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2006 National ITS Rural Conference

Pennsylvania Turnpike Commission (PTC)
Fog Detection, Traveler Information and Dynamic Traffic Control System

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Reason for Project

5 dead, 25 injured in two crashes on fog-shrouded PA Turnpike…

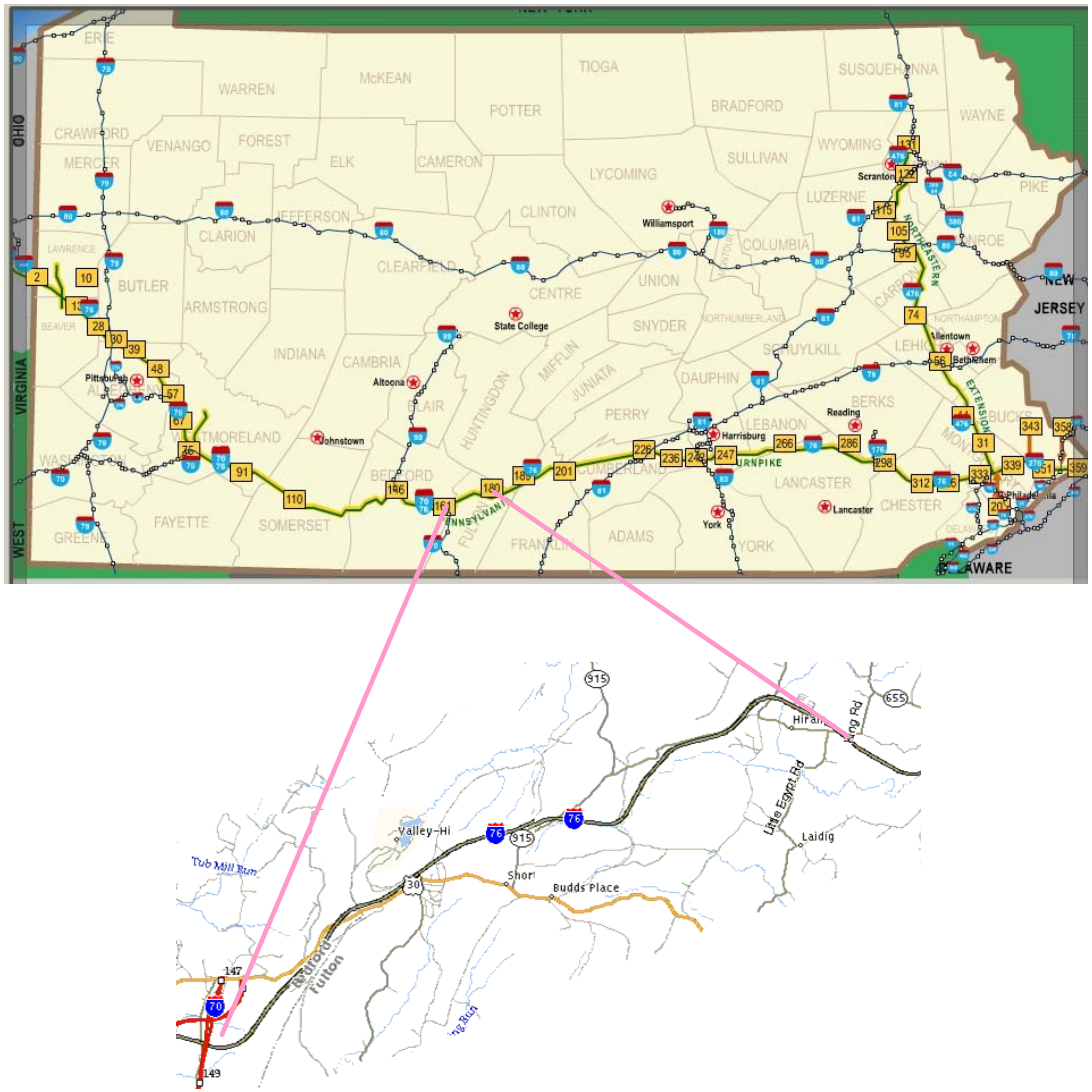
Associated Press

April 5, 2003

Why the Need for a Fog Warning System?

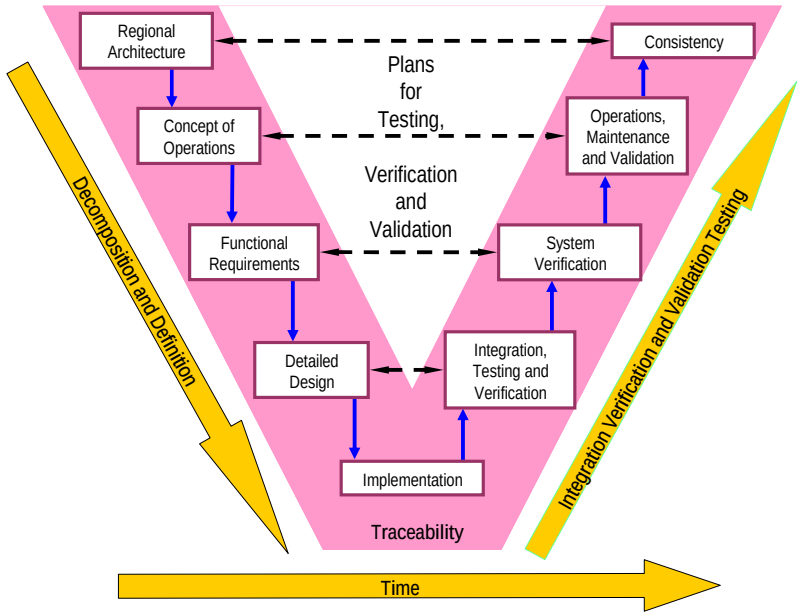
- Goal – Zero Fog-Related Crashes
- Issues
  - Large Variations In Travel Speed
  - Driver Uses His/Her Own Judgment
  - Standard warning signs ineffective
- Existing Equipment in Project Area
  - One RWIS site in fog prone area
  - One camera for verification
  - One DMS within one and four miles outside of Project Area
  - Existing Central Control Software
- Inspired by Effective System on I-75 in TN

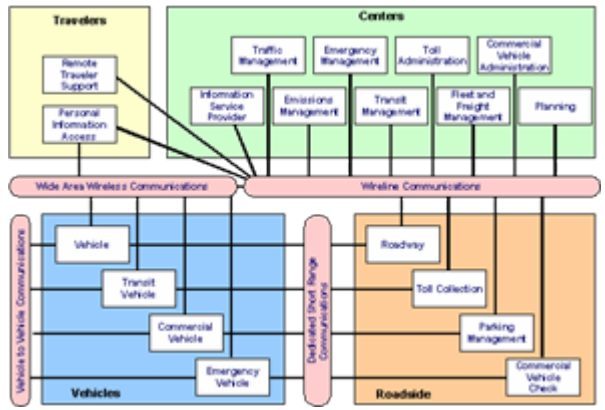
Project Location within Pennsylvania



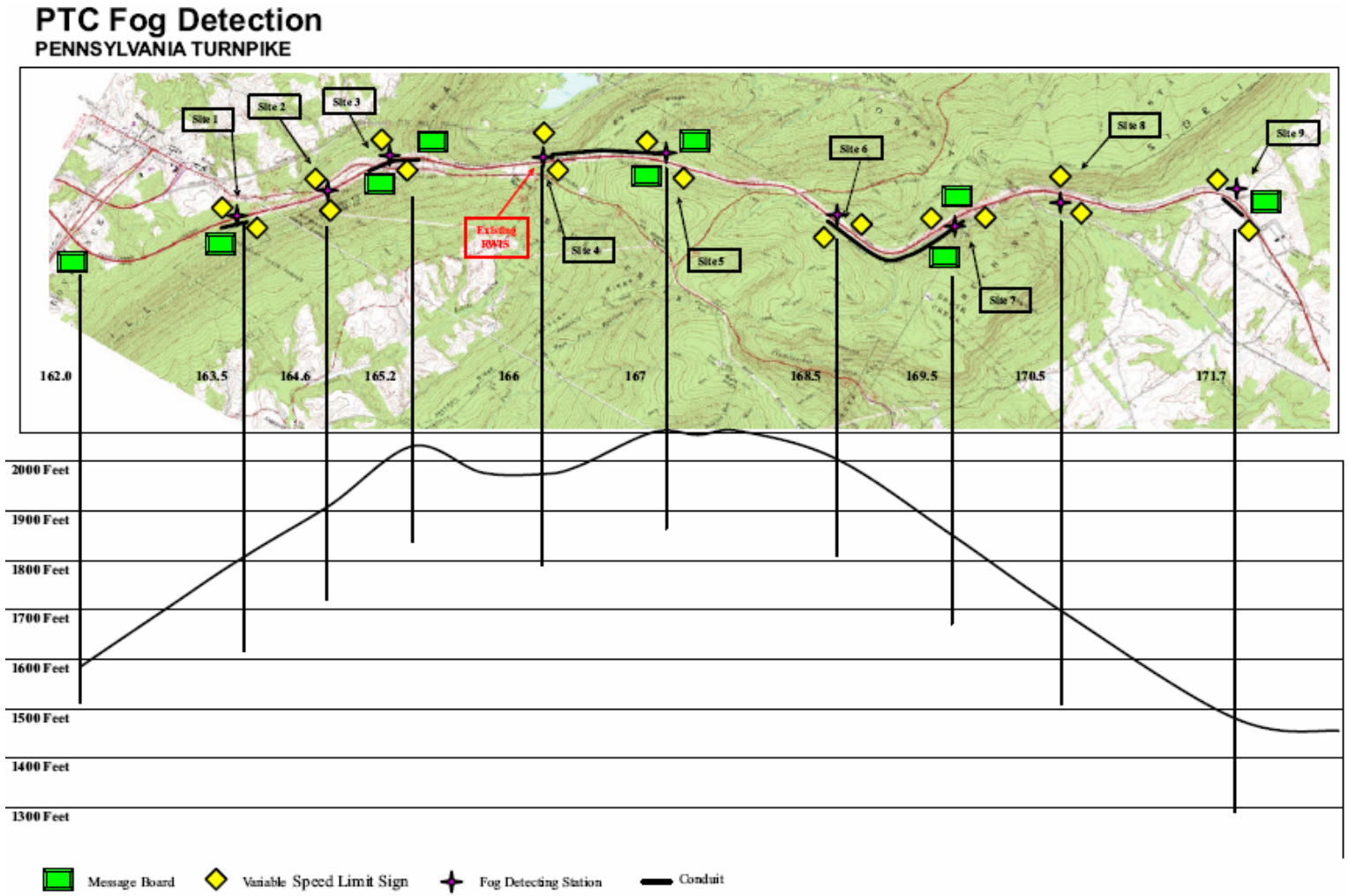
System Development

- Based on System Engineering Process (SEP)
  - Required National ITS Architecture
  - Requires NTCIP for DMS, VSLS, RWIS
- Concept of Operations
- Functional Requirements based on ConOps Needs
- Turn-key System
  - Designer of System was also Project Manager
  - General Contractor = Sub
  - DMS / VSLS / RWIS vendors = 2nd tier Subs to General Contractor
  - Central System Developer = Sub





Device Layout with Topology

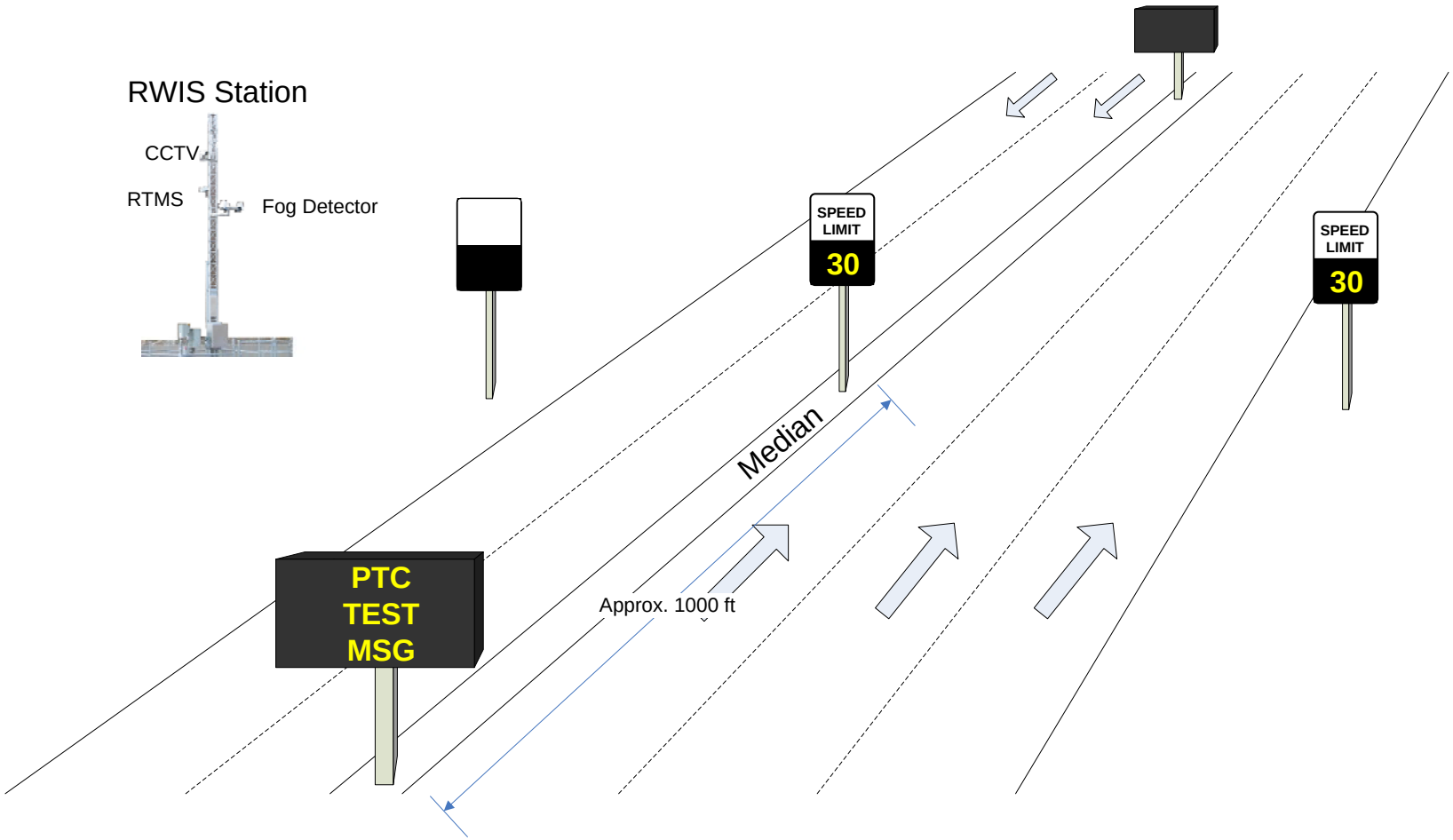


•*Note: existing DMS at Site 10 (Milepost 175.4) is not shown*

Site Configurations

- 10 field device sites over 19 km (12 mile) stretch with all sites spaced at approx. 1 mile, except the most eastern site at approx. 3 miles.
- Nine of the sites house
  - 1 road weather information system (RWIS) sensor system
  - 1 radar-based speed detector
  - 1 CCTV camera providing a snapshot every 30-seconds
  - Up to 3 variable speed-limit signs (VSLS) at each site
    - 1 VSLS facing each direction of traffic; Sometimes 2 in one direction, if there are 3 lanes
    - VSLS spaced at 1.6 km (1 mile) intervals to encourage drivers to reduce their speed when approaching a fog bank.
    - A total of 25 VSLS throughout the project.
- 11 dynamic message signs are placed at every other site and the tenth site to inform approaching vehicles

Typical Site Layout w/ DMS



Hybrid Communications Infrastructure

- Level 1: Existing high-speed, wireless communications backbone
  - From Harrisburg TMC to 54m (180 foot) Tower in Project Area
  - 154 km (90 miles) distance
  - Level 1 proven to be extremely reliable
- Level 2: Mix of Spread Spectrum and Fiber-Optics
  - 2 separate spread spectrum paths from Tower to 2 roadside receivers
  - Fiber Optics backbone between the 2 roadside receivers
  - Fiber Optics drops to each of the 9 individual device sites
  - Level 2 designed for Redundancy

Central Control Software

- PTC has an existing Central System (MIST©) managing other devices along the Turnpike
- PTC wanted to expand MIST© to manage the Fog Warning System
- MIST© already supported:
  - NTCIP-compliant DMS (VSLS are considered DMS, but with limited functionality enforced by MIST©)
  - Radar Detection Units (RTMS) for Speed Detection
  - CCTV for Verification
- MIST© software development for:
  - FWS algorithms
  - RWIS interface

Road Weather Information System (RWIS) Interface

- Different ways to integrate RWIS:
  - Direct interface with each RWIS station
  - Indirect interface with existing RWIS Central System
- Decided on Indirect Interface
  - Lower Software development costs
  - Existing RWIS Central System located in TMC
  - MIST© uses operational data, i.e., fog (reduced visibility) values and display of other sensor data
  - Retaining of Existing RWIS Central System
    - RWIS station diagnostics capabilities
    - Extensive History displays / reports build-in
- The CCTV cameras are snapshot cameras connected to the RWIS Central System
- 30 sec polling of RWIS field devices by RWIS Central Software and 30 sec polling of RWIS – MIST© interface

Fog Warning System Module - Design

- Designed for maximum flexibility – Examples
  1. Respond with a single response to fog detected anywhere within the system
  2. Suggest different responses for each RWIS site

  Example 2 is the current configuration.
- 2 methods to address competing FWS and Incident responses:
  - Assignment of Priority Levels to each message
    - Example: "Accident Ahead" message has higher priority than "Reduced Vision Ahead" message.
    - Situation and FWS reaction: Fog appears / Accident Exists => FWS wants to display "Reduced Vision Ahead" message but cannot override existing "Accident Ahead" message.
  - Manual Operator decision (computer cannot determine severity of incidents) – function can be disabled

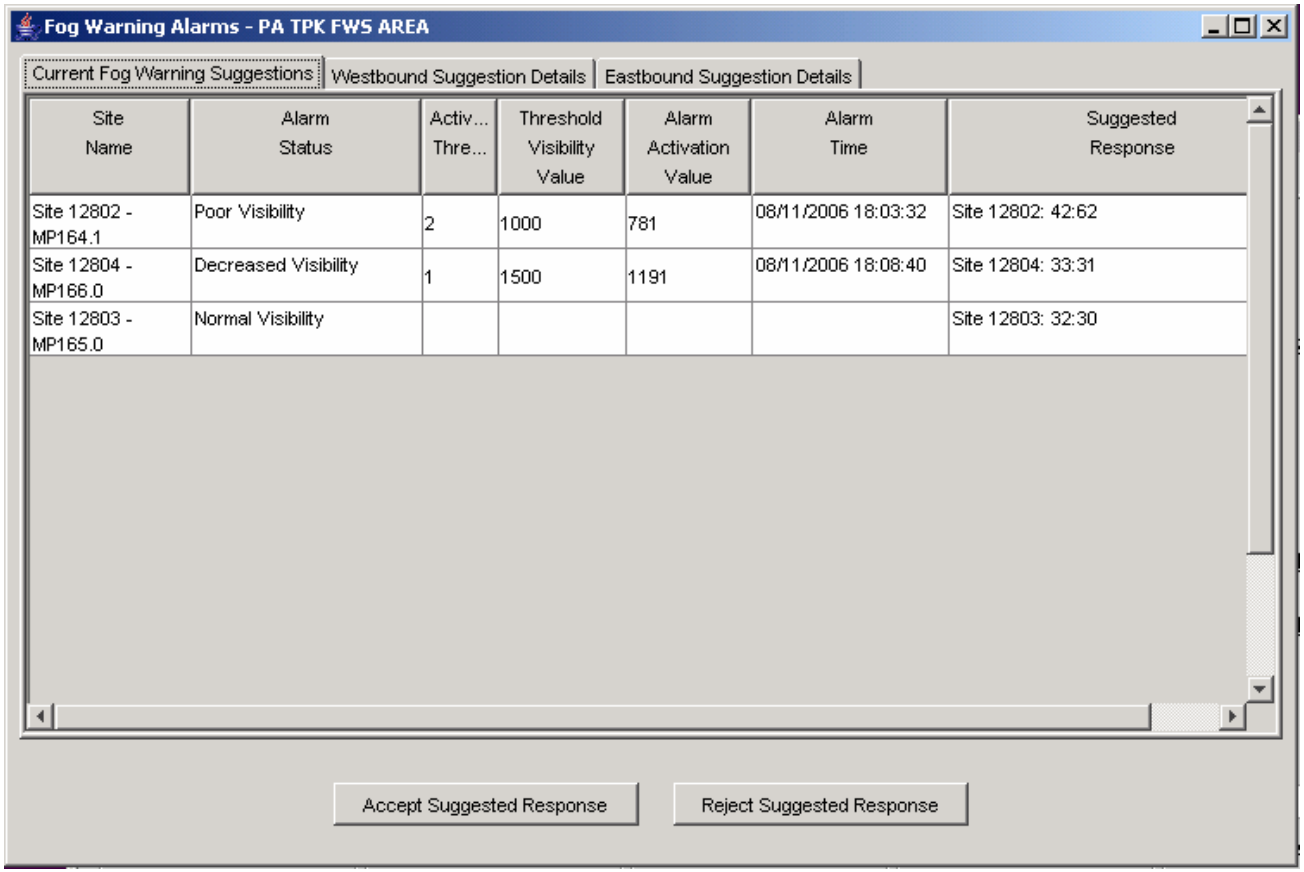
Fog Warning System Module - Logic

- Sequence of Events when Fog is detected:
  - Perform Evaluation for each Site separately
  - Consideration of any device and communications failures. If existing:
    - At least 1 DMS operational within 6 miles => If not, blank VSLS
    - RWIS prior to detecting site is failed, display of 'special' message on DMS (cannot determine where fog starts)
  - If no Failures, determine which of 3 user-definable thresholds has been exceeded
    - Select and display associated VSLS speed limit at site in both directions
    - Select and display associated DMS message for all DMS within 6 miles in both directions
  - Overlay suggested Messages for each DMS and VSLS and display the Messages with the Highest Priority

Fog Warning System Module – Special Functions

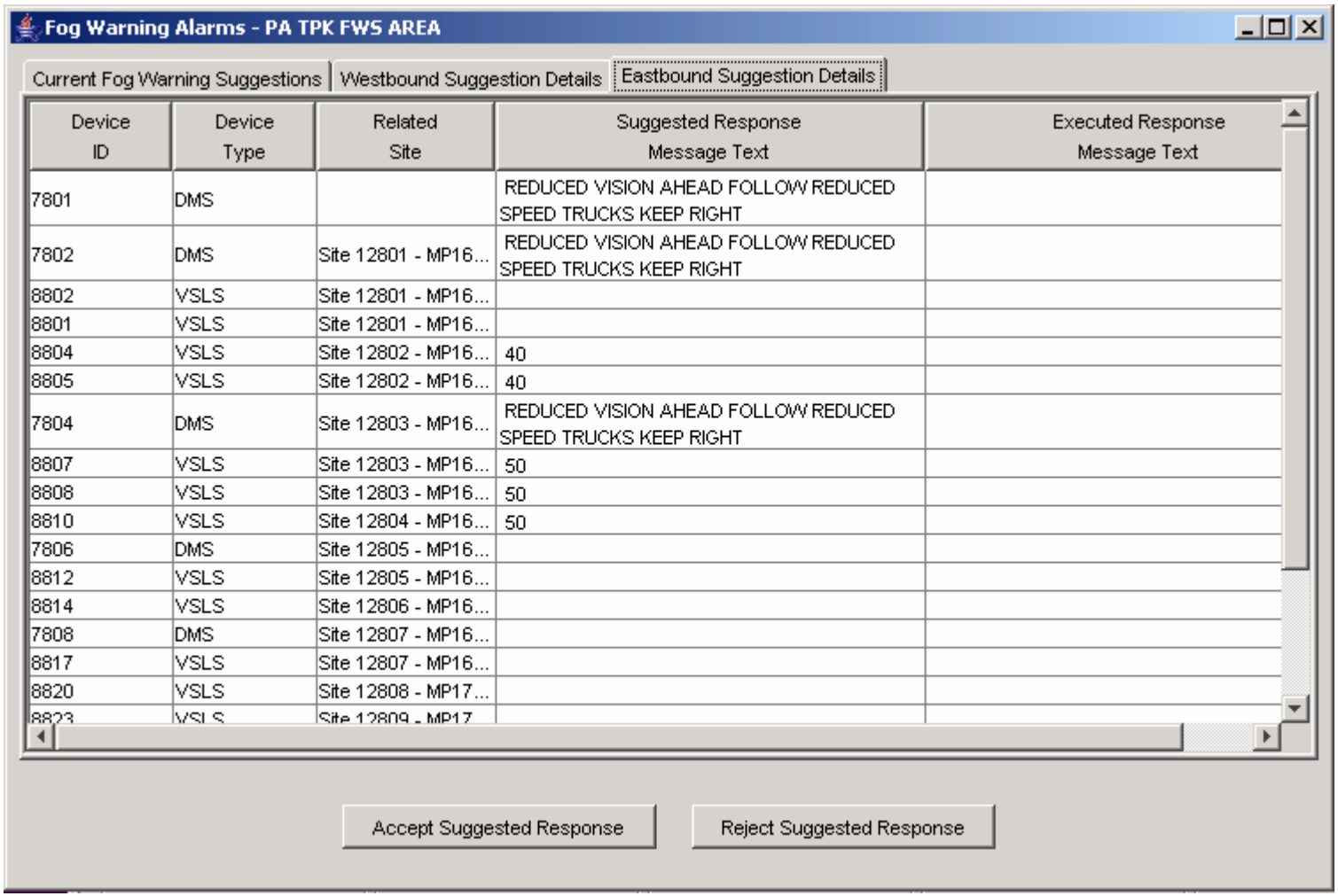
- VSLS Smoothing Algorithm
  - VSLS in between 2 VSLS with lower speeds => reduce VSLS to the higher of the 2 outer speed limits
- Toggle Execution Functionality
  - Operator Confirmation of Suggested Fog Response
  - Automatic Execution of Fog Response (System Admin Setting)
- Performance Evaluation capabilities
  - All inputs and response actions suggested and executed by the system, either automatic or manual, are recorded

FWS Response Interface – Main GUI



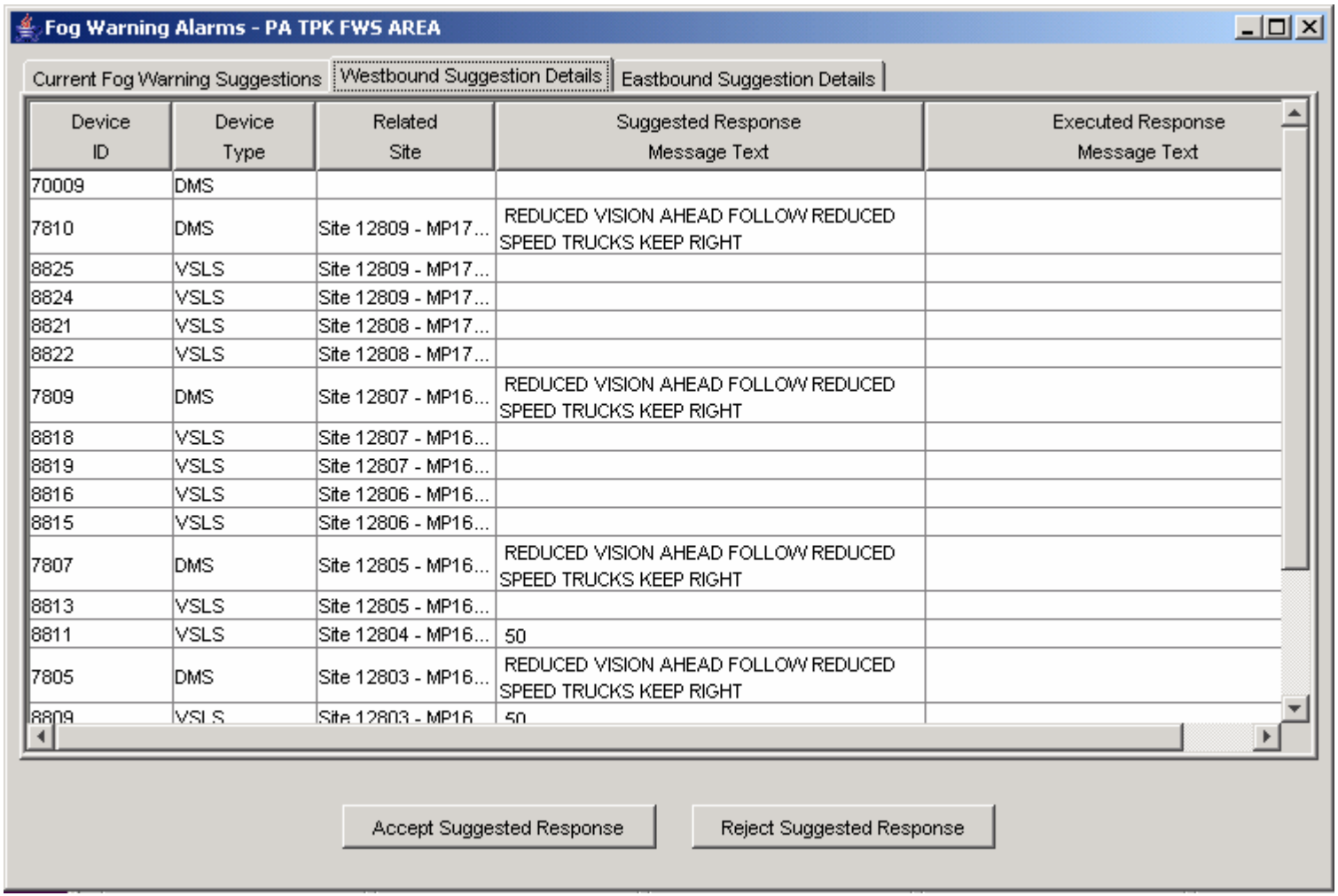
- Operator can select ‘Accept’ or ‘Reject’
- Row 1 = threshold 2 crossed, Row 2 = threshold 1 crossed
- Third row is displayed because of VSLS smoothing

FWS Response Interface – EB Details



Device ID	Device Type	Related Site	Suggested Response Message Text	Executed Response Message Text
7801	DMS		REDUCED VISION AHEAD FOLLOW REDUCED SPEED TRUCKS KEEP RIGHT	
7802	DMS	Site 12801 - MP16...	REDUCED VISION AHEAD FOLLOW REDUCED SPEED TRUCKS KEEP RIGHT	
8802	VSLS	Site 12801 - MP16...		
8801	VSLS	Site 12801 - MP16...		
8804	VSLS	Site 12802 - MP16...	40	
8805	VSLS	Site 12802 - MP16...	40	
7804	DMS	Site 12803 - MP16...	REDUCED VISION AHEAD FOLLOW REDUCED SPEED TRUCKS KEEP RIGHT	
8807	VSLS	Site 12803 - MP16...	50	
8808	VSLS	Site 12803 - MP16...	50	
8810	VSLS	Site 12804 - MP16...	50	
7806	DMS	Site 12805 - MP16...		
8812	VSLS	Site 12805 - MP16...		
8814	VSLS	Site 12806 - MP16...		
7808	DMS	Site 12807 - MP16...		
8817	VSLS	Site 12807 - MP16...		
8820	VSLS	Site 12808 - MP17...		
8823	VSLS	Site 12809 - MP17		

FWS Response Interface – WB Details



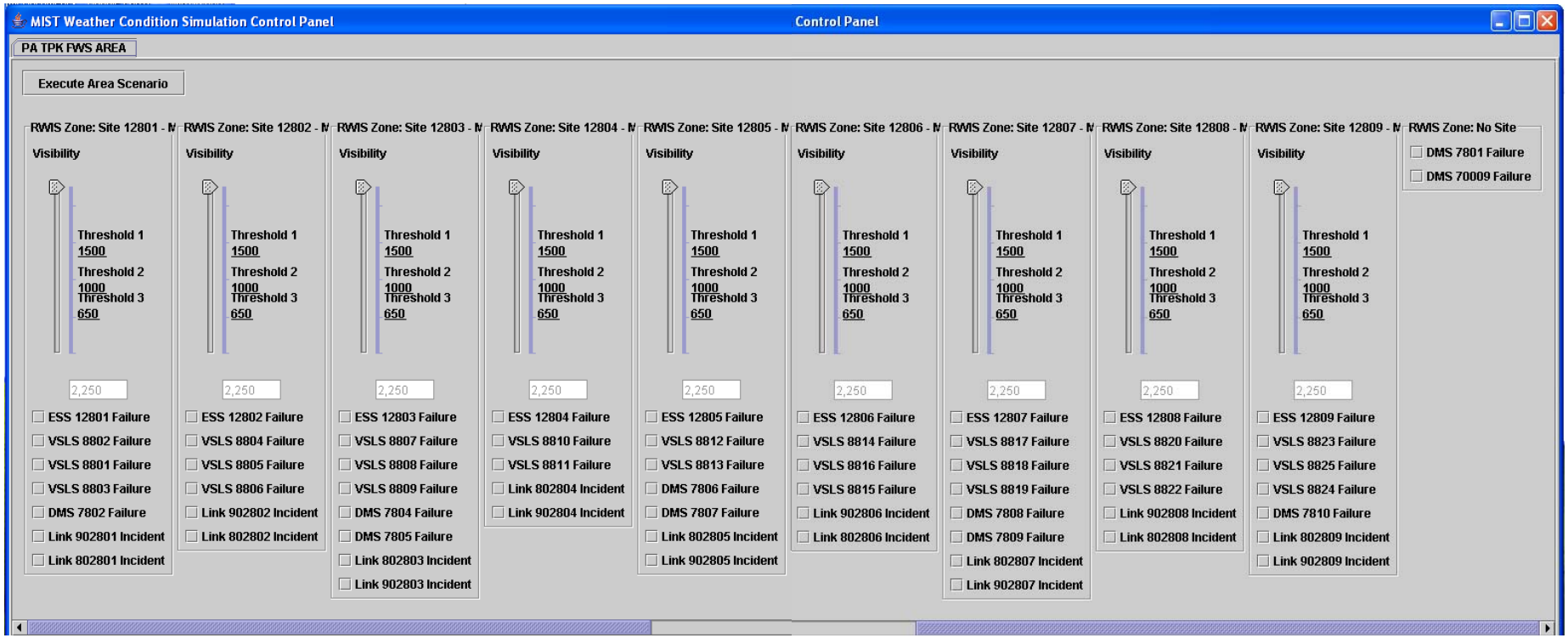
Software Development Challenges

- DMS and VSLS were the only field devices available for direct testing in lab
- Needed to develop Fog Input Simulator to create
  - Fog events,
  - Incident Events,
  - DMS Device Failures,
  - VSLS Device Failures
  - RWIS Device Failures,
  - Communications Failures
- RTMS and CCTV failures not considered for FWS algorithms => not an input into FWS algorithm
- Biggest issue was integration and interaction of different modules (DMS/VSLS message priority vs Manual Message display priority)

Software Development Challenges

- Theoretical number of possible combinations for 3 different thresholds, each possible device and communications failure > 1.3 Quadrillion
  - How to do meaningful testing?
  - Agreed to several scenarios that will likely occur, test those extensively in both lab and later in field.
  - Observe system continually for several months during the SW Observation Period.

Simulator Interface



- Simulated different fog scenarios in conjunction with various failure types
- Tested for about 6 wo/man weeks in laboratory
- Additional testing at client site without simulator (fog season)

System Acceptance Testing

- System Acceptance Test onsite revealed punch-list items
  - GUI synchronization problem between existing MIST© modules and new FWS module
  - Synchronization problem of FWS displays between different Operator Workstations
  - VSLS Smoothing not correct under certain conditions
  - Output of RWIS Central System to MIST© was modified and not communicated
- Punch List items were fixed and re-tested in lab
- Re-installation of FWS module at PTC and re-testing

Observations and Conclusions

- FWS module performance appears to be without errors
  - Confirmed by Operators and System Administrator as well as Analysis of performed actions
  - High probability that not all possible deviations have been tested
- Confidence Level of FWS module by PTC is Very High
  - FWS is very flexible allowing System Administrator to modify configuration parameters (Messages, Speed Limits, Priority Levels)
  - FWS module now in Automatic Execution mode
  - PTC considers deployment of additional FWS areas along the Pennsylvania Turnpike
- Entire PTC system viewable on Internet:

www.paturnpike.com

Questions?

Thank You

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