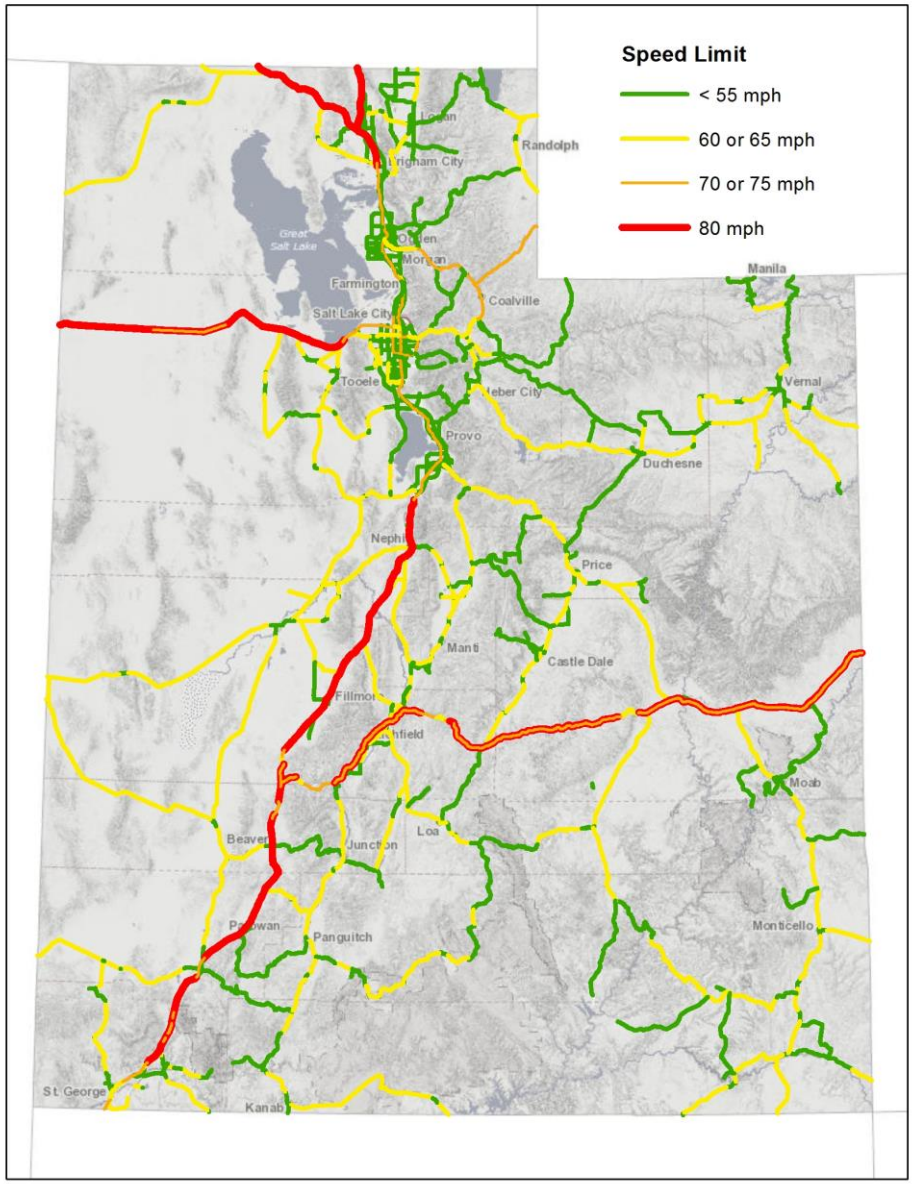
Smart Work Zones in Utah

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



Project Goal

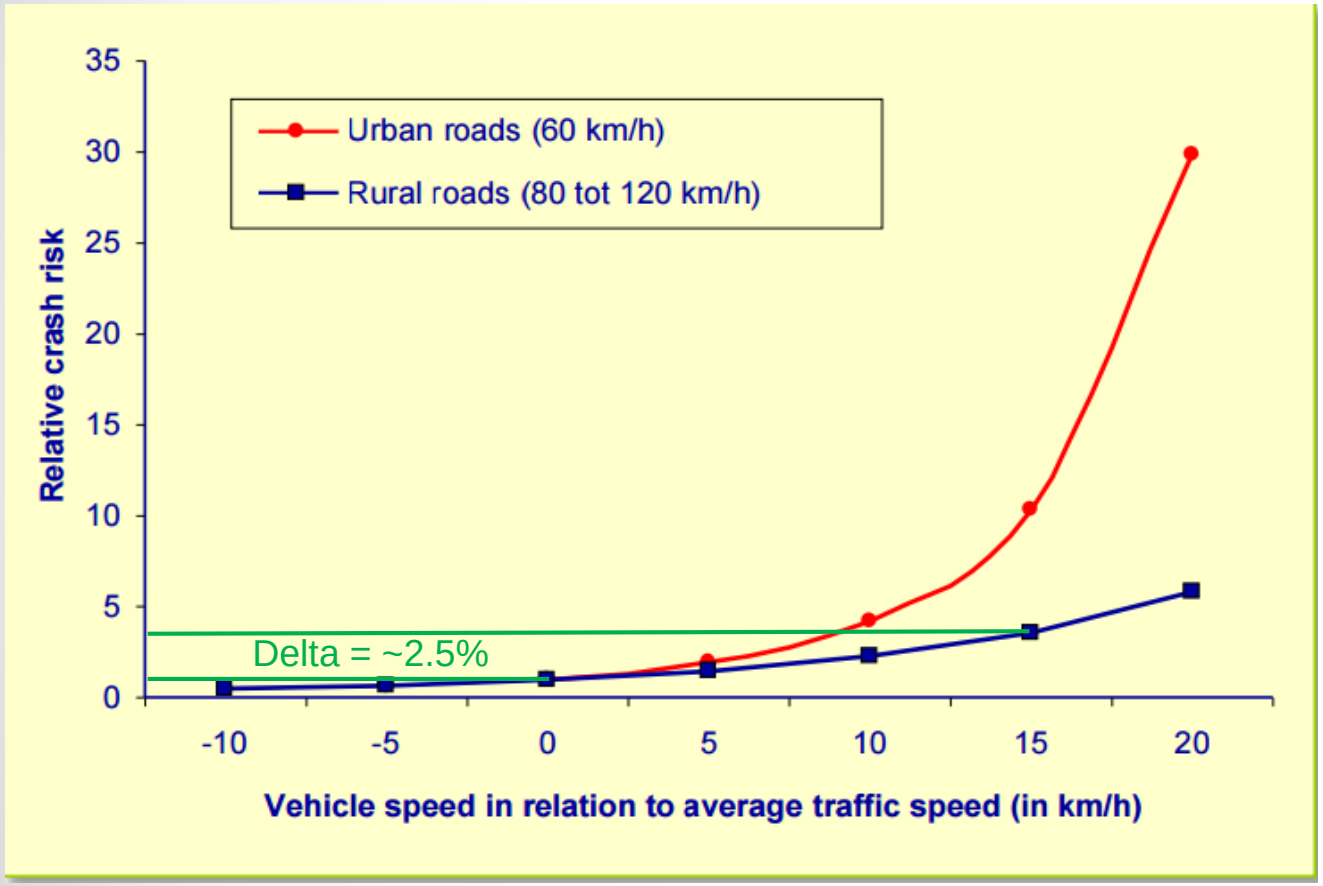
Goal: Improve safety within construction work zones through <u>significant</u> reduction in traveler speed within the boundary of <u>Active Work Space.</u>

Slower ≠ Safer

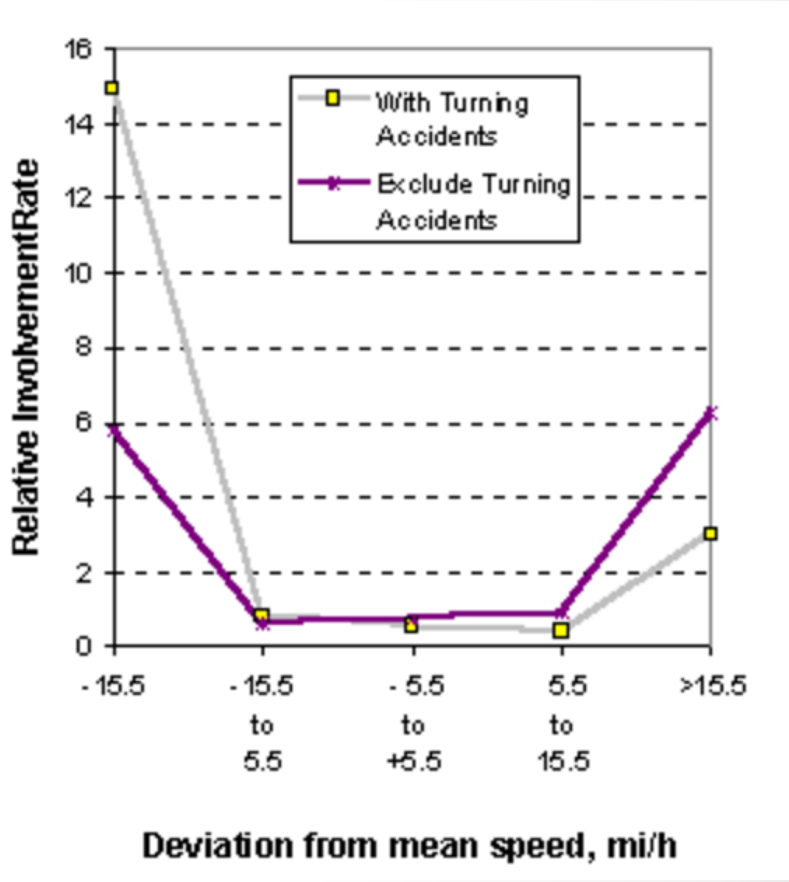
- Motorists:
  - Increase the time available for a motorist to react
  - Reduce stopping distances
  - Allow more significant (recoverable) evasive maneuvers

- 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



West and Dunn 1971

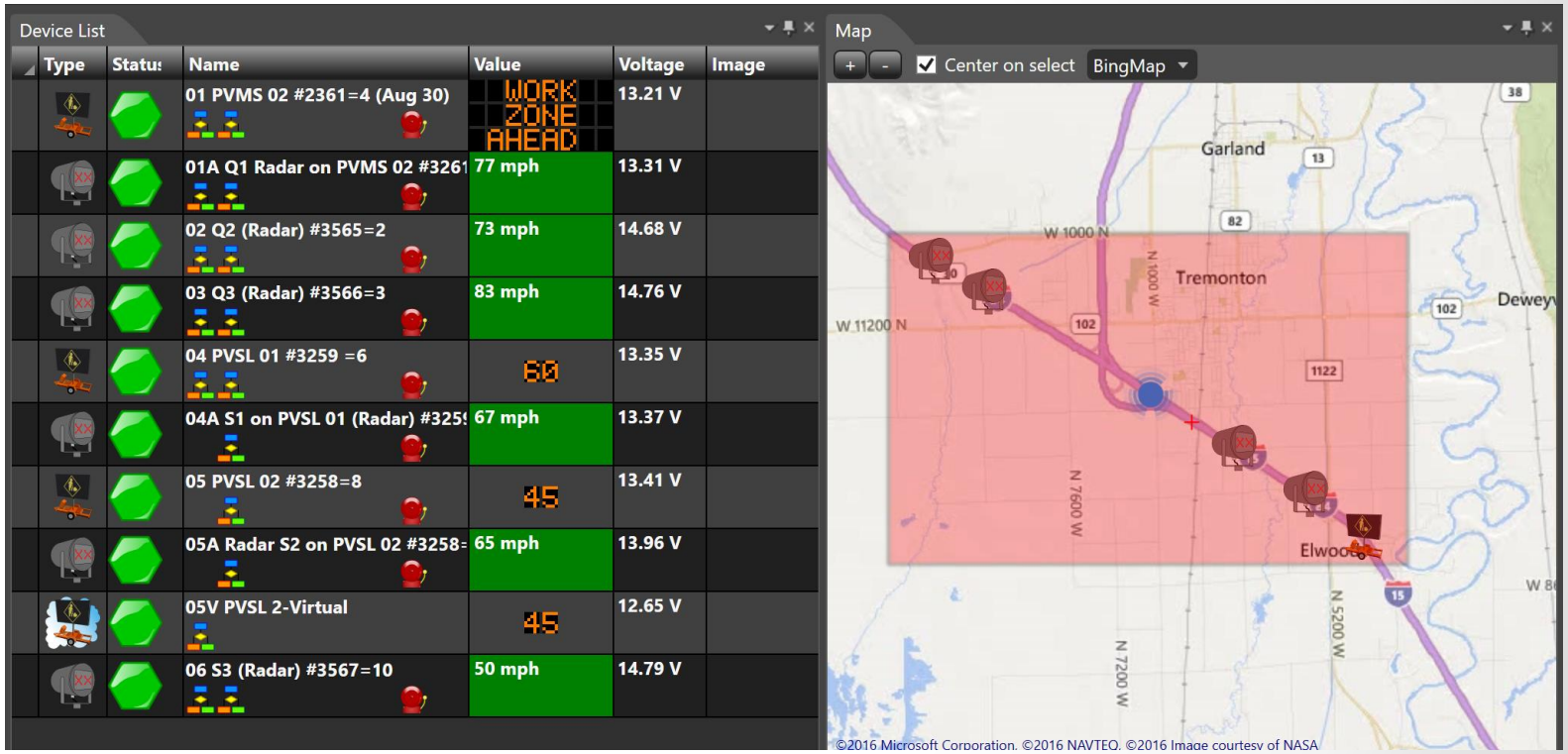
Speed Harmonization!!!

PVSL Candidate Projects

- 4 lane divided / undivided roads
  - No experience with multi through lanes yet
- High Speed (50mph +)
- Example
  - Resurfacing
  - Slab Replacement
  - Bridge Work
  - 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

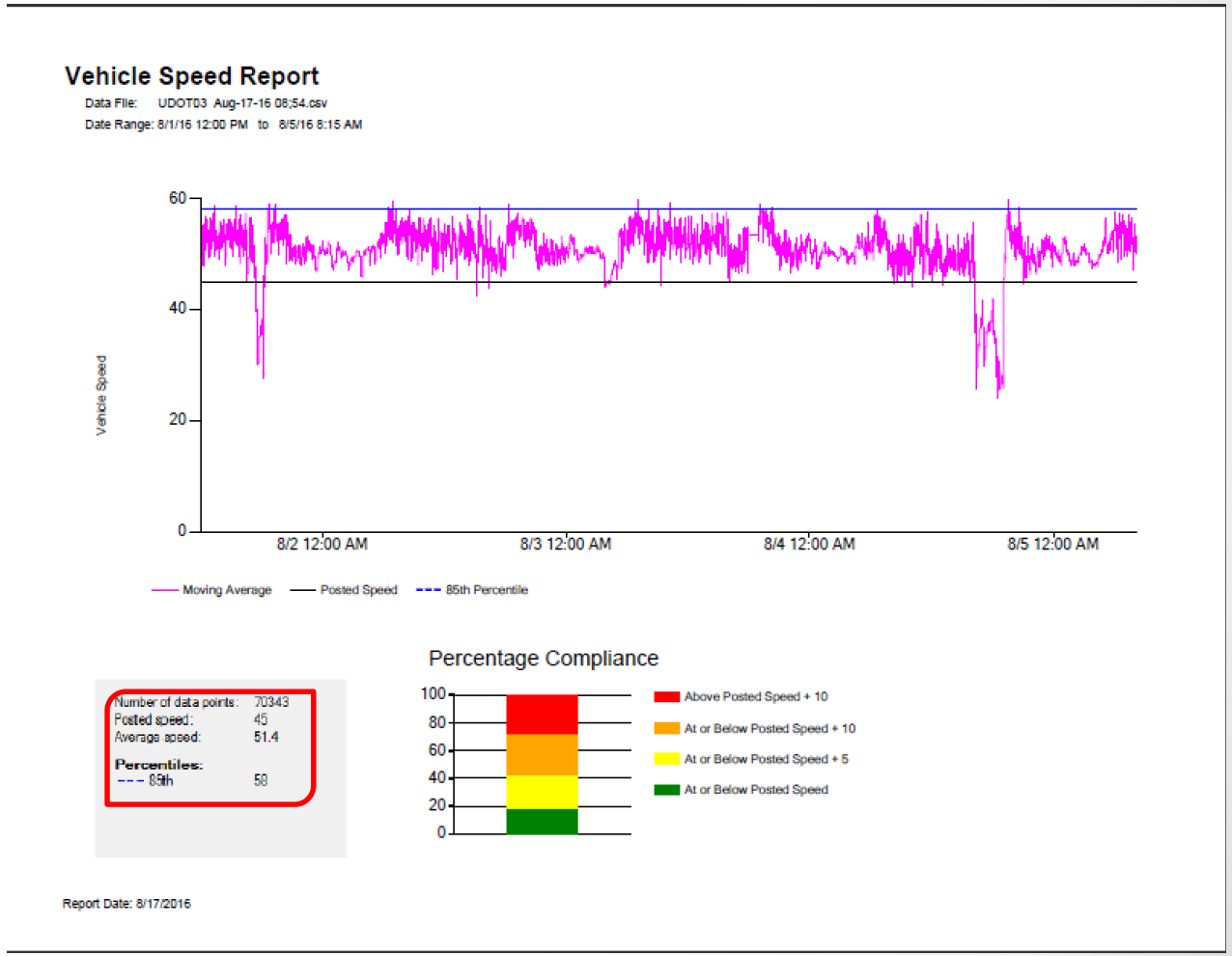
- We have done 12+ projects to date with PVSL
- No detection
- Field crew remotely changes speeds per TEO
- There is data collection
- Basically low or high

SMRT- Success Stories

US 40 Deck Replacement

- Original Posted Speed = 65 mph
- Reduced Speed = 45mph
  - 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

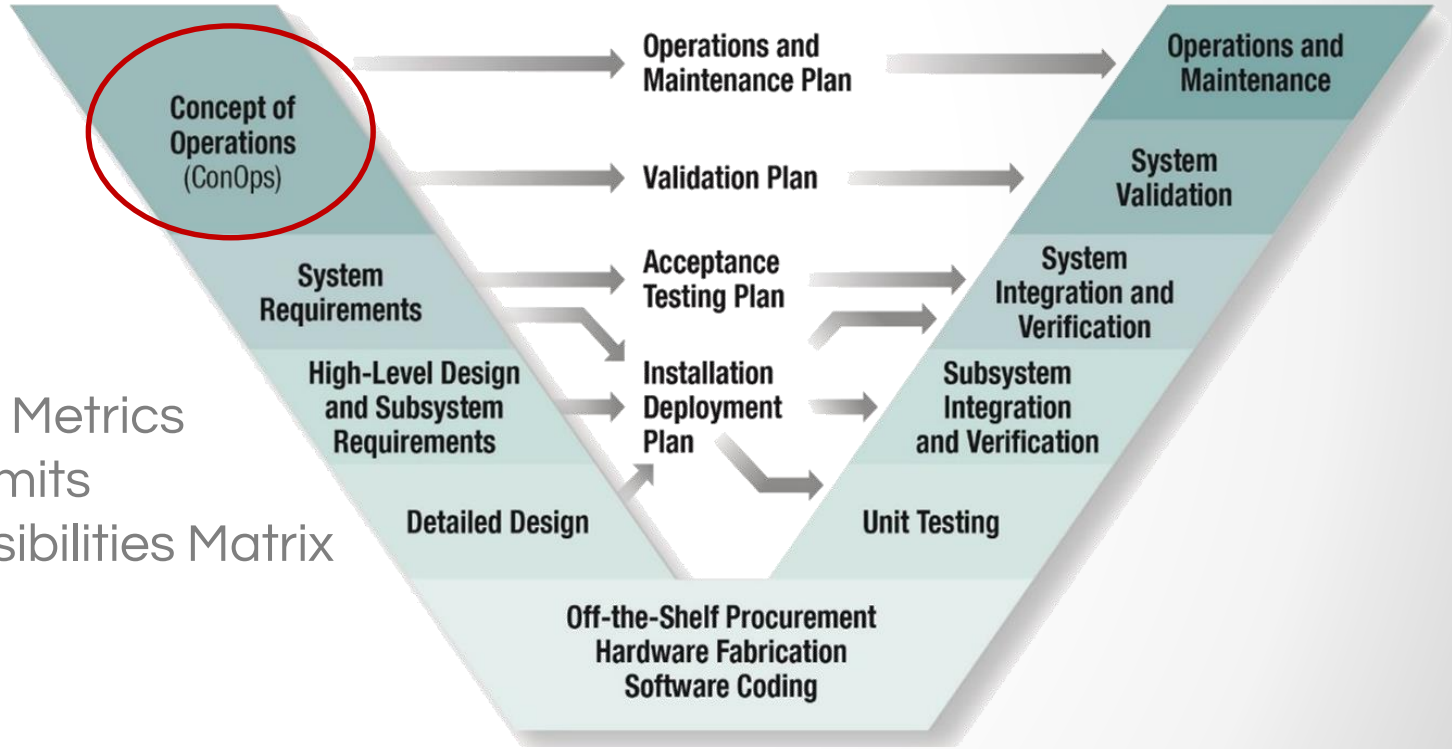
- PVSL *System*
- Portable, Intelligent and Dynamic
- Multiple Devices (PVSL, Detectors, PVMS)
  - Integrated as one system
  - Dynamically posting speed limits, and
  - Traveler information messages
  - Operated by RE and Roadway Contractor (No TOC)

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

Goals, Objectives and Performance Measures (FIELD)

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

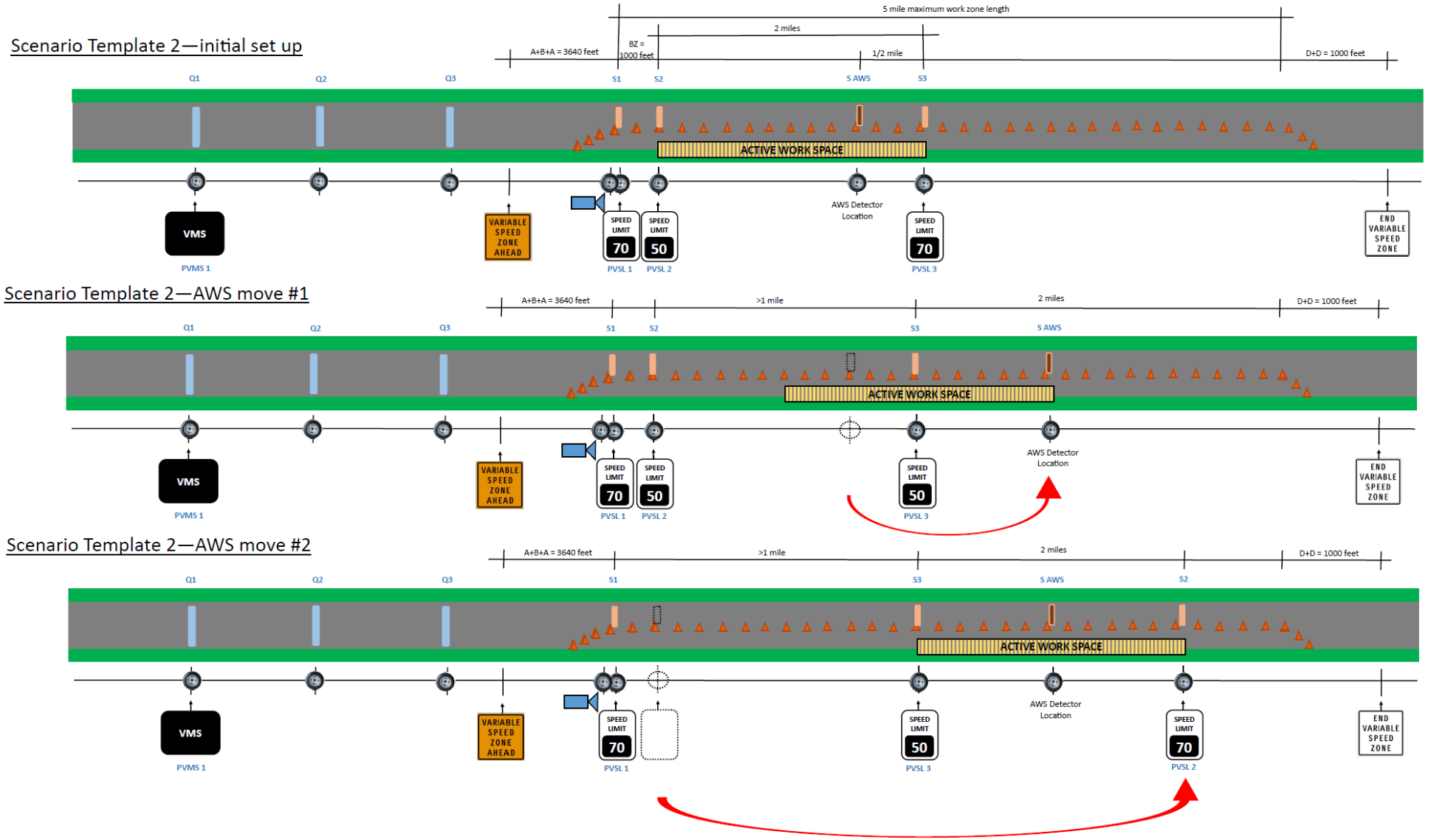
A Goal We Can All Live With

Goals, Objectives and Performance Measures (PUBLIC)

Category	Goal	Objective	Measure
PUBLIC	Safety	Safer for public	• Number of crashes • Customer satisfaction
	Public trust	Posted speeds comply with worker activity	All measurers 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 reliable information	• Travel time through the work space • Uptime of system
	Easy to use	Easy for public to understand	• Speed variation

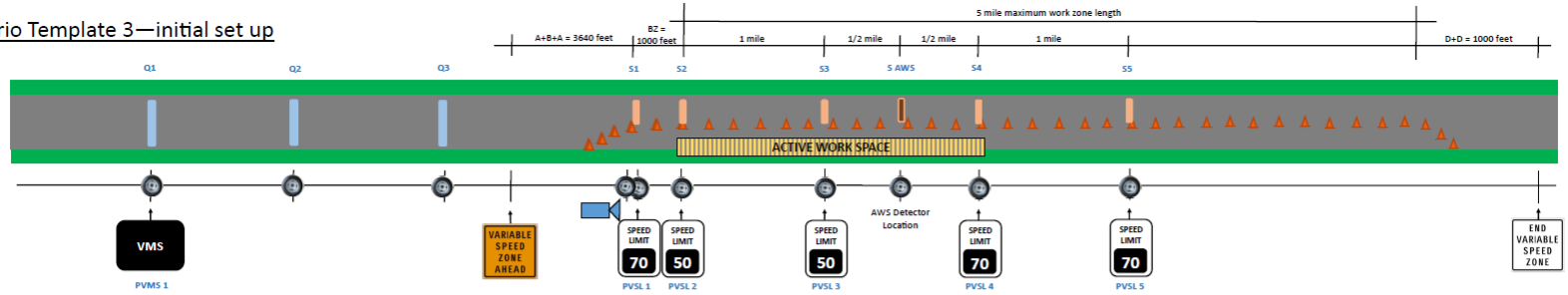
A Goal We Can All Live With

Operational Scenarios

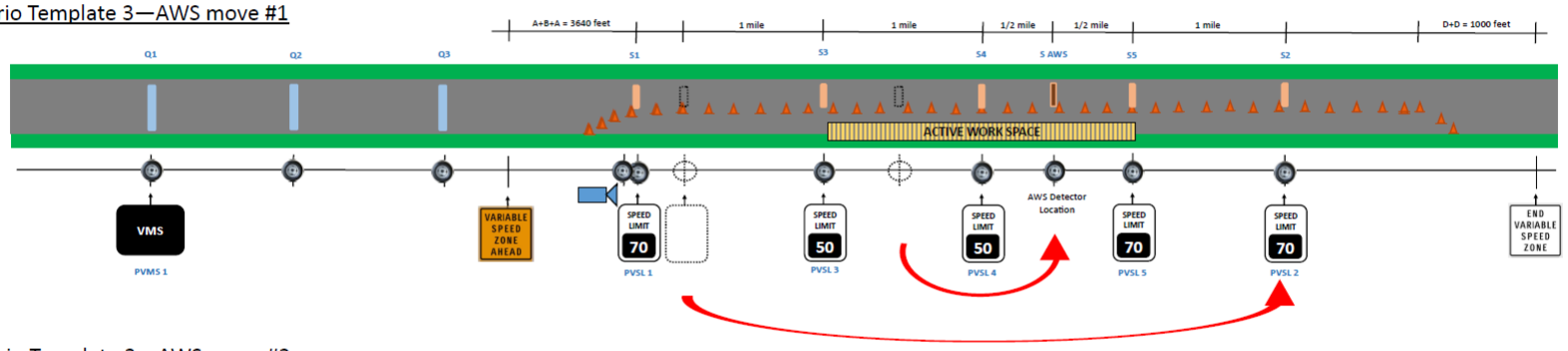


Operational Scenarios

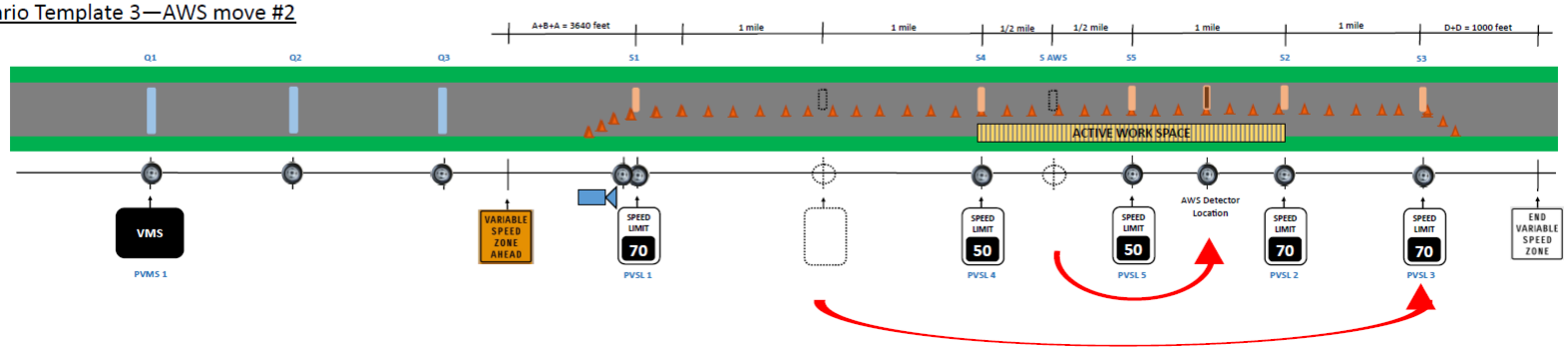
Scenario Template 3—initial set up



Scenario Template 3—AWS move #1



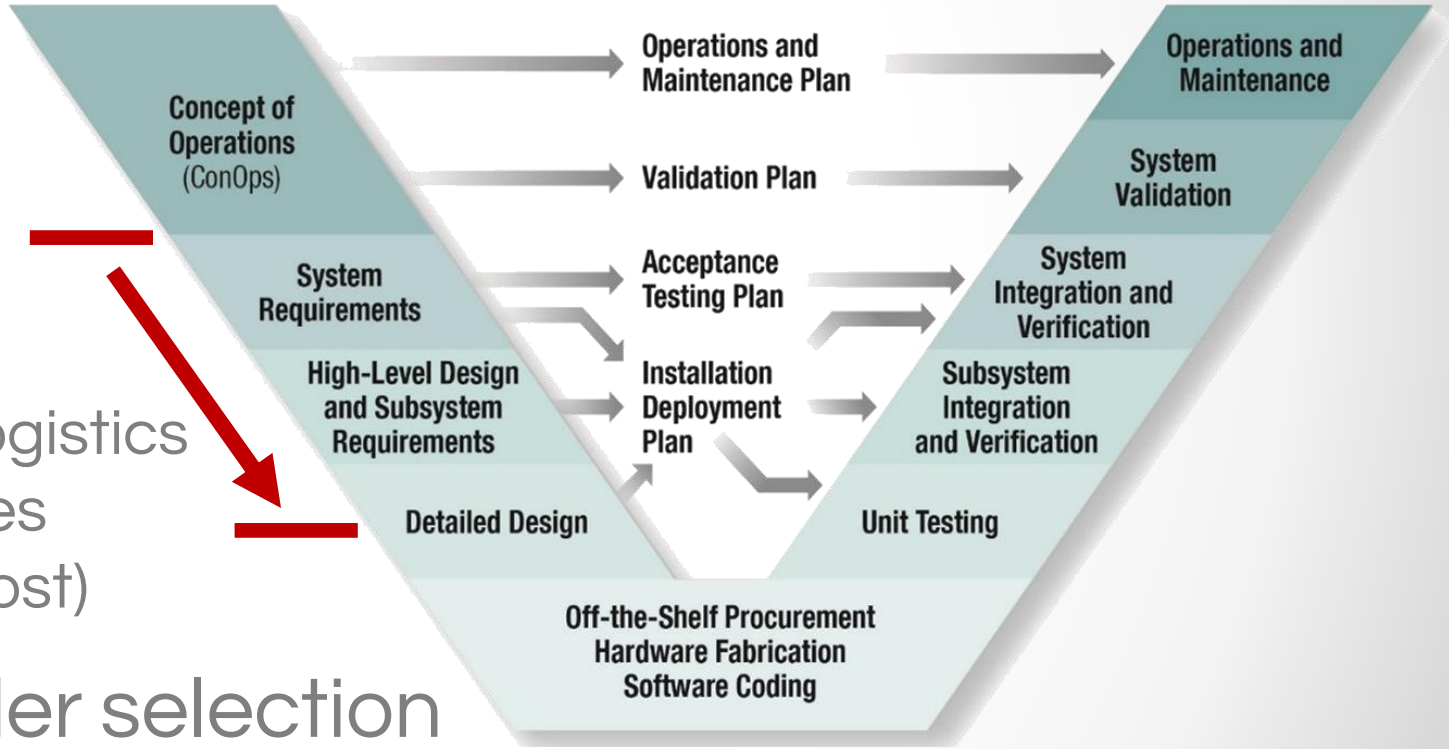
Scenario Template 3—AWS move #2



PVSL System: RFP Development

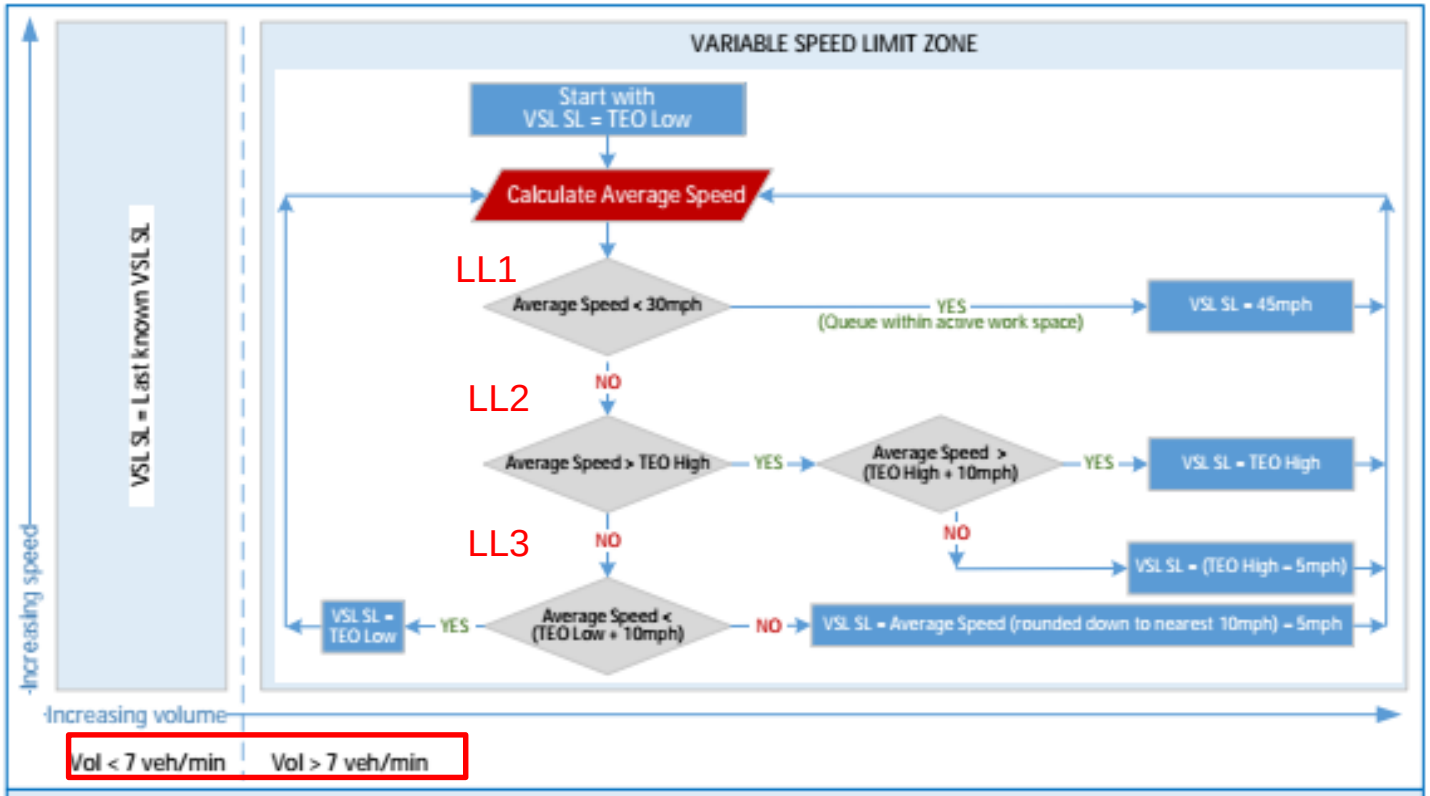
- RFP Development
  - System Requirements
  - High-Level Design
  - Industry Outreach
  - System Algorithms
  - Measurement / Payment Logistics
  - Quantity Deployment Phases
  - Selection Criteria (quals + cost)
- Turn-key Solution Provider selection

Systems Engineering Process



Kimley»Horn
avenue CONSULTANTS

VSL Subsystem Algorithm



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".

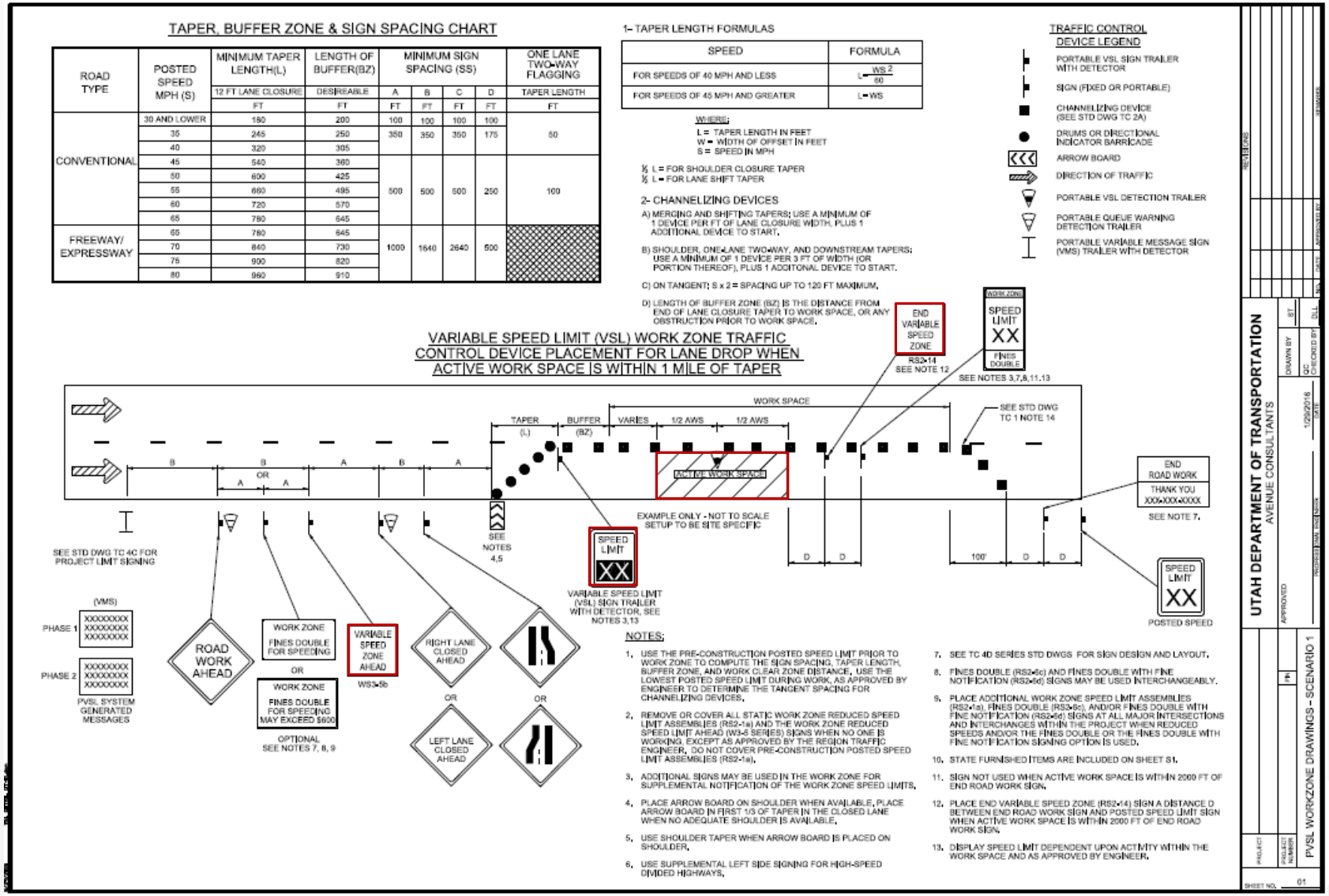
TEO Low = The lowest speed limit allowed by TEO.

Low Volume = Vol < 7 veh/min = Post last known VSL SL

Frequency of Speed Limit Change = every 20 min when increasing speed

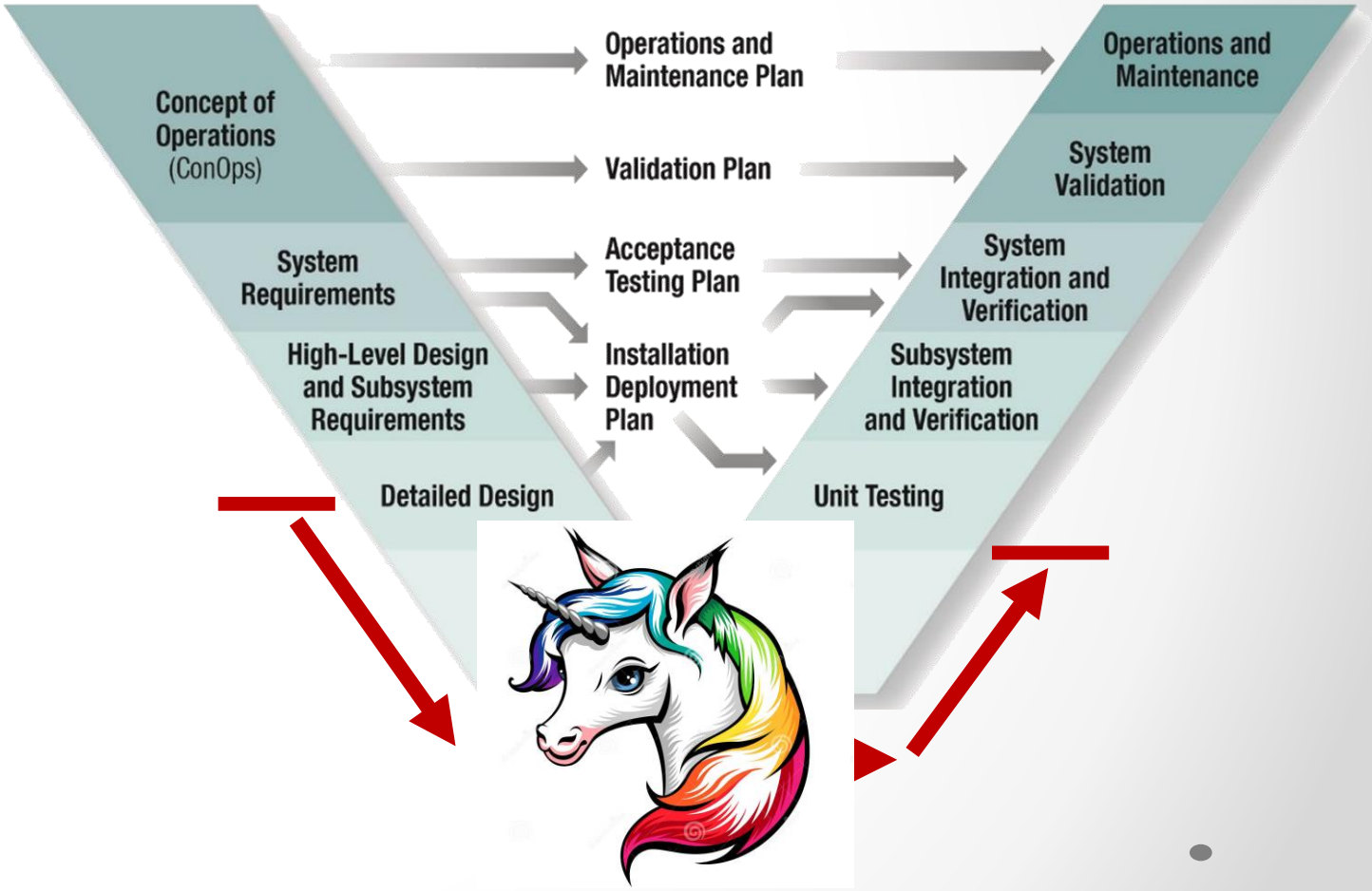
If bad or no data is received from the detector at the center of the active work space, then VSL SL = Last known VSL SL

Scenario 1 - AWS w/in 1 mile



PVSL System: System Procurement

Systems Engineering Process



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

System Components

- **Portable Variable Speed Limit Signs (PVSL)**
  - Trailer Mounted with variable speed digits
  - White LEDs on black background (Regulatory)
- **Portable variable message sign (PVMS)**
  - Orange LEDs on black background (30° view angle)
- **Speed Detection Trailers**
  - Trailer mounted
  - K-Band Doppler Speed Radar
  - Selected for ease/speed to deploy

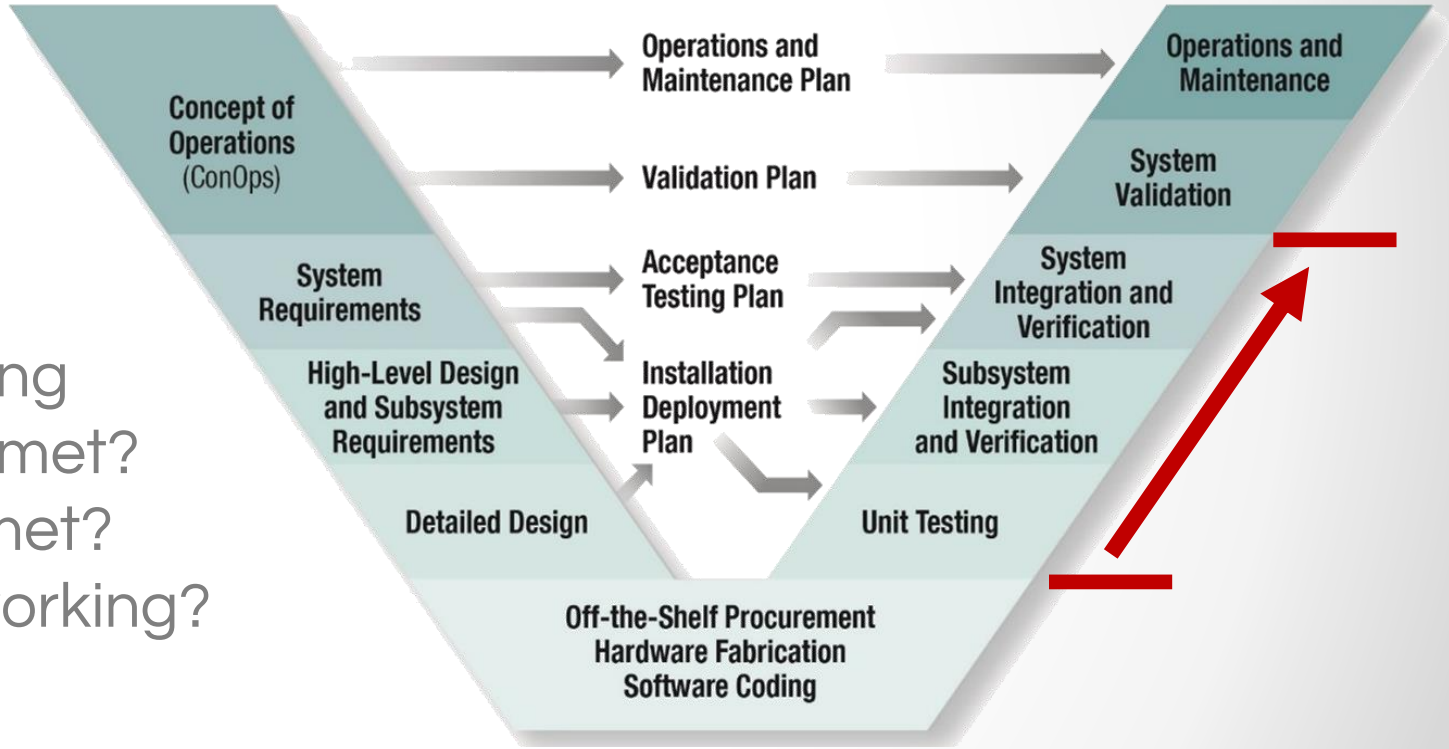
System Components

- **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

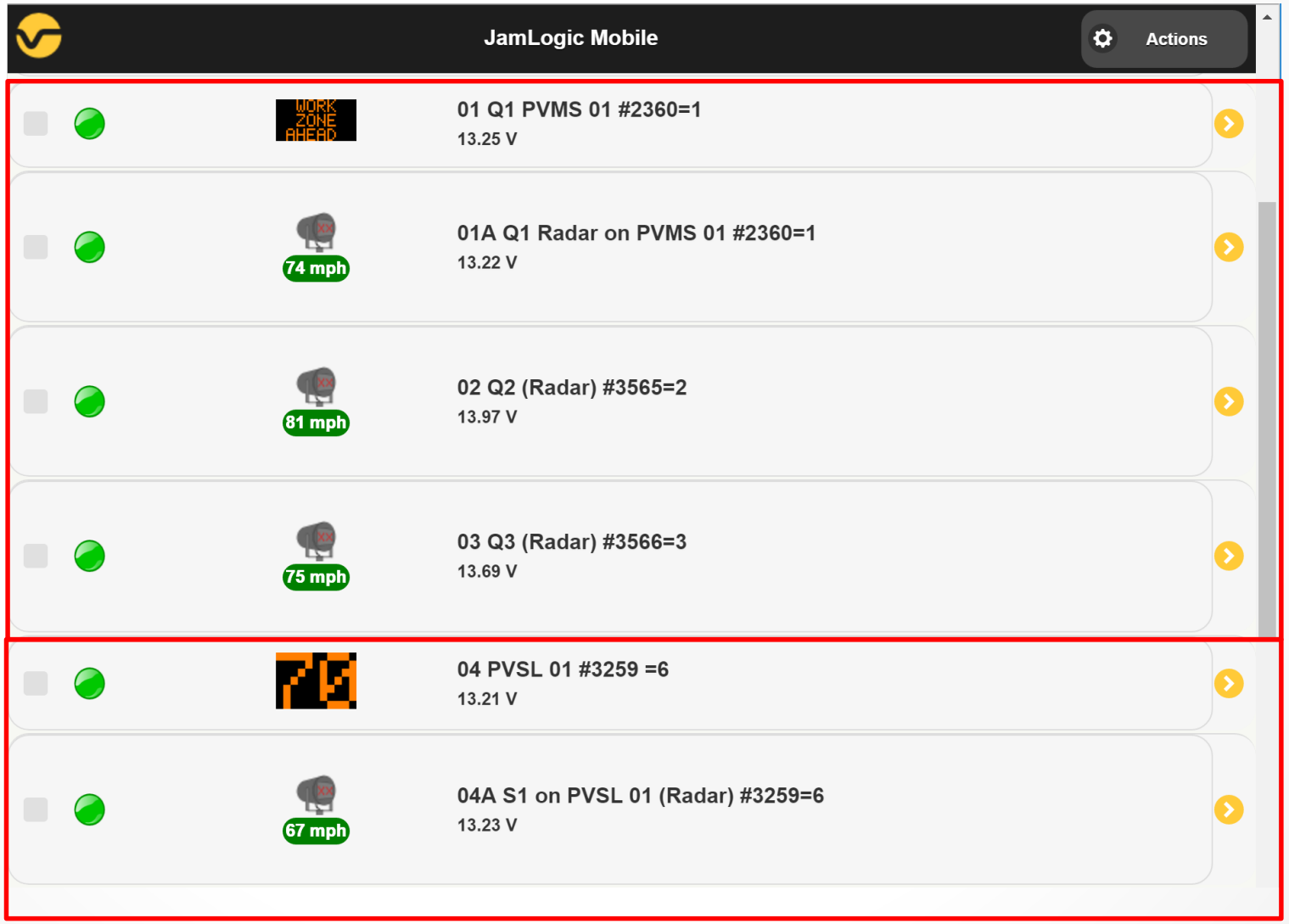


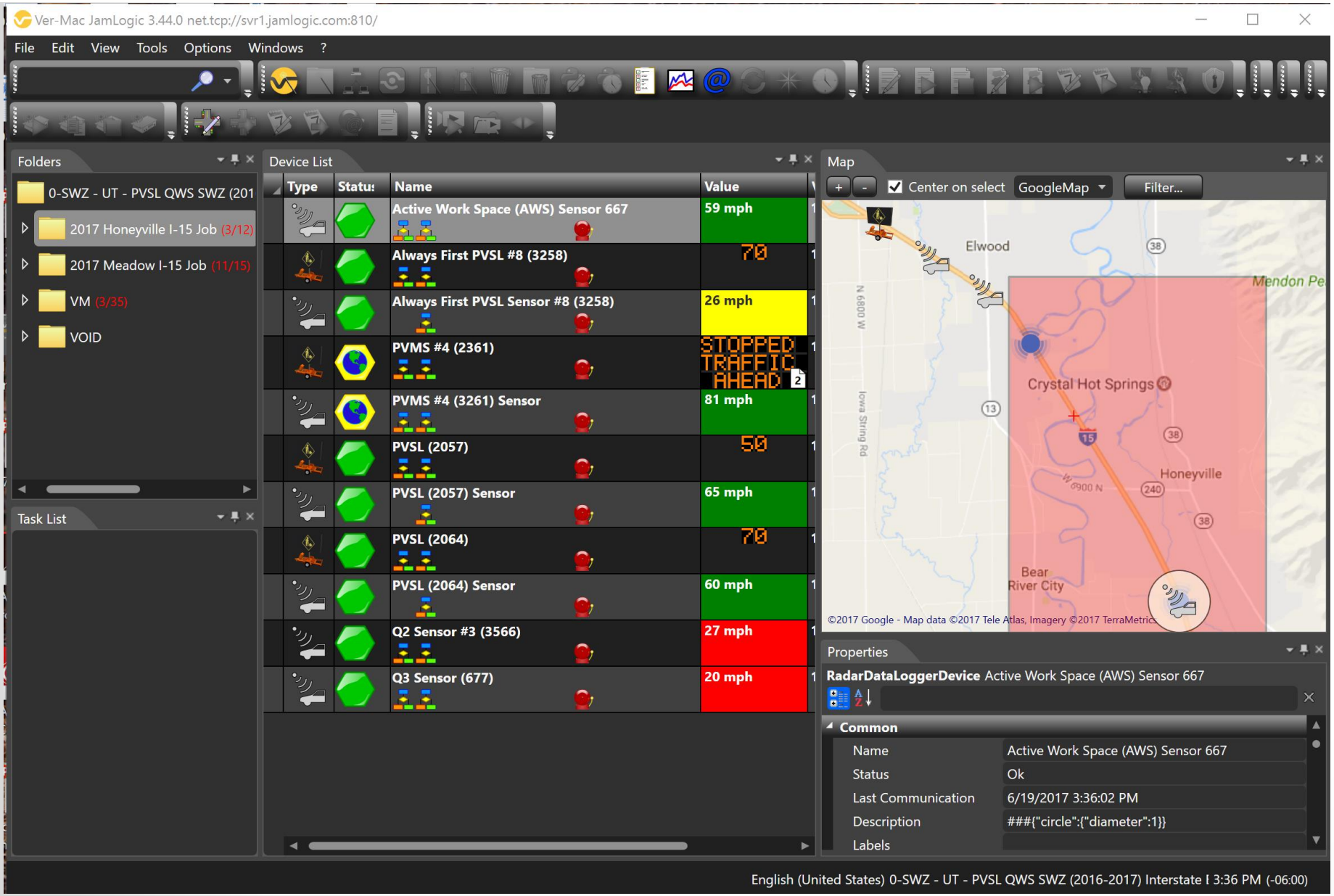
- Testing & Verification
  - Testbed Deployment
  - Pass/Fail Acceptance Testing
    - Hardware requirements met?
    - Software requirements met?
    - Integration/algorithms working?

Software (Mobile)

Queue Warning

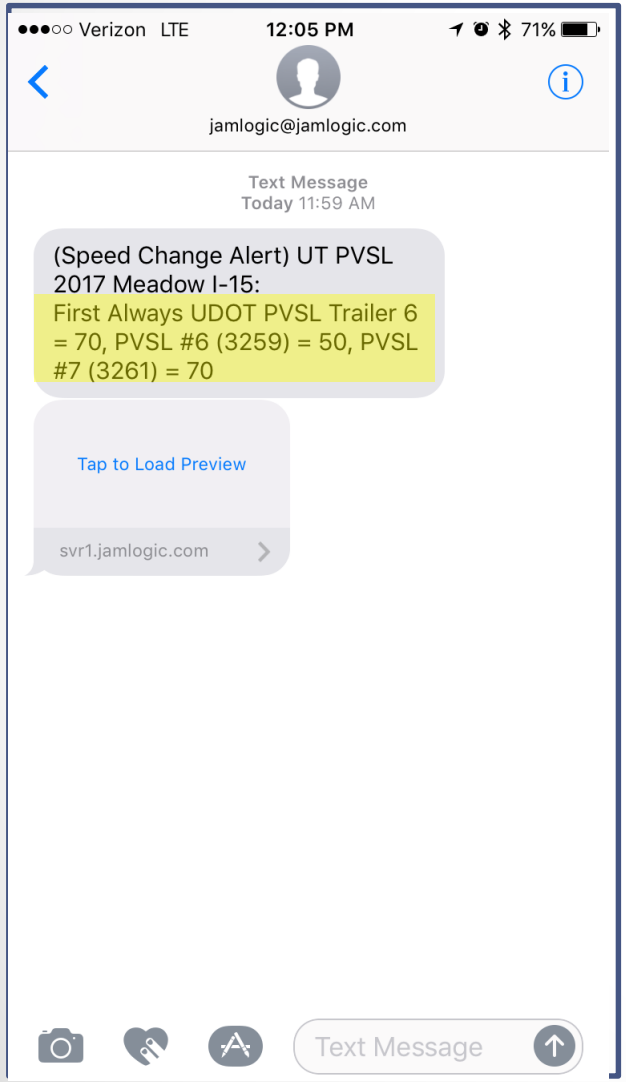
PVSL

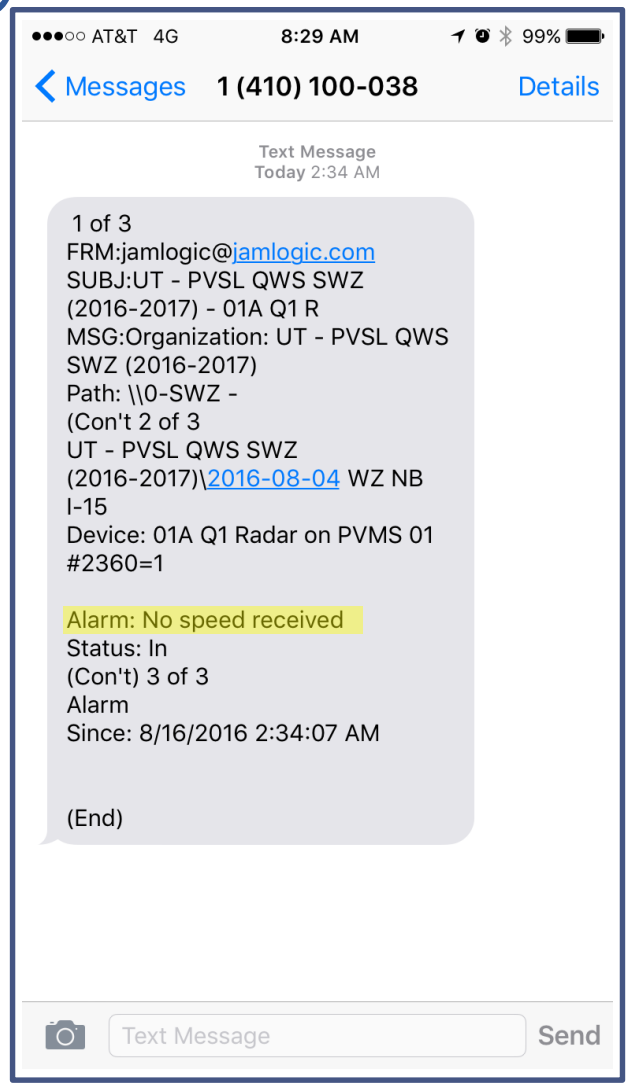


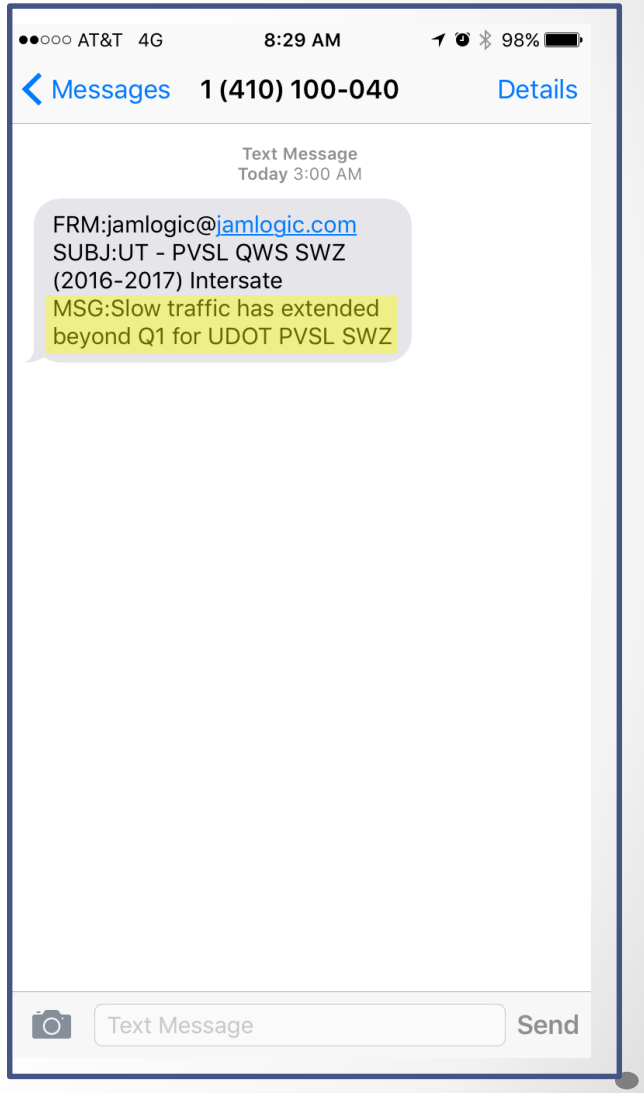


Software (Desktop)

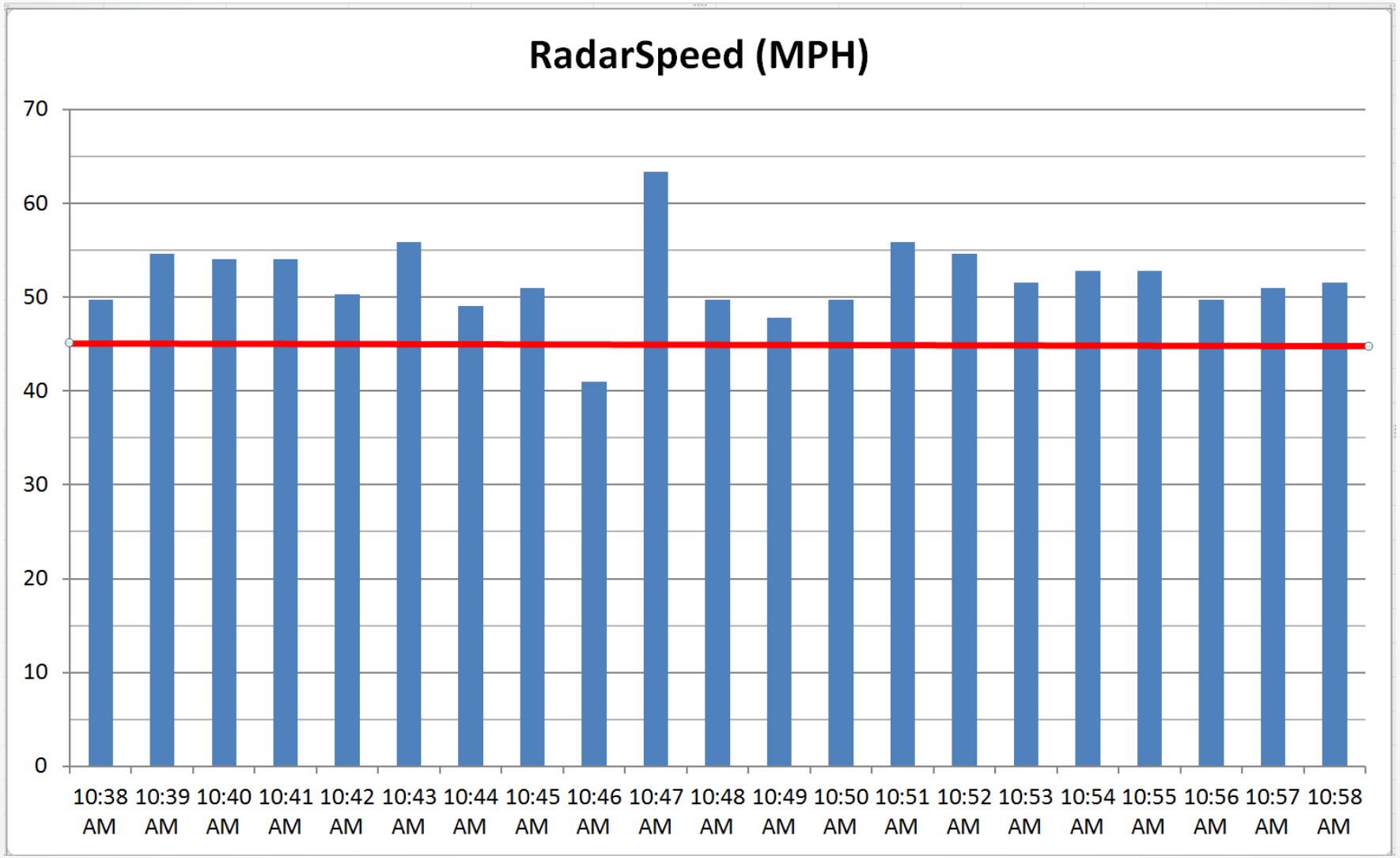
System Alerts







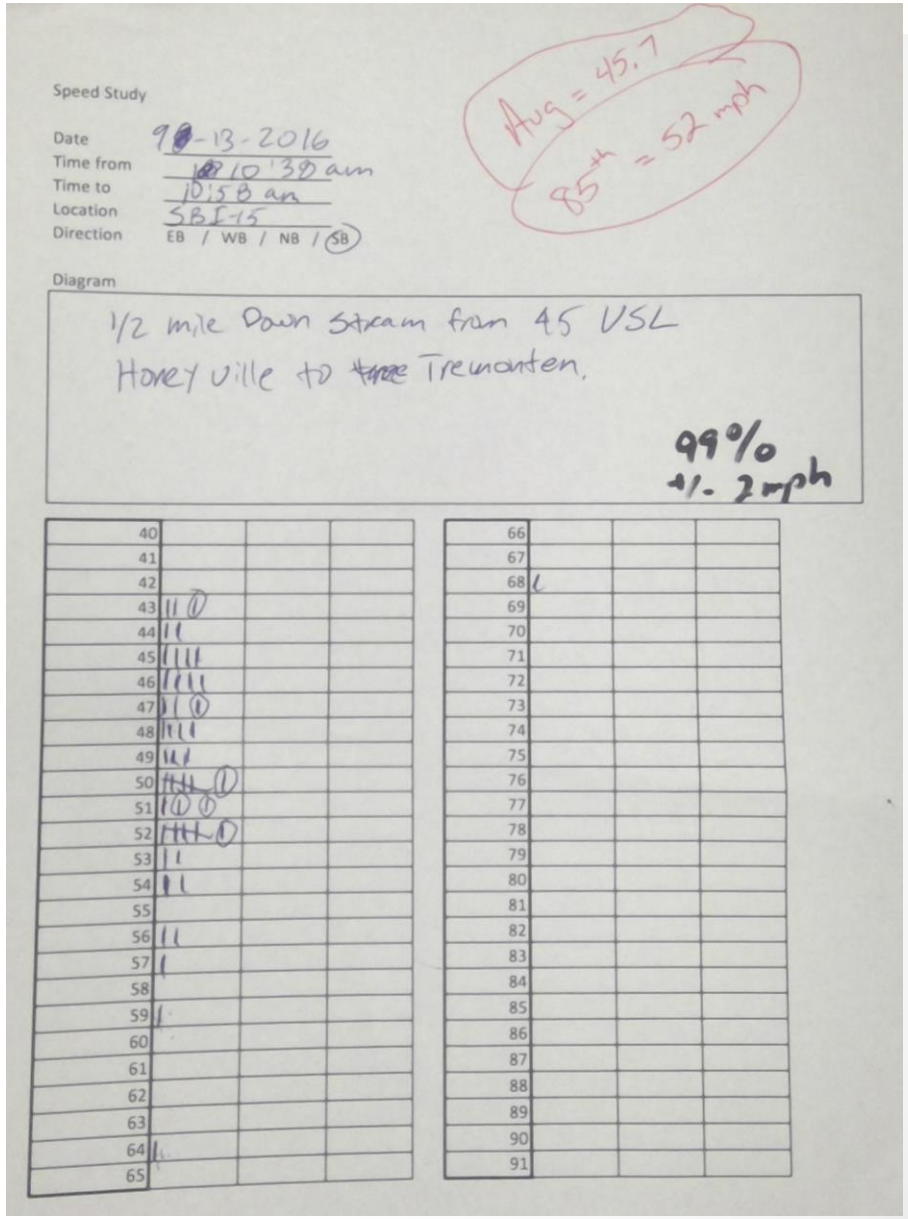
Project 1 Preliminary Results



Spot Speed Study

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

- AVG = 45.7 mph
- 85th% = 52 mph



Speed Study

Date 9-13-2016
Time from 10:30 am
Time to 10:50 am
Location SB I-15
Direction EB / WB / NB / SB

Avg = 45.7
85th = 52 mph

Diagram

1/2 mile Down Stream from 45 VSL
Honeyville to Tremonton.

99%
+/- 2mph

40			
41			
42			
43	11 1		
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45	1111		
46	1111		
47	11 1		
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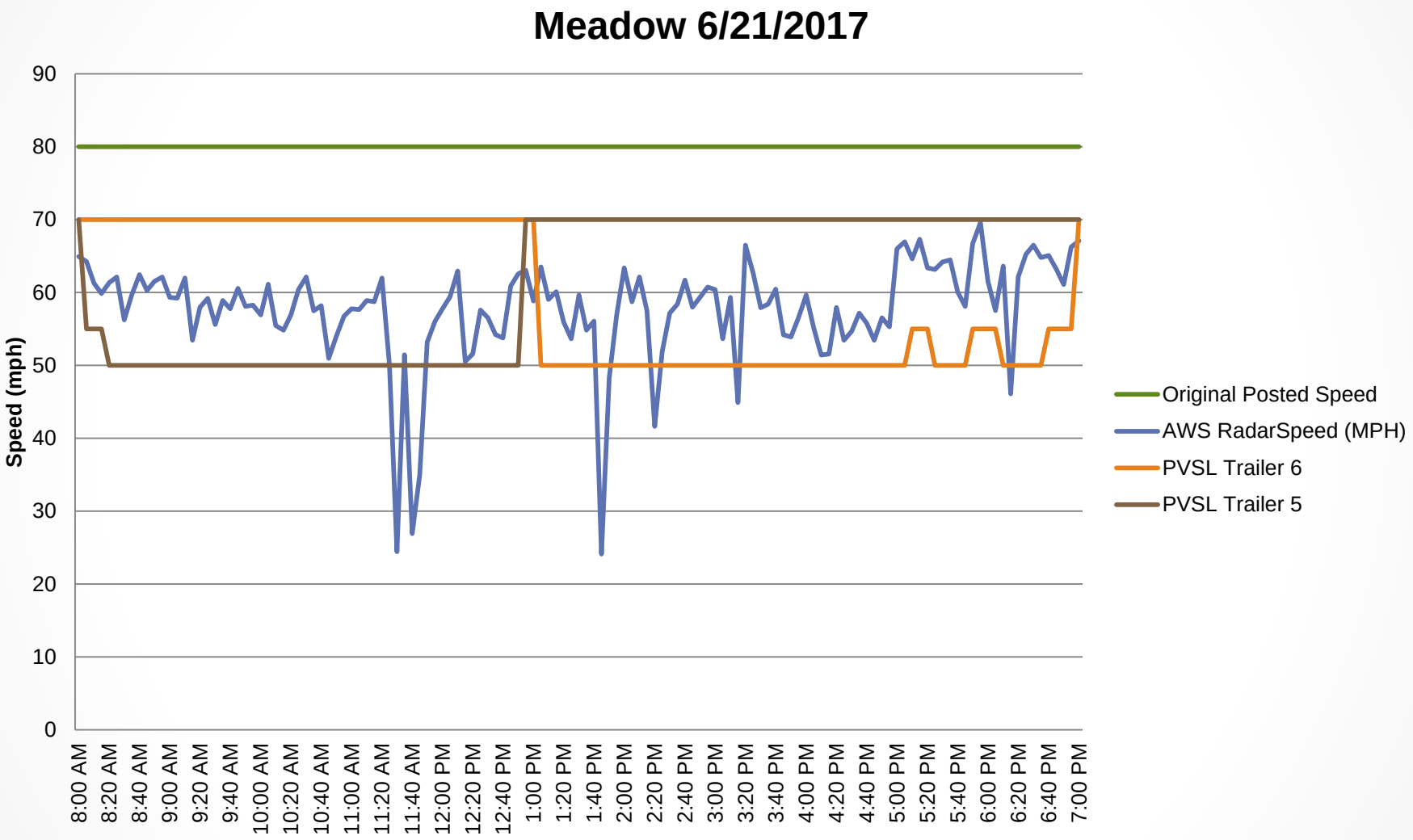
Meadow 6/21/2017
Speed (mph)
90
80
70
60
50
40
30
20
10
0
8:00 AM
8:20 AM
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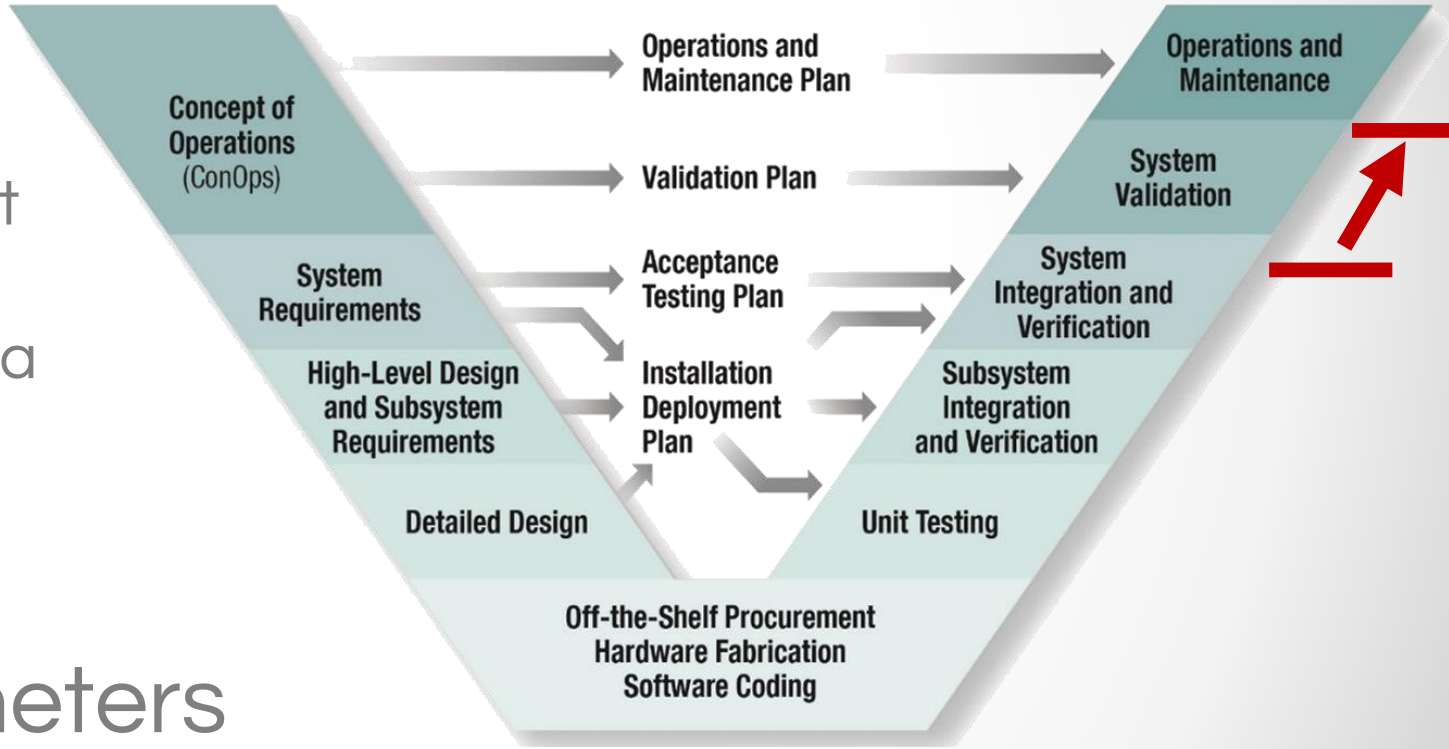
6:00 PM
6:20 PM
6:40 PM
7:00 PM
Original Posted Speed
AWS RadarSpeed (MPH)
PVSL Trailer 6
PVSL Trailer 5

PVSL System: Next Steps

Systems Engineering Process



- 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:
  - Communicate impact and duration
  - 1.5 miles = 52 seconds
  - Real time messages

- Challenges
  - Getting the change made
    - Go Automated
  - Lag time (Camera)
  - Supporting Litigation
  - Just because you can doesn't mean you should

Contact Information

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