INCITS xxxx-Part.7

Date: 2006-10-25

Information Technology – Geographic Information Framework Data Content Standard

Part 7: Transportation base

Secretariat:
INFORMATION TECHNOLOGY INDUSTRY COUNCIL
Approved:
YEAR-MM
American National Standards Institute

American National Standard

Approval of an American National Standard requires verification by the American National Standards Institute (ANSI) that the requirements for due process, consensus, and other criteria for approval have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he or she has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Request for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

Published by:
Information Technology Industry Council
1250 Eye Street NW, Suite 200
Washington, DC 20005
Voice: 202.737.8888
FAX: 202.638.4922
WEB: www.itic.org

Contents

Introduction ... v

1 Scope ... 1

2 Conformance ... 1

3 Normative references ... 2

4 Maintenance authority ... 2
4.1 Level of responsibility ... 2
4.2 Contact information ... 2

5 Terms and definitions ... 2

6 Symbols, abbreviated terms, and notations ... 5

7 Requirements ... 5
7.1 Transportation base model ... 5
7.2 Transportation feature model ... 6
7.3 Transportation segmentation model ... 7
7.3.1 Introduction ... 7
7.3.2 TranSeg ... 7
7.3.3 TranPoint ... 8
7.3.4 TranPath ... 9
7.3.5 Transportation system ... 11
7.4 Transportation event model ... 14
7.4.1 LinearAttributeEvent ... 16
7.4.2 PointAttributeEvent ... 16
7.4.3 LinearFeatureEvent ... 16
7.4.4 PointFeatureEvent ... 16
7.4.5 Attributes for events ... 18

Annex A (informative) Equivalencies ... 20

Annex B (normative) Package: Linear reference systems ... 22
B.1 Semantics ... 22
B.2 LR_PositionExpression ... 22
B.2.1 Semantics ... 22
B.2.2 Attribute: measure : Measure ... 22
B.2.3 Role: LRM : LR_LinearReferenceMethod ... 22
B.2.4 Role: referent [0..1] : LR_ReferenceMarker ... 23
B.2.5 Role: referenceDomain : LR_Element ... 23
B.2.6 Role: offset[0..1] : LR_OffsetExpression ... 23
B.3 LR_LinearReferenceMethod ... 24
B.3.1 Semantics ... 24
B.3.2 Attribute: name : CharacterString ... 24
B.3.3 Attribute: type : CharacterString ... 24
B.3.4 Attribute: units : UnitOfMeasure ... 24
B.3.5 Attribute: offsetUnits : UnitOfMeasure ... 24
B.3.6 Attribute: positiveOffsetDirection : LR_OffsetDirection = "right" ... 24
B.3.7 Role: marker[1..*] : LR_ReferenceMarker ... 25
B.3.8 Role: referenceElement[1..*] : LR_Element ... 25
B.3.9 Operation: project ... 25
B.4 LR_OffsetDirection ... 25

B.5 LR_ReferenceMarker ... **26**
B.5.1 Semantics ... **26**
B.5.2 Attribute: name : CharacterString ... **26**
B.5.3 Attribute: type : CharacterString ... **26**
B.5.4 Attribute: position[0..1] : GM_Point ... **26**
B.5.5 Attribute: location[0..1] : LR_PositionExpression ... **26**
B.6 LR_Feature ... **27**
B.7 LR_Element ... **27**
B.7.1 Semantics ... **27**
B.7.2 Role: datumMarkers[1..*] : LR_ReferenceMarker ... **27**
B.8 LR_OffsetReference ... **28**
B.9 LR_OffsetExpression ... **28**
B.9.1 Semantics ... **28**
B.9.2 Attribute: offsetReference : LR_OffsetReference ... **28**
B.9.3 Attribute: offset[0..1] : Number ... **28**

Annex C (informative) Bibliography ... **29**

Figures

Figure 1 – Transportation base model ... **6**
Figure 2 – Transportation feature type hierarchy ... **7**
Figure 3 – Relationships among TranSeg, TranPoint, and TranPath ... **8**
Figure 4 – Proper use of TranPoint class ... **9**
Figure 5 – TranPath model ... **10**
Figure 6 – Transportation event model (1) ... **14**
Figure 7 – Transportation event model (2) ... **15**
Figure A.1 – Sample datasets representing the same segment of road ... **20**
Figure B.1 – LRS classes ... **23**
Figure B.2 – LR_PositionExpression ... **24**
Figure B.3 – LR_LinearReferenceMethod ... **25**
Figure B.4 – LR_OffsetDirection ... **26**
Figure B.5 – LR_ReferenceMarker ... **26**
Figure B.6 – LR_Feature ... **27**
Figure B.7 – LR_Element ... **27**
Figure B.8 – LR_OffsetExpression ... **28**

Tables

Table 1 – Data dictionary for transportation system objects ... **11**
Table 2 – Data dictionary for transportation event objects ... **18**

Foreword

Geographic information, also known as geospatial information, both underlies and is the subject of much of the political, economic, environmental, and security activities of the United States. In recognition of this, the United States Office of Management and Budget issued Circular A-16 (revised 2002), which established the Federal Geographic Data Committee (FGDC) as a coordinating organization.

Work on this standard started under the Geospatial One-Stop e-Government initiative. The standard was developed with the support of the member agencies and organizations of the FGDC and aids in fulfilling a primary objective of the National Spatial Data Infrastructure (NSDI), that is, creation of common geographic base data for seven critical data themes. The seven core data themes are considered framework data of critical importance to the spatial data infrastructure.

The increasing need to coordinate collection of new data, identify applicability of existing data, and exchange data at the national level led to the submission of this standard to the ANSI process to become an American National Standard. The national standard contained in this document and its parts was sponsored by Technical Committee L1, Geographic Information Systems, of the InterNational Committee for Information Technology Standards (INCITS), an ANSI-accredited standards development organization.

As the Geographic Information Framework Data Content Standard was developed using public funds, the U.S. Government will be free to publish and distribute its contents to the public, as provided through the Freedom of Information Act (FOIA), Part 5 United States Code, Section 552, as amended by Public Law No. 104-231, “Electronic Freedom of Information Act Amendments of 1996”.

Introduction

The primary purpose of this part of the Geographic Information Framework Data Content Standard is to support the exchange of transportation data. This part seeks to establish a common baseline for the semantic content of transportation databases for public agencies and private enterprises. It also seeks to decrease the costs and simplify the exchange of transportation data among local, Tribal, State, and Federal users and producers. That, in turn, discourages duplicative data collection. Benefits of adopting this part of the standard also include the long-term improvement of the geospatial transportation data within the community, improved integration of safety, emergency response, and enforcement data, and streamlines maintenance procedures.

Framework Data Content Standard – Transportation base

1 Scope

The Geographic Information Framework Data Content Standard, Part 7: Transportation Base defines the data model for describing transportation systems components of transportation systems for five modes that compose the Transportation theme of the NSDI. The primary purpose of this part of the standard is to support the exchange of transportation data related to transportation systems. It is the intent of the Transportation Base part to set a common baseline that will ensure the widest utility of transportation data for the user and producer communities through enhanced data sharing and the reduction of redundant data production.

At a high level, the transportation system described in this part of the Framework Data Content Standard is made up of transportation features, which can have geographic locations and characteristics. These transportation features can be interconnected in various ways and across several modes to represent transportation networks for path finding/routing applications. While the design team has considered the need for path finding applications, the level of data required by such applications is beyond the scope of many organizations. Specifically, many State and local government agencies do not have adequate data for routing purposes, and they do not have the budget to create and maintain this data. It is expected that the content in the part will support the development of specialized networks for routing applications, but this level of information is not a requirement of the data standard.

This part of the standard can be implemented using a variety of software packages and is designed to accommodate data encoded without geometry as well as to support the exchange of data encoded in a variety of geographic information systems. The part accommodates assets associated with the transportation system that are typically used for navigation, safety, and measurement.

The part applies to NSDI framework transportation data produced or disseminated by or for the Federal Government. According to Executive Order 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure, Federal agencies collecting or producing geospatial data, either directly or indirectly (for example, through grants, partnerships, or contracts with other entities), shall ensure, prior to obligating funds for such activities, that data will be shared in a manner that meets all relevant standards adopted through the Federal Geographic Data Committee (FGDC) process.

The Geographic Information Framework Data Content Standard for the Transportation theme is comprised of six parts: Base, Air, Rail, Road, Transit, and Inland Waterways. While there are enough differences in the transportation modes to warrant separate parts, the reader should be aware that there are many similarities. The six parts are meant to complement each other and to represent a complete, if somewhat basic model of a whole transportation system.

The Transportation Base part integrates the five modes of transportation systems: air, rail, road, transit, and water. To accommodate multi-modal transportation systems, transportation points and transportation paths are instantiable, whereas transportation segments are not. This allows the linear segments of each mode to be mode-specific (for example, roadway segments) but allows them to be connected to segments from other modes. A multi-modal node such as a passenger rail station could be used to connect roadway segments and rail segments. In this case, it would be represented as a transportation point instead of a roadway point or rail point. Alternatively, it could be modeled as both a roadway point and a rail point, with the two being equivalenced. A transportation path instance would be able to use roadway segments and rail segments to define a multi-modal route.

2 Conformance

This thematic part includes a data dictionary/model based on the conceptual schema presented below. To conform to this part, the user shall satisfy the requirements of the data dictionary/model. The user's conforming dataset shall include a value for each mandatory element, and a value for each conditional element for which the condition is true. It may contain values for any optional element. The data type of each value shall be that specified for the element in the data dictionary/model and the value shall lie within the specified domain. This part only specifies the special requirements of conformance for a dataset containing transportation information. Conformance to the standard requires additional actions specified in the Base Document (Part 0) and the appropriate modal parts for Air (Part 7a), Rail (Part 7b), Roads (Part 7c), Transit (Part 7d), and Inland Waterways (Part 7e).

3 Normative references

Annex A of the Base Document (Part 0) lists normative references applicable to two or more parts of the standard, including those other than the transportation parts. No additional normative references are specified for the Transportation Base (Part 7). Informative references applicable to two or more transportation parts only are listed in Annex C of the Transportation Base part. Annex D of the Base Document lists informative references applicable to two or more of the parts, including those other than the transportation parts.

4 Maintenance authority

4.1 Level of responsibility

The FGDC is the responsible organization for coordinating work on all parts of the Geographic Information Framework Data Content Standard. The United States Department of Transportation (USDOT), working with the FGDC, is the responsible organization for coordinating work on the Geographic Information Framework Data Content Standard, Part 7: Transportation Base and subparts (Parts 7a, 7b, 7c, and 7d, excluding 7e) and is directly responsible for development and maintenance of the transportation parts (excluding 7e) of the Framework Data Content Standard.

The FGDC shall be the sole organization responsible for direct coordination with the InterNational Committee for Information Technology Standards (INCITS) concerning any maintenance or any other requirements mandated by INCITS or ANSI.

4.2 Contact information

Address questions concerning this part of the standard to:

Federal Geographic Data Committee Secretariat
c/o U.S. Geological Survey
590 National Center
Reston, Virginia 20192 USA

Telephone: (703) 648-5514
Facsimile: (703) 648-5755
Internet (electronic mail): gdc@fgdc.gov
WWW Home Page: http://fgdc.gov

5 Terms and definitions

Definitions applicable to this part or multiple transportation parts of the standard are listed here. More general terms and definitions can be found in the Base Document (Part 0) of the standard. Other terms and definitions specific to a particular transportation mode are listed within the modal part of the standard. Users are advised to consult these documents for a complete set of definitions.

5.1
anchor point

physical location in the field that can be unambiguously described so that it can be clearly located in the real world using its description [NCHRP 20-27(2)]

NOTE An anchor point is a link between the computer representation of the road system and the real world.

5.2
distance expression

linear distance measured along a **linear element**

NOTE Distance expression is used as a component of a position expression.

5.3
entity

feature that has separate and distinct existence and objective or conceptual reality

5.4
event

mechanism for locating an attribute value or feature along a **transportation feature**

5.5
event model

part of the transportation model that defines a manner in which to model attributes that may have values that change along the length of a segment or path

5.6
feature event

way of specifying the **linear location** of a feature along a **transportation segment** or **transportation path**

NOTE The located feature can have its own attributes, including its own (optional) geometry, independent of the geometry of any transportation segment or transportation path along which it is linearly referenced, for example, a bridge might be located with a feature event so that it can have attributes such as type, length, and year of construction and its own spatial representation, either as a point, line, or polygon (it may have all three) as well as being linearly referenced along a transportation segment or transportation path.

5.7
linear element

underlying curvilinear element along which a linearly referenced measure is taken

NOTE This is consistent with ISO 19133.

5.8
linear event

event that occurs for an interval along the length of a linear feature

NOTE The location of a linear event is specified by a start and end position expression.

5.9
linear location

location that is specified as a distance along a one-dimensional **linear element**, such as a roadway, specified with a single coordinate, whose coordinate axis is the **linear element** itself

5.10
linear reference

description of a location using a one-dimensional measurement along a **linear element** based upon the rules and units of some linear reference method

5.11
offset

optional part of a linearly referenced **position expression** which specifies the lateral distance left or right of the **linear element** being measured [ISO 19133]

5.12
point event

event that occurs at a single position along a linear feature

NOTE The location of a point event is specified by a single position expression.

5.13
position expression

expression used to describe a position using linear referencing and comprised of a measured value (**distance expression**), the curvilinear element being measured (**linear element**), the method of measurement (LRM), and an optional lateral **offset** (**offset** expression)

5.14
referent

known location from which a relative measurement can be made

NOTE Referents are used in the distance expression of a position expression, for example, a milepost or reference post along a highway.

5.15
road point

road segment terminus in the road segmentation model

5.16
road segment

continuous nonbranching linear section of a road

5.17
road system

part of the **transportation system** that relates to roads or their appurtenances such as road signs or signals

5.18
route

ordered list of **transportation segments**

5.19
route

‹transit› collection of patterns in revenue service and with a common identifier

5.20
transportation feature
TranFeature

representation of transportation entities that include **transportation segmentation model** features, as well as other features relevant to transportation

5.21
transportation path
TranPath

ordered list of whole or partial sections of the physical **transportation system** (that is to say, **transportation segments**)

5.22
transportation point
TranPoint

topological connection between **transportation segments**

5.23
transportation segment
TranSeg

linear section of the physical transportation network

NOTE A transportation segment shall be continuous (no gaps) and cannot branch; no mandates are provided on how to segment the transportation network except that a data provider adopt a consistent method.

5.24
transportation segmentation model

set of **transportation features** (**TranPath**, **TranPoint**, and **TranSeg**) and their topological relationships which together define all possible movements through the **transportation system**

5.25
transportation system

set of components that allow the movement of goods and people between locations

6 Symbols, abbreviated terms, and notations

The following symbols, abbreviations, and notations are common to two or more transportation parts of the Framework Data Content Standard. More symbols, abbreviations, and notations applicable to multiple parts, including the transportation parts, are listed in the Base Document (Part 0). Those specific to a particular transportation mode are listed in that respective part.

DOT – Department of Transportation

GDF – Geographic Data Files

7 Requirements

7.1 Transportation base model

Transportation entities are represented as TranFeatures. The transportation network is represented by TranSegs, TranPoints, and TranPaths. TranFeatures can have attributes. For linear TranSegs and TranPaths, if the values for these attributes can change along the length of the feature, the attributes are represented by AttributeEvents. FeatureEvents allow Features to be linearly located along TranSegs and/or TranPaths. See Figure 1.

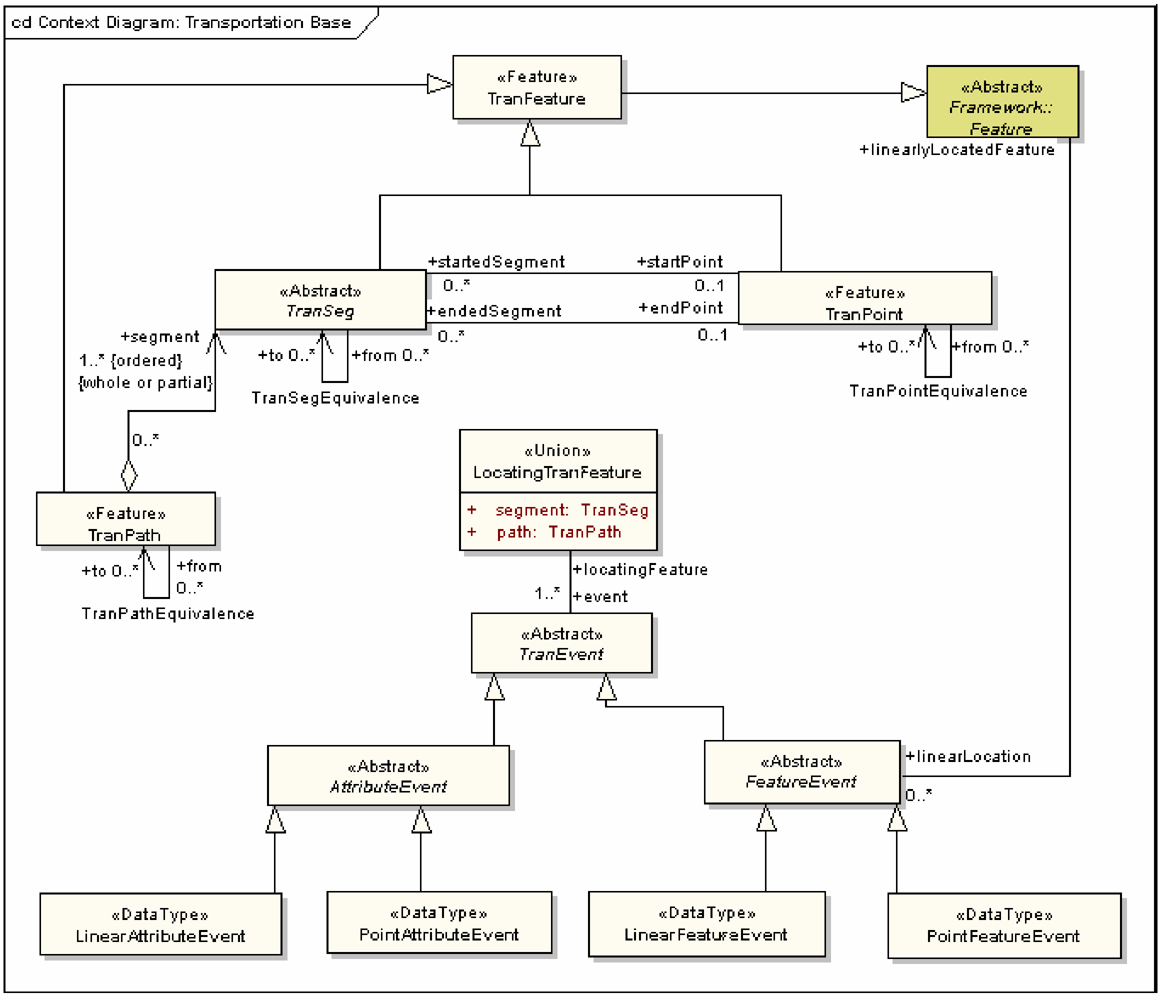

Figure 1 – Transportation base model

7.2 Transportation feature model

Many transportation features have certain characteristics in common, such as linear geometries, a connective nature, and a system for indexing these real world features. In this part of the standard, rail, road, and transit modes share a common model for representation shown in Figure 2. TranFeature is simply an extension of Feature that includes any and all transportation features. TranFeature has three explicit feature subclasses: TranPath, TranSeg, and TranPoint to represent the Transportation Segmentation Model. These three feature subclasses have analogues in the rail, road, transit, and waterway modes of transportation. All other transportation related real world entities are represented as instances of TranFeature or user-defined TranFeature subtypes.

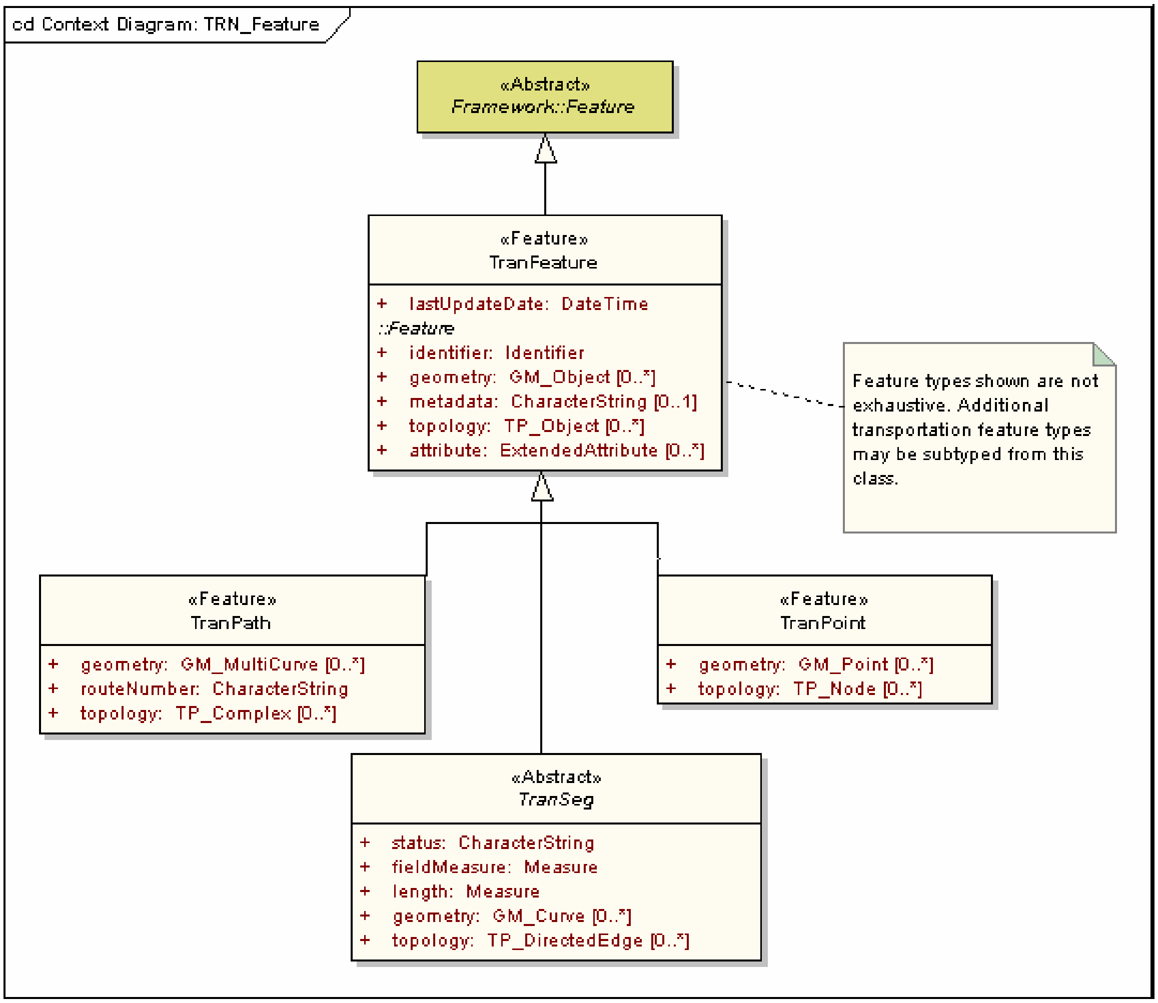

Figure 2 – Transportation feature type hierarchy

7.3 Transportation segmentation model

7.3.1 Introduction

The transportation segmentation model is the set of transportation features and their topological relationships which together define all possible movements through the transportation system. It can be broken up into segments called TranSegs. TranSegs represent individual pieces of the physical network, such as that part of Main Street which exists between First and Second Avenue. It is highly recommended that TranSegs be topologically connected by TranPoints. TranPoints merely serve to connect two TranSegs. TranPaths prescribe a usage of part of the transportation network. They represent a path through a set of whole or partial TranSegs, such as Route 66 or Bus Route 101.

7.3.2 TranSeg

TranSeg represents a linear section of the physical transportation network designed for, or the result of, human or vehicular movement. As shown in Figure 3, TranSeg extends TranFeature. Within this part of the standard, TranSeg may be defined in a variety of ways depending on mode and business application. It is left to the data creator to decide how to segment their transportation system in a manner that supports their organizational functions. A single TranSeg can represent an entire segment between two points, or, a separate TranSeg can be defined for each direction of travel. Defining how and where segments are defined is dictated by the need of the application and the dataset being exchanged.

TranSeg can have geometry of type GM_Curve as defined in ISO 19107. According to ISO 19107, GM_Curve extends GM_OrientabletableCurve and therefore, has direction. The direction of a TranSeg is determined by its “from” and “to” TranPoints. TranSeg can also have a topology of type TP_DirectedEdge as defined in ISO 19107. TP_DirectedEdge has been introduced to facilitate the representation of feature topology through its combinatorial structures independent of its geometry. This has practical application within the Rail, Roads, and Transit parts as providers of those data may choose to represent only topology, without geometry, for rapid network tracing. Users are recommended to consult each modal part of the standard for more specific information.

The relationships between TranSeg and TranPoint in Figure 3 show that each TranSeg is recommended to have a startPoint and endPoint.

7.3.3 TranPoint

The sole purpose of TranPoints is to provide the topological connection between TranSegs. It is highly recommended that each TranSeg have exactly one start TranPoint and one end TranPoint. This will help insure that the resultant set of TranSegs forms a complete coverage of the transportation system without gaps or overlaps. For exchanging datasets without such explicit connectivity, TranPoints can be considered to be optional. If a roadway transportation network is segmented at all roadway intersections, each TranSeg represents the physical roadway between two intersections and the TranPoints correspond to intersection locations. If instead, the transportation network is segmented into exactly five-mile long TranSegs, there may not be a physical entity where the resultant TranPoints occur. An intersection shall be represented as a Transportation Feature rather than a TranPoint. This allows flexibility in defining the intersection geometry as being a point, an area, or both.

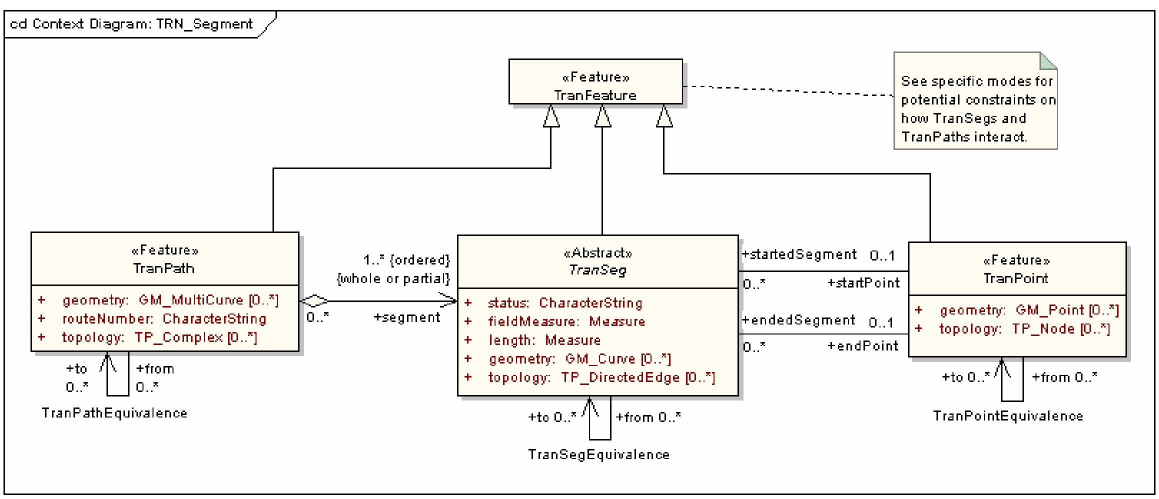

Figure 3 – Relationships among TranSeg, TranPoint, and TranPath

Figure 4 illustrates a TranSeg bounded by two TranPoints, A and B. Point C represents the location of some real world entity such as an intersection or a bridge somewhere along the TranSeg. Point D represents the location of another entity along the TranSeg, but offset a lateral distance to one side. Because C and D do not terminate or represent the topological connection between TranSegs, they shall not be represented as TranPoints. Instead, if they represent real world entities (with attributes), they shall be represented as Transportation Features. FeatureEvents can be used to define their location along and optionally offset from a TranSeg. Alternatively, Points C and D can be represented as AttributeEvents if they represent attributes instead of entities, such as the start of a bridge. This is explained further in the transportation event model section below. No requirements are specified on how or where to place TranPoints, except as indicated above for TranSeg termini and that it is done consistently throughout the dataset.

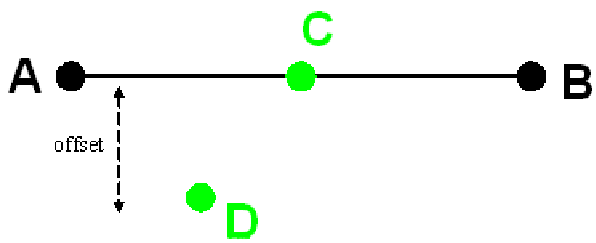

Figure 4 – Proper use of TranPoint class

TranPoint is a subtype of TranFeature. TranPoints can therefore have a geometry and topology attribute and may have one or more attributes that are associated with the location where the point occurs. Geometry is restricted to be of type GM_Point and topology to be of type TP_Node. Both GM_Point and TP_Node are defined in ISO 19107.

7.3.4 TranPath

A TranSeg is used to represent a physical transportation real world entity and attributes about that entity. TranPath, as applied in the Rail, Roads, and Transit modal parts of the standard, shall represent how the TranSegs are organized and used such as administrative routes like US 50, or bus or train routes. Because it is a path through the physical transportation system, a TranPath is defined by a list of the one or more, whole or partial, TranSegs it uses.

Figure 5 shows how TranPath extends TranFeature. It is an instance of the Feature class in the model shown in Figure 1. A TranPath can therefore have its own geometry. This optional TranPath geometry is of type GM_MultiCurve to allow for discontinuities in the path. The TranPath also inherits any geometry that may be defined by the TranSeg parts that comprise it. For example, the TranSeg geometries may be a more precise representation of the transportation feature, whereas the TranPath geometry may be a more generalized representation. Refer to each modal part for more information.

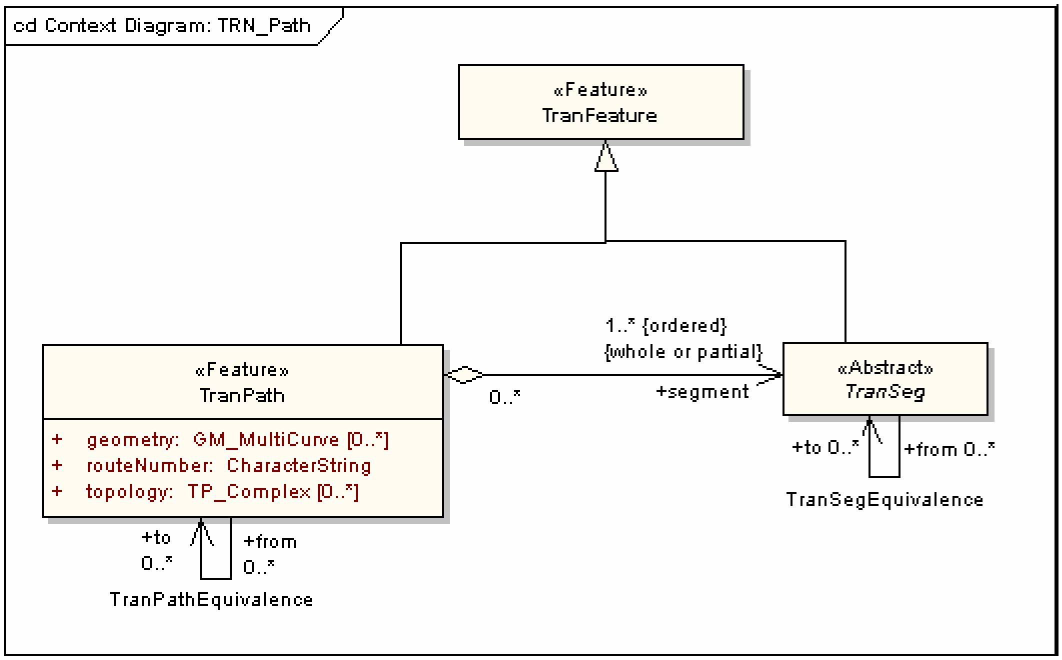

Figure 5 – TranPath model

7.3.5 Transportation system

Listed below in Table 1 are the transportation objects and their attributes.

Table 1 – Data dictionary for transportation system objects

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
1	TranFeature	Transportation feature			<<Feature>>	Lines 2-7
2	lastUpdateDate	Timestamp indicating when the TranFeature object was last edited	M	1	DateTime	Valid historical or current date and time
3	Framework::Feature::identifier	Feature identifier for the TranFeature	M	1	<<DataType>> Framework::Identifier	Unrestricted
4	Framework::Feature::geometry	Geometric representation of the instantiated TranFeature entity	O	*	<<Type>> GM_Object	Defined in ISO 19107
5	Framework::Feature::metadata	Structured or unstructured metadata as defined by the community of practice	O	1	CharacterString	May be text or structured metadata fragment
6	Framework::Feature::topology	Topological representation	O	*	<<Interface>> TP_Object	Defined in ISO 19107
7	Framework::Feature::attribute	Producer-defined attribute for inclusion in transfer	O	*	<<DataType>> Framework:: ExtendedAttribute	Unrestricted
8	TranPath	Linear, possibly discontinuous portion of the transportstion system that may be a collection of TranSeg instances			<<Feature>>	Lines 9-14
9	geometry	Geometric representation of the instantiated TranPath entity	O	*	<<Type>> GM_MultiCurve	Defined in ISO 19107
10	routeNumber	Public TranPath identifier	M	1	CharacterString	Unrestricted
11	topology	Topological representation	O	*	<<Type>>	Defined in ISO 19107

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
					TP_Complex	
12	Role name: segment	Transportation segment feature used by the TranPath	M	*	<<Abstract>> TranSeg	Whole or partial TranSeg
13	Role name: from	Source TranPath in equivalency	C/part of equivalency?	*	<<Feature>> TranPath	Whole or partial TranPaths
14	Role name: to	Destination TranPath in equivalency	C/part of equivalency?	*	<<Feature>> TranPath	Whoel or partial TranPaths
15	TranPoint	TranSeg terminus (start, end)			<<Feature>>	Lines 16-21
16	geometry	Geometric representation of the instantiated road point entity	O	*	<<Type>> GM_Point	Defined in ISO 19107
17	topology	Topological representation	O	*	<<Type>> TP_Node	Defined in ISO 19107
18	Role name: startedSegment	Segment that starts at the transportation point	C/TranSeg starts at TranPoint?	*	<<Abstract>> TranSeg	Unrestricted
19	Role name: endedSegment	Segment that ends at the transportation point	C/TranSeg ends at TranPoint?	*	<<Abstract>> TranSeg	Unrestricted
20	Role name: from	Source TranPoint in equivalency	C/part of equivalency?	*	<<Feature>> TranPoint	Unrestricted
21	Role name: to	Destination TranPoint in equivalency	C/part of equivalency?	*	<<Feature>> TranPoint	Unrestricted
22	TranSeg	Linear, continuous, non-branching portion of the transportation system			<<Feature>>	Lines 23-31
23	status	Status of segment entity; for example, proposed, under construction, open to traffic, abandoned, and so on	M	1	CharacterString	Unrestricted
24	fieldMeasure	Length of segment, as determined in the field	M	1	<<Type>> Measure	Defined in ISO 19103

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
25	length	Length of the TranSeg feature, which may differ from the field measured length due to differences in calculation	M	1	<<Type>> Measure	Unrestricted
26	geometry	Geometric representation of the instantiated segment entity	O	*	<<Type>> GM_Curve	Defined in ISO 19107
27	topology	Topological representation	O	*	<<Type>> TP_DirectedEdge	Defined in ISO 19107
28	Role name: startPoint	TranPoint corresponding to segment start	O	1	<<Feature>> TranPoint	Unrestricted
29	Role name: endPoint	TranPoint corresponding to segment end	O	1	<<Feature>> TranPoint	Unrestricted
30	Role name: from	Source TranSeg in equivalenye	C/part of equivalency?	*	<<Abstract>> TranSeg	Whole or partial TranPaths
31	Role name: to	Destination TranSeg in equivalency	C/part of equivalency?	*	<<Abstract>> TranSeg	Whole or partial TranPaths

7.4 Transportation event model

Events are the mechanism by which attributes or entities can be linearly located along either a TranSeg or a TranPath linear feature. As can be seen in Figure 6, transportation events can be either AttributeEvents or FeatureEvents.

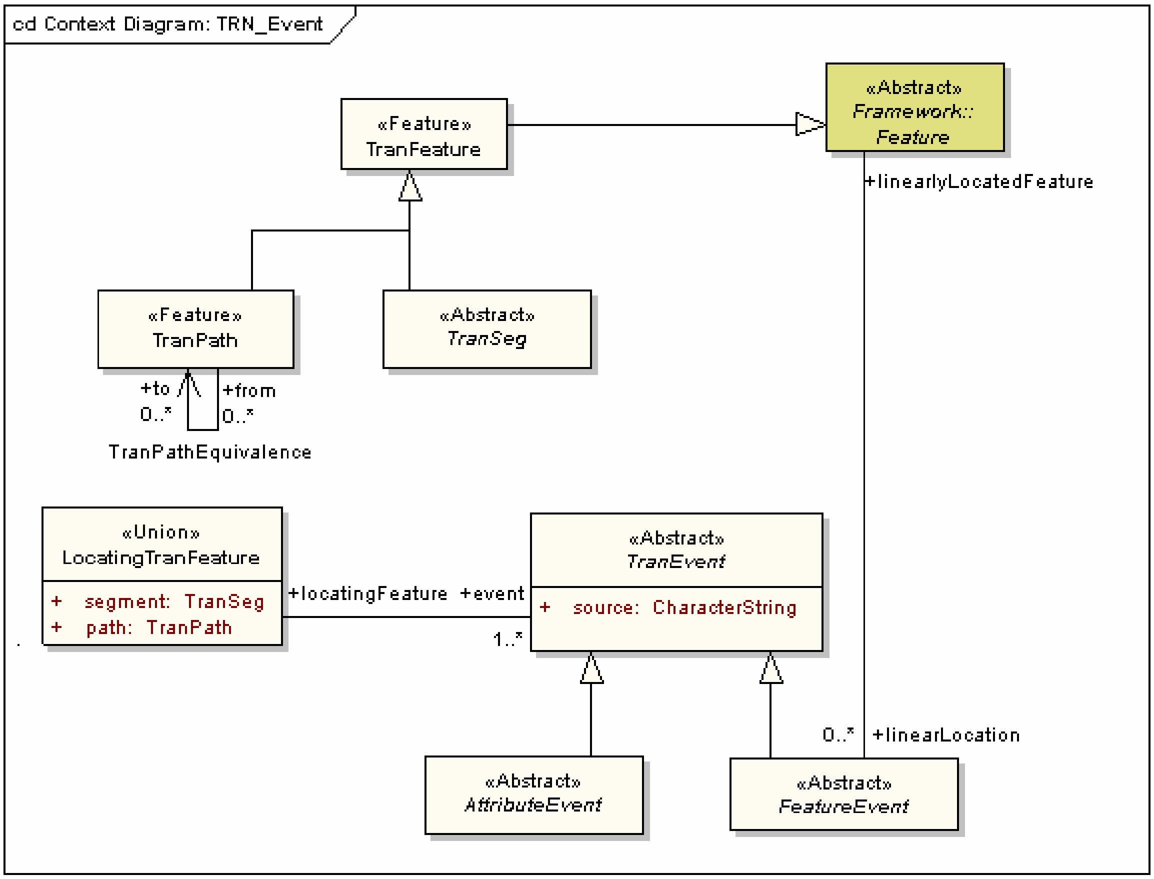

Figure 6 – Transportation event model (1)

If an attribute value of a TranSeg or TranPath linear feature has a single, constant value along the entire length of the feature (for example, status and fieldMeasure), the attribute exists at the feature (TranSeg or TranPath) level and it is sufficient to specify this single value with the feature. If the value of the attribute can change along the length of the linear feature (for example, speed limit, number of lanes), the location where each change occurs must also be specified. To accomplish this, AttributeEvents are used. Each attribute event specifies a particular value for an attribute of a linear feature along with the location along that feature for which the value applies.

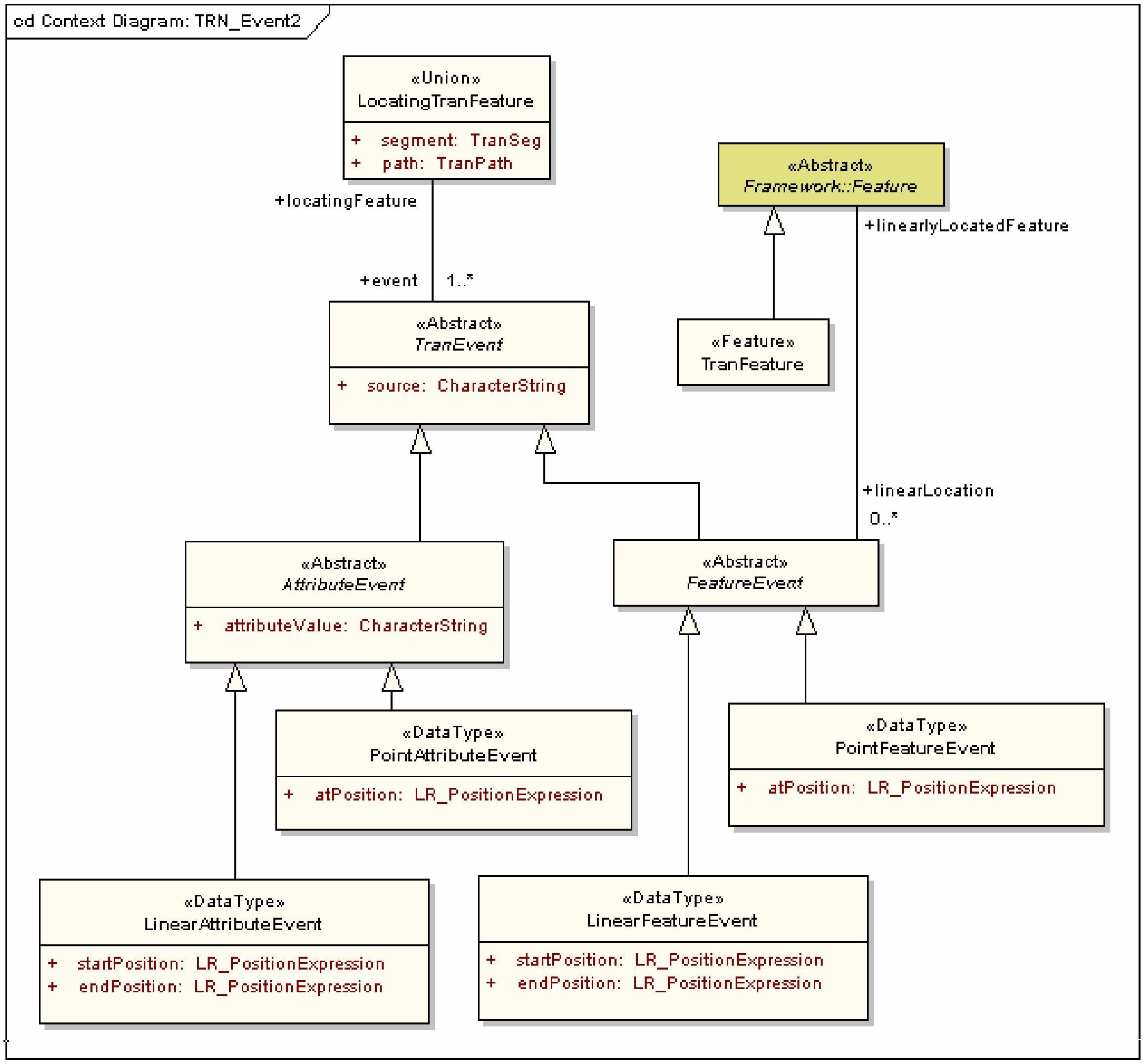

Figure 7 – Transportation event model (2)

Similarly, TranFeatures other than TranSegs, TranPaths, and TranPoints can have attributes, each with a single, constant value. One of these attributes can be the geometry of the feature. For example, a street sign Transportation Feature can have a height attribute and a point geometry. This feature can also be linearly located along one or more TranSegs or TranPaths. Each such linear location is specified by a Feature Event. The Feature Event linearly locates any TranFeature along a TranSeg or TranPath.

As shown in Figure 7, both AttributeEvent and FeatureEvent are subtyped into point and linear events. A point event occurs at a single position along a TranSeg or TranPath. This position is called an “at” position. Linear events apply to a length of the TranSeg or TranPath. This interval is defined by a “start” and an “end” position on the TranSeg or TranPath. The “at”, “start”, and “end” positions used to locate an event are specified using a linearly referenced position expression. This expression specifies the linear reference method used to perform the measurement, the linear feature (TranSeg or TranPath) being measured, the measurement along the TranSeg or TranPath, and optionally the measurement laterally offset to either side.

7.4.1 LinearAttributeEvent

LinearAttributeEvents (see Figure 7) provide the means of specifying the value and location of a single segment or path attribute that applies only to part of the segment or path. The value of the segment or path attribute is specified as the attributeValue, inherited from AttributeEvent. The location interval along which the value applies is specified by a start and end position along the segment or path, using two linearly referenced position expressions. The name of the attribute is specified by the linearEventType attribute. For subtypes of LinearAttributeEvent, see subsequent, transportation mode-specific parts of this standard. An example of a LinearAttributeEvent is the speed limit of a road. "Speed limit" is the road attribute (linearEventType). A value of 55 MPH (attributeValue) might apply for only part of the road segment, delineated by start and end positions along the road segment. LinearAttributeEvents have no geometry of their own but instead inherit any geometry which may have been defined for the segment or path to which they apply.

7.4.2 PointAttributeEvent

PointAttributeEvents (see Figure 7) provide the means of specifying the value and location of a single segment or path attribute that has a particular value only at a single point along the segment or path. The value of the segment or path attribute is specified as the attributeValue, inherited from AttributeEvent. The point location is specified by an atPosition along the segment or path, using a linearly referenced position expression. The name of the attribute is specified by the pointEventType attribute. For subtypes of PointAttributeEvent, see subsequent, transportation mode-specific parts of this standard. An example of a PointAttributeEvent is a stop sign along a road. "Sign" is the road attribute (pointEventType). A value of "stop" (attributeValue) specifies the type of sign. The sign is located at a position along the road segment. The position expression allows the sign to be located at a position laterally offset from the center of the road. (If more information is needed about the sign, the sign shall instead be represented as a feature and then linearly located with a PointFeatureEvent. See section 7.4.4 below.)

PointAttributeEvents can also be used to specify where something like a pedestrian cross walk crosses the segment or path. PointAttributeEvents have a linear location along a segment or path but have no explicit geospatial coordinate location of their own. This can be obtained from any geometry which may have been defined for the segment or path to which the PointAttributeEvent applies.

7.4.3 LinearFeatureEvent

A LinearFeatureEvent provides the means of specifying a linear location for a feature along a segment or path. All of the feature's attributes, including optional geometry, are included with the feature itself. The LinearFeatureEvent is only attributed with the linear location of the feature along a segment or path, specified by a start and end position along the segment or path using two linearly referenced position expressions (see Figure 7). There are no restrictions on the type of feature being located. The feature can be linear, like guardrail. Guardrail attributes, like date installed or manufacturer are kept with the guardrail feature. The guardrail feature may not have geometry of its own, but instead rely on the geometry of the locating segment or path. Features with area geometries, like a county, are also supported by LinearFeatureEvents. In this case, the LinearFeatureEvent depicts what part of the segment or path is in the County feature.

7.4.4 PointFeatureEvent

A PointFeatureEvent provides the means of specifying a linear location for a feature along a segment or path. All of the feature's attributes, including optional geometry, are included with the feature. The PointFeatureEvent is only attributed with the linear location of the feature along a segment or path, specified by a single atPosition along the segment or path using a single linearly referenced position expression (see Figure 7). There are no restrictions on the type of feature being located. The feature can have a point footprint, like a stop sign. Sign attributes, like date installed or height are kept with the sign feature. The sign feature may not have geometry of its own, but instead rely on the geometry of the locating segment or path. Features with linear geometries, like a railroad, are also supported. In this case, the PointFeatureEvent depicts where the railroad crosses the segment or path.

7.4.5 Attributes for events

Listed below in Table 2 are transportation event objects and their associated attributes.

Table 2 – Data dictionary for transportation event objects

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
32	TranEvent	Mechanism for locating an attribute value or feature along a transportation feature			<<Abstract>>	Lines 33-34
33	source	Supplier of the event object	M	1	CharacterString	Unrestricted
34	Role name: locatingFeature	Transportation feature to which event is referenced	M	1	<<Union>> LocatingTranFeature	Unrestricted
35	AttributeEvent	Mechanism for locating an attribute value along a transportation feature			<<Abstract>>	Line 36
36	attributeValue	Value of the attribute at the specified location	M	1	CharacterString	Unrestricted
37	LinearAttributeEvent	Mechanism for locating an attribute value for an interval along a transportation feature			<<DataType>>	Lines 38-39
38	startPosition	Starting location along the transportation feature for the attribute value	M	1	<<Type>> LR_PositionExpression	Defined in ISO 19133
39	endPosition	Ending location along the transportation feature for the attribute value	M	1	<<Type>> LR_PositionExpression	Defined in ISO 19133
40	PointAttributeEvent	Mechanism for locating an attribute value at a single point along a transportation feature			<<DataType>>	Line 41
41	atPosition	Point location along the transportation feature at which the	M	1	<<Type>> LR_PositionExpression	Defined in ISO 19133

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
		attribute value applies				
42	FeatureEvent	Mechanism for locating a feature along a transportation feature			<<Abstract>>	Line 43
43	Role name: linearlyLocatedFeature	Feature that is located along the transportation feature	M	1	<<Abstract>> Framework:: Feature	Unrestricted
44	LinearFeatureEvent	Mechanism for locating a feature along an interval along a transportation feature			<<DataType>>	Lines 45-46
45	startPosition	Starting location along the transportation feature for the feature	M	1	<<Type>> LR_PositionExpression	Defined in ISO 19133
46	endPosition	Ending location along the transportation feature for the feature	M	1	<<Type>> LR_PositionExpression	Defined in ISO 19133
47	PointFeatureEvent	Mechanism for locating a feature at a single point along a transportation feature			<<DataType>>	Line 48
48	atPosition	Point location along the transportation feature at which the feature is located	M	1	<<Type>> LR_PositionExpression	Defined in ISO 19133
49	LocatingTranFeature	Transportation feature used to locate a transportation event			<<Union>>	Lines 50-52
50	segment	TranSeg used to locate a transportation event	C/if path is not specified	1	<<Abstract>> TranSeg	Unrestricted
51	path	TranPath used to locate a transportation event	C/if segment is not specified	1	<<Feature>> TranPath	Unrestricted
52	Role name: event	Transportation event located by the feature	M	*	<<Abstract>> TranEvent	Unrestricted

Annex A
(informative)
Equivalencies

The central issue for the Transportation theme is how to equate disparate databases that represent the same real world features. For example, different databases may have different positional accuracies, different linear reference methods (LRMs), or different schemes for partitioning (segmenting) the transportation network. End users may have a variety of compelling business needs to distinguish each representation but also know that each is a representation of the same transportation system. “Equivalency” is the term given to the process of equating transportation segments or points from disparate databases.

Assume that there are three segmentation schemes developed for a real road, as depicted in Figure A.1. All datasets include only RoadSegs. The basic difference between the two local RoadSeg datasets is the use of different intersections to base the segmentation; that is to say, to form RoadSeg termini.

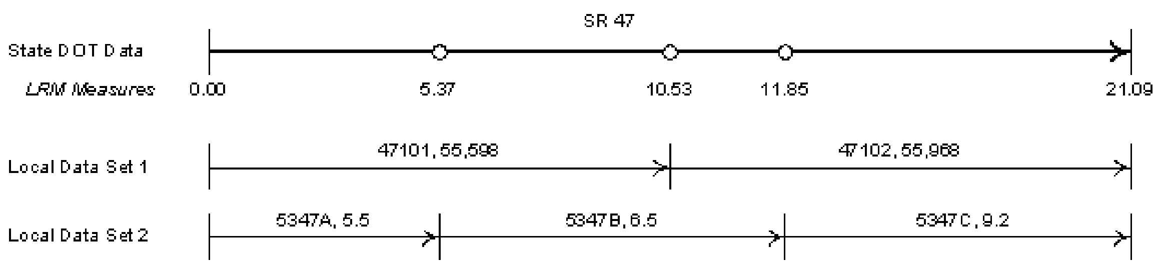

Figure A.1 – Sample datasets representing the same segment of road

For simplicity, the only mandatory attributes of a RoadSeg are its identifier and length. The State DOT dataset includes a single RoadSeg with linear reference method (LRM) measures for the intersections (point events) and RoadSeg termini. To make it more interesting (and realistic), different resolutions for LRM measures are shown on the three datasets. Here are all the numbers:

- The State DOT dataset states that the road is 21.09 miles long, is modeled as a single road segment (SR 47), and includes three intersection point events along its extent at distances of 5.37, 10.53, and 11.85 miles from the LRM origin
- Local Dataset 1 states that the road is 111,566 feet long and consists of two RoadSeg features, one has the feature ID of 47101 and is 55,598 feet long, and the other has a feature ID of 47102 and a length of 55,968 feet
- Local Dataset 2 states that the road is 21.2 miles long and consists of three segments, 5347A at 5.5 miles in length, 5347B at 6.5 miles in length, and 5347C at 9.2 miles in length

Local Dataset 1:

- Because RoadSeg 47101 ends at a location equivalent to the second intersection point event at 10.53 miles along the 21.09 mile long State DOT RoadSeg, RoadSeg 47101 is equivalent to the first 49.93% of the State DOT RoadSeg (10.53/21.09)
- RoadSeg 47102 is therefore equivalent to the last 50.07% of the State DOT RoadSeg ((21.09-10.53)/21.09)

Local Dataset 2:

- Because RoadSeg 5347A ends at a location equivalent to the first intersection point event at 5.37 miles along the 21.09 mile long State DOT RoadSeg, RoadSeg 5347A is equivalent to the first 25.46% of the State DOT RoadSeg (5.37/21.09)
- RoadSeg 5347B starts at a location equivalent to the first intersection point event at 5.37 miles along the 21.09 mile long State DOT RoadSeg and ends at the third intersection point event at 11.85 miles along the State RoadSeg. RoadSeg 5347B is therefore equivalent to that part of the State DOT RoadSeg starting at 25.46% and ending at 56.19% (11.85/21.09)
- RoadSeg 5347C is therefore equivalent to the last 43.81% of the State DOT RoadSeg (100-56.19)

With these equivalences, it is now possible to use linear interpolation to determine equivalent locations along the RoadSegs in these datasets. For example, a point 3.00 miles along 5347A would be 13.89% along the State DOT RoadSeg: (3.00 / 5.5) x 25.46%. This equates to only 2.93 miles (13.89% of 21.09) along the State RoadSeg. This lower mileage is expected, since the State believes it is 5.37 miles to the first intersection whereas Local Dataset 2 believes it is 5.5 miles.

Note Two important points, first, this is exactly the same straight-line interpolation as used by dynamic segmentation. Second, the differences in LRM units and values between the datasets are inconsequential as the distances are computed in the separate LRM values and are consistent within each linear reference method.

Annex B
(normative)
Package: Linear reference systems

B.1 Semantics

This annex is clause 6.6 from ISO 19133:2005, Geographic information – Location based services – Tracking and navigation. "The package "Linear Reference Systems" supplies classes and types to the definition of linear reference systems. Linear reference systems are in wide use in transportation. They allow for the specification of positions along curvilinear features by using measured distances from known positions, usually represented by physical markers along the right-of-way of the transportation feature. The classes for this system and their relationships are depicted in Figure B.1.

B.2 LR_PositionExpression

B.2.1 Semantics

The class "LR_PositionExpression" is used to describe position given by a measure value, a curvilinear element being measured, and the method of measurement. The UML for LR_PositionExpression is given in Figure B.2.

B.2.2 Attribute: measure : Measure

The attribute "measure" gives measure (usually a distance) of this position expression.

LR_PositionExpression :: measure : Measure

B.2.3 Role: LRM : LR_LinearReferenceMethod

The role "LRM" gives the linear reference method used for this position expression.

LR_PositionExpression :: LRM : LR_LinearReferenceMethod

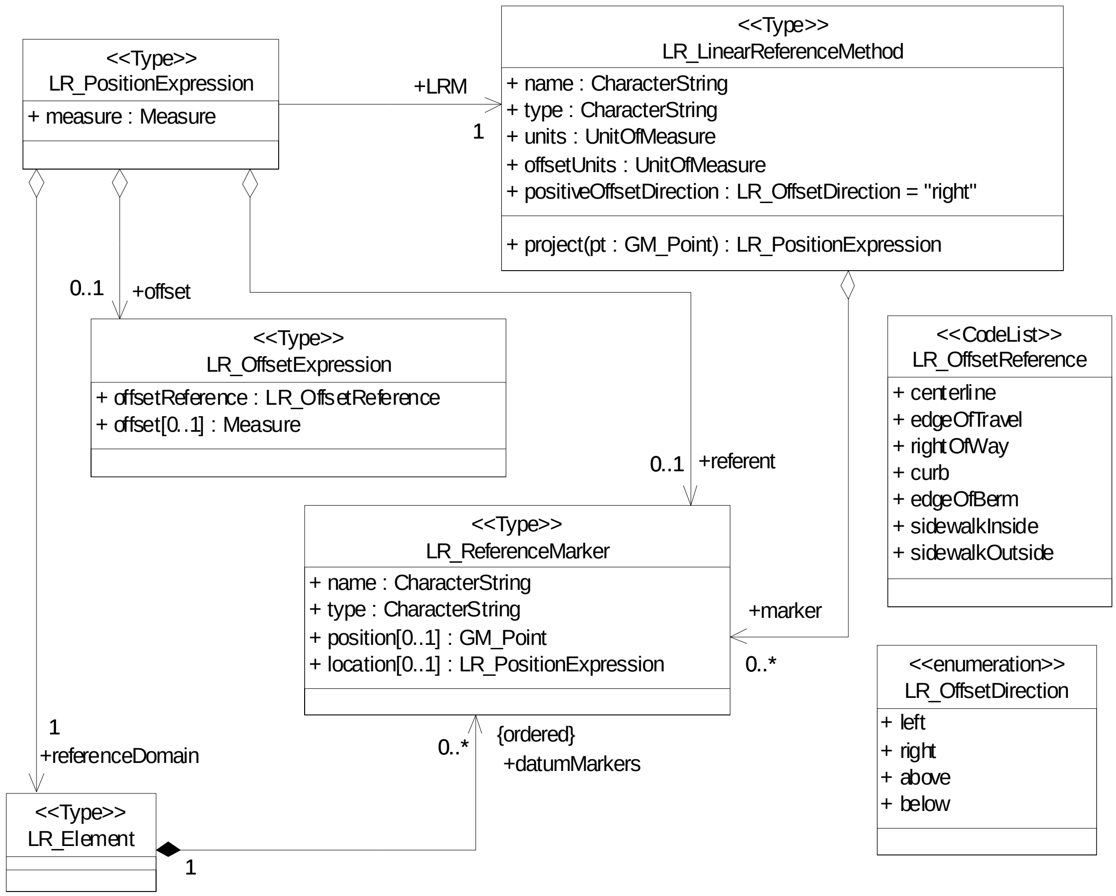

Figure B.1 – LRS classes

B.2.4 Role: referent [0..1] : LR_ReferenceMarker

The optional association role "referent" gives the marker or known position from which the measure is taken for the linear reference method used for this position expression. If the referent is absent, the measurement is made from the start of the LR_element.

LR_PositionExpression :: referent [0..1]: LR_ReferenceMarker

B.2.5 Role: referenceDomain : LR_Element

The role "referenceDomain" gives the linear object upon which the measure is taken for the linear reference method used for this position expression.

LR_PositionExpression :: referenceDomain : LR_Element

B.2.6 Role: offset[0..1] : LR_OffsetExpression

The optional association role "offset" gives perpendicular distance offset of this position expression. If the offset is absent, then the position is on the LR_element.

LR_PositionExpression :: offset[0..1] : LR_OffsetExpression

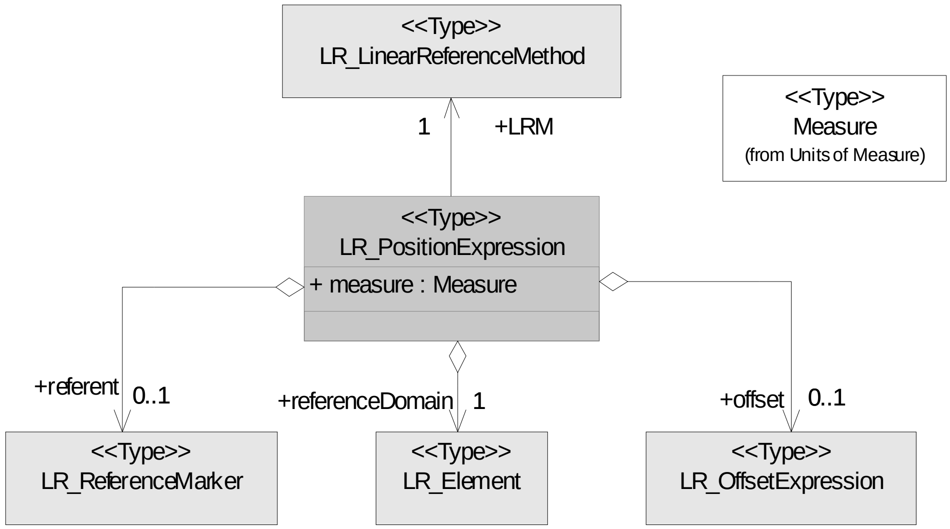

Figure B.2 – LR_PositionExpression

B.3 LR_LinearReferenceMethod

B.3.1 Semantics

The type “LR_LinearReferenceMethod” describes the manner in which measurements are made along (and optionally laterally offset from) a curvilinear element. The UML for LR_LinearReferenceMethod is given in Figure B.3.

B.3.2 Attribute: name : CharacterString

The attribute: “name” gives the name of this linear reference method.

R_LinearReferenceMethod :: name : CharacterString

B.3.3 Attribute: type : CharacterString

The attribute: “type” gives the type of this linear reference method.

LR_LinearReferenceMethod :: type : CharacterString

B.3.4 Attribute: units : UnitOfMeasure

The attribute: “units” gives the units of measure used for this linear reference method for measures along the base elements.

R_LinearReferenceMethod :: units : UnitOfMeasure

B.3.5 Attribute: offsetUnits : UnitOfMeasure

The attribute: “offsetUnits” gives the units of measure used for this linear reference method for measures perpendicular to the base elements.

R_LinearReferenceMethod :: offsetUnits : UnitOfMeasure

B.3.6 Attribute: positiveOffsetDirection : LR_OffsetDirection = "right"

The attribute: “positiveOffsetDirection” gives the direction used as positive for this linear reference method for measures perpendicular to the base elements. The default value is right for positive, left for negative.

R_LinearReferenceMethod :: positiveOffsetDirection : LR_OffsetDirection = "right”

B.3.7 Role: marker[1..*] : LR_ReferenceMarker

The association role “marker” aggregates all reference markers used by the linear reference methods. Normally, this will be grouped by linear element.

R_LinearReferenceMethod :: marker[0..*] : LR_ReferenceMarker

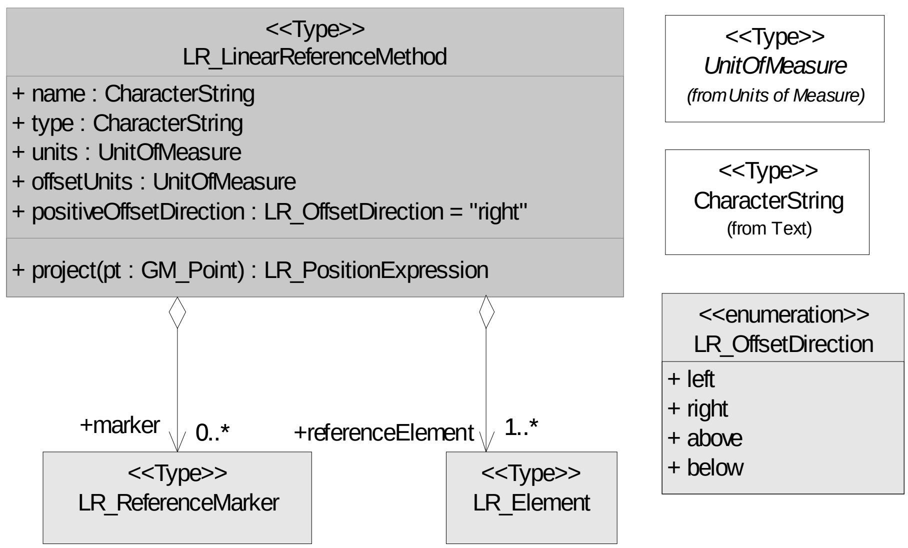

Figure B.3 – LR_LinearReferenceMethod

B.3.8 Role: referenceElement[1..*] : LR_Element

The role “referenceElement” aggregates all the linear elements along which this method is supported.

R_LinearReferenceMethod :: referenceElement[1..*] : LR_Element

B.3.9 Operation: project

The operation “project” will find the measure of the point on a base element closest to the given point, and then express the point as a position expression for the linear reference method. If the point is precisely on one of the linear elements, then the offset will be zero there is no offset expression.

R_LinearReferenceMethod :: project(GM_Point pt) : LR_PositionExpression

B.4 LR_OffsetDirection

The enumeration “LR_OffsetDirection” gives the four options for offset measure. The values “left” and “right” are the ones most commonly used. These offset directions are as viewed from above the linear element facing in the direction of increasing measure. If measures for above or below the pavement are needed such as for clearance measures, the vertical options are “above” and “below”. The UML for LR_OffsetDirection is given in Figure B.4.

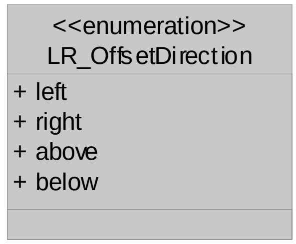

Figure B.4 – LR_OffsetDirection

B.5 LR_ReferenceMarker

B.5.1 Semantics

The type "LR_ReferenceMarker" is used to describe reference markers used in linear reference systems. At least one of the attributes "position" or "location" shall be given. If both are given they shall refer to the same physical location. The UML for LR_ReferenceMarker is given in Figure B.5.

B.5.2 Attribute: name : CharacterString

The attribute "name" is the identifier used for this marker.

R_ReferenceMarker :: name : CharacterString

B.5.3 Attribute: type : CharacterString

The attribute "type" is the type of this marker.

R_ReferenceMarker :: type : CharacterString

B.5.4 Attribute: position[0..1] : GM_Point

The optional attribute "position" is the position of this for this marker, given in some coordinate system. If this attribute is not given, then the "location" shall be given.

R_ReferenceMarker :: position[0..1] : GM_Point

B.5.5 Attribute: location[0..1] : LR_PositionExpression

The optional attribute "location" is the location of this marker given as a linearly referenced measure along and from the start of the underlying linear element.

R_ReferenceMarker :: location[0..1] : LR_PositionExpression

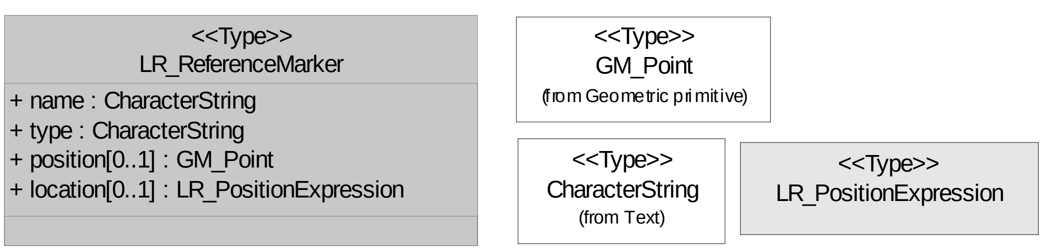

Figure B.5 – LR_ReferenceMarker

B.6 LR_Feature

The type “LR_Feature” is a behavioral description of features used as base elements in a linear reference method. This is the most common approach used for LRSs. The UML for LR_Feature is given in Figure B.6.

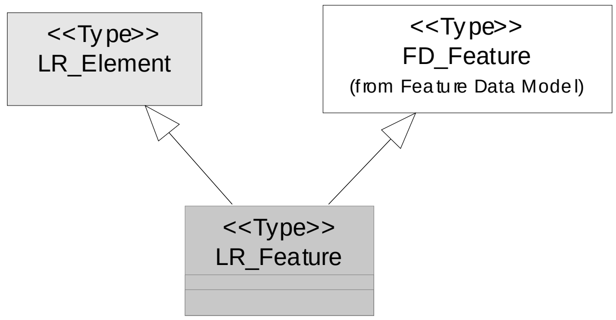

Figure B.6 – LR_Feature

B.7 LR_Element

B.7.1 Semantics

The type “LR_Element” describes the underlying curvilinear elements upon which the measures in the linear reference system are taken. The UML for LR_Element is given in Figure B.7.

B.7.2 Role: datumMarkers[1..*] : LR_ReferenceMarker

The ordered association role “datumMarkers” aggregates the markers along this element. The ordering of the markers is consistent with the order in which the markers would be found in traversing the LR_Element from beginning to end (that is to say, in increasing order of distance from the “zero marker” the beginning of the element).

R_Element :: datumMarkers[1..*] : LR_ReferenceMarker {ordered}

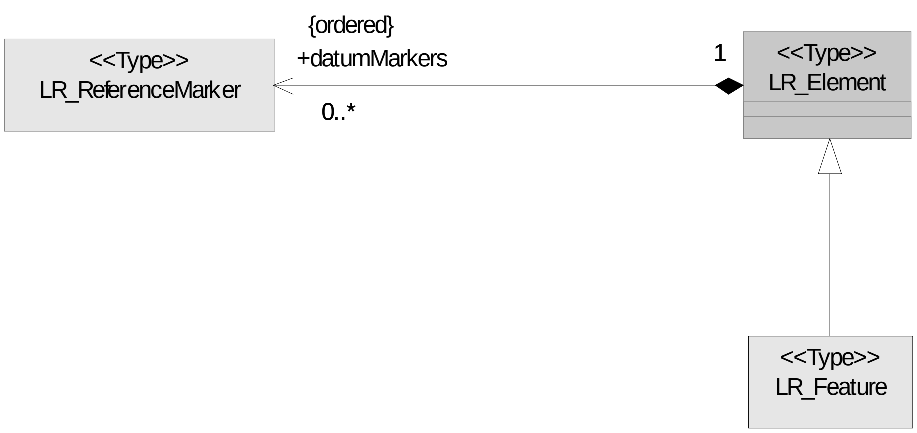

Figure B.7 – LR_Element

B.8 LR_OffsetReference

The code list “LR_OffsetReference” enumerates the offset reference types used for this linear reference method, see Figure B.8. The initial value domain included:

1) "centerline" center of the structure of the highway, or reference line for the highway
2) "edgeOfTravel" outside edge of all travel lanes
3) “edgeOfPavement” outside edge of travel-lane quality paved surface
4) "rightOfWay" edge of the legal right of way
5) "curbFace" side of curb towards travel lanes (the roadway must be curbed for this to be used)
6) "curbBack" side of curb away from travel lanes (the roadway must be curbed for this to be used)
7) “edgeOfShoulder” outside edge of all hardened surfaces (paved or gravel)
8) ”edgeOfBerm" outside edge of leveled land for the road structure
9) ”walkwayInside" sidewalk edge closest to travel lanes (a walkway must exist for this to be used)
10) ”walkwayOutside” sidewalk edge furthest from travel lanes (a walkway must exist for this to be used)

B.9 LR_OffsetExpression

B.9.1 Semantics

The type “LR_OffsetExpression” is used to describe the offset for a position described using a linear reference method. The UML for LR_OffsetExpression is given in Figure B.8.

B.9.2 Attribute: offsetReference : LR_OffsetReference

The attribute “offsetReference” indicates the base line for the offset measure.

R_OffsetExpression :: offsetReference : LR_OffsetReference

B.9.3 Attribute: offset[0..1] : Number

The optional attribute “offset” is the measure of the offset of the position expression. A missing value is to be interpreted as being located at the offset reference.

R_OffsetExpression :: offset[0..1] : Measure

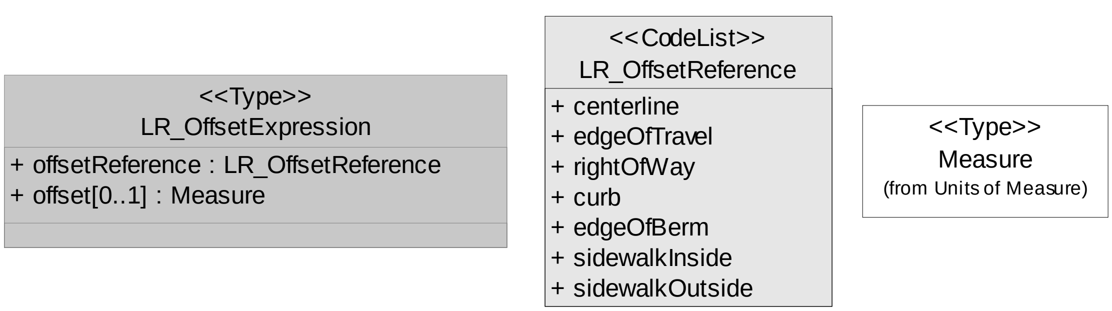

Figure B.8 – LR_OffsetExpression

Annex C
(informative)
Bibliography

The following documents contain provisions that are relevant to two or more transportation parts of the Framework Data Content Standard. References applicable to a single transportation part are reported in the respective part. Annex D of the Base Document (Part 0) lists informative references applicable to two or more parts of the standard, including the transportation parts. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies.

ANSI and ISO standards may be purchased through the ANSI eStandards Store at http://webstore.ansi.org/ansidocstore/default.asp, accessed October 2006.

ISO 14825:2004, Intelligent transport systems – Geographic data files (GDF) – Overall data specifications

NCHRP Project 20-27 (2), 1997, A generic data model for linear referencing systems, National Cooperative Research Program of the Transportation Research Board