Bentley
Sustaining Infrastructure

311 Conceptual Modeling of Linear Referenced and Geospatial Data and Operations

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1. What / Why / How Linear (vs. Spatial)
2. LR Concepts (from ISO 19148)
   - Linearly Referenced Location
     - HOW
     - WHAT
     - MEASURE
3. Application

1. Linear Referencing

(spatial) location:

at some (x, y), or

at lat/long position

(linear) location:

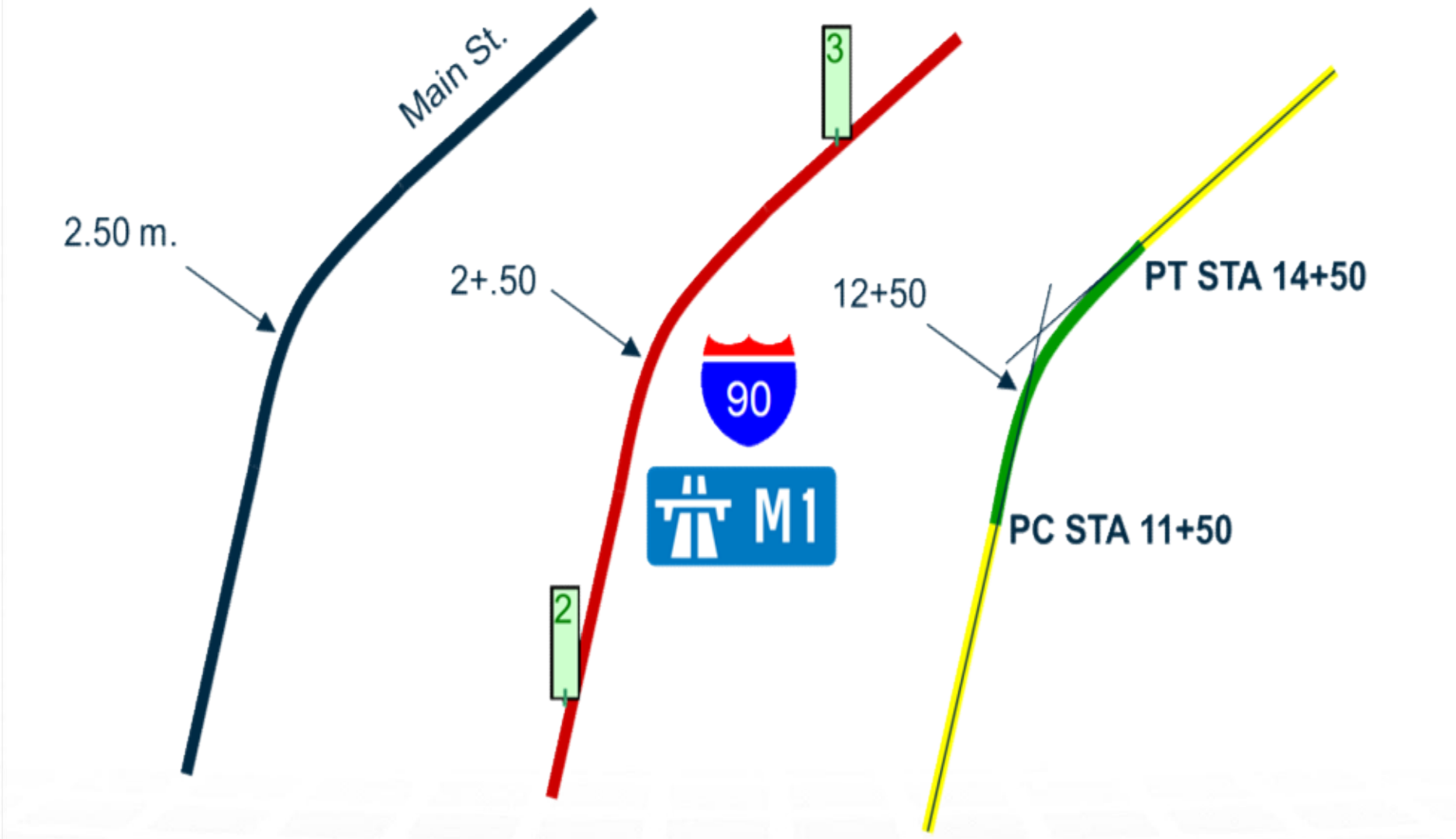
Along Route 95

at milepoint 2.1

Why is linear referencing needed ?

- Lots of data is currently stored that way and many existing applications depend on it
- Requires less storage (single coordinate)
- Reduce redundancy (represent geometry once)
- Computationally simpler (intersect)
- More accurate in some situations
  - divided or grade-separated highways
  - railroad lateral clearances

Linear Referencing Methods (LRM)



2. CONCEPTS

- From ISO 19148:2012 Linear referencing
- Sound, theoretical underpinning:
  The Generalized Model for Linear Referencing
  - Simplified and standardized concepts
  - Single representation assures closure, determinacy
  - Single translation algirithm is commutatively and transitively closed
- Published in US and International, Civil and GIS Journals
- Adopted by 14 National and International Standards
- ... because there is no single best LRM

Linearly Referenced Location

- **HOW**: Linear Referencing Method (LRM)
- **WHAT**: Linear Element (LE)
- **MEASURE**: Distance Expression
  - Distance along
  - Referent(s)
  - Offset
    - Lateral
    - Vertical
    - Vector

HOW: Linear Referencing Methods

- **Absolute**
  - MilePoint
  - Chainage
- **Relative**
  - MilePost
  - ReferencePost
  - County MilePoint
- **Interpolative**
  - Percentage
  - Address

LRM

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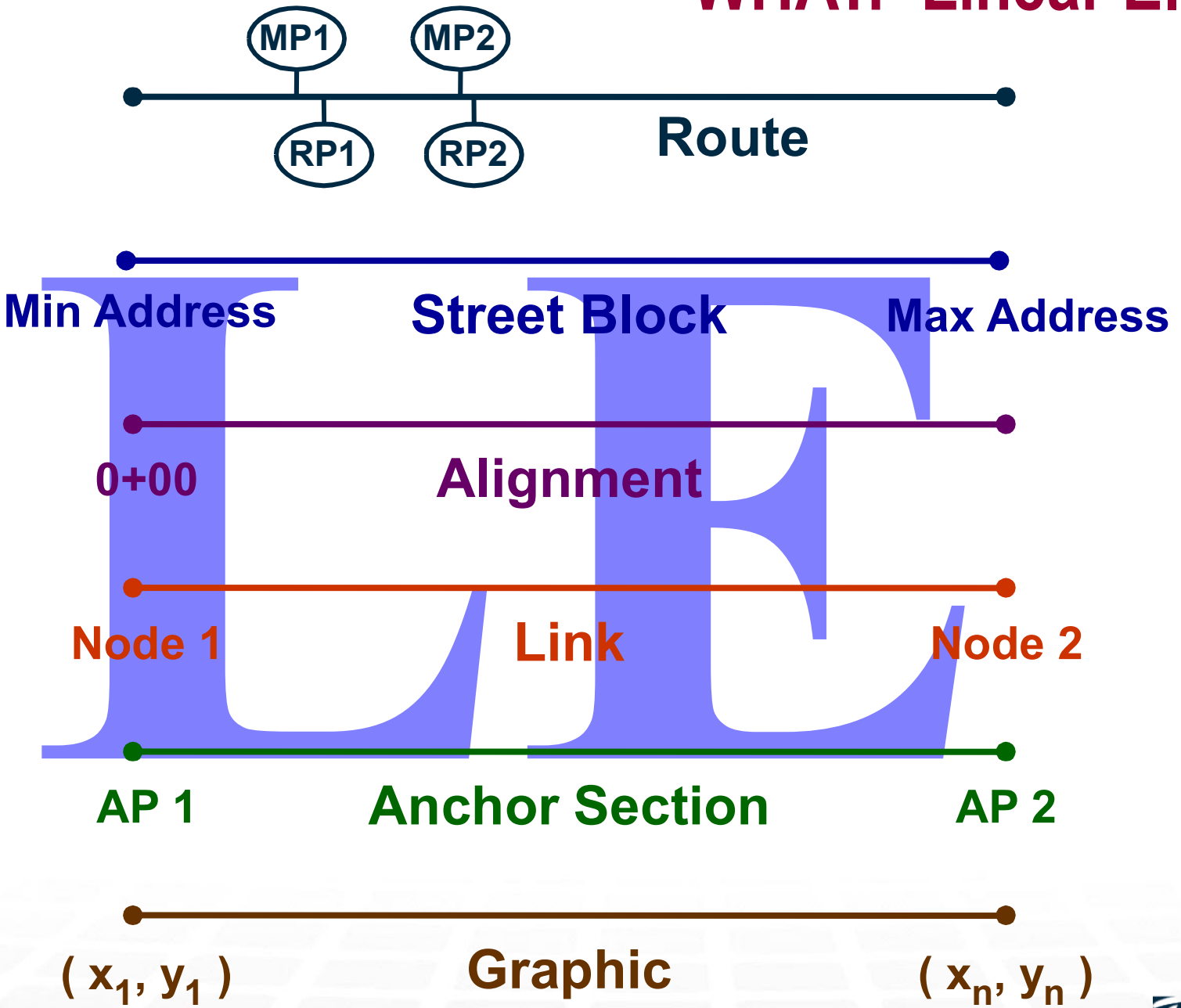
WHAT: Linear Elements



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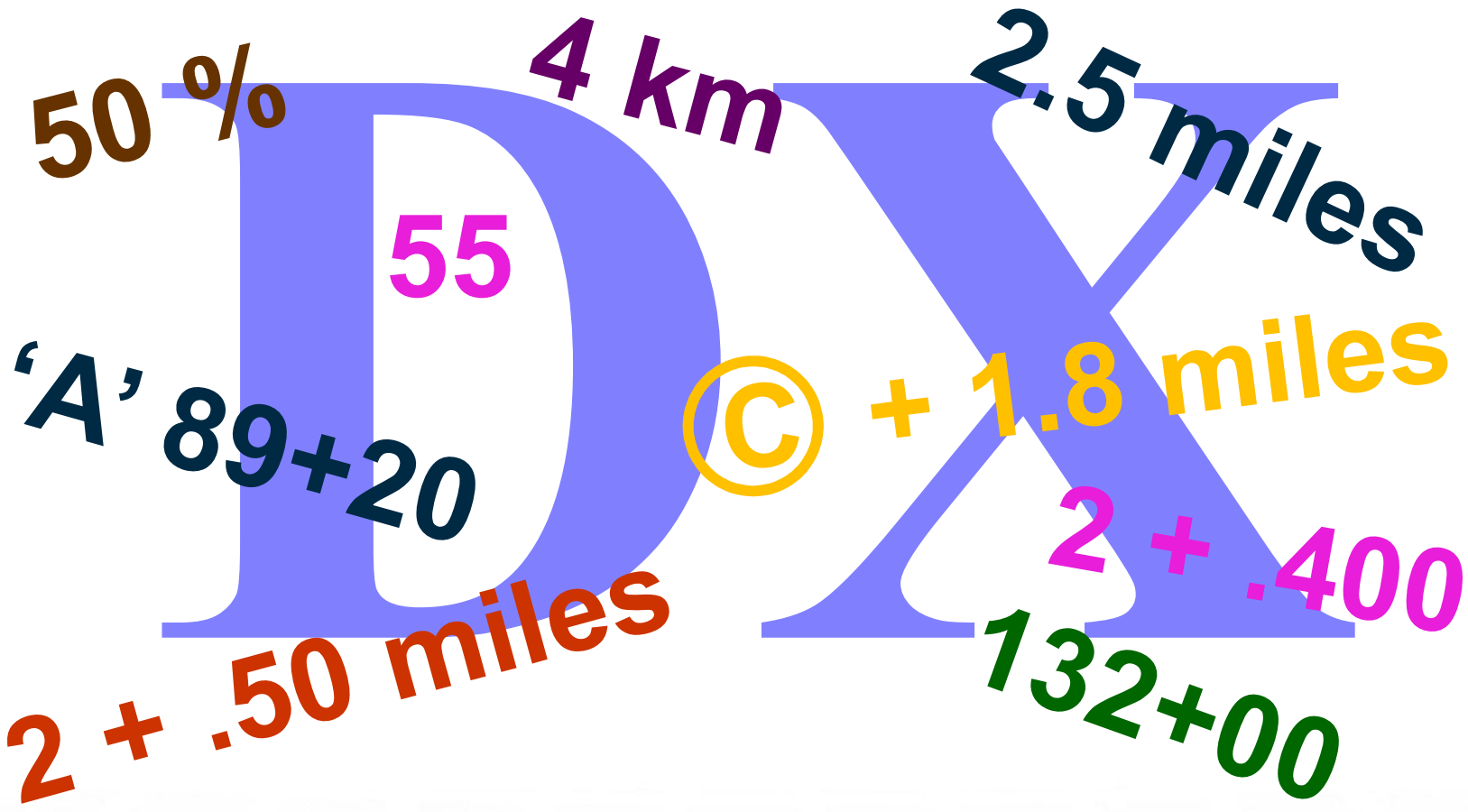
MEASURE: Distance Expressions



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Linearly Referenced Locations

(LRM, Linear Element, Measure)

(MilePoint, *Route:* I-95, 2.5)

(KilometerPoint, *Route:* I-95, 4)

(Percentage, *Link:* Link 1034, 50)

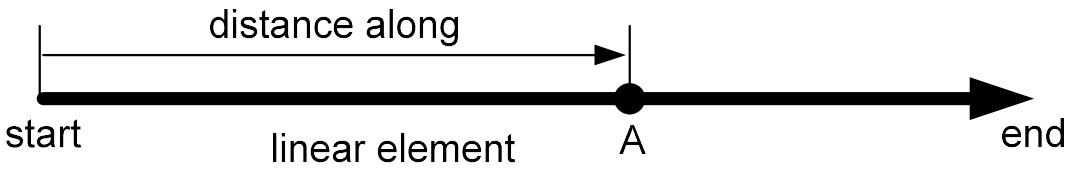
(MilePost, *Route:* US-40, 2 + .50)

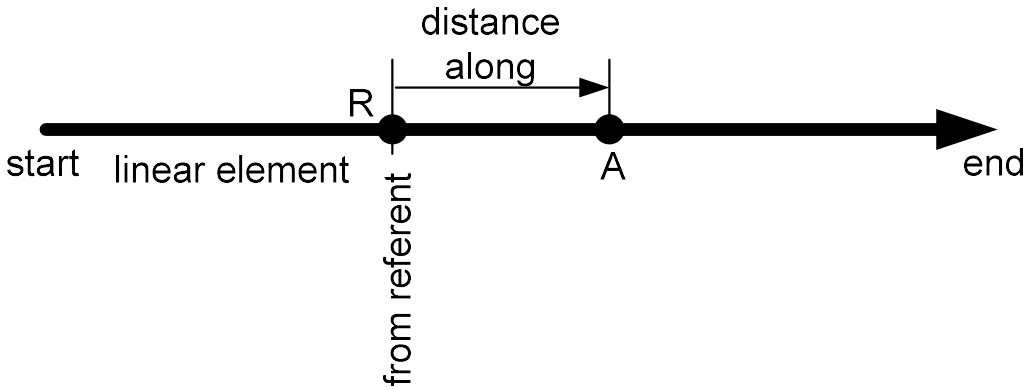
(Reference Post, *Route:* I-95, 2 + .400)

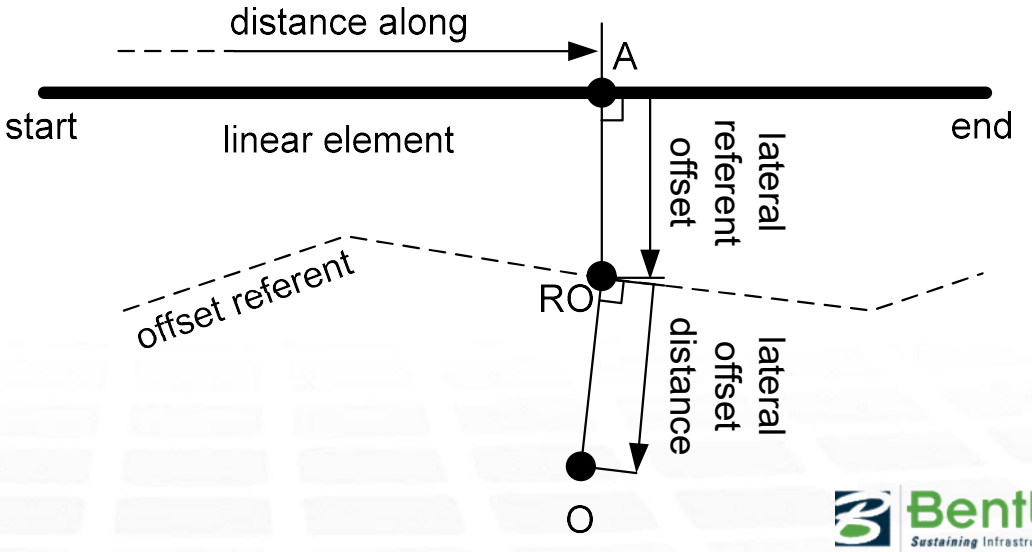
(County MilePoint, *Route:* I-95, ©+1.8)

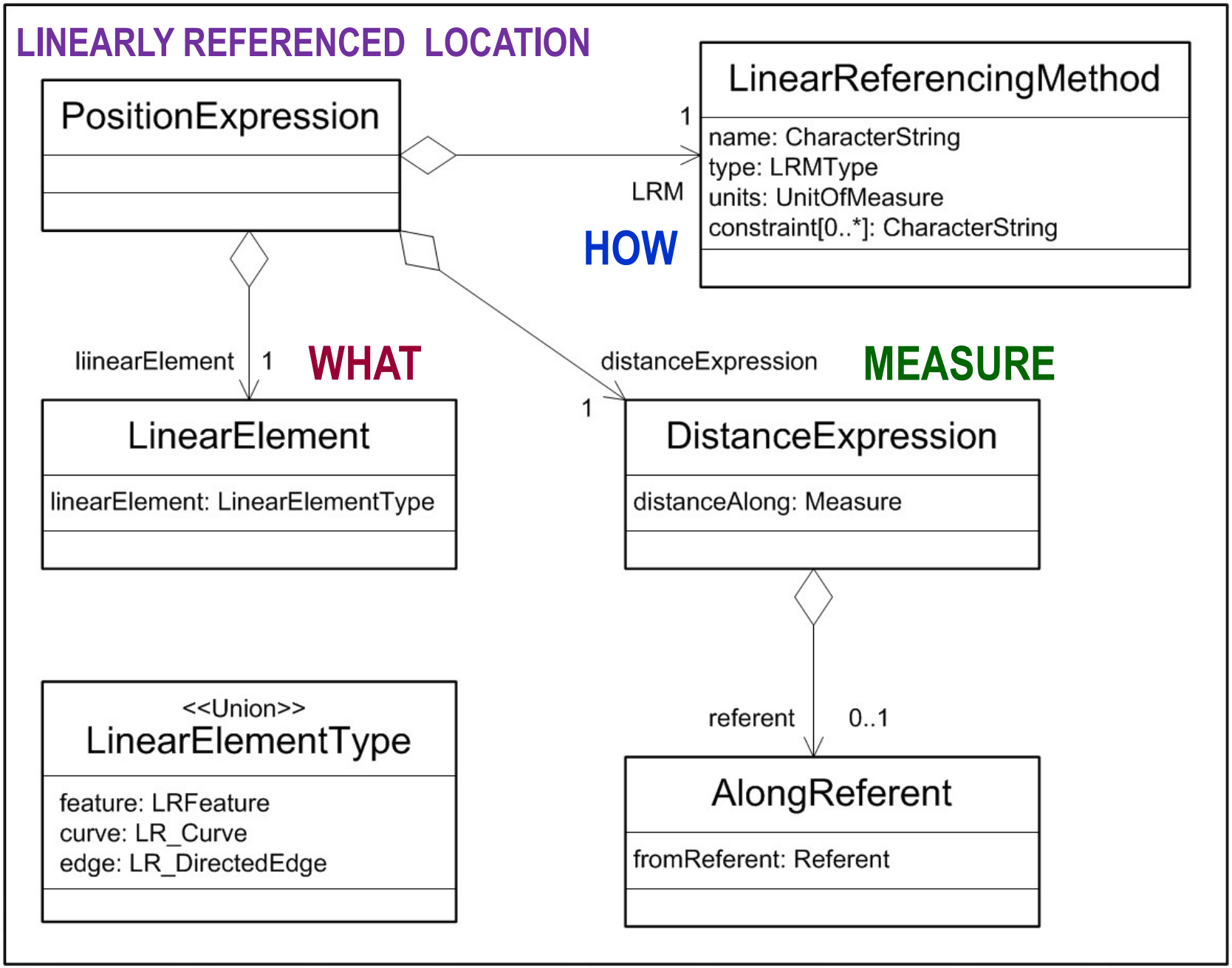
(Station, *Alignment:* Project 42, 132+00)

(Address, *Street:* Smith Rd., 55)









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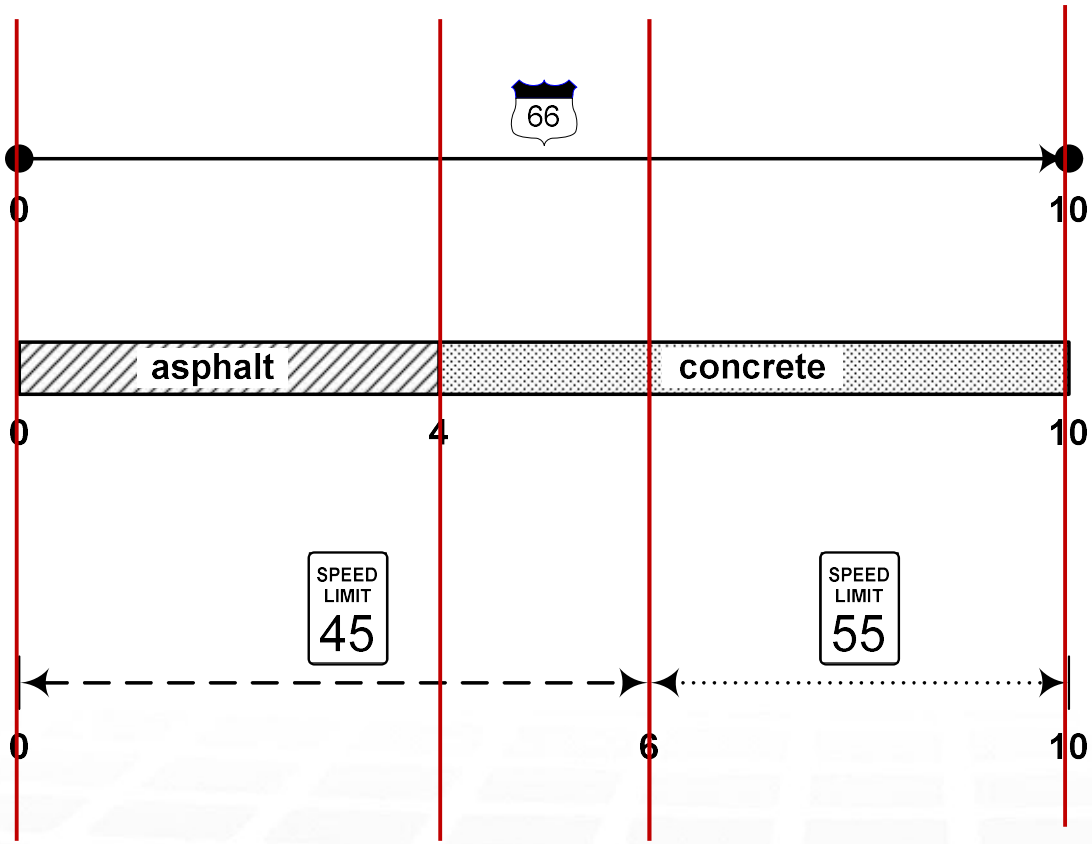
3. Application

- Locating things along
  - 19148 feature event
  - COBie Component location
  - InfraGML, IFCAlignment
- Discretizing continuous objects
  - COBie Facility / Region / Location
- Variably valued attributes
  - 19148 attribute events
  - COBie attribute value applicability
  - InfraGML, IFCAlignment

Event and Segmentation Example

Linear Segmentation Example



Attribute Events:

linear attribute event
- name = “pavement type”
- value = “asphalt”
- from position = 0
- to position = 4

linear attribute event
- name = “pavement type”
- value = “concrete”
- from position = 4
- to position = 10

linear attribute event
- name = “speed limit”
- value = 45
- from position = 0
- to position = 6

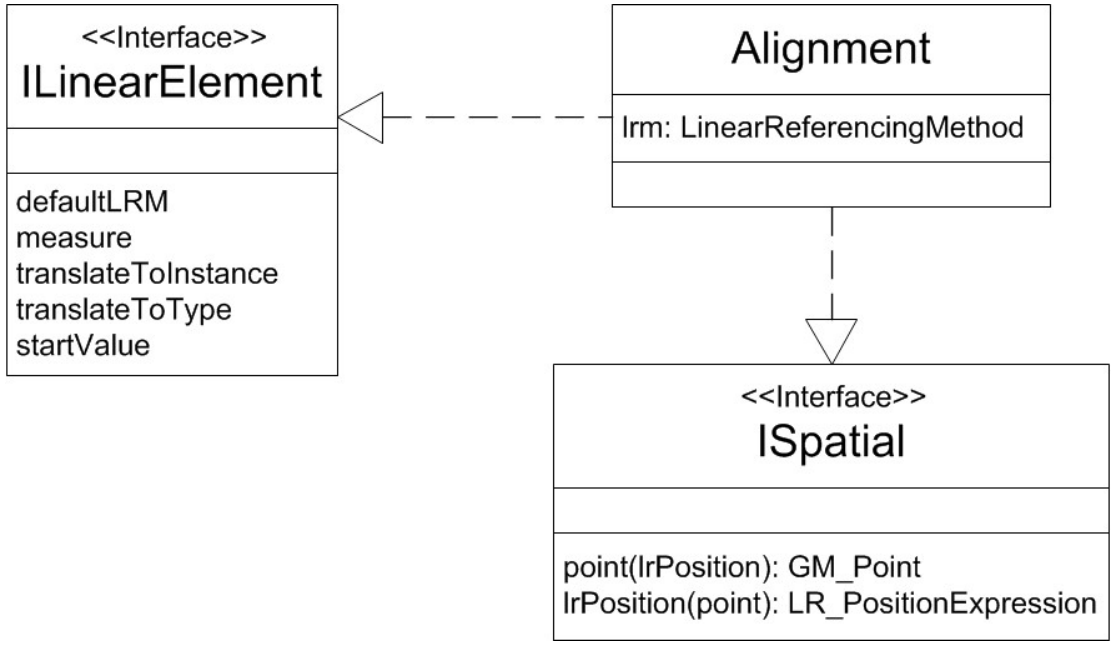
linear attribute event
- name = “speed limit”
- value = 55
- from position = 6
- to position = 10

Operations

- All LinearElements shall support the ILinearElement interface
  - defaultLRM
  - measure
  - translateToInstance
  - translateToType
  - startValue
- Curve types shall also support the ISpatial interface
  - point
  - lrPosition

Data Modelling

- LinearReferencingMethod should be used as the type for LRM
  - e.g., InfraGML/IFCAlignment lrm for an Alignment



- ILinearElement can be realized by a Feature without subtyping (and ISpatial by a Curve)
  - e.g., to make InfraGML Alignment a Linear Element

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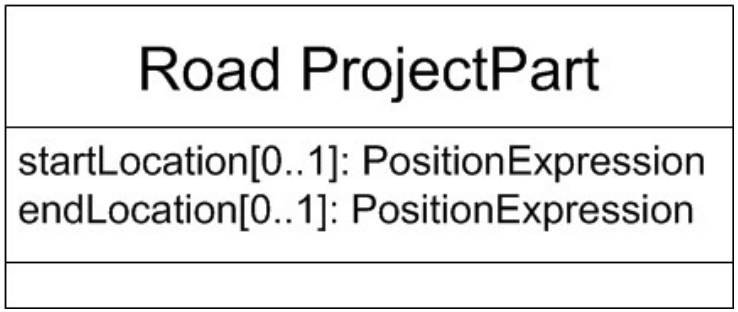
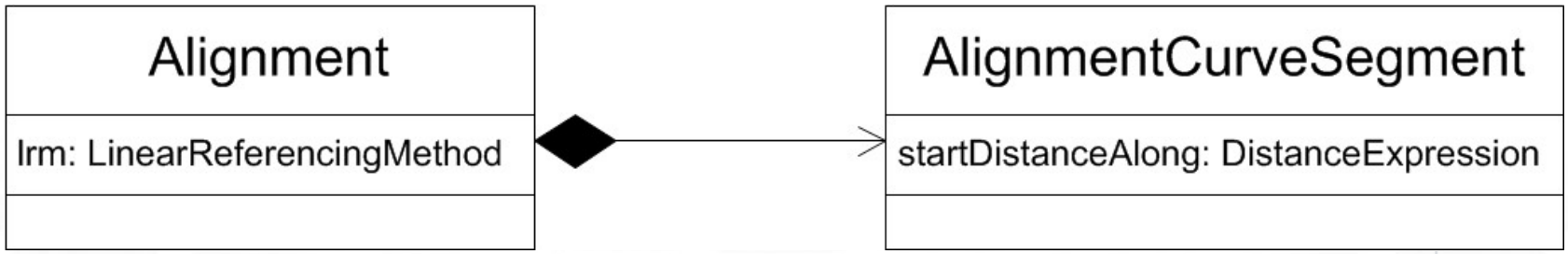
Data Modelling

- PositionExpression should be used as the type for linearly referenced location attributes
  - e.g., InfraGML definition for a Road ProjectPart location



- If the LE and LRM are known, DistanceExpression alone is acceptable
  - e.g., CurveSegment part of Alignment LE having lrm LRM



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4. References
   - SCARPONCINI, PAUL, Generalized Model for Linear Referencing in Transportation, *Geoinformatica*, 6(1): 35-55.
   - InfraGML conceptual model (for comment): http://www.opengeospatial.org/standards/requests/129

