Introduction & Agenda

- CDOT Stats
- Colorado Risk Based Asset Management Plan and Trade-Off Analysis
- Maintenance Asset Management and Maintenance Levels of Service Program
- How CDOT-DHM is Collecting Data
- What Data is Being Collected
- Expanding Data Beyond Inventory and the future of Data Collection
- Further Discussion & Questions
**Purpose**
To save lives and make lives better by providing freedom, connection and experience through travel.

**Values**
Safety, people, integrity, customer service, excellence and respect are at the heart of all that we do.

**Summit**
The best DOT in the country for all customers by focusing on our people, leading-edge technology and a healthy multi-modal system.

**Peaks**
- **Technology**
  - Help Our People with Technology
  - Improve Travel Experience with Technology
- **People**
  - Internal Customer Focus
  - Develop Leaders
- **System**
  - Asset Condition
  - Improve Customer Experience

**Base Camps**
- Big Data
What Does CDOT Do?

CDOT Responsibilities

- Administers $208 million each year in federal grants
- 3,454 bridges
- CDOT maintains & operates 23,000 total lane miles of highway
- Division of transit and rail administers fed/state grants and operates Bustang
- 6.1 million miles plowed of snow per year
- 35 mountain passes open year-round

Source: Colorado Department of Transportation, 2014
CDOT Asset Management
Risk Based Asset Management Plan

CDOT’s Risk-Based Asset Management Plan

final plan

prepared for
Colorado Department of Transportation
prepared by
Cambridge Systematics, Inc.

Larry Redd, P.E.

December 9, 2013
CDOT Asset Management

Asset Management Oversight Structure

Figure 5.1 CDOT Transportation Asset Management Organizational Structure

CDOT Transportation Asset Management (TAM) Structure

Transportation Commission

Transportation Commission Asset Management Committee

TAM Oversight Committee

TAM Working Committee

Asset Investment Management System Task Force
Asset Management Pilot Selection Task Force
Tunnel Task Force
Risk Task Force
Maintenance Operations and Traffic Operations Task Force (MCTO)

Source: CDOT

2/10/2014
11 Asset Programs in CDOT’s Risk Based Asset Management Plan

- MLOS
- Surface Treatment
- Bridge
- Signals
- ITS
- Rock Fall
- Equipment
- Property Management
- Culverts
- Tunnels
- Walls
AIMS Performance Curve

Pavements - Percent High/Moderate Drivability Life
Fiscally Constrained Target is 80%

- AIMS Cross Asset FY20 Recommendation: $x Million
- FY20 Request: $260 Million
Priority 1 – Treatments Plants, Route Segments, Maintenance Yards

Priority 2 – Guardrails and End Treatments, Traffic Signals, Rock Fall Protection Devices, Traffic Controllers, Runaway Ramps, Fences, Drainage Structures, Walls, Culverts, Road Closure Gates


Priority 5 – Divided Highway Crossovers, Power Supply Connection Points, Curb Ramps, Sidewalks, Game Crossings, Streambeds in ROW, Blank Out Signs, Cattle Guards, In-ground Pull Boxes, Landscaping Acreage
How are you collecting data?

• **Collection Methods**
  - Field - visit and collect using GPS, tools, and mobile devices
  - Remote - visual identification, measure, location

• **Data Update**
  - Maintenance employees
  - Regular inspections
  - Revisit every few years - build new inventory
  - Surveys and As-Built data
How is Data Collected?

- **LIDAR**
  Mobile Laser Mapping System, an optical sensing technology, determines the position, orientation, and other characteristics of pavement and roadside objects.

- **PAVE3D TEXTURE (Option 2)**
  Pave3D sensors calculate full lane width texture measured in 5 AASHTO standards.

- **PAVEMENT DISTRESS**
  The ARAN’s Pave3D subsystem collects 3D profile data, which is used for automated distress detection and image display.

- **RUTTING**
  The Pave3D System accurately measures the transverse profile of the road with 4000 points over 4 meters.

- **ROUGHNESS**
  The Laser SDP measures longitudinal road profile in real-time Class I roughness index calculation.

- **TEXTURE (Option 1)**
  Smart Texture measures the mean profile depth of the road surface macrotexture.

- **RIGHT-OF-WAY VIDEO**
  ARANs can be outfitted with up to six 4K cameras to capture right-of-way images, allowing a virtual road view from the comfort and safety of an office.

- **GPR**
  Ground Penetrating Radar detects changes in road structure, including material thickness, composition, and condition.

- **POSITIONING – INERTIAL**
  Provides real-time ARAN position and orientation tracking, combining data from tactical-grade fiber optic gyro, accelerometers, differential GPS and DMI.

- **POSITIONING – GPS**
  ARANs are equipped with a differential Global Positioning System integrated with a DMI and Inertial Measurement System that will fill in the gaps in the event of lost satellite reception.

- **POSITIONING – DMI**
  The Distance Measuring Instrument measures linear distance travelled. It also acts as a GPS position backup, in the event of a poor satellite connection, the DMI and Inertial Reference System will fill in the gaps.

- **Two vans started collection in January and should complete collection by May**
Current Condition of Pavements

**High/Moderate/Low Drivability Life**

- 82% DL > 3
- 14% DL 4 - 10
- 18% DL <= 3

**Entire Statewide Network**

**2013 Condition Distribution**

<table>
<thead>
<tr>
<th></th>
<th>HIGH DL&gt;10</th>
<th>MODERATE DL 4-10</th>
<th>LOW DL&lt;=3</th>
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<td>Statewide</td>
<td>14%</td>
<td>68%</td>
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<td>Interstate</td>
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<td>52%</td>
<td>14%</td>
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<td>NHS</td>
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<tr>
<td>Other</td>
<td>3%</td>
<td>75%</td>
<td>22%</td>
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</table>

**Drivability Life**

- HIGH - 14% - 1537 Data Collection Miles
- MODERATE - 68% - 7467 Data Collection Miles
- LOW - 18% - 1977 Data Collection Miles

Created: 9/23/2013
Example: Highway 076A, Milepost 35.9–40.5
- 2000 Concrete construction
- AADT = 11,000 AADT Combination Trucks = 1,634
- DL = 17 Years

Recommendation:
2021 Preventive Maintenance $218,000 per mile
2032 Minor Rehab $870,000 per mile
Bridge Condition Assessments

- Bridge inspections completed by Staff Bridge inspectors
- Inspection results entered into BrM
- All bridges inspected every 2 years
- Inspection results shared with Maintenance for performance-based budgeting
- Bridge rating scales defined by Staff Bridge
- Critical bridge repair list provided to Maintenance
- Manual data entry into SAP

Future Plans

- Create interface between SAP and BrM to:
  - Auto-populate inspection data
  - Automatically create notifications in SAP for critical bridge repairs
  - Eliminate manual data entry
CDOT Collaboration

Purpose of Project

• Annually collect roadway condition data and images for all state maintained highways and off-system NHS routes (roughly 12,000 miles a year)
• The condition data is used for federal reporting by Pavement Management and HPMS reporting
• Pavement Management uses data to calculate Drivability Life metric, maintenance calculations, and project selection
• Make pavement condition data and images available for all of CDOT and the public to use

Stakeholders

• Pavement Management
• Division of Transportation Development
  • Data Management Unit (HPMS)
  • GIS Support Unit (Imagery)
• Division of Highway Maintenance
Where Can You Find This Data?

CDOT Online Transportation Information System
This is the access point to information frequently used for transportation planning and project development. Information is provided on current and projected traffic volumes, state highway attributes, summary roadway statistics, demographics and geographic data.

What's new?
2016 roadway imagery and condition data now available in Windshield/Videolog
DRAPP 2016 aerial imagery now available in MapView (Internal Only)
• **# of Vehicular Tunnels**: 39 total  
  - On-System 20 vehicular, 2 closed  
  - Off- System 11 with 6 closed

• **Types of Tunnels:**  
  - Rock Lined  
  - Cast in Place Lined  
  - Shotcrete Lined

• **Max Elevation**: 11,158 ft with avg snowfall of 380 inches

• **Asset Valuation Efforts**: $1.8B
Plan of Action

• Year 1
  • Figure out program
  • Implementation support meeting
  • Analyze different options

• Year 2
  • Implementation of NDT technique
Finding areas of interest and comparing to confirm effectiveness.
• Maintenance section staff are also responsible for conducting periodic field inventories to ensure that a complete data inventory of maintainable roadway and roadside features (such as box culverts, curb and gutter, and lighting) is available.
Funding Maintenance: Elements of LOS-Based Funding

- Current Annual Expenditures and Unit Costs & Adjustments
- Current Asset Inventories
- Current Annual Accomplishments
- Current Levels of Service

Target Level of Effort → Level of Effort Factors → New Annual Work Plan → New Annual Budget
6 of 9 MPA’s included in the Budget Model that are performance-based and have sound performance data.

- 150-Roadway Surface - 14%
- 200-Roadside Facilities - 9%
- 250-Roadside Appearance - 4%
- 300-Traffic Services - 24%
- 350-Structure Maintenance - 2%
- 450-Buildings and Equipment - 7%

3 of the 9 MPA’s do not have sound performance-based targets for this model

- 100-Planning and Training - 6%
- 400-Snow and Ice Removal - 30%
- 500-Tunnels - 2%

Managed Corridors - 1%
## MLOS Performance Goals and Results

### Maintenance Levels of Service by Program Area

<table>
<thead>
<tr>
<th>Maintenance Program Area Description</th>
<th>Funding Needed for ‘A’ Rating</th>
<th>Budget FY2016-17 Funding</th>
<th>FY 2013-14 Budget</th>
<th>FY 2014-15 Actual</th>
<th>FY 2016-17 Projected</th>
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<td>Planning, Training and Scheduling</td>
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<td>Traffic Services</td>
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<td>Bridges &amp; Structures</td>
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<td>Snow &amp; Ice</td>
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<td>Service Equipment, Buildings &amp; Grounds</td>
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<td>C-</td>
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<td>Tunnels</td>
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<td>$6.2M</td>
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<td>B-</td>
<td>C+</td>
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<td>US 36 (mtc. contract)</td>
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<td>OVERALL MLOS</td>
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</table>
MLOS Actual Performance Trends


B+  B  B  B  B  B+  B-  B-  B-  B-  B-  B-  B  B  B-  C+
Overview - Condition Assessments

- There are 6 MLOS condition assessments conducted each year.
  - Roadway Surface Remote Data Collection
  - Bridge Inspections
  - Winter (October through March) - snow and ice control
  - Night Inspections
  - Summer (Last week of June) - all infrastructure
  - Buildings, Grounds and Rest Areas

- Winter surveys are conducted by all employees during storms.
- Night inspections are conducted quarterly starting in July. All assets that reflect or give off light are assessed.
- Summer surveys are conducted by 8 survey teams outside their own maintenance section.
- Buildings, grounds and rest areas assessments conducted by Property Management.
Condition Assessments

• Creating a more objective condition data model
  • Using quarterly night-inspection for specific assets
  • Leveraging Pavement Management condition data and allowing Pavement Management to define levels of service rating scales
  • Measuring sample length/quantity vs. deficiency in sample
Asset Condition Surveys
Maintenance and Surface Treatment

Condition Assessments by CDOT Staff

- Annual pavement condition data collection by Maintenance employees
- Random survey locations, assessing 3/10th of a mile for pavement defects
- Subjective ratings
- Manual data entry into the SAP system
- Safety concerns having employees in right-of-way

Remote Condition Data Collection

- Annual pavement condition data collection as part of the Long-Term Pavement Performance (LTPP) program
- 100% pavement condition collected
- Leveraging IRI, rutting and photo images for
  - Longitudinal cracking
  - Transverse cracking
  - Fatigue cracking
  - Rut depth
  - Faulting
  - Potholes
Winter Condition Surveys

Winter Condition Assessments

- Time to bare pavement after snow fall ends
- Grading scales differ based on highway category
- All maintenance employees plowing provide time to bare pavement data
- Data used to populate Snow LOS Map

<table>
<thead>
<tr>
<th>Category 1</th>
<th>Category 2</th>
<th>Category 3</th>
<th>Category 4</th>
<th>Category 5</th>
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<td>&gt; 16 Hours</td>
<td>&gt; 24 Hours</td>
<td>&gt; 72 Hours</td>
</tr>
</tbody>
</table>

**HIGHWAY CATEGORY DESIGNATIONS**

- Category 1: Interstate, > 75,000 ADT
- Category 2: Interstate, 15,000 – 75,000 ADT
- Category 3: Interstate, < 15,000 ADT
- Category 4: NHS, > 75,000 ADT
- Category 5: NHS, 15,000 – 75,000 ADT
- Category 6: NHS, < 15,000 ADT
- Category 7: Other, > 50,000 ADT
- Category 8: Other, 5,000 – 50,000 ADT
- Category 9: Other < 5,000 ADT
- Category 10: Mountain Passes (Non-Interstate)
- Category 11: Seasonal Highways (Mt. Evans and Independence Pass) (No survey on Cat 11 highways for winter maintenance)
**Expanding Data Beyond Inventory**

**Winter Condition Surveys**

### MPA: Snow and Ice Control

<table>
<thead>
<tr>
<th>Illustrations</th>
<th>LOS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="LOS A Illustration" /></td>
<td>A</td>
<td>Plowing and chemicals or abrasives applications proactively maintain very high levels of mobility throughout storms (refer to accompanying tables). Snow drifts and localized ice patches are treated quickly to avoid closures and hazards. Proactive avalanche control minimizes traffic interruptions and avoids unanticipated road closures.</td>
</tr>
<tr>
<td><img src="image" alt="LOS B Illustration" /></td>
<td>B</td>
<td>Plowing and abrasives or chemicals applications maintain high levels of mobility as much as possible (refer to accompanying tables). Snow drifts and localized ice patches may be treated during storm with abrasives or chemicals. Proactive avalanche control minimizes traffic interruptions and avoids unanticipated road closures.</td>
</tr>
<tr>
<td><img src="image" alt="LOS C Illustration" /></td>
<td>C</td>
<td>Plowing and abrasives or chemicals applications maintain good levels of mobility on high-standard roads (refer to accompanying tables). Snow drifts and localized ice patches are treated as soon as possible at end of storm. Avalanche control focuses on high-priority locations and situations.</td>
</tr>
<tr>
<td><img src="image" alt="LOS D Illustration" /></td>
<td>D</td>
<td>Plowing and abrasives or chemicals applications are performed on limited basis, and some traffic delays are anticipated on all roads (refer to accompanying tables). Snow drifts and localized ice patches are treated after mainline roads are cleared. Limited avalanche control is performed. Chain station operation may be scaled back.</td>
</tr>
<tr>
<td><img src="image" alt="Living Snow Fence Illustration" /></td>
<td>F</td>
<td>Plowing and abrasives or chemicals applications are performed on very limited basis, impairing mobility on all roads (refer to accompanying tables). Snow drifts and localized ice patches may not be treated for some time. No preventive avalanche control is performed. Chain station operations are scaled back or suspended.</td>
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Expanding Data Beyond Inventory
Winter Snow Map
Expanding Data Beyond Inventory
Maintenance Night Inspections

Current Process

### Night Inspection Form

<table>
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<tr>
<th>Patrol No.</th>
<th>Route:</th>
<th>Begin MP:</th>
<th>End MP:</th>
<th>Date</th>
<th>Survey Team:</th>
<th>Roadway Elements</th>
</tr>
</thead>
</table>

#### Roadway Elements

<table>
<thead>
<tr>
<th>Mile Post</th>
<th>Delineators</th>
<th>Guardrail Delineators</th>
<th>Signs</th>
<th>Roadway Lighting</th>
<th>Tunnel Lights</th>
<th>Flashing Beacons</th>
<th>Shoulder Line Visibility</th>
<th>Center Line Visibility</th>
<th>Stencil Visibility</th>
<th>Road Closure Gates</th>
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<tbody>
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</tbody>
</table>

#### Comments

- Please include the mile post(s) and asset you are referring to in your comments.
- Guardrail end treatments stickers need replaced
- Hospital sign needs replaced at exit 30
- Exit 30 speed 30
- 26 lights out along interstate

### Night Inspection Form

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<td>reflectivity</td>
<td>reflectivity</td>
<td>out</td>
<td>out</td>
<td>good</td>
<td>fair</td>
<td>good</td>
<td>fair</td>
<td>reflectivity</td>
</tr>
</tbody>
</table>

#### Comments

- Please include the mile post(s) and asset you are referring to in your comments.
- Guardrail end treatments stickers need replaced
- Hospital sign needs replaced at exit 30
- Exit 30 speed 30
- 26 lights out along interstate

### Night Inspection Form

<table>
<thead>
<tr>
<th>Mile Post</th>
<th>Delineators</th>
<th>Guardrail Delineators</th>
<th>Signs</th>
<th>Roadway Lighting</th>
<th>Tunnel Lights</th>
<th>Flashing Beacons</th>
<th>Shoulder Line Visibility</th>
<th>Center Line Visibility</th>
<th>Stencil Visibility</th>
<th>Road Closure Gates</th>
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<tbody>
<tr>
<td>96.3 n/b</td>
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<td>missing</td>
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<td>fair</td>
<td>good function</td>
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<tr>
<td></td>
<td>button</td>
<td>reflectivity</td>
<td>reflectivity</td>
<td>out</td>
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<td>fair</td>
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<tr>
<td>100.1 n/b</td>
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<td>fair</td>
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<td>99.8 n/b</td>
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<td>100 n/b fr</td>
<td>button</td>
<td>reflectivity</td>
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<td>missing</td>
<td>good</td>
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<td>94.769</td>
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<td>damaged</td>
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<tr>
<td>102.161</td>
<td>button</td>
<td>reflectivity</td>
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<td>good</td>
<td>fair</td>
<td>good</td>
<td>fair</td>
<td>reflectivity</td>
</tr>
</tbody>
</table>

#### Comments

- Please include the mile post(s) and asset you are referring to in your comments.
- Guardrail end treatments stickers need replaced
- Hospital sign needs replaced at exit 30
- Exit 30 speed 30
- 26 lights out along interstate
Expanding Data Beyond Inventory

Maintenance Night Inspections

Future Process
Over 800 1/10th mile random survey locations

- Boots on the ground assessments of:
  - Shoulder drop-offs
  - Drop inlets and catch basins
  - Pipes and culverts
  - Ditches and streambeds
  - Slopes
  - Fence, gates and cattle guards
  - Snow fence
  - Retaining walls

- Litter and debris
- Roadway sweeping
- Mowing and vegetation
- Brush and trees
- Signs
- Delineators
- Metal guardrail
- Concrete guardrail
- Cable guardrail
- End Treatments
- Impact attenuators
- Roadway lighting
How Ratings are Set: Condition Assessment Surveys

- Specific questions and measurements are made for each asset
- Survey over 800 randomly selected 1/10th mile road segments every year
## LOS Target Setting Results - Traffic Services Example

<table>
<thead>
<tr>
<th>Asset Group</th>
<th>Asset Feature</th>
<th>Current LOS</th>
<th>Target LOS</th>
<th>Target FY</th>
<th>Yrs to Target</th>
<th>Activity</th>
<th>Description</th>
<th>Labor</th>
<th>Equipment</th>
<th>Materials</th>
<th>Other</th>
<th>Total</th>
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<tbody>
<tr>
<td><strong>Traffic Services</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Traffic Signs</td>
<td>B+</td>
<td>B+</td>
<td>2018</td>
<td></td>
<td>1</td>
<td>302 Single Post Signs - Install &amp; Replace</td>
<td>2,473,306 $853,564 $1,100,914 $5,965 $4,033,751</td>
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<td>303 Multi Post Signs - Install &amp; Replace</td>
<td>528,925 $232,434 $388,083 $1,264,059 $2,432,493</td>
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<tr>
<td></td>
<td>A</td>
<td>B+</td>
<td>2018</td>
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<td>304 Delineator Post Install &amp; Replace</td>
<td>2,330,584 $747,779 $710,425 $636 $3,769,574</td>
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<tr>
<td></td>
<td>A</td>
<td>B+</td>
<td>2018</td>
<td></td>
<td>1</td>
<td>305 Metal Guard Rail Install &amp; Replace</td>
<td>1,421,157 $408,439 $951,056 $96,653 $2,529,263</td>
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<tr>
<td></td>
<td>A+</td>
<td>B+</td>
<td>2018</td>
<td></td>
<td>1</td>
<td>306 Concrete Rail Mts Install &amp; Straighten</td>
<td>1,421,157 $408,439 $951,056 $96,653 $2,529,263</td>
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<tr>
<td>Cable Guardrail</td>
<td>A</td>
<td>B+</td>
<td>2018</td>
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<td>350 Cable Rail Mts &amp; Install &amp; Repair</td>
<td>424,824 $110,006 $678,899 $65 $129,374</td>
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<td>Striping</td>
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<td>2020</td>
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<td>308 Pavement Striping - Machine</td>
<td>$2,229,023 $1,714,503 $14,304,588 $9,375,425 $27,820,640</td>
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<td>Markings</td>
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<td>312 Roadway &amp; Sign Lighting</td>
<td>636,891 $359,569 $1,360,141 $10,035 $2,368,326</td>
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<td></td>
<td>A</td>
<td>C</td>
<td>2018</td>
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<td>326 Traffic Signal Interconnect Systems</td>
<td>167,708 $73,568 $1,451,364 $ - $1,802,640</td>
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<td>Energy Attenuators</td>
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<td>2018</td>
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<td>Electrical Systems, Wire</td>
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<td>B</td>
<td>2018</td>
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<td>320 Electrical Wiring - Repair &amp; Install</td>
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<tr>
<td>ITS Equipment</td>
<td>A</td>
<td>B</td>
<td>2018</td>
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<td>321 Intelligent Transport Systems</td>
<td>75,823 $8,765 $22,652 $ - $107,239</td>
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<tr>
<td>MPA 300 Summary</td>
<td>C+</td>
<td>C+</td>
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<td></td>
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</tbody>
</table>

**Annual Budget (For LOS-Rated Assets Only)**
### Striping Example

#### 3 Year Target

<table>
<thead>
<tr>
<th>LOS Target</th>
<th>Labor</th>
<th>Equipment</th>
<th>Materials</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-</td>
<td>$2,017,634</td>
<td>$1,586,704</td>
<td>$13,397,427</td>
<td>$8,794,257</td>
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<tr>
<td>C</td>
<td>$2,226,023</td>
<td>$1,714,503</td>
<td>$14,304,588</td>
<td>$9,375,425</td>
<td>$27,620,540</td>
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<tr>
<td>C+</td>
<td>$2,434,413</td>
<td>$1,842,302</td>
<td>$15,211,750</td>
<td>$9,956,593</td>
<td>$29,445,058</td>
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<tr>
<td>B-</td>
<td>$2,642,802</td>
<td>$1,970,101</td>
<td>$16,118,912</td>
<td>$10,537,761</td>
<td>$31,269,576</td>
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</table>

#### 1 Year Target

<table>
<thead>
<tr>
<th>LOS Target</th>
<th>Labor</th>
<th>Equipment</th>
<th>Materials</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-</td>
<td>$2,968,172</td>
<td>$2,141,155</td>
<td>$17,725,403</td>
<td>$12,131,536</td>
<td>$34,966,266</td>
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<tr>
<td>C</td>
<td>$3,593,340</td>
<td>$2,524,551</td>
<td>$20,446,888</td>
<td>$13,875,041</td>
<td>$40,439,820</td>
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<tr>
<td>C+</td>
<td>$4,218,509</td>
<td>$2,907,948</td>
<td>$23,168,373</td>
<td>$15,618,545</td>
<td>$45,913,375</td>
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<tr>
<td>B-</td>
<td>$4,843,677</td>
<td>$3,291,345</td>
<td>$25,889,858</td>
<td>$17,362,050</td>
<td>$51,386,930</td>
</tr>
</tbody>
</table>
Current Data Collection Efforts - Culverts and Walls

• Boots on the ground
  • Maintenance Crews
  • Trimble Juno Handheld units
  • Collected data on culverts:
    Type, orientation, inlet/outlet type, culvert material, length, height, width, diameter, latitude/longitude coordinates, location
  • Collected data on walls:
    Type, location, latitude/longitude, use, material, orientation, height, length, condition
Future of Data Collection

• What was the catalyst that allowed your effort to get off the ground (I.e., how did you convince management)?
  • Change in how budget is allocated, asset management
  • Competing with other assets for funding
    • Voting process

• Setting budgets four years in advance

What types of analysis are you planning (or have you performed) with the data?
  • Maintenance Optimization Project
    • Lane Mile per FTE
    • Facilities
    • Performance-based budgeting

• What is your longer-term maintenance plan to keep the data current?
  • Using mobile applications for boots-on-the-ground updates
  • LIDAR - using contractors to collect specific assets
Expanding Data Beyond Inventory

- GIS Integration - visualizing Data with charts, tables, and maps.
- Creating “Heat Maps” for deficient assets based on field condition assessments.
- Complete asset inventories and statistically-significant condition data at the Maintenance Area level provide the framework for bottom-up, performance-based budgeting.
- Enterprise asset inventory database that integrates with standalone asset inventory databases, i.e., Pavement Management, Bridge (BrM), Division of Transportation Development (DTD) (Online Transportation Information (OTIS))
SAP Linear Asset Manager, GEOe, and Mobile Work Manager
LIDAR-Based Asset Inventory
TRB - Practical Technology-Based Approaches to Highway Infrastructure Maintenance

UDOT Snow and Ice Performance Measure

Presented By:

Kevin E. Griffin  P.E.
Director of Maintenance
Utah Department of Transportation
Outline

- How Salt Works
- UDOT Snow and Ice Performance Measure
- Safety Around Snow Plows
How Salt Works
How Salt Works

- Is more salt always better?

- There is a fine line between not enough and too much.

- 23% brine solution is the maximum.

- What happens when you exceed that amount?
How Salt Works

Phase Diagram for Salt

- Freeze Point
- Melting Occurs
- Too Little Salt Refreezing Occurs
- Too Much Salt Refreezing Occurs
- Eutectic Temperature of Salt
- Too Cold Refreezing Occurs

Temp. (°F)

Solution Concentration (% by Weight)

Temp. (°C)
New UDOT Snow and Ice Performance Measure Using RWIS
Winter Road Weather Index

Why is this important?

- Real time road condition
- Resource deployment benefits
- Can set performance targets
- Budget to meet identified performance level
- Full build out 150 RWIS stations in 3 years
UDOT Snow and Ice Performance Measure

- **Road Condition**
  - Snow, ice and road grip (coefficient of friction)

- **Road Temperature**
  - The colder the road, the more difficult to mitigate

- **Visibility**
  - Used to estimate snowfall rate
  - Precipitation occurrence (yes or no)
    - Define start and end time of storm event
    - Precipitation occurrence used to differentiate fog from snow

- **Wet-bulb Temperature**
  - Lower the wet-bulb temperature equates to drier snow thus more transportable
  - Used to distinguish rain from snow

- **Wind Gust (>= 20 mph)**
  - More impact with lowering wet-bulb temperatures
# Winter Road Weather Index

- **Winter Maintenance Performance Metric Basis**

<table>
<thead>
<tr>
<th>Winter Weather Index</th>
<th>Snowfall Rate</th>
<th>Expected Mitigated Road Condition</th>
<th>Expected Grip</th>
</tr>
</thead>
<tbody>
<tr>
<td>⭐⭐⭐ Heavy</td>
<td>&gt; 1&quot; per hour</td>
<td>Snow Covered</td>
<td>&lt; .30</td>
</tr>
<tr>
<td>⭐⭐ Light to Moderate</td>
<td>.25 to 1&quot; per hour</td>
<td>Slushy/ Partially Snow Covered</td>
<td>.30 to .50</td>
</tr>
<tr>
<td>⭐ Flurries or no snow</td>
<td>&lt; .25&quot; per hour</td>
<td>Wet or dry</td>
<td>.50 to .82</td>
</tr>
</tbody>
</table>

**Contributing factors also considered with Winter Weather Index**

<table>
<thead>
<tr>
<th>Contributing Factor</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Temperature</td>
<td>Blowing snow</td>
</tr>
<tr>
<td></td>
<td>Wet or dry snow</td>
</tr>
</tbody>
</table>
Performance Metric “Rubik’s Cube”

Definitions:

**Green** – Road condition exceeds acceptable road conditions per given weather conditions

**Yellow** – Acceptable road conditions per given weather conditions

**Red** – Recovery time. Potential for improved road conditions per given weather conditions
SR-12 @ Boulder Summit

Current Conditions
- Sample Time: 8/26/15 10:00 AM
- Temp/RH: 49 °F / 99%
- Wind: S 15 MPH, Gust 24 MPH
- Visibility: 0.14 mi
- Snowfall Rate: n/a
- Precipitation Intensity: Heavy
- Snow Depth: n/a
- Road: 50 °F, Wet
- Road Grip: 0.50
- Storm Intensity Index: 0.00 (Sun/snowflake symbol)

Past 48 hrs

Current Season 2014-2015
- Average Resource Performance: 92.8% (A-) (high)
- Number of Storms: 17 (moderate)
- Average Storm Duration (hrs): 30.2 (moderate)
- Total Storm Duration: 513.4 (high)
- Average Storm Intensity Index: 0.74 (low)
- Storm Intensity Index Sum: 12.6 (moderate)
- Average Storm Severity Index: 20.1 (moderate)
- Storm Severity Index Sum: 341.7 (moderate)

More information on the Storm Intensity Index and snow and ice performance:
- Video
- Powerpoint

UDOT Weather Desk: 801-887-3703
Statewide Snow and Ice Performance Dashboard

2015-2016 Statewide Winter Storm Statistics

- Average Snow & Ice Performance
- Number of Winter Storms
- Avg. Winter Storm Intensity (SII)
- Avg. Winter Storm Duration (hrs)
- Total Winter Storm Duration (hrs)
- Total Winter Storm Severity (SSI)

2015-2016 Average Statewide Snow and Ice Performance

Statewide Grade: B+

- Exceptional: 9%
- Acceptable: 39%
- Unacceptable: 52%

Data for winter storm events: 10/01/15 12:00 A.M. – 04/30/16 12:10 P.M.

XX compatible RWIS sites

Average Statewide Snow and Ice Performance
(% of acceptable/exceptional ? road conditions during winter storms)
AVL/GPS

Why would we want this?
AVL/GPS

Know where your fleet is

Know where your fleet has been

Know what your truck is doing
  - Plow up/down
  - Application of salt or brine
  - Truck speed

Show the public the real picture

Feed road condition data to the TOC
AVL/GPS

- 500+ Snow Plow equipped with GPS/AVL
- Real Time Engine Diagnostics
- Incident Management Trucks also Equipped
- Potentially other equipment
Snow Plow Route Optimization
Snow Plow Route Optimization

- Using same defined routes for many years
- Based on Station and Region boundaries
- Some routes still incorporate “Deadhead”
- Did the best with the tools we had
Snow Plow Route Optimization

- Navteq data software driven solution

- Look at doing things differently

- Possible outcomes:
  - Interstate plow groups
  - Combining stations
  - Some areas are at optimal
Snow Plow Route Optimization

Currently Analyzing the Wasatch Front From Provo to Box Elder County Line

Evaluate the entire state

Results Implemented Next Winter Plow Season
Safety Around Snow Plows
UDOT Plow Accident

https://youtu.be/S9jrCEVOvrY
Wing Plow Lights
Safety Around Snow Plows

- What is the safe Traveling Distance Behind a Plow?
- Don’t Crowd the Snow Plow
- Echelon Plowing
Safety Around Snow Plows

- Watch for Plows Operating in Your Lane
- Don’t Travel Beside the Plows
- Snow Plows Operate at Slower Speeds
- Slow Down During Adverse Weather Conditions
Safety Around Snow Plows

- Wings and Tow Plows
- Plows Create Their Own Weather Environment
- Snow Plow Operators Field of Vision is Limited
- Snow Plows Turn and Exit the Road Frequently
THANK YOU
Evaluation of Emerging Technologies for Safety & Operations Infrastructure Inventory and Condition Assessment

Paul Carlson, PhD, PE
Texas A&M Transportation Institute
Technical Area 2: Zero-intrusive maintenance

- TxDOT seeks innovative proposals under this area to identify, develop, and prove infrastructure maintenance technologies and methods that produce no disruption to facility use during maintenance activities.
Motivation

• TxDOT’s maintenance budget is $1 billion short and growing (circa 2014)
• Need to make more cost-effective decisions with limited resources
• Need the right data to make more cost-effective decisions
• Need to keep traffic flowing and TxDOT personnel safe
• Need to be able to respond to vendors’ request to collect highway infrastructure data
Traditional Forms of Data Collection

• Subjective Accuracy
• Low frequency
• Low dollar

• Objective Accuracy
• Low frequency
• High dollar
Why mobile high speed?

• Manual Data Collection
  • Can be time-consuming
  • Exposes DOT staff to traffic
  • Is often asset specific
  • Subjective
Can mobile high speed...

• Reduce costs?
• Increase safety?
• Obtain accurate data?
• Provide robust data for predictive modeling?
• Collect multiple asset data simultaneously?
What is Mobile High Speed?

- No limits on technology
- Had to be a mobile platform
- High speed preferably >35 mph

<table>
<thead>
<tr>
<th></th>
<th>Avg. Speed (mph)</th>
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<tr>
<td>A</td>
<td>IH 45</td>
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<td>B</td>
<td>FM 3090</td>
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<td>43.10</td>
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<td>C</td>
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<td>45.30</td>
</tr>
<tr>
<td>L</td>
<td>FM 3090</td>
</tr>
<tr>
<td></td>
<td>42.50</td>
</tr>
</tbody>
</table>
Routes and Testing Conditions

• TxDOT Highways:
  • IH-45 (north of Houston)
    • ~10 miles
    • Rural environment
    • Two-way frontage roads
  • FM 3090 (near Navasota)
    • ~10 miles
    • Low ADT
    • Horizontal and vertical curvature
Selection of Contractors

• Contractor selection criteria:
  • Past Experience
  • Technology – Lidar, 3D Photogrammetry...
  • Unique Capabilities – Retroreflectivity
  • Unique Mobile Platform – Unmanned Aerial Vehicle

• Contractors:
  • Data Transfer Solutions (DTS)
  • DBi Services, (AMAC)
  • Arch Aerial (AALLC)
  • Mandli Comm.
  • Pathway Services
  • Fugro Roadware
Performance Metrics

• **Service Metrics**
  • mobilization time,
  • data collection time,
  • processing time,
  • approximate cost

• **Identification Metrics**
  • asset identification (e.g., MUTCD sign designations),
  • asset material (e.g., sign sheeting, pavement markings),
  • general sizes.

• **Quantification Metrics**
  • asset quantities
    • both point and linear totals.

• **Accuracy Metrics**
  • horizontal,
  • linear, and
  • elevation measurements (GPS accuracy)
  • sign text
  • retroreflectivity
  • mowable acres
What did we learn?

• Data Dictionary is key to success
  • Contractors/TxDOT not given enough time for comment
• Examples
  • Rumble Strips without Left/Right positioning
• Specific guidance on measurements
  • Lane measurements – from inside stripe or centerline?
• Mailboxes – The assembly not the number of boxes.
• Count of pavement markers: single v double yellow
What did we find?

- **Cost comparison per miles delivered**

<table>
<thead>
<tr>
<th>Delivered Miles</th>
<th>Collection</th>
<th>Processing/Reporting</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>$ 751.01</td>
<td>$ 498.99</td>
<td>$ 1,250.00</td>
</tr>
<tr>
<td>42</td>
<td>$ 391.35</td>
<td>$ 271.34</td>
<td>$ 662.69</td>
</tr>
<tr>
<td>10</td>
<td>$ 1,387.40</td>
<td>$ 883.37</td>
<td>$ 2,270.77</td>
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<tr>
<td>20</td>
<td>$ 338.51</td>
<td>$ 86.49</td>
<td>$ 425.00</td>
</tr>
<tr>
<td>40</td>
<td>$ 333.00</td>
<td>$ 207.00</td>
<td>$ 540.00</td>
</tr>
<tr>
<td>20</td>
<td>$ 988.01</td>
<td>$ 735.99</td>
<td>$ 1,724.00</td>
</tr>
<tr>
<td>Per Mile Average</td>
<td>$ 698.21</td>
<td>$ 447.20</td>
<td>$ 1,145.41</td>
</tr>
</tbody>
</table>

- **Includes processing and reporting**
- **Estimated manual costs**
  - 740 man-hours @ $100 (40) = $1,850 per lane mile
Unique Aspects

• Measured retroreflectivity of signs and markings allows predictive modeling (i.e., cost savings)
• GPS accuracies have considerable variability
• Easy to use results?
• All technologies provide a snapshot in time
For more info

• Full Report
  • [http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6869-1.pdf](http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6869-1.pdf)

• Condensed Version
  • TRB Annual Meeting, Paper 17-05078
Vehicle Sensors and Crowd Sourcing Strategies to Provide Safety & Operations Infrastructure Inventory and Condition Assessment
Vehicle Sensor Crowd Sourcing

Requiring NO work from vehicle operators
In-Vehicle Connections
Web-Based Interface
Sessions
Visualizations
Meta Data – Speed Profile
Raw Data
Trips in last 30 days
Poor Markings
More Assets and Analytics Coming