U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology

DMA Webinar Series

MMITSS Bundle

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February 23, 2015

TODAY'S AGENDA

- Ben McKeever

  Team Leader, Transportation Operations Applications, FHWA R&D
  - DMA Program Overview
  - MMITSS Bundle Overview
  - Prototype Description and Current Project Status

- Govind Vadakpat

  Research Transportation Specialist, Transportation Operations Applications, FHWA R&D
  - Current Project Status of Impact Assessment
  - Testing Results and Impacts/Benefits from IA

- Stakeholder Q&A
  - We can only answer the questions related to the DMA program.
  - We cannot answer any questions related to the CV Pilots.

DMA Program Overview

DYNAMIC MOBILITY APPLICATIONS PROGRAM

- **Vision**
  - Expedite development, testing, commercialization, and deployment of innovative mobility application
    - maximize system productivity
    - enhance mobility of individuals within the system
- **Objectives**
  - Create applications using frequently collected and rapidly disseminated multi-source data from connected travelers, vehicles (automobiles, transit, freight) and infrastructure
  - Develop and assess applications showing potential to improve nature, accuracy, precision and/or speed of dynamic decision
  - Demonstrate promising applications predicted to significantly improve capability of transportation system
  - Determine required infrastructure for transformative applications implementation, along with associated costs and benefits
- **Project Partners**
  - Strong internal and external participation
    - ITS JPO, FTA, FHWA R&D, FHWA Office of Operations, FMCSA, NHTSA, FHWA Office of Safety

DMA Program Approach To Overcoming Two Key Challenges To Application Deployment

- **Challenge 1 (Technical Soundness)**
  Are the DMA bundles technically sound and deployment-ready?
  - Create a "trail" of systems engineering documents (e.g., ConOps, SyRs)
  - Share code from open source bundle prototype development (OSADP website: http://www.itsforge.net/)
  - Demonstrate bundle prototypes (in isolation)
  - Field test integrated deployment concepts from across CV programs

- **Challenge 2 (Transformative Impact)**
  Are DMA bundle-related benefits big enough to warrant deployment?
  - Engage stakeholders to set transformative impact measures and goals
  - Assess whether prototype show impact when demonstrated
  - Estimate benefits associated with broader deployment
  - Utilize analytic testbeds to identify synergistic bundle combinations

DMA Bundles and Applications

FRATIS: Freight Advanced Traveler Information Systems

Apps: Freight-Specific Dynamic Travel Planning and Performance, Drayage Optimization (DR-OPT)

IDTO: Integrated Dynamic Transit Operations

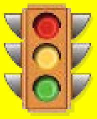
Apps: Connection Protection (T-CONNECT), Dynamic Transit Operations (T-DISP)
Dynamic Ridesharing (D-RIDE)

R.E.S.C.U.M.E.: Response, Emergency Staging and Communications, Uniform Management, and Evacuation

Apps: Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
Emergency Communications and Evacuation (EVAC)

MMITSS: Multimodal Intelligent Traffic Signal System

Apps: Intelligent Traffic Signal System (I-SIG), Transit and Freight Signal Priority (TSP and FSP)
Mobile Accessible Pedestrian Signal System (PED-SIG), Emergency Vehicle Preemption (PREEMPT)



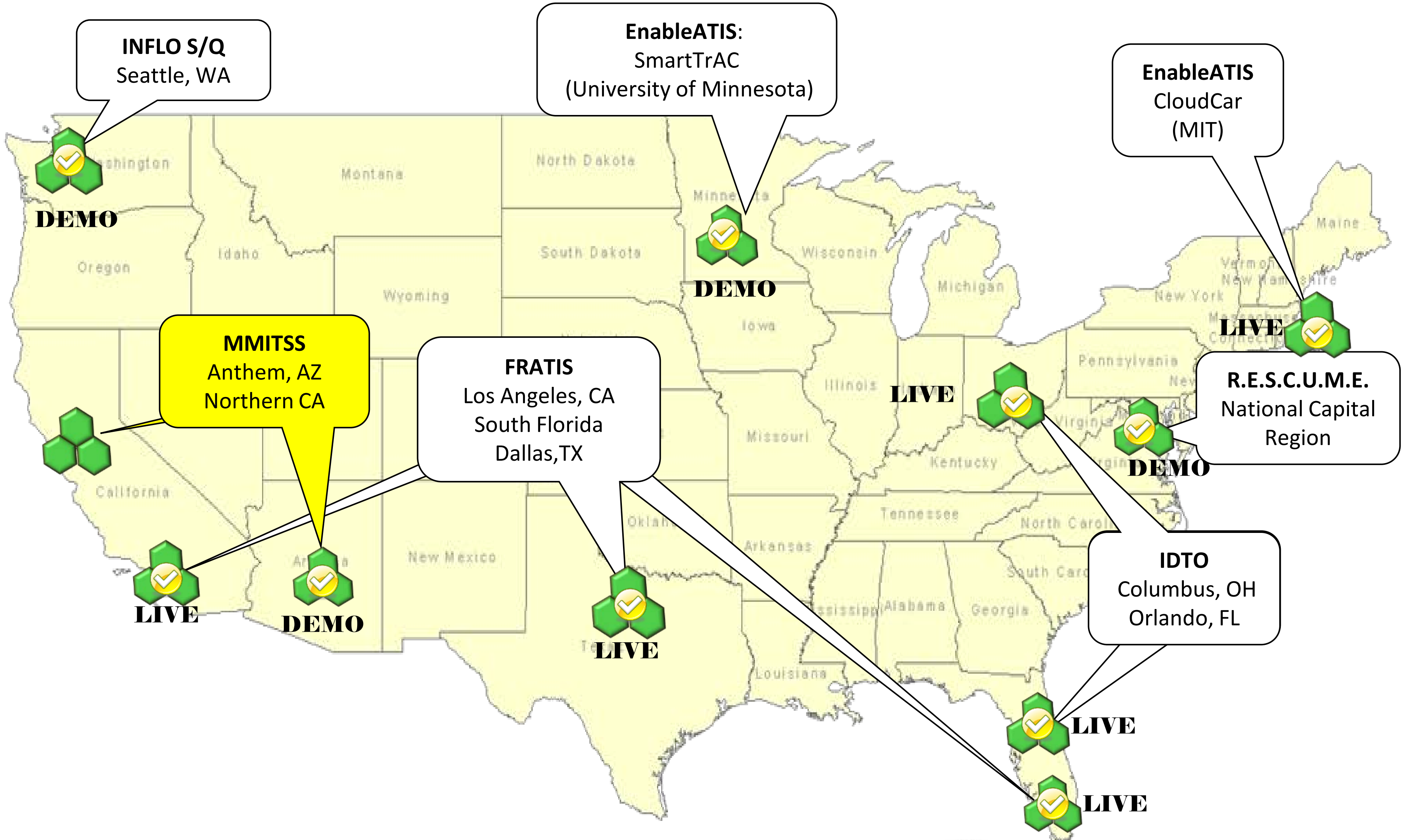
INFLO: Intelligent Network Flow Optimization

Apps: Dynamic Speed Harmonization (SPD-HARM), Queue Warning (Q-WARN)
Cooperative Adaptive Cruise Control (CACC)

Enable ATIS: Enable Advanced Traveler Information Systems

Apps: EnableATIS (Advanced Traveler Information System 2.0)

DMA Prototype Development Activity



MMITSS Bundle Overview

MMITSS Overview

- Objectives
  - To develop a comprehensive traffic signal system that services multiple modes of transportation including
    - Passenger vehicles,
    - Transit
    - Emergency vehicles
    - Freight fleets (e.g. Trucks)
    - Pedestrians

  - To demonstrate the developed Multi-Modal Intelligent Traffic Signal System
    - Anthem, AZ
    - Northern CA

MMITSS Application Descriptions

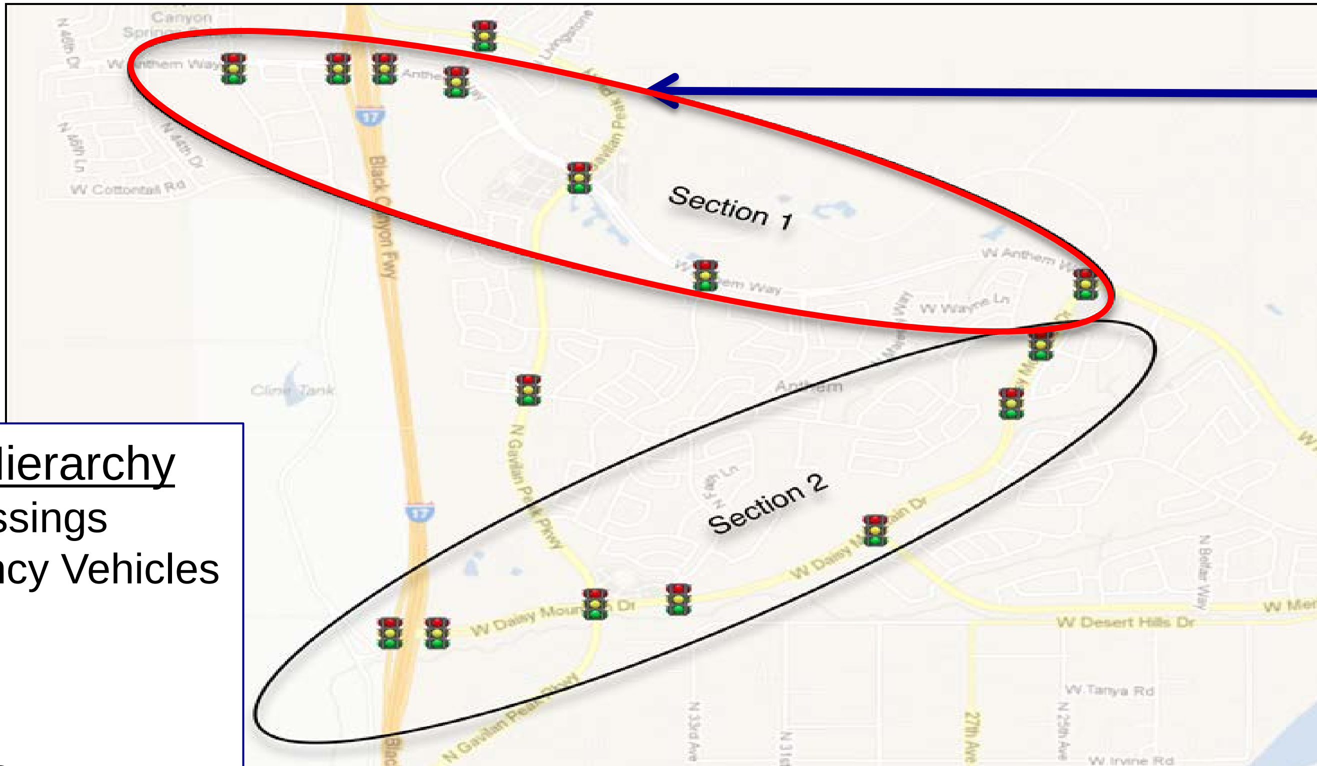
- Next generation of traffic signal systems that seeks to provide a comprehensive traffic information framework to service all modes of transportation:
  - Intelligent Traffic Signal System (I-SIG)
  - Transit Signal Priority (TSP) and Freight Signal Priority (FSP)
  - Emergency Vehicle Preemption (PREEMPT)
  - Mobile Accessible Pedestrian Signal System (PED-SIG)

MMITSS TEAM

- Technical Team
  - University of Arizona (Prime)
  - University of California Berkeley (PATH)
  - Savari
  - Econolite

- Sponsors
  - Pooled Fund Project
    - FHWA
    - Virginia DOT/UVA
    - Maricopa County DOT
    - Caltrans
    - Minnesota DOT
    - Florida DOT
    - Michigan DOT
    - …

MMITSS Basic Concepts

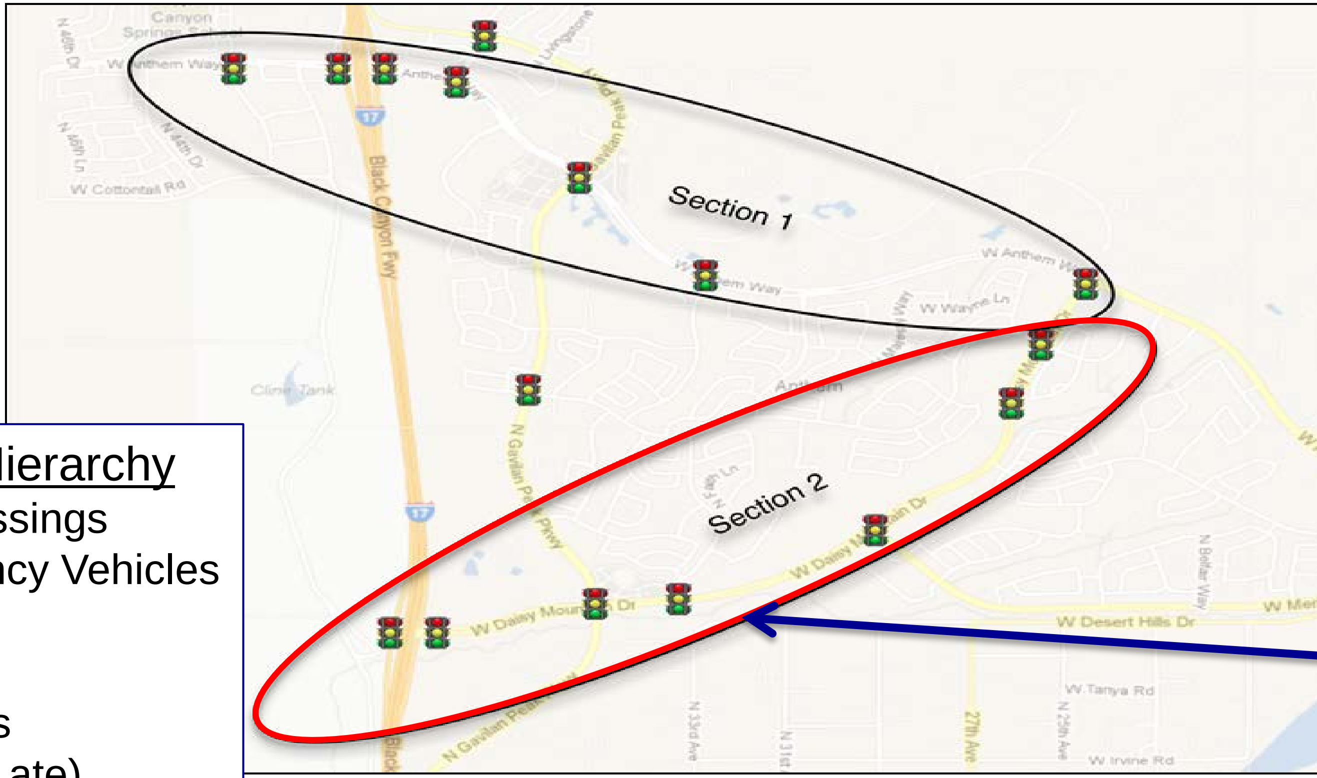


Section 1
- Priority for
  - Freight

A Traffic Control System

Priority Hierarchy
- Rail Crossings
- Emergency Vehicles
- Freight
- Transit
  - BRT
  - Express
  - Local (Late)
- Coordination
- Pedestrians

MMITSS Basic Concepts

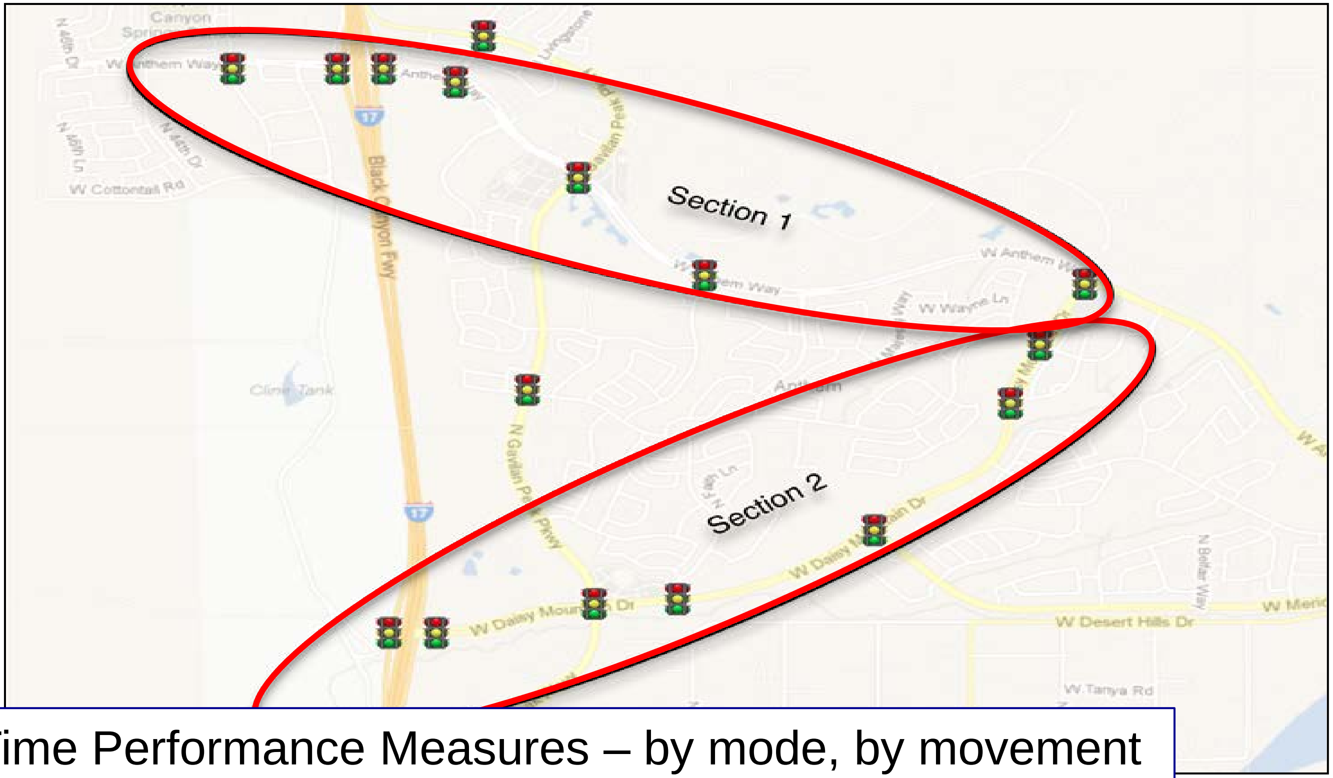


Priority Hierarchy
- Rail Crossings
- Emergency Vehicles
- Transit
  - BRT
  - Express
  - Local (Late)
- Pedestrians
- Coordination
- Freight

Section 2
- Priority for
  - Transit
  - Pedestrians

A Traffic Control System

MMITSS Basic Concepts



Real-Time Performance Measures – by mode, by movement

- Volume (mean, variance)
- Delay (mean, variance)
- Travel Time (mean, variance)
- Throughput (mean, variance)
- Stops (mean, variance)

MMITSS Prototype

MMITSS PROTOTYPE SITES

- Anthem, AZ
  - 6 Intersections + 1 Diamond Interchange
  - Equipped with RSE, Controller (ASC/3), and multiple OBE's
  - MAP & SPaT at every intersection
  - MMITSS applications at every intersection

- Northern CA
  - 11 Intersection along Camino Real
  - Equipped with RSEs, Controller (2070 ATC/Caltrans software), multiple OBE's

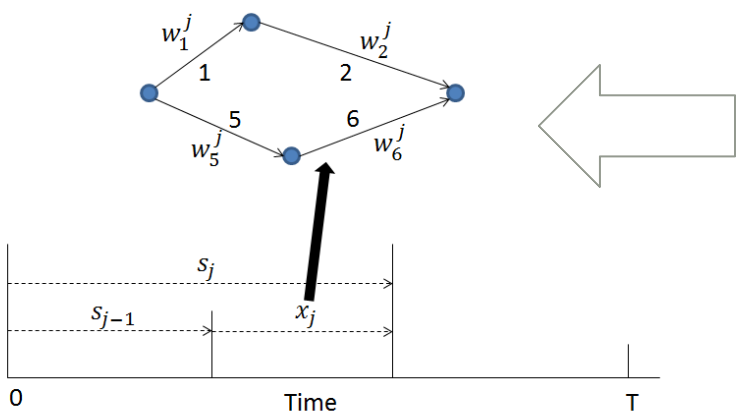
MMITSS PROTOTYPE CORE FEATURES

- Intelligent Traffic Control based on Awareness of Equipped Vehicles
  - Signal actuation, gap out, extension, dilemma zone protection
  - Pedestrians, Disabled Pedestrians
  - Signal coordination, congestion control
- Traffic State, Flow, and Performance Observation
- Priority Control for EV, Transit, Trucks, and other Special Vehicles
- Smartphone application for Pedestrians

MMITSS Prototype Core Features

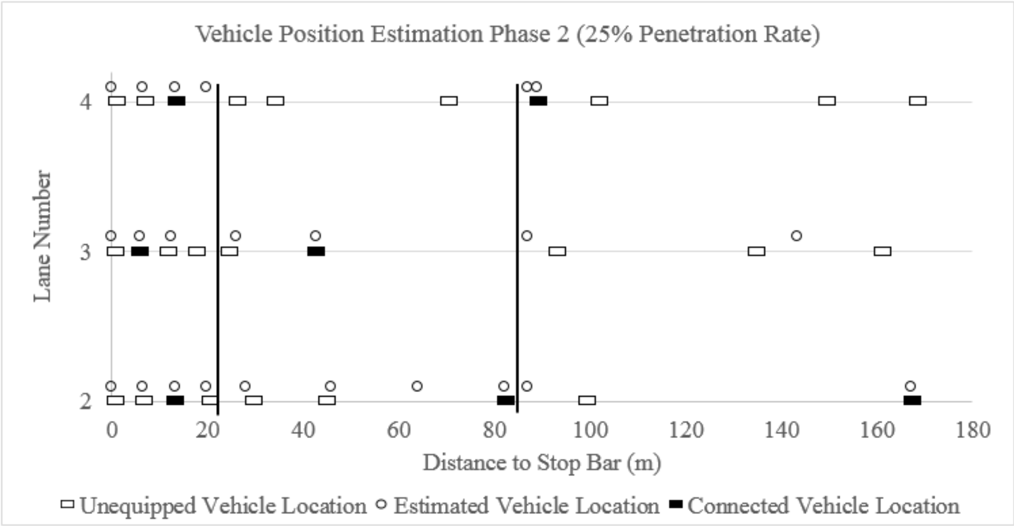
- Intelligent Traffic Control
  - Responsible for allocation of available green, given priority control constraints (coordination, priority requests)
  - Responsible for providing Dilemma Zone protection

Adaptive Control Algorithm for allocating phase green times



Based on the COP algorithm for the RHODES adaptive control prototype

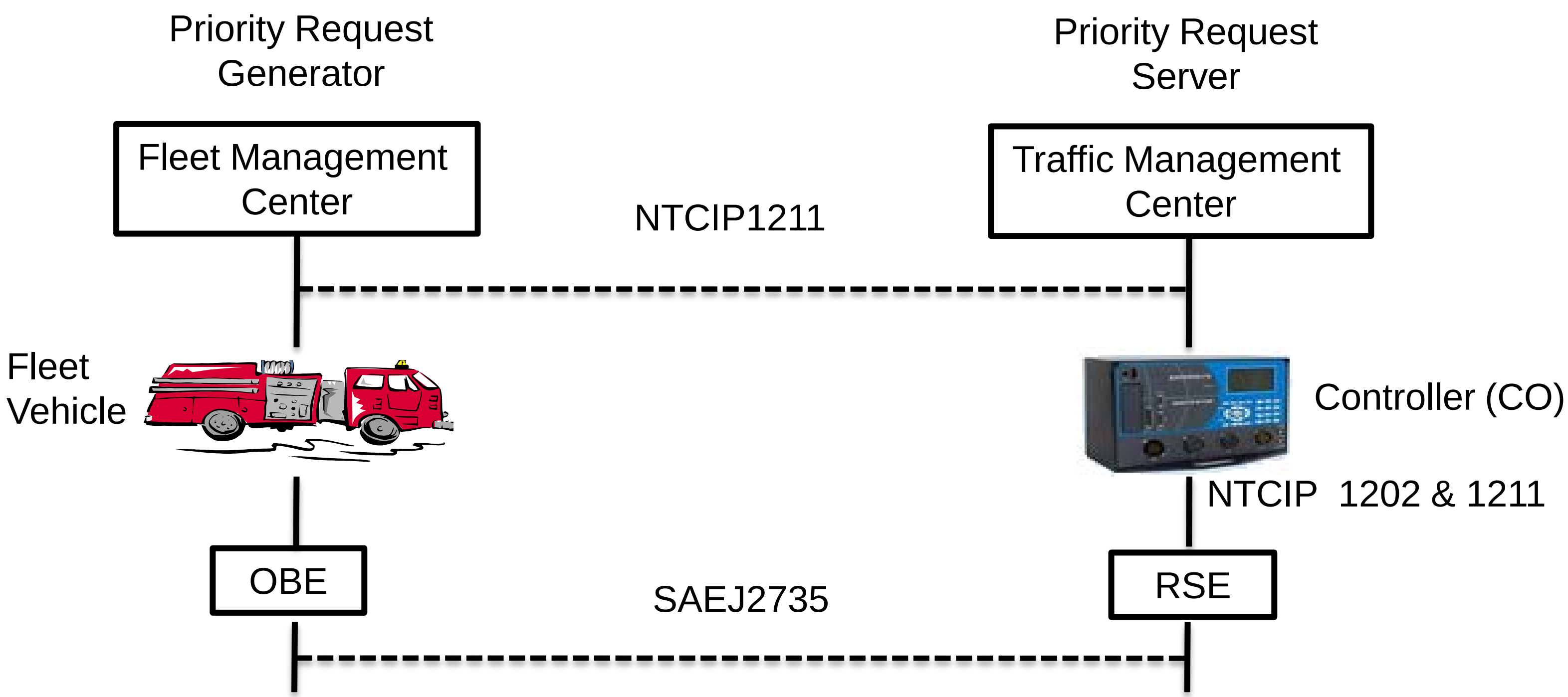
Connected Vehicle Data to Estimate Arrivals (Queue, Slow Down, and Free Flow Regions)



Vehicle arrival data for one approach (phase 2)

MMITSS Prototype Core Features

- Priority Control Architecture



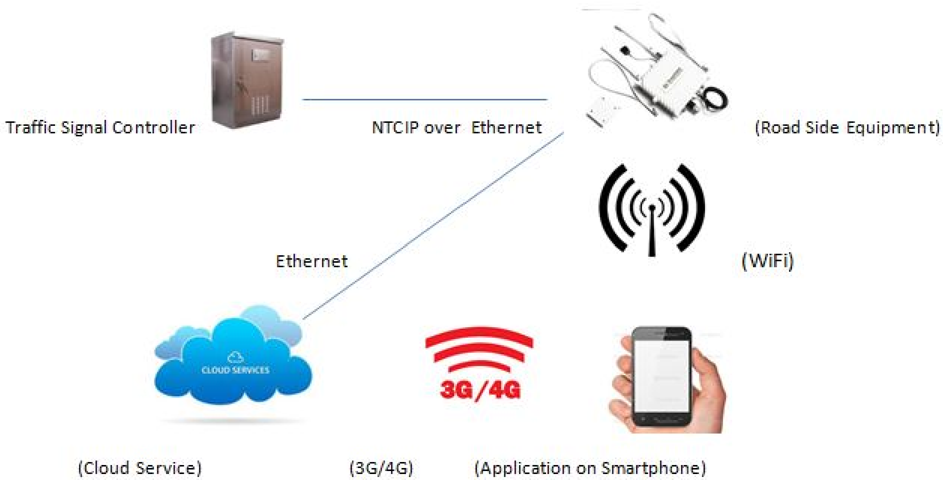
Note: NTCIP1211 assumes that there are many possible architectures. The one shown above highlights the roles of both J2735 and NTCIP

MMITSS PROTOTYPE CORE FEATURES

- Performance Observer
  - Derived from BSM Data (Trajectories)
  - Process Trajectories to compute observed
    - Delay (Average, Variability), Travel Time (Average, Variability), and Traffic States (Queue Length)
  - Performance Measures Used for
    - Monitoring and Assessment, DSRC Performance, and Section Level Control (Coordination Updates)
- Approach
  - Defining appropriate performance measures and metrics
    - Traditional: Overall Vehicle Delay, Number of Stops, Throughput, Maximum Queue Length, Total Travel Time
    - More recent: Time to Service, Queue Service Time
    - Connected Vehicle System: DSRC Range, Packet Drop
  - Understanding how improvements to one mode may impact another mode
  - Understanding how connected vehicles information, can help to estimate performance measures

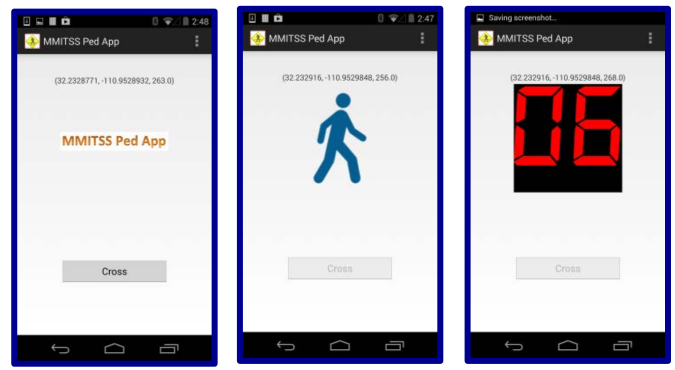
MMITSS Prototype Core Features

- Pedestrian Smartphone App



Savari SmartCross Application Architecture

MMITSS Pedestrian Smartphone app



Allows Pedestrian to receive auditory and haptic feedback

- Align with Crosswalk
- Send Call for Service
- Be given WALK
- PedCLEAR Countdown

Key Challenges

- Institutional
  - Requires training for engineering and staff to understand technology and system operation
- Technical
  - DSRC Range from multiple nearby RSE’s broadcasting MAP and SPaT data require OBE algorithms to determine which MAP and SPaT is relevant
  - Current BSM specification doesn’t contain Mode information
  - Current SSM (Signal Status Message) doesn’t acknowledge all Signal Request Messages (SRM) – only acknowledges one
- How to overcome
  - Multiple MAP’s resolved algorithmically
  - Working with SAE DSRC Technical Committee on BSM, SSM and other issues

MMITSS DOCUMENTATION AND CODE

- Supporting documentation available at - http://www.its.dot.gov/pilots/pilots_mobility.htm
  - MMITSS Final ConOps
  - Multi-Modal Intelligent Traffic Signal System Final System Requirements Document
  - Multi-Modal Intelligent Traffic Signal System - System Design

- Code from open source MMITSS prototype developments will be available at: http://www.itsforge.net/ in April, 2015

- Research Data will be available at RDE website: https://www.its-rde.net/

MMITSS Impact Assessment

MMITSS Impact Assessment Description

- Separate Contract for Impact Assessment
  - LEIDOS and Virginia Tech

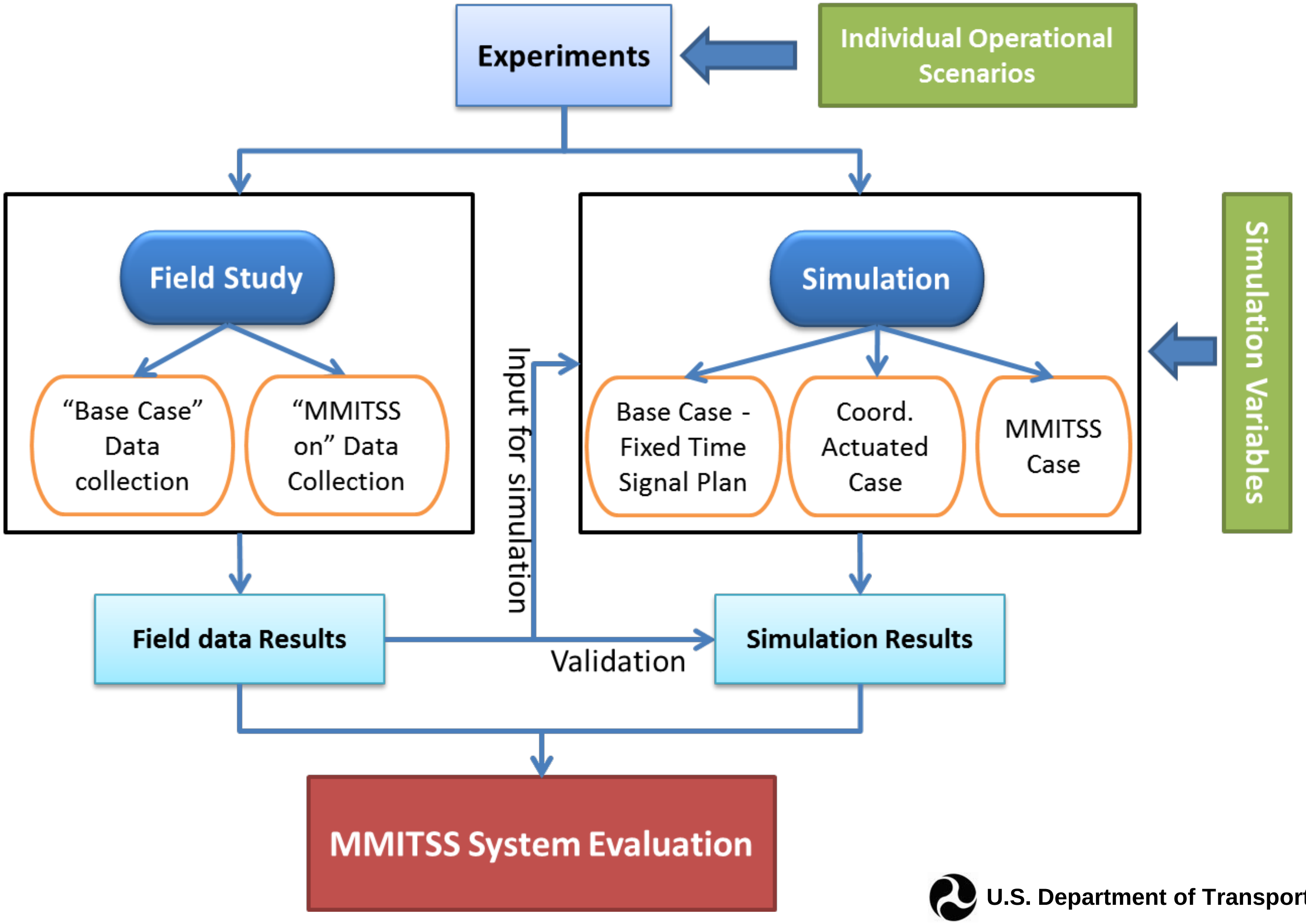
- The MMITSS Impacts Assessment includes two major tasks
  - **Field data analyses** utilizing the data collected from two MMITSS prototypes
  - **Simulation analyses** to assess the performance of MMITSS applications at two prototype sites and a third site

IA Task	Anthem, AZ	Northern CA	US-50, VA
Field Test	✓	✓	
Simulation Analysis	✓	✓	✓

- Field data vs. Simulation study
  - The simulation study will compare and confirm the findings of the field data.
  - The simulation study will identify the most beneficial operation conditions for each scenario which can be identified by a combination of specific traffic demand levels.

MMITSS Impact Assessment Methods

- Experimental Design of IA Plan



MMITSS Impact Assessment Methods

- Impact Assessment Approach
  - Field test will be recreated in the simulation environment.
  - The simulation output will be compared with data from the field tests to properly calibrate the models.
  - The simulation environment will be customized to match the traffic signal controller interface, communications environment, and priority algorithms.

- Major simulation variables include
  - Throughput Volumes, Market Penetration of Connected Vehicles, and Traffic Composition

- IA study will identify the most beneficial operation conditions for each operational scenario, which can be identified through a combination of specific traffic demand levels and other simulation variables.

MMITSS Impact Assessment Methods

- Operational Scenarios
  - I-SIG: Basic Signal Actuation
  - I-SIG: Coordinated Section of Signals
  - I-SIG: Dilemma Zone Protection
  - TSP: Basic Transit Signal Priority
  - TSP: Extended Transit Signal Priority
  - PED-SIG: Equipped, Non-Motorized Traveler
  - FSP: Basic Freight Signal Priority Scenario
  - FSP: Coordinated Freight Signal Priority along a Truck Arterial
  - PRE-EMPT: Single Intersection Emergency Vehicle Priority/Preemptions

- Bundled Scenarios
  - Transit Signal Priority and Emergency Vehicle Priority at a Single Intersection
  - Connected Passenger Cars and Transit Vehicles Operation in a Coordinated Section of Signals

MMITSS Impact Assessment Methods

- The Bundled Scenarios Evaluates
  - How the MMITSS system will provide a hierarchical level of priority
  - A priority policy objective function considers the weight factors of modes, the delay of modes, the weight factors of coordination and actuation flexibility, coordination delay, and actuation time factor.

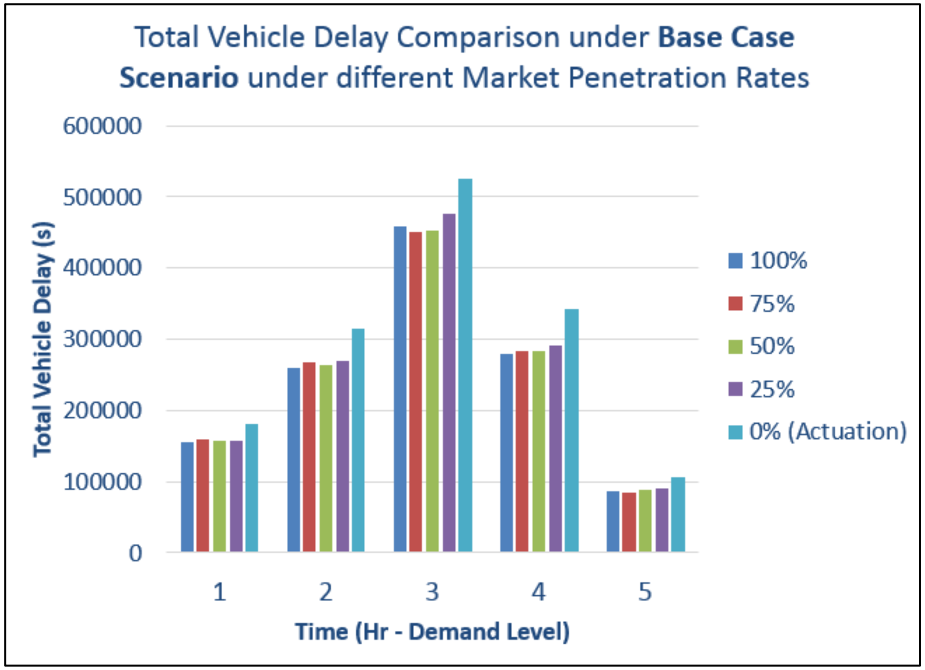
- Hypotheses in IA Plan
  - The basic components of the connected vehicle system (RSE and OBE) is configured properly, powered-on, and communicating with the infrastructure.
  - The priority server can accurately predict the arrival time to the intersection of requesting vehicles and need to deal with multiple signal priority requests.
  - The MMITSS system has an intelligent algorithm for providing priority signal for priority requests based on a hierarchical level of priority.
  - Multiple signalized intersections are equipped with RSEs and have RSE-to-RSE communication enabled.

MMITSS IA Preliminary Results

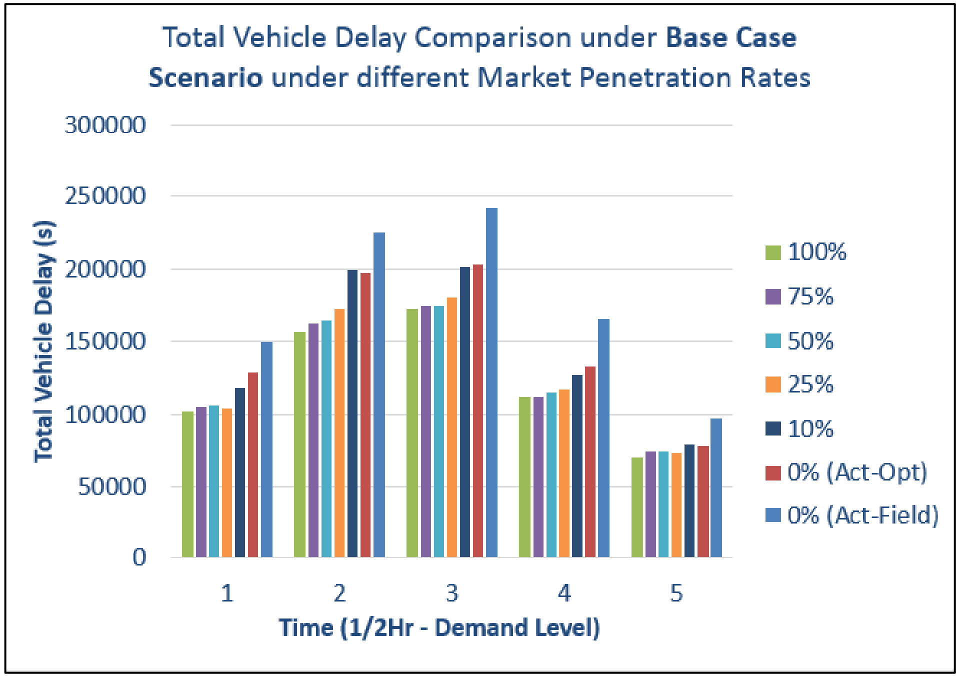
PRELIMINARY SIMULATION RESULTS AND FINDINGS FROM NORTHERN CA AND ANTHEM AZ SIMULATION

- MMITSS I-SIG effective at reducing total delay in network at 25% and above under regular traffic condition

Northern CA Network



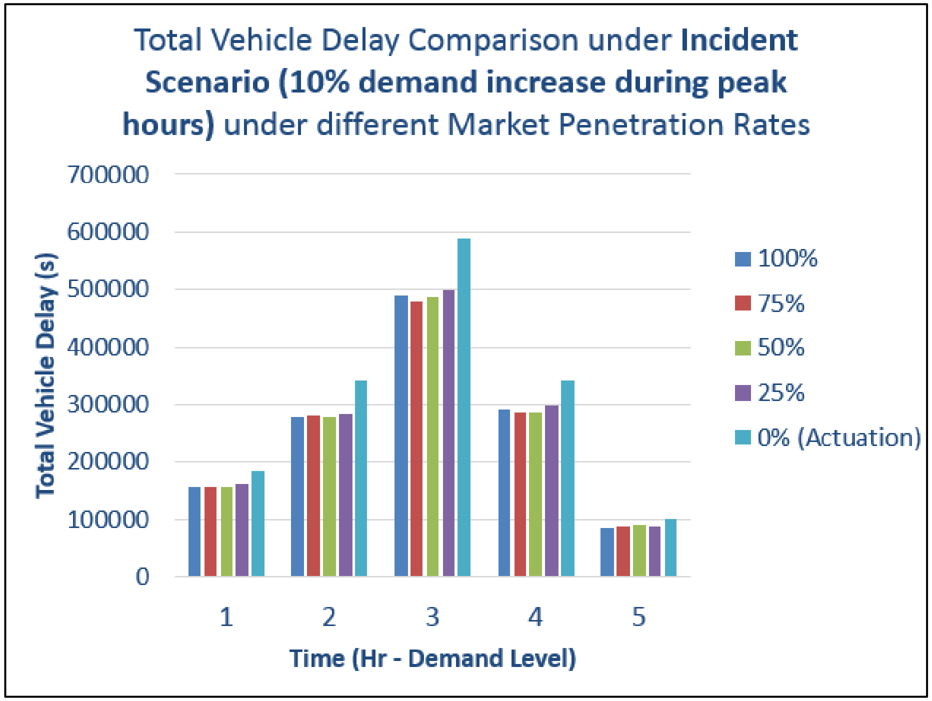
Anthem AZ Network



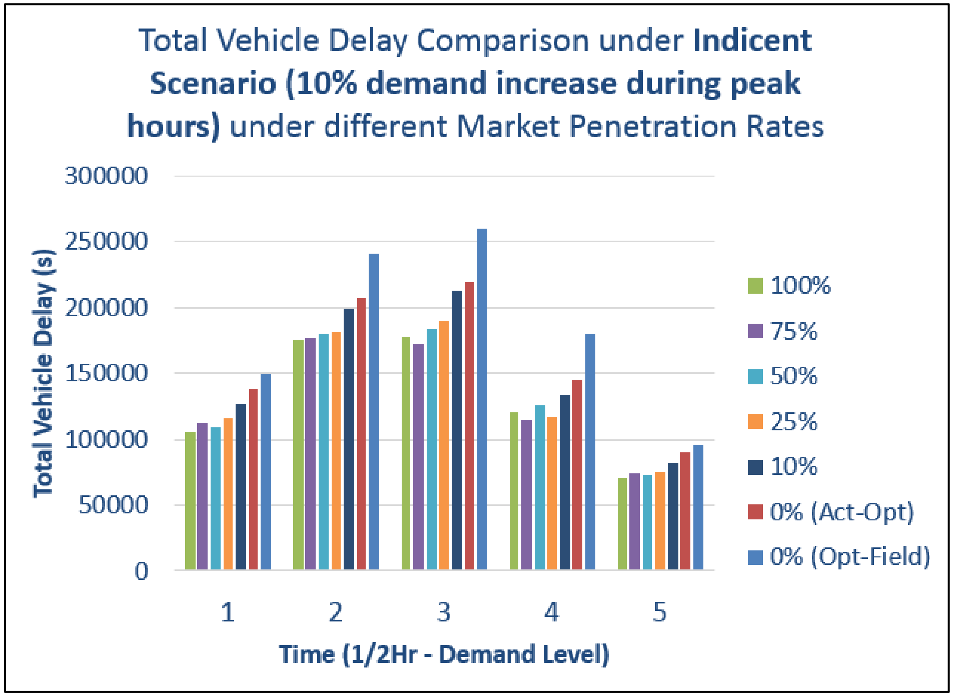
PRELIMINARY SIMULATION RESULTS AND FINDINGS FROM NORTHERN CA AND ANTHEM AZ SIMULATION

- MMITSS I-SIG effective at reducing total delay in network under semi-saturated conditions (10% of demand increase)

Northern CA Network



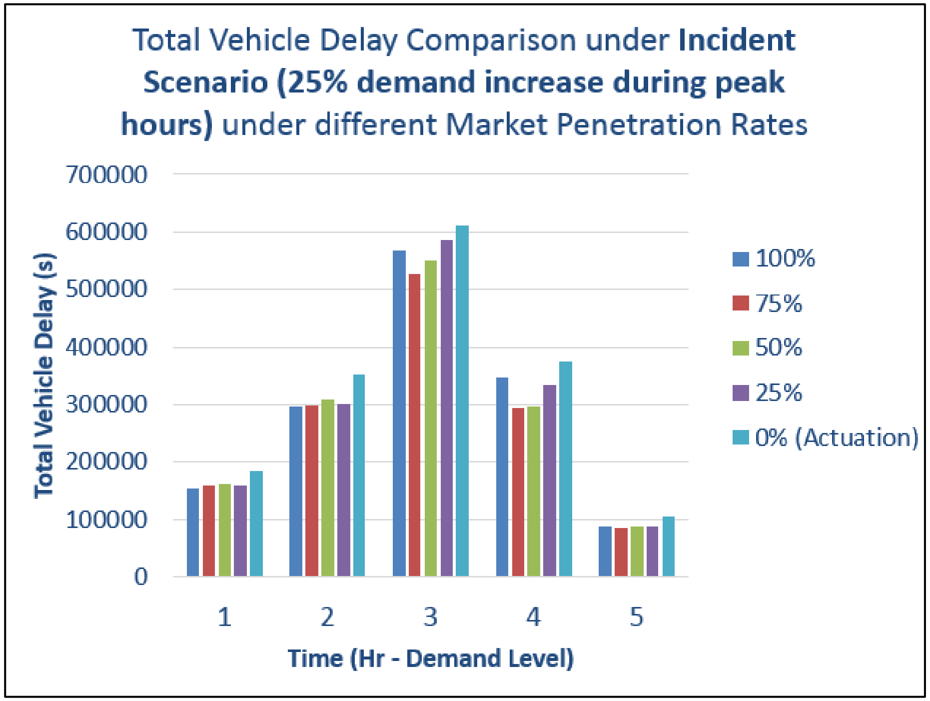
Anthem AZ Network



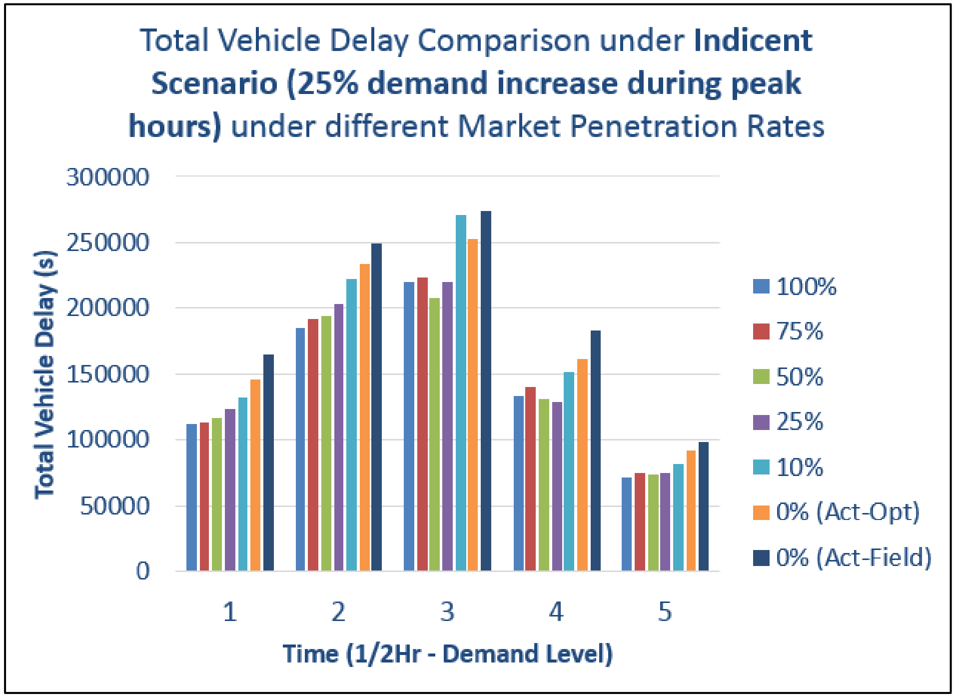
PRELIMINARY SIMULATION RESULTS AND FINDINGS FROM NORTHERN CA AND ANTHEM AZ SIMULATION

- MMITSS I-SIG effective at reducing total delay in network under saturated conditions (25% of demand increase)

Northern CA Network



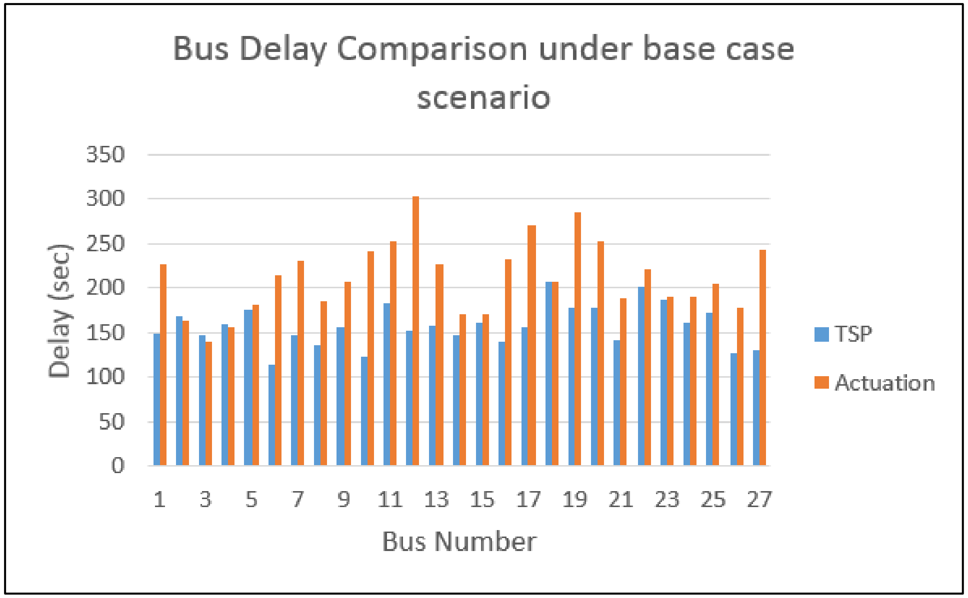
Anthem AZ Network



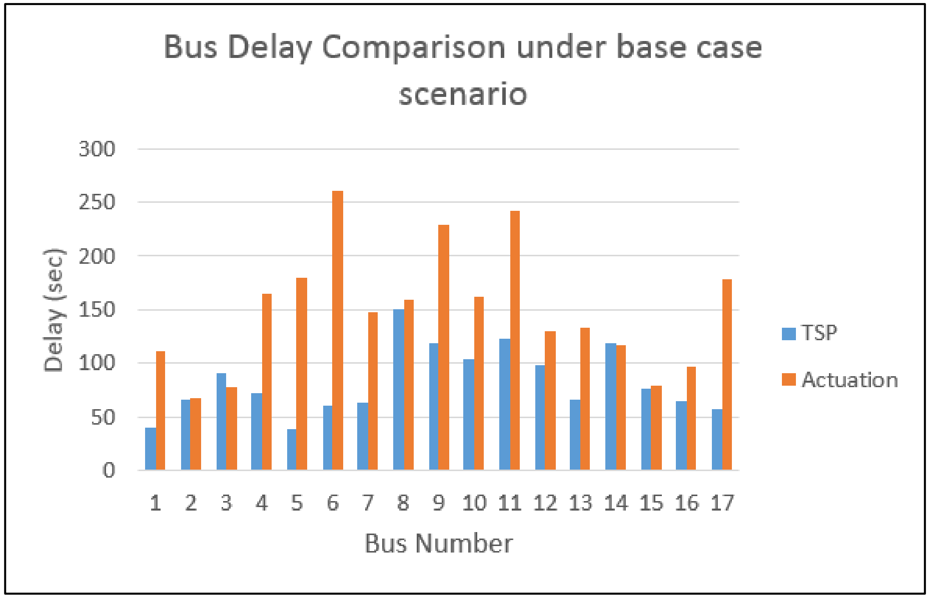
PRELIMINARY SIMULATION RESULTS AND FINDINGS FROM NORTHERN CA AND ANTHEM AZ SIMULATION

- MMITSS effective at reducing delay and travel time of priority vehicles if priority can be allocated to the desired mode of travel (e.g. TSP or FSP)

Northern CA Network



Anthem AZ Network



Preliminary Simulation Results and Findings from Northern CA and Anthem AZ Simulation

- MMITSS effective at reducing delay and travel time of priority vehicles if priority can be allocated to the desired mode of travel (e.g. TSP or FSP)

Northern CA Network

TRANSIT PRIORITY				
	Southbound	%	Northbound	%
Average Delay (sec)	157.29	**-25.80**	166.90	**-27.88**
Average TT (sec)	531.73	**-9.34**	545.23	**-10.58**
TT Standard Deviation	25.36	**-38.00**	25.36	**-44.53**
Average Weighted Delay of Regular Vehicles (sec)			18.79	**0.8**

Anthem AZ Network

TRANSIT PRIORITY				
	Eastbound	%	Westbound	%
Average Delay (sec)	82.87	**-44.42**	87.58	**-41.64**
Average TT (sec)	326.15	**-16.91**	349.26	**-15.24**
TT Standard Deviation	44.79	**-13.78**	17.69	**-67.25**
Average Weighted Delay of Regular Vehicles (sec)			21.49	**-0.92**

Preliminary Simulation Results and Findings

- The PERM MEAS component will allow observation of modal performance
- Nomadic devices are envisioned for PED SIG, But it is possible that they could be used for priority applications (TSP, FSP, and EVP)
- Level of Market Penetration
- Possible Effects of Communication Errors and Latency
- The marginal benefit with data from existing sensors
- The modal benefits of connected vehicle data are critical
- Both communication media have potential benefits for deployment.
- Cellular for EVP might be subject to network outages under extreme events (e.g. hurricane, earthquake, terrorist attack,…)
- Potential Near-, Mid- and Long-term Deployment Impacts

Current Project Status

- Prototype and Demonstration
  - Field test in AZ in early March 2015
  - Field test in CA in Summer 2015
  - Post code and data on OSADP and RDE
  - Finalize the Project Report in June 2015

- Impact Assessment
  - AZ Field data evaluation in March 2015
  - Simulation evaluation in April 2015
  - Final report in July 2015

Stakeholder Q&A

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DMA Website
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