest part of the diagram illustrates how the "cartographic primitives" Face, Edge and Node are mutually related.

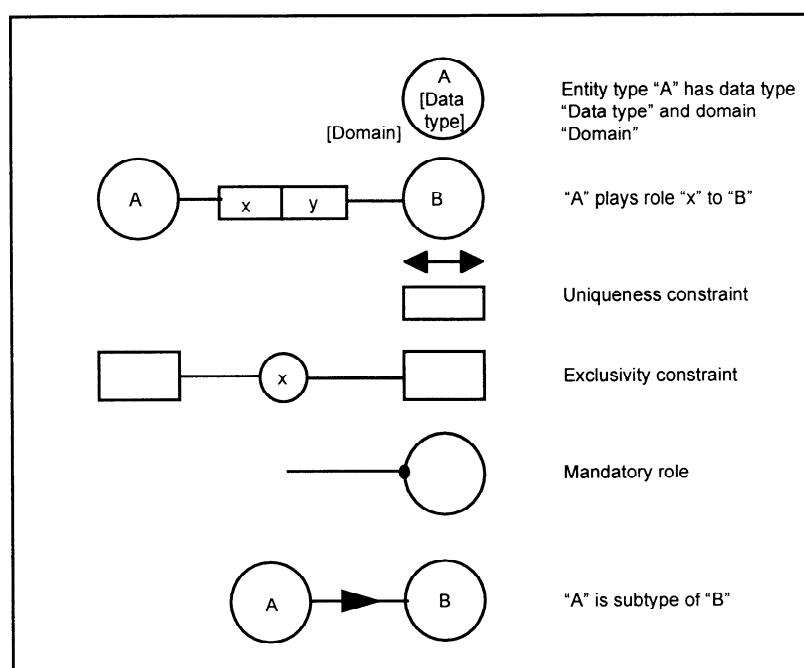


Figure 4.1 Key to NIAM diagrams for GDF data models.

The Feature Catalogue

This Catalogue defines only feature classes, not the individual feature instances. For that reason the Feature Catalogue uses the term “feature” as a synonym for “feature class”.

The diagram shows that each feature must 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. The dotted lines around these indicate that they are only used for referencing.

The diagram shows furthermore that certain features are composed of one or more other features. These are called *Complex Features*. For example, a *Road* may contain *Road Elements*.

The Attribute Catalogue

The Attribute Catalogue defines a set of attribute types and a corresponding reference name and code as shown in Figure 4.3. It defines the feature class that a particular attribute type may be attached to.

The diagram shows that an attribute may be an aggregation of other attributes. Such an attribute is called a Composite Attribute. Some Attribute types that are used in a Composite Attribute may never be directly attached to a feature. This is indicated by the exclusion constraint (the “X”) between the roles “belongs to” and “is part of” of Attribute Type.

The Relationship Catalogue

A semantic relationship is a meaningful link between two or more features, which are not necessarily of different classes.

Semantic relationships with a common structure (e.g. linking feature A to feature B, where the instances of A are always of the same class and where the instances of B are always of the same class) and with a common meaning, are grouped into a relationship type.

A particular relationship type is uniquely referred to by a relationship name or a relationship code (see figure 4.4).

Relationships are in most cases binary, i.e. involving two features. However there are instances when three or more features are involved in a relationship. For example, the relationship *Prohibited Manoeuvre* requires a *Road Element*, a *Junction* and at least one other *Road Element*. The order in which these feature instances occur is significant. That is why Figure 4.4 shows a “Partner No.” which specifies the order in which the individual feature types should occur in the relationship.

The Feature Representation Scheme

The Feature Catalogue, the Attribute Catalogue and the Relationship Catalogue can be considered as being valid for a wide range of applications. With the Feature Representation Scheme however, we enter the world of a more restricted group of applications that share the same representation needs.

In this Feature Representation Scheme for instance, it is defined that a Road Element shall always be considered as a Line feature. Another FRS however, possibly may specify that a Road Element should be considered as an Area feature.

The most important role of the Feature Representation Scheme is to specify to what Feature category or categories a particular feature class must or may belong. Four different categories are distinguished: Point, Line, Area and Complex features.

Figure 4.5 illustrates that two different possibilities exist for a particular feature class:

- 1) all instances must be of one and the same category
- 2) some instances may be of one category, other instances of another one.

In the latter case, the FRS describes when a particular instance must be considered as one category and when as the other.

A representation of a feature by means of Points, Lines and Areas, is called a Level-1 representation, whereas a representation by means of Complex features is called a Level-2 representation.

Depending to what category it belongs, a simple feature is represented by a Node, one or more Edges or one or more Faces. All Nodes, Edges and Faces of the feature instances of a particular layer form together a so-called Level-0 representation. An important requirement is that this representation must be plane, i.e. should contain Nodes where Edges meet each other in the plane.

Furthermore the FRS gives guidelines how the geometry for a particular feature class has to be constructed and how curved lines have to be represented by Segments.

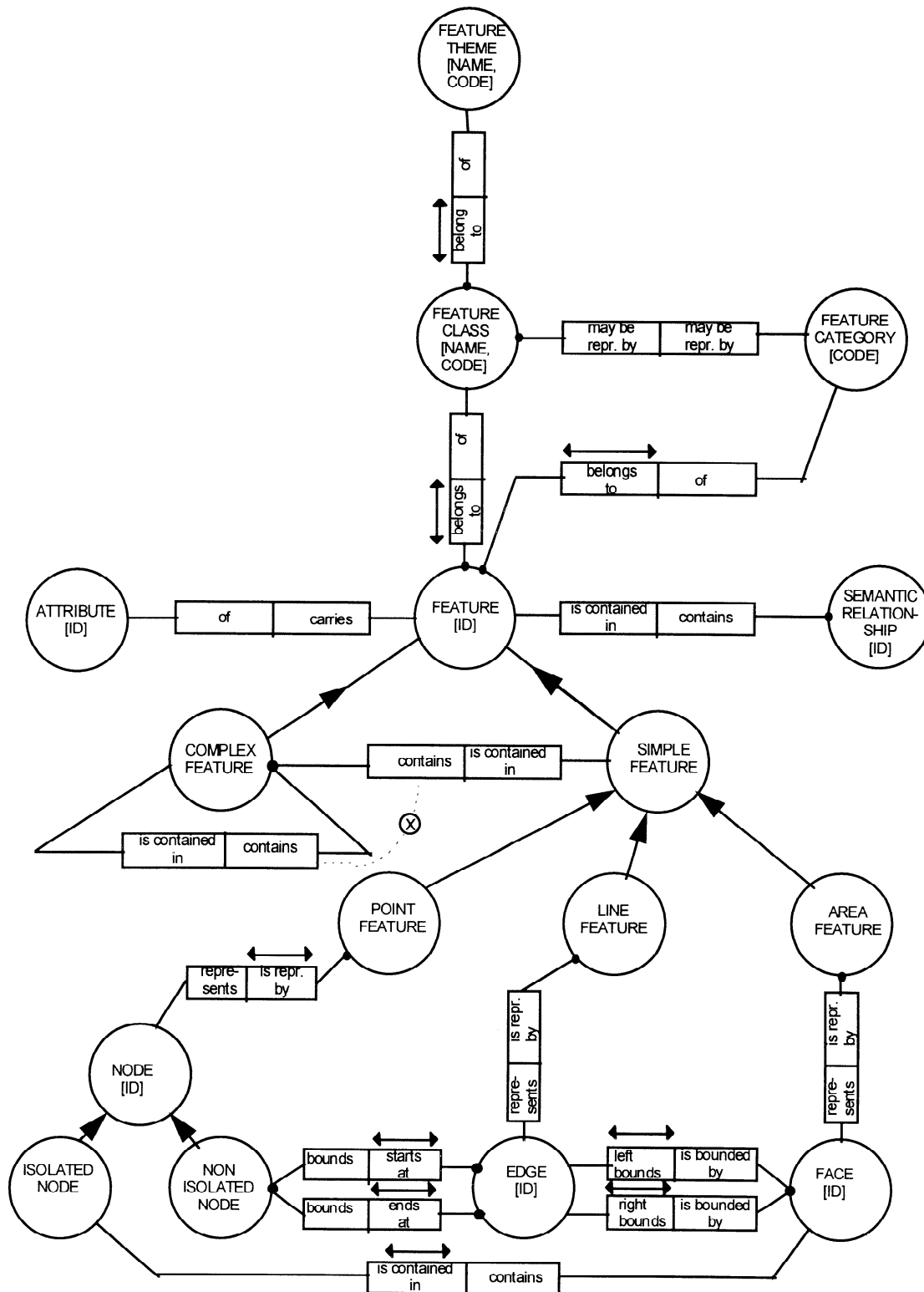


Figure 4.2. The overall Data Model

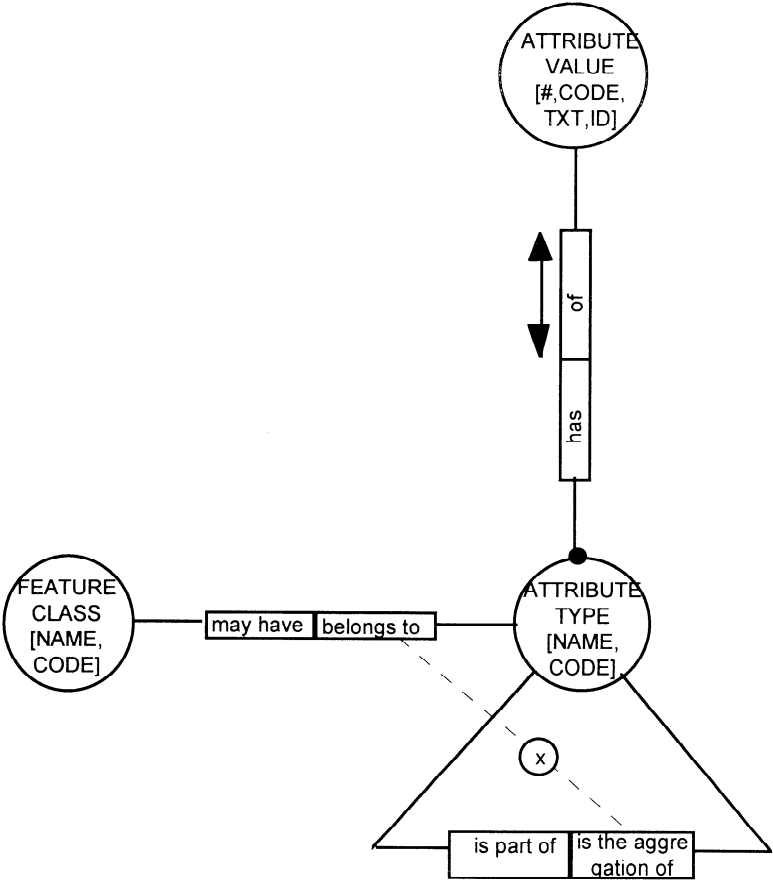


Figure 4.3. The Data Model for Attributes

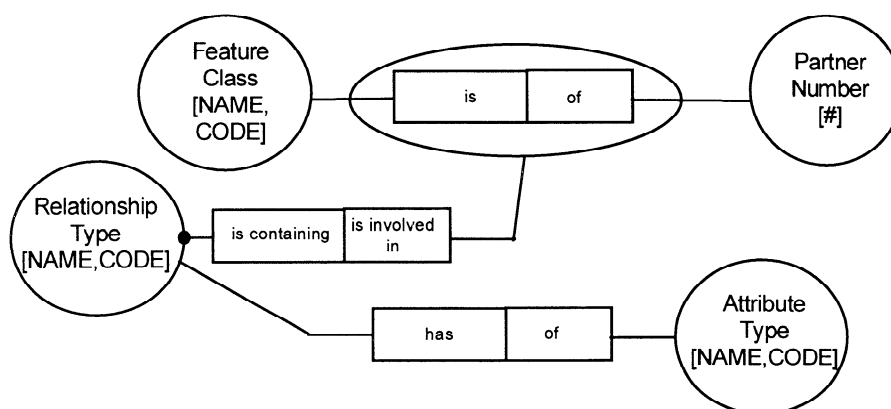


Figure 4.4. The Data Model for Relationships between Features

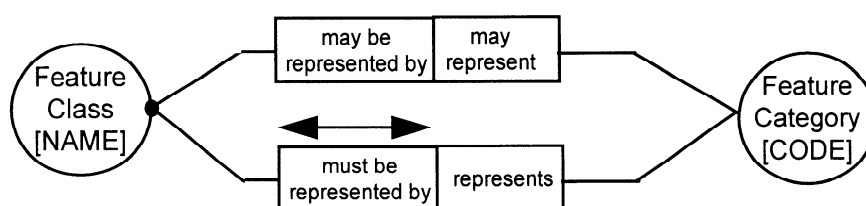


Figure 4.5. The Data Model for Feature Representation

5. FEATURE CATALOGUE

5.1 Generic Specifications

5.1.1 Features and Feature Themes

In GDF, real world objects, such as roads and buildings, are represented by 'features'. Features such as 'Roads' and 'Ferries' may be grouped together into 'feature themes' (for example '*Roads and Ferries*').

All features and feature themes in the GDF are referenced throughout the manual by a feature name or feature theme name. Most of these names are derived from terms commonly used in daily life (for example road, building). In order to distinguish a GDF feature name from these commonly-used terms, the names of the features and feature themes are written in italics with an uppercase character at the beginning of each word (for example '*Road Element*' versus 'road element').

5.1.2 Feature Class Names

For data exchange the features and feature themes are not referenced by their names but by a numeric code. A four digit code is used for features and a two digit code for feature themes. A strict 1:1 relationship exists between feature class name and feature class code and between feature theme names and feature theme codes. A full list of codes is given in Appendix A1.1.

5.1.3 Simple and Complex Features

GDF makes a distinction between simple and complex features. A simple feature is a feature composed only from geometrical primitives. In GDF, these are nodes, edges and faces. A complex feature is composed of other simple or complex features. For example, a '*Road Element*' is a simple feature constructed only of edges, and an '*Intersection*' is a complex feature, made up of a set of features such as '*Road Elements*' and '*Junctions*'.

5.1.4 Data Model for the Feature Catalogue

Figure 5.1 shows that part of the data model which is relevant for the Feature Catalogue. The relations between features and attributes have been left out for simplicity. They will be shown in the sub-schemes of the Attribute Catalogue. Also, there are relationships which exist, which are not part of a feature's definition. These are described in the Relationship Catalogue.

5.1.5 Overview Of Feature Themes

In the current Feature Catalogue the following feature themes are defined:

- Roads and Ferries
- Administrative Areas
- Settlements and Named Areas
- Land Cover and Use
- Brunnels
- Railways
- Waterways
- Road Furniture
- Services
- Public Transport
- General Features

These will be discussed in the following sections.

5.1.6 User-defined Features

The standard supports the ability for a user to define features which are not already defined. For these, special Feature Class Codes have been reserved. (See appendix A 1.1).

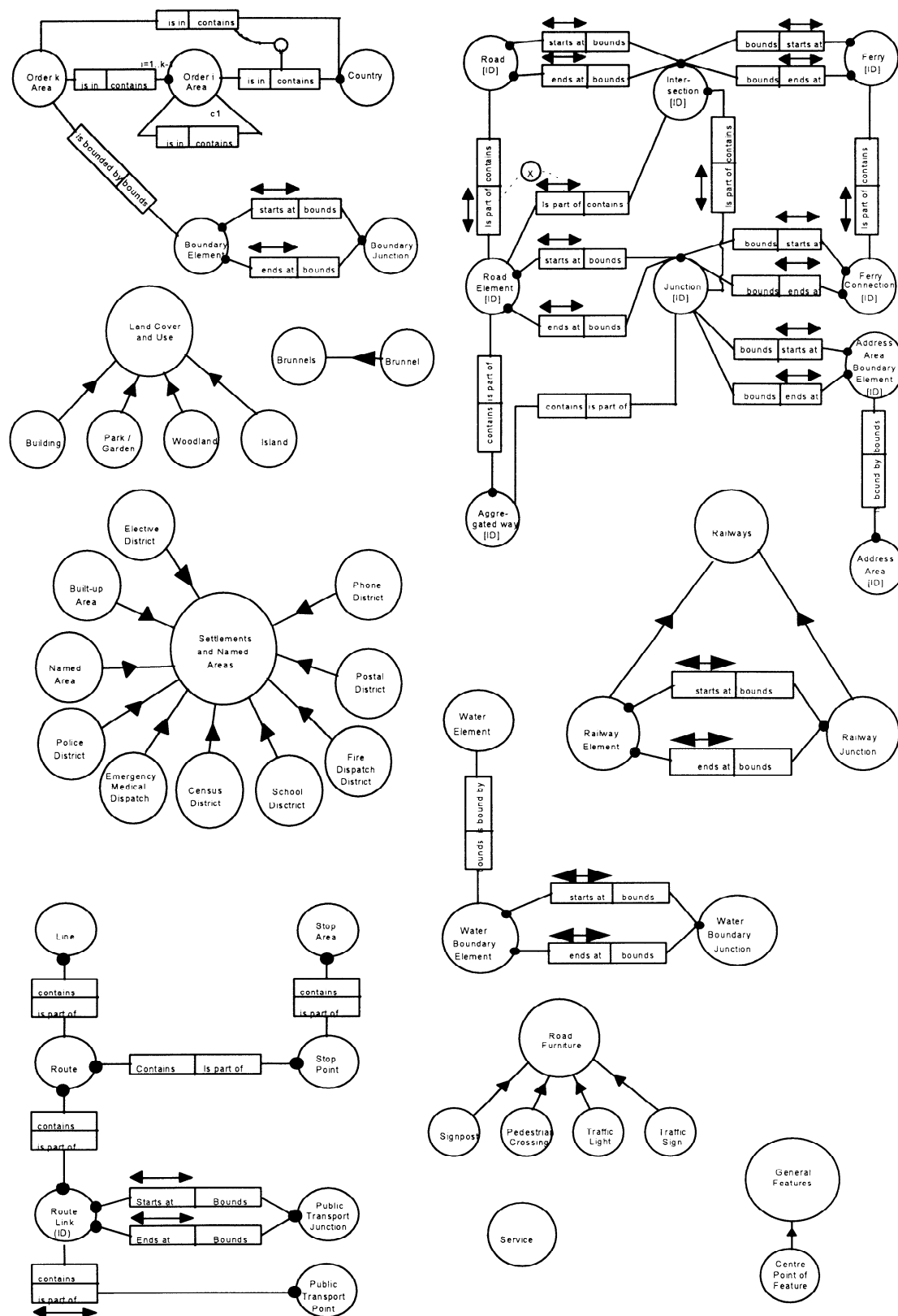


Figure 5.1. Data Model of Feature Catalogue

5.2 Roads and Ferries

5.2.1 General Overview

The road network is seen here primarily from the viewpoint of transportation and traffic. Ferry connections are therefore placed together with road network elements in one theme.

The road network can be represented at two different levels, Level 1 and Level 2. Level 1 describes all the simple features such as *Road Element*, *Junction*, *Ferry Connection*, *Enclosed Traffic Area*, *Address area Boundary Element* and *Address Area*, whereas Level 2 describes the complex features *Road*, *Intersection*, *Ferry* and *Aggregated Way*.

For example, in a vehicle navigation system application Level 1 can be used by the system to calculate routes. Level 2 may be used to give guidance instructions to the driver.

The Data Model for *Roads and Ferries* is given in Figure 5.2 which describes relationships between features within and between Levels 1 and 2.

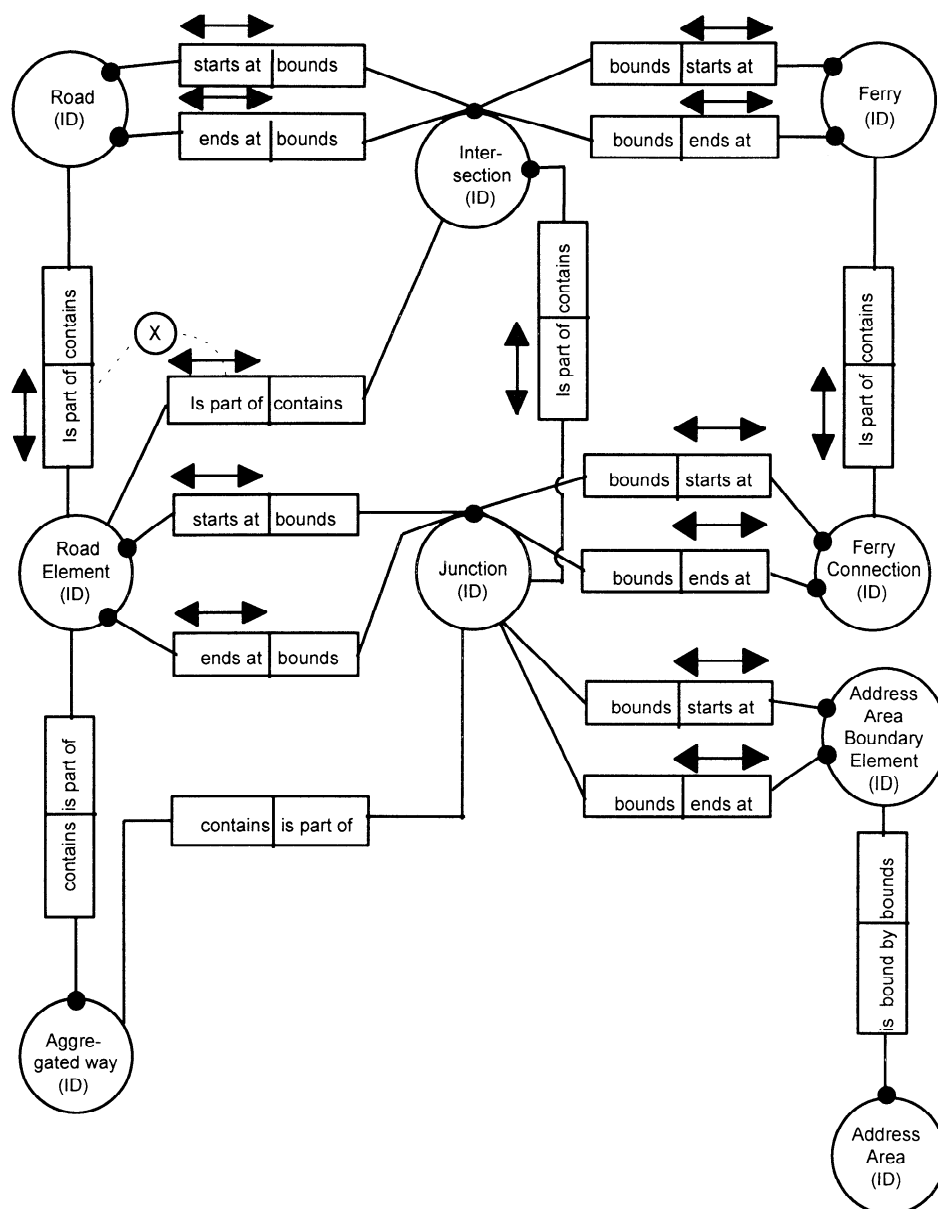


Figure 5.2 Data Model for Roads and Ferries

5.2.2 Road Element

5.2.2.1 Definition

A linear section of the earth which is designed for or the result of vehicular movement. It serves as the smallest unit of the road network at Level 1 that is independent and having a *Junction* at each end.

5.2.2.2 Independence of Road Elements

Individual *Road Elements* must be independent of one another. A change in the status of one *Road Element* must not affect a change in another. In Figure 5.3 for example, AB, BE, ED, DC and CA are all *Road Elements*. Their independence is illustrated by the fact that a barrier placed on *Road Element* CD creates a no through road CD, but does not affect the status of the other *Road Elements*.

Road Elements may also have a distinguishing set of attributes. For example, in Figure 5.4, *Road Elements* AF, FB have different names. AD, DE and EC have different restrictions. Within the context of the attributes *Official Name* and *Direction of Traffic Flow*, the elements AF, FB, AD, DE, EC and BC may be considered as being the smallest independent units and can consequently be considered as individual *Road Elements*. Alternatively, changes in attributes along a single road element can be described by stating the starting and ending positions along the road element for which the attribute is valid. This procedure is further described in the Attribute Catalogue (see chapter 6.1.10, Relation between attributes and features: Segmented Attributes)

5.2.2.3 Aggregation Rules

Any additions to the attributes of a *Road Element*, such as a restriction, or another name, may require it to be split into two or more separate *Road Elements*. In the example of Figure 5.4, the addition of a width restriction can cause the *Road Element* BC to be split into three new elements in order to be able to distinguish the influence of the narrow bridge from the other parts of the road. Alternatively, the limits for which attributes are valid along a road element may be described together with the attribute value.

In Figures 5.5 and 5.6, both carriageways are considered as being independent and consequently are treated as two individual *Road Elements*. A road with a physical separation between two parts of a road can be represented by two different *Road Elements*. Alternatively, the physical separation can be indicated by attributes.

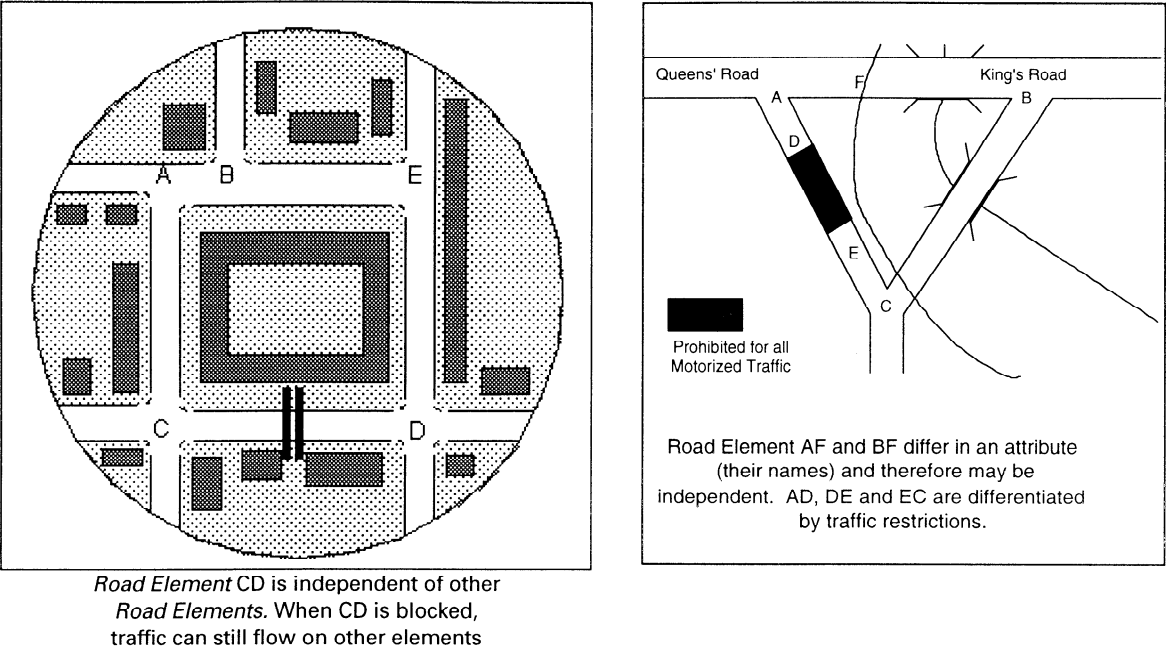


Figure 5.3. Independence of *Road Elements* by function

Figure 5.4. Independence of Road Elements by Attribute

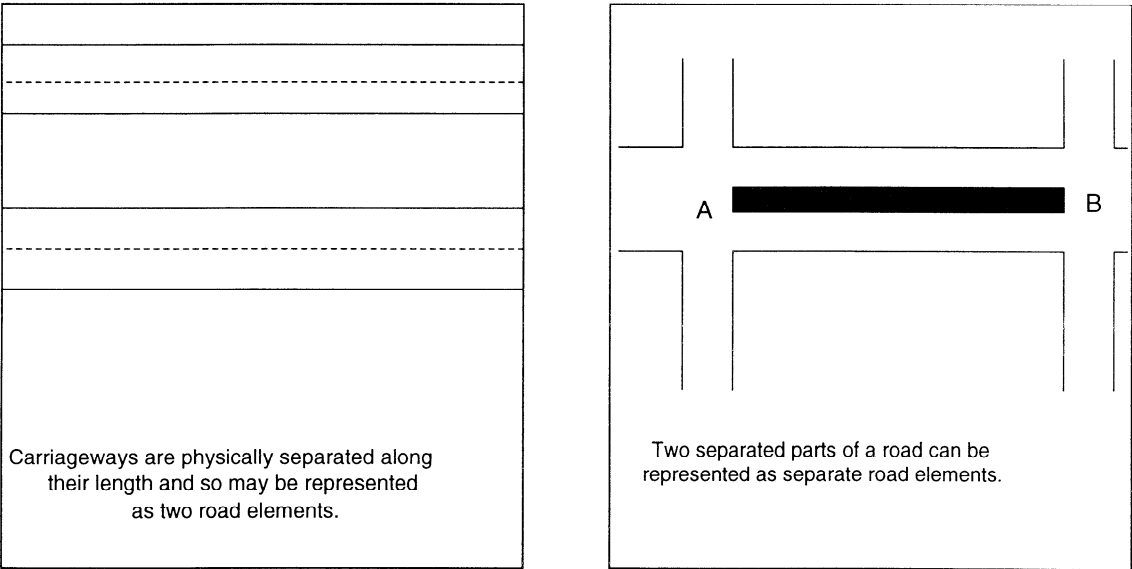


Figure 5.5. *Road Elements* as Physically Separated Carriageways

Figure 5.6. *Road Elements* as separated carriageways

5.2.3 Enclosed Traffic Area

5.2.3.1 Definition

Any confined area within which unstructured traffic movements are allowed.

5.2.3.2 Description

Examples of *Enclosed Traffic Areas* are: Industrial Sites, Car Parks, Harbour areas, Camp Sites, Military Areas, Unstructured Traffic Squares

5.2.4 Junction

5.2.4.1 Definition

A feature that bounds a *Road Element* or a *Ferry Connection*. A *Road Element* or *Ferry Connection* always forms a connection between two *Junctions* and, a *Road Element* or *Ferry Connection* is always bounded by exactly two *Junctions*. A *Junction* feature represents the physical connection between it's adjoining *Road Elements* and *Ferry Connections*.

5.2.4.2 Relation between Junction, Road Element, Enclosed Traffic Area, Ferry Connection and Address Area

Road Elements, *Ferry Connections* and *Junctions* are mutually dependent: a change in the first set will cause a change in the second one and vice versa.

A *Junction* is located at the intersection of two or more road centrelines. If the road centrelines intersect in two different points, the situation has to be interpreted as two different *Junctions*.

A *Junction* is also located at the end of a dead end road or at the intersection of a *Road Element* and an *Enclosed Traffic Area*, or a *Road Element* and a *Ferry Element*, or a *Road Element* and an *Address Area*.

5.2.4.3 Valency of a Junction

The number of *Road Elements* or *Ferry Connections* joining at a *Junction* is termed the Valency of a *Junction*. For example a *Junction* that connects a total of two *Road Elements* is called a two valent *Junction*.

The occurrence of *Junctions* that bound only two *Road Elements* or *Ferry Connections* is generally restricted to the following situations:

- An extra *Junction* may be used if two *Road Elements* have at least one different attribute value or participate in at least one different relationship. Figure 5.7 uses the example of traffic restrictions.
- An extra *Junction* may be used to avoid a *Road Element* having the same *Junction* at the start and at the end, as shown in Figure 5.8.
- An extra *Junction* may be used to form independent complex *Road* features. In Figure 5.9, a *Junction* may be introduced to allow a complex *Road* feature to be formed.

Junctions which bound only two *Road Elements* or bound only two *Ferry Connections* should not exist in the road network if none of the above conditions are fulfilled.

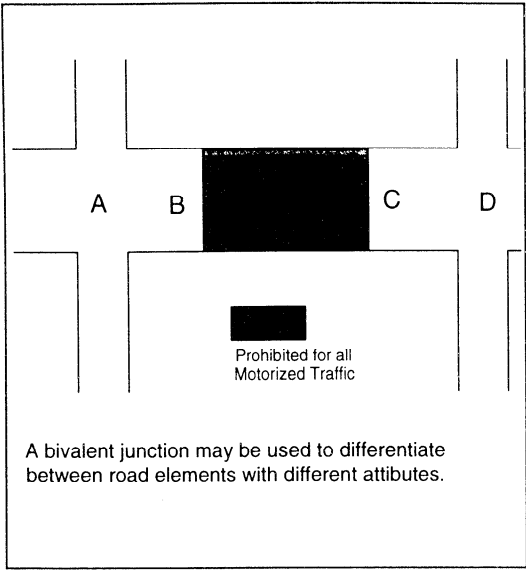


Figure 5.7. A change in attribute values may change the *Road Elements*.

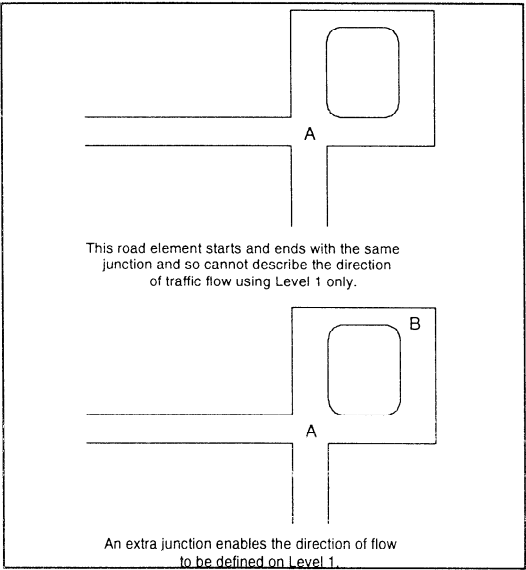


Figure 5.8. *Road Elements* as a Loop in the Road Network.

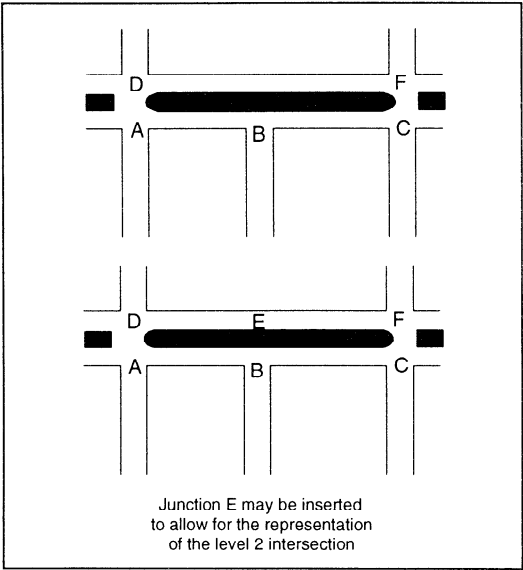


Figure 5.9. Formation of Level 2 *Road*.

5.2.4.4 Topological requirements

The set of *Junctions*, *Road Elements*, *Enclosed Traffic Areas*, *Address Areas* and *Ferry Connections* has to be constructed so it represents the topological relations in the road network correctly.

This important requirement is illustrated in Figure 5.10. This figure shows a T-junction. The correct interpretation is to see it as consisting of three *Road Elements* AB, BC and BD joining at *Junction B*.

5.2.4.5 Grade Separated Crossings

Grade separated crossings in the road network cover objects such as bridges, overpasses, and underpasses. Grade separated crossings are not represented by a *Junction*. An example of this is given in Figure 5.11, where AB and CD are *Road Elements*. Any interpretation of the network which uses a *Junction* at Z to represent the split level crossing is incorrect (for example {AZ,ZB,CD} or {AB,CZ,ZD} or {AZ,ZB,CZ,ZD}).

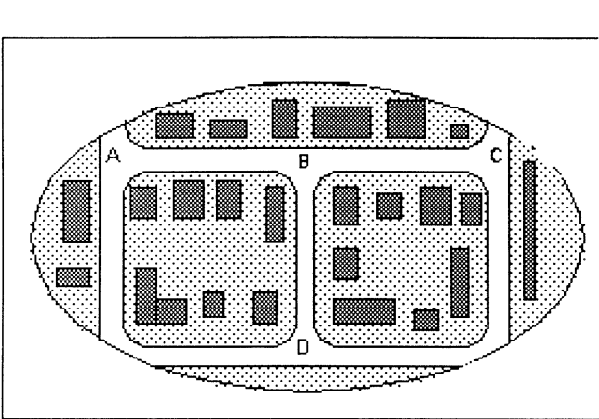
5.2.4.6 Squares

Traffic squares, which are not completely unstructured, but which have some legally defined traffic flow or internal structure (for example a fountain, flower beds, painted lines on the road surface, etc.) which prescribe a traffic flow, have to be considered as being composed of different *Road Elements*. Figure 5.12 shows a traffic square with a grass bed in its centre. The traffic square is composed of the sequence of *Road Elements* AB,BC,CD and DA which together form a closed ring.

Figure 5.13 shows an area where traffic movements are not regulated in a strict geometrical sense. These are considered *Enclosed Traffic Areas*. These features are represented as an area at which the incoming *Road Elements* end in a *Junction*. The *Enclosed Traffic Area* itself forms the topological connection between these *Road Elements*. Inside the area, *Road Elements* may be defined which have only topological, and not a geometrical, significance.

5.2.4.7 Parking areas

Parking areas are to be considered *Enclosed Traffic Areas* (see Section 5.2.3).



Junctions and Road Elements need to be constructed, so that they represent the road network correctly.

Figure 5.10. Topological Requirements.

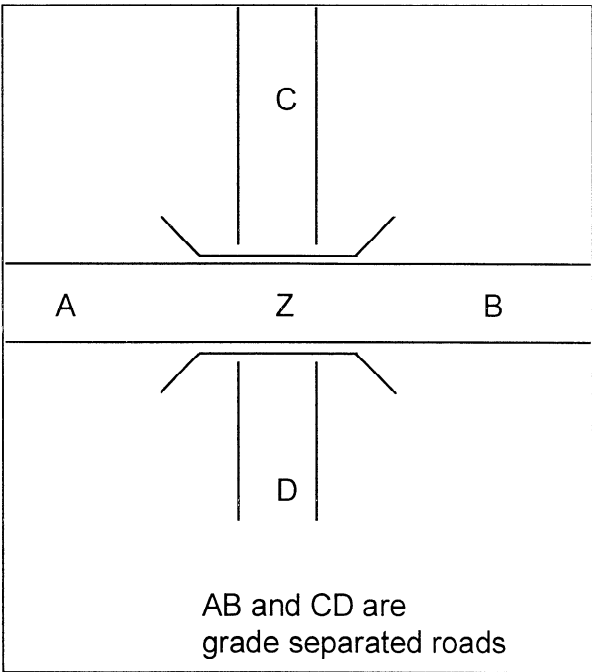
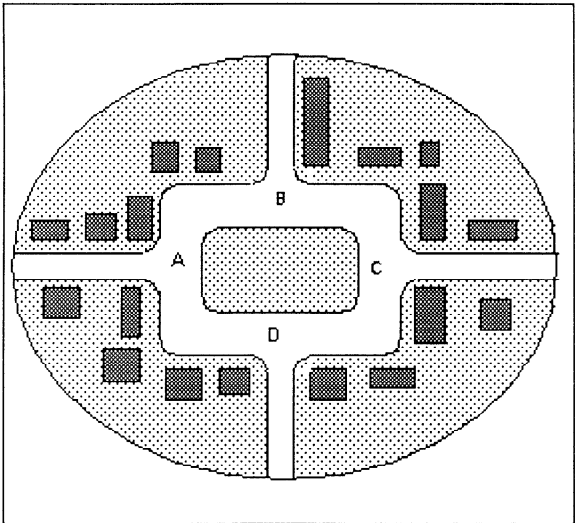


Figure 5.11. Topological Requirements.



Traffic Squares which have some internal structure need to be represented by different Road Elements.

Figure 5.12. Topological Requirements for Structured Squares.

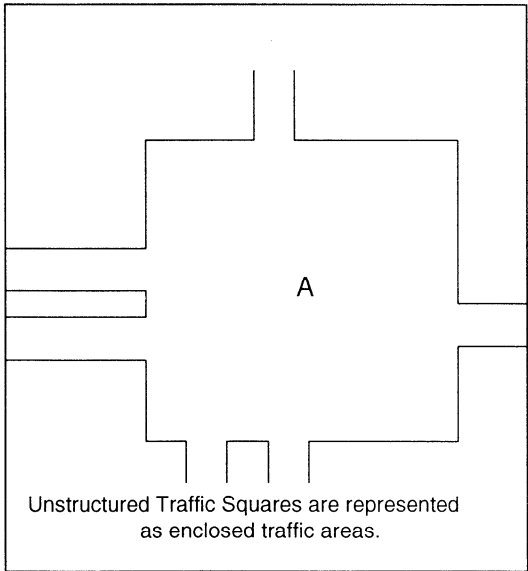


Figure 5.13. An Unstructured Traffic Area.

5.2.5 Ferry Connection

5.2.5.1 Definition

A vehicle transport facility between two fixed locations on the road network and which uses a prescribed mode of transport, for example, ship or train.

5.2.5.2 Characteristics

The feature *Ferry Connection* is the smallest independent unit of the road network operated by a *Ferry* that is represented at Level 1.

Many situations look like Figure 5.14. This is interpreted as one single *Ferry Connection*. But situations exist where one ferry service joins more than two locations as shown in Figure 5.15. This situation has to be interpreted as three different *Ferry Connections*: AB, BC and CA.

5.2.6 Ferry

5.2.6.1 Definition

A set of *Ferry Connections* which describe a single passage of a particular ferry line.

The rules that govern Level 1 *Road Element* and Level 2 *Road* also apply to Level 1 *Ferry Connection* and Level 2 *Ferry*.

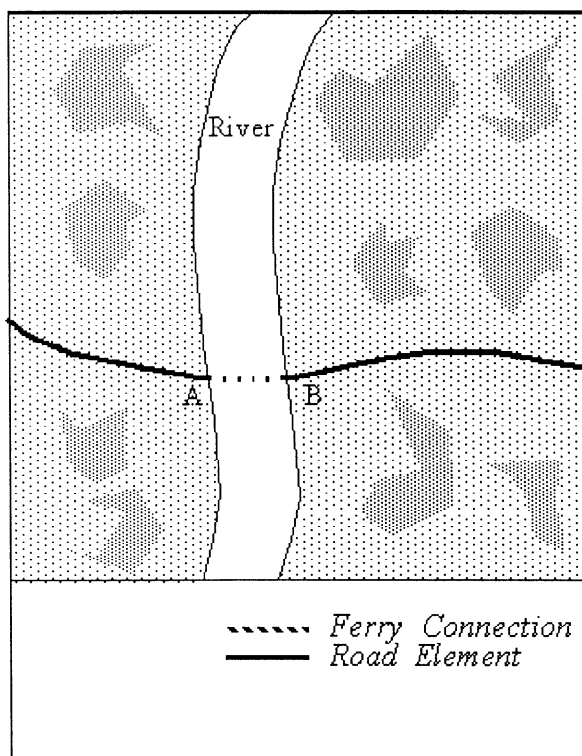


Figure 5.14. Ferry joining two terminals

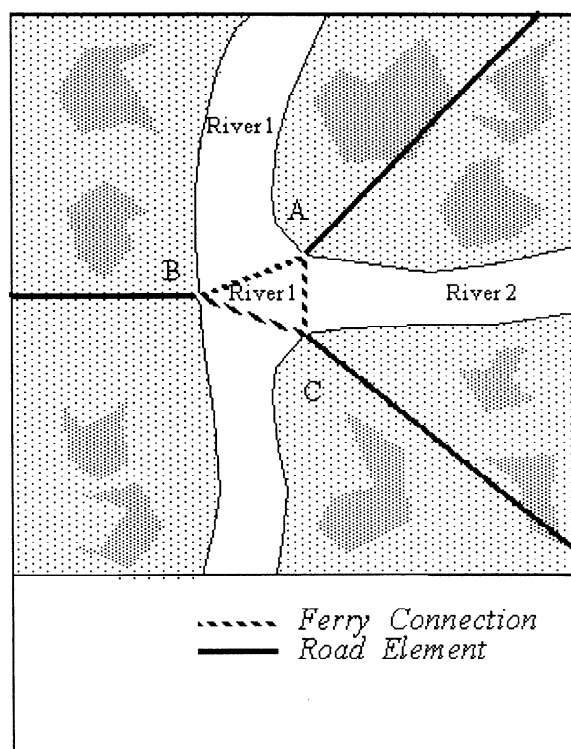


Figure 5.15. Ferry joining three terminals.

5.2.7 Road

5.2.7.1 Definition

A Level 2 feature composed of one, many or no *Road Elements* and joining two *Intersections*. It serves as the smallest independent unit of a road network at Level 2.

5.2.7.2 Relation Between Road, Road Element And Intersection

A *Road* always forms a connection between two *Intersections*. *Roads* are defined in terms of the *Road Elements* that they contain. Below some basic construction rules are given. For a more elaborated description see Appendix A1.3.

5.2.7.2.1 A Road Containing One Road Element

This is the most common case and is illustrated by Figure 5.16. At Level 1 this road can be seen as consisting of one *Road Element*. At Level 2 the same road can be seen as one *Road*. *Road* CL 573 is bounded by the *Intersections* CS 204 and CS 204, and contains *Road Element* L 203.

5.2.7.2.2 A Road Containing Two Road Elements

Figure 5.17 shows a dual carriageway. Both carriageways are physically separated and can be consequently interpreted as individual *Road Elements*.

At Level 2 however, both carriageways are considered as making up one single *Road*. *Road* CL 583 contains *Road Elements* L 452 and L 854 and is bounded by the *Intersections* CS 723 and CS 721.

The concept of "dual carriageway" is an important one. A dual carriageway will usually contain two parallel *Road Elements*. There are occasions where each carriageway may be divided by an obstruction and the *Road Elements* no longer remain parallel. In these cases, if the *Road Elements* make up one functional unit and there are no *Junctions* involved, these *Road Elements* may be considered as one Level 2 *Road*. Not all *Road Elements* which run parallel to one other, however, are a multi-carriageway.

5.2.7.2.3 A Road Containing More Than Two Road Elements

In occasional cases a *Road* may contain more than two *Road Elements*. Figure 5.18 shows an example: a road has two parts having a single carriageway and one part with separated carriageways. At Level 1, this road can be interpreted as four *Road Elements*. At Level 2 however, the road should be interpreted as one *Road*. *Road* CL 599 is built up by *Road Elements* L 258, L 259, L 260 and L 261.

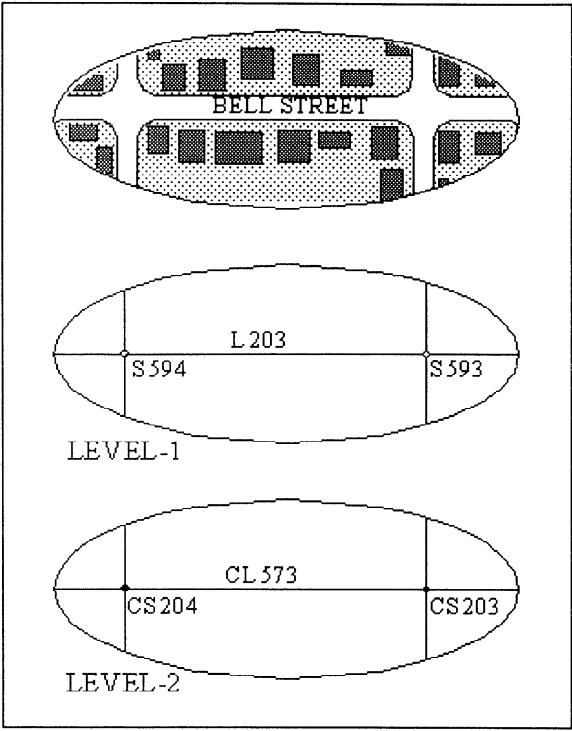


Figure 5.16 A Road containing on Road Element

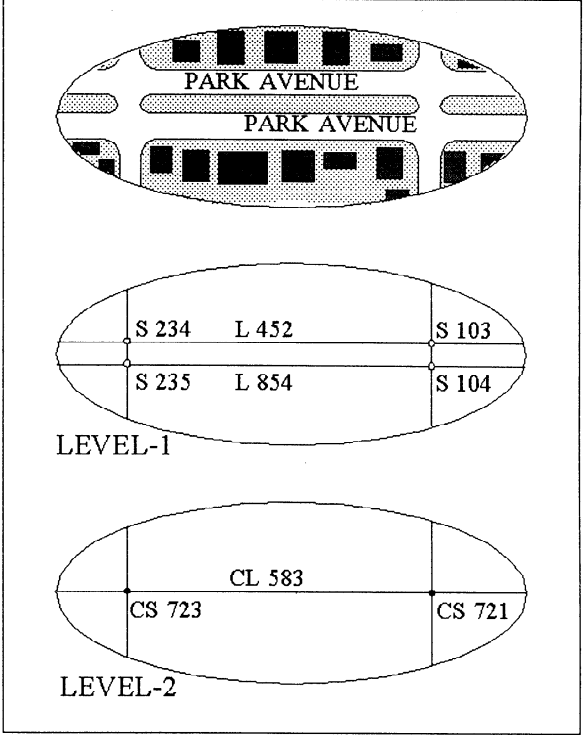


Figure 5.17. A Road containing two Road Elements

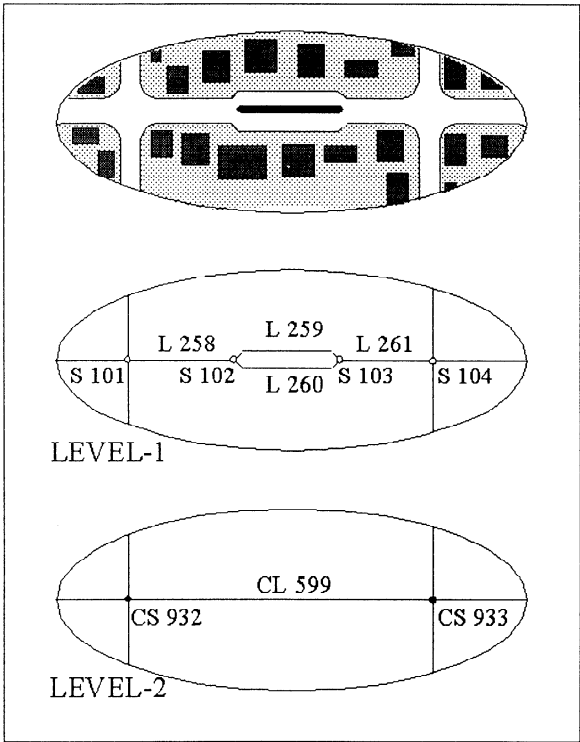


Figure 5.18. A Road containing more than 2 Road Elements

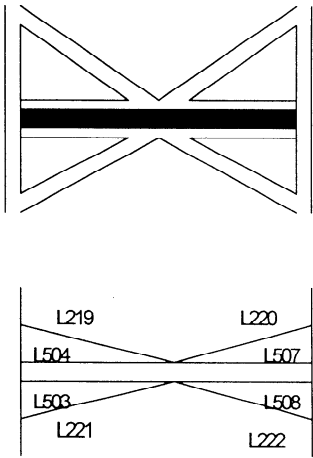


Figure 5.19. A Road containing no Road Elements

5.2.7.2.4 A Road Containing No Road Elements

In rare cases a *Road* may contain no *Road Elements* at all. Figure 5.19 shows two sequential split-level crossings between a dual carriageway and two single carriageways.

In the example, Level 2 is constructed from Level 1 by:

- The *Road Elements* L 219, L 221, L 504 and L 503 are mapped onto the *Intersection* CS 754.
- The *Road Elements* L 507, L 220, L 508 and L 222 are mapped onto the *Intersection* CS 755.

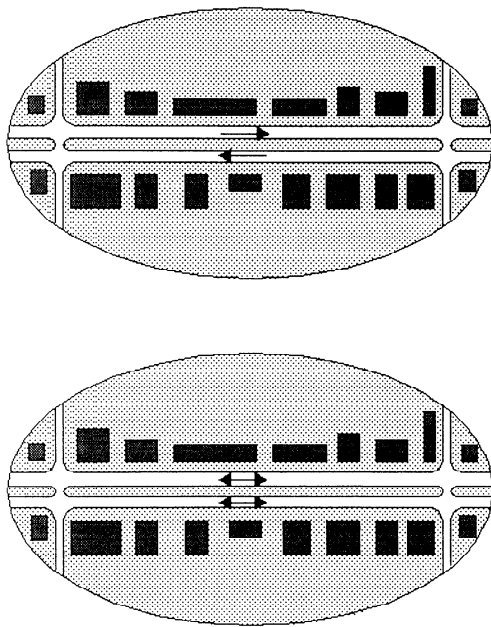
Consequently no *Road Elements* remain that are mapped onto *Road* CL 891. This *Road* contains no *Road Elements* and is bounded by the *Intersections* CS 754 and CS 755.

The basic guideline for formation of a Level 2 *Road* is that when the *Road Elements* in question represent the carriageways of a multi carriageway, these *Road Elements* may be considered to form a *Road*.

In addition, each of the following requirements have to be fulfilled for a multi-carriageway:

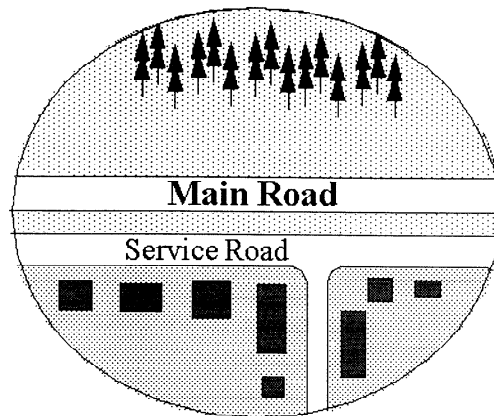
- Each *Road Element* must be a “one way road”, as drawn in Figure 5.20.
- The *Road Elements* need to have the same road class. Figure 5.21 shows a situation of a street having a service road at its side. The *Road Element* that represents the service road has a different road class to the *Road Element* representing the main road. Consequently, these two *Road Elements* cannot form a multi-carriageway.
- It must be possible to see the *Road* as one single functional unit. This is often indicated by the fact that the different *Road Elements* have the same road name or road number.

A *Road* may not be formed from *Road Elements* separated by a *Road Element* belonging to a different *Road*. This condition is illustrated in Figure 5.22. A main road is shown having service roads at both sides. Though they fulfil all the other requirements, *Road Elements* representing the service roads may not be considered as forming a *Road* because they are separated by the *Road Element* representing the main road.



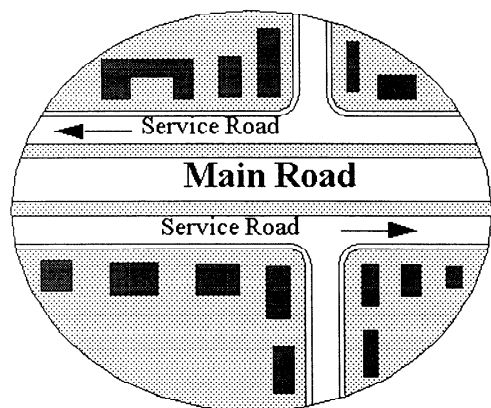
For a road to be considered as a multi-carriageway each *Road Element* must be 'one-way'

Figure 5.20. Guidelines for formation of *Road*.



For a road to be considered as a multi-carriageway and declared as a road, each *Road Element* needs to be of the same classification

Figure 5.21. Guidelines for formation of *Road*.



A road may not be formed from *Road Elements* separated by an element belonging to another road

Figure 5.22. Guidelines for formation of *Road*.

5.2.8 Intersection

5.2.8.1 Definition

The Level 2 representation of a crossing which bounds a *Road* or a *Ferry*. It is a Complex Feature composed of one or more Level 1 *Junctions*, *Road Elements* and *Enclosed Traffic Areas*.

5.2.8.2 Similarities and differences between Intersection and Junction

At Level 2, the feature *Intersection* plays the same role as the feature *Junction* does as Level 1; it bounds *Roads* and *Ferries* and joins them to other ones.

The difference between an *Intersection* and a *Junction* lies in the degree of generalisation; where a multi-element crossing will be described at Level 1 by many *Road Elements* and *Junctions*, it may be represented at Level 2 by one single *Intersection*.

Note: The number of different *Roads* that are bounded by one single *Intersection* may be any number other than two or zero.

Rules for Formation of *Intersections* may be found in Appendix 1.3.

5.2.9 Aggregated Way

5.2.9.1 Definition

A set of associated *Road Elements* and, optionally, *Junctions* which share a common function or characteristic.

5.2.9.2 Description

An *Aggregated Way* is a feature which has been defined by a user, for example a road authority, for the purpose of identifying and relating features in their user-specified model to level 1 features in the GDF.

A *Road Element* or *Junction* can belong to more than one *Aggregated Way*. *Aggregated Ways* do not have an implied topology, that is, they are not necessarily connected to other *Aggregated Ways*, and do not necessarily form a complete network.

5.2.10 Address Area

5.2.10.1 Definition

An area containing addresses which cannot be related to one or more *Road Element*.

5.2.10.2 Description

In certain situations addresses are defined in such a way that the information cannot be related to one or more *Road Element*. Two different situations can be identified:

1. The addresses are located in a square which has a name which is different from the name of the *Road Element(s)* representing the road network on that square.
2. The addresses are defined according to building blocks. In these cases a building block has a name which differs from the name of an adjacent building block and of the *Road Element* which possibly divides the two building blocks.

An *Address Area* should always have a connection with the road network.

5.2.11 Address Area Boundary Element

5.2.11.1 Definition

A representation of the boundary of an *Address Area*

5.2.11.2 Description

A *Address Area Boundary Element* describes the outer confinement of an *Address Area*. An *Address Area Boundary Element* is start and end bounded by a *Junction* which is defined where the *Address Area* intersects with the road network.

At least one of the edges defining the complete boundary of an *Address Area* has also to be referenced by a *Road Element* which is connected to the rest of the road network.

5.3 Administrative Areas

5.3.1 General Overview

For administrative purposes, the territory of a country is subdivided in a hierarchy of political units. These units are called *Administrative Areas* in this document. Countries are subdivided into regions, which in turn may be subdivided into sub-regions, which in turn may be subdivided further.

Each of these subsets is said to be of a particular Order. The number of administrative area orders differ from country to country but is fixed (with only some rare exceptions) for the whole territory of a country.

The highest level of *Administrative Areas* is called the *Country*. The sub-divisions of a *Country* are termed *Order-i Areas* where i ranges from 1 (the highest order subdivision) to Order-8 (country-specific equivalent to municipality). A subdivision of Order-8 Areas may also be used for local areas only. This is termed an Order-9 Area and does not apply country-wide.

The Data Model for *Administrative Areas* is shown in Figure 5.23.

Appendix A1.2 shows for a number of European countries how the generic features Order-i Area can be substituted by native terms and languages.

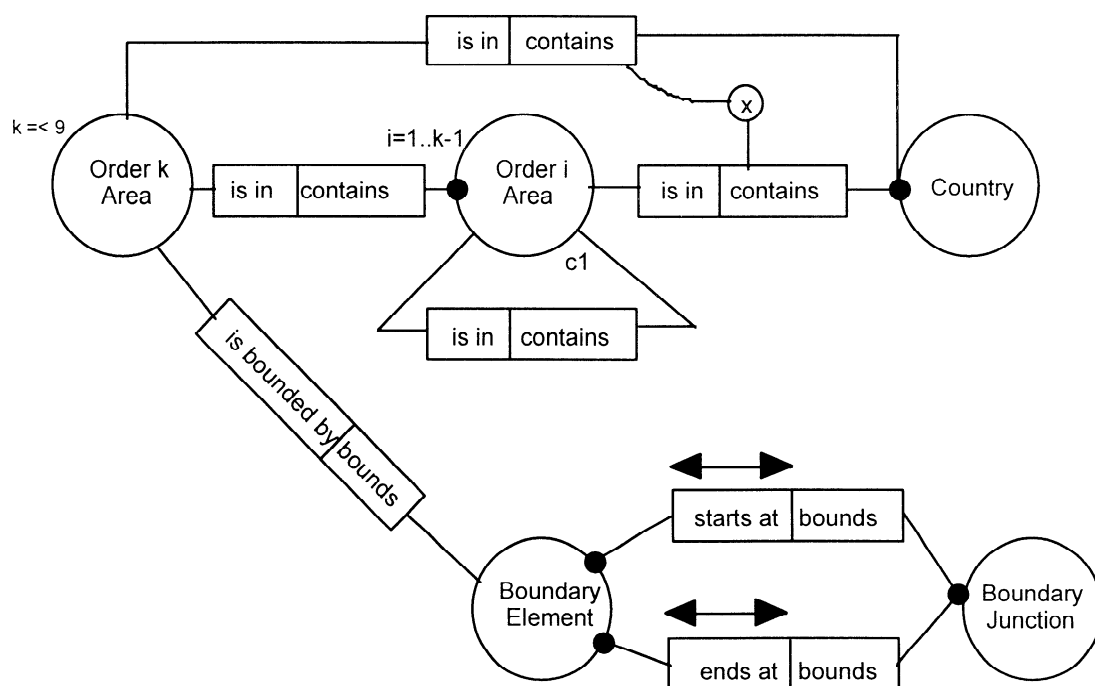


Figure 5.23. Data Model for *Administrative Areas*

5.3.2 Boundary Element

5.3.2.1 Definition

The smallest unit of a boundary which delimits an *Administrative Area*.

5.3.2.2 Explanation of Boundary

A boundary is formed between two adjacent *Administrative Areas* of equal order, or between an *Administrative Area* and a geographical barrier such as a foreign country.

5.3.2.3 Constraints

A *Boundary Element* is bounded by exactly two *Boundary Junctions*. These need not necessarily be different nodes (see Figure 5.24). A *Boundary Element* may never bound the same *Administrative Area* twice (see Figure 5.25).

5.3.3 Boundary Junction

5.3.3.1 Definition

The location where *Boundary Elements* join.

5.3.3.2 Constraints

A *Boundary Junction* joins/connects one, three, or more *Boundary Elements*. It will typically bound three but never two. Figure 5.26 illustrates the case when it joins one single *Boundary Element*.

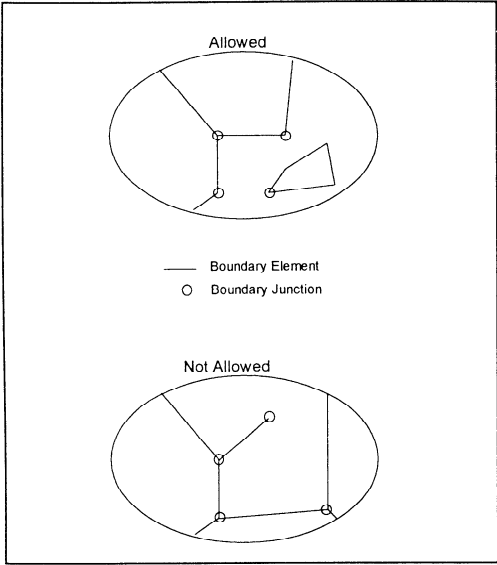


Figure 5.24. *Boundary Elements and Boundary Junctions.*

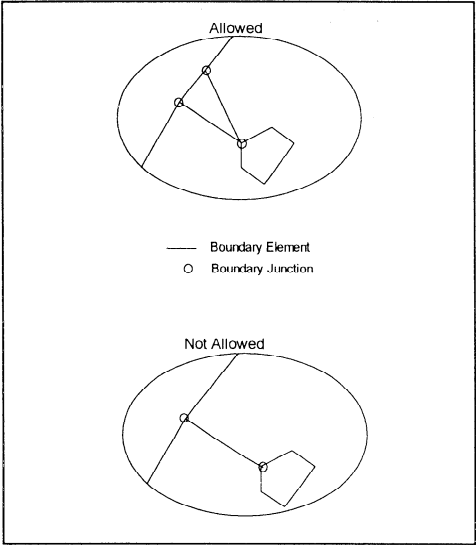


Figure 5.25. *Boundary Elements and Boundary Junctions.*

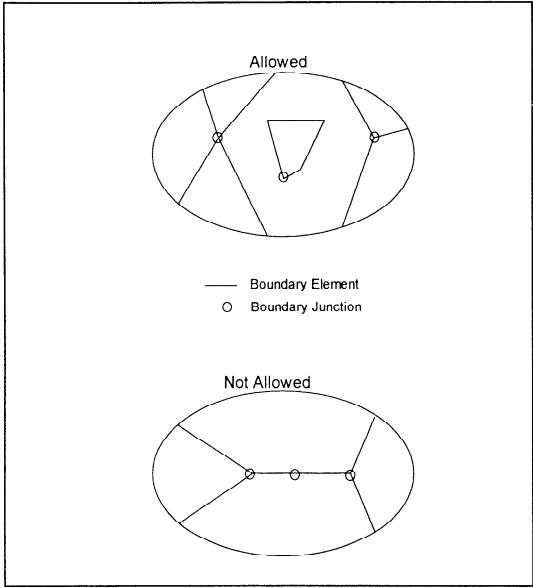


Figure 5.26. *Boundary Elements and Boundary Junctions.*

5.3.4 Country

5.3.4.1 Definition

A country as defined by national boundaries.

5.3.4.2 Explanation

A requirement for a *Country* is that it must be subdivided in a uniform manner (i.e. by lower level administrative areas of the same kind).

Some very small *countries* may have no further administrative subdivisions. In such a case the *Country* has to be considered as being composed of one simple area feature, carrying the same name.

5.3.5 Order 1 to 7 Areas

5.3.5.1 Definition

An area defined for administrative purposes governed by a government specially established for that area.

5.3.5.2 Explanation

These areas are intermediate subdivisions of the administrative hierarchy. In some small *countries*, these intermediate layers of the administrative hierarchy may not exist.

Appendix A1.2 lists some examples.

5.3.6 Order 8 Area

5.3.6.1 Definition

The *Administrative Area* level that is the country specific equivalent to municipality.

5.3.6.2 Explanation

Appendix A1.2 lists some examples by country of *Order-8 Area* names.

5.3.7 Order 9 Area

5.3.7.1 Definition

The Administrative Area level that is a subdivision of Order-8 Administrative Areas.

5.3.7.2 Explanation

Some *Order-8 Areas* may be split into smaller units. This may be the case for one single *Order-8 Area* (for example Rotterdam) or for all *Order-8 Areas* in a particular region (for example all municipalities in Hessen).

These smaller units are classed as *Order-9 Areas*.

5.4 Settlements and Named Areas

5.4.1 General Overview

Settlements and Named areas are areas which have a distinguishing functional or physical purpose. These may include areas with a concentration of homes and buildings which designate residential areas, areas with a commonly known name, or areas which are serviced by the same service provider, such as police precincts, or school districts.

The Data Model for *Settlements and Named Areas* is shown in Figure 5.27.

5.4.2 Built-up Areas

5.4.2.1 Definition

An area with a concentration of buildings. In these areas, an inner city speed limit generally applies.

5.4.2.2 Description

No exact relationship exists between a *Built-up Area* and a municipality. In some cases a *Built-up Area* relates to exactly one municipality having the same name. However, in rural areas in particular, one municipality can contain several small *Built-up Areas*. Also situations exist (Paris, Brussels) in which a *Built-up Area*, referenced by most people by one single name, is spread over several municipalities or other kinds of *Administrative Areas*.

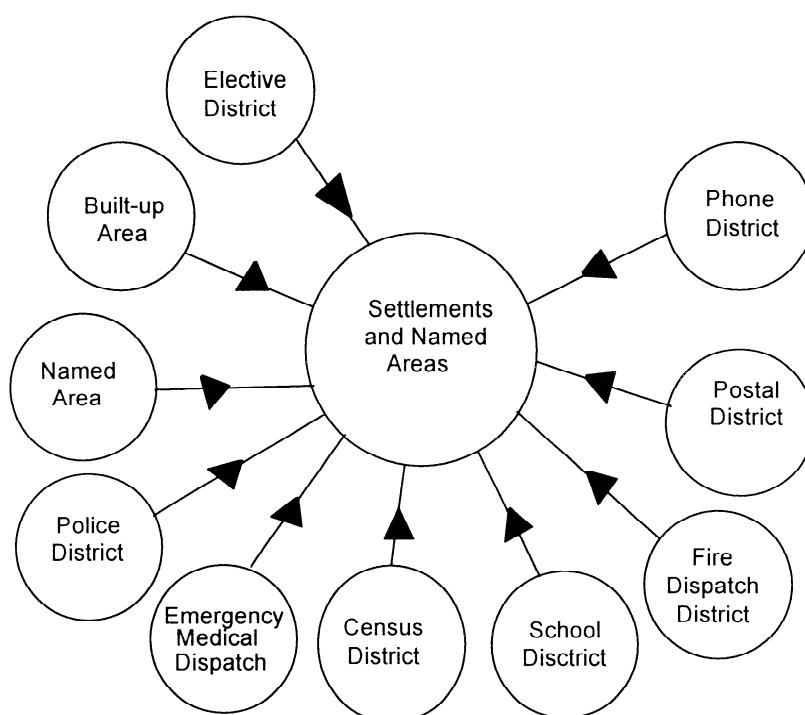


Figure 5.27. Data Model for *Settlements and Names Areas*.