Where Utah is…
Where Utah is going…

Josh Van Jura
Overview of UDOT

- Centerline Miles by Type
  - 935 miles of Interstate
  - 2,945 miles of Level 1 (AADT>1,000)
  - 1,985 miles of Level 2 (AADT<1,000)
  - 5,865 miles total

- Speed Limits
  - 13% @ 80 mph
  - 35% @ 70 mph or higher
  - 60% @ 60 mph or higher
  - 82% @ 50 mph or higher

90% Mortality @ 60 mph
Goal: Improve safety within construction work zones through significant reduction in traveler speed within the boundary of Active Work Space.

August 2016
Operating vs. Posted

Goal:
Reduce operating speed so that all vehicles are within +/- 15mph of average speed.

Essentially Speed Harmonization…

August 2016
PVSL Candidate Projects

- 4 lane divided / undivided roads
- High Speed (50mph +)
- Project with simple geometries
- Example
  - Resurfacing
  - Slab or Bridge Deck replacement
  - Patching
Regulatory Enforcement

Work with Highway Patrol

System logs speed changes & time of

Document location of device

Not tested in court to date
SMRT System

A Marginally Smart Work Zone

• We have done 12+ projects to date with PVSL
• No detection
• Field crew changes speeds per TEO
• There is data collection
SMRT- Success Stories

US 40 Deck Replacement
- Original Posted Speed = 65 mph
- Reduced Speed = 45 mph
  - Single drop
- > 70,000 vehicles
- AVG Speed = 51.4 mph
• PVSL: Where we are going?
PVSL: Where we are going

- **PVSL System**
- Portable, Intelligent and Dynamic
- Multiple Devices (PVSL, Detectors, PVMS)
  - Integrated as one system
  - Dynamically posting speed limits, and
  - Traveler information messages
  - Operated by RE and Roadway Contractor (No TOC)
PVSL System: How we are getting there

- FHWA AID Grant
  - Awarded December 2014

- System Planning & Design
  - NTP June 2015
  - Kimley-Horn and avenue | CONSULTANTS

- Turn-key Solution Provider
  - NTP May 2016
  - Ver-Mac and Interstate Barricades
PVSL System: How we are getting there

Systems Engineering Process

- Con Ops Phase
  - Goals/Objectives/Performance Metrics
  - Operational Parameters and Limits
  - Stakeholder Roles and Responsibilities Matrix
  - Operational Scenarios
  - User and System Needs

Kimley-Horn

USE OF VSL IN CONSTRUCTION ZONES
Goals, Objectives and Performance Measures

<table>
<thead>
<tr>
<th>Category</th>
<th>Goal</th>
<th>Objective</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD</td>
<td>Safety</td>
<td>Safer for field personnel</td>
<td>• Limits exposure to workers for making VSL adjustments (i.e., limits need to go to each VSL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Speed in work space</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Speed compliance within the work space when field personnel are present</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Worker satisfaction</td>
</tr>
<tr>
<td>Ease of use</td>
<td>Ease of deployment and operation</td>
<td></td>
<td>• Time it takes to set up, adjust or shift the system in a work zone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Time it takes to learn how to operate the PVSL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Cost of the system (labor hours and renting devices)</td>
</tr>
</tbody>
</table>
## Goals, Objectives and Performance Measures

<table>
<thead>
<tr>
<th>Category</th>
<th>Goal</th>
<th>Objective</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUBLIC</td>
<td>Safety</td>
<td>Safer for public</td>
<td>• Number of crashes&lt;br&gt;• Customer satisfaction</td>
</tr>
<tr>
<td></td>
<td>Public trust</td>
<td>Posted speeds comply with worker activity</td>
<td>All measurers below are measured within the work space:&lt;br&gt;• Speed compliance when workers are present.&lt;br&gt;• % of drivers that encounter reduced speed limits&lt;br&gt;• The length (distance) for which the speed is reduced&lt;br&gt;• Delay (time it takes to transverse the work space) for when a driver encounters reduced speed limits.</td>
</tr>
<tr>
<td></td>
<td>Increased and reliable information</td>
<td></td>
<td>• Travel time through the work space&lt;br&gt;• Uptime of system</td>
</tr>
<tr>
<td></td>
<td>Easy to use</td>
<td>Easy for public to understand</td>
<td>• Speed variation</td>
</tr>
</tbody>
</table>
Operational Scenarios

Legend

Scenario 1

Scenario 2

Scenario 3
PVSL System: How we are getting there

Systems Engineering Process

- RFP Development
  - System Requirements
  - High-Level Design
  - Industry Outreach
  - System Algorithms
  - Measurement / Payment Logistics
  - Quantity Deployment Phases
  - Selection Criteria (quals + cost)

- Turn-key Solution Provider selection
VSL Subsystem Algorithm
Scenario 1 - AWS w/in 1 mile

### Taper Buffer Zone & Sign Spacing Chart

<table>
<thead>
<tr>
<th>ROAD TYPE</th>
<th>POSTED SPEED (MPH)</th>
<th>MINIMUM TAPER LENGTH (INT.)</th>
<th>LENGTH OF BUFFER (FT)</th>
<th>MINIMUM SIGN SPACING (SR)</th>
<th>ONE LANE (SRM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONVENTIONAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Speed</td>
<td>70</td>
<td>200</td>
<td>50</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Medium Speed</td>
<td>50</td>
<td>200</td>
<td>50</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Low Speed</td>
<td>30</td>
<td>200</td>
<td>50</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>FREQUENT INTERRUPTIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Speed</td>
<td>70</td>
<td>200</td>
<td>50</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Medium Speed</td>
<td>50</td>
<td>200</td>
<td>50</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Low Speed</td>
<td>30</td>
<td>200</td>
<td>50</td>
<td>10</td>
<td>100</td>
</tr>
</tbody>
</table>

### Taper Length Formulas

<table>
<thead>
<tr>
<th>SPEED</th>
<th>FORMULA</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOR SPEEDS OF 45 MPH OR LESS</td>
<td>$L = \frac{V^2}{2g}$</td>
</tr>
<tr>
<td>FOR SPEEDS OF 45 MPH OR GREATER</td>
<td>$L = \frac{V^2}{g}$</td>
</tr>
</tbody>
</table>

### Traffic Control

- **Portable Signal Barricade:**
  - **INFO-01:**
    - **Purpose:** Provides an extra layer of safety for drivers.
    - **Direction:** Install at the beginning of the taper zone.
  - **PORT-01:**
    - **Purpose:** Enhances visibility and alerts drivers to the taper zone.
    - **Direction:** Install at the beginning of the taper zone.

### Variable Speed Limit (VSL) Work Zone Traffic Control

- **Control Device Placement:**
  - **LANE DROP WHEN ACTIVE WORK SPACE IS WITHIN 1 MILE OF TAPER:**
    - Place control devices at least 1 mile before the taper zone.
    - Ensure devices are visible and clearly marked.

**NOTES:**

1. Variable speed limit signs should be placed at least 1 mile before the taper zone to signal drivers to reduce speed.
2. Ensure control devices are visible and clearly marked.
3. Place control devices at least 1 mile before the taper zone.
4. Ensure devices are installed according to the guidelines provided.
5. Regularly inspect and maintain control devices to ensure they are functioning properly.
6. Placement of control devices should follow standard traffic control practices.
7. Ensure devices are properly secured to prevent damage or theft.
8. Regularly inspect and maintain control devices to ensure they are functioning properly.
9. Use control devices only when necessary and in accordance with traffic control guidelines.
10. Ensure that all equipment is properly secured and able to withstand harsh weather conditions.
Scenario 1A – AWS beyond 1 mile
**Scenario 2A – AWS beyond 1 mile**

**Taper, Buffer Zone & Sign Spacing Chart**

<table>
<thead>
<tr>
<th>ROAD TYPE</th>
<th>POSTED SPEED (MPH)</th>
<th>MINIMUM TAPER LENGTH (FT)</th>
<th>LENGTH OF BUFFER (FT)</th>
<th>MINIMUM SIGN SPACING (FT)</th>
<th>ONE LANE HANGING CONVENTIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONVENTIONAL</td>
<td>30</td>
<td>200</td>
<td>200</td>
<td>108</td>
<td>350</td>
</tr>
<tr>
<td>35</td>
<td>230</td>
<td>230</td>
<td>158</td>
<td>350</td>
<td></td>
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<tr>
<td>40</td>
<td>260</td>
<td>260</td>
<td>210</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>290</td>
<td>290</td>
<td>290</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>320</td>
<td>320</td>
<td>350</td>
<td>350</td>
<td></td>
</tr>
</tbody>
</table>

**VARIABLE SPEED LIMIT ZONE TRAFFIC CONTROL**

DEVICES Platzement for When Active Workspace is Greater Than 1 Mile from Taper

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**NOTES:**

1. **TAPER LENGTH FORMULA:**
   
   \[ L = \frac{V^2}{32g} \]
   
   where:
   
   - \( L \) = Taper Length
   - \( V \) = Speed
   - \( g \) = Acceleration due to gravity

2. **One Lane Hanging:**
   
   - Conventional
   - Depends on traffic density and available space

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**UTAH DEPARTMENT OF TRANSPORTATION**

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**Legend:**

- **CONVENTIONAL:**
  - Taper, Buffer Zone & Sign Spacing Chart
  - Variable Speed Limit Zone Traffic Control
- **NOTE:**
  - Additional notes and symbols for traffic flow and spacing

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**Drawing Information:**

- **Project:**
  - Name and number of the construction project
- **Phase:**
  - Different phases of the construction project
- **Scale:**
  - Scale of the drawing
- **Drawing Date:**
  - Date of the drawing

---

**CHECKS:**

- Review and approval of the plan by relevant authorities

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PVSL System: How we are getting there

Systems Engineering Process

- System Development
  - Submittal Reviews
  - Hardware Fabrication
  - Algorithm Refinement
  - Test Plan Development
Technologies

• **Portable VSL (PVSL) Signs, and**
  o Trailer Mounter with variable speed digits
  o White LEDs on black background (30° view angle)

• **Portable variable message sign (PVMS)**
  o Orange LEDs on black background (30° view angle)

• **Portable Operator Control Device**
  o Laptop / Tablet / Cell Phone
  o Cell Service Req’d
Technologies

• Detectors
  o K-Band Doppler Speed Radar
  o Selected for ease/speed to deploy

• Communications
  o Internet via cell phone network

• Power
  o Solar system with 7-day batteries
PVSL Trailers
PVSL System: How we are getting there

Systems Engineering Process

- Testing & Verification
  - Testbed Deployment
  - Pass/Fail Acceptance Testing
    - Hardware requirements met?
    - Software requirements met?
    - Integration/algorithms working?
FRM:jamlogic@jamlogic.com
SUBJ: New Speed Recommendation
MSG: Speed on PVLS2 should be 55
08/17/2016 08:25:42 PM

FRM:jamlogic@jamlogic.com
SUBJ: UT - PVSL QWS SWZ (2016-2017) O1A Q1 R
Path: \(0\)-SWZ - (Con't 2 of 3)
UT - PVSL QWS SWZ
(2016-2017) 2016-08-04 WZ NB
I-15
Device: O1A Q1 Radar on PVMS O1
#3360=1

Alarm: No speed received
Status: In
(Con't 3 of 3)
Alarm
Since: 8/16/2016 2:34:07 AM

FRM:jamlogic@jamlogic.com
MSG: Slow traffic has extended beyond Q1 for UDOT PVSL SWZ
Very Very Preliminary Results

AVG Speed (MPH)
PVSL System: Next Steps

Systems Engineering Process

• System Validation
  o Year 1 Project 1 deployment
  • Baseline data collection
  o Full system deployment data
  o Compute & compare with performance measurers
  o Lessons learned workshop

• Refine System Parameters
• Repeat Validation Steps 3 more deployments
Contact Information

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(801) 231-8452