Lessons Learned in LRS Migration
NMDOT’s ARNOLD Project

April 24, 2019
Who is ARNOLD?
Famous Arnolds
Project Background
ARNOLD Program Overview

Phase 1: FHWA Pooled Fund Study
- Create statewide LRS network that complies with MAP-21 requirements
- Combine NMDOT legacy LRS network currently housed in TIMS with the following sources:
  - E911
  - ProMiles
  - Navajo
  - Federal (BLM, USFS, BIA, NPS, USCOE, Army, BOR, DOE & FWS)
- Establish processes to identify and incorporate network changes

Project Timeline
- Start: Nov, 2014
- Complete: 5/1/2016
- Project Phase
  - Closed - July, 2016

Phase 2: Stand up Esri R&H and Migrate TIMS Data
- Stand up Esri R&H test and production environments
- Migrate Phase 1 LRS to Esri environments
- Migrate TIMS asset data, including Bridge, Traffic & HPMS Data (some data sourced from Mandli)
- Terminate TIMS

Project Timeline
- Start: Aug, 2016
- Complete: August, 2018
- Project Phase
  - Closed - August 2018

Phase 3: Connect Other LRS-Dependent Systems and Data Sources
- Prioritize interfaces for other NMDOT systems to connect to Phase 2 Esri R&H Implementation
- Includes the following systems:
  - Pavement Management
  - Maintenance Management
  - STIP
  - Traffic
  - Bridge Management
  - Outdoor Advertising
  - Right of Way
  - Crash

Project Timeline
- Start: Oct/Nov, 2017
- Complete: TBD
- Project Phase
  - In progress
NMDOT Network Progression

Pre Phase 1

After Phase 1
## Objectives

- Increased efficiency and productivity through a well-managed Linear Referencing System (LRS).
- Optimized business processes.
- Lower cost of government.

- Improve reporting capability.
- Manage roadway information in an industry standard solution. Migrate to a COTS system with an architecture that will allow future interface with NMDOT asset management systems.

- Facilitate a common data structure which will allow later data linkage with asset data requirements such as pavement, bridge, crash, traffic monitoring data, roadway inventory assets, maintenance data, FMIS and HSIP data.

- System complies with all applicable NMDOT security, business continuity, and redundancy requirements.

- Project does not exceed budget and remains on schedule.
Phase 2
Technical Approach
Project Implementation

• Phase 1 Data Assessment
• Project Workshop/Kickoff
• Develop Initial R&H database model
• Provide System Architecture Recommendations
• Data Migration
• Calibrate LRS
• Configure and Test R&H model and components
• On-site Implementation
  • 2 Weeks of System Configuration and Testing
  • SLD Implementation
  • HPMS QA/QC Tool Implementation
• Training & Support
  • 1 Week Comprehensive R&H (Desktop and EE)
  • 1 Week Supporting Tools (WMX, Geoprocessing, Admin)
  • 3 Weeks Staff Onsite during Production Transition
Route ID Management

Original Recommendation
– Use Existing Route ID Construct
• Route ID “USX-84-P-182.0-O”
  • ID is broken down into 5 components
    • Route Group USX
    • Route Number 84
    • Route Direction P
    • Interchange Location 182.0
    • Ramp Element O

Character Separator capability was removed between 10.3 and 10.4
Design Considerations

Route ID Management
Alternatives: I-25

• **Option 1 - Single Field ID - “IX-25-P-100.0B”**
  - Retain current structure/format
  - Could be error prone as the ID would be manually entered each time.
  - Fields for route dominance would have to be entered separately (duplicate data entry)

• **Option 2 - New Fixed Width ID - “INT000025P100.0B”**
  - Supports route dominance rules - contributing columns can be used for dominance and can be populated using domains.
  - Ability to query routes by contributing categories or positional searches of the Route ID field.
  - Requires re-adoption of new scheme by GIS/HPMS, and other business integration points.
  - Could require revision of route types and other components to have common widths, or add additional padding.
  - Hard to read/interpret
  - Would have to expand out to include Interchange/Ramp elements for all routes, adding confusion where these elements are not required

• **Option 3 - New ID with separators removed - “IX25P100.0B”**
  - Easiest to implement – concatenate existing fields with no padding required.
  - Format similar to current structure
  - Ability to query routes by contributing fields
  - Route Dominance rules enabled with contributing fields
  - Easiest to implement for business systems integration.
  - Requires re-adoption of new scheme by GIS/HPMS, and other business integration points.
  - Slightly harder to read

• **Implemented Option 3 along with a separate Display ID field to store the current format, but created from a trigger or post process after route is created with Options 2 and 3.**
Data Model

- 45 Events
  - 38 Linear Events
  - 5 Point Events
  - 3 Planned Events
- 68 Domains
- 2 Related Tables
### HPMS Data Items

Source of Assets: HwmsDataItemLoadSourceToRH10-26-2015.xlsx

This tab contains the HPMS data items that we covered while PMG & Mandl were onsite at NMDOT the week of Sept. 22nd. Please review and revise, where necessary. Please pay particular attention to those marked with a "?" as these items were to be revised.

<table>
<thead>
<tr>
<th>HPMS #</th>
<th>Data Item Name</th>
<th>Include in R&amp;H Data Model</th>
<th>Original Data Source</th>
<th>Table.Column</th>
<th>Data Type</th>
<th>Code List?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Functional Sys</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Urban Code</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Facility Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### MIRE Roadway Segment Descriptors (Items 1-106) - Updated 2/6/2017

* Indicates MIRE Fundamental Data Element

TBD - These MIRE elements will not be modeled during this phase of the project. It is anticipated that they will be modeled during the design of a future MIRE application.

NOTE: The MIRE elements are comprised of three categories: Roadway Segment Descriptors, Roadway Alignment Descriptors and Roadway Junction Descriptors. This spreadsheet only covers the Roadway Segment Descriptors. It is anticipated that the remaining 2 categories will be modeled during the design of a future MIRE application.

<table>
<thead>
<tr>
<th>MIRE Number</th>
<th>MIRE Element</th>
<th>RIS R&amp;H Database</th>
<th>Notes/Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Segment Location/Linkage Elements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>County Name</td>
<td>FIPSCounty.FIPSCountyCode</td>
<td>This will be the description associated with the county code.</td>
</tr>
<tr>
<td>2</td>
<td>County Code</td>
<td>FIPSCounty.FIPSCountyCode</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Highway District</td>
<td>District.District</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>*Type of Governmental Ownership</td>
<td>Ownership.Ownership</td>
<td>John to talk to Phil about source data.</td>
</tr>
<tr>
<td>5</td>
<td>Specific Governmental Ownership</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>City/Local Jurisdiction Name</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>City/Local Jurisdiction Urban Code</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>*Route Number</td>
<td>Routelnformation.RouteNumber</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>*Route/Street Name</td>
<td>Streetname.Streetname</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>*Begin Point Segment Descriptor</td>
<td>Route.ToFromMeasure</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>*End Point Segment Descriptor</td>
<td>Route.ToMeasure</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>*Segment Identifier</td>
<td>Route.RouteID</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>*Segment Length</td>
<td>Route.ToMeasure - Route.FromMeasure</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Route Signing</td>
<td>Routelnformation.RouteSigning</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Route Signing Qualifier</td>
<td>RouteQualifier.RouteQualifier</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Coinciding Route Indicator</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Coinciding Route – Minor Route Information</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>*Direction of Inventory</td>
<td>Route.CardinalDirection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Segment Roadway Classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>*Functional Class</td>
<td>Pystem.FunctionalClass</td>
<td></td>
</tr>
</tbody>
</table>
System Architecture

NMDOT
Phase 2 System Architecture Concept

NMDOT Central Office Data Center

Publication
- ArcGIS Server
- Web Adaptor
- IIS
- SOL Server 2016
- Enterprise Geodatabase

Production
- Web Adaptor
- ArcGIS Server
- SOL Server 2016
- R&H Geodatabase

Staging
- ArcGIS Server
- Web Adaptor
- R&H Server
- SOL Server
- R&H Geodatabase

Field Crews (Mobile)
- Field Data Synchronization

District Offices
- Web Viewers
- And Event Editor

HPMS Editors
- Road Inventory
- General Users
- Pavement
- Traffic

Public Web Viewers
- ArcGIS Online Services

Web Viewers
- Traffic

Web Apps and Viewers
- Event Editor WMX

Viewers and Web Services
- R&H Desktop WMX

Web Services
Establish Migration and Calibration Processes

MigrationTools.tbx

1. Create FGDB with LRS Templates
2. Copy Source Features to LRS DB
3. Change Route Field Name to DisplayID
4. Add Temporal Dates to Source
5. Calculate From Dates
6. Copy and Load from Template
7. Get Route List
8. Add Editor Tracking Fields
9. Add Event ID
10. Alter Field Name
11. Calculate Creation Date and User
12. Calculate EGDB Measure Differences
13. Calculate FGDB Measure Differences
14. Calculate Route Dominance
15. Copy Loader Tables
16. Delete Temp Fields
17. Enable Editor Tracking
18. Extract Location Errors
19. Fix RouteID Field Name
20. Load Domains
21. Migrate Events
22. Project to UTM
23. Purge Loader Tables
24. Set Projection
Data Migration
Network Calibration

Multi-Pass Process to ensure event migration without data loss

1. Create and Calibrate On-System Network
   • Use Fixed Measures from TIMS network
   • Established a detailed set of calibration points
   • Used the “Frankenstein” Method to bring the network to life
   • Migrate events to temporary TIMS network

2. Create Local Network
   • Load routes and use geometry calibration

3. Merge Networks
   • Load routes from Local Network to TIMS Network

4. Update selected routes with Mandli calibration
   • Enable matching of field collected data to the new route network

5. Update ~200 selected routes manually
   • Match measurements of gapped M side routes to P side
   • Match measurements to handle concurrent, dominance, and subordinance for US and State routes
Implementation

R&H Desktop

NMDOT Initial Workflow
- Integrated Route and Event Edit Workflow
- Calls both Desktop and Web
  - ArcMap/WMX applications
  - Roads&Highways
  - Editing tools
  - Event Editor
- Handles Version Management

WMX

Event Editor w/ SLD
Training and Support

Overview of Demo/Exercises

Setup Exercise – Enabling Extensions and Toolbars
1. Exercise 1 – Creating a new route (Create Route)
2. Exercise 2 – Adding length to a route (Extend Route)
3. Exercise 3 – Characterizing a route using route and measure
4. Exercise 4 – Creating new point events
5. Exercise 5 – Selecting, modifying, and exporting events
6. Exercise 6 – Redlining routes
7. Exercise 7 – Checking events
8. Exercise 8 – Creating attribute sets
9. Exercise 9 – Selecting routes and returning attribute sets

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- Integrated Route and Event Edit Workflow
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Quick Start for Creating New Routes
Steps:
1. Start WMX job
2. Say Yes to perform Network Edits
3. Add the Timberon Feature Class from the Training ODB
4. Find the route/street using the Timberon Feature Class attribute table
5. Choose the centerline(s) to be applied to routes
   - Ensure proper order of selection
   - Flip direction if necessary
6. Click Create Route button
7. Assign effective date as 4/6/2018
8. Assign route ID
9. Add in additional attributes
   - Route Dominance – Other
   - Caliberation Type – Shore Length
   - Cardinal Direction
10. Confirm measures
11. Click Apply
12. Save, Reconcile, and Post

NOTE: The attributes are unpopulated and must be filled in by the editor. If a redline is chosen, one or more attributes will be prepopulated.

L. Populate the window with the following attributes:
   - Start Date: 7/12/2018
   - Route ID: Click
   - Route Group: UCD-Local
   - Route Number: 20333
   - Route Direction: P - Positive
   - Interchange Location: NULL
   - Ramp Element: NULL

G. Digitize a new centerline using ArcGIS editing tools as in the example circled and highlighted below.

H. Once the centerline is digitized:
1. From the tab bar, select the Editor tab
2. From the left side, select Create Route
3. Once the Create Route window is open,
   - Click On
   - Measures should be automatically populated. If they are not, use the next steps to calculate the measures.
   - From Measure 0
Project Post Mortem
Accomplishments, Return on Investment, and Lessons Learned
Project Accomplishments

► Compliance with FHWA All Roads Network of Linear Referenced Data requirements.
► Data Repository for Roadway Information modernized and easily maintainable.
► Legacy (TIMS) Oracle Databases retired.
► Data cleanup of existing data, before it was imported into new system, minimized churn at GoLive and improved overall accuracy of system from Day 1.
► Having Linear System and Roadway Characteristics in an industry-standard platform. More people have access to the network and it enables better/faster integrations to support other agency strategic initiatives for data visualization, to improve transparency.
► System has built-in validation rules and tracks changes with date snap. Data, including historical data, is more accessible.
► Event Editor and Straight Line Diagram provides NMDOT a simple interface for updating event data, to easily attribute a highway.
NMDOT Network Progression

Pre Phase 1

After Phase 1

Current State
Return On Investment

Current ROI projection
• $274K per year average cost to use the new system, which includes yearly maintenance, licensing, and all direct and indirect costs associated with use.
• The average cost to use the legacy TIMS system was ~$683K per year.
• Based on these cost savings, this project will have paid for itself in ~2 years.

Business Process Optimization
• 50% reduction in staff hours to perform QA/QC of data and respond to data requests
• 90% reduction in business team staff hours to generate HPMS and Annual Certified Mileage submittals, and support other federal reporting for bridge, traffic, etc.
• 20% reduction in contract services

Further reduction in Agency Oracle footprint
• Eliminated 2 legacy Oracle databases and 2 Oracle WebLogic servers
• ~1/10th the cost to run new system versus legacy TIMS system
• Efficiency of project standup allowed elimination of legacy system ~1 year earlier than projected, saving an additional $98K
Lessons Learned

► Strong project management processes amongst all sub-teams, and strong team collaboration, contributed to project progress during critical federal reporting timelines and schedule bottlenecks.

► Clear prioritization of data cleanup that was needed to ensure system integrity and maintainability, as well as use of subject matter experts to perform priority cleanups, allowed project team to optimize time for these tasks.

► Frequent review of schedule performance and active management of issues, risks and schedule on a weekly (and sometimes more frequent) basis ensured the project remained on-track.

► The project team tightly managed scope and stakeholder expectations to ensure any scope change requests were evaluated quickly and interim solutions could be defined with the requestors. This allowed the project to maintain scope integrity and keep to the timeline.

► Team noted that creating an email alias that included all project team members and stakeholders would have streamlined communications.
Lessons Learned

► Extensive preplanning to identify required data, and involvement of stakeholders in kickoff, ensured clarity of requirements during development of the schema.

► Has met all requirements and is flexible, given changes are expected over time. For example, the initial system meets MIRE 1.0 requirements for federal reporting, but during the project timeline, MIRE 2.0 was adopted, which has more extensive data requirements.

► Very few schema changes were identified during the course of the project indicating few requirement gaps.

► Our IT project management and GIS team were very supportive throughout project, and the GIS team ensured a smooth transition to GoLive server stand-up and support.

► Work stoppage due to State Purchasing State Price Agreement issues required a contract amendment.
Yolanda Duran Todd

Chief, Data Management Bureau
NMDOT
NMDOT
505.827.0961
505.470.1977

Yolanda.Duran@state.nm.us
Todd.Howell@state.nm.us

David Harrison Troy
Marsh, GISP
Project Manager
Project Manager
Mandli Communications
PMG Software

608-316-0510
678.576.5844

ddh@mandli.com
Troy.Marsh@pmgpro.com
While Visiting New Mexico
Check out these famous landmarks!

- Rent a RV!
- Walter White’s house
- Hank Schrader’s House
- The Dog House
- Saul Goodman’s Office
- Octopus Car Wash
- Twisters (Los Pollos Hermanos)
- Crossroads Motel (The Crystal Palace)
Famous Arnolds