

# NCHRP 20-27 to ISO 19148: 18 Years of Progress in Linear Referencing



Paul Scarponcini, PE, PhD

Independent Consultant

April 17, 2012

- **1995:** “Results of a Workshop on a Generic Data Model for Linear Referencing Systems”, NCHRP 20-27, Alan Vonderohe, Chih-Lin Chou, Forest Sun, Teresa Adams, GIS-T ‘95, Sparks, Nevada
- **2012:** *ISO IS 19148:2012, Geographic Information – Linear referencing*, International Organization for Standardization, Geneva, Switzerland



What problem are we trying to solve?

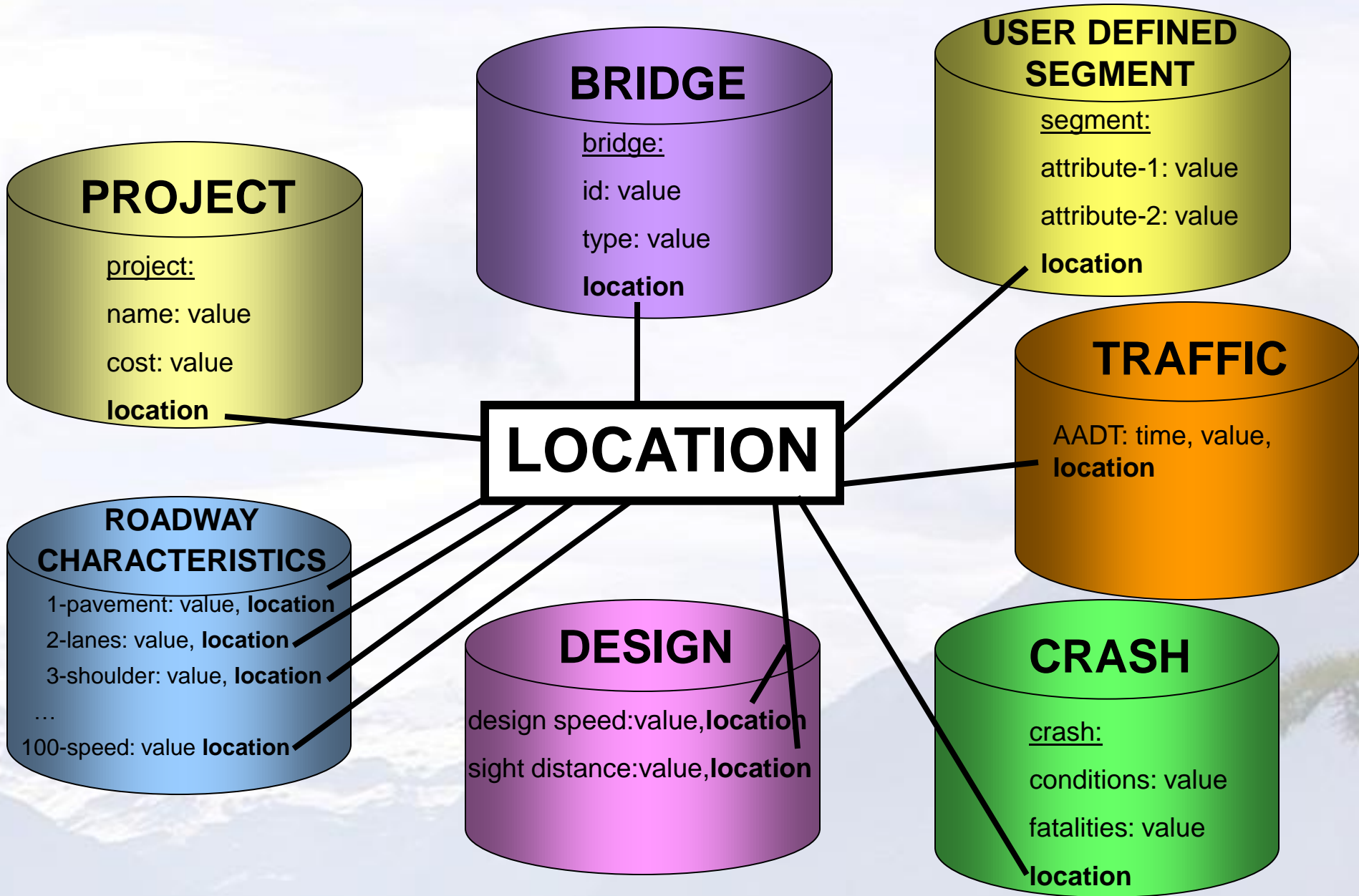
# Integration by Location

US Transportation Research Board (TRB)<sup>1</sup>:

“ data integration across different application areas is an urgent, long-standing need of DOTs ”

“ the concept of location ... can serve as an integrative concept across a wide variety of data, both geographic and of other kinds ”

<sup>1</sup>NCHRP Report 359, 1993



# Locations

132+00

(1.00, 1.00, 5280.00)

4 km

©

+ 1.8 miles

2.5 miles

50 %

(39.580613, -105.157732)

'A' 89+20

2 + .50 miles

2 + .400

(10.251, 20.507 )

55

# Premise

There is no single “best” location referencing method.

- each database / application has unique requirements which need not be compromised.
- integration can still be achieved.

# Linear Referencing

Measuring along a line  
... or any linear element

How we measure:

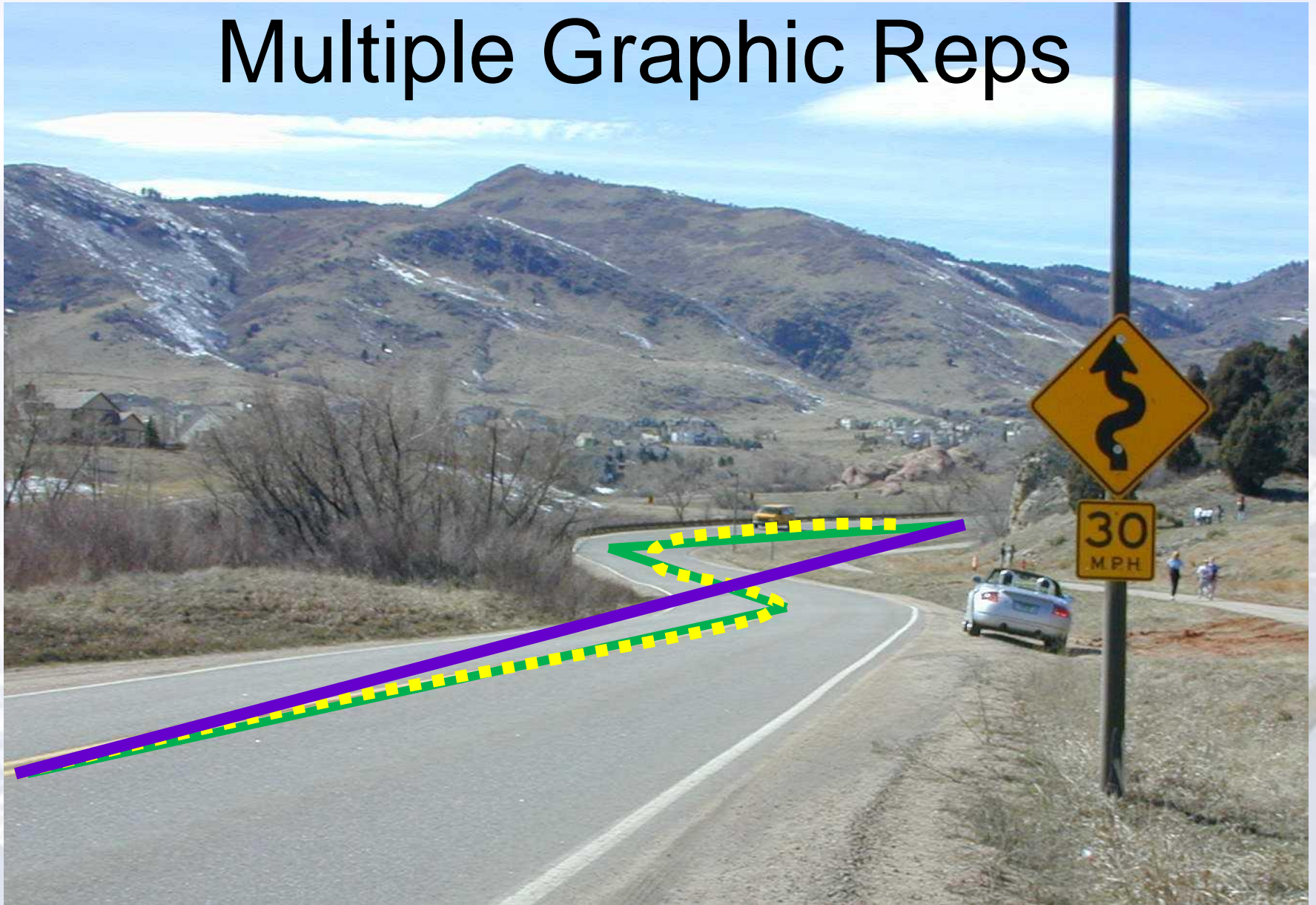
Linear Referencing Method (LRM)



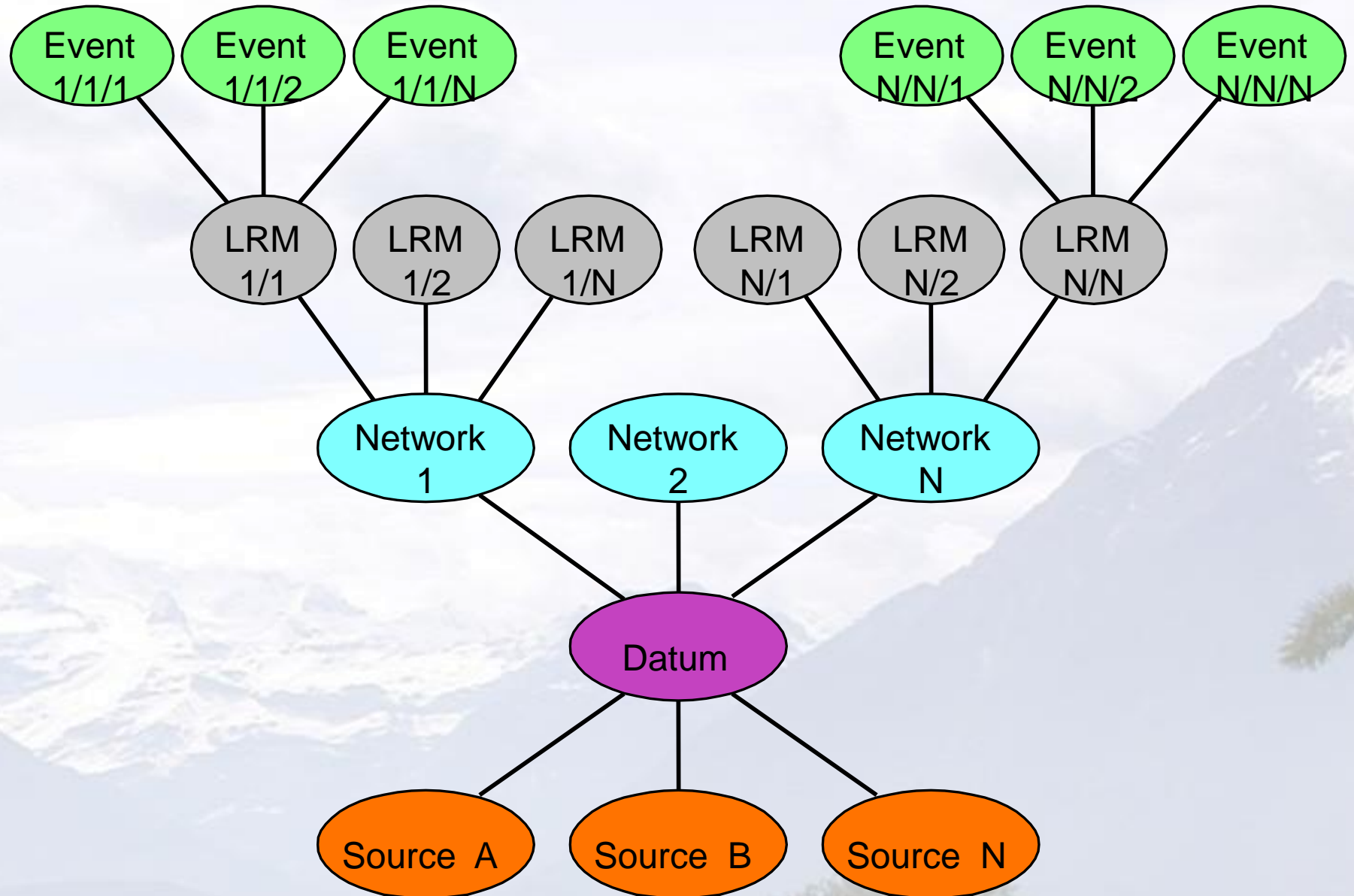
# Why linear referencing ?

- Lots of data is currently stored that way
- 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

# Multiple Graphic Reps



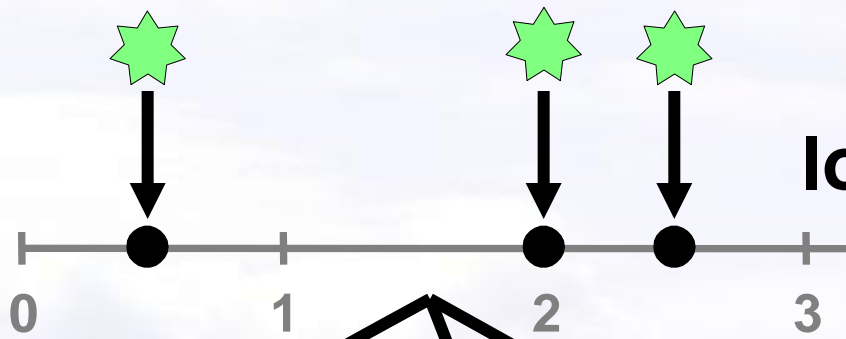
# NCHRP LRS Data Model Conceptual Overview



# NCHRP 20-27

- Seminal effort on standardizing LR
- Strengths
  - introduced the notion of a linear datum
  - separated out [0..\*] cartographic representation similar to geospatial GFM
  - topology also “separate”
  - supported point and linear “events”

# Events

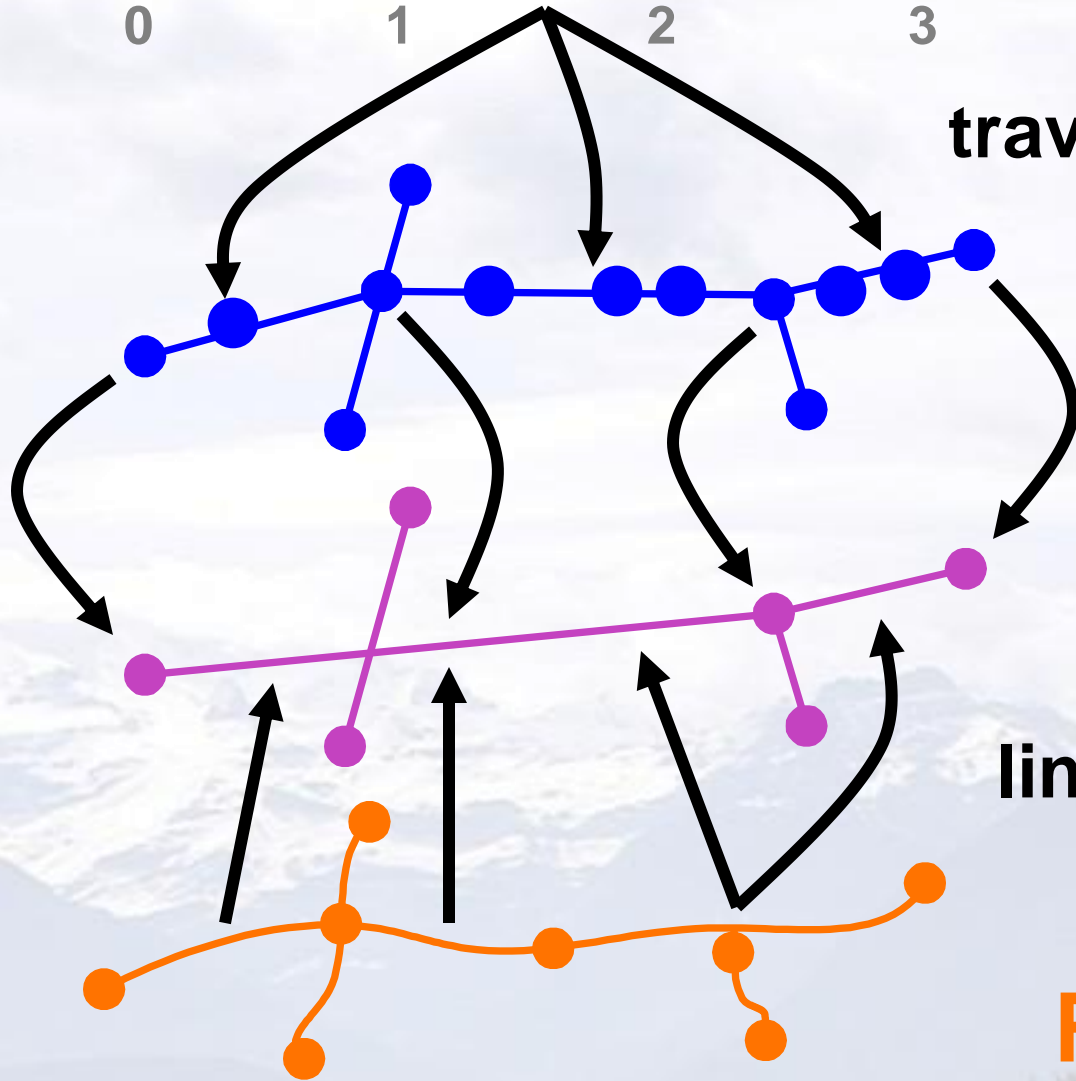


location --> TRP

LRMs

traversal --> link

# Networks



node --> anchor  
section

# Datum

line --> anchor section

# Cartographic Representations

# NCHRP 20-27

- Improvement Opportunities
  - simplify the model
  - optionalize the topology level
  - normalize events
  - eliminate extraneous nodes
  - consistently map between levels
  - allow multiple datums

# Generalized Model for Linear Referencing

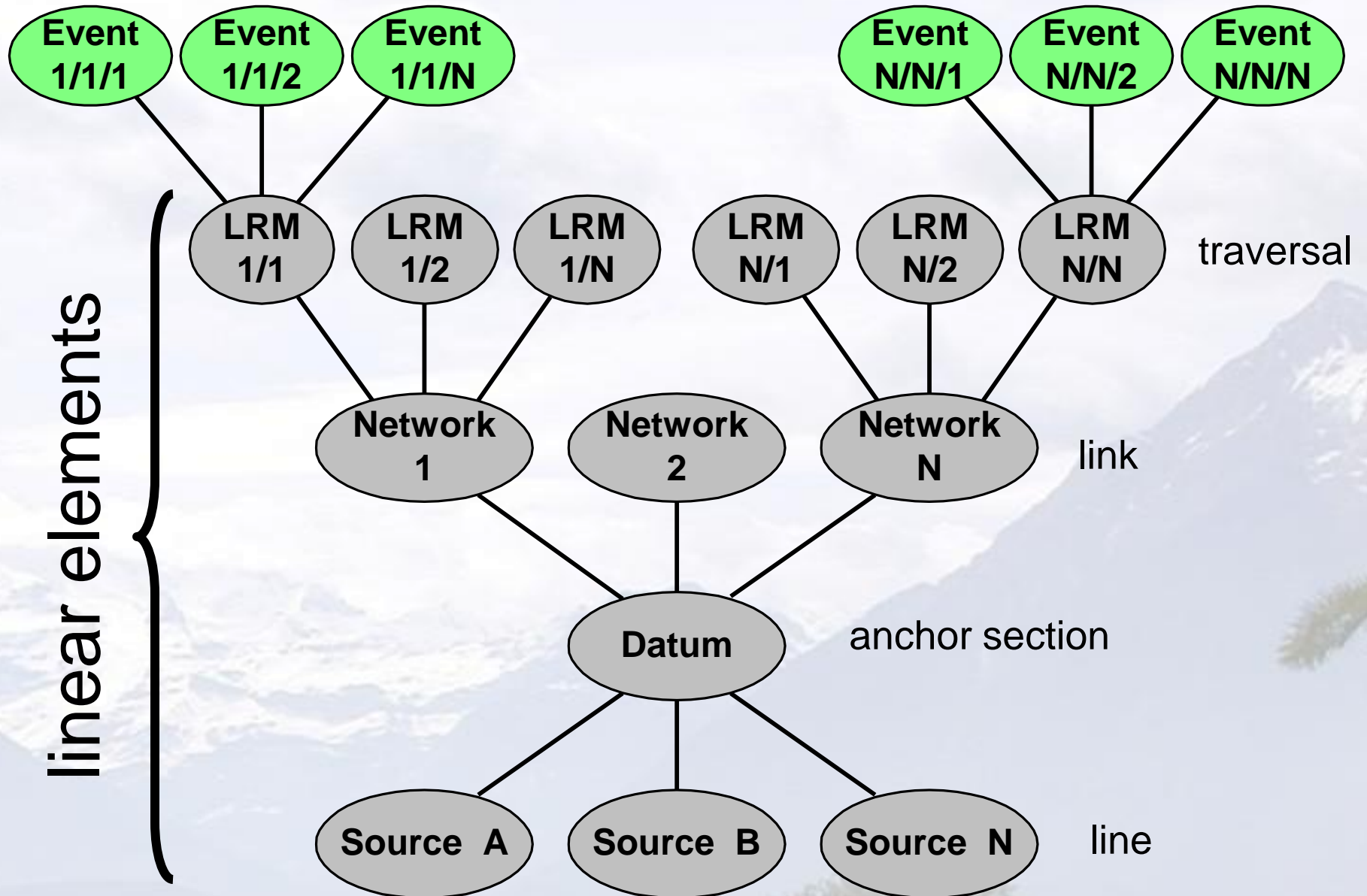
- Developed in 1998: need for simplified, COTS solution
- Introduced at GIS-T '99, San Diego
- Published for peer review in US and International, Civil and GIS Journals:
  - Journal of Computing in Civil Engineering*, Jan '01
  - Geoinformatica*, Mar '02
- Commercial Product Release (Bentley ProjectWise) 2009

# Standards Adopting the Generalized Model

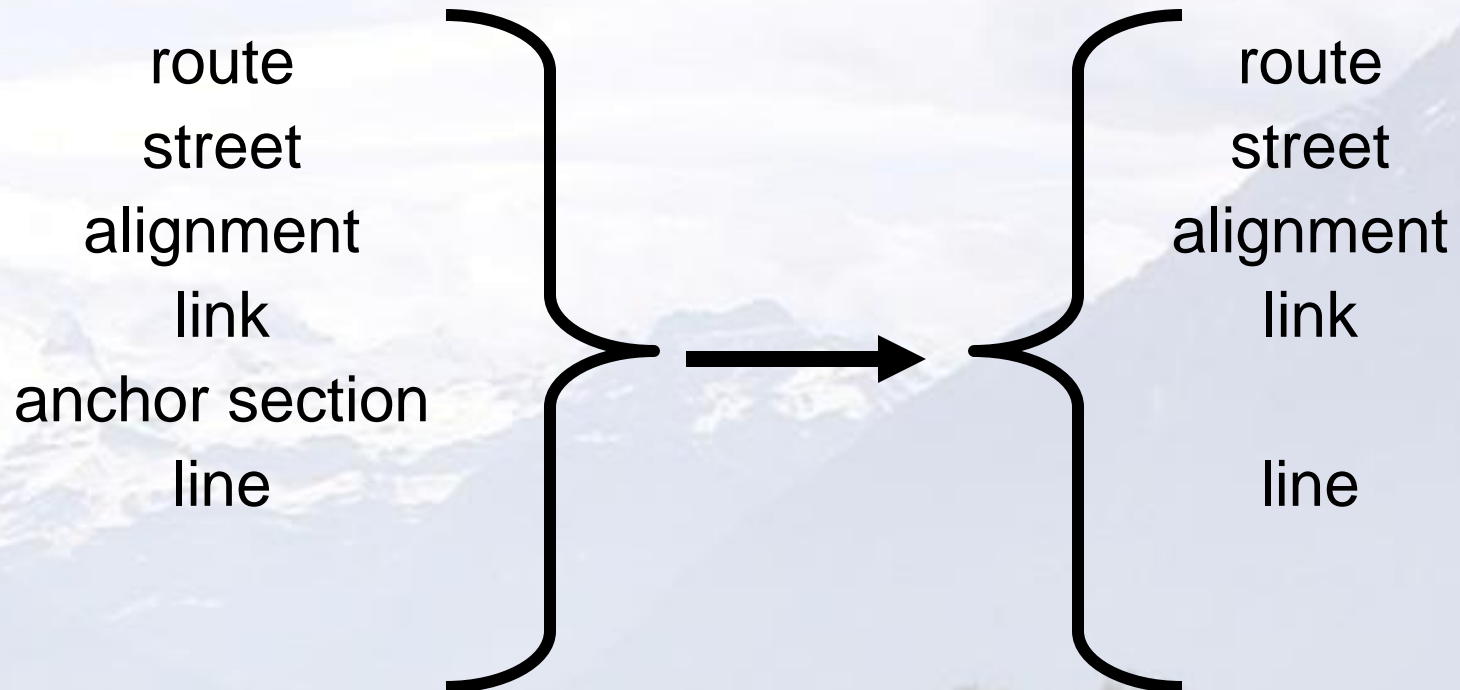
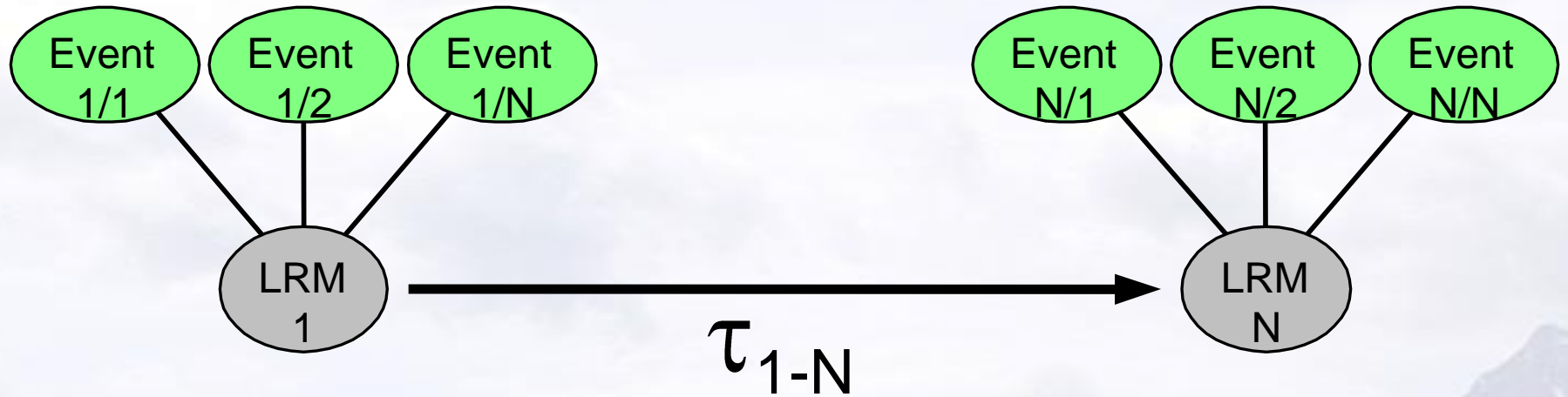
- ISO (TC211) IS 19133:2005 Clause 6.6; TRR 2005
- AASHTO TransXML, NCHRP 20-64, 2006
- FGDC STD-014-2008 Geographic Information Framework Data Standard
- ISO (TC204) IS 14825:2011, Graphic Data Files (GDF)
- ISO (TC211) IS 19148:2012 Linear referencing
- OGC Abstract Specification Topic 19
- OGC GML 3.3 (+ ISO 19136-2 pending)
- ISO/IEC 13249-3, SQL/MM Part 3: Spatial, 5<sup>th</sup> ed., (in progress) + OGC Simple Features, ISO 19125



# Generalized Model



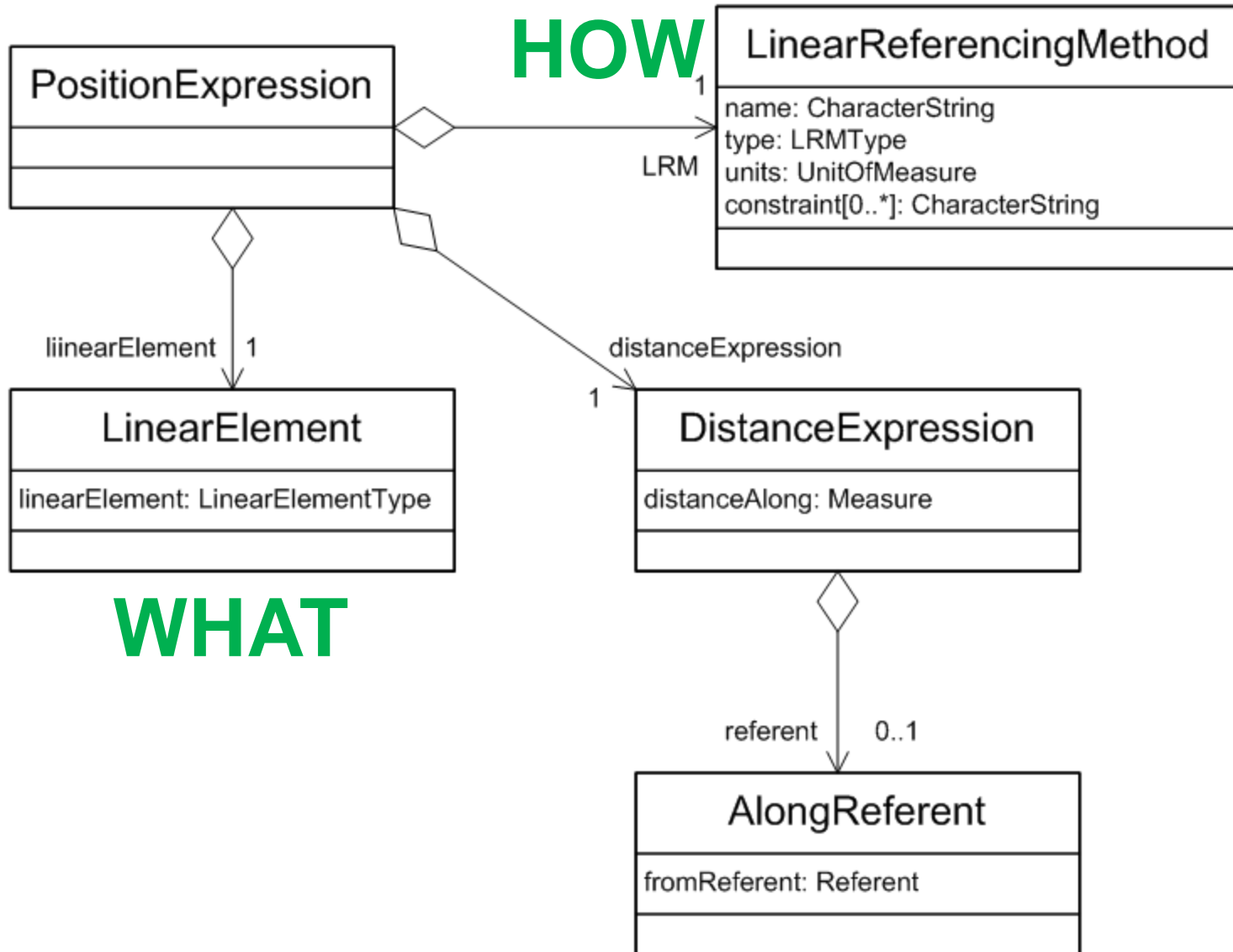
# Generalized Model



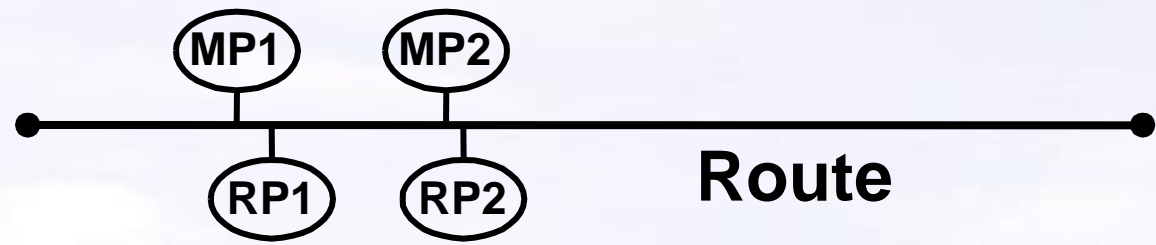
# Generalized Model: Characteristics

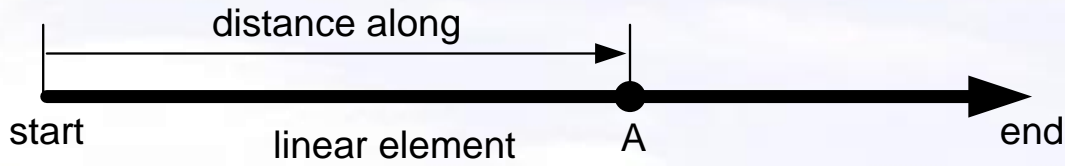
- Formalizes “linearly referenced location”, “linear element” (LE), “linear referencing method” (LRM), “distance expression”
- De-couples LE from LRM
- Focuses on LE similarities
- Enables event locations on any LE
- *Generalizes the translation process*
- Expandable for new LE and LRM types
- Supports existing IT investment in legacy data, systems, expertise and LRM selection
- Minimizes change and risk

# ISO TC211 19148 UML

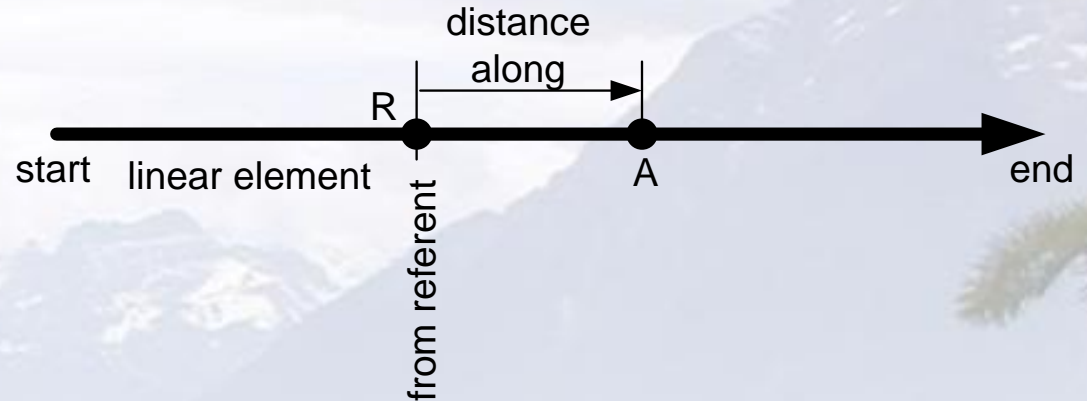
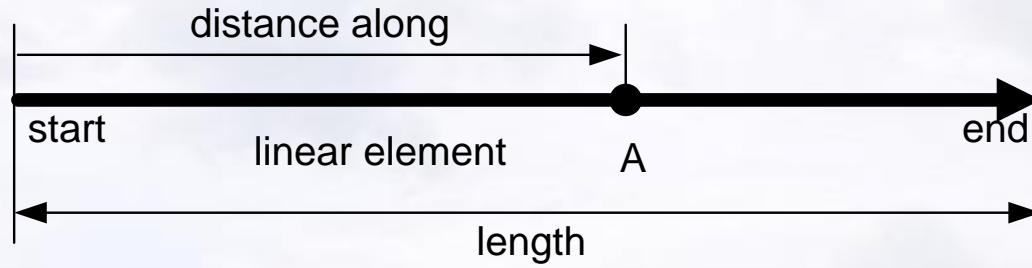


# Linear Elements





# LRM Types



# Linear Reference Methods:

**“a way  
to identify  
a specific  
location  
with  
respect to  
a known  
point”**

- **Absolute**
  - MilePoint
  - KilometerPoint
  - Stationing\*
- **Relative**
  - MilePost
  - ReferencePost
  - County MilePoint
  - CrossStreet
- **Interpolative**
  - Percentage
  - Normalized
  - Address
- **Local Interpolative**
  - M values

# Distance Expressions

50 %

4 km

2.5 miles

55

132+00

'A' 89+20

2 + .50 miles

2 + .400

© + 1.8 miles



# Linearly Referenced Locations

(**HOW: LRM**, **WHAT: LinearElement**, **Measure**)

(**MilePoint**, *Route: C-470*, **2.5** )

(**KilometerPoint**, *Route: C-470*, **4** )

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

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

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

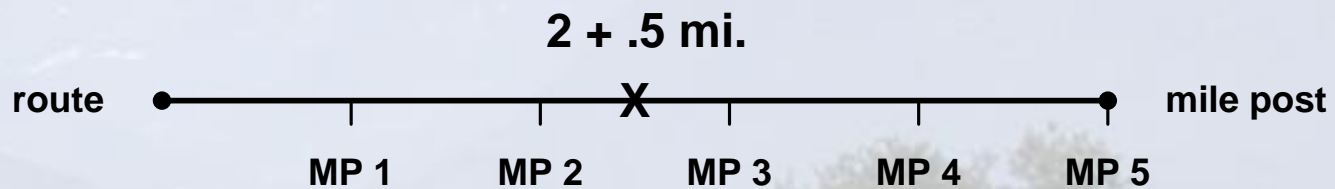
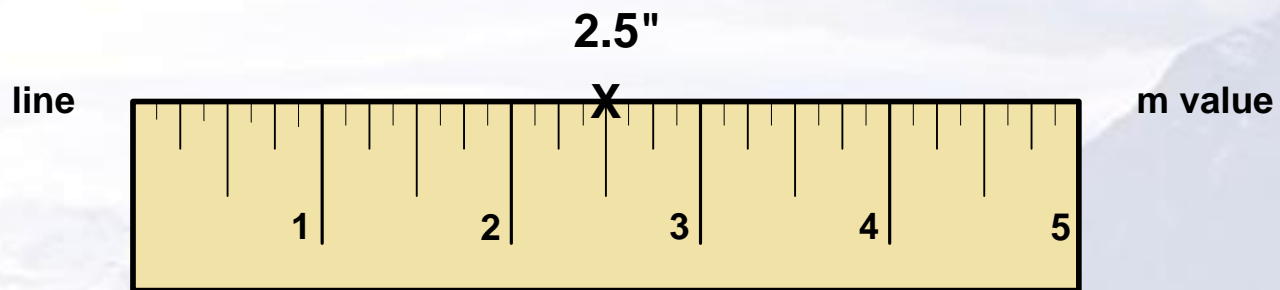
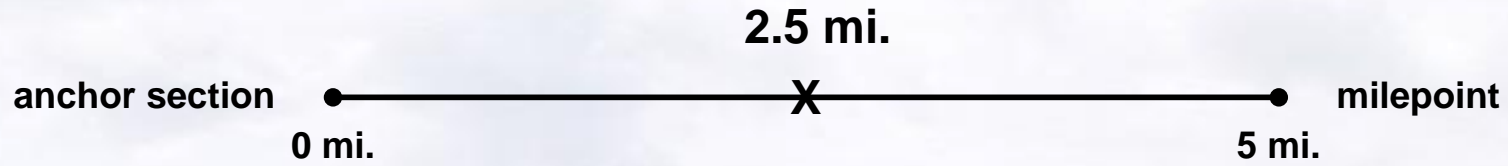
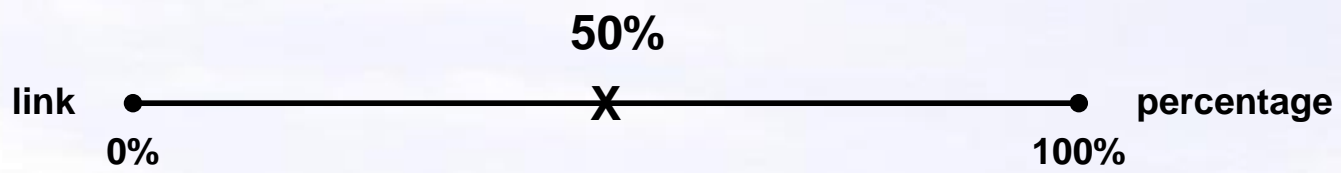
(**County MilePoint**, *Route: I-95*, **©+1.8** )

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

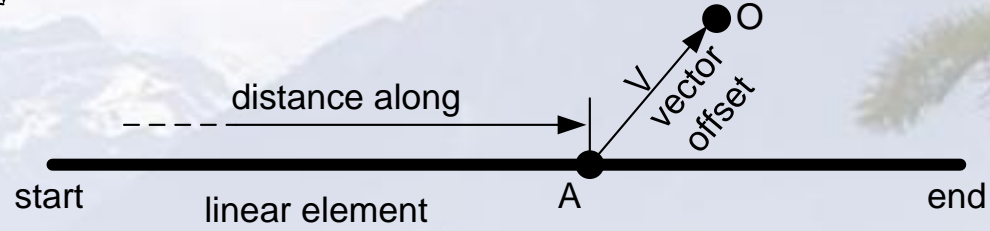
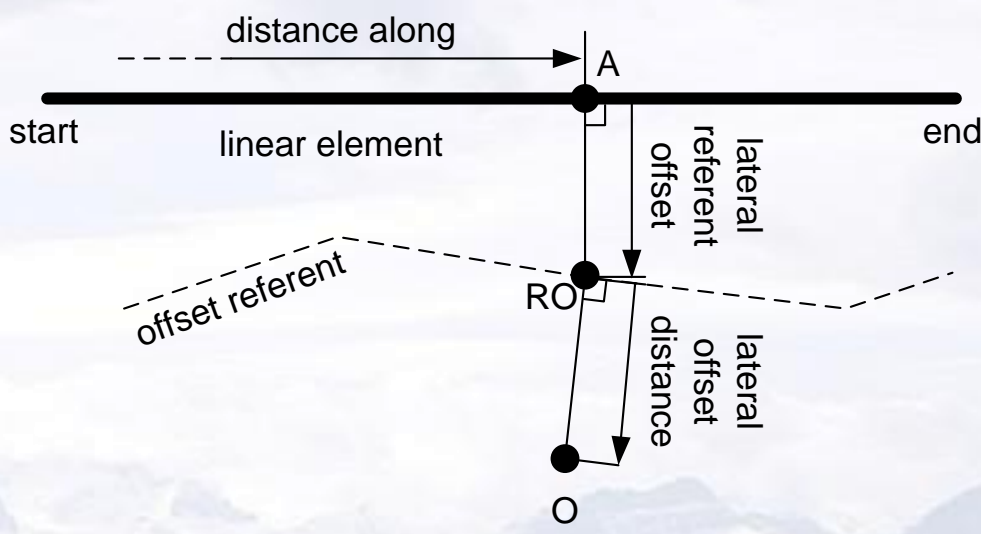
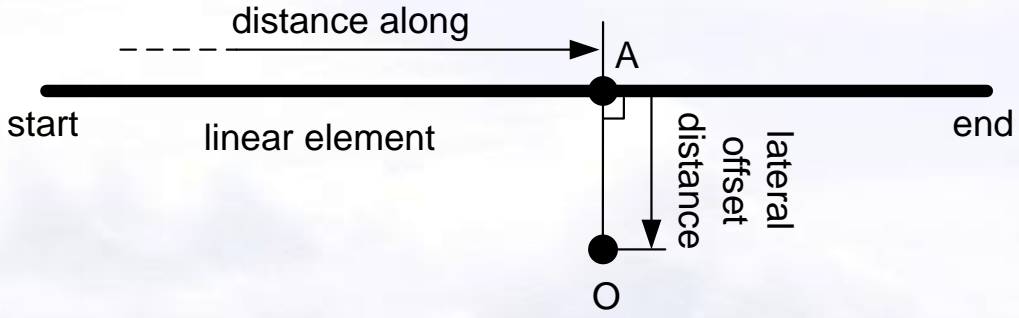
(**Address**, *Street: Smith Rd.*, **55** )

# Translations

- Between LRMs and/or Linear Elements
  - single algorithm (linear interpolation)
  - determinate, closed
  - commutative, transitive
- Between Linear and Spatial (GIS)
  - point
  - IrPosition



# Offsets



# Also in 19148

- Linearly Located Events
  - Attribute vs. Feature
  - At (Point) vs. From / To (Linear)
  - Instant vs. Period
- Segmentation
- Linear SRS

# Summary

- NCHRP 20-27 was a seminal contribution to standardizing linear referencing
- ISO IS 19148 is the new standard
- Based on Generalized Model
  - sound theoretical basis
  - widespread standards acceptance
- Can retain the “best” method for each database / application and still be able to integrate data
- For additional information:  
[paul.scarponcini@live.com](mailto:paul.scarponcini@live.com)