Smart Work Zones in Utah

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% @ 70mph or higher
  - 60% @ 60mph or higher
  - 82% @ 50mph or higher

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

• Motorists:
  - Increase the time available for a motorist to react
  - Reduce stopping distances
  - Allow more significant (recoverable) evasive maneuvers

• Workers:
  - Greater time for workers to move out of the way
  - Reduce the likelihood of severe injury
Operating vs. Posted

Kloeden et al., 1997, 2002

Delta = ~2.5%

Speed Harmonization!!!
PVSL Candidate Projects

• 4 lane divided / undivided roads
  o No experience with multi through lanes yet
• High Speed (50mph +)
• Example
  o Resurfacing
  o Slab Replacement
  o Bridge Work
  o Maintenance Work
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 remotely changes speeds per TEO
- There is data collection
- Basically low or high
SMRT- Success Stories

US 40 Deck Replacement
- Original Posted Speed = 65 mph
- Reduced Speed = 45 mph
  - Single drop

```
Number of data points:    70343
Posted speed:             45
Average speed:           51.4
Percentiles:              85th  58
```
SMRT - Success Stories
• 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: Con Ops

Systems Engineering Process

• Con Ops Phase
  o Goals/Objectives/Performance Metrics
  o Operational Parameters and Limits
  o Stakeholder Roles and Responsibilities Matrix
  o Operational Scenarios
  o User and System Needs
## Goals, Objectives and Performance Measures (FIELD)

<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>• Time it takes to set up, adjust or shift the system in a work zone</td>
<td></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 (PUBLIC)

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

Scenario Template 3—Initial set up

Scenario Template 3—AWS move #1

Scenario Template 3—AWS move #2
PVSL System: RFP Development

- 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

USE OF VSL IN CONSTRUCTION ZONES

VARIABLE SPEED LIMIT ZONE

- Start with VSL SL = TEO Low
- Calculate Average Speed
- Average Speed < 30mph
  - YES: VSL SL = 45mph
  - NO: Average Speed > TEO High
- Average Speed > (TEO High + 10mph)
  - YES: VSL SL = TEO High
  - NO: Average Speed (rounded down to nearest 10mph) = 5mph

Legend:
- Average Speed = Calculated Average Speed based on 1 minute speed measurements in active work space and reports as a rolling average for the last 5 minutes of the minutes that meet the volume threshold (single minutes that do not meet the volume threshold are thrown out).
- VSL SL = Speed limit posted on VSL sign.
- TEO High = Reduced speed allowed by TEO, typically "Original Posted Speed" or "Original Posted Speed - 10 MPH".
- TEO Low = The lowest speed limit allowed by TEO.
- Low Volume = Vol < 7 veh/min = Post last known VSL SL
- Frequency of Speed Limit Change = every 20 min when increasing speed

If bad or no data is received from the detector at the center of the active work space, then VSL SL = Last known VSL SL
Scenario 1 - AWS w/in 1 mile

**TAPER BUFFER ZONE & SIGN SPACING CHART**

**TAPER LENGTH FORMULAS**

<table>
<thead>
<tr>
<th>ROAD TYPE</th>
<th>SPEED</th>
<th>FORMULA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONVENTIONAL</td>
<td>50-55 MPH</td>
<td>L = 0.016 x S x V</td>
</tr>
<tr>
<td>Freeway Exits</td>
<td>60-70 MPH</td>
<td>L = 0.016 x S x V</td>
</tr>
</tbody>
</table>

**VARIABLE SPEED LIMIT WORK ZONE TRAFFIC CONTROL DEVICES**

**NOTES**

1. When a speed reduction is installed, the speed zone is limited to the speed reduction zone. When the speed is reduced, the taper length is calculated using the reduced speed.
2. If the speed reduction is installed, the speed limit must be reduced to the speed reduction zone. When the speed is reduced, the taper length is calculated using the reduced speed.
3. The taper length is determined in the speed reduction zone. When the speed is reduced, the taper length is calculated using the reduced speed.
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PVSL System: System Procurement

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

• Portable Variable Speed Limit Signs (PVSL)
  o Trailer Mounted with variable speed digits
  o White LEDs on black background (Regulatory)

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

• Speed Detection Trailers
  o Trailer mounted
  o K-Band Doppler Speed Radar
  o Selected for ease/speed to deploy
System Components

- **Portable Operator Control Device**
  - Laptop / Tablet / Cell Phone
  - Cell Service Req’d

- **Communications**
  - Internet via cell phone network

- **Power**
  - Solar system with 7-day batteries
PVSL Trailers
PVSL System: System Testing

Systems Engineering Process

- Testing & Verification
  - Testbed Deployment
  - Pass/Fail Acceptance Testing
    - Hardware requirements met?
    - Software requirements met?
    - Integration/algorithms working?
### Software (Mobile)

**Queue Warning**

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
<th>Speed</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Q1 PVMS 01</td>
<td>Zone Range</td>
<td>13.25 V</td>
<td></td>
</tr>
<tr>
<td>01A Q1 Radar on PVMS 01</td>
<td>74 mph</td>
<td>13.22 V</td>
<td></td>
</tr>
<tr>
<td>02 Q2 (Radar)</td>
<td>61 mph</td>
<td>13.97 V</td>
<td></td>
</tr>
<tr>
<td>03 Q3 (Radar)</td>
<td>75 mph</td>
<td>13.69 V</td>
<td></td>
</tr>
<tr>
<td>04 PVSL 01</td>
<td>80 mph</td>
<td>13.21 V</td>
<td></td>
</tr>
<tr>
<td>04A S1 on PVSL 01 (Radar)</td>
<td>67 mph</td>
<td>13.23 V</td>
<td></td>
</tr>
</tbody>
</table>
System Alerts

(Speed Change Alert) UT PVSL 2017 Meadow I-15:
First Always UDOT PVSL Trailer 6 = 70, PVSL #6 (3259) = 50, PVSL #7 (3251) = 70

FRM@jamlogic@jamlogic.com
SUBJ: UT - PVSL QWS SWZ (2016-2017) - 01A Q1 R
Path: 10-SWZ - (Con't 2 of 3)
UT - PVSL QWS SWZ (2016-2017) [2016-08-04] WZ NB I-15
Device: 01A Q1 Radar on PVMS 01 #2360=1
Alarm: No speed received
Status: In
(Con't) 3 of 3
Alarm
Since: 8/16/2016 2:34:07 AM

(End)
Spot Speed Study

- Same timeframe
- 99% C.I.
- +/- 2mph

- AVG = 45.7 mph
- 85th% = 52 mph
PVSL System: Next Steps

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

Refine System Parameters

Repeat Validation Steps 3 more deployments
Other Important Factors:

• Public Information:
  o Communicate impact and duration
  o 1.5 miles = 52 seconds
  o Real time messages

• Challenges
  o Getting the change made
    • Go Automated
  o Lag time (Camera)
  o Supporting Litigation
  o Just because you can doesn’t mean you should
Contact Information

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