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Intelligent transport systems — Extension of map database specifications for Local Dynamic Map for applications of Cooperative ITS

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National foreword

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TECHNICAL SPECIFICATION

ISO/TS 17931

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2013-06-15

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2013-10-15

Intelligent transport systems — Extension of map database specifications for Local Dynamic Map for applications of Cooperative ITS

Systèmes intelligents de transport — Extension des spécifications de base de données cartographiques pour cartes dynamiques locales aux applications collaboratives des SIT

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Foreword

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

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

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An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

ISO/TS 17931 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

This corrected version of ISO/TS 17931 contains higher quality figures in Annex D, which improve legibility.

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Introduction

The purpose of this proposal is to extend the existing specifications for map databases in order to provide greater support for applications and/or application developments of Cooperative ITS that may use Local Dynamic Map.

The functional requirements and data model for in-vehicle navigation are already defined in ISO/TS 20452. However, the map-related functional requirements, data model, and data elements needed for Local Dynamic Map for Cooperative ITS have not yet been defined.

This proposal can help developers of applications for Cooperative ITS by broadening its applicability. Such applications will benefit by the availability of a standardized data model and data elements. The resulting work will shorten developers' time-to-market for new products and services.

The scope of this proposal is within the scope of ISO 14296[1)] which was approved in April, 2011. However, in order to meet the schedule requirement of Mandate M/453 issued by European Commission, the scope of this proposal is limited to publishing a Technical Specification for the Local Dynamic Map component of ISO 14296.

1) Under preparation.

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Intelligent transport systems — Extension of map database specifications for Local Dynamic Map for applications of Cooperative ITS

1 Scope

This Technical Specification provides the map-related functional requirements, data model (logical data model/logical data organization), and data elements for Local Dynamic Map for those applications of Cooperative ITS that require information derived from map databases.

It is focused on data elements of a static nature.

2 Conformance

Data structures shall be provided as specified in Clauses 8.

Any data structure claiming conformance with this Technical Specification shall pass the requirements presented in the abstract test suite in Annex A.

UML Expressions for diagrams in this Technical Specification shall be compliant with ISO/IEC 19501:2005.

3 Normative references

The following referenced documents are indispensable for the application 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 14825:2011, *Intelligent transport systems — Geographic Data Files (GDF) — GDF5.0*

ISO/TS 20452:2007, *Requirements and Logical Data Model for a Physical Storage Format (PSF) and an Application Program Interface (API) and Logical Data Organization for PSF used in Intelligent Transport Systems (ITS) Database Technology*

ETSI TC ITS TR 102638, *Basic set of applications definitions*

ETSI TC ITS TR 102863, *Intelligent Transport Systems (ITS); Vehicular Communications; Basic set of applications; Local Dynamic Map (LDM); Rationale for and guidance on standardization*

4 Terms and definitions

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

4.1
Address Location
application category that deals with the task of expressing a real-world position in terms of the PSF data representation

Note 1 to entry: Address Location is one of the six application categories.

4.2
Advisory Point
data model entity that provides information about an approaching condition on a road that may require some action by the driver of a vehicle

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4.3
Application category
basic sub-function within the set of functionality for vehicle navigation and traveler information system applications

Note 1 to entry: This Technical Specification identifies six application categories: Positioning, Route Planning, Route Guidance, Map Display, Address Location, Services and POI Information Access.

4.4
Background
data model package that is composed of Background Imagery, Map Data Background, Cartographic Feature Type, Figure Element and Picture file entity for displaying Map

4.5
Background Imagery
data model entity that provides background images upon which the road network of an area may be displayed

4.6
Building & Facility
data model entity that provides the location and shape of road side features such as a toll gate, or a fixed Road Side ITS station

4.7
Cartographic
data model package represents geometric information for display purposes, having non-explicit topology and 0-, 1- and 2-dimensional types and images

4.8
Cartographic Feature Type
data model entity that provides cartographic feature by their type (Symbol, Point, Polyline and Polygon)

4.9
Caution Point
data model entity that provides warning information about an approaching potential hazard on the Road Elements that may require some action by the driver of a vehicle

4.10
Detailed Special Route
data model entity that provides the detailed information of Special Route such as the ordered sequence of Link and Intersection lists, length of route and fee of toll road

4.11
Direction Guide
data model entity that provides the guidance information for a path which is composed of the entrance Link and the exit Link connected to an Intersection

4.12
Display point
0-dimensional type of cartographic feature

4.13
District Name
data model entity that provides the name of a geographic area feature for each Link connected to an intersection

4.14
Figure Element
data model entity that provides the shape data of a cartographic feature for displaying a map

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4.15
Geo cording
determination of a link or node based on address information describing and/or naming a location

4.16
Graphic Text
data model entity that stores name text that is associated with all or part of a cartographic feature

Note 1 to entry: It is language-dependent and can contain a suggested display location, orientation, language code, priority (or importance), suggested scale range, and bounding box.

4.17
Intersection
GDF level 2 representation of a crossing which bounds a road or a ferry as a complex feature composed of one or more GDF level 1 junctions, Road Elements and enclosed traffic areas

4.18
Intersection Connecting Point
data model entity for a topological junction of two or more links or end bounding a link

Note 1 to entry: A link stores the coordinate value of the corresponding GDF junction.

4.19
Intersection Cost
data model entity that provides the time or monetary cost between the entrance Link and exit Link of Intersection for calculating route

4.20
Intersection Link
data model entity that provides the Links in the Intersection used for determining the path through an intersection

4.21
Intersection Link Shape
data model entity that provides the shape of the Intersection Link for displaying a path

4.22
Intersection Name
data model entity that provides the name of an Intersection. An Intersection may have one or more names corresponding to the direction of entering into the intersection

4.23
Junction
it represents a navigable feature which is either a named GDF junction or named GDF intersection, and that relates a named navigable feature to a set of links and nodes and a place

4.24
Landmark
point, line or area feature that can be used to clarify the directions generated to describe a route

Note 1 to entry: It can be associated to a node or a link.

Note 2 to entry: A Landmark cannot be in the Services, Administrative Areas, or Public Transportation Feature themes of the GDF; however a facility in which a service is located can be a landmark.

4.25
Lane
data model entity that provides the lane information such as lane direction or lane width of Road Element

4.26
Lane Shape
data model entity that provides the shape geometry of the lane

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4.27
Layer
sub-set of map data resulting from a subdivision of data of the same coverage area based on contents (similar to ISO-GDF layer) and which is typically related to one or only a few of the application categories

EXAMPLE Route guidance data can be considered as one layer.

4.28
Level
sub-set of map data resulting from classification of data of the same semantically contents based on the level of details/density, related to the concept of different map scales

Note 1 to entry: Level 0 is considered the lowest level (greatest detail); higher levels are numbered level 1, level 2, etc.

EXAMPLE Map display data can be organized into 6 levels representing different zoom scales.

4.29
Link
directed topological connection between two nodes, composed of an ordered sequence of one or more segments and represented by an ordered sequence of zero or more shape points

4.30
Link Cost
data model entity that provides the time or monetary cost of the Link for calculating route

4.31
Local Dynamic Map
a conceptual data store which is embedded in an ITS station and which contains topographical, positional and status information

4.32
Location Image
data model entity that provides a background image of the Road Element and the intersection upon which guidance information is displayed

4.33
Map Data Background
data model entity that provides map database features for background display

4.34
Map Display
application category that deals with graphical information presentation

Note 1 to entry: Map Display is one of the six application categories.

4.35
Multilink
ordered aggregation of links which are at the same level, connected in sequence, share the same functional classification, form of way, direction of travel, and perhaps additional PSF-builder-specified characteristics, such that each link is contained in exactly one multilink

4.36
Parcel
database partitioning unit, corresponding to a certain coverage area and associated with one level and containing data of one or more layers

Note 1 to entry: A parcel contains (at least) all nodes with positions enclosed by or located on the outline of its coverage area plus (parts of) all links attached to these nodes.

Note 2 to entry: It can be partitioned such that the amount of data of one parcel is nearly the same as that of another.

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4.37
Picture File
this entity is the file of picture object

4.38
Place
named area which can be used as part of address location

4.39
Place Reference Point
data model entity that provides a representative point within a Place

4.40
Point of Interest
destination and/or site of interest to travelers, usually non-commercial by nature

4.41
Polygon
2-dimensional type of cartographic feature

4.42
Polyline
1-dimensional type of cartographic feature

4.43
Positioning
application category that deals with the determination of vehicle location and map-matching

Note 1 to entry: Positioning is one of the six application categories.

4.44
Rectangle
unit of geographic space, defined by two parallels of min/max latitude and by two meridians of min/max longitude, that represents the coverage area of the map data enclosed by or located on the outline of the rectangle

4.45
Regular parcel
parcel shaped like a rectangle

Note 1 to entry: Regular parcels on the same generalization level are not intended to overlap.

4.46
Reverse geo cording
determination of the address description of a link or node (i.e. determination of an upwards path across the place tree)

4.47
Road
GDF level 2 feature composed of one, many or no Road Elements and joining two intersections, serving as the smallest independent unit of a road network at GDF level 2

4.48
Road Bridge and Tunnel
data model entity that provides information such as the length, height and slope of bridges and tunnels

4.49
Road Element
data model entity that is a primitive road feature. Road Element is the same as the Link except for connecting to the Intersection

Note 1 to entry: Road Element is the same as Link.

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4.50
Road Element Shape
data model entity that provides the shape geometry of the Road Element for displaying Road and Positioning

4.51
Route Guidance
application category that deals with the generation of graphical, textual, and/or audio instructions for following a planned route

4.52
Road Marking
data model entity that provides the shape of painted markings on roads such as lane markings these may be used for display purposes

4.53
Road Section
data model entity that is represented by an ordered sequence of one or more Road Element

4.54
Road Signage
data model entity that provides the detailed text of the road signage on the Road Element

Note 1 to entry: Route Guidance is one of the six application categories elements and joining two intersections, serving as the smallest independent unit of a road network at GDF level 2.

4.55
Route Planning
application category that deals with the determination of routes between specified points

Note 1 to entry: Route Planning is one of the six application categories.

4.56
Segment
straight section of a link connecting either two successive shape points, or a shape point and a node, or two nodes in case the link does not contain shape points

4.57
Service
data model entity for a commercial activity of interest to travelers as a destination and/or orientation that is associated with Road Element(s), by which it can be accessed, and place(s)

Note 1 to entry: Service is further described by attributes including (at least) name and type; it can be associated with other services by parent/child relationships (many to many).

Note 2 to entry: Service is used synonymously with POI within the logical data model.

4.58
Service and POI Information Access
application category that deals with the provision of POI information to the navigation application

Note 1 to entry: Services and POI Information Access is one of the six application categories.

4.59
Service and POI Reference Point
data model entity that provides a representative point of a Service and POI

4.60
Shape point
position along a link used to more accurately represent its geometric course, bounded by exactly two segments

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4.61
Special Route
data model entity that provides the pre-determined route such as scenic route or highway route

4.62
Street Address
data model entity that provides the geocoded Street Address of the Road Element

4.63
Symbol
it represents an icon associated with a cartographic feature

4.64
Topological Road Network
data model package that is composed of Road Element, Intersection, Link Cost, Intersection Cost, Traffic Restriction, Special Route and Detailed Special Route

4.65
Traffic Location
data model entity that contains an external reference (e.g. VICS or RDS-TMC) and is linked to either place or Road entities

4.66
Traffic Restriction
data model entity that provides the traffic restrictions such as one way or turn restrictions for route calculation purposes

4.67
Transportation element
any feature from the Roads and Ferries feature theme of the GDF

5 UML Expressions for diagrams

This Technical Specification uses UML to express specific circumstances; the graphical elements are used to express specific constraints and structural relationships. A full definition can be found in ISO/IEC 19501:2005. However, a short introduction of elements is given in Annex B.

6 Symbols (and abbreviated terms)

ADAS Advanced Driver Assistance System

BSA Basic set of applications

DB Database

GDF Geographic Data File

ITS Intelligent Transport System

LDM Local Dynamic Map

LDO Logical Data Organization

POI Point of Interest

PSF Physical Storage Format

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7 Requirements

7.1 Introduction

This Technical Specification defines application requirements and functional requirements.

7.2 Application Requirements

This Technical Specification supports Basic set of applications of Cooperative systems, Driving support services, and navigation services.

Basic set of applications of Cooperative systems are defined in Annex C. Driving support services are defined in Annex D. Relationship between Basic set of applications of Cooperative systems and Driving support services are defined in Annex F.

7.3 Functional Requirements

7.3.1 Overview

Six functions (Map Display, Positioning, Route Planning, Route Guidance, Service/POI Information Access and Address Location) are the same as ISO/TS 20452:2007. The other functions are newly defined by this technical specification.

7.3.2 Map Display

7.3.2.1 General Description

The Map Display function is used to display a map of a specified geographic area. An application may display maps to the end-user. The application may also accept end-user input that references the map display (such as from a point and click device).

7.3.2.2 Functional Description

An application may display Points Features, Lines Features, Areas Features, Cartographic Text and Symbols for a specified geographic area. This may include roads, physical features, administrative boundaries, and names for all of these. Text and symbols can be positioned on a display to annotate this map.

The Map Display function provides cartographic data that can be used to display a map of any application specified arbitrarily-oriented rectangle in the database. The data consist of the following database entities to support a variety of map drawing styles: Cartographic Features, Cartographic Text and Symbols.

The application may allow the map to be zoomed in or out. The application may display different levels of detail on a map display based on the zoom level. The application may allow the map to be rotated and scrolled. When scrolling, if detailed data are not available, the application may automatically zoom the map out to a level where data are available. The application may allow the end-user to access additional information by selecting objects on the display. The application may display multiple windows. Generating map images and managing displays are beyond the scope of this function.

To facilitate data access speed, this application groups cartographic data into levels. The higher levels contain only the more significant cartographic features. The set of cartographic data is also selectable by level.

7.3.2.3 Requirements for Data model

Map Display provides the following methods of accessing data:

— R-1. via the Cartographic Features, Cartographic Text and Symbols for an application-specified rectangle, *level* and *Feature type*;

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— R-2. via the coordinates for application-specified Cartographic Features;

— R-3. via attributes for Cartographic Features, such as: feature type, name, and functional classification;

— R-4. via the complete or partial Cartographic Features associated with application-specified Transportation Elements;

— R-5. via the area (size) of an application-specified *Area Feature*;

— R-6. via the ability to retrieve additional information for *Point, Line and Area Features* which are associated with Cartographic Features which may have been selected from the displayed map;

— R-7. via the Cartographic Text associated with a Cartographic Feature;

— R-8. via the Symbol associated with a Cartographic Feature;

— R-9. via returning the Cartographic Features and Cartographic Text in "draw-order". For example, if water is drawn before bridges, water features should be returned before bridge features.

— R-10. When no map data are available for an area requested by a function, the function may distinguish between the case of "off the map" and the case of "no data at this location at this *level*".

— R-11. The API shall allow a pre-fetch area of interest to be specified by a rectangle and application specified *level* for retrieving Map Display data.

— R-12. display a map at the current location of the navigation system;

— R-13. display a marker on the map indicating the navigation system's current location;

— R-14. scroll the displayed map as the navigation system moves, maintaining the position of the marker indicating the navigation system's current location;

— R-15. display a map at any location selected by the end-user. The end-user may specify the location as an address, an intersection, a service, or by cursor position on the display;

— R-16. provide latitude and longitude, street address, and other information for a point indicated by the cursor on the display;

— R-17. highlight a route on the display;

— R-18. highlight the point on a displayed map of a particular routing maneuver.

— R-19. Several *levels* of data are required for cartographic data, corresponding to different map scale ranges. At the higher *levels*, the drawing detail for line features and area features is generalized.

— R-20. Access is required for data from all GDF Feature Themes, as well as attributes and conditions.

— R-21. Map display data shall be organized into Parcels.

— R-22. In order to allow easy identification of Parcels, Parcels shall be rectangular.

— R-23. Links crossing Parcel boundaries shall be cut at the Parcel boundary.

— R-24. In order to minimize the number of Parcels accessed, any link crossing into a parcel, with or without a node or *intermediate point* in that Parcel, shall be represented in that parcel.

7.3.3 Positioning

7.3.3.1 General Description

The Positioning function is used to determine vehicle location, for example latitude and longitude of a road network entity and for Map Matching. Map Matching is the method of determining where the navigation

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system has moved in the road network based on the navigation system's previous location and data about the navigation system's motion from external inputs. It corrects the geo-localization on the routes.

7.3.3.2 Functional Description

"Positioning" seeks a position and orientation of a navigation system relative to the transportation network with respect to the map data representing the real world. An application may dynamically determine the navigation system's current position while the navigation system is in motion. Map Matching can continue "in the background" even while other functions are being performed so the navigation system always "knows where it is", with an accuracy depending on the map-matching. Map Matching algorithms are beyond the scope of this Technical Specification.

7.3.3.3 Requirements for Data model

For the purpose of positioning, the following functions shall be provided:

— R-25. a single set of coordinates for an application-specified *Point Feature* in the *Roads and Ferries* theme;

— R-26. the set of *Edges, Nodes* and/or *Intermediate Points* for an application-specified *Feature* or set of connected *Features* in the *Roads and Ferries* theme;

— R-27. the set of topologically connected *Features* in the *Roads and Ferries* Theme connected to an application specified *Feature* in the *Roads and Ferries* theme;

— R-28. a single set of coordinates for an application-specified *Line Feature in the Roads and Ferries* theme and application-specified percentage of the distance along the *Feature*;

— R-29. the set of *Features, Edges, Nodes* and/or *Intermediate Points* in the *Roads and Ferries* theme within an application-specified rectangle;

— R-30. positioning related Attributes, Conditions and Relationships (i.e. Prohibited Manoeuvres, Direction of Traffic Flow) for an application-specified Feature in the *Roads and Ferries* theme;

— R-31. the entry and exit angles for the set of *Transportation Elements* connected to an application-specified *Intersection or Junction*;

— R-32. The specification shall support a single, world-wide, latitude/longitude-based coordinate reference system. The International Terrestrial Reference Frame (ITRF) is chosen because it is maintained by an international body. It is considered equivalent to WGS84 because the two systems currently have less than 1 m difference;

— R-33. only one coordinate system can be used in a single piece of storage media;

— R-34. when an application tracks progress along the route and provides maneuver instructions at appropriate points to the end-user;

— R-35. when an application determines whether the navigation system has left the planned route;

— R-36. when an application calculates a route to the requested destination from the navigation system's current position;

— R-37. when an application scrolls the displayed map;

— R-38. when an application selects services by geographic proximity;

— R-39. when an application is displaying the navigation system's position on a map;

— R-40. when an application displays a map around a location relative to the navigation system's current position;

— R-41. Positioning may receive planned route information from the Route Planning application for use in Map Matching.

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— R-42. Only access to the lowest level of data is required.

— R-43. Only access to the data represented in the Roads and Ferries theme is required.

— R-44. Positioning data shall be organized into parcels.

— R-45. In order to minimize the number of parcels accessed, any link crossing into a parcel, with or without a *node* or *intermediate point* in that parcel, shall be represented in that parcel.

— R-46. In order to allow fast spatial access to parcels, parcels shall be accessed by their bounding rectangles. The shapes of parcels on the lowest level shall not overlap.

7.3.4 Route Planning

7.3.4.1 General Description

The Route Planning function is used to determine routes from one user-specified location to another.

7.3.4.2 Functional Description

Navigation applications may calculate routes based on attributes of the transportation network. Applications may allow end-users to specify criteria for the route such as "shortest distance", "no highways", etc. As a basic operation, a user indicates a departure position, which could be the navigation system's current position, and selects a destination (place to go) and possibly one or more waypoints. A suitable route is then calculated. Routing is not limited to automobile transportation only. This function supports routing via any mode represented in the database. This may include rail and water ferries, taxis, and routes only accessible by bicycle or foot. Other forms of public transportation may be considered in the future.

The route calculation algorithms are outside the scope of this functional description.

To improve data access speed, the Logical Data Organization groups transportation features into levels. The higher levels contain only the more significant features (e.g. highways and main roads). These may be aggregated. Correspondences between features at different levels shall be made available to the application. The functions specified in the requirements below allow selection by level.

7.3.4.3 Requirements for Data model

The Route Planning application provides the following methods of accessing data that can be used for routing:

— R-47. via the set of topologically connected *Links* for an application-specified *Link* at an application-specified level;

— R-48. via routing-related Attributes for an application-specified Transportation Element or set of connected Transportation Elements, such as: Node Coordinates (of the bounding Nodes of a Link), Measured Length, Functional Road Class, Number Of Lanes, Average Speed, Divided Road Element, Form Of Way, as well as access characteristics, Conditions, and other Relationships;

— R-49. via navigation attributes for *Roads and Intersections*;

— R-50. via corresponding *Link* for an application-specified *Link* at an application-specified different level;

— R-51. via a set of topologically connected *GDF Roads* for an application specified *GDF Road* at an application specified level at certain levels to be determined;

— R-52. via a set of GDF Road Elements and GDF Junctions, which comprise a GDF Road or GDF Intersection;

— R-53. via the GDF Road or GDF Intersection for an application-specified GDF Road Element or GDF Junction;

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— R-54. via the corresponding entity representing a GDF *Junction or Intersection* for an application-specified entity representing a GDF *Junction or Intersection* at an application-specified different level;

— R-55. via effective time or date periods for turn, travel, or other Conditions;

— R-56. via location references which are stored in the database for an application-specified set of *Transportation Elements*;

— R-57. via a set of *Transportation Elements* for an application-specified location reference, which is stored in the database;

— R-58. via the entry and exit angles for the set of *Links* connected to an application-specified *Intersection or Junction*;

— R-59. via historic and forecast traffic conditions, incidents, and events information for a specified *Transportation Element* or set of *Transportation Elements*;

— R-60. via a DAL capable of providing transparent access to static and dynamic traffic information. It shall not preclude or require the integration of dynamic traffic information from external systems;

— R-61. via an API allowing a pre-fetch area of interest specified by feature ID or rectangle for retrieving Route Planning data at an application-specified level.

— R-62. The Route Planning application accepts other information from the Positioning application when calculating a route to the requested destination from the navigation system's current position.

— R-63. The Route Planning application provides information about the planned route to the Positioning application when determining whether the navigation system has left the planned route.

— R-64. The Route Planning application provides information about the planned route to the Route Guidance application for generating driving instructions.

— R-65. The Route Planning application provides information about the planned route to the Services and POI Information Access application for geographic selection of services with proximity to the planned route.

— R-66. The Route Planning application accepts input from the Services and POI Information Access and Address Location application when determining end-points or way-points for a route.

— R-67. The Route Planning application provides information about the planned route to the Map Display Application when indicating the course of the planned route on the graphical map display.

— R-68. Only access to the data represented in the *Roads and Ferries* theme is required. Enclosed traffic areas shall be represented by links and nodes.

— R-69. The shape of a parcel on a given level shall be contained in the shape of exactly one parcel at a higher level. The shapes of parcels on the same level shall not overlap.

— R-70. For route planning data, references to parcels on the same level and on the level(s) above and below are required.

— R-71. In order to have optimally filled parcels, parcels may have different coverage sizes.

— R-72. For route planning data, no intermediate points are required for the representation of links. A representation of turn angles, link length and the link cost are required.

— R-73. There is no requirement to create an additional node where a link crosses a parcel boundary.

— R-74. For route planning data, links crossing a parcel boundary should be stored as a whole in those parcels where they are connected to other links in the same parcel.

— R-75. In order to have fast access to parcels, parcels shall be accessed by their bounding rectangles.

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— R-76. A separate computation is required to find nodes or links in the network data corresponding to origin, intermediate and destination points. The manner in which the nodes or links are found is outside the scope of this Technical Specification.

7.3.5 Route Guidance

7.3.5.1 General Description

The Route Guidance function is used to generate instructions for following a route.

7.3.5.2 Functional Description

The Route Guidance function generates step-by-step instructions for following a route. These instructions may include compass heading, distance, road names, sign text, landmarks, and still or motion images. These instructions may also include maneuver details such as turn angle, merges, and road name changes. Route Guidance may be given using text, voice or graphics.

7.3.5.3 Requirements for Data model

Route Guidance provides the following methods of accessing data used for guidance of a route:

— R-77. via guidance-relevant features and relationships related to an application-specified Transportation Element, or set of Transportation Elements, such as: intersecting *Road Elements, Signpost Information*, Conditions and Landmarks along the Transportation Element;

— R-78. via guidance attributes for an application-specified Transportation Element, or set of Transportation Elements, such as: *Road Names, Length, Direction Of Traffic Flow*, and *Form Of Way*;

— R-79. via indicating whether an application-specified *Junction* is a part or all of an *Intersection*;

— R-80. via indicating whether an application-specified link is a regular link, a super link or part of a super link;

— R-81. via connected Transportation Elements for an application-specified Junction;

— R-82. via connected Transportation Elements for an application-specified Intersection which are not part of that Intersection, such as the set of *Road Elements* connected to a Roundabout;

— R-83. via component Transportation Elements of an application-specified Intersection, such as the set of *Road Elements* and *Junctions* which make up a roundabout;

— R-84. via data about the transition from an application-specified Link to an application-specified series of connected Links, such as: the existence of a tollbooth or gate;

— R-85. via node and Intermediate Point positions for *Line Features* to support displaying maneuver “arrows” for route guidance;

— R-86. via cartographic data for the *Line Features* comprising an intersection for the derivation of intersection schematics;

— R-87. via entry and exit angles for the set of *Transportation Elements* connected to an application-specified *Intersection or Junction*;

— R-88. via phonetic strings in an application-specified language for pronunciation of any named entity in the database;

— R-89. via phonetic strings in an application-specified language for commonly used guidance words;

— R-90. via digitized pronunciation data in an application-specified language for commonly used guidance words;

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— R-91. via API allowing a prefect area of interest specified by a rectangle for retrieving Route Guidance data;

— R-92. via image data for optional picture guidance.

— R-93. provide guidance while the navigation system is in motion, based on a calculated route and map matching;

— R-94. track progress along the route and provide maneuver instructions at appropriate points to the end-user.

— R-95. Route Guidance data shall be organized into Parcels.

— R-96. In order to allow fast access to Parcels, Parcels shall be accessed by their bounding rectangles.

— R-97. In order to have optimally filled Parcels, Parcels may have different coverage area sizes.

7.3.6 Service/POI Information Access

7.3.6.1 General Description

The Service and Points-of-Interest (POI) Information Access function provides access to data which are commonly used as origins or destinations for a route and which contain information useful to travellers. Services are single point or area locations that are typically known by name rather than address. Services include traveller-related commercial services such as hotels, restaurants, and gas stations. Services also include locations or points of interest to travellers, such as national parks, monuments, and tourist attractions. Services can be categorized by type (e.g. airport, city centre, hotel) and may carry a variety of other attribute information (e.g. rating, cuisine type, credit cards accepted).

Typically, third party organizations, such as tourist or motoring organizations, can offer a rich content of traveller information which may be of interest to the user. This type of service information is called Third Party Data (TPD). The amount of service information supplied by Third Parties may vary and may consist of comprehensive Service data, including locational aspects and a linkage to the road network. Some TPD may originate from a party which has imposed proprietary restrictions on the use of the data. This is a subset referred to as Branded Third Party Data (BTPD) which imposes additional requirements.

7.3.6.2 Functional Description

An application may provide Service data to the end-user. Also, an application may allow the use of Services in Address Location, Route Planning, and Map Display. An application may provide information about Services, including Third Party Data (TPD). The Services may be selectable by types, geographic areas (e.g. within a rectangle or within distance of a point), places (e.g. Administrative Areas, Districts, Postal Areas), Service attributes, or whether the Service is associated with TPD. Services may be associated with Road Elements or other components of the Transportation Network based on their location. This provides a location on a road element which gives access to a Service.

Additionally, searches for Services may be qualified by an application-specified partial or full spelling match to the beginning of the Service type, attribute, name, or to any individual word within the type, attribute or name.

Services may be associated with each other. A primary Service is called a parent. A parent Service may have many secondary Services called child Services. A child Service may also have many parent Services. One example of how this relationship is used is in the definition of an Airport Service that has multiple Parking Lots. In this case, the Airport is designated as the parent Service and the Parking Lots are designated as children of that parent.

A Service may be associated with multiple places. For example, the Dallas/Fort Worth Airport is physically located in Arlington and Grapevine. It is also logically associated with Dallas and Fort Worth.

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Service and POI Information Access shall support different entry orders by means of appropriate data structures. Typically, a hierarchical top-down entry order may be used. However, permutations thereof shall also be supported, e.g. POI brand name first.

Service and POI Information Access shall support extensions to the search criteria when no match is found. The user may demand an expanded search area, i.e. areas close to the specified place(s) or spelling tolerance for similarly pronounced/written names.

7.3.6.3 Requirements for Data model

Service data may be accessed by the following methods:

— R-98. via Service attribute data for an application-specified Service (to the extent they exist in the database) for example: name, address, phone number, chain, facility type, and days and times the Service is open;

— R-99. via the coordinates of an application-specified Service;

— R-100. via the related Road Elements and position along the Road Elements for the entry to an application-specified Service;

— R-101. via the related Services of an application-specified Road Element;

— R-102. via the set of Services within an application-specified set of places;

— R-103. via the set of Services within an application-specified set of rectangles;

— R-104. via the set of Services where an application-specified partial or full spelling matches the beginning of the Service name;

7.3.7 Address Location

7.3.7.1 General Description

This function is used to access data that are used to determine positions, both on the earth and in the map data representation of the earth.

7.3.7.2 Functional Description

Address Location is the determination of a location based on information describing or naming the location. An application may determine locations based on various types of information. For example, this information can be an address or cross-streets. There are also two basic methods of address location:

— *Geocoding*: determining a link or a node, or a polygon or representative point by its address description.

— *Reverse geocoding*: determining an address description of a link or node or representative point or area.

End users or applications may not know the complete specification of a location. For example, they may not know the complete address and administrative area, or they may not know whether a street is a “street” or an “avenue”. They may need to search the database based on the information they do know, and examine a set of locations matching their criteria.

Address Location may support different entry orders by means of appropriate data structures. Typically, a hierarchical top-down entry order may be used. However, permutations thereof shall be supported (e.g. street name first).

Address Location may support extensions to the search criteria when no match is found. The user may demand an expanded search area (e.g. areas close to the specified place(s) or spelling tolerance for similarly pronounced/written names).

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7.3.7.3 Requirements for Data model

— R-105. Address Location is the determination of a location based on information describing or naming the location.

— R-106. An application may determine locations based on various types of information. For example, this information can be an address or cross-streets.

— R-107. There are also two basic methods of address location.

7.3.8 Driving support

7.3.8.1 General Description

The Driving Support function is used to provide information for supporting safe driving.

7.3.8.2 Requirements for Data model

— R-108. Provide the driver with the attention information on intersection and road.

— R-109. Provide the driver with the Road Signage information on intersection and road.

— R-110. Provide the driver with detailed road segment information around the vehicle.

EXAMPLE Lane, Lane Shape, Surface shape of Intersection, and Surface shape of Link.

— R-111. The location reference for cooperating to external system shall be defined.

— R-112. The data for Driving support services shall keep the coverage, accuracy, and freshness.

7.3.9 Update

— R-113. Updating data of each record shall be possible (addition, correction, and deletion).

— R-114. The addition of the new data entity in the future shall be possible.

— R-115. Data structure shall receive the minimum influence by updates.

— R-116. Updating intersection information shall be possible by the boundary.

— R-117. Updating protocols and data structures shall be achieved by ISO 24099.

7.3.10 System Performance

— R-118. Data structure shall be possible to suit ISO 17267 API for car navigation system.

— R-119. Data structure shall be possible to select both Relational DB and Navigable DB.

8 Logical Data Model

8.1 Overall Model

8.1.1 General

The overall model as shown in Figure 1 presents the relation between the following data model entities.

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This overall model is based on ISO/TS 20452. It consists of the following packages:

— Map
  — Transportation
  — Cartographic
— Address Location
— Service/POI
— Dynamic Traffic Information

Figure 1 illustrates Overall Model.

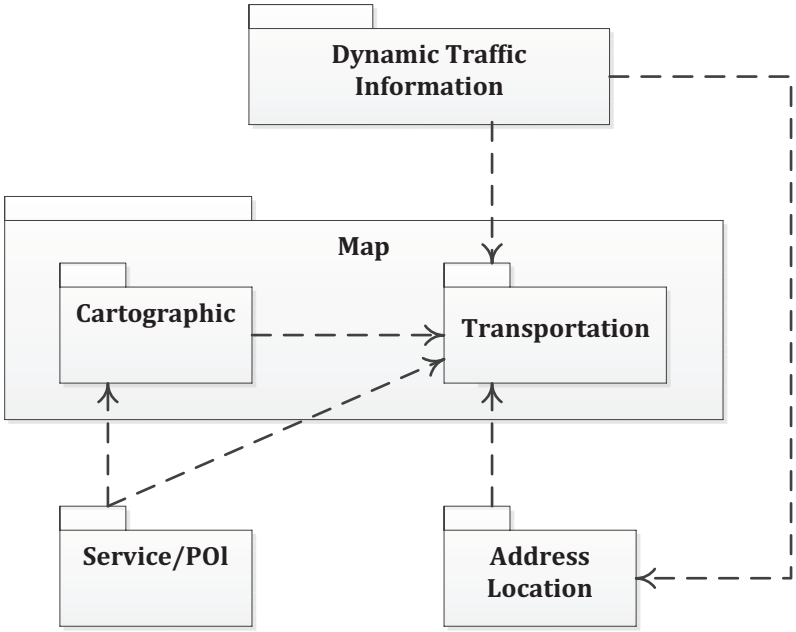


Figure 1 — Overall Model

In the following section, extensionally-defined entities are shown "Transportation package", "Cartographic package", "Service/POI package" and "Address Location package".

8.2 Transportation

8.2.1 Overview

Transportation is reconstructed to support Cooperative ITS.

Transportation consists of Road data, Topological Road Network and Guidance.

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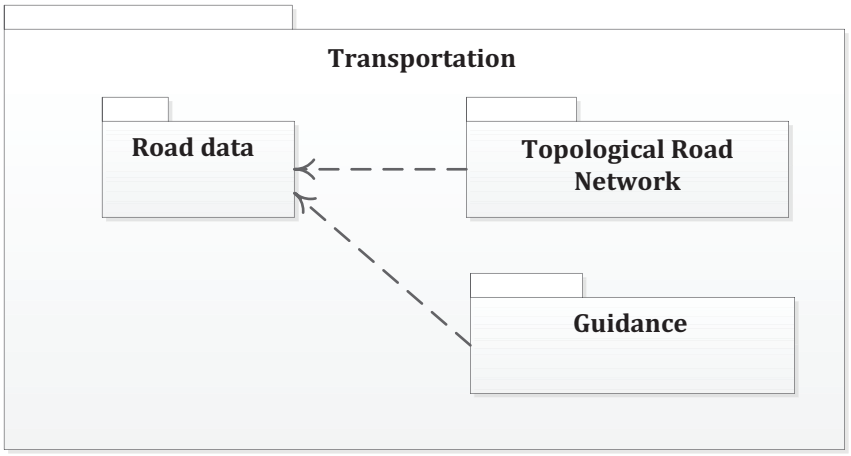


Figure 2 — Transportation

8.2.2 Road data

8.2.2.1 Overview

Road data are set up as the independent entity.

Road data consists of Road Section, Road Element, Intersection Connection Point, Intersection, Road Element Shape, Intersection Link, Intersection Link Shape, Lane, Lane Shape, Road Marking, Road Structure Change Point and Advisory Point.

Figure 3 illustrates Road data.

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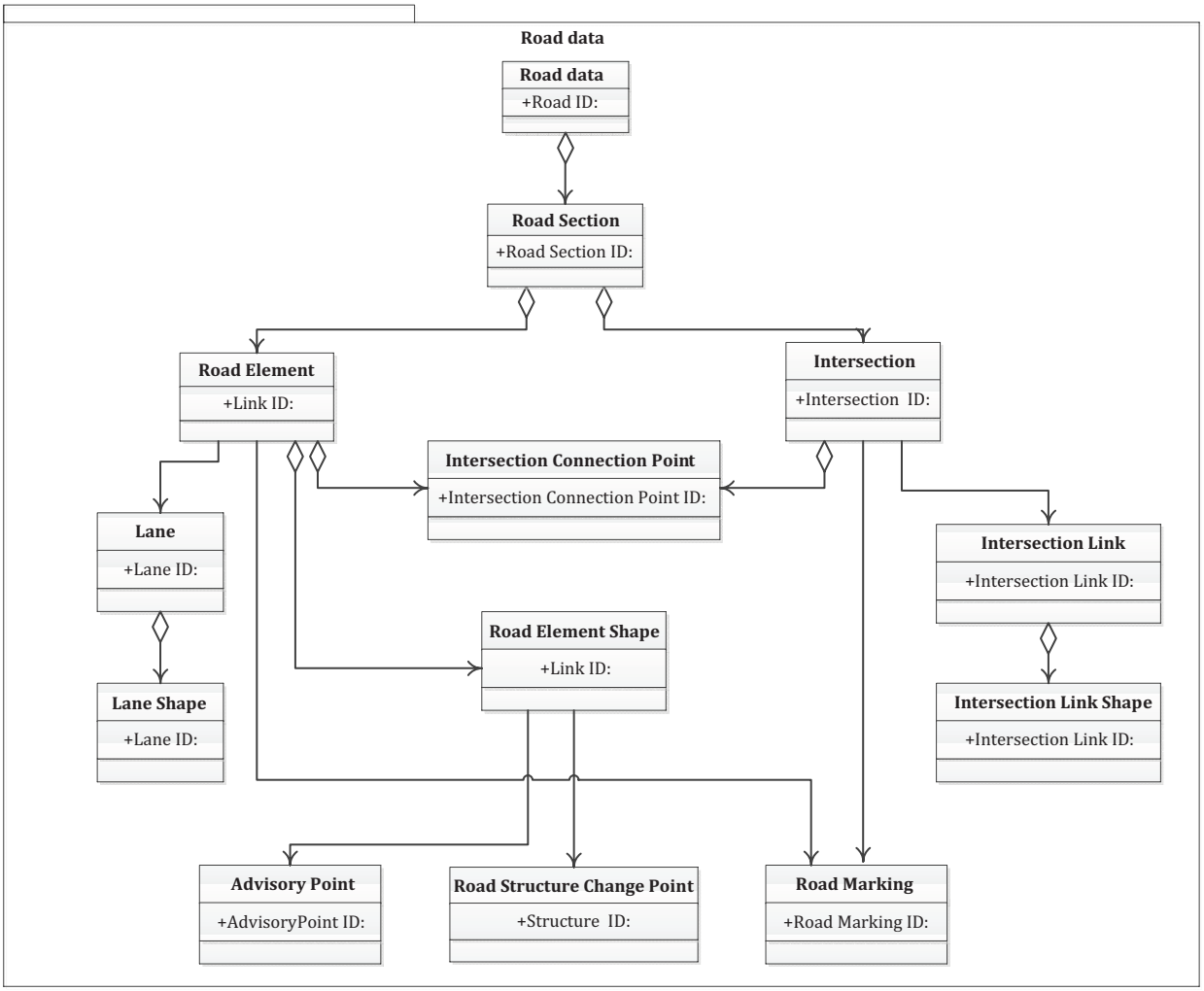


Figure 3 — Road data

8.2.2.2 Road data

8.2.2.2.1 Definition of Road data

Road data are a root entity of the Road.

Road object is a passable area which is called a street / road etc in specific parcel area.

Each Road object is separated and/or divided into the road section objects.

8.2.2.2.2 Data elements of Road data

Data elements of Road data are described in Table 1.

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Table 1 — Data elements of Road data

Data Element / Attribute	Note
Road ID	reference key
number of Road Section	
Road class	
Road Route Number	it is set by road operator
Road identifier code	it is set by road operator

8.2.2.3 Road Section

8.2.2.3.1 Definition of Road Section

Road Section is a part of the street is composed of the road element and the intersection.

Road Section is expressed by intersection – road element – intersection (or end of road element).

Start and end of Road Section are intersections.

If road is expressed by double Line, each line is defined by each Road Section.

Road Section ID is set as an entity identifier.

Road Section entity has the Road Section information.

The Road Section does not include the same Road Element (link) that is used for other road section in the same level.

NOTE Expression of the road by road section is the same as used the multi-link of TS20452, except the intersection part. Then road is changed from double line (simple link) to single line (complex link), it sets the merge intersection on the changing point and two road sections are set. One is to define the road section A and the other is to define the road section B. Double lined road section in the lower level can aggregate the single line road section in the upper level.

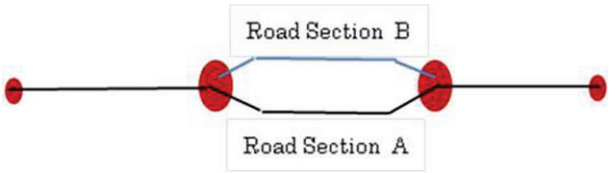


Figure 4 — Road Section

8.2.2.3.2 Data elements of Road Section

Data elements of Road Section are described in Table 2.

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Table 2 — Data elements of Road Section

Data Element / Attribute	Note
Road ID	
Road Section ID	reference key
Road Route Number	
Road identifier code	
number of Intersection in this road section	
start Intersection ID	
end Intersection ID	
existing Link flag corresponding to traffic information	it corresponds to ITS-RSU, VICS / RDS/TMS
Tool road flag	

8.2.2.4 Road Element (Link)

8.2.2.4.1 Definition of Road Element (Link)

Road Element (Link) is composed of two Intersection Connection Point that are in each intersection of the road section.

Road Element has the road element information and attributes for the shape information.

The start and end of Road Element are an Intersection Connection Point at intersection.

Link ID is set as an entity identifier.

Road Element also has an attributes for the lane information.

Shape information of link expresses the road by line (polyline) and/or surface (polygon).

However surface shape information of link is optional.

Link ID must be unique in the system.

The same road element (link) in the different level which is composed of the same Intersection Connecting Point must set the same link ID.

The purpose that Road Element (Link) does not contain the Intersection, Link is to be used for new application.

8.2.2.4.2 Data elements of Road Element (link)

Data elements of Road Element (link) are described in Table 3.

Table 3 — Road Element (link)

Data Element / Attribute	Note
Road Section ID	
Link Connection order	it intents to store link order
Link ID	reference key
start Intersection ID	
One-way Information	
Investigation Information	
Lane information flag	

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Table 3 *(continued)*

Data Element / Attribute	Note
Road Bridge and Tunnel Point flag	Has this link a Road Bridge and Tunnel objects
start Intersection Connecting Point ID	
end Intersection Connecting Point ID	
Upper level Existence flag	
Upper level Link ID	
Link Type code	
Road functional code	
Slope information	Ascent/ descent/ flat
Adjacent intersection Link flag	
Street Name Existence flag	
Street Address Existence flag	
Road name Existence flag	
Road width(normal direction)	the mean value
Road width(opposite direction)	
number of Road Signage	
Stop sign existence flag (start / end side)	
Speed Limits	
number of Traffic sign except with in resection	for pedestrian crossing / crosswalk
Pass-through flag	
On-the-street parking lot flag	

8.2.2.5 Intersection Connection Point

8.2.2.5.1 Definition of Intersection Connection Point

The Intersection Connection Point is a point where the link connects with the intersection link or links of other road element at intersection.

The Intersection Connection Point is the start point and the end point of shape of the links. Also it is used for defining Intersection Link.

Intersection Connection Point ID is set as an entity identifier.

The location of the Intersection Connection Point is set to the position where the expression that shows the connection of the shape of the link and the shape of the intersection link are appropriate.

When the location of the Intersection Connection Point is different such as aggregated point in the upper level and two or more points in the intersection, different Intersection Connection Point ID is given to each point.

Intersection Connection Point has the information on some attributes.

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When the connection of the roads disappears in the upper level, the Intersection Connecting Point is not set in the upper level.

NOTE The location of Intersection Connection Point; 1) to show the road shape in a single-line, it shall be defined in the centre of the intersection. 2) To show the road shape in double-lines, it shall be defined at the entrance point of the intersection or connection point of other link. When there are two or more Intersection Connecting Points in the intersection, each Intersection Connecting Point is given different Intersection Connecting Point ID. Also when they are aggregated in the upper level, different Intersection Connecting Point ID is given to each Intersection Connecting Point.

8.2.2.5.2 Data elements of Intersection Connection Point

Data elements of Intersection Connection Point are described in Table 4.

Table 4 — Data elements of Intersection Connection Point

Data Element / Attribute	Note
Intersection Connection Point ID	Reference key
Intersection ID	
Coordinates of Intersection Connection Point	
Offset from Intersection reference	
Intersection Connection Point Type	normal, boundary
number of Connected Link	

8.2.2.6 Intersection

8.2.2.6.1 Definition of Intersection

The Intersection is a connecting place in road sections. Also dead end of road and dividing / margining point of roads is defined as intersection.

Intersection ID is set as an entity identifier.

Intersection relates the attribute information and the shape information of the intersection.

One or more Intersection Connecting Point exists in the intersection.

The reference location of the intersection;

1) When there is an Intersection Connecting Point in the intersection, a location of the intersection is the same as the location of Intersection Connecting Point.

2) When there are some Intersection Connecting Points in the intersection, a location of intersection is the same as the location of aggregated Intersection Connecting Point in the upper level.

The ID and the position of the intersection do not change in the upper level.

A new intersection in the upper level cannot be defined by aggregating intersections in the lower level.

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The shape information of the intersection is shown in a point and surface shape. The point is shown at the location of intersection, and the surface shape is optional.

NOTE When the Intersection Connecting Point is not set at the upper level, the intersection is not set in the upper level. When the links / Intersection Connecting Points are aggregated in the upper level, the location of the aggregated Intersection Connecting Point in upper level is set at the location of the intersection in lower level. Because neither the location nor the ID of the intersection is changed between the levels, the identity of the intersection is secured in intersection ID. When the Intersection Connecting Point of neighbourhood is set as a separate intersection in the lower level, it is not possible to aggregate it into an intersection by the upper level. When two or more Intersection Connecting Points are aggregated into an Intersection Connecting Point by the upper level, it shall be defined from the lowest level as the same intersection.

8.2.2.6.2 Data elements of Intersection

Data elements of Intersection are described in Table 5.

Table 5 — Data elements of Intersection

Data Element / Attribute	Note
Intersection ID	Reference key
number of Intersection Connecting Point in the Intersection	
Intersection Connecting Point ID list	
Type of Intersection	normal, boundary, runabout, plaza, marge
reference coordinates of the Intersection	
Boundary flag	
Boundary Intersection type	parent/child
number of connected Link	
coverage of Upper level	
Traffic signal flag	

8.2.2.7 Road Element Shape

8.2.2.7.1 Definition of Road Element Shape

Road Element Shape is described by the polyline in the central line of Road Element.

The beginning point of Road Element Shape is defined by an Intersection Connection Point, and it is set as the shape point information on the order of appearance of shape data.

The ending point of Road Element Shape is adjusted to the position of the adjacent Intersection Connecting Point. The ending point of the last shape point is the location of the adjacent Intersection Connecting Point.

Link ID is used as an entity identifier.

Because the Road Element does not include the intersection link, Road Element Shape does not include the shape of the intersection link.

Road Element Shape has three dimensional data. However, the altitude is set by optional entity.

8.2.2.7.2 Data elements of Road Element Shape

Data elements of Road Element Shape are described in Table 6.

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Table 6 — Data elements of Road Element Shape

Data Element / Attribute	Note
Road Section ID	
Link Connection order	
Link ID	
start Intersection Connection Point coordinates	
number of Shape point	
coordinates Offset list	Polyline data
X coordinates offset	
Y coordinates offset	
Road Structure Change Point ID	if it exists on this offset
Advisory Point ID	if it exists on this offset

8.2.2.8 Intersection Link

8.2.2.8.1 Definition of Intersection Link

This entity is set as the link between Intersection Connecting Points at the intersection.

Intersection Link ID is set as an entity identifier.

Intersection Link Shape is optional part of this entity.

NOTE This entity is used for expressing a path of a right-turn, left-turn, go-straight, U-turn, and the roundabout way at the intersection. Because its shape can be shown by using the position of the Intersection Connecting Point when the shape of intersection link is a straight line, the intersection link shape is assumed to be optional. It does not have the altitude information. Rule of the intersection link ID is the same as that of link ID.

8.2.2.8.2 Data elements of Intersection Link

Data elements of Intersection Link are described in Table 7.

Table 7 — Data elements of Intersection Link

Data Element / Attribute	Note
Intersection ID	
Intersection Link ID	Reference key
start Intersection Connecting Point ID	
end Intersection Connecting Point ID	
Link Type code	
length of intersection Link	
average traveling time	
Offset from Intersection coordinates	

8.2.2.9 Intersection Link Shape

8.2.2.9.1 Definition of Intersection Link Shape

This entity is optional part of intersection link.

It is the shape information of the intersection link.

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Intersection Link ID has used as an entity identifier.

Nonlinear shape of the intersection link is necessary so that this entity is set.

NOTE This shape information is the same definition as Road Element Shape.

8.2.2.9.2 Data elements of Intersection Link Shape

Data elements of Intersection Link Shape are described in Table 8.

Table 8 — Data element of Intersection Link Shape

Data Element / Attribute	Note
Intersection ID	
Intersection Link ID	
start Intersection Connecting Point ID	
end Intersection Connecting Point ID	
Offset from Intersection coordinates	
start Intersection Connecting Point coordinates	
Shape point offset list	
X coordinates offset	
Y coordinates offset	

8.2.2.10 Lane

8.2.2.10.1 Definition of Lane

This entity is as optional part of Road Element at the lowest level.

Lane information is used when the new application needs detailed information and shape information of lane.

Road Element consists of one or more serial Lane sections for treating the Lane data. When Road Element has bidirectional Lane, different Lane section must be set up. Lane section is a portion between the points where the number of the lane changes. Lane sections are put in order according to the direction of passing. Lane section consists of one or more parallel Lanes. Lane data are set up from left-hand side in Lane section.

Figure 5 illustrates Lane structure.

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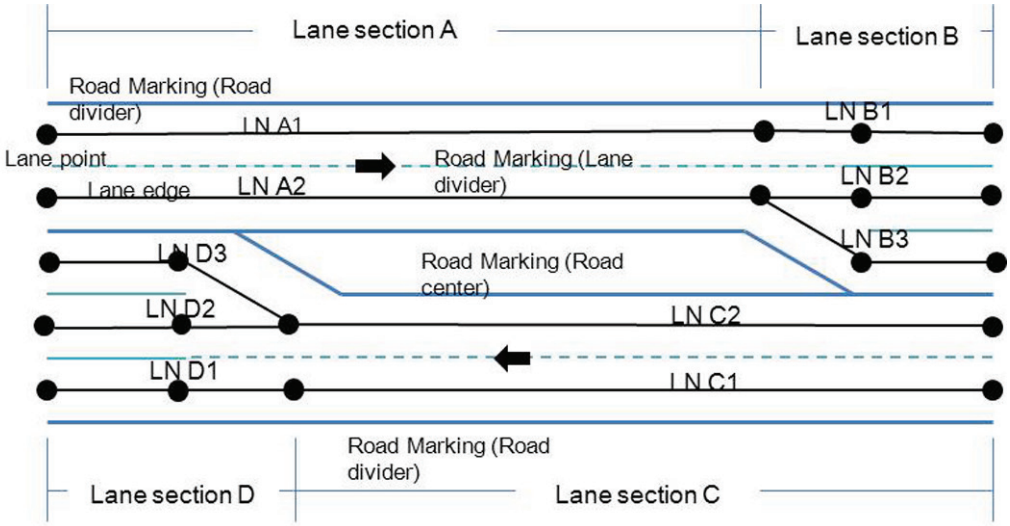


Figure 5 — Lane structure

8.2.2.10.2 Data elements of Lane

Data elements of Lane are described in Table 9.

Table 9 — Data elements of Lane

Data Element / Attribute	Note
Road section ID	
Link ID	
Order/ Reverse of traffic flow of Road Element	
Lane section ID	Order number is available
Lane section attributes	number of Lane,
Lane position in same Lane section	Lane position from left-hand side is defined
Lane ID	
start Lane point ID	
end Lane point ID	
Lane usage type	Normal, Bus, HOV, reversible
Direction of travel at lane end	sharp left, left, slight left, straight, slight right, right, sharp right, u-turn

8.2.2.11 Lane Shape

8.2.2.11.1 Definition of Lane Shape

This entity is as optional part of lane.

Lane shape provides shape data of each lane in road element.

Lane Shape consists of one or more serial Shape data.

Shape data are defined by the polyline in the central line of each lane.

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Shape data are composed of Lane point and Lane edge. Lane point is the starting / ending point of Lane edge. Lane edge is defined by polyline. Lane point is defined at starting / ending point of Lane and changing point of attributes of Lane edge.

8.2.2.11.2 Data elements of Lane Shape

Data elements of Lane Shape are described in Table 10.

Table 10 — Data elements of Lane Shape

Data Element / Attribute	Note
Road section ID	
Link ID	
Lane section ID	
Lane position in same Lane section	Lane position of most left-hand side is defined
Lane ID	
number of Lane edge	
Lane edge List	
Lane edge ID	
Lane edge attributes	Length of Lane edge,
start Lane point ID and coordinates	
end Lane point ID and coordinates	
Adjoining Lane moving availability	
number of shape point	
Shape point Offset List	
X coordinates offset	
Y coordinates offset	

8.2.2.12 Road Marking

8.2.2.12.1 Definition of Road Marking

This entity provides the shape of painted markings on roads such as lane markings these may be used for display purposes.

This entity is optional part of Road Element and Intersection in the lowest level.

Road Marking ID is set as an entity identifier.

The sideline of road, lane line, centre line, stop line, pedestrian crossing, and tram traffic belt are assumed.

This entity is used for drawing, map matching, giving attention, and driving support etc.

NOTE Road Marking is related to surface shape of link and intersection. Not all the Road Marking information is maintained now. It expects that surface shape and Road Marking shall be provided by the public sector.

8.2.2.12.2 Data elements of Road Marking

Data elements of Road Marking are described in Table 11.

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