Iowa’s Multi-Level Linear Referencing System

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ABSTRACT

The Iowa Department of Transportation’s Linear Referencing System (LRS) has been recognized as an advance in transportation technology by the American Association of State Highway and Transportation Officials’ Technology Innovation Group. Iowa is in the first year of a three technology innovation grant to assist states in implementation of the NCHRP 20-27(2) LRS model.

The purpose of an LRS is to accurately place business data located by a Linear Referencing Method (LRM) on a cartographic representation of a transportation feature. Examples of LRMs are milepoint, milepost, coordinate route, and literal description. Iowa’s LRS consists of a spatial accurate centerline, temporal location of transportation systems, datum objects, a network layer, and routes.

The PowerPoint presentation will discuss:

1. What is the LRS
   a. Conceptual model
   b. Iowa’s implementation
2. Why did Iowa develop the system
   a. Business data integration
   b. Improved accuracy in both space and time
3. What Iowa gained from its development
   a. Centralized location component for transportation system location
   b. Navigable network
4. Lessons learned
   a. What we did right
   b. What we might do differently
5. Questions

Iowa has made multiple presentations at the Geographic Information System (GIS) for Transportation Symposium since 2000, had webinars with the Illinois Tollway Authority and the Montana Department of Transportation, and was visited by the Minnesota Department of Transportation.

Key words: asset management—data needs—GIS applications—integration
Iowa’s Multi Level Linear Referencing System
August 20, 2009
Agenda

- Iowa DOT participants
- Definitions
- Why Iowa chose NCHRP 20-27 Model
- How Iowa implemented its MLLRS
- Architecture
- What Iowa is gaining from the MLLRS
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Linear Referencing System (LRS)

A set of procedures and methods for specifying a location as a distance, or offset, along a linear feature, from a point with known location.
“The requirements for a comprehensive location referencing system data model encompass all the elements and abstractions for the multidimensional representation of events and objects. The data model must be able to represent objects and events in the form or dimension in which they occur in the real world, whether it be one-dimensional (e.g. guard rail), two-dimensional (e.g. a parking lot), or three-dimensional (e.g. an interchange). Additionally, without the incorporation of the fourth dimension (time), much of the data collected, analyzed, and reported become useless because all real-world objects are referenced by their state in time. An object may be permanent, but its characteristics change with time and, therefore, the object evolves with time.”

“Functional Requirements for a Comprehensive Transportation Location Referencing System”
Teresa M. Adams, Nicholas Koncz and Alan P. Vonderohe
University of Wisconsin-Madison, Madison, WI 53706
Business Reasons to Update Iowa’s LRS

- Needed to improve spatial representation
- Use NCHRP (20-27) project model
- Need ability to integrate variety of data
  - Coordinate route referenced data (Lat, Long, US 20)
  - Mile post referenced data (US 30 @ 135.23)
  - Literal description data (2.51 mi past 1st St)
  - Mile point (IA 27 115.11 miles from Missouri, IA 76 24.22 miles from Adams County border)
- Need to provide a navigable network
- Improve temporal location of data
Why Iowa chose NCHRP 20-27 Model
Spatial Resolution Improved
for all 114,000 miles of public roads
NCHRP 20-27 Model

LRS Components

Coordinate Route
Reference Post
Coordinate Route
Milepoint
Stationing
Literal Description
Address Range

Centerline Representation 1
Centerline Representation 2
Centerline Representation 3
NCHRP 20-27 Components

- Datum
  - Anchor Points, Anchor Sections
- Network (navigable)
  - Transport Nodes, Transport Links
  - Routes
- Location Referencing Methods
  - Coordinate Route, Reference Post, Mile Point, Literal Description
  - Segmental, Stationing, Addresses
- Multiple Cartographic Representations
  - Travelled Way Spatial, Roadway Spatial
Location Referencing Method

LRM -
Different methods of measuring linear locations; (Coordinate Route, Reference Post, Mile point, Literal Description, Segmental, Stationing, Address Ranges, etc.)
Transformation between LRM

A common linear description of the network that can relate all the methods.
Navigable Network

Embargo
LANL's "NetworkX" package
http://networkx.lanl.gov/
Navigable Network
Shortest Path
LANL's "NetworkX" package
http://networkx.lanl.gov/
Temporal Resolution
US 67 Davenport 12/31/2002 to 12/31/2005
How Iowa Implemented It’s MLLRS
Oracle Requirements & Additions

- SDO Geometry
- EDL (addition)
- ILX (addition)
- LDMx
Oracle SDO (Spatial Data Option)

- A schema that prescribes the storage, syntax, and semantics of supported geometric data types.
- A spatial indexing system.
- Operators, functions, and procedures for performing area-of-interest queries, spatial join queries, and other spatial analysis operations.
- Functions and procedures for utility and tuning operations.
- A topology data model for working with data about nodes, edges, and faces in a topology.
- A network data model for representing capabilities or objects (modeled as nodes and links) in a network.
- A GeoRaster feature to store, index, query, analyze, and deliver GeoRaster data (raster image and gridded data and its associated metadata).
Effective Date Lineage (EDL) Iowa LRS enhancement

- Added Effective end and start dates to all features
- Added Lineage parent/child relationships to selected features
- Added temporal functionality to GeoMedia and Oracle
Iowa DOT LRS (ILX)

- Published SQL API
- Business Logic Internal JAVA API
- Transformation Engine
  - Linear Feature Classes
  - LRM Management Modules
- Maintenance
  - Change Propagation Engine (CPE)
  - Maintenance Module
  - Units and Precision
- Data Abstraction Layer
Bentley LDMx

- Published SQL API
- Business Logic Internal JAVA API
Why use COTS (Oracle & GeoMedia Pro)

- Ability to store data in a vendor neutral environment
- Ability to use database functionality to do both spatial and database queries using SQL
- Leverage existing feature creation functionality in a GIS
- Control costs by enhancing robust software
Maintenance Tool

Custom Components added to GeoMedia Pro & GeoMedia TM
Maintenance Tool
Change Propagation Engine

- Propagates spatial accuracy changes to dependent features
- Propagates conflation relationships to dependent features
- Propagates temporal changes to dependent features
- Retires features when features they depend upon are retired
Maintenance Tool
Quality Control

- QC_Test table provides user control of
  - QA tests descriptions (text appearing in log)
  - Precision of the test (how close a feature is required to be to pass)
    - Proximity distance
    - Length vs conflation percentage
  - Whether or not the test will be performed
  - What kind of check
    - Error (must be corrected)
    - Warning (must be looked at and accepted/corrected)
What Iowa is gaining from the MLLRS
Snow Runs

- Verify all routes are covered and how many miles does each maintenance garage cover
- Look into route optimization
- Store snow run data in a master Excel file
  - Change file to store route in well formed LRS format
  - Transformed Excel file to Oracle to produce geometries
Missing Snow Runs
Iowa Five Year Program

- Office of Program Management responsible for Iowa DOT 5 Year Program
- Uses LRS to locate project locations
  - IDMS System stores reference post and business data
  - Process in place to transfer data to Oracle and transform reference post locations to geometry
  - Geometry created automatically!
- Analysis can be done with GIS software, SQL statements
- Provide shape and Google Earth files for public for consumption
Iowa Five Year Program
Iowa Five Year Program
Sign Inventory

- Collect location with GPS or Reference Post
  - Collect using well formed route (US 69 or I 35)
  - Use location and Route to locate sign on LRS network
- Data and geometry stored in Oracle
- Scripts developed to produce geometry from well formed location component