Texas Variable Speed Limit Pilot Project

Active Traffic Management

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With thanks to the Texas Department of Transportation (TxDOT)
Traffic Operations Division and Texas A&M Transportation Institute
Texas and Variable Speed Limits

- Background
- Planning deployments
- Software changes
- Pilot project operations
- Lessons learned
Background

- Texas Legislation currently does NOT allow for variable speed limits
- May 2013 Texas State Legislature approved and required a pilot program to evaluate variable speed limits (VSL) to be completed by Feb 2015
  - Weather conditions
  - Congestion
  - Construction
  - Other conditions warranting temporary lower speed limits
Deployment Planning

- Hardware
- Location selection
- Physical deployment planning
- Planning for operations
VSL Hardware

- Communication and power
- VSL signs
  - Allow speed limit to change
  - May be on the side of the road or over lanes
- Traffic detection devices
  - Provide congestion information
- Weather devices
  - Friction
  - Visibility
Communication & Power

- Communication
  - In locations selected, fiber communication was not in place
  - Cellular modems
  - VSL and radar detection on same modem

- Power
  - No infrastructure in the selected locations
  - Used solar power and batteries
VSL Signs

- Typical VSL signs are similar to normal speed limit signs with a 2 digit changeable message used for the speed limit.
- Lead time for the project was too short for a procurement turn around, so portable message signs were used with an overlay.
  - LEDs were not as bright—changed to brighter ones part way through pilot.
Typical Traffic Detection

- Radar or other detection device
- Typically, detection and VSL signs would be staggered
- This allows downstream traffic to trigger speeds as shown in the picture
Traffic Detection for Pilot

- Wavetronix HD Smart Sensor radar
- Detection was co-located with the VSL signs
  - Solar power was at the VSL sign
  - Less infrastructure to deploy
Weather Devices

- Selected devices
  - Non-intrusive (no installation into the roadway)
  - Public, simple XML or ASCII protocol
- Visibility
  - Sensor selected was Sentry
  - Provided visibility in feet
- Friction
  - Sensor selected was IceSight
  - Measured co-efficient of pavement friction
Location Selection

- Interested in evaluating several conditions where VSL could assist
  - Congestion and queue formation
    - Required area where regular congestion occurred
  - Weather
    - Weather could be a factor in other conditions as well, but looking for a site with recurring weather conditions causing traffic problems
  - Construction
    - Looking for location where construction and lane closures caused queue formation
Congestion Location-Urban

- San Antonio area selected
  - Loop 1604 Westbound
  - Recurring congestion most mornings and afternoons
  - Room on side of the roadway for the portable message signs
  - No construction anticipated (to isolate congestion for the results of the pilot)
Construction Location-Suburban

- Temple in the TxDOT Waco district
  - Section of IH-35 Southbound
  - Lane closures further downstream often caused queues to form
Weather Location-Rural

- Ranger Hill in Eastland County (Brownwood District) on IH-20
  - Steep grade on the hill with a curve in the roadway
  - History of icy roads and foggy conditions
Physical Deployment Planning

- Deployments were staggered over time
  - Lessons learned in initial deployment could be applied to subsequent ones
  - “No VSL” traffic data was collected after initial deployment but before VSL was activated
- Deactivation of VSL was also staggered
  - Allowed additional weather data to be collected on Ranger Hill
Planning for Operations

- Required integration with statewide traffic management software, Lonestar
  - Determine algorithms for software
  - What data collection was required for evaluation of the pilot?
  - How would the maintenance company be notified of hardware problems?

- Needed an operations view of the system
  - Webpage with login
  - Data could be viewed or downloaded
Software Changes

- Lonestar
  - Selected detector, Wavetronix HD, already supported
  - Support for selected weather devices was added
  - Added VSL functionality
  - Added notifications (operator alerts and email notifications) for:
    - Device failures
    - VSL plans suggested, activated, and deactivated

- VSL website for status and data download
Congestion Algorithm

- Detector data evaluated
- Do we have enough cars?
- Is the speed less than our threshold (50 MPH)?
- If so, that VSL sign’s target speed is set to the reported speed
- Activation waits until a configurable number of times lower speed limits are triggered
Weather Algorithm

<table>
<thead>
<tr>
<th>Friction Level</th>
<th>Good</th>
<th>Moderate</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F \geq F^{UT}$</td>
<td>$F^{LT} &lt; F &lt; F^{UT}$</td>
<td>$F \leq F^{LT}$</td>
<td></td>
</tr>
<tr>
<td>$V &gt; V^T$</td>
<td>Normal speeds</td>
<td>Speed1</td>
<td>Speed2</td>
</tr>
<tr>
<td>$V \leq V^T$</td>
<td>Speed3</td>
<td>Speed4</td>
<td>30 MPH</td>
</tr>
</tbody>
</table>

- Two thresholds for friction were used based upon impact to traffic speeds
  - Upper: Moderate-high—heavy rain, actively flowing water
  - Lower: Low-moderate—lighter rain, roads still wet
- Visibility used a single threshold
- Either congestion or weather could activate VSL
  - Lowest triggered speeds would be used
VSL Activation: Sample Values

Congestion forming downstream triggers reduced speeds back to initial VSL sign

As congestion increases further upstream, speed limits are lowered
Activation Approvals

- Activations were required to be approved by an operator.
- For the suburban and rural locations, operations are NOT 24/7.
- Operator approval occurred at the regional center, Fort Worth (FTW) in both cases.
  - Remote Command Application (RCA) updated to allow approval information to be passed to the controlling district.
Lonestar VSL Activation Alert

- Operators approved activations (legislatively required)
- If denied, a reason was selected
- Once activated, speed limits were automatically adjusted during the activation time frame
- Emails notifications were sent to district personnel
VSL Website Functionality

Active plan information was displayed including weather/traffic conditions. Also available were traffic and weather detection values and VSL status over time.
VSL Pilot Operations Summary

- Slight algorithm modifications were made after initial deployment
  - Require consecutive triggers before activating to prevent quick activation/deactivation sequences
  - Initially applied to deactivation as well, but removed as quicker return to normal speed limits was desired
  - Friction thresholds were initially set too high
    - At 70% friction, traffic returned to normal speeds and roads were not hazardous
    - Recovery to a “dry road” condition took too long as the sensors were over the shoulder rather than the main lanes
VSL Pilot Operations Statistics

- 3 month pilot period for evaluation report
- Over 400 activations of temporary speed limits
  - Most activations: congestion
  - Least activations: weather
- Typical activation duration was under an hour
  - Some activations lasted as long as 10 hours during weather events
- Speed limits typically changed multiple times per activation
VSL Pilot Effectiveness

- Reduction in number of crashes overall
  - San Antonio showed an increase from prior year
  - Other changes to roadway configuration could affect numbers

![Crash Frequency and Crash Rate by Site](image)
VSL Pilot Effectiveness, cont.

- Reduction in severity of crashes
- No fatal or incapacitating crashes reported!
Lessons Learned—VSL Signs

- Portable message signs had shortcomings including:
  - Placement of the sign on the side of the road
  - Non-standard speed limit sign “look”
  - LEDs initially not bright enough for single pixel characters
  - Ease of damage from weather events
  - Additional detector deployed caused power consumption problems which affected operations of the signs

Signs were further off the roadway than typical placements
Lessons Learned—Other Hardware

- Radar detectors were co-located with VSL signs which did not allow for quickly noticing changes in speeds.
- Weather devices were not available quickly enough for profiling and calibration to be adequately tested.
- Friction sensor would have recovered more quickly if directed at roadway pavement rather than the shoulder.
- Cameras should be deployed in conjunction with the VSL signs to verify operations of the signs.
Lessons Learned—Software

- Hardware errors were ignored in the algorithm because of the quick timeframe for the pilot
  - At times a VSL site’s algorithm had to be turned off because of hardware errors
  - Device errors can cause complicated algorithms!

- Additional changes would be required to handle longer segments of VSL signs
  - REDUCED SPEED AHEAD message warning sign was required
  - Might want to display additional information about WHY the speed limits were lowered

- Algorithm favored 5 MPH speed drops between consecutive signs
  - For congestion, this often resulted in lowered speed limits upstream but before the drivers could see any traffic slowdown
  - May need to be adjusted to favor steeper reductions in some cases
Lessons Learned—Rural

- Approvals handled by a different district added complexity
  - Website was critical to providing current information to FTW
  - Network connectivity between the districts was now REQUIRED or VSL was NOT activated!

- Hardware issues more difficult to handle
  - Maintenance with spare hardware was MUCH further away
  - If a trip was required, had to be sure to bring EVERY possible hardware replacement
Lessons Learned—General

- Public understood that lowered speed limits were enforceable and could result in tickets
  - But, they did not always obey them!
  - Drivers were more observant of the lowered speed limits while law enforcement was present (no surprise!)
  - For the pilot, law enforcement did not enforce lowered speed limits or issue tickets

- Communication pathway should be as failure resistant as possible
  - Device failures can result in inconsistent speed limit displays
Questions?

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## Site Specific Algorithm Settings

<table>
<thead>
<tr>
<th>Configuration Value</th>
<th>San Antonio (congestion site)</th>
<th>Temple (construction site)</th>
<th>Ranger Hill (weather site)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V^T$</td>
<td>n/a</td>
<td>n/a</td>
<td>500’</td>
</tr>
<tr>
<td>$F^{LT}$</td>
<td>0.25 (25%)</td>
<td>0.25 (25%)</td>
<td>0.25 (25%)</td>
</tr>
<tr>
<td>$F^{UT}$</td>
<td>0.45 (45%)</td>
<td>0.55 (55%)</td>
<td>0.45 (45%)</td>
</tr>
<tr>
<td>Speed1</td>
<td>60</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>Speed2</td>
<td>45</td>
<td>30</td>
<td>45</td>
</tr>
<tr>
<td>Speed3</td>
<td>n/a</td>
<td>n/a</td>
<td>50</td>
</tr>
<tr>
<td>Speed4</td>
<td>n/a</td>
<td>n/a</td>
<td>40</td>
</tr>
</tbody>
</table>

- Final settings for each location, original friction settings were higher
- Only Ranger Hill had a visibility sensor
- Configurable to allow specific roadway types and conditions to be considered
- Area district engineers approved settings
Algorithm was run once per minute

Setting speed limit values used the following rules:

- Step downs occurred in 5-15 MPH increments with 5 MPH preferred
  - Where a larger step down than allowed would be required, the speeds displayed were higher than would have been generated
  - If a larger step down was required on one VSL sign than other VSL signs, the first sign showed the larger drop in speed
  - For the pilot, speeds were stepped down when activated, but not necessarily back up on deactivation
  - Step ups may occur between two slow target speeds