TECHNICAL SPECIFICATION

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Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2) —

Part 22: OpenLR location referencing (TPEG2-OLR)

Systèmes intelligents de transport — Informations sur le trafic et le tourisme via le groupe expert du protocole de transport, génération 2 (TPEG2) —

Partie 22: Référencement d'Emplacement OpenLR (TPEG2-OLR)

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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).

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

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

A list of all parts in the ISO 21219 series can be found on the ISO website.

Introduction

History

TPEG technology was originally proposed by the European Broadcasting Union (EBU) Broadcast Management Committee, who established the B/TPEG project group in the autumn of 1997 with a brief to develop, as soon as possible, a new protocol for broadcasting traffic and travel-related information in the multimedia environment. TPEG technology, its applications and service features were designed to enable travel-related messages to be coded, decoded, filtered and understood by humans (visually and/or audibly in the user's language) and by agent systems. Originally, a byte-oriented data stream format, which may be carried on almost any digital bearer with an appropriate adaptation layer, was developed. Hierarchically structured TPEG messages from service providers to end-users were designed to transfer information from the service provider database to an end-user's equipment.

One year later, in December 1998, the B/TPEG group produced its first EBU specifications. Two documents were released. Part 2 (TPEG-SSF, which became ISO/TS 18234-2) described the syntax, semantics and framing structure, which was used for all TPEG applications. Meanwhile, Part 4 (TPEG-RTM, which became ISO/TS 18234-4) described the first application for road traffic messages.

Subsequently, in March 1999, CEN/TC 278, in conjunction with ISO/TC 204, established a group comprising members of the former EBU B/TPEG and this working group continued development work. Further parts were developed to make the initial set of four parts, enabling the implementation of a consistent service. Part 3 (TPEG-SNI, ISO/TS 18234-3) described the service and network information application used by all service implementations to ensure appropriate referencing from one service source to another.

Part 1 (TPEG-INV, ISO/TS 18234-1) completed the series by describing the other parts and their relationship; it also contained the application IDs used within the other parts. Additionally, Part 5, the public transport information application (TPEG-PTI, ISO/TS 18234-5), was developed. The so-called TPEG-LOC location referencing method, which enabled both map-based TPEG-decoders and non-map-based ones to deliver either map-based location referencing or human readable text information, was issued as ISO/TS 18234-6 to be used in association with the other applications parts of the ISO/TS 18234 series to provide location referencing.

The ISO/TS 18234 series has become known as TPEG Generation 1.

TPEG Generation 2

When the Traveller Information Services Association (TISA), derived from former forums, was inaugurated in December 2007, TPEG development was taken over by TISA and continued in the TPEG applications working group.

It was about this time that the (then) new Unified Modelling Language (UML) was seen as having major advantages for the development of new TPEG applications in communities who would not necessarily have binary physical format skills required to extend the original TPEG TS work. It was also realized that the XML format for TPEG described within the ISO/TS 24530 series (now superseded) had a greater significance than previously foreseen, especially in the content-generation segment and that keeping two physical formats in synchronism, in different standards series, would be rather difficult.

As a result, TISA set about the development of a new TPEG structure that would be UML based. This has subsequently become known as TPEG Generation 2.

TPEG2 is embodied in the ISO/TS 21219 series and it comprises many parts that cover introduction, rules, toolkit and application components. TPEG2 is built around UML modelling and has a core of rules that contain the modelling strategy covered in ISO/TS 21219-2, ISO/TS 21219-3 and ISO/TS 21219-4 and the conversion to two current physical formats: binary and XML; others could be added in the future. TISA uses an automated tool to convert from the agreed UML model XMI file directly into an MS Word document file, to minimize drafting errors, that forms the annex for each physical format.

TPEG2 has a three container conceptual structure: message management (ISO/TS 21219-6), application (several parts) and location referencing (ISO/TS 21219-7). This structure has flexible capability and can accommodate many differing use cases that have been proposed within the TTI sector and wider for hierarchical message content.

TPEG2 also has many location referencing options as required by the service provider community, any of which may be delivered by vectoring data included in the location referencing container.

The following classification provides a helpful grouping of the different TPEG2 parts according to their intended purpose.

— Toolkit parts: TPEG2-INV (ISO/TS 21219-1), TPEG2-UML (ISO/TS 21219-2), TPEG2-UBCR (ISO/TS 21219-3), TPEG2-UXCR (ISO/TS 21219-4), TPEG2-SFW (ISO/TS 21219-5), TPEG2-MMC (ISO/TS 21219-6), TPEG2-LRC (ISO/TS 21219-7), TPEG2-LTE (ISO/TS 21219-24).

— Special applications: TPEG2-SNI (ISO/TS 21219-9), TPEG2-CAI (ISO/TS 21219-10).

— Location referencing: TPEG2-ULR (ISO/TS 21219-11[1)]), TPEG2-GLR (ISO/TS 21219-21[1)]), TPEG2-OLR (ISO/TS 21219-22).

— Applications: TPEG2-PKI (ISO/TS 21219-14), TPEG2-TEC (ISO/TS 21219-15), TPEG2-FPI (ISO/TS 21219-16), TPEG2-TFP (ISO/TS 21219-18), TPEG2-WEA (ISO/TS 21219-19), TPEG2-RMR (ISO/TS 21219-23), TPEG2-EMI (ISO/TS 21219-25).

TPEG2 has been developed to be broadly (but not totally) backward compatible with TPEG1 to assist in transitions from earlier implementations, while not hindering the TPEG2 innovative approach and being able to support many new features, such as dealing with applications having both long-term, unchanging content and highly dynamic content, such as parking information.

This document is based on the TISA specification technical/editorial version reference: SP14006/1.0/002.

1) Under development.

Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2) —

Part 22: OpenLR location referencing (TPEG2-OLR)

1 Scope

This document specifies the logical data format of OpenLR™ location references and general requirements of the method in Clause 6 and defines the structure of the TPEG toolkit for OpenLR location referencing (OLR) in Clauses 7, 8 and 9. The toolkit is intended to be used in the TPEG location referencing container (TPEG-LRC).

OpenLR™ has been designed for the use case of transferring traffic information from a centre to in-vehicle systems, built-in or used as an add-on (PND, smart phone). The information transferred can consist of the current traffic situation at a certain location, a traffic forecast or special alerts. The corresponding locations are roads, a list of connected roads, points of interest, or areas.

In order to transmit location information from a sending to a receiving side, the OpenLR™ method defines rules for generating map-independent location references, that is, the actual location references are generated dynamically not requiring use of pre-defined location references.

2 Normative references

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

ISO/TS 21219-1, *Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2) — Part 1: Introduction, numbering and versions (TPEG2-INV)*

3 Terms and definitions

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

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
area
two-dimensional part of the surface of the earth which is bounded by a closed curve

Note 1 to entry: An area may cover parts of the road network, covering several roads or parts of roads.

3.2
decoder
software component which decodes a location code and finds the corresponding location back in a map

3.3
encoder
software component which generates a location code for a location in a map

3.4
intermediate/intermediate location reference point
internal location reference point (LRP) which is neither the start LRP nor the end LRP

3.5
line
one-dimensional representation of a road or part of road in a road network

Note 1 to entry: A line starts and ends at a node. It is directed. This means two-way traffic flows are represented by two (directed) lines, one per direction.

3.6
location
specification of the position on the earth surface of an object in a digital map

3.7
location reference
location code, created according to a specific set of rules, used to reference a location

3.8
location reference path
route in a road network in a digital map which is referenced by the location reference

Note 1 to entry: Note1 to entry: This path might be longer than the location itself.

3.9
location reference point
point representing a real-world point location

Note 1 to entry: Besides the position or line information, additional data may be used to further specify the character of a location.

3.10
map
geospatial representation of an area on the earth surface

3.11
node
zero-dimensional object in the road network acting as start and end for lines

3.12
offset
specification of a position along a referenced path to indicate the start or the end of a location

3.13
orientation
describes the relationship between a point of interest and the direction of a referenced line

Note 1 to entry: The point may be directed in the same direction as the line, against that direction, in both directions, or the direction of the point might be unknown.

3.14
point
zero-dimensional element that specifies a spatial location by a coordinate pair

3.15
route
collection of line objects in a digital map connecting a departure location and a destination location, defined according to certain criteria which might include time distance or cost

3.16
side of road
relationship between a point of interest and a referenced line

Note 1 to entry: The point can be on the right side of the reference line, on the left side of the reference line, on both sides of the reference line or directly on the reference line, in the position direction of the reference line.

4 Abbreviated terms

ADD	against driving direction
BEAR	bearing
CEN	Comité Européen de Normalisation
COORD	coordinates
DESC	location description
DNP	distance to next point
FOW	form of way
FRC	functional road class
FUZ	fuzzy area
lat	latitude
LFRCNP	lowest functional road class to next point
lon	longitude
LRP	location reference point
LRC	location reference container
n.a.	not available
NCOLS	number of columns
NOFF	negative offset
NROWS	number of rows
ORI	orientation
POFF	positive offset
POI	point of interest
RAD	radius
SFW	TPEG service framework: modelling and conversion rules

SHP	shape
SOR	side of road
SRBL	side road bearing left
SRBR	side road bearing right
TISA	Traveller Information Services Association
TPEG	Transport Protocol Expert Group
TTI	traffic and travel information
UML	Unified Modelling Language
XML	eXtensible Markup Language

5 Toolkit specific constraints

5.1 Version number signalling

Version numbering is used to track the separate versions of a toolkit through its development and deployment. The differences between these versions may have an impact on client devices.

The version numbering principle is defined in ISO/TS 21219-1.

Table 1 shows the current version numbers for signalling the OLR version in use within this toolkit's top level component (see 7.1) and within TPEG-ML.

Table 1 — Current version number for signalling of OLR

Major version number	1
Minor version number	0

5.2 Extension

Future toolkit extensions may insert new components without losing backward compatibility. That means an OLR decoder shall be able to detect and skip unknown components.

6 OLR structure

6.1 Location types

6.1.1 Supported location types

OpenLR™ supports several types of locations. Table 2 lists the supported types and also provides a link to the clause where the specific type is explained in detail.

Table 2 — Supported location types

Name	Category	Details
Linear location	Linear location	See 6.1.2
Geo-Coordinate	Point location	See 6.1.3.2
PointAlongLine	Point location	See 6.1.3.3

Table 2 *(continued)*

Name	Category	Details
PoiWithAccessPoint	Point location	See 6.1.3.4
Circle	Area location	See 6.1.4.2
Rectangle	Area location	See 6.1.4.3
Grid	Area location	See 6.1.4.4
Polygon	Area location	See 6.1.4.5
ClosedLinear	Area location	See 6.1.4.6

6.1.2 Linear locations

A linear location is a one-dimensional singular continuous path through a road network, from one start point location to one end point location. Offsets may be used to identify locations which do not start or end exactly at a network node.

NOTE Examples of linear locations are jams, (temporary) speed limits and (calculated) routes. Figure 1 and Figure 2 show different types of linear locations where the location is marked and the position of the offsets are shown as dots.

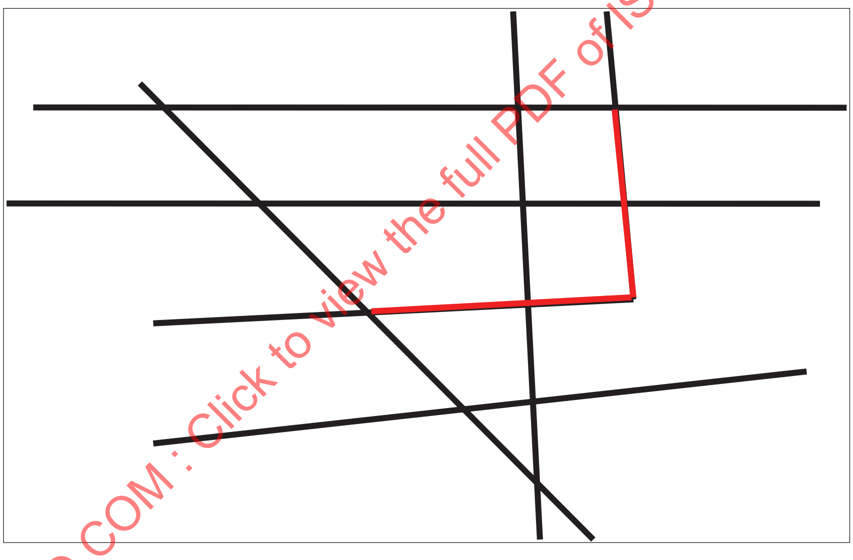

Figure 1 — Linear location without offsets

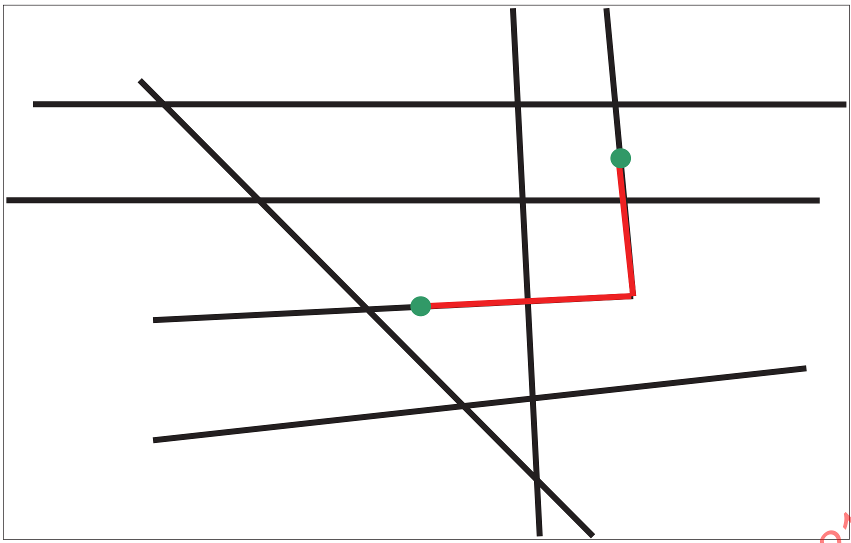

Figure 2 — Linear location with offsets

6.1.3 Point locations

6.1.3.1 General

A point location is a zero-dimensional element that specifies a spatial location by a coordinate pair. One coordinate pair specifies the point location. The following clauses outline different point location types when seen in combination with a (road) network and their real-world examples. The types differ in how the coordinate pair is related to the (road) network.

6.1.3.2 Geo-coordinate

A geo-coordinate pair is a position in a map defined by its longitude and latitude coordinate values. This type of point location may or may not be bound to the network and can be everywhere on the surface. Figure 3 shows an example of such a point location (filled circle).

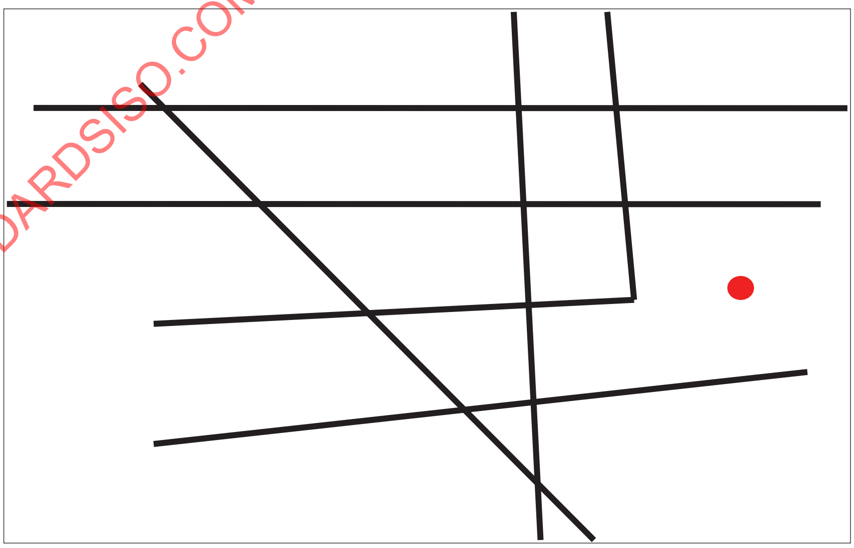

Figure 3 — Example — Geo-coordinate

Real-world examples for a geo-coordinate as a point location are all coordinate pairs on the surface. This is the general type of a point location. All other types can also be expressed by only using the geo-coordinate pair.

6.1.3.3 Point along line

The next point location type is a location along a line. Such a line shall be bounded by two nodes. This point location is dependent on the road network and Figure 4 shows such an example (filled circle). The point may be on the right side of the line, on the left side of the line, on both sides of the line, or directly on the line. Additionally, the point may have an orientation to indicate in which direction of the line the information referenced at that point is useful.

Real-world examples of this point location type are points of interests closely or directly being related to the road network such as petrol stations, shopping malls and restaurants and also property locations and address points. But it can also be used to reference the location of speed cameras or induction loops.

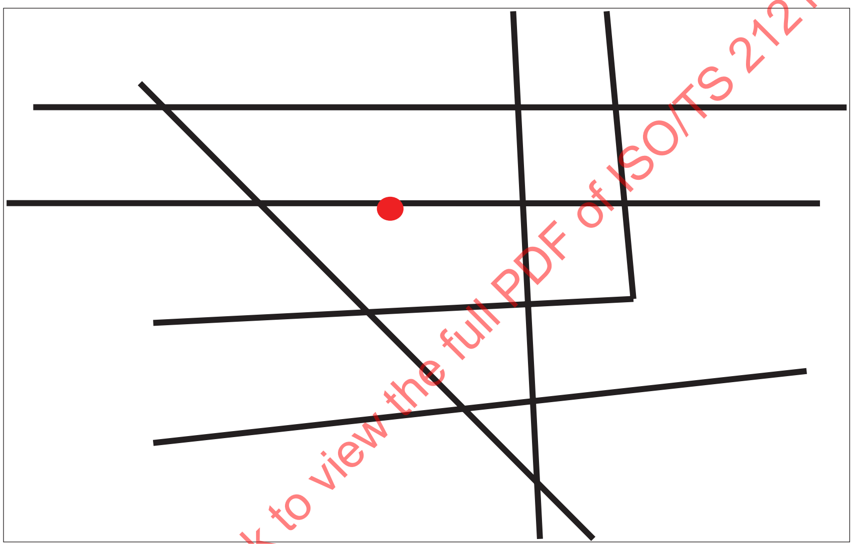

Figure 4 — Example — Point along line

6.1.3.4 Point of interest (POI) with access point (on a line)

Another point location type combines a point on a line with a geo-coordinate. The point on a line functions as an access point from the road network to a POI location represented by the geo-coordinate part. The access point may be on the right side of the line, on the left side of the line, on both sides of the line, or directly on the line. Additionally, the point may have an orientation to indicate in which direction of the line the information referenced at that point is useful.

Figure 5 shows an example of this point location type. The filled circle not related to the road network (coloured red in Figure 5) indicates the point location to be referenced. In combination with this point location, there is an access point (filled circle related to the road network) (coloured green in Figure 5). The access point identifies the location within the network used to access the point of interest. An application may use the network related point to navigate the user to the desired point location.

Examples for such point locations may be address points but also all point of interests (POI) not being closely related to the road network. Alternatively, the POI location may be used to reference other interesting locations such as access to petrol stations or parking garages.

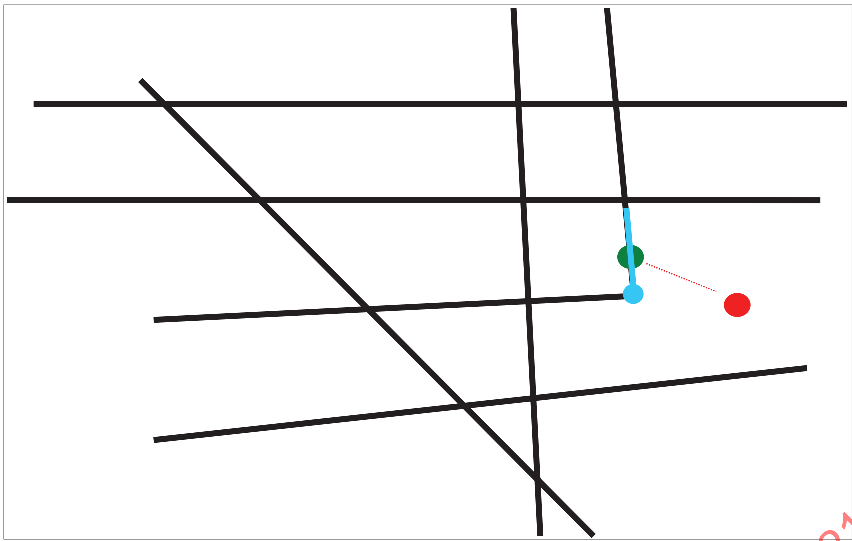

Figure 5 — Example — POI with access point

6.1.4 Area locations

6.1.4.1 General

An area location is a two-dimensional part of the surface of the earth which is bounded by a closed curve. An area location may cover parts of the road network but does not necessarily need to. Examples for area locations not covering the network are areas describing an area of woodland, a sea or agricultural land. In OpenLR™, area locations are defined by their boundary.

6.1.4.2 Circle

A circle location shall be given by the position of the centre and the radius. The centre position shall be a geo-coordinate pair of longitude and latitude coordinate values that may be everywhere on the surface. The radius shall be integer-valued and given in metres. Figure 6 shows an example of such an area location.

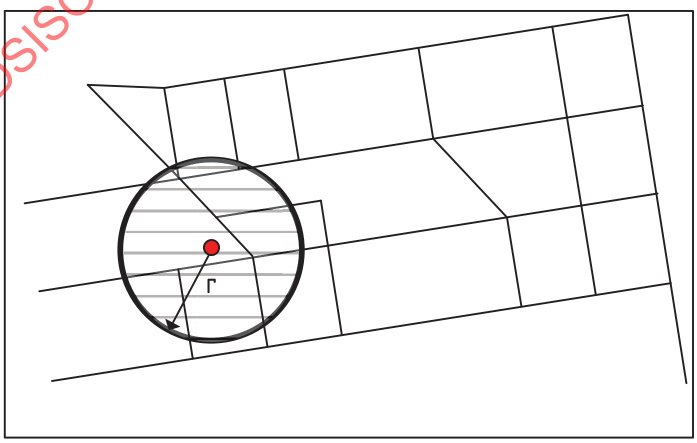

Figure 6 — Example — Circle

A real-world example for a circle location is a Wi-Fi hotspot with an approximation of its signal range.

6.1.4.3 Rectangle

A rectangle location references to a rectangular shape. It shall be given by two geo-coordinate pairs which may be everywhere on the surface. The geo-coordinate pairs shall define the lower left (A) and the upper right (B) corner of the rectangular shape (see Figure 7).

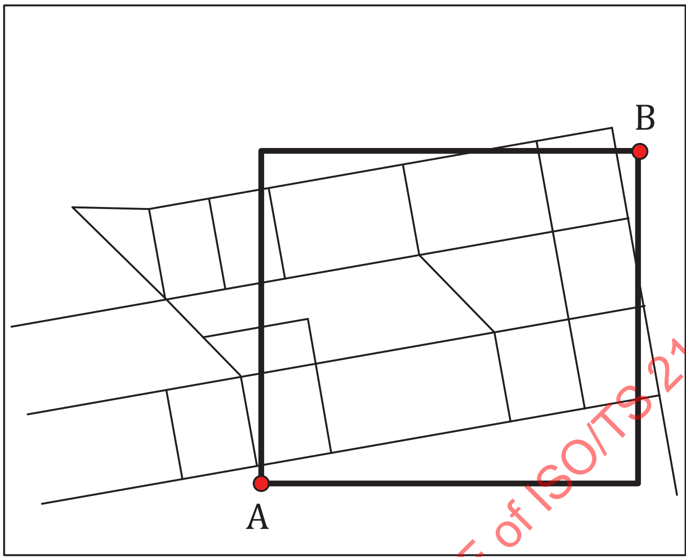

Figure 7 — Example — Rectangle location

Real-world examples are weather information or any area where the shape is not exactly specified and the location references shall be light-weighted.

6.1.4.4 Grid

A grid location is a special instance of a rectangle location. It shall be given by a base rectangular shape as described in 6.1.4.3. This base rectangle shall be the lower left cell of the grid and shall be multiplied to the north (by defining the number of rows) and to the East (by defining the number of columns). Figure 8 shows an example of such an area location.

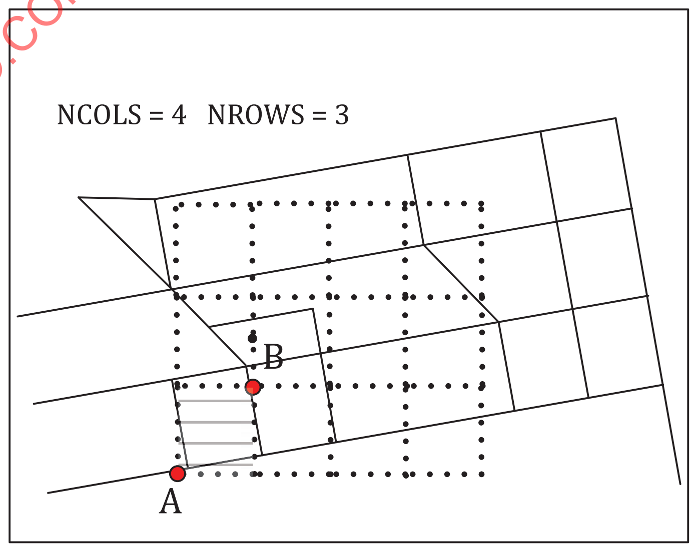

Figure 8 — Example — Grid location

Real-world examples are weather reports about, for example, average rainfall for every cell of the grid.

6.1.4.5 Polygon

A polygon location is a non-intersecting shape defined by a sequence of geo-coordinate pairs. The coordinate pairs may be everywhere on the surface. They shall define the vertices of the underlying geometrical polygon. The boundary of this polygon shall be constituted by straight lines between every pair of consecutive geo-coordinates pairs in the sequence, plus the straight line between the last and the first geo-coordinate pairs. The order of the geo-coordinates pairs may be clockwise or counter-clockwise.

Figure 9 shows an example of such an area location, defined by the interior of the polygon.

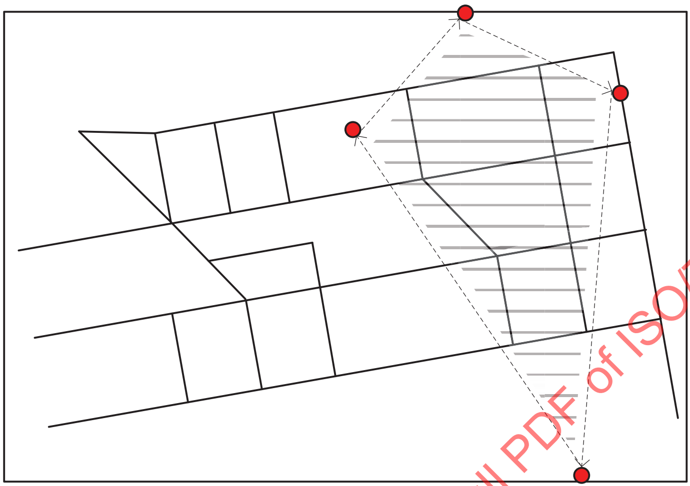

Figure 9 — Example — Polygon

Real-world examples for such area locations include low emission zones, areas affected by weather or environmental conditions (bad weather, smog), flood areas, areas that are congested (due to any cause, e.g. traffic overload, public event, or disaster), administrative areas, pedestrian areas, large crowds of people, areas that are blocked for traffic, and areas subject to city toll.

6.1.4.6 Closed linear location

A closed linear location references the area defined by a closed path (i.e. a circuit) in the road network. The boundary shall always consist of road segments. The path of a closed linear location may contain self-intersections if courses (e.g. marathon course) are referenced. Otherwise, for referencing areas, self-intersections should not appear. Figure 10 shows an example of such an area location.

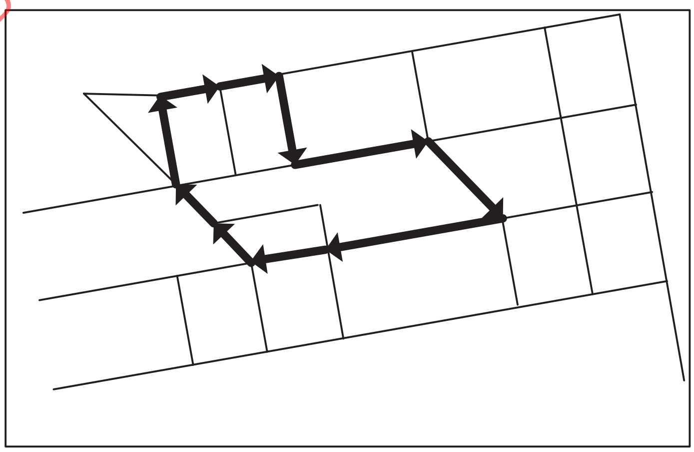

Figure 10 — Example — Closed linear location

Real-world examples include low emission zones, congestion areas, areas that are blocked for traffic.

6.2 Requirements

6.2.1 General

The OpenLR™ approach focuses on creating map agnostic references for line, point and area locations. The digital map used for encoding and decoding and the location itself shall fulfil some requirements in order to guarantee acceptable results for the OpenLR™ method. Furthermore, the different location types may also define requirements in order to transmit meaningful locations.

6.2.2 Map requirements

A digital map consists of nodes and lines. Lines represent real-world roads or parts of a road. Nodes represent crossings of roads or parts of roads. Nodes are the connecting points between the lines.

The encoder and decoder map might differ but nevertheless, the OpenLR™ approach provides a method to reference to the same location represented in both maps.

To be able to generate a map-independent location reference and also able to resolve locations properly, a map should contain information about the following data:

— Coordinates in WGS84

  — Every node in the network should have coordinates in the WGS84 format.

  — The preferable accuracy is decamicrodegrees for each value.

— Length in metres

  — Every line should have a length value in metres indicating its real dimension along the geometry.

— Geometry

  — Every line should know about its real geometry in the real world.

  — Lines shall not be abstracted by the airline.

— Functional road class (FRC)

  — Every line in the network should have a functional road class value indicating its importance in the network.

— Form of way (FOW)

  — Every line in the network should have a form of way value indicating its physical properties.

If the coordinates are not in the WGS84 format, they shall be transformed into WGS84. The same applies if length values are not available in metres.

Different digital maps may have different classifications for the functional road class and the form of way values. It may also happen there exist more or less values. Therefore, OpenLR™ defines its own ranges for FRC and FOW. There shall be a mapping between the FRC values in the digital map and the FRC values as defined in the logical data format (see 6.3.2.3). The same applies for the FOW values (see 6.3.2.4). If no such functional road class values or form of way values are provided by the digital map data, then these shall be derived from other information available in the digital map.

If a digital map provides less information than required, the encoding and decoding processes do generally still succeed but the error rate can increase considerably. At least two out of the following three information types shall be available in the map data: geometry [for the calculation of bearing values (angle to the true north)], functional road class, form of way. The order geometry, FRC and FOW also indicate the importance of the information for a location reference point to be unique.

6.2.3 Location properties

6.2.3.1 General

The location types may also define additional requirements in order to deal with a meaningful location. Locations which do not fulfil the location type requirements cannot be encoded with OpenLR™. The OpenLR™ encoder shall check each location if the requirements are met and shall report on any error.

6.2.3.2 Linear location

Linear locations shall fulfil the following requirements:

- A linear location shall be connected.
- Two subsequent lines in the location shall also be connected and adjacent in the underlying network. A linear location is represented by an ordered list of line elements.
  - The list of line elements shall be ordered from the start of a location to the end of a location.
- Offsets are always indicated by positive values and the total length of the offsets shall not exceed the length of the complete location.

6.2.3.3 Point locations

6.2.3.3.1 Geo-coordinate

Geo-coordinate locations do not have further requirements.

6.2.3.3.2 Point along line

Point along line locations shall fulfil the following requirements:

- The referenced line shall be a single line in the road network.
- The offset value defining the position of the location on the referenced line shall not exceed the length of the line.

6.2.3.3.3 POI with access point

POI with access point locations shall fulfil the following requirements:

- The referenced line shall be a single line in the road network.
- The offset value defining the position of the location on the referenced line shall not exceed the length of the line.
- The distance between the start node of the referenced line and the position of the POI shall not exceed the maximum distance between two location reference points as defined in Rule 1 in 6.4.

6.2.3.4 Area locations

6.2.3.4.1 General

Area locations should focus on simple (geometric) shapes. Mathematical operations like union or intersection of shapes are not supported and may be implemented by the application using OpenLR™ area locations.

6.2.3.4.2 Circle

Circle locations shall fulfil the following requirements:

— The radius value shall be positive.

6.2.3.4.3 Rectangle

Rectangle locations shall fulfil the following requirements:

— The lower left coordinate and the upper right coordinate shall differ in both components (longitude and latitude values).

— The lower left coordinate shall be southwestern of the upper right coordinate.

6.2.3.4.4 Grid

Grid locations shall fulfil the following requirements:

— The lower left coordinate and the upper right coordinate shall differ in both components (longitude and latitude values).

— The lower left coordinate shall be southwestern of the upper right coordinate.

— The number of rows and the number of columns of a grid location shall be greater than 1.

— The number of cells forming a grid shall be exactly the product of the number of rows and the number of columns (number of cells = number of rows × number of columns).

6.2.3.4.5 Polygon

Polygon locations shall fulfil the following requirements:

— The boundary of an area defined by a polygon shall not cross itself.

— The sequence of geo-coordinates of a polygon location shall be ordered.

6.2.3.4.6 Closed linear location

Closed linear locations shall fulfil the following requirements:

— The lines shall be connected.

  — Two subsequent lines in the location shall also be connected and adjacent in the underlying network.

  — If a driving direction is available, then the location shall be traversable from its start to its end.

— The lines shall form a closed circuit.

— The last line shall be a predecessor of the start line and both lines shall be connected.

6.3 Logical data format specification

6.3.1 General

A location reference is a description of a designated part of a digital map or a sequence of geographical positions. OpenLR™ uses for this description the model of “location reference points” (LRPs). Each LRP is a combination of building blocks. The composition of an LRP depends on the location type. The building blocks are defined in the following clauses. They provide a logical view onto the data required to describe a location uniquely. This logical interpretation may result in different physical formats.

A location reference point shall determine a position in a digital map or a line in a digital map if further line or path properties are provided. Besides the position or line information, additional data may be used to further specify the character of a location.

6.3.2 Building blocks

6.3.2.1 General

6.3.2 describes the building blocks which are used to compose a location reference point.

6.3.2.2 Coordinate pair

Coordinate pair stands for a pair of WGS84 longitude (lon) and latitude (lat) values, plus an additional value representing elevation. This coordinate pair specifies a geometric point in a digital map. The lon and lat values shall be stored in decamicrodegree resolution (10^{-5}, five decimals). Each coordinate pair may also provide an altitude value representing the elevation above/below mean sea level. Coordinates may be expressed in absolute or relative values (see 6.5).

Abbreviation: COORD

6.3.2.3 Functional road class

The functional road class (FRC) of a line is a road classification based on the importance of the road represented by the line. The possible values of the FRC attribute are shown in Table 3, covering the range of navigable roads from highest to lowest importance. If there are fewer or more FRC values defined in the encoder map or decoder map, respectively, than these eight values, then a mapping shall be done; if required, less important classes shall be ignored.

Table 3 — Logical format: Functional road class

FRC
FRC 0 – Main road
FRC 1 – First class road
FRC 2 – Second class road
FRC 3 – Third class road
FRC 4 – Fourth class road
FRC 5 – Fifth class road
FRC 6 – Sixth class road
FRC 7 – Other class road

Abbreviation: FRC

6.3.2.4 Form of way

The form of way (FOW) describes the physical road type of a line. The possible values of the FOW attribute are shown in Table 4. This definition slightly differs from the open source version defined in the OpenLR™ white paper v1.

Table 4 — Logical format: Form of way

FOW	Description
UNDEFINED	The physical road type is unknown.
MOTORWAY	A motorway is defined as a road permitted for motorized vehicles only in combination with a prescribed minimum speed. It has two or more physically separated carriageways and no single-level crossings.
MULTIPLE_CARRIAGEWAY	A multiple carriageway is defined as a road with physically separated carriageways regardless of the number of lanes. If a road is also a motorway, it should be coded as such and not as a multiple carriageway.
SINGLE_CARRIAGEWAY	All roads without separate carriageways are considered as roads with a single carriageway.
ROUNDABOUT	A roundabout is a road which forms a ring on which traffic travelling in only one direction is allowed.
TRAFFICSQUARE	A traffic square is an open area (partly) enclosed by roads which is used for non-traffic purposes and which is not a roundabout.
SLIPROAD	A slip road is a road especially designed to enter or leave a line.
OTHER	The physical road type is known but does not fit into one of the other categories.
BIKE_PATH	A bike path is defined as a path only allowed for bicycles.
FOOTPATH	A footpath is defined as a path only allowed for pedestrians.
PEDESTRIAN_ZONE	Roads in a pedestrian zone are reserved for pedestrian use.

Abbreviation: FOW

6.3.2.5 Bearing

The bearing (BEAR) describes the angle between the true north and a line which is defined by the coordinate of the LR-point and a coordinate which is BEARDIST along the line defined by the LR-point properties. If the line length is less than BEARDIST, then the opposite point of the line shall be used (regardless of BEARDIST). If the bearing is measured from the start node, the opposite node is the end node of the line. If the bearing is measured from the end node, the opposite node is the start node of the line. The bearing is measured in degrees and always positive (measuring clockwise from the north). The constant BEARDIST is defined in Table 5.

Abbreviation: BEAR

Table 5 — Logical format: Constant BEARDIST

Abbreviation	Description	Value	Unit
BEARDIST	distance measured along the line between two coordinates positioned on that line	20	m

Figure 11 shows how the second point for the bearing calculation is determined. Figure 11 shows a line from A to B which is longer than BEARDIST. The shaded part of this line is exactly BEARDIST metres long so that the point marked with B′ is BEARDIST metres away from A when we walk along the line from A to B. The straight line from A to B′ is now considered for the calculation of the bearing value. Note that this is different to the angle we would calculate if we always took the other terminal node of the line (in this case, this would be B).

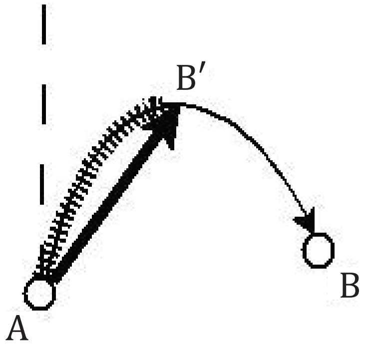

Figure 11 — Logical format: Bearing point

Figure 12 shows two examples of the bearing value calculation. There are two lines: one from A to B and one from A to C. For both lines, the arcs indicate the angles measured from the north.

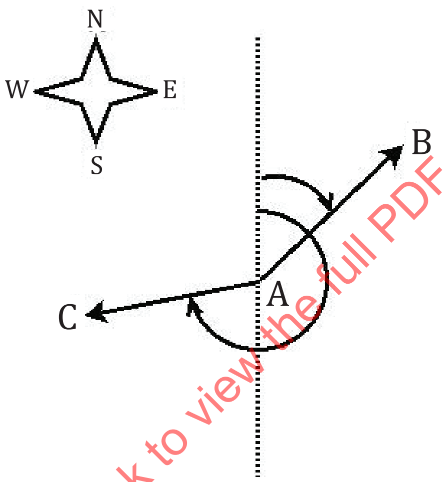

Figure 12 — Logical format: Bearing

6.3.2.6 Distance to next LR-point

The distance to next point (DNP) field describes the distance to the next LRP in the topological connection of the LRPs. The distance shall be measured in metres and shall be calculated along the location reference path between two subsequent LR-points. The last LRP shall have the distance value 0 (see Figure 13).

Abbreviation: DNP

Figure 13 shows an example of the distance calculation and assignment. The three LRPs are in a sequence from A to B then C. The distance between A and B along the location reference path is assigned to A. The LRP B holds the distance between B and C and the LR-point C has a distance value of 0.

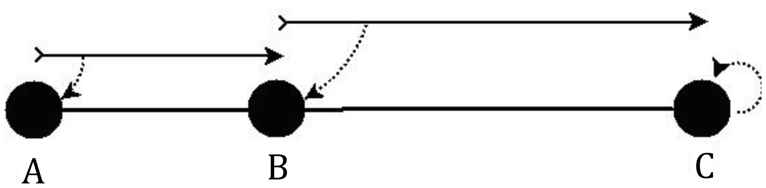

Figure 13 — Logical format: Distance to next point

6.3.2.7 Lowest FRC to next LR-point

The lowest FRC to the next point (LFRCNP) is the lowest FRC value which appears in the location reference path between two consecutive LR-points. This information may be used to limit the number of road classes which need to be scanned during the decoding.

Abbreviation: LFRCNP

6.3.2.8 Radius

The radius describes the distance from a centre point to a circle's boundary. It shall be given as an integer value given in a resolution of 1 m with an accuracy of 1 m.

Abbreviation: RAD

6.3.2.9 Number of columns/rows

The number of columns (NCOLS) defines the total number of base cells of a grid in the eastern direction. The number of rows (NROWS) defines the total number of base cells of a grid in the northern direction. Both shall be given as non-negative integer values.

Abbreviation: NCOLS

Abbreviation: NROWS

6.3.2.10 Offsets

6.3.2.10.1 General

Offsets are needed to locate start and end of a linear location and the position of a point location precisely. Offset values shorten the location reference path down to the desired location and shall be measured in metres.

Linear locations in OpenLR™ rely on the condition that the path defined by the location reference points (location reference path) covers the location completely. The location reference path may be longer than the location path. Point locations identified by a network line may also use offsets to determine the position of the desired point on that line.

OpenLR™ defines two offset values. A positive offset (POFF) is used to locate the start of a location. The POFF defines the distance between the start of the location reference path and the start of the location. The negative offset (NOFF) is used to locate the end of the location and it defines the distance between the end of the location and the end of the location reference path.

6.3.2.10.2 Positive offset

The positive offset (POFF) is the (road) distance between the first LRP and the start point of the desired location along the location reference path. The value shall be measured in metres. Figure 14 shows an example for the calculation of the positive and negative offset. The lines indicate the location reference path and the hatching indicates the desired location.

Abbreviation: POFF

6.3.2.10.3 Negative offset

The negative offset (NOFF) is the (road) distance between the end point of the desired location and the last LRP of the location reference along the referenced path. The value shall be measured in metres. Figure 14 shows an example for the calculation of the positive and negative offset. The lines indicate the location reference path and the hatching indicates the desired location.

Abbreviation: NOFF

Figure 14 — Logical format: Positive and negative offset

6.3.2.11 Against driving direction

The “against driving direction” flag indicates the driving direction of all lines of a path to the next location reference point. If the flag is set to true, then all lines in the path shall be traversed from the end node of a line to the start node of a line. If the flag is set to false, then the lines are traversed in the order from start node to end node.

Abbreviation: ADD

6.3.2.12 Side road bearing left/right

The side road bearing provides information about the next line to the right/left with respect to the line which shall be referenced to. Side roads are taken into account only if the traversal of the line equals the traversal of the referenced line. If the referenced line is traversed from the start node to the end node, then only these lines are taken into account which share the start node with the referenced line. If the “against driving direction” flag (ADD, see 6.3.2.11) is set, then only lines sharing the same end node are taken into account.

The side road bearing values are given as the angle between the line and the true north. Both side road bearing values are calculated in the same way as the bearing value is calculated. See 6.3.2.5 for further details.

Abbreviation: SRBL/SRBR

Figure 15 shows an example for further explanation of the side road bearing feature. The referenced line is marked with an A and the position direction of A is from start node to end node.

Figure 15 shows five lines A to E. Line E is not taken into account as this line can only be traversed from end node to start node. In such a case, line B is the next line to the left and the bearing value for B will be used for the side road bearing left (SRBL). The lines C and D are lines on the right side of line A. But line C is closest to line A and therefore the next line on the right side. The bearing value of line C is used for the side road bearing right (SRBR).

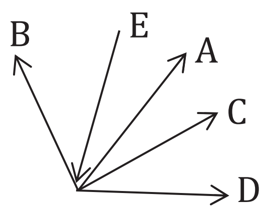

Figure 15 — Side road bearing

6.3.3 Additional data

6.3.3.1 General

Additional data specify the character of a location. It is not required to retrieve a location in the decoding process.

6.3.3.2 Side of road

The side of road information (SOR) (see Table 6) describes the relationship between the point of interest and a referenced line. The point can be on the right side of the line, on the left side of the line, on both sides of the line or directly on the line.

Table 6 — Side of road

SOR	Description
0	Point is directly on (or above) the road, or determination of right/left side is not applicable (default).
1	Point is on the right side of the road.
2	Point is on the left side of the road.
3	Point is on both sides of the road.

Abbreviation: SOR

6.3.3.3 Orientation

The orientation information (ORI) (see Table 7) describes the relationship between the point of interest and the direction of a referenced line. The point may be directed in the same direction as the line, against that direction, in both directions, or the direction of the point might be unknown.

Table 7 — Orientation of a point location

ORI	Description
0	Point has no sense of orientation, or determination of orientation is not applicable (default).
1	Point has orientation from first LRP towards second LRP.
2	Point has orientation from second LRP towards first LRP.
3	Point has orientation in both directions.

Abbreviation: ORI

6.3.3.4 Fuzzy area

The boundary of an area location (except for the closed linear location) may be marked as “fuzzy”. In such a case, the boundary should not be considered as a hard boundary but as a rough enclosing of the area. The default is “false” so that the boundary should be considered as exact.

Abbreviation: FUZ

6.3.3.5 Location description

Every location reference may have a textual description of the location.

Abbreviation: DESC

6.3.3.6 Shape

Every location reference which is bound to the network may have a geometrical shape attached. The shape consists of an ordered sequence of coordinate pairs and represents the location or a connection between two points such as an access point and the point of interest.

Abbreviation: SHP

6.3.4 Location reference point

6.3.4.1 General

The basis of a location reference is a sequence of location reference points (LRPs). Such an LRP is composed of the building blocks defined in 6.3.2. A single LRP may be bound to the road network. In such a case, all values of the LRP refer to a node or line in the road network. The coordinates refer to a node of a line or a point on a line and the additional information refers to properties of a line. The relationship between the properties and an LRP are shown in 6.3.4.3.

If an LRP is not bound to the road network, then the LRP consists of at least one coordinate pair (see 6.3.2.2).

6.3.4.2 Topological connection of LR-points

The location reference points shall be stored in a topological order so that a point, A, will directly be followed by a point, B, if B comes after A in the location reference path and there is no other LR-point in between. This topological order defines a “next point” relationship of successive LR-points. The last point in this order has no next point in this relationship.

Figure 16 shows an example of this relationship. The LR-points are indicated by A, B and C and the black lines and arrows indicate the order of the points from A to C in the location reference path. In this example, the LR-point A has B as the next point, B has C as the next point and C has no next point. The arrows may indicate a path in the road network or a direct line connection between two coordinates.

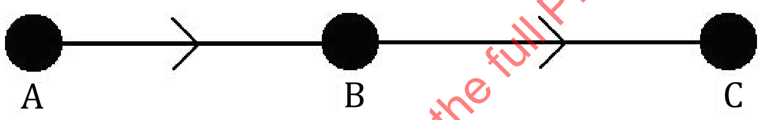

Figure 16 — Topological connection of LRPs

6.3.4.3 Relationship between properties and LR-points

If an LRP is bound to the road network, all properties are linked to this LR-point. The following definition specifies the case where the ADD flag is set to false and where all lines are traversed in the driving direction. In case the ADD flag is set to true, all line directions are reversed.

For all LR-points (except the last LR-point), the properties describe an outgoing line of the node at the LR-point coordinate which belongs to the location. The properties of the last LR-point direct to an incoming line of the node at the LR-point coordinate which belongs to the location.

Figure 17 shows an example of the relationship between an LR-point and the properties. The lines indicate the location reference path and the nodes A, B and C are the LR-points. Note that there is also a line whose start and end node is not an LR-point (the third line in the sequence). This line does not need to be referenced because it is covered by the shortest path between the LR-points B and C.

The LR-points A and B direct to an outgoing line and the last LR-point C directs to an incoming line.

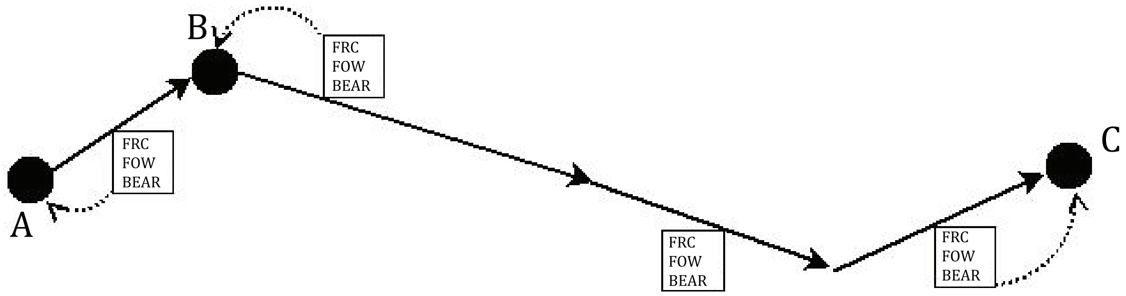

Figure 17 — Relationship between properties and LR-points

6.3.4.4 LRP composition per location type

6.3.4.4.1 General

The composition of an LRP depends on the location type. The layout of an LRP may also vary for a single location type. The following specifications collect the building blocks on a logical level but do not define the physical layout.

6.3.4.4.2 Linear

The location type linear uses three different types of location reference points. The "First LRP" describes the start line of the linear location. The "Last LRP" refers to the end line of the location. Both types are mandatory for a linear location.

An "Intermediate LRP" may be added to the list of location reference points if the encoder decides to mark additional lines along the location path. These additional LRPs act as a guide for the decoder to reconstruct the location.

Besides the reference information to a specific line in the network, the First LRP and any Intermediate LRP shall contain information to reduce the calculation effort on decoder side and to verify the correctness of the calculated path.

For further precision of the location, the location reference may contain information about positive and negative offsets.

Building blocks used:

- First LRP
  - COORD
  - BEAR
  - FRC
  - FOW
  - LFRCNP
  - DNP
  - SRBL/SRBR
  - ADD
- Intermediate LRP
  - COORD

  - BEAR
  - FRC
  - FOW
  - LFRCNP
  - DNP
  - SRBL/SRBR
  - ADD
- Last LRP
  - COORD
  - BEAR
  - FRC
  - FOW
  - SRBL/SRBR

Additional building blocks (optional):

- POFF
- NOFF

6.3.4.4.3 Geo-coordinate

The geo-coordinate location type makes use of a single LRP type which contains a single coordinate pair.

Building blocks used:

- COORD

6.3.4.4.4 Point along line

The point along line location type describes the reference line using a "First LRP" and a "Last LRP" type. The "First LRP" shall describe the start line of the reference path. The "Last LRP" shall refer to the end of the reference path. Both types are mandatory for a point along line location.

Besides the reference information to a specific line in the network, the First LRP shall contain information to reduce the calculation effort on decoder side and to verify the correctness of the calculated path.

The specification of a positive offset defines the desired point along the location path that shall be encoded. If the offset is missing, the point is implicitly defined by the first LRP.

Optionally, the side of the road and/or the orientation with respect to the direction from start to end may be added to the location reference.

Building blocks used:

- First LRP
  - COORD
  - BEAR

- FRC
- FOW
- LFRCNP
- DNP
- SRBL/SRBR
- ADD

— Last LR

- COORD
- BEAR
- FRC
- FOW
- SRBL/SRBR

Additional building blocks (optional):

- POFF
- SOR
- ORI

6.3.4.4.5 POI with access point

The POI with access point location type describes the reference line using a “First LRP” and a “Last LRP” type. The “First LRP” shall describe the start line of the location. The “Last LRP” shall refer to the end line of the location. The POI shall be referenced by a pair of relative coordinates referring to the first LRP of the location line. Both LRP types and the coordinate pair are mandatory for this location type.

Besides the reference information to a specific line in the network, the First LRP shall contain information to reduce the calculation effort on decoder side and to verify the correctness of the calculated path.

The specification of a positive offset defines the desired access point along the location path that shall be encoded. If the offset is missing, the access point is implicitly defined by the first LRP.

Optionally, the side of the road and/or the orientation with respect to the direction from start to end may be added to the location reference.

Building blocks used:

— First LRP

- COORD
- BEAR
- FRC
- FOW
- LFRCNP
- DNP

  - SRBL/SRBR
  - ADD
- Last LRP
  - COORD
  - BEAR
  - FRC
  - FOW
  - SRBL/SRBR
- COORD

Additional building blocks (optional):

- POFF
- SOR
- ORI

6.3.4.4.6 Circle

The circle location type shall make use of a coordinate pair and a radius value.

Building blocks used:

- COORD
- RAD

6.3.4.4.7 Rectangle

The rectangle location type shall use two coordinate pairs to describe the lower left and upper right coordinate of the rectangle.

Building blocks used:

- COORD

6.3.4.4.8 Grid

The grid location type shall use two coordinate pairs to describe the lower left and upper right coordinate of the basis rectangle. The number of rows and number of columns shall specify how many cells form this grid in total (number of cells = number of rows * number of columns).

Building blocks used:

- COORD
- NCOLS
- NROWS

6.3.4.4.9 Polygon

The polygon location type shall use coordinate pairs. The minimum number of coordinate pairs shall be three and there exists no maximum number.

Building blocks used:

- COORD

6.3.4.4.10 Closed linear location

The closed linear location defines three different types of location reference points. The “First LRP” shall describe the start line of the closed linear location. The “Last ClosedLinear LRP” shall refer to the end line of the location whereby the end node of the end line shall be equal to the start node of the start line. Both types are mandatory for a closed linear location.

An “Intermediate LRP” may be added to the list of location reference points if the encoder decides to mark additional lines along the location path. These additional LRPs act as a guide for the decoder to reconstruct the location.

Besides the reference information to a specific line in the network, the First LRP and any Intermediate LRP shall contain information to reduce the calculation effort on decoder side and to verify the correctness of the calculated path.

Building blocks used:

- First LRP
  - COORD
  - BEAR
  - FRC
  - FOW
  - LFRCNP
  - DNP
  - SRBL/SRBR
  - ADD
- Intermediate LRP
  - COORD
  - BEAR
  - FRC
  - FOW
  - LFRCNP
  - DNP
  - SRBL/SRBR
  - ADD
- Last ClosedLinear LRP
  - BEAR
  - FRC
  - FOW

— SRBL/SRBR

6.4 Data format rules

6.4.1 OpenLR™ rules

The OpenLR™ rules describe additional regulations for OpenLR™ location references, supplementary to the general "shortest-path" rule for sub-dividing the location reference path. These rules shall be used to simplify the encoding and decoding process and to increase the accuracy of the results.

Rule 1 *The maximum distance between two location reference points shall not exceed 15 km. The distance is measured along the location reference path. If this condition is not fulfilled for a location reference, then a sufficient number of additional LR-points shall be inserted or the location reference points shall be placed onto a line.*

The maximum distance between two consecutive location reference points is restricted in order to speed up shortest-path computation because several short routes can be computed more quickly than one large route if the routing algorithm has to take the whole network into account. The restriction also provides the opportunity to form a compact physical format with an acceptable accuracy.

Rule 2 *All lengths shall be integer values. If there are float values available, then they shall be rounded to an integer representation.*

Different maps might store the length values in different formats and also with different precision. The uniform basis for all is the use of integer values.

Rule 3 *All location types bound to the road network shall consist of at least two LR-points.* A location reference which is bound to the road network shall always have at least two location reference points indicating the start and the end of the location. In addition, further intermediate location reference points shall be included if conditions of shortest-path or Rule 1 are not met. If the encoder detects critical situations where the decoder (on a different map) might get into trouble, the location reference may be enhanced with additional (optional) intermediate LR-points. The number of intermediate LR-points is not limited for the linear location and closed linear location.

Rule 4 *The coordinates of the LR-points should preferably be chosen on valid network nodes.*

Valid network nodes shall represent junctions in the real world because it is expected that these junctions can be found in different maps with a higher probability than positions somewhere on a line. Additional nodes other than junctions (invalid nodes) shall be avoided if these can be easily skipped during a route search. At these invalid nodes, it is not possible to deviate from a route.

Nodes having only one incoming and one outgoing line (as directed connectivity) shall be invalid and therefore avoided since these nodes are not related to junctions (see Figure 18, node in the middle). These nodes can be stepped over during a route search. Nodes which have two incoming and two outgoing lines and there exist only two adjacent nodes shall also be invalid, unless a U-turn is possible at that node (see Figure 19, node in the middle).

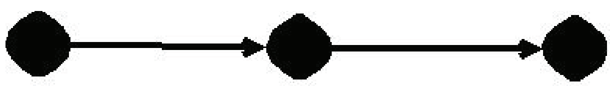

Figure 18 — Invalid node (1)

Figure 19 — Invalid node (2)

If such node is selected for an LR-point, then this LR-point should be shifted along the location reference path in order to find a suitable node. This can be done since a route calculation will step over such invalid nodes without leaving the desired path.

If the encoder cannot determine a valid node at all, then exceptionally an invalid node may be chosen for an LR-Point. Examples are lines which are longer than 15 km (see Rule 1).

In order to fulfil Rule 4, it is recommended to check the start node and end node of the location path. If the start or the end of a location is placed on invalid nodes, then the encoder might expand the location uniquely and should find a suitable node outside of the location. This expansion shall never go into the location because this will shorten the location's spatial extent.

Rule 5 *Offsets shall refer to the location reference path defined by the first two (the last two) location reference points.*

Offsets may be placed only between the first two location reference points (positive offset) and between the last two location reference points (negative offset). Otherwise, the first (or last) location reference point is useless as it brings no additional information to describe the location or the offsets. Figure 20 shows where the offset values may be placed along a location and it also indicates that the maximum offset value is 15 000 m (see Rule 1).

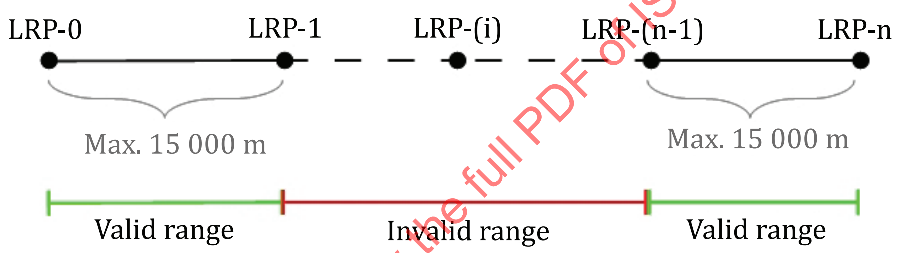

Figure 20 — Offset placement and restrictions

Rule 6 *Area locations shall focus on simple (geometric) shapes. The boundary of an area shall not cross itself. Mathematical operations such as union or intersection of shapes are not supported and may be implemented by the application using OpenLR™ area locations.*

Area locations in OpenLR™ shall be simple. In addition, the boundary of an area location shall not cross itself. For more complex area locations, the encoding and decoding side should agree on common mathematical operations such as union or intersection. These operations are not part of the OpenLR™ specification.

6.4.2 Overview of the data format rules

Table 8 summarizes the data format rules.

Table 8 — Data format rules overview

Rule	Description	Value
Rule 1	maximum distance between two consecutive LR-points	15 000 m
Rule 2	road length values	treated as integer values
Rule 3	number of LR-points	at least two LR-points (for network bound location types)

Table 8 *(continued)*

Rule	Description	Value
Rule 4	invalid nodes	LR-points should preferably be placed on valid network nodes
Rule 5	offsets	offsets shall refer to the first two (last two) LR-points
Rule 6	area locations focus on simple geometric shapes, their boundary shall not cross itself	

6.5 Physical representations of geo-coordinates

6.5.1 General

In the physical format, geo-coordinates shall have a compact representation. Instead of using float values, the decimal values are converted into integer values. The representation of absolute geo-coordinates is depicted in 6.5.2. The calculation rule for relative geo-coordinates is defined in 6.5.3.

6.5.2 Absolute geo-coordinates

The values are generated using Formula (1) which calculates a 24-bit integer representation. The resolution parameter is set to 24. This translation leads to a coordinate resolution ("error") of about 2,4 m at most. The backward translation is described in Formula (2). Both formulae make use of the signum (sgn) function which is −1 for negative values, 1 for positive values and 0 otherwise. This is used for rounding. The conversion from a decimal value to an integer value is done by trimming the non-integer decimal places.

$$\mathrm{int} = \left(\mathrm{sgn}(\mathrm{deg}) \times 0{,}5 + \frac{\mathrm{deg} \times 2^{\mathrm{Resolution}}}{360°} \right) \tag{1}$$

$$\mathrm{deg} = \left(\frac{\left(\mathrm{int} - \mathrm{sgn}(\mathrm{int}) \times 0{,}5\right) \times 360°}{2^{\mathrm{Resolution}}} \right) \tag{2}$$

6.5.3 Relative geo-coordinates

Relative geo-coordinates are used to describe differences between two consecutive coordinates. The difference is calculated for each value (lon/lat) separately as shown in Formula (3). The current and previous values represent the latitude (longitude) value in degrees. The difference between these two values is multiplied with 100 000 (10^5) in order to resolve an integer value.

$$relative = round\left(100\,000 \times \left(currentPoint - previousPoint\right)\right) \tag{3}$$

Table 9 shows the maximum distances which are possible to encode within that resolution for a location in the Netherlands. The ranges for relative coordinates are calculated for a given coordinate in the Netherlands at lon = 5° and lat = 52°.

Table 9 — Physical format: Longitude/latitude ranges for relative coordinates (example)

Latitude		Longitude	
Lower bound	**Upper bound**	**Lower bound**	**Upper bound**
−36 459 m	36 460 m	−22 504 m	22 504 m

7 OLR message components

7.1 OpenLRLocationReference

Component OpenLRLocationReference (see Figure 21 and Table 10) is the toolkit component. It provides an abstract location reference which could be a linear location, a point location, or an area location.

In Annex A, the TPEG binary representation for the OpenLRLocationReference is defined. In Annex B, the TPEG-ML representation for the OpenLRLocationReference is specified.

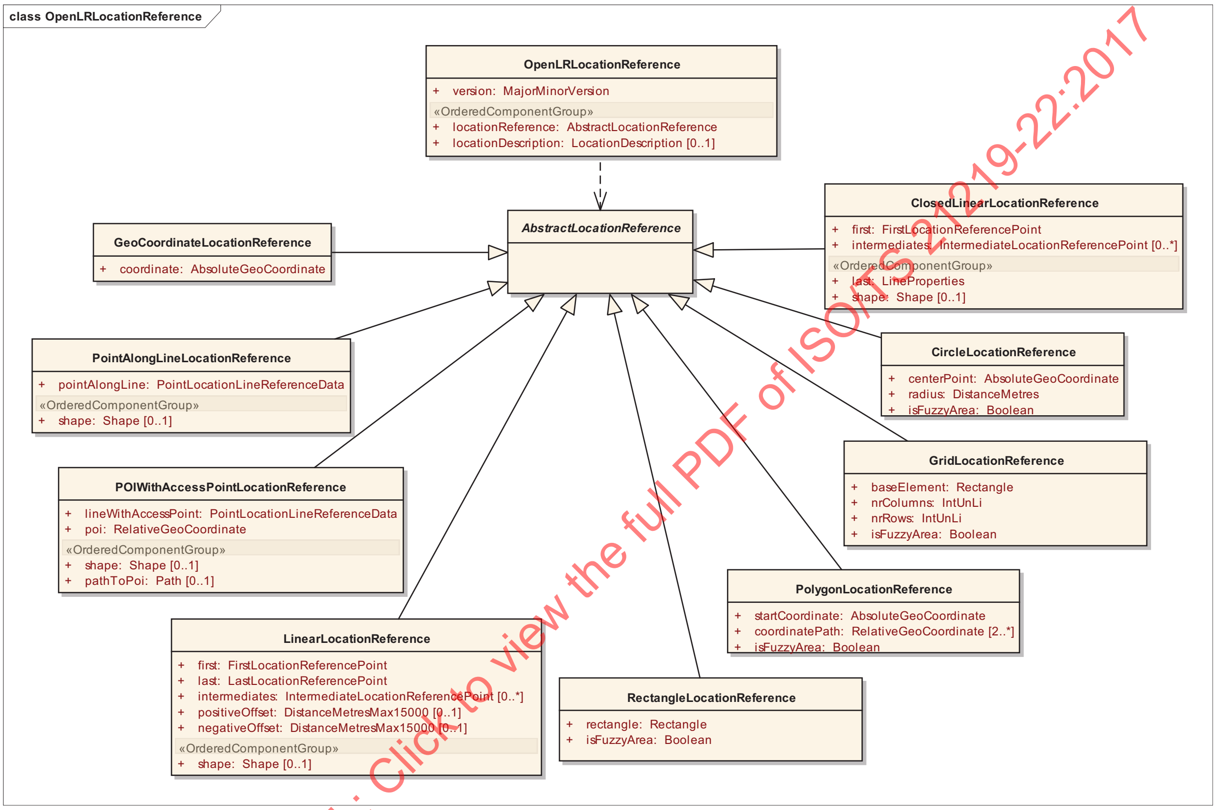

Figure 21 — Structure of OpenLRLocationReference

Table 10 — Structure of OpenLRLocationReference

Name	Type	Multiplicity	Description
version	MajorMinorVersion	1	The version information of OpenLRLocationReference.
Ordered components			
locationReference	AbstractLocationReference	1	Switch between location reference types.
locationDescription	LocationDescription	0..1	The textual description of the location reference.

7.2 AbstractLocationReference

The abstract location reference shall function as a switching class between all the defined location reference types.

7.3 LinearLocationReference

Component LinearLocationReference (see Figure 22 and Table 11) specifies an OpenLR linear location reference.

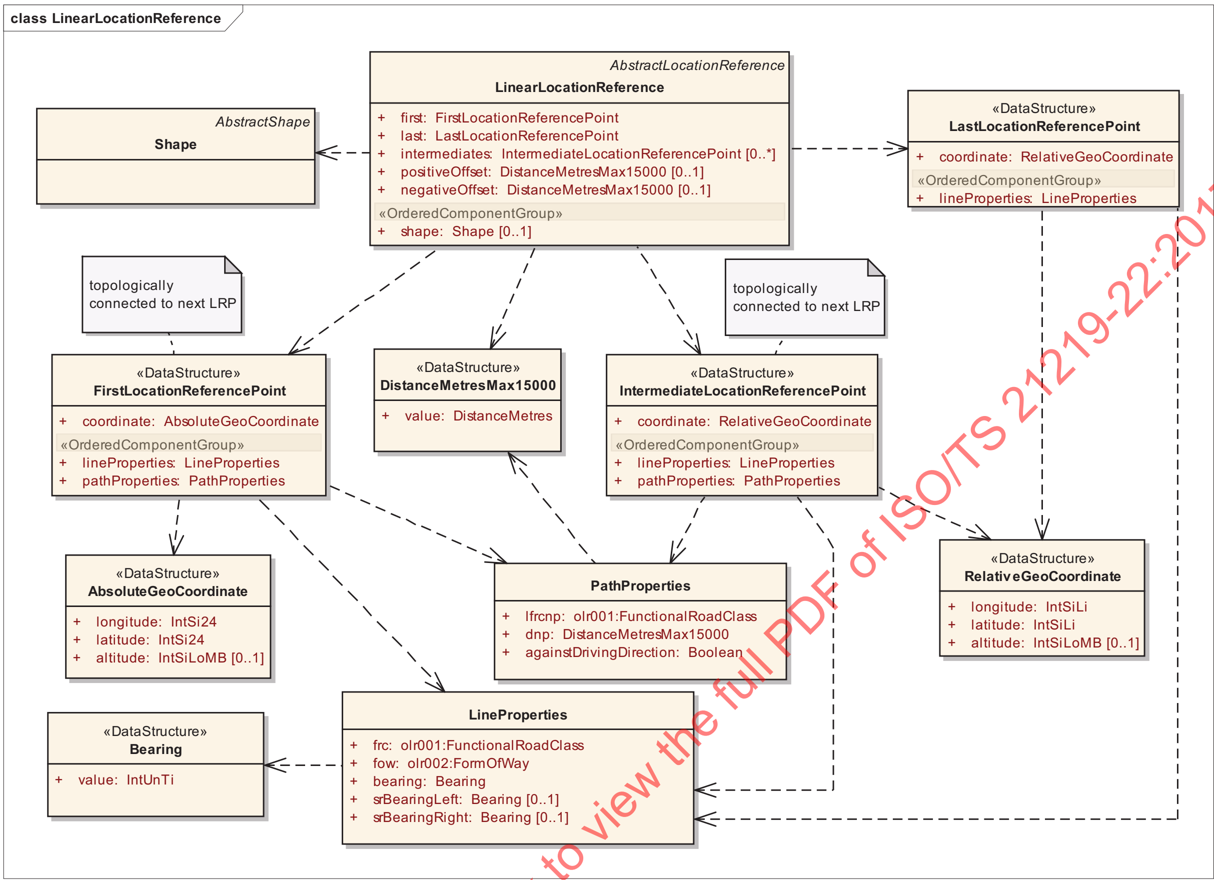

Figure 22 — Structure of LinearLocationReference

Table 11 — Structure of LinearLocationReference

Name	Type	Multiplicity	Description
first	FirstLocationReferencePoint	1	The first LRP.
last	LastLocationReferencePoint	1	The last LRP.
intermediates	IntermediateLocationReferencePoint	0..*	The sequence of intermediate LRP.
positiveOffset	DistanceMetresMax15000	0..1	The positive offset in metres.
negativeOffset	DistanceMetresMax15000	0..1	The negative offset in metres.
Ordered components			
shape	Shape	0..1	The shape describes the location geometry.

7.4 GeoCoordinateLocationReference

Component GeoCoordinateLocationReference (see Figure 23 and Table 12) specifies an OpenLR geo-coordinate location reference.

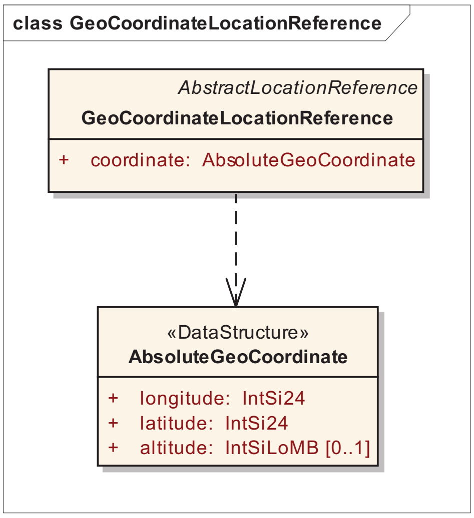

Figure 23 — Structure of GeoCoordinateLocationReference

Table 12 — Structure of GeoCoordinateLocationReference

Name	Type	Multiplicity	Description
coordinate	AbsoluteGeoCoordinate	1	The absolute geo-coordinate.

7.5 PointAlongLineLocationReference

Component PointAlongLineLocationReference (see Figure 24 and Table 13) specifies an OpenLR point-along-line location reference.

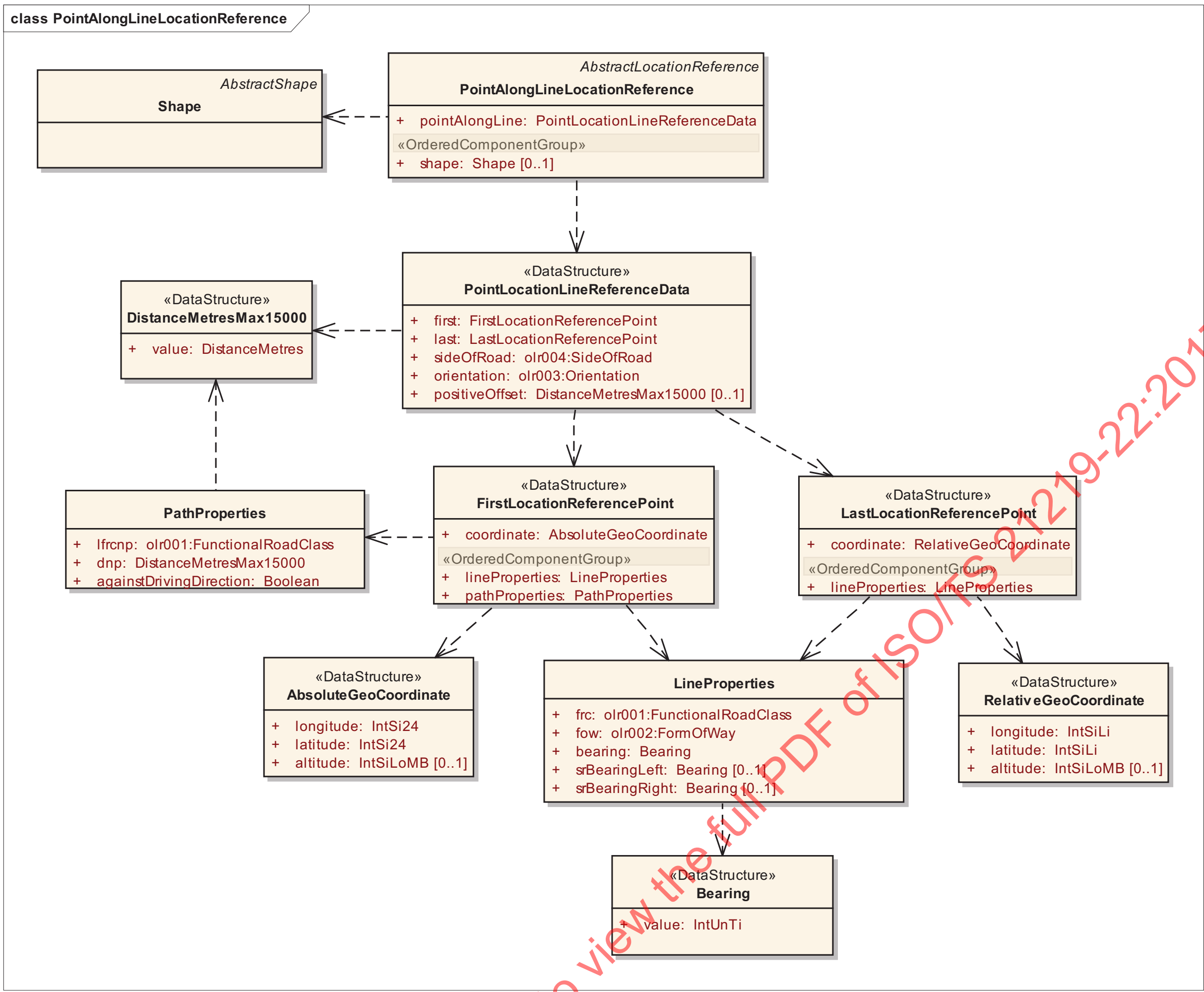

Figure 24 — Structure of PointAlongLineLocationReference

Table 13 — Structure of PointAlongLineLocationReference

Name	Type	Multiplicity	Description
pointAlongLine	PointLocationLineReferenceData	1	The network bound point location.
Ordered components			
shape	Shape	0..1	The shape describes the location geometry.

7.6 POIWithAccessPointLocationReference

Component POIWithAccessPointLocationReference (see Figure 25 and Table 14) specifies an OpenLR POI-with-access-point location reference.

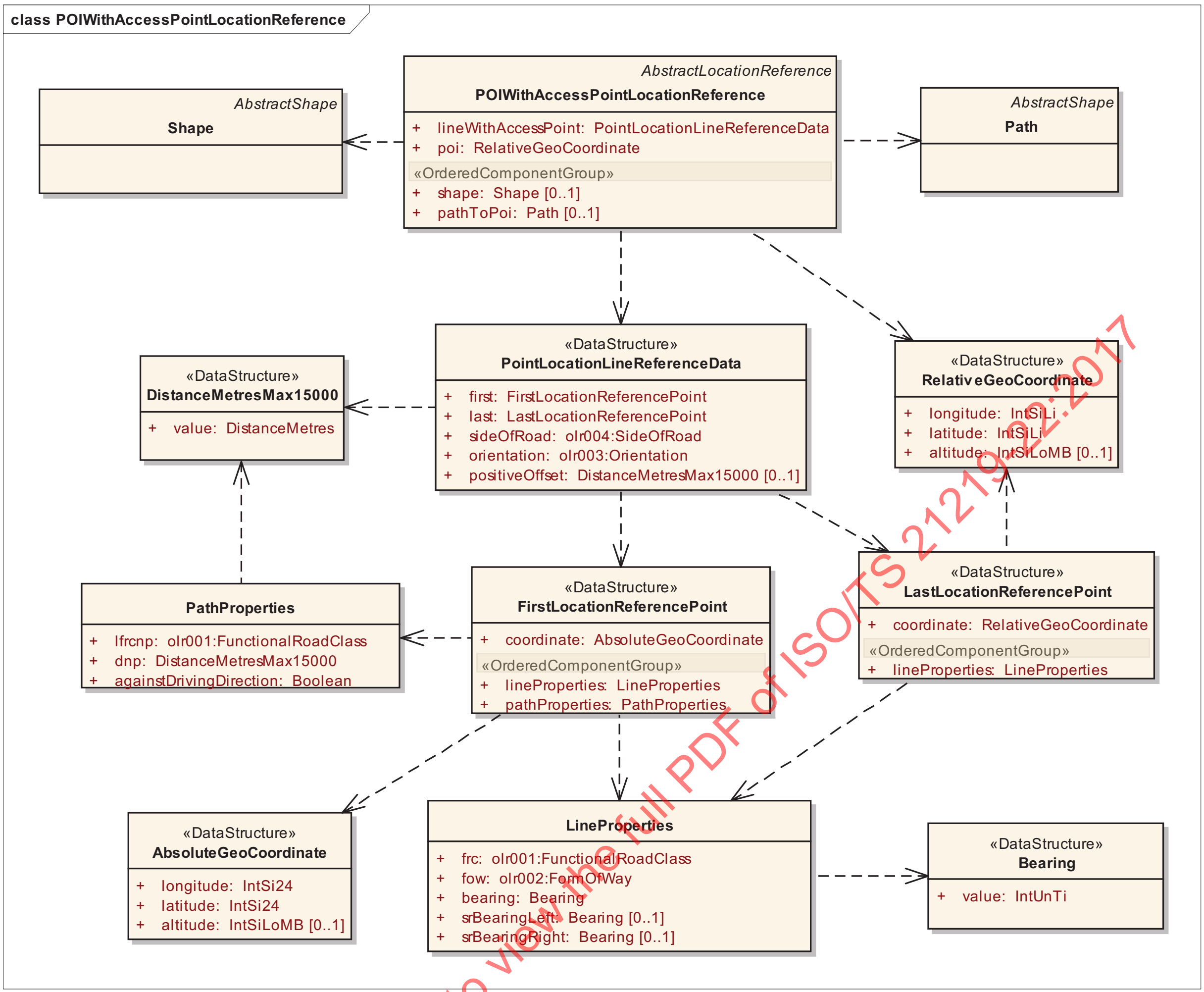

Figure 25 — Structure of POIWithAccessPointLocationReference

Table 14 — Structure of POIWithAccessPointLocationReference

Name	Type	Multiplicity	Description
lineWithAccessPoint	PointLocationLineReferenceData	1	The network bound part defining the access point to the POI.
poi	RelativeGeoCoordinate	1	The POI.
	Ordered components		
shape	Shape	0..1	The shape describes the location geometry.
pathToPoi	Path	0..1	The shape describes the path between the access point and the point of interest.

7.7 CircleLocationReference

Component CircleLocationReference (see Figure 26 and Table 15) specifies an OpenLR circular area location reference.

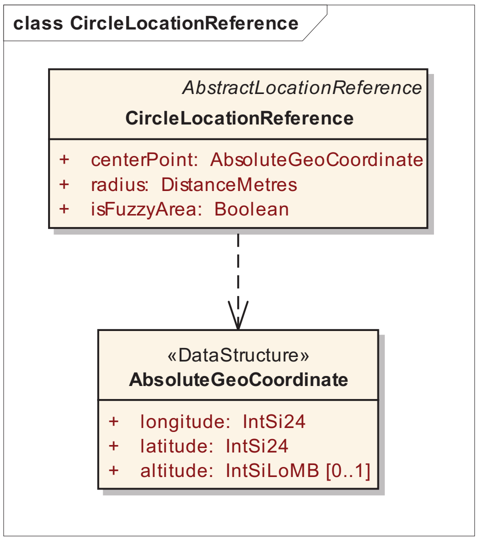

Figure 26 — Structure of CircleLocationReference

Table 15 — Structure of CircleLocationReference

Name	Type	Multiplicity	Description
centrePoint	AbsoluteGeoCoordinate	1	The centre point of the circle.
radius	DistanceMetres	1	The radius measured in metres.
isFuzzyArea	Boolean	1	The boundary of the area is fuzzy.

7.8 PolygonLocationReference

Component PolygonLocationReference (see Figure 27 and Table 16) specifies an OpenLR polygon area location reference.

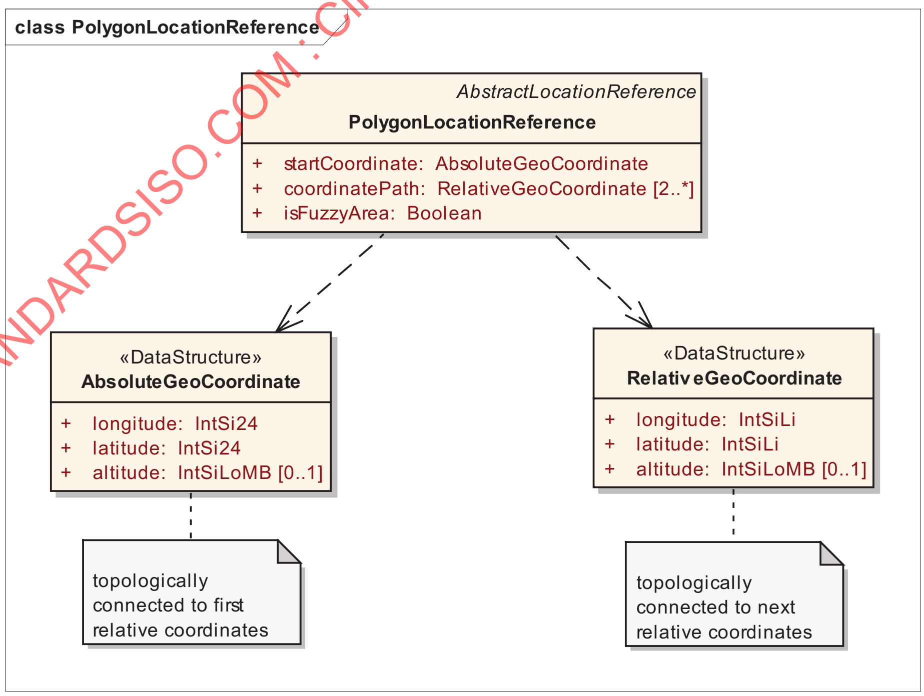

Figure 27 — Structure of PolygonLocationReference

Table 16 — Structure of PolygonLocationReference

Name	Type	Multiplicity	Description
startCoordinate	AbsoluteGeoCoordinate	1	The first coordinate of the polygon area location reference.
coordinatePath	RelativeGeoCoordinate	2..*	The ordered sequence of relative coordinates defining the remaining corner points of the polygon. The first relative coordinate is relative to the absolute coordinate.
isFuzzyArea	Boolean	1	The boundary of the area is fuzzy.

7.9 RectangleLocationReference

Component RectangleLocationReference (see Figure 28 and Table 17) specifies an OpenLR rectangle area location reference.

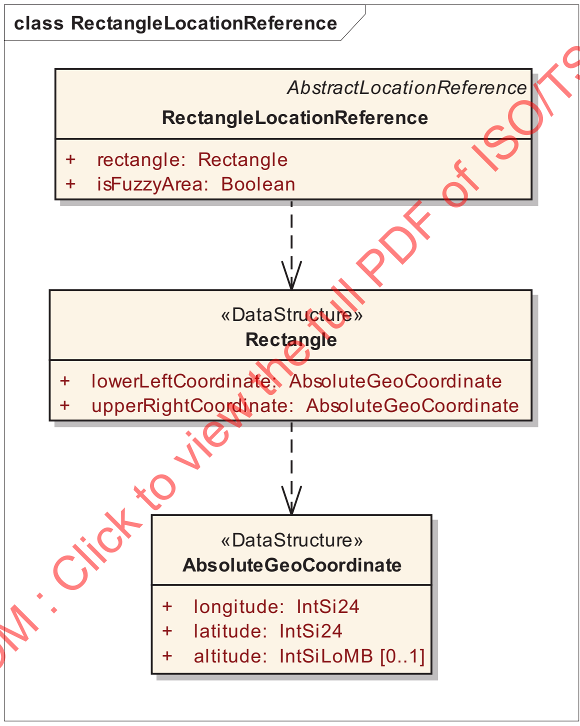

Figure 28 — Structure of RectangleLocationReference

Table 17 — Structure of RectangleLocationReference

Name	Type	Multiplicity	Description
rectangle	Rectangle	1	The actual rectangle.
isFuzzyArea	Boolean	1	The boundary of the area is fuzzy.

7.10 GridLocationReference

Component GridLocationReference (see Figure 29 and Table 18) specifies an OpenLR grid area location reference.

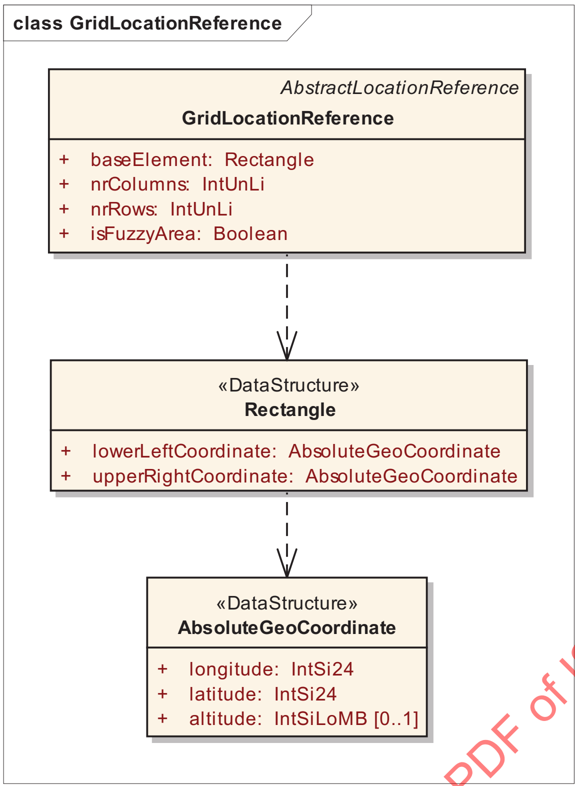

Figure 29 — Structure of GridLocationReference

Table 18 — Structure of GridLocationReference

Name	Type	Multiplicity	Description
baseElement	Rectangle	1	The base element of the grid.
nrColumns	IntUnLi	1	Column count of the grid, with nrColumns > 1.
nrRows	IntUnLi	1	Row count of the grid, with nrRows > 1.
isFuzzyArea	Boolean	1	The boundary of the area is fuzzy.

7.11 ClosedLinearLocationReference

Component ClosedLinearLocationReference (see Figure 30 and Table 19) specifies an OpenLR closed linear area location reference.

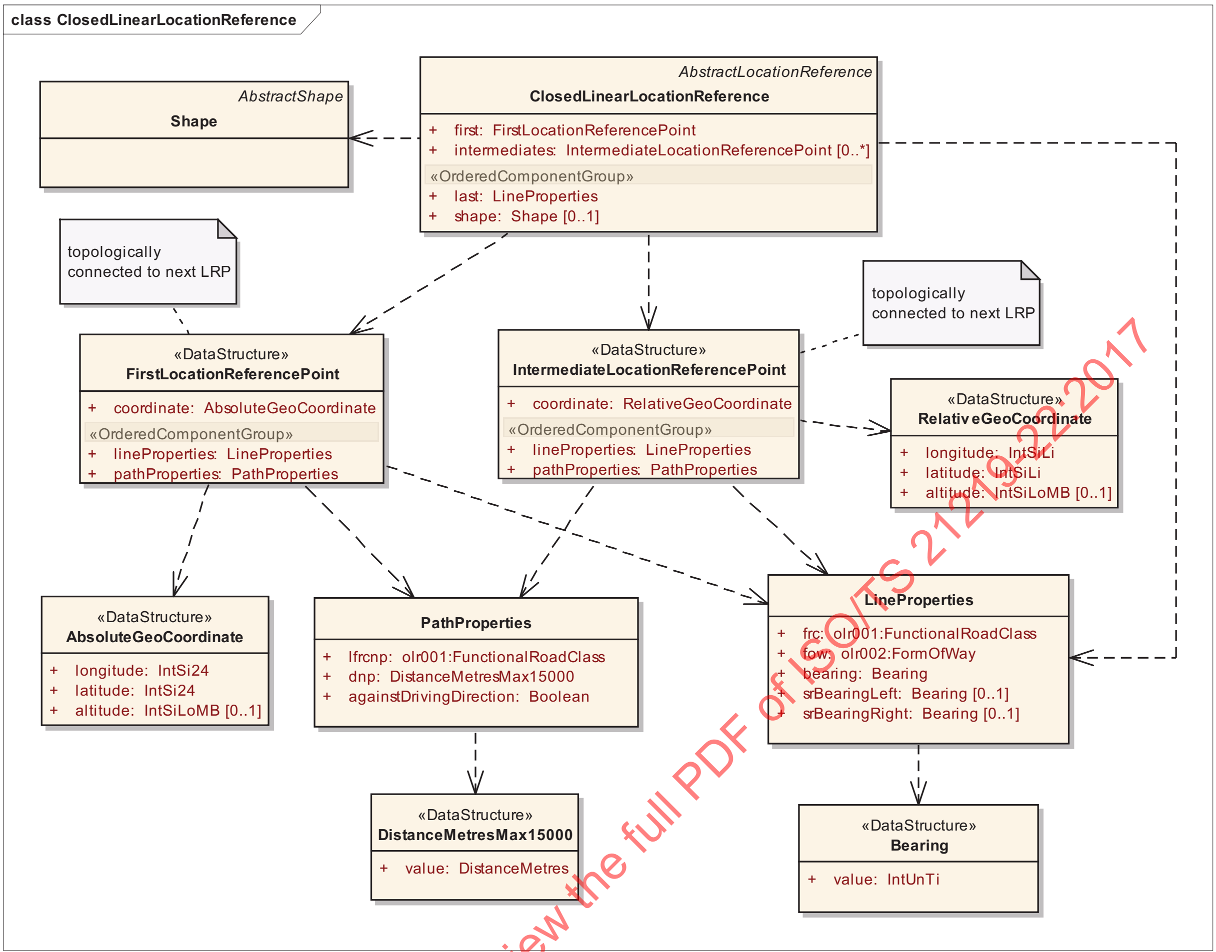

Figure 30 — Structure of ClosedLinearLocationReference

Table 19 — Structure of ClosedLinearLocationReference

Name	Type	Multiplicity	Description
first	FirstLocationReferencePoint	1	The first LRP of the closed linear location.
intermediates	IntermediateLocationReferencePoint	0..*	The ordered sequence of intermediate LRP.
	Ordered components		
last	LineProperties	1	The line properties are combined with the coordinates of the first LRP and from the last LRP of the closed linear location.
shape	Shape	0..1	The shape describes the location geometry.

7.12 LineProperties

Component LineProperties (see Table 20) specifies the line properties of an LRP.

Table 20 — Structure of LineProperties

Name	Type	Multiplicity	Description
frc	olr001:FunctionalRoadClass	1	The functional road class value.
fow	olr002:FormOfWay	1	The form of way value.
bearing	Bearing	1	The bearing value.
srBearingLeft	Bearing	0..1	Bearing of road on the left-hand side of the referenced line.
srBearingRight	Bearing	0..1	Bearing of road on the right-hand side of the referenced line.

7.13 PathProperties

Component PathProperties (see Table 21) specifies the path properties of an LRP, that is, the set of attributes defining the location reference path between two subsequent LRPs.

Table 21 — Structure of PathProperties

Name	Type	Multiplicity	Description
lfrcnp	olr001:FunctionalRoadClass	1	The lowest functional road class to the next LRP along the location reference path.
dnp	DistanceMetresMax15000	1	The distance to the next LRP, i.e. the length of the location reference path.
againstDrivingDirection	Boolean	1	True indicates that the direction of traffic is against driving direction for all lines in the path.

7.14 LocationDescription

Component LocationDescription (see Table 22) provides localized textual descriptions of the location.

Table 22 — Structure of LocationDescription

Name	Type	Multiplicity	Description
description	LocalizedLongString	1..*	The list of localized location descriptions.

7.15 AbstractShape

The abstract component AbstractShape (see Table 23) shall be used to model shapes and paths.

Table 23 — Structure of AbstractShape

Name	Type	Multiplicity	Description
points	AbsoluteGeoCoordinate	1..*	Sequence of absolute coordinates.

7.16 Shape

Component Shape (see Table 24) specifies a sequence of coordinates defining a shape.

Table 24 — Structure of Shape

Name	Type	Multiplicity	Description
points	AbsoluteGeoCoordinate	1..*	Sequence of absolute coordinates.

7.17 Path

Component Path (see Table 25) specifies a sequence of coordinates defining a path.

Table 25 — Structure of Path

Name	Type	Multiplicity	Description
points	AbsoluteGeoCoordinate	1..*	Sequence of absolute coordinates.

8 OLR datatypes

8.1 AbsoluteGeoCoordinate

Data structure AbsoluteGeoCoordinate (see Table 26) specifies a geo-position with longitude and latitude values with a decamicrodegree accuracy stored in 24-bit integer value. The calculation rules to convert geo-coordinates from degree to integer value and back are outlined in 6.5.2. Elevation information can be assigned optionally.

Table 26 — AbsoluteGeoCoordinate

Name	Type	Multiplicity	Description
longitude	IntSi24	1	24-bit representation of a longitude value in decamicrodegree precision.
latitude	IntSi24	1	24-bit representation of a latitude value in decamicrodegree precision.
altitude	IntSiLoMB	0..1	Elevation of location in metres above/below mean sea level.

8.2 RelativeGeoCoordinate

Data structure RelativeGeoCoordinate (see Table 27) stores geo-coordinates as relative values in decamicrodegree precision. The calculation rule for relative geo-coordinates are outlined in 6.5.3. Elevation information can be assigned optionally.

Table 27 — RelativeGeoCoordinate

Name	Type	Multiplicity	Description
longitude	IntSiLi	1	The relative longitude value in decamicrodegree precision.
latitude	IntSiLi	1	The relative latitude value in decamicrodegree precision.
altitude	IntSiLoMB	0..1	Elevation of location in metres above/below mean sea level.

8.3 Bearing

Data structure Bearing (see Table 28) stores the value of a bearing angle in a compressed way. The full circle is divided into 256 sectors which yields a precision of 360/256°.

Table 28 — Bearing

Name	Type	Multiplicity	Description
value	IntUnTi	1	Stores compressed bearing angle value.

8.4 DistanceMetresMax15000

Data structure DistanceMetresMax15000 (see Table 29) stores a distance value in metre precision up to 15 000 m.

Table 29 — DistanceMetresMax15000

Name	Type	Multiplicity	Description
value	DistanceMetres	1	Distance in metres, value ≤ 15 000.

8.5 FirstLocationReferencePoint

Data structure FirstLocationReferencePoint (see Table 30) specifies the first LRP of an ordered sequence of LRPs.

Table 30 — FirstLocationReferencePoint

Name	Type	Multiplicity	Description
coordinate	AbsoluteGeoCoordinate	1	The coordinate of the first LRP.
Ordered components			
lineProperties	LineProperties	1	The line properties of the first LRP.
pathProperties	PathProperties	1	The path properties of the first LRP.

8.6 IntermediateLocationReferencePoint

Data structure IntermediateLocationReferencePoint (see Table 31) specifies an LRP which is not the first LRP and not the last LRP of an ordered sequence of LRPs.

Table 31 — IntermediateLocationReferencePoint

Name	Type	Multiplicity	Description
coordinate	RelativeGeoCoordinate	1	The coordinates of the intermediate LRP which are relative to the coordinates of the preceding LRP in the sequence of LRPs.
Ordered Components			
lineProperties	LineProperties	1	The line properties of the intermediate LRP.
pathProperties	PathProperties	1	The path properties of the intermediate LRP.

8.7 LastLocationReferencePoint

Data structure LastLocationReferencePoint (see Table 32) specifies the last LRP of an ordered sequence of LRPs.

Table 32 — LastLocationReferencePoint

Name	Type	Multiplicity	Description
coordinate	RelativeGeoCoordinate	1	The coordinates of the last LRP which are relative to the coordinates of the preceding LRP in the sequence of LRPs.
Ordered components			
lineProperties	LineProperties	1	The line properties of the last LRP.

8.8 PointLocationLineReferenceData

Data structure PointLocationLineReferenceData (see Table 33) combines common properties of point location types with network connectivity. It provides information about the location reference path described by the first LRP and the last LRP, the actual point location along that path as defined by the positive offset value and orientation and side of road information of that point location with respect to the referenced path.

Table 33 — PointLocationLineReferenceData

Name	Type	Multiplicity	Description
first	FirstLocationReferencePoint	1	The first LRP.
last	LastLocationReferencePoint	1	The last LRP.
sideOfRoad	olr004:SideOfRoad	1	The side-of-road information.
orientation	olr003:Orientation	1	The orientation information.
positiveOffset	DistanceMetresMax15000	0..1	The positive offset relative to the first LRP marking the actual point location on the reference path.

8.9 Rectangle

Data structure Rectangle (see Table 34) specifies a rectangle with a lower left and an upper right coordinate.

Table 34 — Rectangle

Name	Type	Multiplicity	Description
lowerLeftCoordinate	AbsoluteGeoCoordinate	1	The coordinates of the lower left corner of the rectangle.
upperRightCoordinate	AbsoluteGeoCoordinate	1	The coordinates of the upper right corner of the rectangle.

9 OLR tables

9.1 olr001:FunctionalRoadClass

The functional road class (FRC) (see Table 35) describes the importance of a road within a road network.

Table 35 — FunctionalRoadClass

Code	Reference-English "word"	Comment	Example
0	FRC0	The first (most important) functional road class.	
1	FRC1	The second functional road class.	
2	FRC2	The third functional road class.	
3	FRC3	The fourth functional road class.	
4	FRC4	The fifth functional road class.	
5	FRC5	The sixth functional road class.	
6	FRC6	The seventh functional road class.	
7	FRC7	The eighth functional road class.	

9.2 olr002:FormOfWay

The form of way (FOW) (see Table 36) describes the physical type of a road.

Table 36 — FormOfWay

Code	Reference-English "word"	Comment	Example
0	undefined		
1	motorway		
2	multiple carriageway		
3	single carriageway		
4	roundabout		
5	traffic square		
6	sliproad		
7	other		
8	bike path		
9	footpath		
10	pedestrian zone		

9.3 olr003:Orientation

The orientation information (ORI) (see Table 37) describes the relationship between the point of interest and the direction of a referenced line. The point may be directed in the same direction as the line, against that direction, both directions, or the direction of the point might be unknown.

Table 37 — Orientation

Code	Reference-English "word"	Comment	Example
0	no orientation or unknown		
1	with line direction		
2	against line direction		
3	both directions		

9.4 olr004:SideOfRoad

The side of road information (see Table 38) describes the relationship between the point of interest and a referenced line. The point can be on the right side of the line, on the left side of the line, on both sides of the line, or directly on the line.

Table 38 — SideOfRoad

Code	Reference-English "word"	Comment	Example
0	on road or unknown		
1	right side of the road		
2	left side of the road		
3	both sides of the road		

Annex A
(normative)

TPEG application, TPEG-Binary Representation

A.1 Message components

A.1.1 List of generic component Ids

Name	Id
OpenLRLocationReference	defined by LRC
LinearLocationReference	0
GeoCoordinateLocationReference	1
PointAlongLineLocationReference	2
POIWithAccessPointLocationReference	3
CircleLocationReference	4
PolygonLocationReference	5
RectangleLocationReference	6
GridLocationReference	7
ClosedLinearLocationReference	8
LineProperties	9
PathProperties	10
LocationDescription	11
Shape	12
Path	13

A.1.2 OpenLRLocationReference

<OpenLRLocationReference(defined by LRC)>:=	
<IntUnTi>(defined by LRC),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes
<MajorMinorVersion>(version),	: The version information of OpenLRLocationReference.
ordered {	
<AbstractLocationReference>(locationReference),	: Switch between location reference types.
n * <LocationDescription>(locationDescription) [0..1]	: The textual description of the location reference.
};	

A.1.3 AbstractLocationReference

<AbstractLocationReference(x)>:=	
<IntUnTi>(x),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr);	: number of bytes in attributes

A.1.4 LinearLocationReference

<LinearLocationReference(0)<AbstractLocationReference(0)>>:=	
<IntUnTi>(0),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes
<FirstLocationReferencePoint>(first),	: The first LRP.
<LastLocationReferencePoint>(last),	: The last LRP.
BitArray(selector),	
if (bit 0 of selector is set)	
{	
<IntUnLoMB>(n),	
n * <IntermediateLocationReferencePoint>(intermediates),	: The sequence of intermediate LRP.
}	
if (bit 1 of selector is set)	
<DistanceMetresMax15000>(positiveOffset),	: The positive offset in metres.
if (bit 2 of selector is set)	
<DistanceMetresMax15000>(negativeOffset),	: The negative offset in metres.
ordered {	
n * <Shape>(shape)[0..1]	: The shape describes the location geometry.
};	

A.1.5 GeoCoordinateLocationReference

<GeoCoordinateLocationReference(1)<AbstractLocationReference(1)>>:=	
<IntUnTi>(1),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes
<AbsoluteGeoCoordinate>(coordinate);	: The absolute geo-coordinate.

A.1.6 PointAlongLineLocationReference

<PointAlongLineLocationReference(2)<AbstractLocationReference(2)>>:=	
<IntUnTi>(2),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes

<PointLocationLineReferenceData>(pointAlongLine),	: The network bound point location.
ordered {	
n * <Shape>(shape)[0..1]	: The shape describes the location geometry.
};	

A.1.7 POIWithAccessPointLocationReference

<POIWithAccessPointLocationReference(3)<AbstractLocationReference(3)>>:=	
<IntUnTi>(3),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes
<PointLocationLineReferenceData>(lineWithAccessPoint),	: The network bound part defining the access point to the POI.
<RelativeGeoCoordinate>(poi),	: The POI.
ordered {	
n * <Shape>(shape)[0..1],	: The shape describes the location geometry.
n * <Path>(pathToPoi)[0..1]	: The shape describes the path between the access point and the point of interest.
};	

A.1.8 CircleLocationReference

<CircleLocationReference(4)<AbstractLocationReference(4)>>:=	
<IntUnTi>(4),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes
<AbsoluteGeoCoordinate>(centrePoint),	: The centre point of the circle.
<DistanceMetres>(radius),	: The radius measured in metres.
BitArray(selector),	
if (bit 0 of selector is set)	
<Boolean>(isFuzzyArea);	: The boundary of the area is fuzzy.

A.1.9 PolygonLocationReference

<PolygonLocationReference(5)<AbstractLocationReference(5)>>:=	
<IntUnTi>(5),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes

<AbsoluteGeoCoordinate>(startCoordinate),	: The first coordinate of the polygon area location reference.
<IntUnLoMB>(n),	: {2 ≤ *n* ≤*}
n * <RelativeGeoCoordinate>(coordinatePath),	: The ordered sequence of relative coordinates defining the remaining corner points of the polygon. The first relative coordinate is relative to the absolute coordinate.
BitArray(selector),	
if (bit 0 of selector is set)	
<Boolean>(isFuzzyArea);	: The boundary of the area is fuzzy.

A.1.10 RectangleLocationReference

<RectangleLocationReference(6)<AbstractLocationReference(6)>>:=	
<IntUnTi>(6),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes
<Rectangle>(rectangle),	: The actual rectangle.
BitArray(selector),	
if (bit 0 of selector is set)	
<Boolean>(isFuzzyArea);	: The boundary of the area is fuzzy.

A.1.11 GridLocationReference

<GridLocationReference(7)<AbstractLocationReference(7)>>:=	
<IntUnTi>(7),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes
<Rectangle>(baseElement),	: The base element of the grid.
<IntUnLi>(nrColumns),	: Column count of the grid, with nrColumns > 1.
<IntUnLi>(nrRows),	: Row count of the grid, with nrRows > 1.
BitArray(selector),	
if (bit 0 of selector is set)	
<Boolean>(isFuzzyArea);	: The boundary of the area is fuzzy.

A.1.12 ClosedLinearLocationReference

<ClosedLinearLocationReference(8)<AbstractLocationReference(8)>>:=	
<IntUnTi>(8),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component
<IntUnLoMB>(lengthAttr),	: number of bytes in attributes
<FirstLocationReferencePoint>(first),	: The first LRP of the closed linear location.

