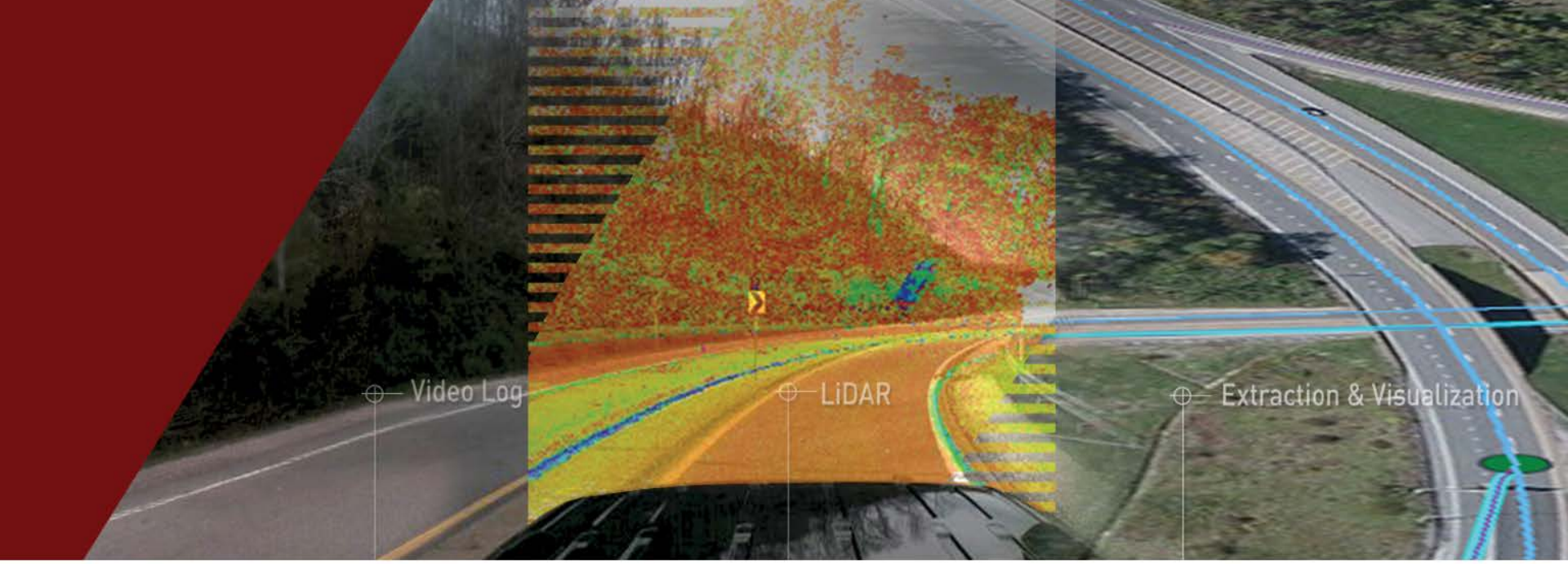


Roads and Highways as a Foundation for DOT Enterprise Data Systems

July 11, 2017

Transcend spatial solutions

Introduction

- Why are Linear Referencing Systems (LRS) a foundation for DOT data systems?
- Approaches to LRS and their evolution
- Case Study #1 – Ohio DOT
- Case Study #2 – Michigan DOT
- Case Study #3 – Iowa DOT
- Summary
- Questions

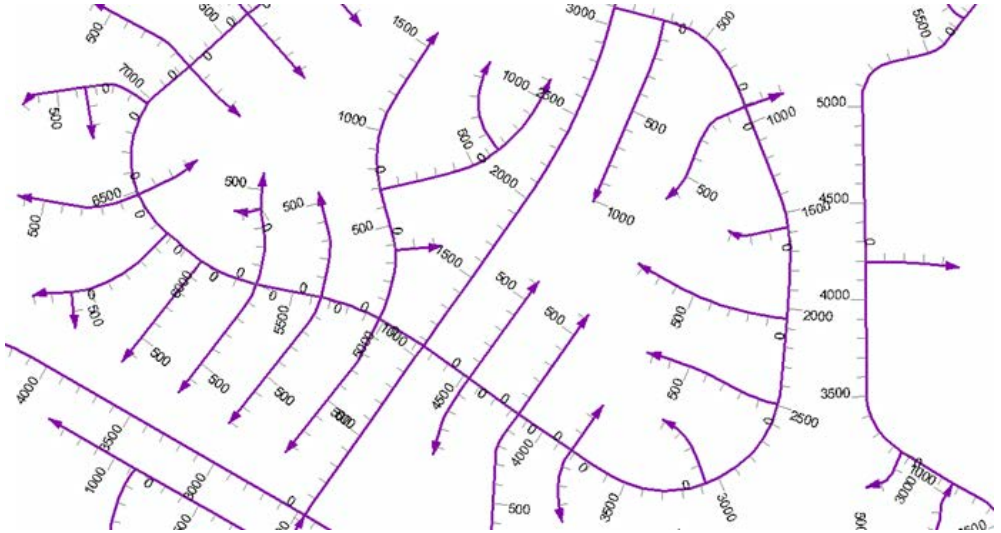
Why LRS at DOTs?

- DOTs have decades of data stored about their roads using the length of road, methods include:
  - Driven Distances – actual mileages from Distance Measuring Instruments (DMIs) in vehicles
  - Reference Post/Mile Post and Offsets – distance locations using the “green paddles” along the road
  - Project Stationing – engineering stations unique per project
  - Control Section and Offset – pavement or traffic sections with offsets for characteristic changes

- GIS Road Lengths (more recent) – leverage the more accurate GIS sources for road lengths

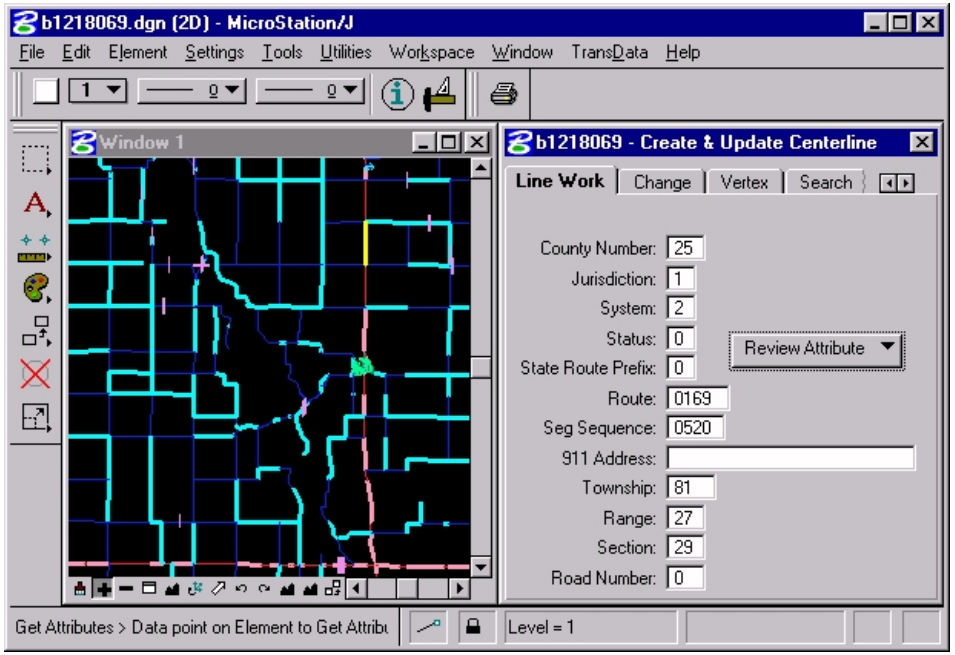
Why LRS at DOTs?

- Federal Highway Administration (US) requires LRS submission for Highway Performance Monitoring System data – road funding depends on this!!
- Easier to understand a distance along a road than a coordinate in 2D or 3D space
- Difficult to change all location systems to a new “non-linear” location method



Evolution of LRS – High-Level

- Mileages stored in a flat-file, mainframe data structure – no map or spatial component (pre 1960-1990)
- CAD Maps carried attributes along the roadway (segmented) format – begin/end measures (1980-2000)
- GIS-enable LRS maintenance software (Unix based solutions) (1985-1998)



- National Cooperative Highway Research Program (NCHRP) 20-27 - Adaptation of Geographic Information Systems for Transportation (later 20-27(2) and 20-27(3)) (1993-2001)

Evolution of LRS – High-Level

- GIS-enabled LRS maintenance software (Windows based solutions) (1995-current)
  - Still needed to maintain LRS and business data separately – manual synchronization processes
  - Temporal components of LRS still largely unaddressed
- Lots of custom solutions using the Windows GIS solutions – still had the same limitations
- Esri Roads and Highways (2011-current)
  - Addressed the synchronization of the LRS with the business data
  - Addressed the temporal components of the data
  - Provided editing of both LRS and business data

Roads and Highways Extension (R&H)

- Provided the core functionality for maintaining the LRS and the business data
- Very configurable implementation strategy
  - Can define how the network is calibrated
    - *Highly calibrated to match old driven distances*
    - *Minimally calibrated using the GIS centerline lengths*
  - Multiple LRMs
    - *Centerline becomes the "datum"*
    - *Multiple "networks" or LRMs defined along the centerlines*
  - Temporality
    - *Dates are accommodated – more "LRS dates" not "real world change dates"*
    - *User date fields can be defined that are not managed by R&H*

Case Studies

- Three DOT case studies
  - Ohio DOT
  - Michigan DOT
  - Iowa DOT
- Information is based on direct implementation experience with the three states
- Information is provided as three unique implementations for comparison, no judgement as to the best approach is inferred or intended
- Information is provided is as factual as possible, but is not vetted by the individual DOTs

Case #1 – Ohio DOT

- R&H was implemented as part of a larger road inventory improvement project – Road Information Management System (RIMS)
- ODOT has very established legacy systems that rely on the linear measurements and could NOT change the measurements between intersections
- Single LRM – mileage based on driven distance
- Migration from older technologies
  - Intergraph GeoMedia Transportation – LRS (still functional)
  - dBASE – Road Inventory (not supported)
- Complex publication process to an Oracle publication/reporting environment called the Base Transportation Referencing System (BTRS)

Case #1 – Ohio DOT

- R&H LRS Model
  - Highly calibrated to match legacy measures (calibration point at every intersection)
  - Single legacy route identifier and network (county based)
  - Publish a “State Route Milepoint” LRM
- R&H Event Data Model
  - Highly “normalized” – business data broken into many event tables
  - Official mileage carried in an event table
    - *May not match the LRS mileage*
    - *Addresses “shared mileages” between jurisdictions*
  - HPMS Sample event carries all sample attributes

Case #1 – Ohio DOT

Insert Screenshot

Case #2 – Michigan DOT

- R&H was implemented as part of a larger asset management project – Transportation Asset Management System (TAMS)
- MDOT had a separate agency that held the official LRS and had long update cycles to get official LRS updates completed
- Multiple LRMs
  - Physical Road Segment/Milepoint
  - Control Section/Milepoint
  - Route/Milepoint

Case #2 – Michigan DOT

- R&H LRS Model
  - Initially highly calibrated to match the external agency LRS, both external agency and MDOT agreed to migrate to R&H and adopt centerline length as official LRS length
  - Multiple networks and route identifiers to match LRMs
- R&H Event Data Model
  - Highly “normalized” – business data broken into many event tables
  - HPMS tables were developed independent of the TAMS project, but incorporated
    - *Very few attributes on Sample Section*
    - *Other HPMS attributes are events that will be aggregated*

Case #2 – Michigan DOT

Insert Screenshot

Case #3 – Iowa DOT

- R&H was implemented as a dedicated project to replace the legacy LRS that was developed by Iowa DOT in the late 1990's/early 2000's
  - Intergraph GeoMedia Transportation
  - Oracle/Oracle Spatial
  - Oracle Workspace Manager
  - Bentley LRSx
- Closely modelled after the NCHRP 20-27 model
  - LRSx provided the "Oracle Conflation Object"
    - *Datum (official length segment*
    - *Network (intersection-to-intersection model)*
  - Temporality was included in the model

Case #3 – Iowa DOT

- R&H LRS Model
  - Calibrated to match the legacy LRS route lengths, but did not use the centerline geometry length
  - Calibrated at the beginning and ending of routes, gaps and concurrencies
  - Official mileage derived from the LRS
- R&H Event Data Model
  - Highly “normalized” – business data broken into many event tables
  - HPMS Sample Section event was created
    - *Many attributes stored on the Sample Section*
    - *Some attributes derived from the related event tables*
- Project was focused on the HPMS submittal above all else, then other components were added

Case #3 – Iowa DOT

Insert Screenshot

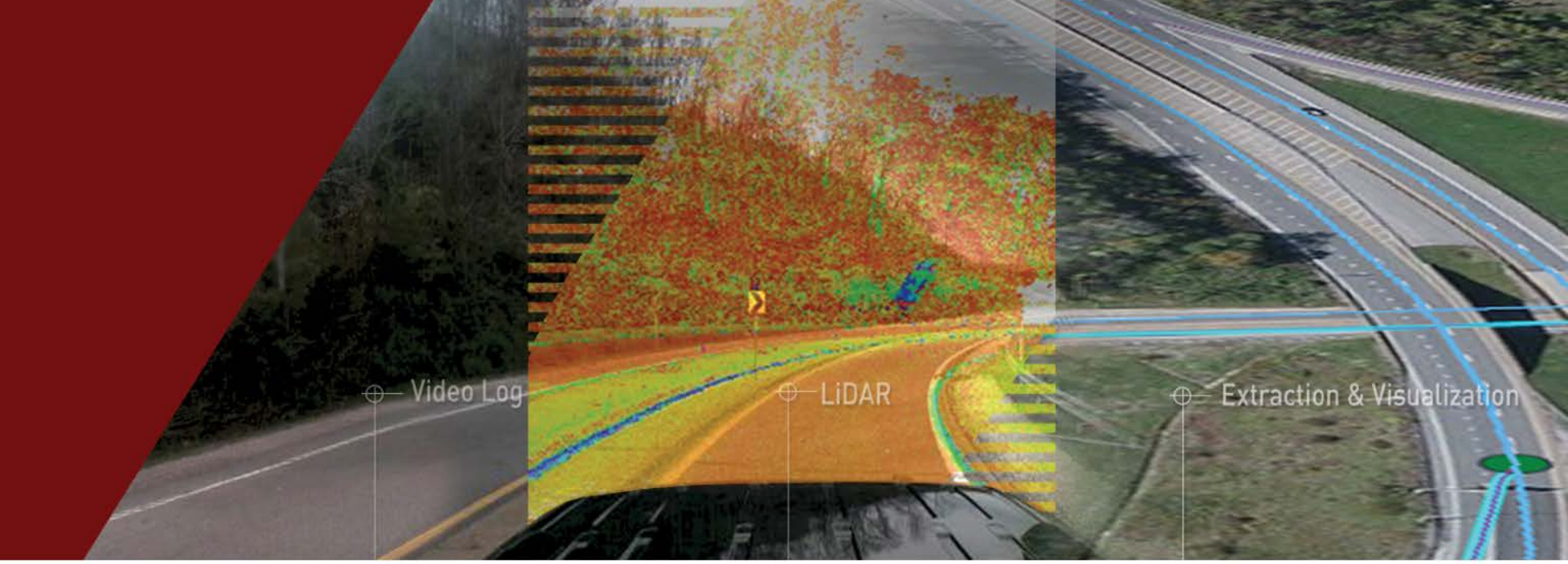
Summary

- LRS is a foundational part of DOT data systems
  - Integration via linear locations
  - Easy to understand locations
  - Legacy data is all linearly referenced
- Key issues for DOTs included:
  - LRS and business data had to be manually kept in sync
  - Temporal changes to LRS/business data was not available
- Roads and Highways Extension
  - Addressed the LRS/business data synchronization
    - *Internal tables*
    - *External tables*
  - Date attribution integrated into all aspects of LRS
  - Full featured GIS capabilities available with the LRS

Summary

- Other Esri extensions integrate into LRS maintenance solution
  - Workflow Manager Extension
  - Data Review Extension
  - Roadway Reporter
- Other add-ins from business partners
  - Transcend Road Analyzer
    - *Straight Line Diagramming*
    - *Video Log integration*
  - Transcend Productivity Tools
    - *Intersection Manager – MIRE intersection data extraction/maintenance*
    - *Segment Analyzer – Robust dynamic segmentation tools via web app*
    - *Validation Assistant – Event/business data validation via web app*
    - *Report Engine – Database reporting via web app*

Questions



THANK YOU!

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