Roads and Highways as a Foundation for DOT Enterprise Data Systems

July 11, 2017
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)
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
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 LRM
  - *Centerline becomes the “datum”*
  - *Multiple “networks” or LRM 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
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
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 LRMIs
- 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 LRM

- **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
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
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
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
THANK YOU!