BS ISO 17572-1:2015

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Intelligent transport systems (ITS) — Location referencing for geographic databases

Part 1: General requirements and conceptual model

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National foreword

This British Standard is the UK implementation of ISO 17572-1:2015. It supersedes BS ISO 17572-1:2008 which is withdrawn.

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

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

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

Published by BSI Standards Limited 2015

ISBN 978 0 580 82013 7
ICS 03.220.01; 35.240.60

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2015.

Amendments/corrigenda issued since publication

Date	Text affected

INTERNATIONAL STANDARD

ISO 17572-1

Second edition
2015-01-15

Intelligent transport systems (ITS) — Location referencing for geographic databases —

Part 1: General requirements and conceptual model

Systèmes intelligents de transport (SIT) — Localisation pour bases de données géographiques —

Partie 1: Exigences générales et modèle conceptuel

Reference number
ISO 17572-1:2015(E)

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Published in Switzerland

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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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 204, *Intelligent transport systems*.

This second edition cancels and replaces the first edition (ISO 17572-1:2008), which has been technically revised.

ISO 17572 consists of the following parts, under the general title *Intelligent transport systems (ITS) — Location referencing for geographic databases*:

— *Part 1: General requirements and conceptual model*

— *Part 2: Pre-coded location references (pre-coded profile)*

— *Part 3: Dynamic location references (dynamic profile)*

Introduction

A location reference (LR) is a unique identification of a geographic object. In a digital world, a real-world geographic object can be represented by a feature in a geographic database. An example of a commonly known location reference is a postal address of a house. Examples of object instances include a particular exit ramp on a particular motorway, a road junction or a hotel. For efficiency reasons, location references are often coded. This is especially significant if the location reference is used to define the location for information about various objects between different systems. For intelligent transport systems (ITS), many different types of real-world objects will be addressed. Amongst these, Location Referencing of the road network, or components thereof, is a particular focus.

Communication of a location reference for specific geographic phenomena, corresponding to objects in geographic databases, in a standard, unambiguous manner is a vital part of an integrated ITS system in which different applications and sources of geographic data will be used. Location referencing methods (LRM, methods of referencing object instances) differ by applications, by the data model used to create the database or by the enforced object referencing imposed by the specific mapping system used to create and store the database. A standard location referencing method allows for a common and unambiguous identification of object instances representing the same geographic phenomena in different geographic databases produced by different vendors, for varied applications and operating on multiple hardware/software platforms. If ITS applications using digital map databases are to become widespread, data reference across various applications and systems has to be possible. Information prepared on one system, such as traffic messages, has to be interpretable by all receiving systems. A standard method to refer to specific object instances is essential to achieving such objectives.

Japan, Korea, Australia, Canada, the US, and European ITS bodies are all supporting activities of Location Referencing. Japan has developed a link specification for VICS. In Europe, the RDS-TMC traffic messaging system has been developed. In addition, methods have been developed and refined in the EVIDENCE and AGORA projects based on intersections identified by geographic coordinates and other intersection descriptors. In the US, standards for Location Referencing have been developed to accommodate several different location referencing methods.

This International Standard provides specifications for location referencing for ITS systems (although other committees or standardization bodies can subsequently consider extending it to a more generic context). In addition, this edition does not deal with public transport location referencing; this issue will be dealt with in a later edition.

Intelligent transport systems (ITS) — Location referencing for geographic databases —

Part 1: General requirements and conceptual model

1 Scope

This International Standard specifies location referencing methods (LRMs) that describe locations in the context of geographic databases and will be used to locate transport-related phenomena in an encoder system as well as in the decoder side. This International Standard defines what is meant by such objects and describes the reference in detail, including whether or not components of the reference are mandatory or optional, and their characteristics.

This International Standard specifies two different LRMs:

— pre-coded location references (pre-coded profile);

— dynamic location references (dynamic profile).

This International Standard does not define a physical format for implementing the LRM. However, the requirements for physical formats are defined.

This International Standard does not define details of the Location Referencing System (LRS), i.e. how the LRMs are to be implemented in software, hardware, or processes.

This part of ISO 17572 specifies the following general LRM-related sections:

— requirements of a location referencing method;

— conceptual data model for location referencing methods;

— inventory location referencing methods (see Annex A);

— examples of conceptual model use (see Annex B);

— description of selected UML elements (see Annex C);

— comparison of definitions with ISO/TC 211 (see Annex D);

— introduction to the TPEG physical format (see Annex E and Annex F).

It is consistent with other International Standards developed by ISO/TC 204 such as ISO 14825.

2 Terms and definitions

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

2.1 General terms

NOTE As part of the general intent to harmonize this International Standard with the ISO/TC 211 family of Geographic Information Systems International Standards, a comparison between terms and definitions of this International Standard and of ISO/TC 211 International Standards is included in Annex D.

2.1.1
accuracy
measure of closeness of results of observations, computations, or estimates to the true values or the values accepted as being true

2.1.2
area
two-dimensional, geographical region on the surface of the earth

Note 1 to entry: An area can be represented as an implicit area or an explicit area.

2.1.3
area location
two-dimensional location, representing a geographical region on the surface of the earth

2.1.4
attribute
characteristic property of an entity like a real-world feature

Note 1 to entry: It allows the identification of that feature by its attributes. An attribute has a defined type and contains a value. Attributes can be either simple, i.e. consisting of one atomic value, or composite (see composite attribute).

2.1.5
coordinate
one of an ordered set of N numbers designating the position of a point in N-dimensional space

Note 1 to entry: N would be 1, 2, or 3.

2.1.6
complex intersection
intersection that consists at least of two or more junctions and one or more road elements

2.1.7
composite attribute
complex attribute
attribute consisting of two or more atomic values and/or attributes

2.1.8
datum
set of parameters and control points used to accurately define the three-dimensional shape of the earth

Note 1 to entry: The corresponding datum is the basis for a planar coordinate reference system.

2.1.9
descriptor
characteristic of a geographic object, usually stored in an attribute

EXAMPLE Road names or road numbers.

2.1.10
digital map database
structured set of digital and alphanumeric data portraying geographic locations and relationships of spatial features

Note 1 to entry: Typically, such structures represent, but are not limited to, the digital form of hard copy maps. For example, drawings can be imported into a Geographic Information System (GIS) and considered as a form of digital map.

2.1.11
dynamic location reference
location reference generated on-the-fly based on geographic properties in a digital map database

2.1.12
explicit area
two-dimensional face on the surface of the earth, with a specified outline either being a simple geometric figure or an irregular outline/polygon

2.1.13
face
two-dimensional element bounded by a closed sequence of edges not intersecting themselves

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

2.1.14
implicit area
selection of road segments to be referenced belonging to a certain area (subnetwork)

Note 1 to entry: One implicit area can be built up of multiple subnetworks that are geographically connected.

2.1.15
international terrestrial reference frame
ITRF
realization of the ITRS

Note 1 to entry: The ITRF94 reference frame is consistent with WGS84 at the 5 cm level, and therefore is equivalent to WGS84 for ITS applications.

2.1.16
international terrestrial reference system
ITRS
reference system for the earth derived from precise and accurate space geodesy measurements, not restricted to GPS Doppler measurements, which is periodically tracked and revised by the international earth rotation service

2.1.17
intersection
crossing and/or connection of two or more roads

Note 1 to entry: In GDF, an intersection is a level 2 representation of a junction 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. The definition is different from GDF because the location referencing system refers to real-world objects rather than a database definition as defined in GDF.

Note 2 to entry: Crossings can be at-grade or grade-separated. Crossings that are grade-separated where no connection between the road segments exists, are excluded from this definition.

2.1.18
junction
elementary element in the road network, connecting two or more road elements

Note 1 to entry: In GDF terms, it is a level 1 feature that bounds a road element or ferry connection. Junctions that represent real crossings are at least trivalent (having three roads connected). A bivalent junction can only be defined in case an attribute change occurs along the road (e.g. road name change). A junction is also coded at the end of a dead-end road, to terminate it.

2.1.19
linear location
location that has a one-dimensional character

EXAMPLE A road segment.

2.1.20
link
edge
direct topological connection between two nodes that has a unique link ID in a given digital map database

Note 1 to entry: A link can contain additional intermediate coordinates (shape points) to better represent the shape of curved features. A link can be directed or undirected.

2.1.21
link identifier
link ID
identifier that is uniquely assigned to a link

Note 1 to entry: A link identifier can be arbitrary or can be assigned by convention, to ensure that no multiple occurrences of the same identifier will be used within one instance of a network or map database.

2.1.22
link location
location identifiable by a part of the road network database having one identifier or having a uniquely identifiable combination of attributes throughout the continuous stretch

Note 1 to entry: One link location can consist of multiple links.

2.1.23
location
simple or compound geographic object to be referenced by a location reference

Note 1 to entry: A location is matched to database objects by location definitions, which specify what is meant by a particular location. Without any explicit remark, it is meant to be a linear stretch in terms of topology in the database network without any loops or discontinuities in between (linear location). It might also be only a point in the network as a specialization of a linear stretch with length zero. In addition to that, a location can also be a set of road elements representing an area. This area is expressible by a polygon or a list of linear locations. For further description of different categories of locations, refer to 5.4.

2.1.24
location definition
actual delineation of exactly what is meant (and, therefore, what is not meant) by a particular location within a specific database

Note 1 to entry: It is the precise location definition of the database object, or set of database objects, which is referenced.

EXAMPLE The GDF road elements that make up a particular instance of an ALERT-C location.

2.1.25
location reference
reference
label which is assigned to a location

Note 1 to entry: With a single LRM, one reference shall define unambiguously and exactly one location in the location referencing system. The reference is the string of data which is passed between different implementations of a location referencing system to identify the location.

2.1.26
location referencing method
LRM
methodology of assigning location references to locations

2.1.27
location referencing system
LRS
complete system by which location references are generated, according to a location referencing method, and communicated, including standards, definitions, software, hardware, and databases

2.1.28
matching
translating a location reference to a specific object in a given map database to attempt recognition of the same identified object in both the sender's and the receiver's map database

Note 1 to entry: Matching is seen as a subsequent part to the method of decoding a location reference adhering to the defined LRM.

2.1.29
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: A node is created for topologically significant points, such as simple intersections of roads or other linear features including boundaries but also for locations such as electric beacons, kilometre-posts, or sensors detecting traffic flows, being significant points specified in a map.

2.1.30
node identifier
identifier assigned to a node

Note 1 to entry: A node identifier can be arbitrary, or can be assigned by convention, to ensure that multiple occurrences of the same identifier will not occur within one network or within the universe of similar networks or databases.

2.1.31
outlined area
explicit area with an outline defined by segments being either polylines or linear locations

2.1.32
point
zero-dimensional element that specifies geometric location

Note 1 to entry: One coordinate pair or triplet specifies the location.

2.1.33
point location
location that has a zero-dimensional character

EXAMPLE A simple crossing.

2.1.34
precision
exactness of the measurement of a data value or of the storage allocated to a measured data value

Note 1 to entry: Alternatively, the closeness of measurements of the same phenomenon repeated under exactly the same conditions and using the same techniques.

2.1.35
pre-coded location reference
location reference using a unique identifier that is agreed upon in both sender and receiver system to select a location from a set of pre-coded locations

2.1.36
quad tree
hierarchical data structure which, on a next lower level, subdivides a given area into four quadrants of the same size where any level has knowledge of its four sublevels and its parent level

2.1.37
relationship
semantic or topological interrelation or dependency between locations in the LRS

Note 1 to entry: Relationships can exist between locations in the LRS. These relationships will generally be structured to allow more sophisticated use of the location reference, such as a topological or hierarchical structure. For example, a county location can be defined as an aggregate of several city locations or a long stretch of road can be an aggregate of several smaller road segments. Referencing the county can be easier than referencing all the cities which make up the county. This allows scalability and ease of use in the LRSs using the LRM.

2.1.38
resolution
smallest unit which can be represented fixing a limit to precision and accuracy

2.1.39
road
part of the road network which is generally considered as a whole and which can be addressed by a single identification like a road name or road number throughout

Note 1 to entry: In general, it is a connection within the road network, with or without crossings, which functionally can be considered as a unity. A road with multiple (associated) carriageways can be considered as one road. (Note that, in the context of this part of ISO 17572, the term also covers the natural language term street).

Note 2 to entry: The subsequent parts of this International Standard intentionally do not make direct use of this term because under different circumstances it might not be possible to define exactly where a road ends. For this reason, reference will be made to artificial but more-precisely-definable road elements or road sections of the road network.

2.1.40
road crossing
location where two or more roads connect or intersect

Note 1 to entry: A road crossing can be “simple”, corresponding to one junction, or “complex”, including internal road elements and junctions.

2.1.41
road element
linear section of the road network which is designed for vehicular movement having a junction at each end

Note 1 to entry: It serves as the smallest unit of the road network at GDF level 1 that is independent.

2.1.42
road section
road segment that is bounded by two intersections and has the same attributes throughout

Note 1 to entry: Generally, the two intersections are different, only in some specific cases are the intersections the same, e.g. a tear-drop street or slip roads inside of complex intersections.

2.1.43
road segment
part of a road, having its start and end along that road

Note 1 to entry: Important difference between a road section and road segment is that the segment does not necessarily end at intersections.

2.1.44
shape point
intermediate coordinate pair to represent the shape of curved features

2.1.45
simple geometric area
explicit area with an outline defined by a simple geometric figure

2.1.46
simple object access protocol
SOAP
protocol providing a platform-independent way for applications to communicate with each other over the Internet

Note 1 to entry: SOAP technology relies on XML to define the format of the information and then adds the necessary HTTP headers to send it. Standardization is done within IETF: http://www.ietf.org/rfc.

2.1.47
subnetwork
plurality of road segments lying in geographical or topological conjunction to each other

2.1.48
synchronization markup language
SyncML
data synchronization protocol

Note 1 to entry: A data synchronization protocol defines the workflow for communication during a data synchronization session when the mobile device is connected to the network. The protocol supports naming and identification of records, common protocol commands to synchronize local and network data, and can support identification and resolution of synchronization conflicts.

2.1.49
topology
properties of spatial configuration invariant under continuous transformation

Note 1 to entry: In a digital map database, this means the logical relationships among map features. It can be used to characterize spatial relationships such as connectivity and adjacency.

2.1.50
world geodetic system of 1984
WGS84
earth-centred global reference frame, including an earth model, based on satellite and terrestrial data

Note 1 to entry: It contains primary parameters that define the shape, angular velocity, and the earth mass of an earth ellipsoid, and secondary parameters that define a gravity model of the earth. Primary parameters are used to derive latitude-longitude coordinates (horizontal datum).

3 Abbreviated terms

AGORA	Implementation of Global Location Referencing Approach (Name of a European project 2000–2002)
ALERT-C	Advice and problem Location for European Road Traffic-Compact
CAD	computer-aided design
EVIDENCE	Extensive Validation of Identification Concepts in Europe (Name of a European project 1998–1999)
GCId	generic component identifier
GDF	Geographic Data File
GIS	Geographic Information System
GPS	Global Positioning System
IETF	Internet Engineering Task Force

ILOC	intersection location
ITS	intelligent transport systems
LR	location referencing (or reference)
LRC	location reference container
POI	point of interest
RDS	Radio Data System
TPEG	Transport Protocol Expert Group
TMC	Traffic Message Channel
TTI	Traffic and Traveller Information
UML	Unified Modelling Language
UTM	Universal Transverse Mercator
VICS	Vehicle Information and Communication System

NOTE This International Standard uses UML to express specific circumstances. As such, the graphical elements are used to express specific constraints and structural relationships. A full definition can be found in the UML standard ISO/IEC 19501. However, a short introduction of used elements is given in Annex C.

4 Objectives and requirements for a location referencing method

4.1 Objectives for an optimal location referencing method

ITS applications have different objectives regarding location referencing, which from their contradictory nature, cannot be fulfilled completely. In theory, a best location referencing method would require every LRS to have at a given time the same, completely accurate map and all locations would be identifiable without any additional computational effort. Even though this is not achievable, the following goals should guide the definition and optimization of a location referencing method. The circumstances of the specific location referencing system can give different weight to the following goals.

The first goal therefore states that processing power in any case is a cost factor to be minimized.

O-1. The LRM should be simple enough to be implemented in a resource- and performance-efficient way.

Secondly, location referencing implies at least two systems communicating with each other. Communication also causes costs and therefore needs to be minimized.

O-2. The LRM should not unduly add to the volume of data to be transferred.

The aim to use the exact location, both in the sender and the receiver system, is the reason of referring to it. In many cases, it will be up to the receiver to decode the location reference as well as possible. To help the receiver to do so, it shall be implied that the sending system sends the location reference as accurately as possible.

O-3. The LRM should provide location references with the highest accuracy possible.

4.2 Requirements of the location referencing method

In addition to the goals, some minimal requirements shall make the different location referencing methods feasible for the foreseen categories of locations (see 5.4).

One of the most important data characteristics for ITS applications is spatial accuracy. Spatial accuracy is an aspect of data quality and is described in GDF in the following way: The shape of a level 0 edge including all positions on the segment as a whole shall not have any position that diverges from the real shape more than an allowed error. Spatial data accuracy requirements for ITS vary according to the application. This means not just categories of applications but how an application works operationally. Some applications, notably those for advanced vehicle safety systems, would require very accurate data. Even within a particular application, requirements for different levels of data accuracy might exist and will be subject to change as applications and products evolve. The spatial data accuracy requirements impact on the location referencing method chosen for an application.

One fundamental requirement across all methods is that, whichever method is used, use of that method does not result in additional spatial location error beyond that already present in the data. However, for the location referencing of area information, for example weather information or information specifying a zone of environmental contamination, some positional error is permitted due to the imprecise ("fuzzy") nature of such information. The key requirement for such references is that they be made with sufficient precision to allow the user to avoid the area or take other appropriate action. Specifically, it is a requirement that:

R-1. An LRM and the process of its operation shall not introduce a supplementary position error relative to that specified in the database from which the reference is generated. The location reference should be conveyed with spatial and temporal accuracy sufficient to enable the vehicle or user to identify the (spatial) extent of the location.

For certain locations, knowing the side of the road or block on which the location is found can be very important to the user. For example, crossing a road to a location on the opposite side might not be possible for vehicles or pedestrians in some road lane configurations without additional routing, whereas turning into a location on the same side can be easily accomplished. Therefore, it is a particular requirement that:

R-2. The LRM shall enable referencing of the relative spatial relationship of objects.

In addition to spatial accuracy requirements, location referencing methods have functional requirements regarding topological relationships, for example that a point is on one side of an object or that many points shall be ordered in a certain way along a road. For example, for locations referenced by positions along a logical or physical route, the ordering of points shall be preserved by the reference. For location referencing, the requirement is that:

R-3. The LRM shall not change the topological relationships within a set of point data by its own action, limitation, or deficiency. For referencing by geographic coordinates, spatial relationships between locations should not be confused by lack of precision or by any other attribute of the referencing system or its operation.

This International Standard is foreseen to be used in a variety of location referencing systems. However, the restriction to some specified categories of locations is understood as a first step of optimization of the defined location referencing methods. For this, the following shall at least hold:

R-4. The definition of an LRM shall adhere to the common terminology and conceptual model defined in this part of ISO 17572.

R-5. The LRM shall provide means to refer only to the categories of locations explicitly defined by that LRM.

R-6. The LRM shall, in principle, allow addressing of every location on the road network.

Location referencing is an important technology for traffic telematics applications in particular and, in general, for any location based service. It provides an understandable reference for a location about which information needs to be provided. Understandable generally means machine-readable, i.e. the location information (as well as the message content) can be understood by equipment that translates the complete message to human understandable information e.g. position on a map or a descriptive way to reach the location. Therefore:

R-7. The location reference shall be machine-readable.

5 Conceptual data model for location referencing methods

5.1 Role of conceptual model

The conceptual model provides a framework to describe and define an LRM in generic, conceptual terms. The conceptual model is generally valid, i.e. not limited to the LRMs defined in this part of ISO 17572. Therefore, examples of other LRMs are mentioned, to illustrate the underlying conceptual view. See also Annex B.

5.2 Components of conceptual model

All location referencing methods have some form of the following components. The detailed definitions of the terms are provided in Clause 2.

Attributes

An attribute allows the LRS to process or evaluate the information about the location. Attributes discriminate the reference in such a way that the receiver system can identify the location correctly.

Location

A location is a part of the road network that is intended to be identified. The sender system aims to refer to it; the receiver system aims to find it in its map database.

Location definition

The location definition is the defined delineation in a digital map database of exactly what is meant. The location definition in a sender system can be different from the one in a receiver system even if the location is the same.

Reference

The reference is the label which is assigned to the location.

Relationship

Relationships to other locations in the LRS are also used to support the use of locations in an LRM.

NOTE Not all LRMs require relationships and attributes. For example, an LRS which uses arbitrary numbers assigned to each location might never need to define how any of the locations relate to each other. However, in an LRS which meets the requirements which have been identified (such as flexibility, extensibility, compactness, etc.), relationships can be inherent in the referencing procedures. For example, pre-coded locations used in RDS-TMC systems arbitrarily number locations, but since the referencing system allows the use of an “extent,” each location can carry the definitions of which location is “before” and “after” it.

5.3 Description of the conceptual model

A reference is the label which is assigned to a location. In a single LRS, a reference shall be defined or definable which unambiguously identifies each location in this LRS. A location is a simple or compound geographic object, which is matched to database objects by location definitions, which specify what is meant by the particular location. A location can aggregate different attributes, which allow for the identification of the methods to process or evaluate the information about the location. Relationships associate different locations, e.g. to allow more sophisticated use of the location reference, such as a topological or hierarchical structure; they are intended to reflect the possibility of two or more locations in a relationship, either ordered or unordered.

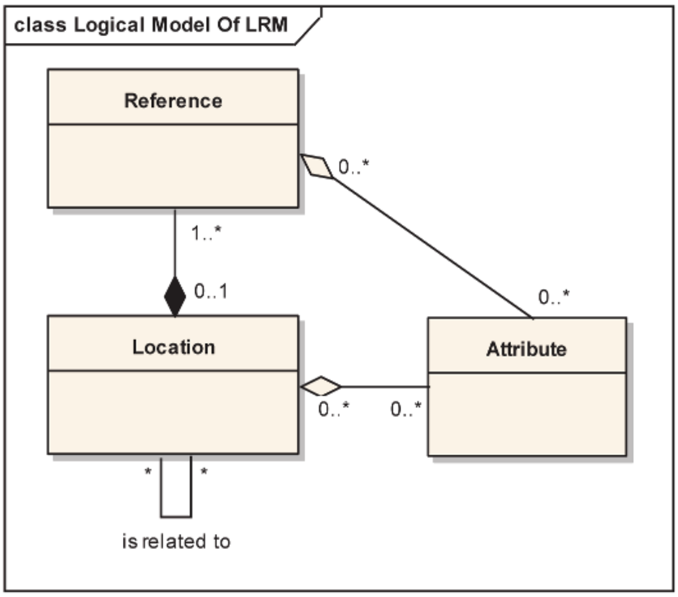


Figure 1 — Diagram of the conceptual model of an LRM

5.4 Location categories

Locations shall be categorized as point locations, linear locations, and area locations. These location categories represent real world objects which can be described as follows:

— existing at a single position (point location);

— between two positions within intersections as road section (linear location, in terms of one or more link locations);

— between two positions as road segment (linear location);

— consisting of two or more link locations (linear location);

— a selection of road segments belonging to a defined collection (subnetwork or collection of subnetworks) (implicit area location);

— within the boundaries of a defined area (explicit area location).

Point locations can be described as existing at a single position. Point locations include, for example, points of interest, public service facilities, commercial establishments, etc. Link locations are linear objects bound by two point locations. Linear locations are two or more consecutive link locations, bounded, therefore, by three or more consecutive point locations that define a connected linear stretch in the road network. Implicit area locations are more than one linear location of a certain area put together in one package. Explicit area locations are two-dimensional features such as governmental administrative area, postal district, telephone exchange district, etc., or just defined outlines as faces at a given place on the map.

Specific reference object instance classes within these categories include the following:

— general points (points that might or might not lie on a road network, including points where a road crosses administrative boundaries or borders of map grid cells);

— points at nodes in a topological network representation of roads and their intersections;

— links defined by two consecutive intersections of roads (road sections);

— points along links bounded by intersections of roads;

— manoeuvres defined by two consecutive links (therefore, three intersections);

— areas defined by a sequence of points;

— areas defined by a sequence of link locations;

— areas defined by an origin point and attributes, such as the radius of a circle around the point or offsets defining a bounding box.

Generally, important location categories for ITS databases are man-made structures like road crossings, road sections or segments, as well as sequences of road sections necessary for describing manoeuvres. Location categories can be arranged in class/type hierarchies to aid in decoding between dissimilar receiver/sender systems.

5.5 Conceptual model of a road network

One purpose of location referencing is to refer to parts of the road network. The conceptual model of the road network is, therefore, depicted in Figure 2 and described in this subclause to give a clear understanding of the different terms and their relationships. This is especially needed because the sophisticated definition of roads and intersections in GDF does not meet the requirements of a conceptual model for location referencing.

In general the road network consists of roads. A road is generally represented by a name (or number) throughout as a whole and consists of a set of road sections. On a road a tremendous (but countable) number of road segments can be defined (and referenced). A road section consists of nodes and edges, is bounded by intersections, and can have intermediate intersections (where the road name does not change). An intersection is a connection or crossing of roads. The simplest intersection consists of just one node (i.e. junction). If an intersection has two or more nodes and one or more edges, it is considered to be a complex intersection.

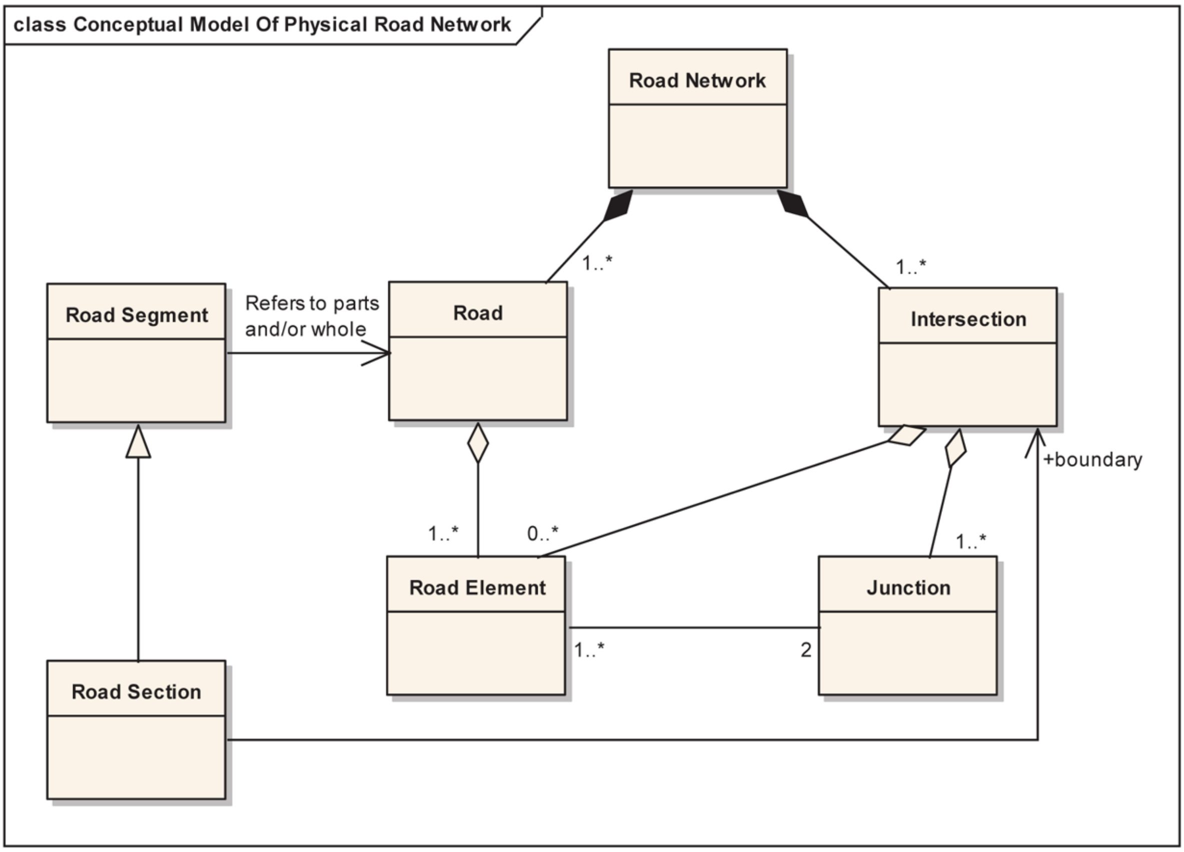


Figure 2 — Conceptual model for the physical road network

5.6 Conceptual model of area locations

An area is considered to be a two-dimensional, geographical region bounded on the surface of the earth. Area locations have specific constraints on location referencing due to requirements of the application. The different requirements of the applications determine if the full geographical figure shall be mentioned or a defined number of roads inside this region. To enable an LRM handling and defining rules for explicit and implicit area types, the conceptual model defines terms for it and describes conceptually their containment.

In one case, it might be feasible to define the area by a geometric figure (explicitly). In other cases, it might be necessary to select a list of road elements spanning an area (implicitly).

An implicit area consists of one or more subnetwork locations which each consist of at least two road segments being aggregated to the subnetwork. The explicit area specifies a part of the earth surface being the area, by means of a geometric (regular) function, defined as region; meanwhile, an area with a shape freely defining the shape of it is called outline. Both of the area types have at least one referenced connection to the surface allowing the decoding system to precisely position the given area.

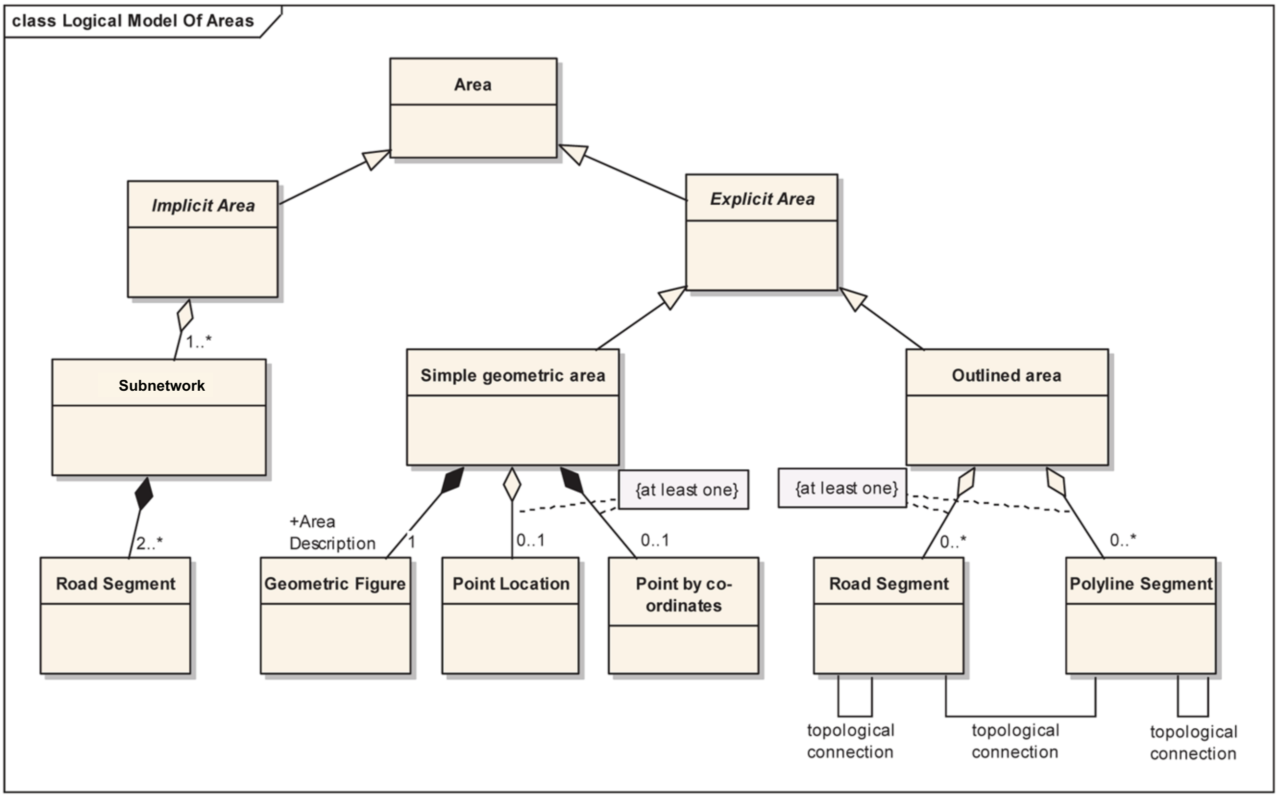


Figure 3 — Conceptual model of areas

Annex A
(informative)

Inventory of location referencing methods

A.1 General

There are two essentially different ways of referencing road locations: with reference to attributes of the road network itself, including linear distances or street addresses, or with reference to a regular or irregular division of space which exists independent of the representation of the road network. The former kind of reference is sometimes called an indirect reference. The latter kind involves coordinate systems, for example US UTM coordinates or geographic latitude/longitude coordinates.

Some indirect referencing methods stress the topology of networks (for example, link ID and Linear Referencing), and some stress the attributes of the features that comprise the network (for example, cross-street offset matching and street addresses). Geographic coordinates express location directly in terms of the geodetic reference framework itself; they are simply measurements on the framework (e.g. longitude/latitude) or as quantized, regular subdivisions (e.g. quad trees). Figure A.1 illustrates indirect (specifically, the link ID method) and coordinate referencing methods (specifically, the method of geographic coordinates).

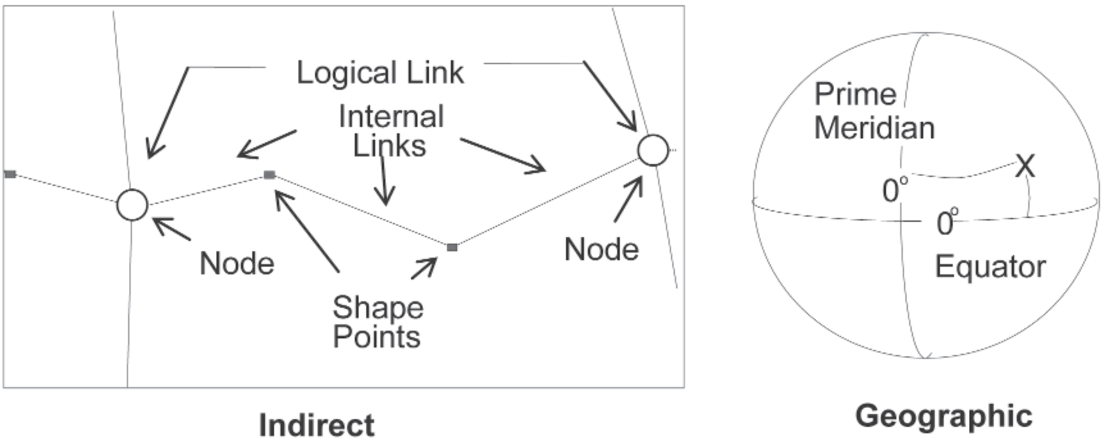


Figure A.1 — Indirect (link ID) vs. geographic coordinate schemes

The following list summarizes location referencing methods in use today, which will be discussed briefly in the next clauses:

- referencing by link ID or node ID;
- referencing by geographic coordinates;
- referencing by grid;
- linear referencing;
- referencing by cross-streets;
- referencing by address information;
- combinations of above methods.

A.2 Referencing by link ID or node ID

Logical links represent topological connectivity between nodes corresponding to real world points like intersections. The real world network can be represented within the data set by a planar or non-planar graph. The difference is that containing links do or do not cross without nodes. Shape points are typically inserted between nodes to represent road geometry between intersections. A link identifier (link ID) is usually a numeric identifier assigned to each link in the network. Link ID references can be passed in more than one way. The link ID can be

— unique,

— non-unique within a hierarchical scheme, or

— derived from some manipulation of location, such as the bit interleaving of end-node coordinates.

The two modes of referencing are as follows

— Unique link ID: The link itself has one identifier (possibly corresponding to only one direction of the link and optionally complemented by a second Identifier for the reverse direction, i.e. the link can either be directed or undirected.

— End node IDs: The link is then identified by two identifiers, those of the link start node and the end node.

Within a link ID reference, additional information can be specified, such as offsets from start and/or end nodes, an indicator for the side of the street or road on which a point-of-interest or linear segment-of-interest resides, or implied directionality for a unique link ID reference. The link ID LRM refers to a previously defined database of identifiers and is, therefore, categorized as a pre-coded LRM.

A.3 Referencing by geographic coordinates

A location on the earth's surface is often expressed in terms of coordinates defined by a coordinate system (axes, origin, and values) and a geodetic datum, the set of geodetic parameters defining the space with respect to which location is to be referenced (see ITRF). Coordinate systems can be earth-centred or local, geodetic or planar, and can allow position specification horizontally, vertically, or both. Geodetic parameters can include the following:

— national geodetic datum;

— reference ellipsoid;

— projection method;

— national map grid;

— geoid ondulation;

— magnetic declination.

Referencing by geographic coordinates is defined in ISO 19111,[16] and ISO 6709:2008.[19]

This LRM is called dynamic LRM because the nature of the defined coordinate system is independent of the road network's locations so that a location's code is produced on demand, for example, while determining the position of the real world object in the geodetic system.

A.4 Referencing by grid

The common element of a grid (or raster) scheme is a regular subdivision of a surface into finite shapes, typically rectangular, and the assignment of coordinates in some regular way (e.g. letters A to Z for columns and numbers 1 to 10 for rows). To minimize data set size and for efficient manipulation and search based on divide-and-conquer algorithms, hierarchical tessellations recursively subdivide a surface into regular groupings of shapes numbered hierarchically. Data sets built on hierarchical tessellations preserve information where, and only where, there is information. Such methods are therefore hybrid between continuous field representations and grids. In terms of the location referencing method here, again the grid is defined independent of the road network and is therefore categorized as dynamic LRM.

A.5 Linear referencing

A linear (one-dimensional) referencing method is a method of identifying a location on a network or part of a network by reference to known positions of (spatial) objects. If space is constrained to the road network itself, distances along roads from established nodes (or even topologically non-significant points) can be used to specify location. Mile point or reference point submethods use a road label and distance measure, and mile marker, reference marker, and addressing submethods use physical features inserted into the digital base map. Because of the reliance on predefined identifiers, this method is categorized as pre-coded LRM even if parts of the reference, e.g. a given offset, do vary inside of different references.

Linear referencing is also addressed in the ISO/TC 211 family of Geographic Information Standards in 6.6 of ISO 19133,[13] which supplies classes and types for the definition of linear reference systems generally. This work is itself related to that developed by the US National Cooperative Highway Research Program (NCHRP) as reported in NCHRP Report 460.[25]

A.6 Referencing by cross-streets

The cross-streets method uses the names of intersecting (cross) streets to identify nodes. This method relies on passing three street names and offset(s) from the first intersection to identify location on a link. Inclusion of the names of two streets that intersect identifies an intersection. Adding a third street name denotes two intersections along the same road, which identifies a specific road segment or link. Offsets specify position along the link for POI or sub-link references. Adding a third street (i.e. two intersections along the same road) identifies the specific road segment and extent of a position along a road. Coordinates of the centreline intersection of streets can be used to resolve ambiguities found when using street names alone. This LRM is the predecessor of the dynamic location referencing method defined in ISO 17572-3. It is, as such, dynamic, as the rules to create the reference are independent of the real world information, although it relies very much in the fact that the street names do exist as pre-defined information on the encoder's and decoder's side. Especially, this deficiency has been reason to enrich the method with more types of information to ensure independence of such names as much as needed. See ISO 17572-3 for more information about dynamic location referencing.

A.7 Referencing by address information

An address is a value unambiguously associated with a known location controlled by an all-sides-accepted authority like a governmental mail system. The most common form is the street mail address (combinations of street names and numbers indicating location along the street). Given a scheme to prevent ambiguity problems between domains and the existence of consistent naming and numbering conventions, addresses are efficient references within larger domains such as nations. In addition, they are potentially useful adjuncts to other location referencing methods. ISO/TC 211 addresses this referencing method in ISO 19112,[17] which provides essential elements for gazetteering. From the nature of the method, it clearly relies on pre-defined identifiers and, therefore, it is categorized as pre-coded location referencing.

A.8 Combinations

Elements of different methods can be combined to form others or to improve a given method's performance. For example, a street or road name can be used to reduce ambiguity in a location reference by geographic coordinates. This is a typical way to make one LRM more robust against mismatches caused by deficiency of it being standalone.

A.9 TPEG location referencing

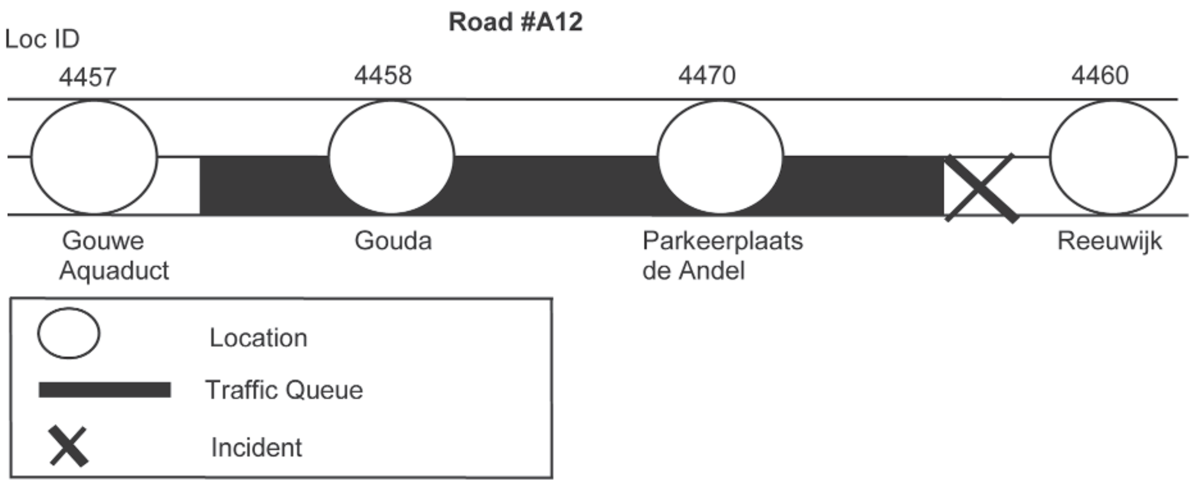
The TPEG location referencing method is categorized as a dynamic LRM as it allows collection of different attributes on request. The TPEG technology makes use of several aforementioned methods. It combines coordinates, location codes, street names, and intersection information and makes it possible to build connectivity trees. With this wide range of choices, the service provider can proprietarily choose which information he wants to send out and receivers might or might not be able to decode automatically the location information. More focus here lies on the idea to transport efficiently a human-readable sentence in a compact way, which, then, the client user can read and recognize the position on its own. It is specified in References [3] and.[4].

Annex B
(informative)

Examples of location referencing methods in use (mapping to conceptual data model for location referencing systems)

B.1 Example of RDS-TMC system (ALERT-C)

In ISO 14819-3, the location referencing method is specified and more information about that can be found in ISO 17572-2. The following example shows a location on one side of a street going over a number of pre-defined location points, which normally represent intersections.



Location number	Type	Road / junction number	First name	Second name	Reference to area	Reference to linear location	Negative offset	Positive offset
4457	Aqua.	A12	Gouwe Aquaduct		2009	949	4456	4458
4458	Exit	A12	Gouda	N207	30089	949	4457	4470
4470	Park.	A12	Parkeerplaats de Andel		30089	949	4458	4460
4460	Exit	A12	Reeuwijk		2009	949	4470	4461
Reference	*Attribute*	*Definition*			*Relationships*			

Figure B.1 — Example of the ALERT-C location referencing system

In relation to the general logical data model in Figure 1, this translates to the following:

Definition = Each point location instance is defined by at least one of the four items "Road/junction number", "road name", "first name", or "'second name". Other location types can be defined using different information.

Reference = Location number.

Attributes = Type.

Relationships = Reference to area, reference to linear location, positive offset, and negative offset.

B.2 Example of VICS system

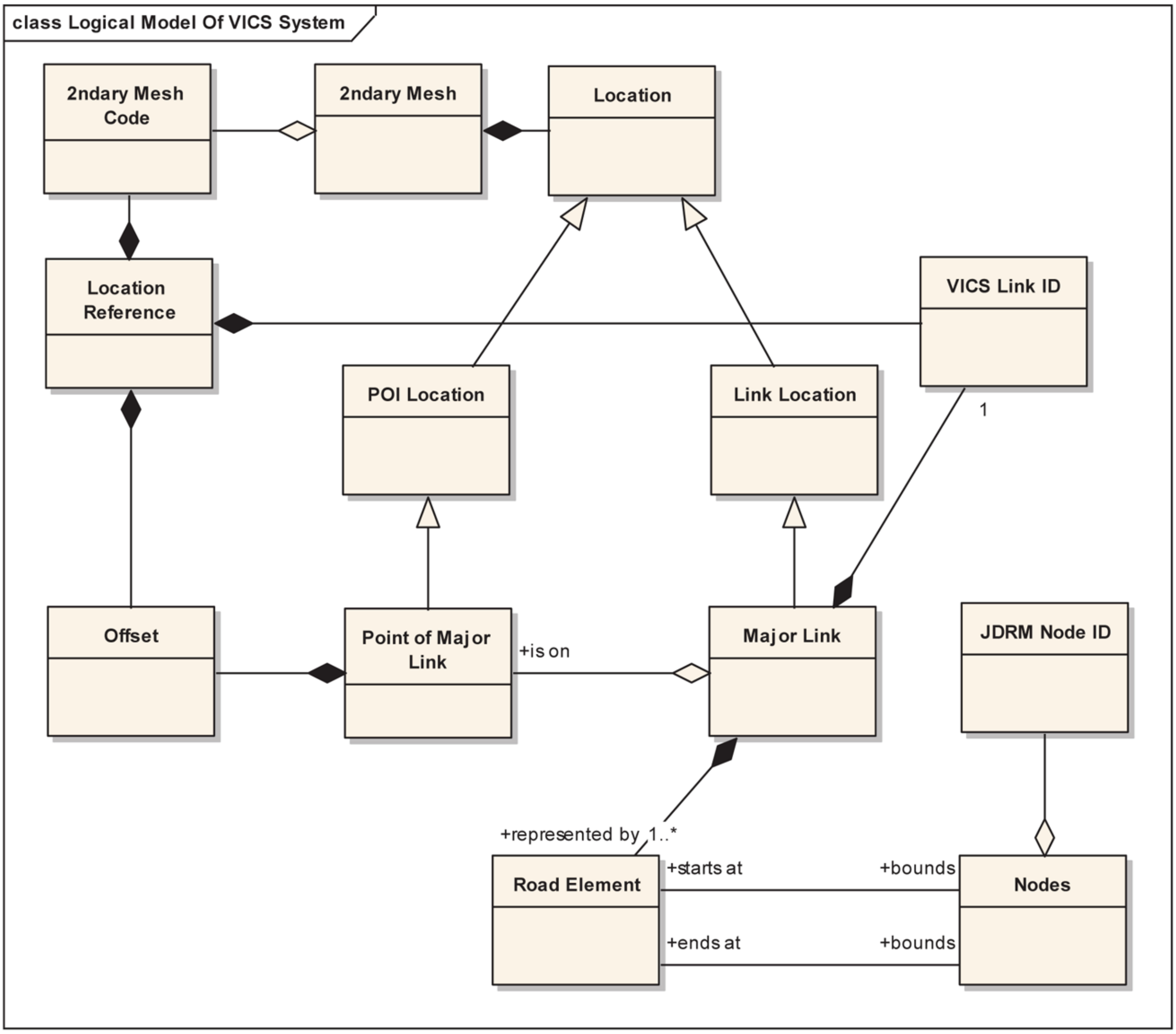


Figure B.2 — Example of conceptual model applied to link ID references of the VICS system

In relation to the general logical data model in Figure 1, this translates to the following:

Definition = JDRM basic roads.

References = VICS link ID.

Attributes = None.

Relationships = Topological connections to other JDRM basic roads in the JDRM database.

Annex C
(informative)

Description of UML expression elements

This International Standard makes use of a newly developed methodology to express structural circumstances called UML. Table C.1 shows a short description of UML diagram elements used to ensure that no misinterpretation can occur caused from further development of UML1.4, which is standardized in ISO/IEC 19501. However, for UML2, the standardization is to be completed by the Object Management Group (http://www.omg.org).

In different class diagrams, light or dark colouring is used, to express the intent of a particular diagram. The light colour implies that the diagram is of logical/explanatory nature; the dark colour implies that a particular instantiation will be introduced afterwards. The dark colouring here is used for the description of the structure of the proposed physical format.

Table C.1 — Description of UML expression elements

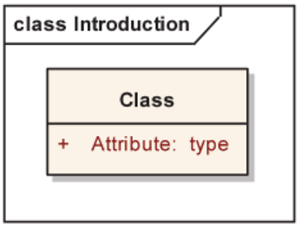
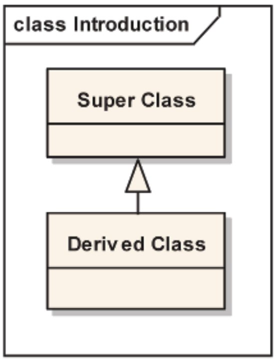
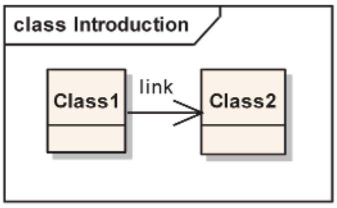
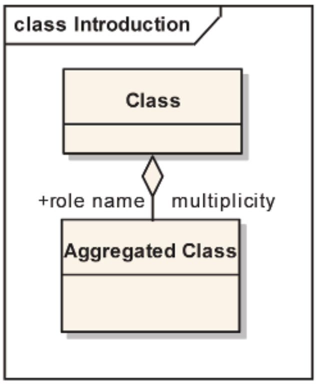
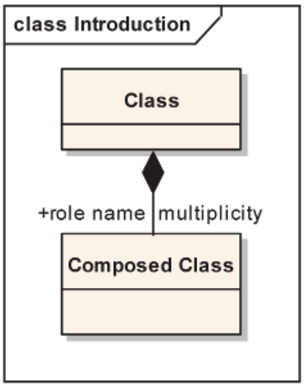
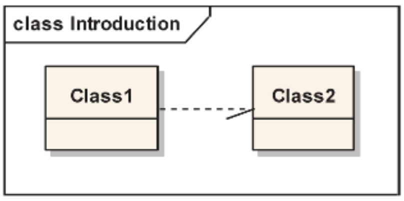
Element name	Element	Description
Class		A class is a template for a given data element which can contain attributes. It is a rectangle divided into three compartments. The topmost compartment contains the name of the class. The middle compartment contains a list of attributes owned by that class and the bottom compartment contains a list of operations which is not shown here because operations are not used in this International Standard. In some diagrams, the bottom compartment of attributes can be omitted for clarity. An attribute line has a specifier "+, #, or –" for the visibility (not used in this International Standard), a name of the attribute, a data type after a colon, and the multiplicity which is described in aggregation, hereunder, in squared brackets.
Specialization		A specialization (i.e. inheritance) defines a general class (super class) whose properties are inherited from the derived class. In data structures, that implies that the derived class has at least the same attributes as the super class and normally will define more attributes to it. The reason for using an inheritance in general is the capability of having different specializations from one super class.
Association		The association shows that two classes do have a connection in between. Associations are used in this International Standard to express a loose linkage having the type of that linkage as a name of the link. An arrow at the head expresses the direction of the association, which means only in the direction of the arrow will the association applies. In the small example, the class 1 is linked (with a link) to class 2, but class 2 does not know anything about class 1. The association has no direct counterpart in data structures but will indirectly be visible somehow.

Table C.1 *(continued)*

Element name	Element	Description
Aggregation		The aggregation is a more explicit design element for describing attributes. It is a stronger association telling that the class on the side of the diamond "has" an instance of the aggregated class. The name of that instance is given on the left side of the connection and starts again with the "+" as a specifier of visibility. On the right side, the multiplicity of that instance is given as a range of the allowed count of occurrences. An aggregation does let open if the aggregated element has the same lifetime as the aggregating class. In data structures, the aggregation can be a reference to another data structure or an embedded data element.
Composition		The composition strengthens the type of aggregation in such a way that the lifetime of the composed element is the same as the composing class, i.e. the structure can be seen as a "composition". In data structures, composition is normally seen as an embedded data element.
Dependency		Dependency is an unspecific type of relationship between two classes.

Annex D
(informative)

Comparison of definitions with TC 211

D.1 Introduction

This annex compares terms and definitions from this part of ISO 17572 with terms and definitions from TC 211 International Standards, in order to establish a mapping of terminology between the two Technical Committees' approaches. The TC 211 definitions are taken from the ISO/TC 211 Terminology spreadsheet, edition 9, and from Annex E of ISO 19132:2007 (crosswalk between common terminology in ISO/TC 211 and ISO/TC 204). In Table D.1, terms and definitions in this part of ISO 17572 are listed in conjunction with definitions for equivalent or near-equivalent terms from ISO/TC 211.

Table D.1 allows side-by-side comparisons. TC 204 terms tend to have more "practical" detail and are more verbose, whereas TC 211 terms are more conceptual and succinct. For example, compare definitions for junction and link below and the 125 words in the definition of "location" in this part of ISO 17572 versus the three words in the TC 211 definition. In the latter case, reusing the simpler TC 211 definition would be semantically inaccurate for the purposes of this part of ISO 17572. In many cases, this part of ISO 17572 terms are not used in TC 211 and vice versa. This can be because of the difference in conceptual level between the groups or just because different terms are used for the same concepts with the same or similar definitions.

From the crosswalk in Annex E of ISO 19132:2007, "All of the differences between ISO/TC 211 and ISO/TC 204 encountered do not constitute a genuine variation of usages, vision, or concept. In general they represent a variation on choices in description of surprisingly similar technical approaches. In general, GDF is an application schema based on ISO 19109 and ISO 19110. This essentially makes it a profile of the ISO/TC 211 standards. A profile (ISO 10000) is allowed to choose options and parameter values set forth in a base standard. This would include the application schema specification as defined in ISO 19110."

D.2 Table of compared terms

Table D.1 — Comparison of TC 204 location referencing and TC 211 terms

Term	TC 204 definition	TC 211 term's definition	Comment
Accuracy	Measure of closeness of results of observations, computations or estimates to the true values or the values as accepted as being true	Closeness of agreement between a test result and the accepted reference value	Same meaning
Attribute	Characteristic property of an entity like a real world feature. It allows the identification of that feature by the sum of its attributes. An attribute has a defined type and contains a value. Attributes can be either simple, i.e. consisting of one atomic value or composite, i.e. consisting of a number of values, each represented by separate, subsequent attributes. Composite attributes are also called complex.	Named property of an entity (Alt: characteristic of a feature)	Same meaning

Table D.1 *(continued)*

Term	TC 204 definition	TC 211 term's definition	Comment
Coordinate	One of an ordered set of *N* numbers designating the position of a point in *N*-dimensional space	One of a sequence of *N*-numbers designating the position of a point in *N*-dimensional space	Same
Datum	A set of parameters and control points used to accurately define the three-dimensional shape of the earth (e.g. as an ellipsoid). The corresponding datum is the basis for a planar coordinate system.	Parameter or set of parameters that serve as a reference or basis for the calculation of other parameters. Geodetic datum: datum describing the relationship of a coordinate system to the earth.	Similar meaning. Interchangeable in practice.
Face	A two-dimensional element bounded by a closed sequence of edges not intersecting themselves. The face is the atomic two-dimensional element.	Two-dimensional topological primitive	Same meaning
Junction	Elementary crossing in the road network, connecting two or more road elements. In GDF terms, it is a level 1 feature that bounds a road element or ferry connection. Junctions that represent real crossings are at least trivalent (having three roads connected). A bivalent junction can only be defined in case an attribute change occurs along the road (e.g. road name change). A junction is also coded at the end of a dead end road, to terminate that.	Single topological node in a network with its associated collection of turns, incoming and outgoing links	Same meaning
Link	A topological connection between two nodes that has a unique link ID in a given map database. A link can contain additional intermediate coordinates (shape points) to better represent the shape of curved features. A link can be directed or undirected.	Directed topological connection between two nodes (junctions), consisting of an edge and a direction	TC 211 meaning differs in directionality. Direction is mandatory for TC 211, optional for TC 204. A TC 204 link also carries other information; it is a more application-oriented meaning.

Annex E
(informative)

TPEG2 UML modelling and physical format representations

E.1 TPEG2 UML modelling

The TISA (Traveller Information Services Association) uses the UML as a representation-independent development tool for a TPEG2 application or toolkit. The TISA defines a set of rules to allow the development of a standard-conform TPEG2 application or toolkit. These rules are defined in Reference [21]. All logical structures of location referencing methods, defined in ISO 17572-2 and ISO 17572-3, follow these rules. The specification[21] defines also the TPEG2 general data types and tables.

E.2 TPEG2 physical formats

The TISA defines the following standard-conform physical formats:

— TPEG2 binary format defined in Reference [22];

— TPEG2 XML format defined in Reference [23].

The Reference [22] and Reference [23] specifications define a set of rules for conversion of a UML model to the corresponding physical format. All physical formats of the location referencing methods, defined in ISO 17572-2 and ISO 17572-3, follow these rules.

Table E.1

Link location	A link location is a location identifiable by a part of the road network database having one ID or having the same attributes throughout the not disjoined stretch	Link position: position within a network on a link defined by some strictly monotonic measure associated with that link	TC 211 link position assumes a linear referencing context; the meaning is position along a link. Not commensurable terms.
Location	A simple or compound geographic object to be referenced by a location reference. A location is matched to database objects by location definitions, which specify what is meant by a particular location. Without any explicit remark it is meant to be a linear stretch in terms of topology in the database network without any loops or discontinuities in between (linear location). It might also be only a point in the network as a specialization of a linear stretch with length zero. In addition to that, a location can also be a set of network database elements representing an area. This area is, for example, expressible by a polygon or a list of linear locations.	Identifiable geographic place	TC 204 definition applies within the context of the location referencing standard only.
Node	A zero-dimensional element that is a topological junction of two or more edges or an end point of an edge	Zero-dimensional topological primitive	Same meaning
Point	A zero-dimensional element that specifies geometric location. One coordinate pair or triplet specifies the location.	Zero-dimensional geometric primitive, representing a position	Same meaning

Table E.1 *(continued)*

Precision	The exactness of the measurement of a data value or of the storage allocated to a measured data value. Alternatively, the closeness of measurements of the same phenomenon repeated under exactly the same conditions and using the same techniques.	Measure of the repeatability of a set of measurements	Same meaning
Resolution	The smallest unit which can be detected. It fixes a limit to precision and accuracy.	Size of a pixel	Same meaning, but the TC 211 definition is from imagery, and is appropriate only in that context.
Road	A road is a part of the road network which is generally considered as a whole and which can be addressed by a single identification like a road name or road number throughout. In general, it is a connection within the road network, with or without crossings, which functionally can be considered as a unity. Associated carriageways shall be considered as one road. (Note that, in the context of this International Standard, the term also covers the natural language term street).	Route: sequence of links, and/or partial links that describe a path, usually between two positions, within a network	
Topology	Properties of spatial configuration invariant under continuous transformation. In a digital map database, this means the logical relationships among map features. It can be used to characterize spatial relationships such as connectivity and adjacency.	Topological object: spatial object representing spatial characteristics that are invariant under continuous transformations	Same meaning

Annex F
(informative)

TPEG2 location referencing container

F.1 General

Many TPEG messages consist of the following high-level containers:

— Message Management Container;

— Application Event Container;

— Location Referencing Container.

NOTE There are TPEG messages which consist of Message Management Container only or do not provide a Location Referencing Container.

A Location Referencing Container (LRC) describes the location information associated with a corresponding TPEG message. The content of LRC can be represented by the different location referencing methods. All location referencing methods, supported by TISA, are defined in Reference [24]. The location referencing methods defined in ISO 17572-2 and ISO 17572-3 are also referenced in Reference [24] The LRC specification[24] defines also the GCId's of the high-level component of each location referencing method.

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[25] NCHRP Report 460, Guidelines for the Implementation of Multimodal Transportation Location Referencing Systems (2001)

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