Texas Variable Speed Limit Pilot Project

Active Traffic Management

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Traffic Operations Division and Texas A&M Transportation Institute

Texas and Variable Speed Limits

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- 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

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

VSL Hardware

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- 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

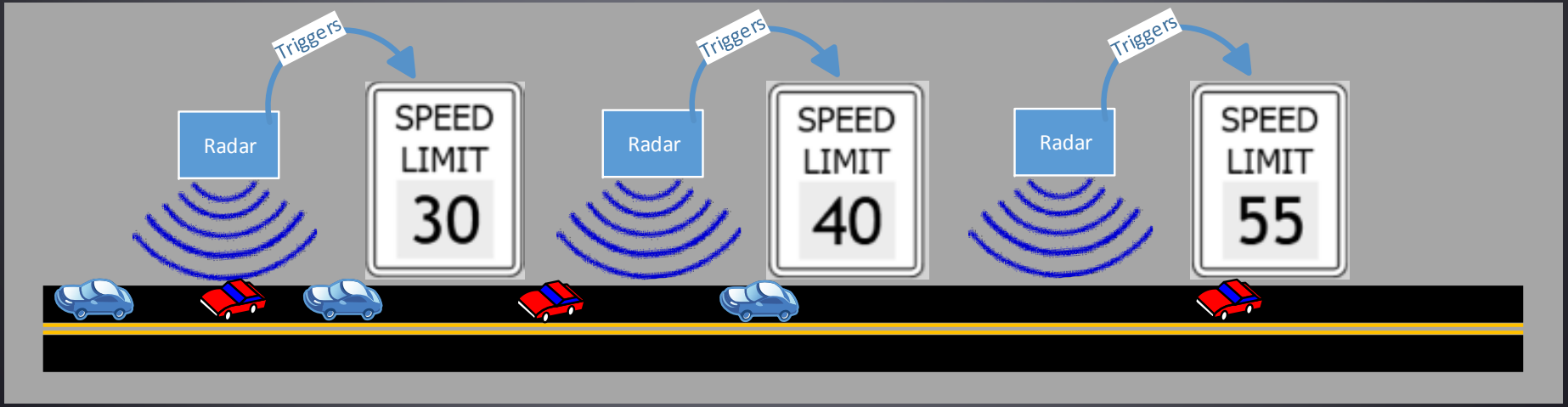
- Communication
  - In locations selected, fiber communication was not in place
  - Cellular modems
  - VSL and radar detection on same modem
- Power
  - No infrastructure in the selected locations
  - Used solar power and batteries

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

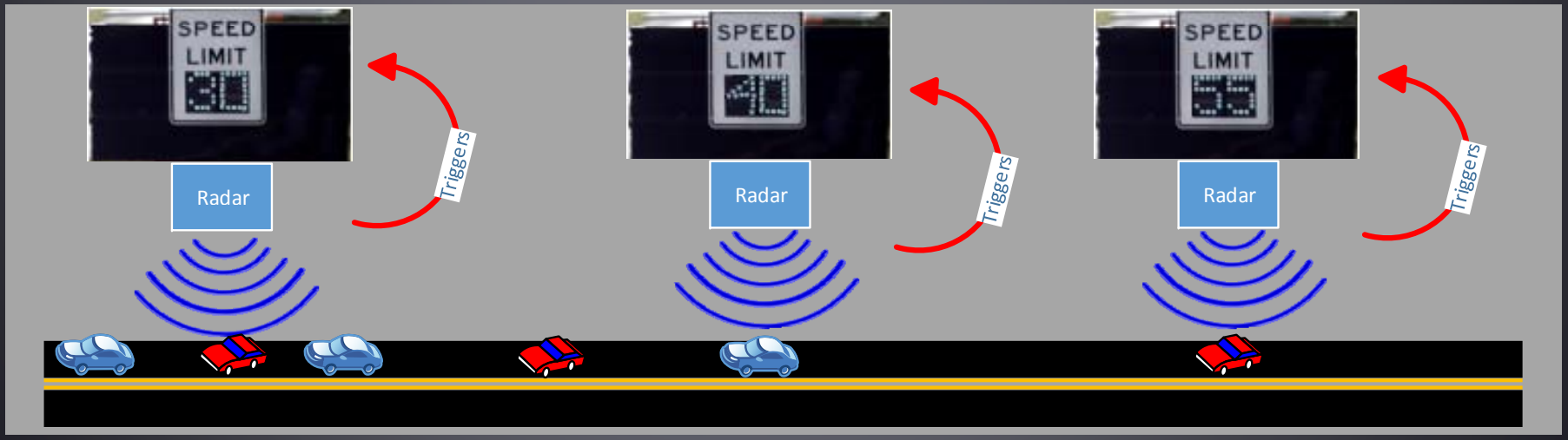
Typical Traffic Detection

- 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

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- 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

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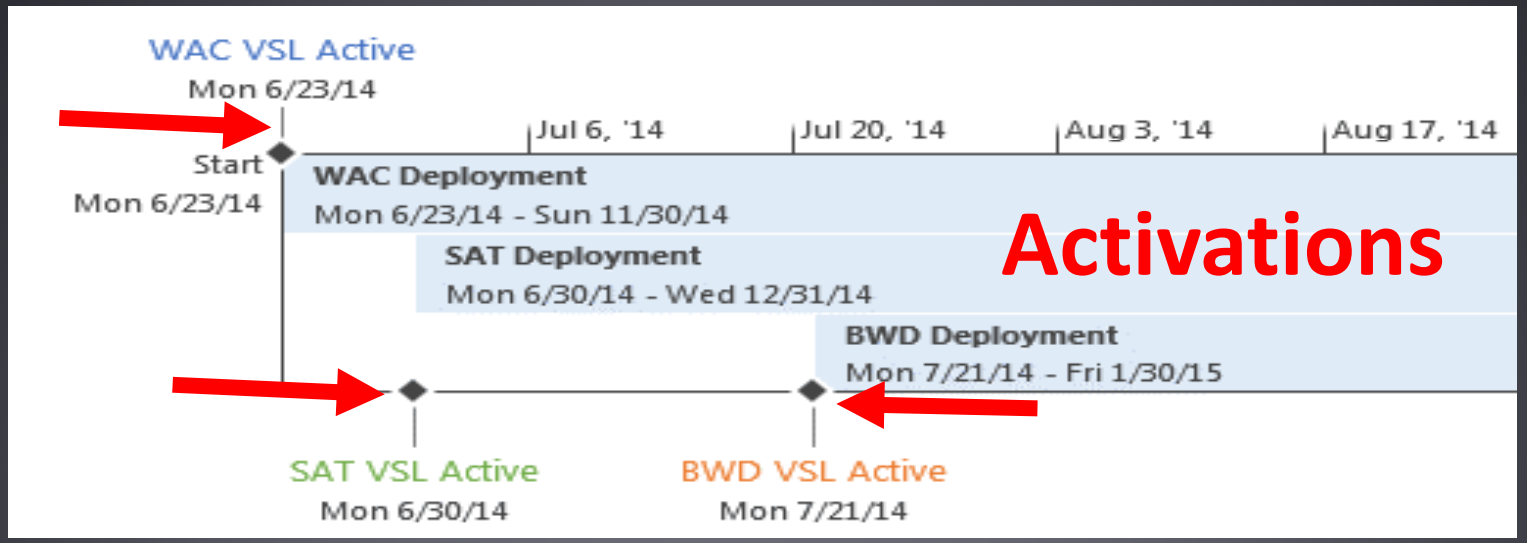
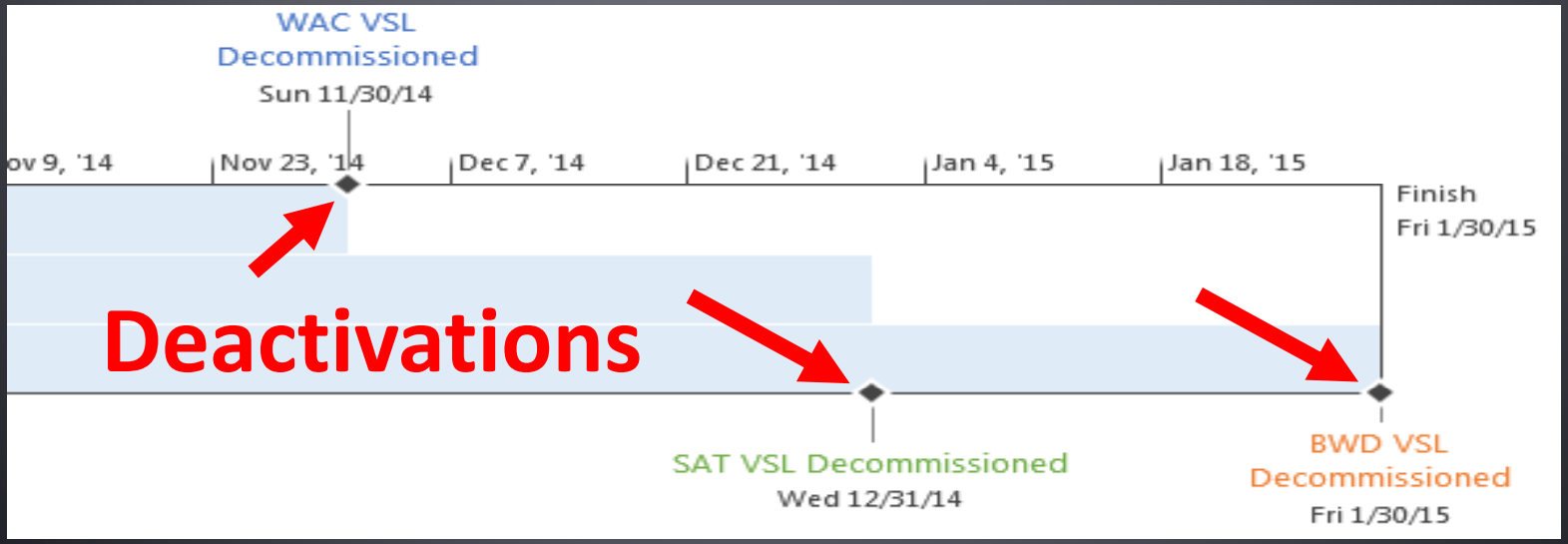
- Required integration with statewide traffic management software, Lonestar
  - Determine algorithms for software
  - What data collection was required for evaluation of the pilot?
  - How would the maintenance company be notified of hardware problems?
- Needed an operations view of the system
  - Webpage with login
  - Data could be viewed or downloaded

Deployment Timeline



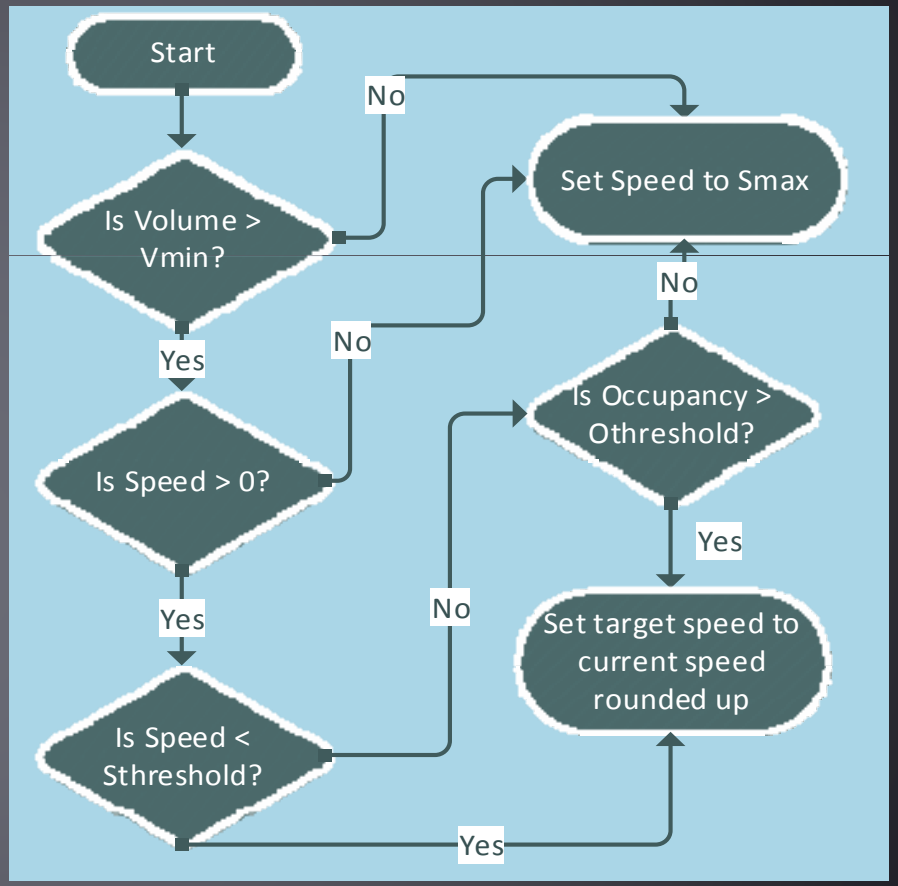


Software Changes

- 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



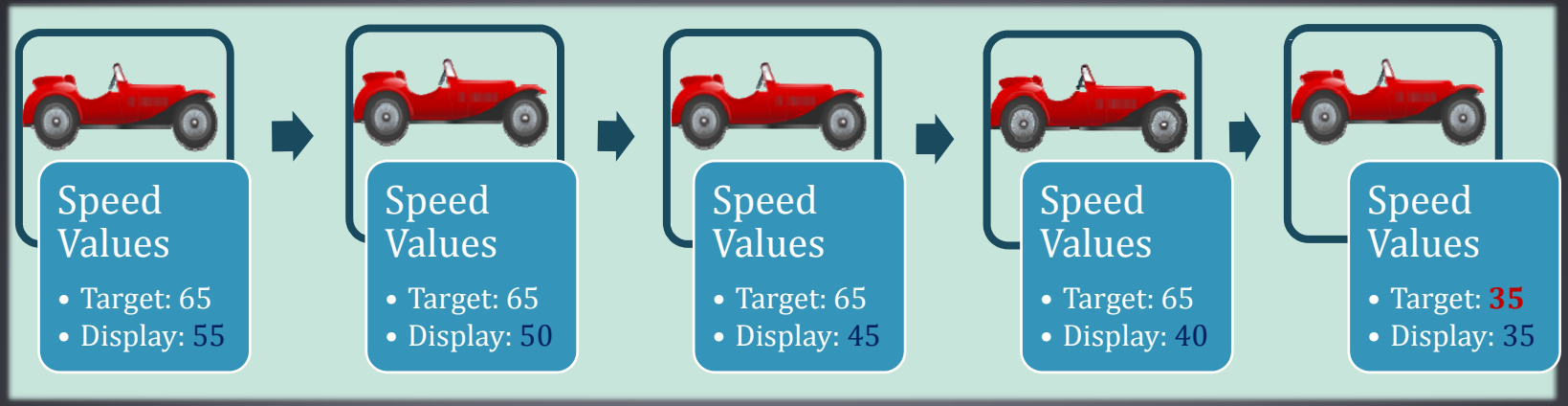
Weather Algorithm

		$F \geq F^{UT}$ Good	$F^{LT} < F < F^{UT}$ Moderate	$F \leq F^{LT}$ Poor
$V > V^T$	Good	Normal speeds	Speed1	Speed2
$V \leq V^T$	Poor	Speed3	Speed4	30 MPH

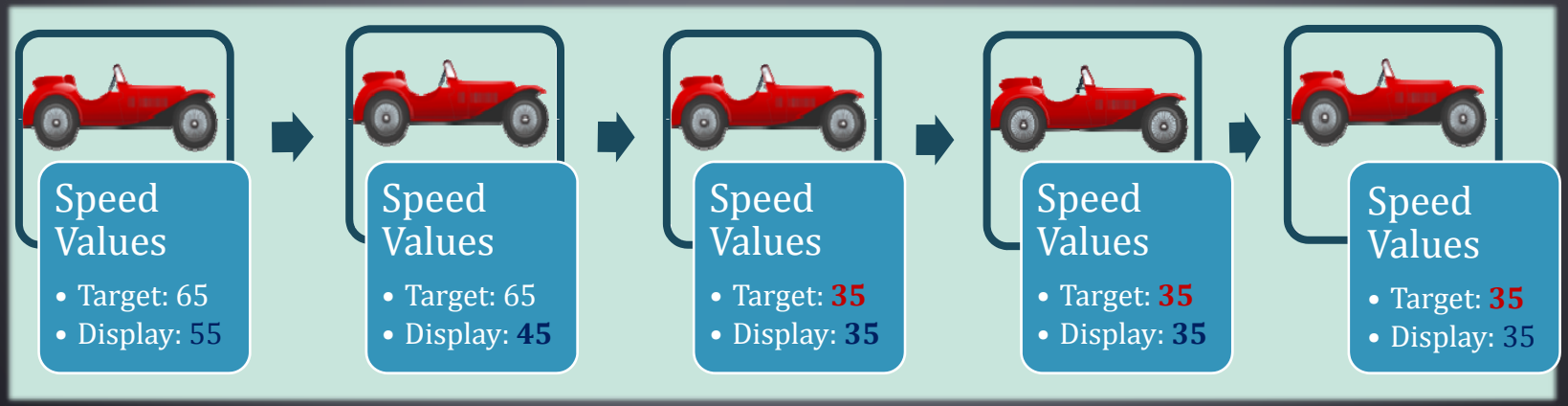
- Two thresholds for friction were used based upon impact to traffic speeds
  - Upper: Moderate-high—heavy rain, actively flowing water
  - Lower: Low-moderate—lighter rain, roads still wet
- Visibility used a single threshold
- Either congestion or weather could activate VSL
  - Lowest triggered speeds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

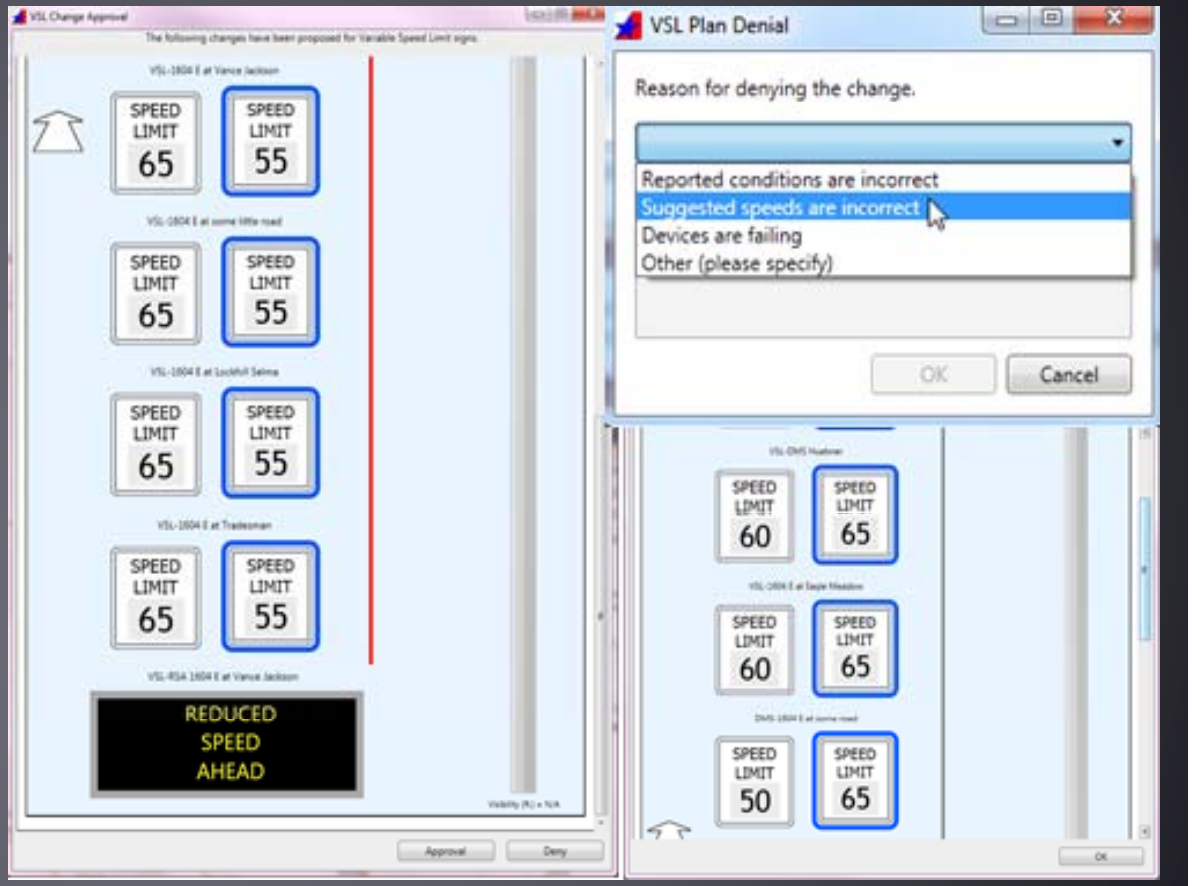


Activation Approvals

- 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

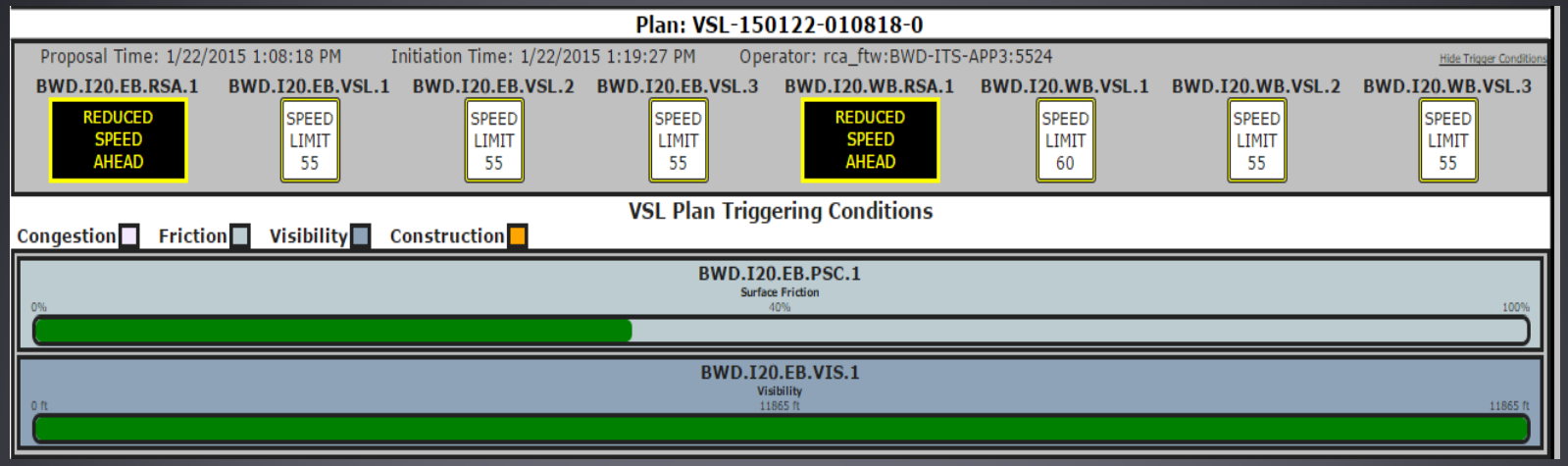
Lonestar VSL Activation Alert

- 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

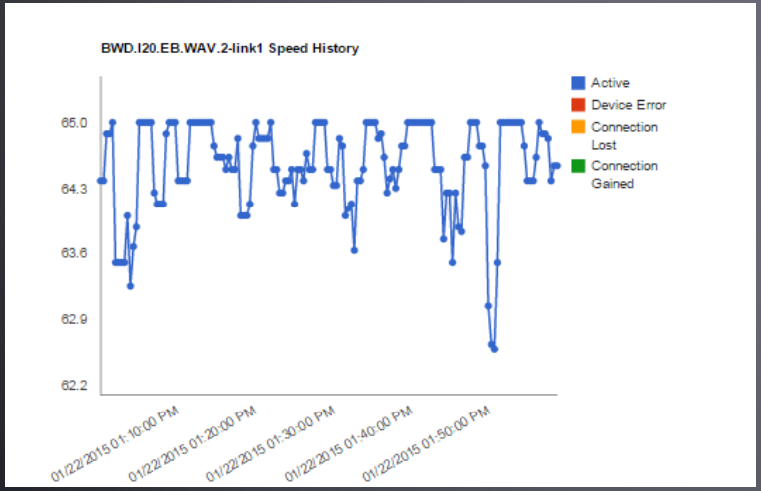


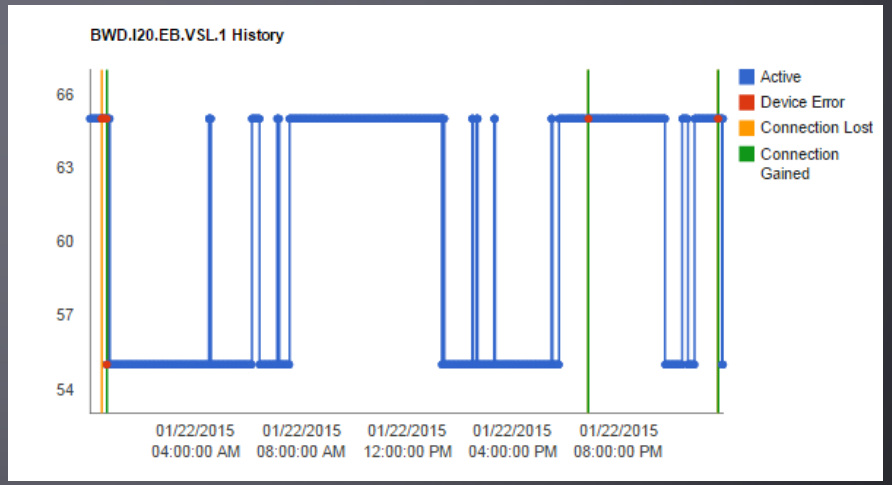
VSL Website Functionality

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

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- 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

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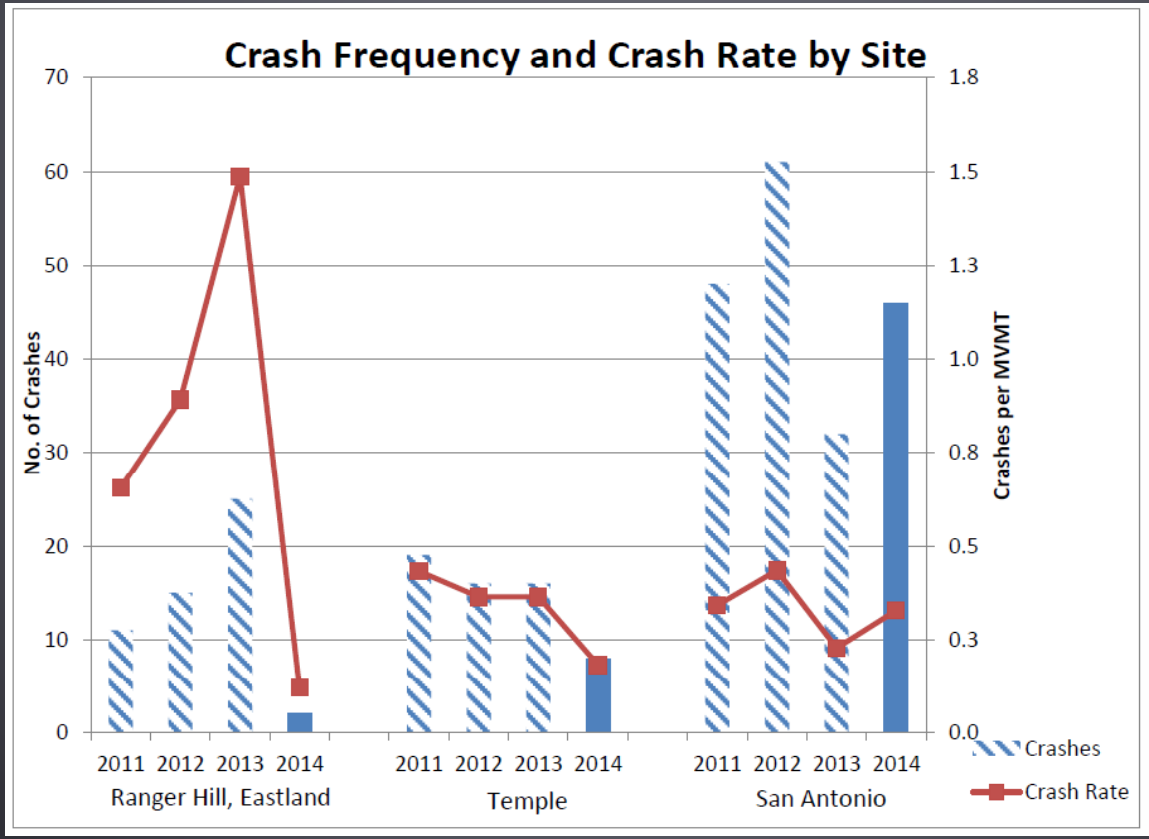
- 3 month pilot period for evaluation report
- Over 400 activations of temporary speed limits
  - Most activations: congestion
  - Least activations: weather
- Typical activation duration was under an hour
  - Some activations lasted as long as 10 hours during weather events
- Speed limits typically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

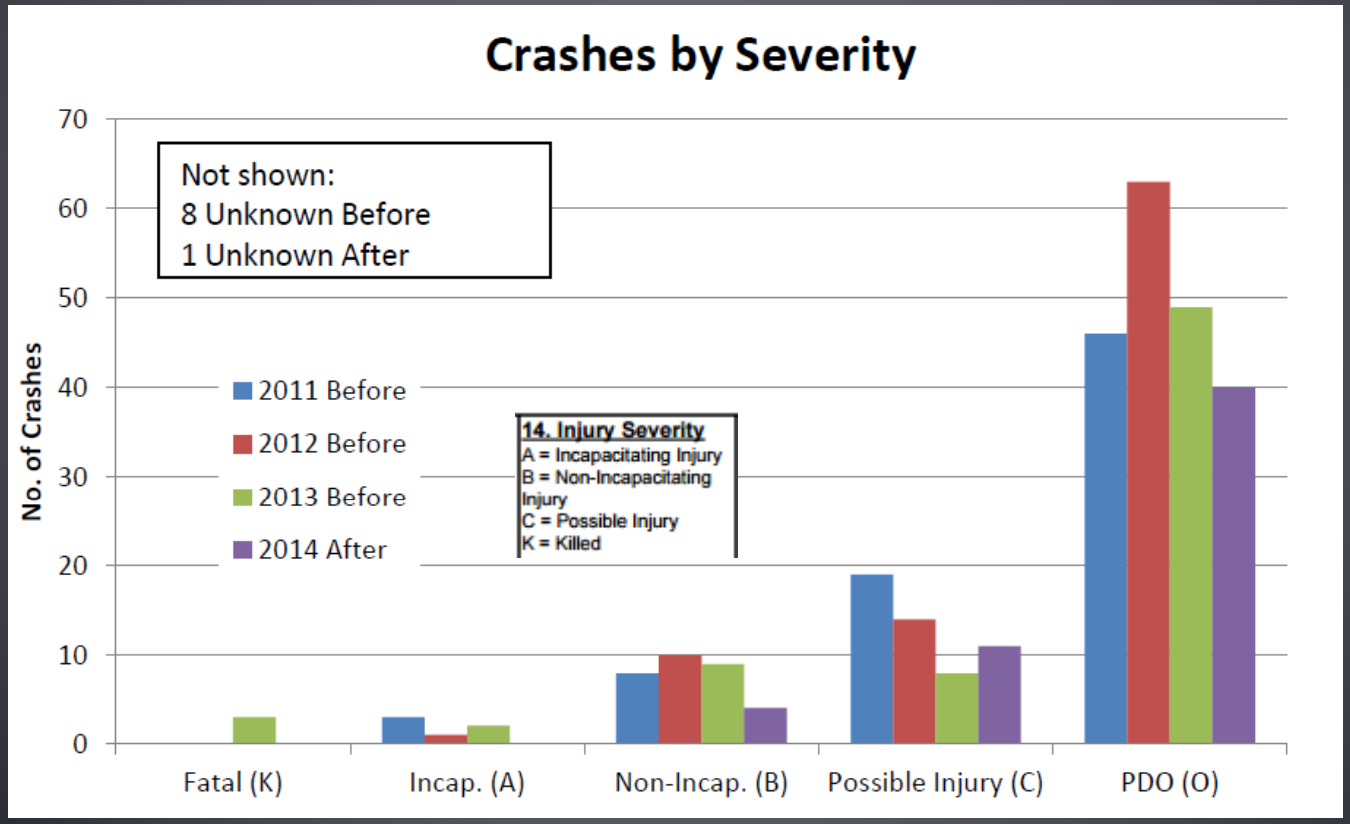
VSL Pilot Effectiveness

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



VSL Pilot Effectiveness, cont.

- Reduction in severity of crashes
  - No fatal or incapacitating crashes reported!



Lessons Learned—VSL Signs

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- Portable message signs had shortcomings including:
  - Placement of the sign on the side of the road

Signs were further off the roadway than typical placements

  - 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

Lessons Learned—Other Hardware

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- 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

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- 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

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- 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

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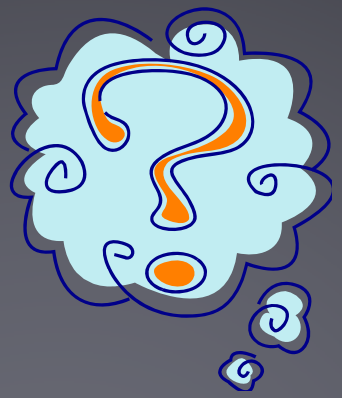
- Public understood that lowered speed limits were enforceable and could result in tickets
  - But, they did not always obey them!
  - Drivers were more observant of the lowered speed limits while law enforcement was present (no surprise!)
  - For the pilot, law enforcement did not enforce lowered speed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

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

- 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

VSL Activation Algorithm

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- 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