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Location Referencing Message Specification (LRMS)

RATIONALE

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Foreword --- This standard specifies standard location references for Intelligent Transportation Systems (ITS). The Location Referencing Message Specification (LRMS) focuses on ITS data having the attribute of location, typically on a transportation network. Many location referencing methods have been described and used for transportation. Since different kinds of location referencing methods must be supported for ITS applications, a variety of location referencing data concepts are provided within the LRMS .

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1. Scope

The Location Referencing Message Specification (LRMS) standardizes location referencing for ITS applications that require the communication of spatial data references between databases. ITS databases may reside in central sites, vehicles, or devices on or off roads or other transportation links. The LRMS is applicable to both homogeneous (same database) and mixed database environments that may be implemented on wireless or landline networks. While developed for ITS applications, the LRMS may be used for non-ITS applications as well within the field of geographic information processing.

2. References

The following documents shall be used, when applicable, in the process of populating and developing the message sets of this standard. The specific revision and issued date stated below shall be used for each document. When the following documents are superseded by an approved revision, the revised version shall be reviewed for applicability.

The references cited below shall be included in the references of the other companion volumes of this standard unless specifically excepted.

ASN.1:1997—Abstract Syntax Notation One¹

IEEE Std 1488-2000—IEEE Trial-Use Standard for Message Set Template for Intelligent Transportation Systems²

IEEE Std 1489-1999—IEEE Standard for Data Dictionaries for Intelligent Transportation Systems

ISO/IEC 8824-1:1998—Information technology—Abstract Syntax Notation One (ASN.1): Specification of basic notation³

ISO/IEC 8824-2:1998—Information technology—Abstract Syntax Notation One (ASN.1): Information object specification

ISO/IEC 8824-3:1998—Information technology—Abstract Syntax Notation One (ASN.1): Constraint specification

ISO/IEC 8824-4:1998—Information technology—Abstract Syntax Notation One (ASN.1): Parameterization of ASN.1 specifications

¹ ASN.1:1997 —Available from the World Wide Web at the following site: <http://asn1.elibel.tm.fr>.

² IEEE Publications—Available from Institute of Electrical and Electronics Engineers (IEEE), 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855.

³ ISO Publications—Available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iso.ch/>). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

SAE J2354—Message Sets for Advanced Traveler Information System (ATIS), June 2003⁴

SAE J2369—Standards for ATIS Message Sets Delivered Over Reduced Bandwidth Media, March 2000

3. *Terms and Definitions*

For the purposes of this standard, the following definitions, abbreviations and acronyms apply. The terms, abbreviations and acronyms cited below shall be a part of the terms of the other companion volumes of this standard and guides unless specifically cited otherwise.

3.1 Definitions

3.1.1 Accuracy: The closeness of results of observations, computations, or estimates to the true values or the values accepted as being true. (NIST, 1992) With regards to a digital base map, accuracy refers to how close observation or computational estimates of the position of mapped features are to true ground position. (MnDOT, 1993)

3.1.2 Administrative Area: For administrative purposes, the territory of a country may be divided into regions that have further subdivisions, forming a hierarchy of political units. Some countries have Administrative Areas that are not part of such a hierarchy. (GDF 4.0)

3.1.3 Altitude: Elevation above or below a reference datum, as defined in FIPSPUB 70-1; the z-value in a spatial address. See also elevation.

3.1.4 Area: A generic term for a bounded, continuous, two-dimensional object that may or may not include its boundary. (NIST, 1992)

3.1.5 Attribute: A defined characteristic of an entity type. (NIST, 1992) Within a digital map database, attribute values of the digital object representation of an entity are typically alpha-numeric data within well-defined ranges.

3.1.6 Complex Intersection: The intersection of roadways involving offsets, central medians or some combination of offsets and central medians that can generate multiple nodes for representation. (Schuman, 1993)

3.1.7 Coordinate: A pair of numbers expressing horizontal distances along orthogonal axes; alternatively, a triplet of numbers measuring horizontal and vertical distances. (NIST, 1992)

3.1.8 Coordinate system: A reference system for the unique definition of a location of a point in n-dimensional space. (Krzanowski et al, 1993)

3.1.9 Data Element: Some single unit of information of interest (such as a fact, proposition, observation, etc.) about some (entity) class of interest (e.g., a person, place, process, property, concept, association, state, event). (ISO/DIS 14817)

⁴ SAE Publications—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

3.1.10 Data Frame: Grouping of data elements primarily for the purpose of referring to the group with a single name, and thereby efficiently reusing groups of data elements that commonly appear together (as an ASN.1 Sequence, Sequence Of, Set, Set Of or Choice) in a message body specification. (ISO/DIS 14817)

3.1.11 Datum: A set of parameters and control points used to accurately define the three-dimensional shape of the Earth (e.g. as an ellipsoid). The corresponding datum is the basis for a planar coordinate system. (MnDOT 1993)

3.1.12 Easting: An east (X-axis) offset of a location within a grid cell or UTM cell with respect to an origin.

3.1.13 Geographic Coordinates: The quantities of latitude and longitude (and, sometimes, altitude) which define the position of a point on the Earth with respect to the reference spheroid or ellipsoid. (MnDOT 1993)

3.1.14 Grid: A set of grid cells forming a regular, or nearly regular, tessellation of a surface. The tessellation is regular if formed by repeating the pattern of a regular polygon, such as a square, equilateral triangle, or regular hexagon. The tessellation is nearly regular if formed by repeating the pattern of an "almost" regular polygon such as a rectangle, non-square parallelogram, or non-equilateral triangle.

3.1.15 Grid Cell: A two-dimensional object that represents the smallest nondivisible element of a grid. (NIST, 1992)

3.1.16 Grid Coordinates: Two distances which fix the position of a point on a grid. The perpendicular distance to the point from the y-axis is called the x coordinate while the perpendicular distance to the point from the x-axis is called the y coordinate. (MnDOT 1993)

3.1.17 Grid Resolution: Distance between neighboring grid nodes. (Krzanowski et al, 1993)

3.1.18 Junction: A Feature that bounds Transportation Elements (ref. 3.1.45). A Junction Feature represents the physical connection between its adjoining Transportation Elements.

3.1.19 Line: A linear object composed of one or more connected line segments formed by a series of points. Commonly, a line represents such geographic entities as roads, rivers and shorelines. (Krzanowski et al, 1993) A one-dimensional object. (NIST, 1992)

3.1.20 Line Segment: A direct line between two points. (NIST, 1992)

3.1.21 Linear Object: A continuous one-dimensional object composed of a sequence of one or more line segments, each point of which bounds a maximum of two line segments.

3.1.22 Linear Referencing: Process of identifying location(s) on a transportation network or specific link in a network by specifying a start position, direction, and distance along a particular route. (NCHRP, 1993)

3.1.23 Link: A topological connection between two nodes. A link may contain additional intermediate coordinates (shape points) to better represent the shape of curved features. (Schuman, 1993) A link may be directed by ordering its nodes.

3.1.24 Message: Grouping of data elements and/or data frames, as well as associated message metadata, that is used to convey a complete unit of information. (ISO/DIS 14817)

3.1.25 Message Set: A collection of messages (see 3.1.24) for an application area.

3.1.26 Metadata: Data describing a set of data, for example its quality, lineage, format, and intended or suitable use.

3.1.27 Milepost: A reference point along the linear objects of a road network used in a linear referencing scheme. A milepost may or may not be at one-mile intervals.

3.1.28 NAD27 (North American Datum 1927): Geodetic datum defined by the geographic position of triangulation station Meades Ranch and the azimuth from that station to station Waldo on the Clarke spheroid of 1866. (MnDOT 1993)

3.1.29 NAD83 (North American Datum 1983): Geodetic datum defining an Earth-fitting ellipsoid and for relating existing coordinate systems to the Earth's center of mass. It is based on both satellite and terrestrial data used in developing the Geodetic Reference System of 1980 and later the World Geodetic System of 1984 (WGS-84). This improved Earth-centered model slightly changes the latitude and longitude of almost every point in North America with respect to the earlier NAD27 datum. (MnDOT 1993)

3.1.30 Network: A system of interconnected linear objects that represent possible paths of resource movement.

3.1.31 Node (0-cell): A topologically significant point, such as a simple intersection of roadways or other linear features, or an endpoint of such a feature. (Schuman, 1993) Alternate: A zero-dimensional object that is a topological junction of two or more links or chains, or an end point of a link or chain. (NIST, 1992)

3.1.32 Node Valence: The number of Transportation Elements joining at a Junction, including road elements, railway elements, ferry elements, water elements, and walkway elements. (XGDF, in development)

3.1.33 Northing: The north (Y-axis) offset of a location within a grid cell or UTM grid square, with reference to an origin.

3.1.34 Point: A zero-dimensional object that specifies geometric location. One coordinate pair or triplet specifies the location. (NIST, 1992)

3.1.35 RDS-TMC: A form of messaging for limited-bandwidth media that references locations within Location Tables by Location Codes.

3.1.36 Record: A data construct that consists of an identifiable collection of one or more related fields, typically in a database.

3.1.37 Reference Point: A local point taken as an origin for a local coordinate system. A reference point may or not be a ground control point.

3.1.38 Resolution: The minimum difference between two independently measured or computed values that can be distinguished by the measurement or analytical method being considered or used. (NIST, 1992)

3.1.39 Road Element: A linear section of the earth that is designed for or the result of vehicular movement. (GDF 4.0)

3.1.40 Route: An aggregation of sequentially connected links in a network typically denoting an intended or scheduled path of a transport resource.

3.1.41 Segment: An element of a line defined by two end points; synonym for line segment. (Krzanowski et al, 1993)

3.1.42 Simple Intersection: An intersection (without offsets) of two roadways (without center medians) which can be represented by one node. (Schuman, 1993)

3.1.43 Spatial Objects: Objects required for digital spatial processing that can be used to construct composite objects that represent a more complex realization of the real world.

3.1.44 State Plane Coordinate System: Rectangular coordinate systems used by particular states, typically for production of state transportation maps and resource management.

3.1.45 Transportation Element: Elements of the transportation network, including road elements, ferry elements, railway elements, water elements, and walkways. Walkways include through buildings, squares, platforms, escalators, stairs and elevators. (XGDF – in development)

3.1.46 United States National Grid (USNG): A proposed national standard grid reference system proposed by the Federal Geographic Data Committee for promotion within the U.S. National Spatial Data Infrastructure (NSDI). The USNG is a grid system based on the Military Grid Reference System (MGRS) using Universal transverse Mercator (UTM) coordinates.

3.1.47 Universal Transverse Mercator: A rectangular coordinate system for world use between 84 degrees North latitude and 80 degrees South latitude. The UTM system uses linear measurements with reference to zones and zone central meridians. Measurements are in terms of meters. (NIST, 1992)

3.1.48 WGS-84 (World Geodetic System 1984): A world coordinate system. 1984 version of World Geophysical Society Standard earth, mass, and surface distribution model.

3.2. Acronyms

ALERT	Advice and problem Location for European Road Traffic
ATIS	Advanced Traveler Information Systems
DE	Data Element
DF	Data Frame
FGDC	Federal Geographic Data Committee
FIPS	Federal Information Processing Standard
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Standards Organization
ITIS	International Traveler Information Systems
ITS	Intelligent Transportation Systems
LRMS	Location Referencing Message Specification
NSDI	National Spatial Data Infrastructure
RDS	Radio Data System
SAE	Society of Automotive Engineers
TMC	Traffic Message Channel
USNG	United States National Grid
USPS	United States Postal Service
XML	eXtensible markup language

4. *The Location Referencing Message Specification*

4.1 Location Referencing Methods

This standard specifies standard location references for Intelligent Transportation Systems (ITS). The LRMS focuses on ITS data having the attribute of location, typically on a transportation network. Many location referencing methods have been described and used for transportation. Generally, methods can be divided into three classes: those based on coordinates of some kind, non-coordinate methods, and combinations. Coordinates can be geographic coordinates – latitude and longitude – or some other coordinate system such as local grids relative to a reference point on the earth, or state plane coordinate systems. Non-coordinate systems include postal addresses, identifiers or indices into tables of locations, linear references, and straight-line distances from origins. Examples of combination methods are a linear offset from a reference point defined by a geographic coordinate, or a local grid defined with respect to a coordinate. Since different kinds of location referencing methods must be supported for ITS applications, a variety of location referencing data concepts are provided within the LRMS.

4.2 LRMS Structure

The LRMS standard is an extension of the LRMS Revision C, originally developed by the Oak Ridge National Laboratory (ORNL). In 1999, LRMS Revision C was incorporated in an SAE Information Report, J2374, also called Location Referencing Message Specification. This standard supercedes the Information Report.

The original LRMS approach had been to develop a set of location “profiles”, which are sets of primitive data elements that, when taken together, describe a location according to a particular location referencing method or combination of methods. The location described might be a point, a segment of road, a house, a building, a city, or some arbitrary area on the face of the earth. Examples of referencing methods used to convey locations are complete addresses, geographic coordinates, and offsets along known roads or links (linear referencing).

Some profiles were developed for combinations of referencing methods, and involve other content useful for a particular user community. For example, the Grid profile, originally developed by the Bandwidth Restricted standards effort (SAE J2369), contains a built-in data compression scheme, and thus provides a very space efficient mechanism for the transmission of spatial information over bandwidth constrained media.

The SAE LRMS maintains the profile concept, but exposes lower-level referencing structures as well as higher-level sets. For example, point, line, and area structures (and others) were contained within the Geometry profile of the former LRMS versions. In LRMS these structures are broken out and can be used in multiple profiles, or can be used directly by applications. A Point Location becomes a general term that can be specified by many LRMS profiles, and, vice-versa, many profiles rely on the concept of a Point Location.

A location reference is the highest level (root) of the LRMS. The LocationReference data frame is a sequence of optional profiles used to describe a location. The seventeen LRMS profiles in a location reference are listed in Table 1. Profiles are, in most cases, choices of sub-profiles and/or other Data Frames and Data Elements. For example, the Address is a CHOICE of an AddressPoint sub-profile or an AddressLink sub-profile. Each profile contains two additional optional items: a text Name and a string LocationID attribute. These data constructs can be used to identify particular locations for reuse. An ITS location reference using the LocationReference data frame may use a single profile, or several profiles. Although only one of each type may be used directly in a single call, the GroupLocation profile may be used to send location references of any number and type.

Table 1—Top-level LRMS Profiles and Sub-Profiles**Root: *LocationReference***

<u>Profiles</u>	<u>Sub-Profiles</u>
Address	AddressPoint AddressLink
AreaLocation	
Chain	
CrossStreets	CrossStreetsLink CrossStreetsPoint
GeographicCoordinate	GeoLocationDelta GeoLocationLink PolarCoordinates
Geometry	
Grid	GridArray GridInfo GridPoint GridPointPair GridPointSequence
GroupLocation	
LinearReference	
LinkLocation	LinkGeneral
NodeAttribute	
PointLocation	PointOffset
PreCoded	
PublicGrid	PublicGridLocalReference PublicGridStatePlane PublicGridUSNG
RouteLocation	
SpatialObject	
Transition	
<u>Other Data Frames</u>	
AdminAreaGroup	
Angle	
Attributes	
Distance	
GeoLocation	
Height	
IdType	
Polygon	
StreetInfo	

4.3 LRMS Profile Descriptions

The Address profile supports a robust mechanism for exchanging Address information as a location reference. This profile is particularly well suited to some Directory Service Applications. The Address profile will contain a combination of address information that uniquely describes a location. Basic information includes postal code, structure numbers (e.g. houses), street direction, street name, street side, and administrative area information (e.g. city, state, county, country, prefecture) for the address.

The AreaLocation profile references an area using an identifier or one or more location referencing profiles or sub-profiles. An area may be specified as a closed polygon whose boundary encloses a homogeneous area, such as a town, city, state, county, region, or it may be referenced only by locationID or identifier.

The Chain profile passes references to chains, defined as continuous, directed, non-branching sequences of links with distinct start and end nodes, direction, and name. A chain may be defined by, for example, jurisdictional boundaries such as county line, town line, or state line, and mode changes. A chain may be decomposed into subchains, which are themselves aggregate links.

The CrossStreets profile specifies a link along a street or road by names and/or coordinates of bounding intersections with other streets. Intersection types are provided as options. Points along the link are defined by offsets from the start intersection in the implicit direction of the link, i.e. from start intersection (from) to end intersection (to). Sub-links are defined by multiple offsets. This profile supercedes SAE J1746, the ISP-Vehicle Location Referencing Standard.

The GeographicCoordinate Profile expresses a location in terms of coordinate-based points, links, or polar coordinates. In addition to absolute geographic coordinates, offsets can be specified from a point.

The GeoLocation profile conveys a two- or three-dimensional geographic location based on coordinates. The standard horizontal datum for a spot location is WGS-84; other horizontal datums can be specified, as well as vertical datums.

The Geometry profile expresses location referencing for geometric objects including nodes, points, links, chains, transitions, areas, and polygons. An area, for example of an incident impact, can be specified by an identifier directly, or by a polygon object. Other objects can be referenced by identifiers also, as defined within the object data frame definitions.

The Grid profile is similar in nature to the geometry profile but bears further discussion. Unlike the other profiles and constructs within the LRMS, the Grid profile includes a built-in compression scheme defined by SAE J2369, Standards for ATIS Message Sets Delivered Over Reduced Bandwidth Media, March 2000.. The Grid profile finds most of its use today as a simple means to encode map points in small "flat" map graphic fragments often used in building web page displays. The Grid Profile works by first sending a context for the message, which defines a tiled area using lat-long-altitude. Once the context has been defined, spatial coordinates are then transmitted in abbreviated form as offsets within the tile. The LRMS suggests the use of the Grid Profile in bandwidth constricted situations. However, because the profile does include a compression scheme (which may not remain the most efficient in the future) and does not provide a complete solution for using location profiles as the identity of objects, it is recommended that its use be restricted to those areas where bandwidth is important.

The GroupLocation profile references a location using an identifier or one or more location referencing profiles. Specifying a group as one location may be useful if the same information applies to all locations within the group. In addition, a GroupLocation may be used to send a sequence of location references within one top-level call.

The LinearReference profile supports identification of a location on a network by distances along transport elements from reference objects or reference locations. In addition to on-element distance to the referenced (target) point or link start and end points, a perpendicular (lateral) offset either left or right of the transport element can be specified along the element with respect to a specified offset reference, e.g. road centerline, shoulder edge, or pavement edge.

The LinkLocation profile references a logical or physical link by an identifier or by one or more location referencing profiles.

The PointLocation profile references point locations by identifiers or by one or more location referencing profiles. Points may be non-topological (occur anywhere), or nodes. A node is a topological junction of two or more links or chains, or a start/end point of a link, subchain, or chain. Nodes may designate the following conditions: intramodal decision points (e.g. intersections), or intermodal network connections (e.g. Park-and-Ride). Nodes are shared by chains. Identifiers may be unique, or non-unique within a hierarchical numbering scheme, or derived from some measure of location such as geographic coordinates.

The Pre-Coded profile supports Alert-C type messages and others based on pre-computed tables of locations.

The PublicGrid profile supports referencing using public sector grids, specifically State Plane Coordinate Systems, the new United States National Grid (USNG), and generic local grids.

The RouteLocation profile references routes by identifiers or by one or more location referencing profiles. A Route location is a collection of points and links treated as one location, for example a bus route.

The SpatialObject profile associates information (attributes) with a spatial object of type defined within the LRMS. Attributes are expressed in text form, but are distinguished as simple (for example a description of the object), or complex (for example topological relationships to other objects).

The Transition profile supports references to transition objects. A transition is a direct, topological, and legal connection between two chains of the same mode (e.g. turn lanes and exit ramps). For each intersection, a table of legal transitions will be maintained. For a transition identified by transtionId, a ground distance offset may be specified along the transition to a given point.

4.4 LRMS Usage

Although the LRMS Standard is designed to support a variety of Location Referencing techniques, it is not absolutely application dependent as to which is chosen. This choice (or choices) will depend on the user community needs and agreements regarding implementation. The SAE LRMS Standard is the baseline standard for all such community agreements for location referencing; it is the "family" of location referencing options. Conformance to the LRMS is achieved by subsetting, both at the level of profiles and sub-profiles, and also at the level of data elements. When a profile has optional elements, they may be implemented or not implemented within a community depending on community agreement or implementation standard. Mandatory elements must be handled by implementation software in order to be called LRMS-compliant. For example, the NTCIP 1402 TCIP standard for the transit community may not require all LRMS profiles, and it will contain additional data elements, but it should conform to LRMS data elements and structures where appropriate. By allowing a choice from multiple location referencing profiles, the LRMS Standard will allow data servers, software developers, and users to work using the system that makes the most sense for their equipment, needs and interface preference. The associated LRMS User's Guide will provide examples of usage of LRMS concepts for ITS communities.

The LRMS structures are intended to support application protocols, although the LRMS is not a protocol specification itself. For example, a general purpose identifier of type LocationID, is provided in each ASN.1 data frame for a referencing profile or sub-profile, and as an attribute in the XML. The identifiers can be passed in a reference with full profile information the first time it is used in an application, then used alone in subsequent references to greatly increase the efficiency of repeated references. LocationID can also be used for other application-specific purposes.

Other useful data frames exist in the LRMS for protocol applications. The Node Attribute profile is used to associate information about a node to a given node. This profile may also be useful within a protocol that reduces transmission bandwidth and/or processing requirements by first sending complete information, including the node identifier, using the NodeAttribute data frame, after which subsequent references can be made by identifier only. The Spatial Object profile is a general purpose structure used to associate information (attributes) with spatial objects defined in the LRMS beyond nodes.

5. Data Frames

This Section describes LRMS Data Frames in alphabetical order. With respect to usage, there are seventeen profiles that are optional choices under the root Data Frame, LocationReference (Section 5.30). Most, but not all, profiles are choices of two or more sub-profiles, often with additional Data Frames or Data Elements.

5.1 Data Frame: Address:frame

Use: The Address profile contains the set of address information that uniquely describes a location for structures such as houses, and address ranges along road elements. The Address profile consists of two sub-profiles: AddressPoint and AddressLink, for a single address and an address range, respectively.

ASN.1 Representation:

```
Address ::= SEQUENCE {
    locationName      Text-name255    OPTIONAL,
    addressChoice     CHOICE {
        addressPoint  AddressPoint,
        addressLink   AddressLink
    },
    locationID        String-index64  OPTIONAL
}
```

XML Representation:

```
<xs:complexType name="Address" >
  <xs:sequence>
    <xs:element name="locationName" type="Text-name255" minOccurs="0"/>
    <xs:choice >
      <xs:element name="addressPoint" type="AddressPoint" />
      <xs:element name="addressLink" type="AddressLink" />
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="locationID" type="String-index64" />
</xs:complexType>
```

Used by: This item is used by the following other data structures in this standard: LocationReference:frame [ASN.1: LocationReference].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.2 Data Frame: AddressLink:frame

Use: The AddressLink sub-profile contains address information defining an address range along a road element, defined by two addressed structures such as houses. Information includes structure numbers for each structure, street information, compass direction of the link, side of the road elements the structures are located along, height of the structures, and the hierarchy of administrative areas within which the structures reside. Note that StreetInfo is optional, which allows use in non-US situations where addresses are by number within administrative areas.

ASN.1 Representation:

```
AddressLink ::= SEQUENCE {
    fromStructureNumber Text-name255,
    toStructureNumber   Text-name255,
    streetInfo          StreetInfo    OPTIONAL,
    direction           Direction     OPTIONAL,
    fromSide            Side           OPTIONAL,
    toSide              Side           OPTIONAL,
    fromHeight          Height         OPTIONAL,
    toHeight            Height         OPTIONAL,
    fromAdminAreas      AdminAreaGroup OPTIONAL,
    toAdminAreas        AdminAreaGroup OPTIONAL
}
```

XML Representation:

```

<xs:complexType name="AddressLink" >
  <xs:sequence>
    <xs:element name="fromStructureNumber" type="Text-name255" />
    <xs:element name="toStructureNumber" type="Text-name255" />
    <xs:element name="streetInfo" type="StreetInfo" minOccurs="0"/>
    <xs:element name="direction" type="Direction" minOccurs="0"/>
    <xs:element name="fromSide" type="Side" minOccurs="0"/>
    <xs:element name="toSide" type="Side" minOccurs="0"/>
    <xs:element name="fromHeight" type="Height" minOccurs="0"/>
    <xs:element name="toHeight" type="Height" minOccurs="0"/>
    <xs:element name="fromAdminAreas" type="AdminAreaGroup" minOccurs="0"/>
    <xs:element name="toAdminAreas" type="AdminAreaGroup" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard: Address:frame [ASN.1: Address], and LinkLocation:frame [ASN.1: LinkLocation].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.3 Data Frame: AddressPoint:frame

Use: The AddressPoint sub-profile contains address information for a structure such as a house along a road element. Information includes structure number, street information, side of the road element the structure is located along, height of the structure, and the hierarchy of administrative areas within which the structure resides. Note that StreetInfo is optional, which allows use in non-US situations where addresses are by number within administrative areas.

ASN.1 Representation:

```

AddressPoint ::= SEQUENCE {
    structureNumber  Text-name255,
    streetInfo       StreetInfo     OPTIONAL,
    side             Side           OPTIONAL,
    height           Height         OPTIONAL,
    adminAreas       AdminAreaGroup OPTIONAL
}

```

XML Representation:

```

<xs:complexType name="AddressPoint" >
  <xs:sequence>
    <xs:element name="structureNumber" type="Text-name255" />
    <xs:element name="streetInfo" type="StreetInfo" minOccurs="0"/>
    <xs:element name="side" type="Side" minOccurs="0"/>
    <xs:element name="height" type="Height" minOccurs="0"/>
    <xs:element name="adminAreas" type="AdminAreaGroup" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard: Address:frame [ASN.1: Address], and PointLocation:frame [ASN.1: PointLocation].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.4 Data Frame: AdminAreaGroup:frame

Use: A list of administrative areas constituting the administrative portion of an address. FIPS codes refer to Federal Information Processing Standards Publication 55-3 and 55-2, which define codes for states, counties, cities and locational entities. within the United States and its territories. The optional localAdminAreaGroup element allows for international applications. It is implied in the ASN.1 representation by "...", and explicit in the XML with a local namespace. This method of representation of local extensions is consistent throughout this standard.

ASN.1 Representation:

```
AdminAreaGroup ::= SEQUENCE (SIZE (1..MAX)) OF CHOICE {
    city          Text-name255,
    county        Text-name255,
    state         Text-name255,
    postalCode    PostalCode,
    countryCode   CountryCode,
    stateFIPS     Int-index8,
    entityIPS     Int-index32,
    countyFIPS    Int-index16,
    cityFIPS      Int-index32
    ...
}
```

XML Representation:

```
<xs:complexType name="AdminAreaGroup" >
  <xs:choice minOccurs="1" maxOccurs="unbounded">
    <xs:element name="city" type="Text-name255" />
    <xs:element name="county" type="Text-name255" />
    <xs:element name="state" type="Text-name255" />
    <xs:element name="postalCode" type="PostalCode" />
    <xs:element name="countryCode" type="CountryCode" />
    <xs:element name="stateFIPS" type="Int-index8" />
    <xs:element name="entityIPS" type="Int-index32" />
    <xs:element name="countyFIPS" type="Int-index16" />
    <xs:element name="cityFIPS" type="Int-index32" />
    <xs:element name="localAdminAreaGroup" type="local:AdminAreaGroup" minOccurs="0"/>
  </xs:choice>
</xs:complexType>
```

Used by: This item is used by the following other data structures in this standard (descriptive name and ASN.1 name of each):

AddressLink:frame [ASN.1: AddressLink], and
 AddressPoint:frame [ASN.1: AddressPoint], and
 AreaLocation:frame [ASN.1: AreaLocation], and
 CrossStreetsLink:frame [ASN.1: CrossStreetsLink], and
 CrossStreetsPoint:frame [ASN.1: CrossStreetsPoint], and
 LinearReference:frame [ASN.1: LinearReference], and
 LinkLocation:frame [ASN.1: LinkLocation].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.5 Data Frame: Angle:frame

Use: An angle expressed as a choice of degrees, radians, or 0.01 (centi-) degrees.

ASN.1 Representation:

```
Angle ::= CHOICE {
    deg      REAL (0..360),
    rad      REAL (0..6.2832),
    cdeg     INTEGER (0..36000) - cdeg is in hundredths of degrees
}
```

XML Representation:

```

<xs:complexType name="Angle" >
  <xs:choice>
    <xs:element name="deg" >
      <xs:simpleType>
        <xs:restriction base="xs:decimal">
          <xs:minInclusive value="0"/>
          <xs:maxInclusive value="360"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:element>
    <xs:element name="rad" >
      <xs:simpleType>
        <xs:restriction base="xs:decimal">
          <xs:minInclusive value="0"/>
          <xs:maxInclusive value="6.2832"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:element>
    <xs:element name="cdeg" >
      <xs:simpleType>
        <xs:restriction base="xs:unsignedShort">
          <xs:maxInclusive value="36000"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:element>
  </xs:choice>
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard: PolarCoordinates:frame [ASN.1: PolarCoordinates].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.6 Data Frame: AreaLocation:frame

Use: The Area Location profile references an area such as a town, city, state, county, or region. An area may be specified in four ways:

1. by area name or ID,
2. by a closed polygon composed of pointLocations,
3. by ID from a preCoded table, or
4. by bounding roads.

If profiles are used, each type may be used only once. Once an association is made between an area and a locationID, the ID may be used alone in future references.

ASN.1 Representation:

```

AreaLocation ::= SEQUENCE {
  locationName Text-name255      OPTIONAL,
  areaId       IdType             OPTIONAL,
  adminAreas   AdminAreaGroup    OPTIONAL,
  polygon      Polygon            OPTIONAL,
  preCoded     PreCoded           OPTIONAL,
  roads        SEQUENCE (SIZE (1..255)) OF StreetInfo OPTIONAL,
  locationID   String-index64    OPTIONAL
}

```

XML Representation:

```

<xs:complexType name="AreaLocation" >
  <xs:sequence>
    <xs:element name="locationName" type="Text-name255" minOccurs="0"/>
    <xs:element name="areaId" type="IdType" minOccurs="0"/>
    <xs:element name="adminAreas" type="AdminAreaGroup" minOccurs="0"/>
    <xs:element name="polygon" type="Polygon" minOccurs="0"/>
    <xs:element name="preCoded" type="PreCoded" minOccurs="0"/>
    <xs:element name="roads" minOccurs="0">
      <xs:complexType>
        <xs:sequence minOccurs="1" maxOccurs="255">
          <xs:element name="road" type="StreetInfo" />
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
  <xs:attribute name="locationID" type="String-index64" />
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard (descriptive name and ASN.1 name of each):

GroupLocation:frame [ASN.1: GroupLocation], and
 LocationReference:frame [ASN.1: LocationReference], and
 SpatialObject:frame [ASN.1: SpatialObject].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.7 Data Frame: Attributes:frame

Use: A data frame used to associate attributes with a spatial object, as defined in a SpatialObject data frame. All attributes are expressed in text form, but are distinguished as simple (for example a description of the object), or complex (for example topological relationships to other objects). Note that ‘attributes’ is used in the general sense of spatial database attributes, e.g. as expressed in ISO/DIS 14825, ITS Geographic Data Files (GDF), not XML attributes.

ASN.1 Representation:

```

Attributes ::= SEQUENCE {
    simpleAttributes SEQUENCE (SIZE (0..100)) OF Text-name255,
    complexAttributes SEQUENCE (SIZE (0..100)) OF Text-name255
}

```

XML Representation:

```

<xs:complexType name="Attributes" >
  <xs:sequence>
    <xs:element name="simpleAttributes" type="Text-name255" minOccurs="0" maxOccurs="100" />
    <xs:element name="complexAttributes" type="Text-name255" minOccurs="0" maxOccurs="100" />
  </xs:sequence>
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard: SpatialObject:frame [ASN.1: SpatialObject].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.8 Data Frame: Chain:frame

Use: The Chain profile passes references to chains, defined as continuous, directed, non-branching sequences of links with distinct start and end nodes, direction, and name. A chain may be defined by, for example, jurisdictional boundaries such as county line, town line, or state line, and mode changes. A chain may be decomposed into subchains, which are themselves aggregate links. Subchains may be formed by, for example: jurisdictional boundaries, name changes, published direction change, or traffic pattern based (i.e. heavy on/off points). ChainOffset is the integer ground distance to a point along a chain from the start of the chain toward the end. Figure 1 illustrates Chains and Subchains. In the figure, a complete chain consisting of two links is specified in the center between Second Ave. and Fourth Ave.. A subchain is shown in the bottom of the figure, part of a larger chain along Front Street. Sequence numbers are a method to sequence nodes along a chain to imply order and direction. Node Identifiers do NOT imply order. Figure 2 illustrates Sequence Numbers. Start and End Sequence Numbers imply order and direction for I-90 West and I-90 East.

Figure 1—Chain and Subchain Description

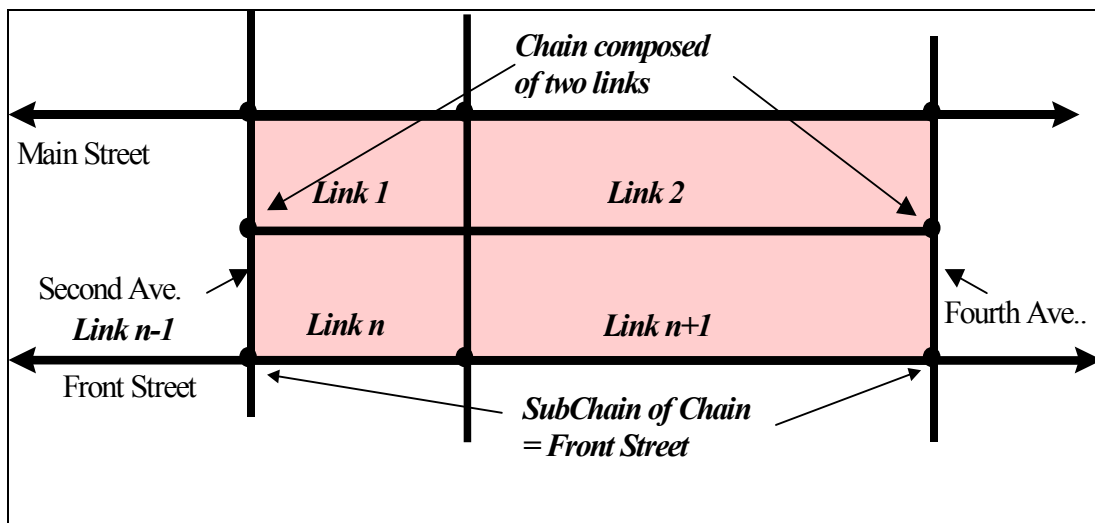
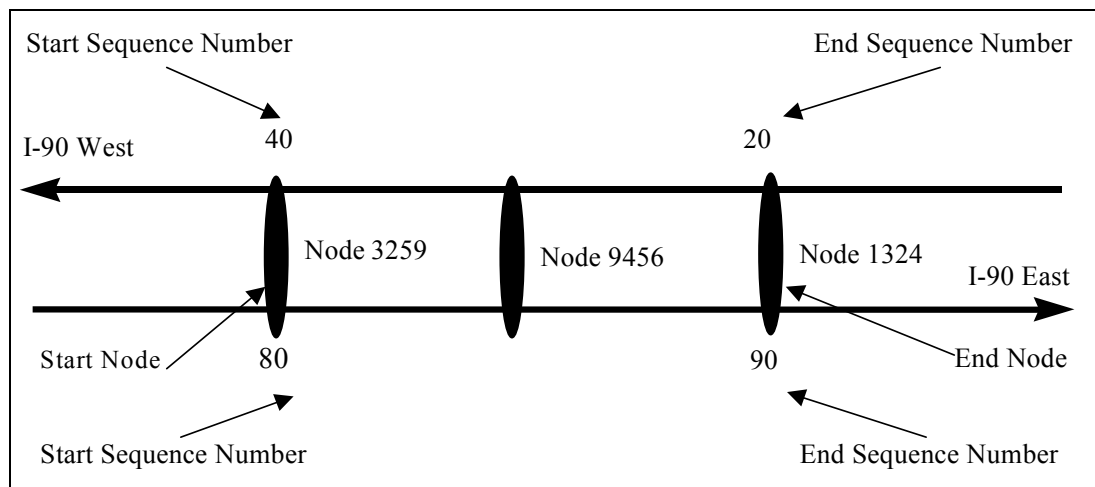


Figure 2—Sequence Numbers for a Chain or Subchain



ASN.1 Representation:

```

Chain ::= SEQUENCE {
    chain CHOICE {
        chainName Text-name255,
        chainId IdType
    },
    startNodeInfo NodeAttribute OPTIONAL,
    endNodeInfo NodeAttribute OPTIONAL,
    chainOffset Distance OPTIONAL,
    startSequenceNum SequenceNum OPTIONAL,
    endSequenceNum SequenceNum OPTIONAL,
    locationID String-index64 OPTIONAL
}

```

XML Representation:

```

<xs:complexType name="Chain" >
    <xs:sequence>
        <xs:element name="chain" >
            <xs:complexType>
                <xs:choice>
                    <xs:element name="chainName" type="Text-name255" />
                    <xs:element name="chainId" type="IdType" />
                </xs:choice>
            </xs:complexType>
        </xs:element>
        <xs:element name="startNodeInfo" type="NodeAttribute" minOccurs="0"/>
        <xs:element name="endNodeInfo" type="NodeAttribute" minOccurs="0"/>
        <xs:element name="chainOffset" type="Distance" minOccurs="0"/>
        <xs:element name="startSequenceNum" type="SequenceNum" minOccurs="0"/>
        <xs:element name="endSequenceNum" type="SequenceNum" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="locationID" type="String-index64" />
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard:

Geometry:frame [ASN.1: Geometry], and

LocationReference [ANS.1: LocationReference], and

SpatialObject:frame [ASN.1: SpatialObject].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.9 Data Frame: CrossStreets:frame

Use: The CrossStreets profile expresses a location for a point or link in terms of road element (street) names and/or geographic coordinates, with additional information useful for resolving location reference ambiguity.

ASN.1 Representation:

```

CrossStreets ::= SEQUENCE {
    locationName Text-name255 OPTIONAL,
    crossStreets CHOICE {
        crossStreetsPoint CrossStreetsPoint,
        crossStreetsLink CrossStreetsLink
    },
    locationID String-index64 OPTIONAL
}

```

XML Representation:

```
<xs:complexType name="CrossStreets" >
  <xs:sequence>
    <xs:element name="locationName" type="Text-name255" minOccurs="0"/>
    <xs:choice >
      <xs:element name="crossStreetsPoint" type="CrossStreetsPoint" />
      <xs:element name="crossStreetsLink" type="CrossStreetsLink" />
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="locationID" type="String-index64" />
</xs:complexType>
```

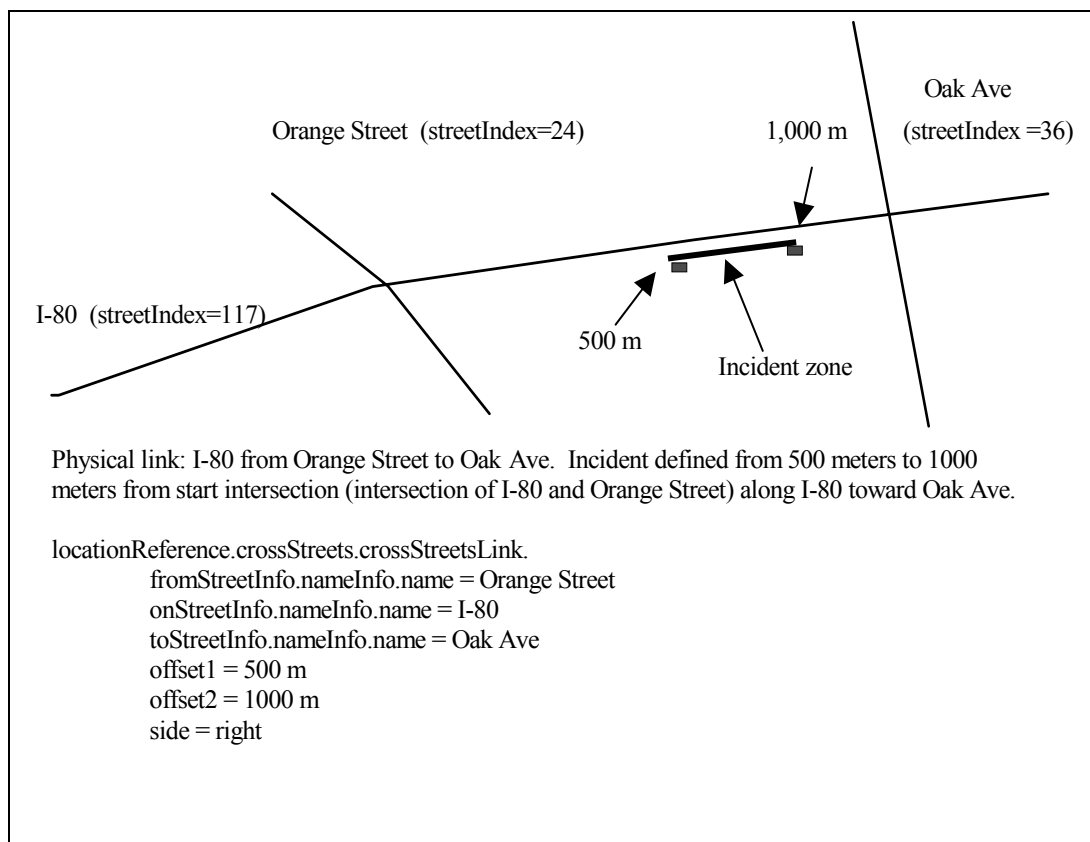
Used by: This item is used by the following other data structures in this standard: LocationReference:frame [ASN.1: LocationReference].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.10 Data Frame: CrossStreetsLink:frame

Use: The CrossStreetsLink subprofile specifies a logical link along a street (onStreet) by names and (optionally) coordinates of bounding intersections with other streets. Intersection types are provided as options to reduce referencing ambiguity. Points along the link are defined by offsets from the start intersection in the implicit direction of the link, i.e. from start intersection (from) to end intersection (to). Sub-links are defined by two offsets. Side of the road on which the event or point of interest occurs is also an option, as well as height for a point of interest. Administrative areas are specified for the point of interest, or for both defining points of a sub-link. Compass direction of the link is also an option.

An example of CrossStreetsLink usage is shown in Figure 3. The required elements for the on-, from-, and to-streets contain both names and indices for the cross streets. An incident zone along the link between the intersection of onStreet and fromStreet and the intersection of onStreet and toStreet is defined by two offsets specified in meters. The zone is defined along the right hand side of the link, by default in the direction of travel indicated by the specification of on/from and on/to intersections. All other elements within the data frame are empty, i.e. not found within the reference.

Figure 3—Cross-Streets Referencing – A Link Example**ASN.1 Representation:**

```

CrossStreetsLink ::= SEQUENCE {
  onStreetInfo          StreetInfo,
  fromStreetInfo         StreetInfo,
  toStreetInfo           StreetInfo,
  startGeoLocation       GeoLocation OPTIONAL,
  endGeoLocation         GeoLocation OPTIONAL,
  startIntersectionType  IntersectionType OPTIONAL,
  endIntersectionType    IntersectionType OPTIONAL,
  offset1                Distance OPTIONAL,
  offset2                Distance OPTIONAL,
  direction              Direction OPTIONAL,
  side                   Side OPTIONAL,
  height                 Height OPTIONAL,
  adminAreas1            AdminAreaGroup OPTIONAL,
  adminAreas2            AdminAreaGroup OPTIONAL
}
  
```

XML Representation:

```

<xs:complexType name="CrossStreetsLink" >
  <xs:sequence>
    <xs:element name="onStreetInfo" type="StreetInfo" />
    <xs:element name="fromStreetInfo" type="StreetInfo" />
    <xs:element name="toStreetInfo" type="StreetInfo" />
    <xs:element name="startGeoLocation" type="GeoLocation" minOccurs="0"/>
    <xs:element name="endGeoLocation" type="GeoLocation" minOccurs="0"/>
    <xs:element name="startIntersectionType" type="IntersectionType" minOccurs="0"/>
    <xs:element name="endIntersectionType" type="IntersectionType" minOccurs="0"/>
    <xs:element name="offset1" type="Distance" minOccurs="0"/>
    <xs:element name="offset2" type="Distance" minOccurs="0"/>
    <xs:element name="direction" type="Direction" minOccurs="0"/>
    <xs:element name="side" type="Side" minOccurs="0"/>
    <xs:element name="height" type="Height" minOccurs="0"/>
    <xs:element name="adminAreas1" type="AdminAreaGroup" minOccurs="0"/>
    <xs:element name="adminAreas2" type="AdminAreaGroup" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard: CrossStreets:frame [ASN.1: CrossStreets], and LinkLocation:frame [ASN.1: LinkLocation].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.11 Data Frame: CrossStreetsPoint:frame

Use: The CrossStreetsPoint subprofile specifies a point along a link with reference to an intersection. The intersection is defined by names of two streets, the onStreet and the atStreet. Coordinates of the intersection, and intersection type, may be provided as options to improve referencing accuracy and resolve ambiguity. The point of interest may be the intersection itself, or may lie along or on the onStreet at a distance specified by 'offset' from the intersection, in a compass direction specified (optionally) by 'direction'. Side of the road, height, and administrative area is an option for the event or point of interest. The 'side' element may also refer to roads that are blocked by an incident at an intersection or along a road.

ASN.1 Representation:

```

CrossStreetsPoint ::= SEQUENCE {
    onStreetInfo      StreetInfo,
    atStreetInfo      StreetInfo,
    geoLocation       GeoLocation OPTIONAL,
    intersectionType   IntersectionType OPTIONAL,
    offset            Distance OPTIONAL,
    direction         Direction OPTIONAL,
    side              Side OPTIONAL,
    height            Height OPTIONAL,
    adminAreas        AdminAreaGroup OPTIONAL
}

```

XML Representation:

```

<xs:complexType name="CrossStreetsPoint" >
  <xs:sequence>
    <xs:element name="onStreetInfo" type="StreetInfo" />
    <xs:element name="atStreetInfo" type="StreetInfo" />
    <xs:element name="geoLocation" type="GeoLocation" minOccurs="0"/>
    <xs:element name="intersectionType" type="IntersectionType" minOccurs="0"/>
    <xs:element name="offset" type="Distance" minOccurs="0"/>
    <xs:element name="direction" type="Direction" minOccurs="0"/>
    <xs:element name="side" type="Side" minOccurs="0"/>
    <xs:element name="height" type="Height" minOccurs="0"/>
    <xs:element name="adminAreas" type="AdminAreaGroup" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard: CrossStreets:frame [ASN.1: CrossStreets], and PointLocation:frame [ASN.1: PointLocation].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.12 Data Frame: Distance:frame

Use: A choice of distance values, in integer or REAL expressions. Note that data elements for REAL representations are suffixed with Dec. Distance choices are, in most cases, standard English and Metric units. The exception is 'block' and 'blkdec', which are common expressions for distance in urban areas.

ASN.1 Representation:

```
Distance ::= CHOICE {
    m      INTEGER (-10000000..+10000000),
    mDec   REAL (-10000000..+10000000),
    mm     INTEGER (-1000000..+1000000),
    mmDec  REAL (-1000000..+1000000),
    dm     INTEGER (-1000000..+1000000),
    dmDec  REAL (-1000000..+1000000),
    yd     INTEGER (-17600000..+17600000),
    ydDec  REAL (-17600000..+17600000),
    ft     INTEGER (-52800000..+52800000),
    ftDec  REAL (-52800000..+52800000),
    in     INTEGER (-1000000..+1000000),
    inDec  REAL (-1000000..+1000000),
    mi     INTEGER (-10000..+10000),
    miDec  REAL (-10000..+10000),
    km     INTEGER (-10000..+10000),
    kmDec  REAL (-10000..+10000),
    block  INTEGER (-1000..+1000),
    blkDec REAL (-1000..+1000)
}
```

XML Representation:

```
<xs:complexType name="Distance" >
  <xs:choice>
    <xs:element name="m" >
      <xs:simpleType>
        <xs:restriction base="xs:int">
          <xs:minInclusive value="-10000000"/>
          <xs:maxInclusive value="+10000000"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:element>
    <xs:element name="mDec" >
      <xs:simpleType>
        <xs:restriction base="xs:decimal">
          <xs:minInclusive value="-10000000"/>
          <xs:maxInclusive value="+10000000"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:element>
    <xs:element name="mm" >
      <xs:simpleType>
        <xs:restriction base="xs:int">
          <xs:minInclusive value="-1000000"/>
          <xs:maxInclusive value="+1000000"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:element>
    <xs:element name="mmDec" >
      <xs:simpleType>
        <xs:restriction base="xs:decimal">
          <xs:minInclusive value="-1000000"/>

```

```
<xs:maxInclusive value="+1000000"/>
</xs:restriction>
</xs:simpleType>
</xs:element>
<xs:element name="dm" >
  <xs:simpleType>
    <xs:restriction base="xs:int">
      <xs:minInclusive value="-1000000"/>
      <xs:maxInclusive value="+1000000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="dmDec" >
  <xs:simpleType>
    <xs:restriction base="xs:decimal">
      <xs:minInclusive value="-1000000"/>
      <xs:maxInclusive value="+1000000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="yd" >
  <xs:simpleType>
    <xs:restriction base="xs:int">
      <xs:minInclusive value="-17600000"/>
      <xs:maxInclusive value="+17600000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="ydDec" >
  <xs:simpleType>
    <xs:restriction base="xs:decimal">
      <xs:minInclusive value="-17600000"/>
      <xs:maxInclusive value="+17600000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="ft" >
  <xs:simpleType>
    <xs:restriction base="xs:int">
      <xs:minInclusive value="-52800000"/>
      <xs:maxInclusive value="+52800000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="ftDec" >
  <xs:simpleType>
    <xs:restriction base="xs:decimal">
      <xs:minInclusive value="-52800000"/>
      <xs:maxInclusive value="+52800000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="in" >
  <xs:simpleType>
    <xs:restriction base="xs:int">
      <xs:minInclusive value="-1000000"/>
      <xs:maxInclusive value="+1000000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="inDec" >
  <xs:simpleType>
    <xs:restriction base="xs:decimal">
      <xs:minInclusive value="-1000000"/>
      <xs:maxInclusive value="+1000000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
```

```

<xs:element name="mi" >
  <xs:simpleType>
    <xs:restriction base="xs:short">
      <xs:minInclusive value="-10000"/>
      <xs:maxInclusive value="+10000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="miDec" >
  <xs:simpleType>
    <xs:restriction base="xs:decimal">
      <xs:minInclusive value="-10000"/>
      <xs:maxInclusive value="+10000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="km" >
  <xs:simpleType>
    <xs:restriction base="xs:short">
      <xs:minInclusive value="-10000"/>
      <xs:maxInclusive value="+10000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="kmDec" >
  <xs:simpleType>
    <xs:restriction base="xs:decimal">
      <xs:minInclusive value="-10000"/>
      <xs:maxInclusive value="+10000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="block" >
  <xs:simpleType>
    <xs:restriction base="xs:short">
      <xs:minInclusive value="-1000"/>
      <xs:maxInclusive value="+1000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="blkDec" >
  <xs:simpleType>
    <xs:restriction base="xs:decimal">
      <xs:minInclusive value="-1000"/>
      <xs:maxInclusive value="+1000"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
</xs:choice>
</xs:complexType>

```

Used by: This item is used by the following other data structures in this standard (descriptive name and ASN.1 name of each):

CrossStreetsLink:frame [ASN.1: CrossStreetsLink], and
 CrossStreetsPoint:frame [ASN.1: CrossStreetsPoint], and
 GeoLocationDelta:frame [ASN.1: GeoLocationDelta], and
 Height:frame [ASN.1: Height], and
 LinearReference:frame [ASN.1: LinearReference], and
 PointOffset:frame [ASN.1: PointOffset], and
 PolarCoordinates:frame [ASN.1: PolarCoordinates].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.13 Data Frame: GeographicCoordinate:frame

Use: The Geographic Coordinate profile expresses a location in terms of coordinate-based points, links, or polar coordinates. In addition to absolute geographic coordinates, offsets can be specified from a point.

ASN.1 Representation:

```
GeoCoord ::= SEQUENCE {
    locationName      Text-name255 OPTIONAL,
    geoCoordChoice CHOICE {
        geoLocationPoint      GeoLocation,
        geoLocationLink       GeoLocationLink,
        polarCoordinates      PolarCoordinates,
        geoLocationDelta      GeoLocationDelta
    },
    locationID         String-index64 OPTIONAL
}
```

XML Representation:

```
<xs:complexType name="GeoCoord" >
  <xs:sequence>
    <xs:element name="locationName" type="Text-name255" minOccurs="0"/>
    <xs:choice >
      <xs:element name="geoLocationPoint" type="GeoLocation" />
      <xs:element name="geoLocationLink" type="GeoLocationLink" />
      <xs:element name="polarCoordinates" type="PolarCoordinates" />
      <xs:element name="geoLocationDelta" type="GeoLocationDelta" />
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="locationID" type="String-index64" />
</xs:complexType>
```

Used by: This item is used by the following other data structures in this standard: LocationReference:frame [ASN.1: LocationReference].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.14 Data Frame: GeoLocation:frame

Use: The GeoLocation data frame conveys a two- or three-dimensional geographic location based on coordinates. The standard horizontal datum for a spot location is WGS-84; other horizontal datums can be specified by HorizontalDatum. Vertical Datum is an option within height.

ASN.1 Representation:

```
GeoLocation ::= SEQUENCE {
    latitude          Latitude,
    longitude         Longitude,
    horizontalDatum   HorizontalDatum OPTIONAL,
    height            Height OPTIONAL
}
```

XML Representation:

```
<xs:complexType name="GeoLocation" >
  <xs:sequence>
    <xs:element name="latitude" type="Latitude" />
    <xs:element name="longitude" type="Longitude" />
    <xs:element name="horizontalDatum" type="HorizontalDatum" minOccurs="0"/>
    <xs:element name="height" type="Height" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
```

Used by: This item is used by the following other data structures in this standard (descriptive name and ASN.1 name of each):

CrossStreetsLink:frame [ASN.1: CrossStreetsLink], and
 CrossStreetsPoint:frame [ASN.1: CrossStreetsPoint], and
 GeographicCoordinate:frame [ASN.1: GeographicCoordinate], and
 GeoLocationLink:frame [ASN.1: GeoLocationLink], and
 Geometry [ANS.1: Geometry], and
 NodeAttribute:frame [ASN.1: NodeAttribute], and
 PointLocation:frame [ASN.1: PointLocation].

In addition, this item may be used by data structures in other ITS standards. Implementers are advised to consult the IEEE ITS data registry for the most current information.

5.15 Data Frame: GeoLocationDelta:frame

Use: The GeoLocationDelta sub-profile specifies local offsets (deltas) from a known geographic coordinate, in either of two forms: 1. east/west and north/south offset distances; 2. coordinate deltas. Height is optional in either case. This data frame is used within a protocol that reduces transmission bandwidth and/or processing requirements by providing deltas with respect to a known point.

ASN.1 Representation:

```
GeoLocationDelta ::= SEQUENCE {
    deltaHeight    Height OPTIONAL,
    delta          CHOICE {
        deltaCoords SEQUENCE {
            deltaLatitude Latitude,
            deltaLongitude Longitude
        },
        deltaDistance SEQUENCE {
            offsetEast    Distance,
            offsetNorth    Distance
        }
    }
}
```

XML Representation:

```
<xs:complexType name="GeoLocationDelta" >
  <xs:sequence>
    <xs:element name="deltaHeight" type="Height" minOccurs="0" />
    <xs:element name="delta" >
      <xs:complexType>
        <xs:choice>
          <xs:element name="deltaCoords" >
            <xs:complexType>
              <xs:sequence>
                <xs:element name="deltaLatitude" type="Latitude" />
                <xs:element name="deltaLongitude" type="Longitude" />
              </xs:sequence>
            </xs:complexType>
          </xs:element>
          <xs:element name="deltaDistance" >
            <xs:complexType>
              <xs:sequence>
                <xs:element name="offsetEast" type="Distance" />
                <xs:element name="offsetNorth" type="Distance" />
              </xs:sequence>
            </xs:complexType>
          </xs:element>
        </xs:choice>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
```