Research Connection:
“Cutting Edge” Transportation Safety Research

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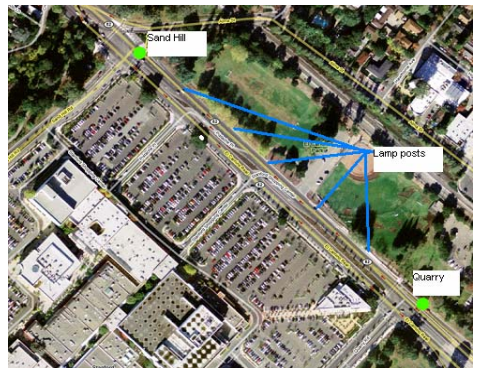
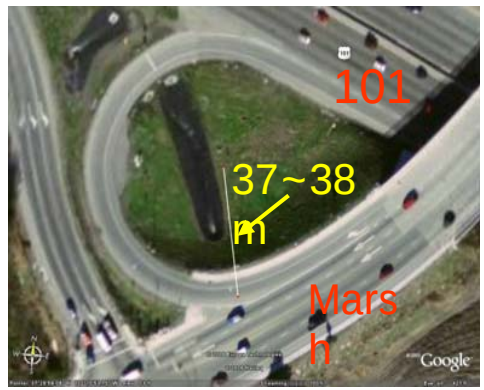
February 3, 2010





Outline

- **Active Safety, Defined**
- **“Leading Edge, High Visibility Research”**
  - **Vehicle-Infrastructure Integration (VII) → IntelliDrive (in California)**
  - **Intersection Safety**
  - **Networked Traveler – Situational Awareness**
  - **(Onboard Monitoring for Trucker Safety)**
- **Recap**

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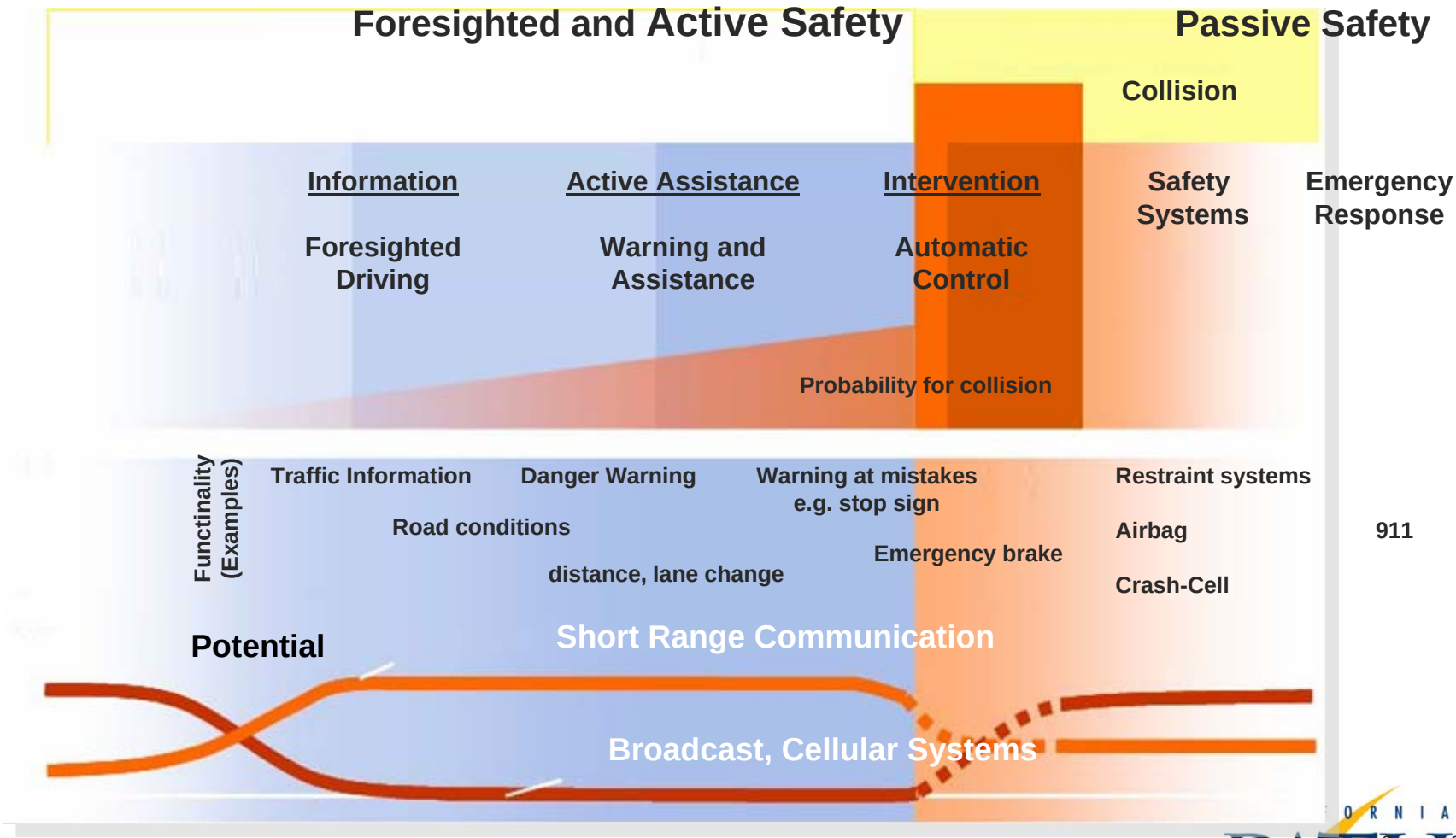
Active Safety Defined
Safety Versus Time… (*Kosch, 2007*)



Source: C2C CC

Active Safety Roadmap

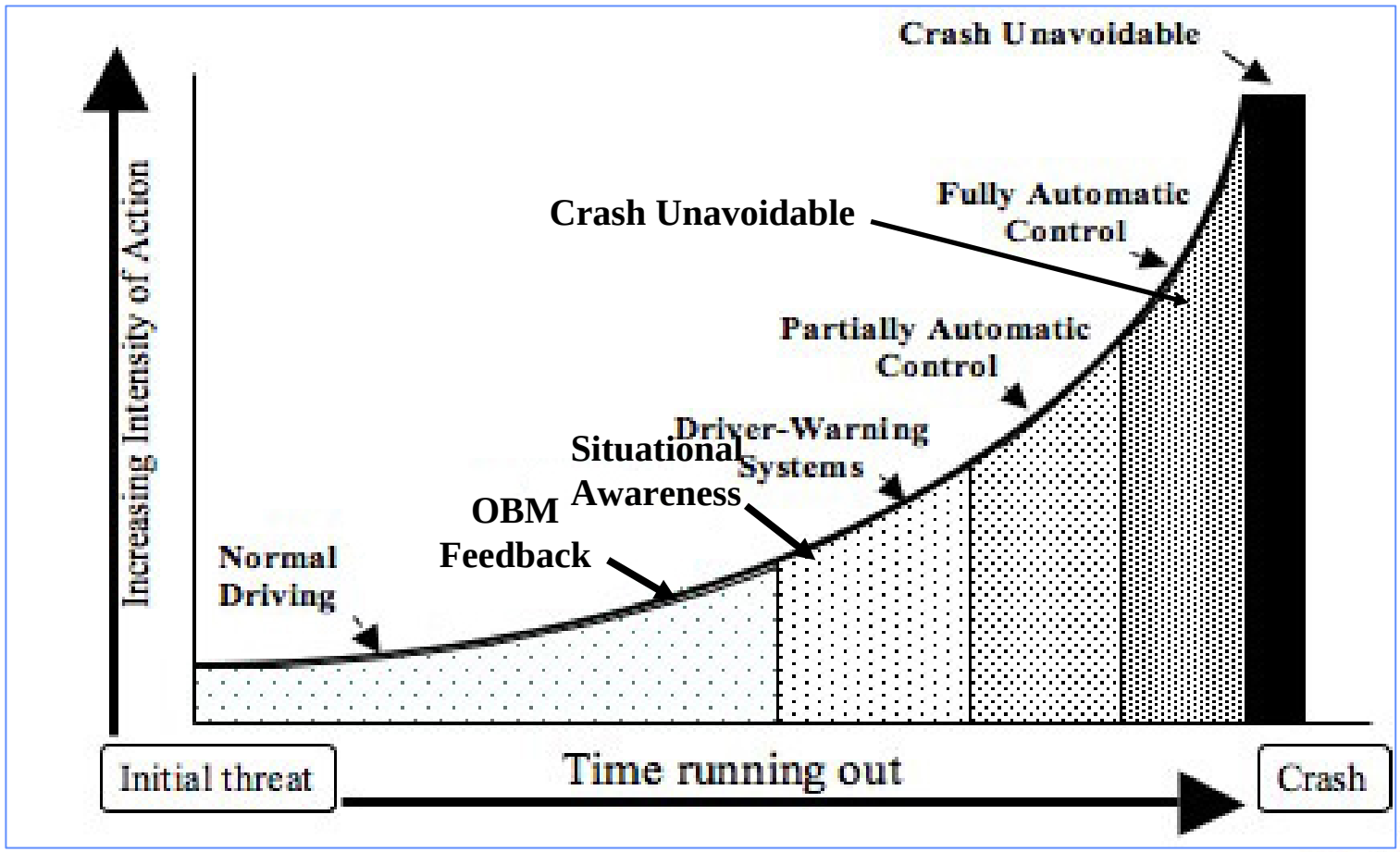


Figure adapted from NHTSA IVHS Plan (1992)

What is VII?
IntelliDrive (SM)

Basic Concept:

- **All new vehicles will be equipped with DSRC radios at 5.9GHz, and GPS receivers.**
- **A nationwide, roadway-based communications network will be created.**
- **Wireless data will be exchanged between the vehicles and the roadside.**
- **A "Backhaul" network will transport this roadside data to/from a central location.**

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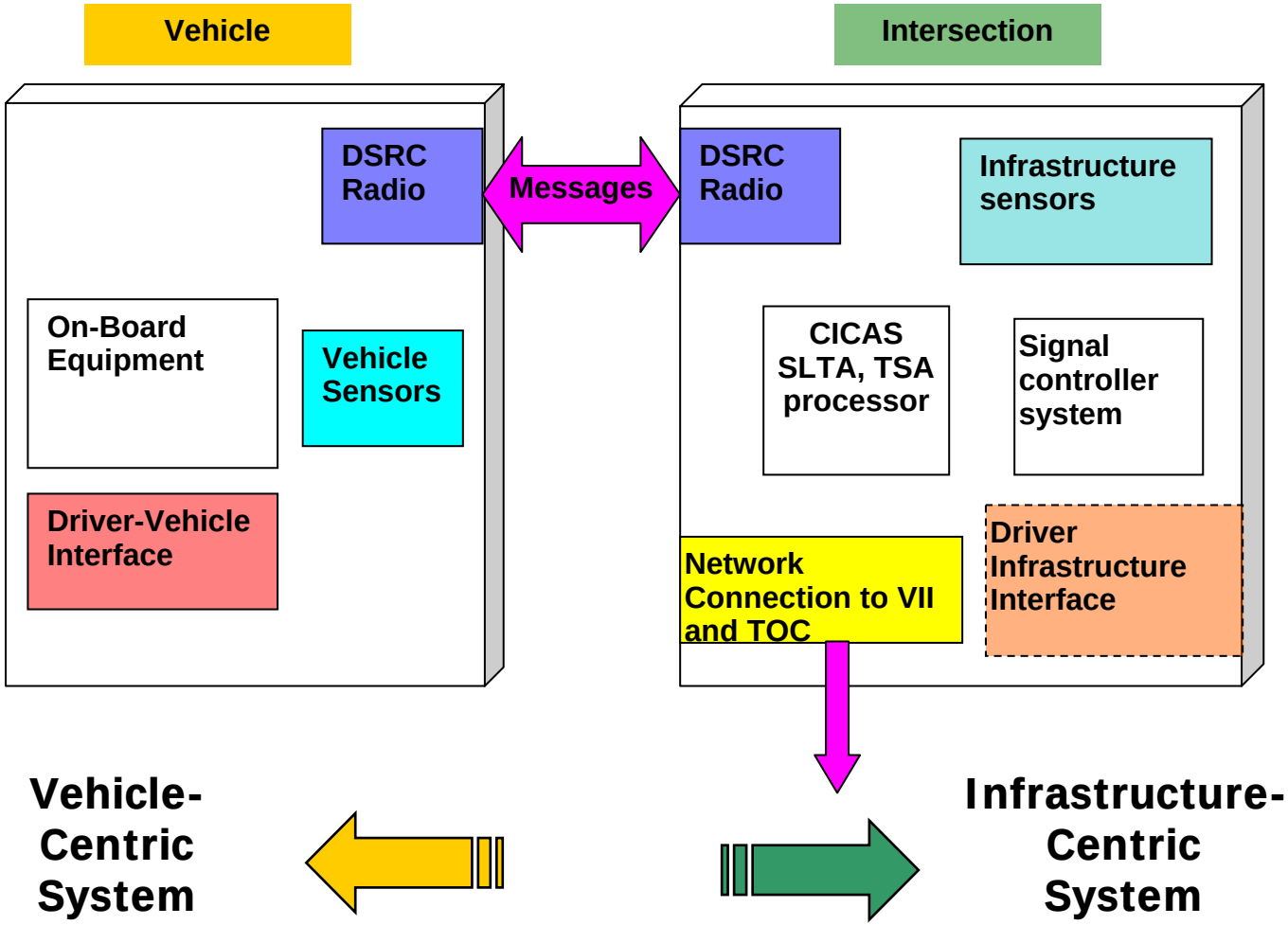
Vehicle-Infrastructure Cooperation

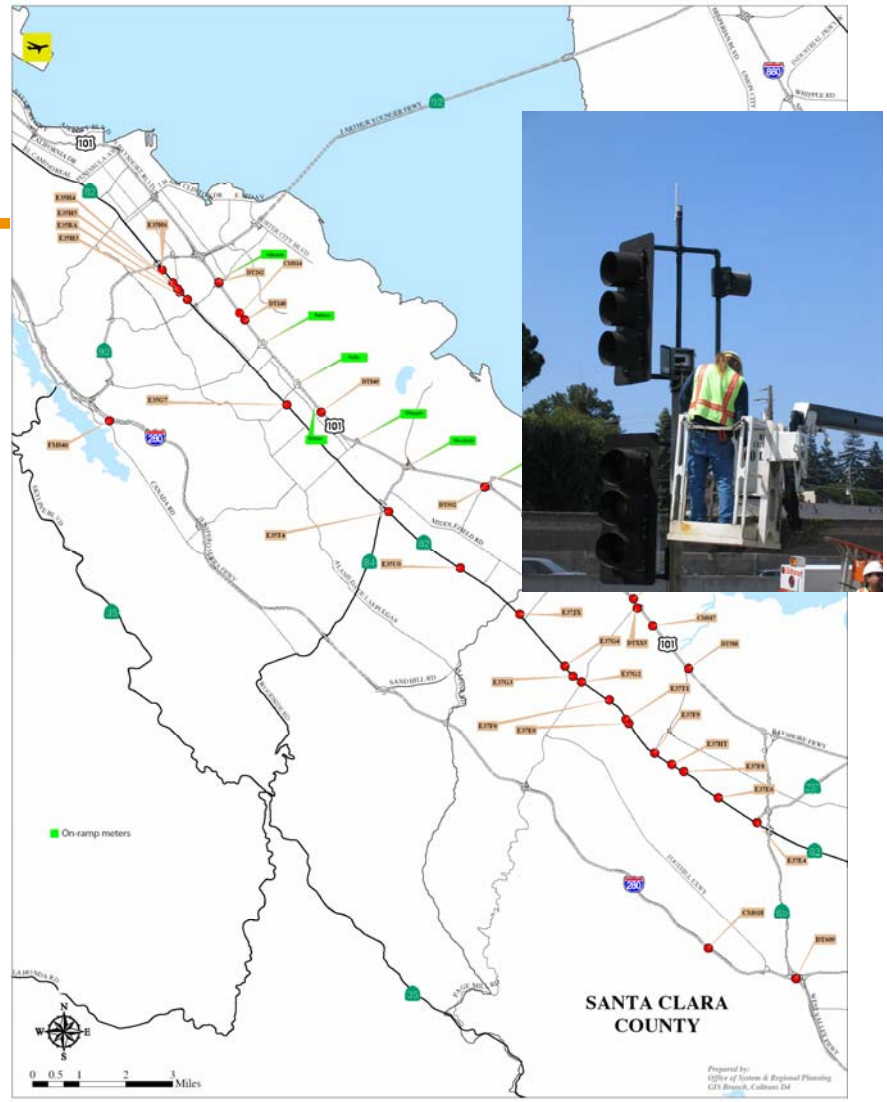


VII California Testbed *Details*

The Vehicle: Perhaps a dozen

The Infrastructure:

- 40 RSE Planned
- 12 Installed



VII California Testbed

Status of R

Sunday eveni

Active RSUs

Active RSUs

Status of RSU 2, California at El Camino

Last report was **Sun Jul 22 20:30:09 PDT 2007**.

Full report

Report index

Variable	Value
Backhaul IP Address	64.81.31.227
WRM Address	192.168.1.148
WRM Channel	Radio Frequency: 5890 MHz (IEEE 178)
WRM Data Rate	6
WRM Power	Transmit Power: 8 dBm; Current Transmit Output Power 16.0 dBm

Recent Signage Broadcasts

First Observed	Last Observed	Message Text
Sun Jul 22 13:05:10 PDT 2007	Sun Jul 22 20:20:09 PDT 2007	Driving time to Page Mill Ave. is 2 minutes
Sun Jul 22 13:15:09 PDT 2007	Sun Jul 22 20:20:10 PDT 2007	Driving time to Quarry Ave. is 4 minutes
Sun Jul 22 13:15:09 PDT 2007	Sun Jul 22 20:20:10 PDT 2007	Driving time to Sand Hill Ave. is 6 minutes
Sun Jul 22 13:05:10 PDT 2007	Sun Jul 22 20:20:09 PDT 2007	Driving time to Stanford Ave. is 2 minutes
Sat Jul 21 15:55:09 PDT 2007	Sun Jul 22 20:20:10 PDT 2007	Speed limit for CA-82 is 35 miles per hour
Sun Jul 22 13:20:09 PDT 2007	Sun Jul 22 20:20:09 PDT 2007	caltrans : Governator Arnold is visiting. Please stay away.
Sat Jul 21 14:30:09 PDT 2007	Sun Jul 22 20:20:10 PDT 2007	test message at California

Recent Signal Messages

Time Sent	Message Data
20:24:52.547	1: R: 55.8 2: G: 25.0 3: R: 61.0 4: R: 84.2 5: Y: 2.2 6: R: 36.8 7: R: 94.2 8: R: 73.0
20:24:52.746	1: R: 55.6 2: G: 24.8 3: R: 60.8 4: R: 84.0 5: Y: 2.0 6: R: 36.6 7: R: 94.0 8: R: 72.8
20:24:52.947	1: R: 55.4 2: G: 24.6 3: R: 60.6 4: R: 83.8 5: Y: 1.8 6: R: 36.4 7: R: 93.8 8: R: 72.6

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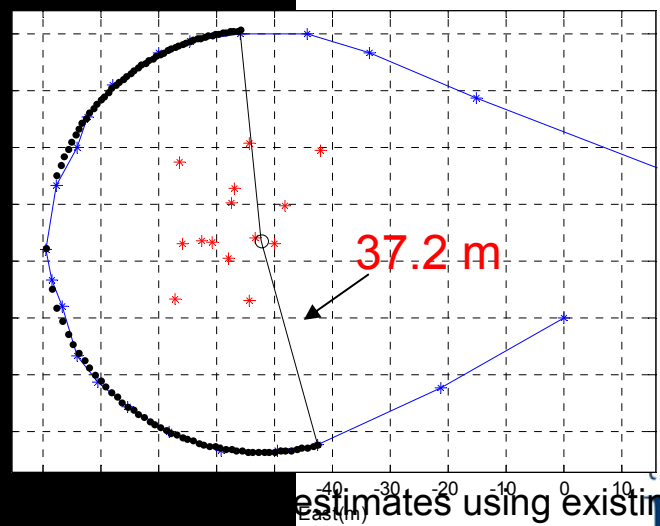
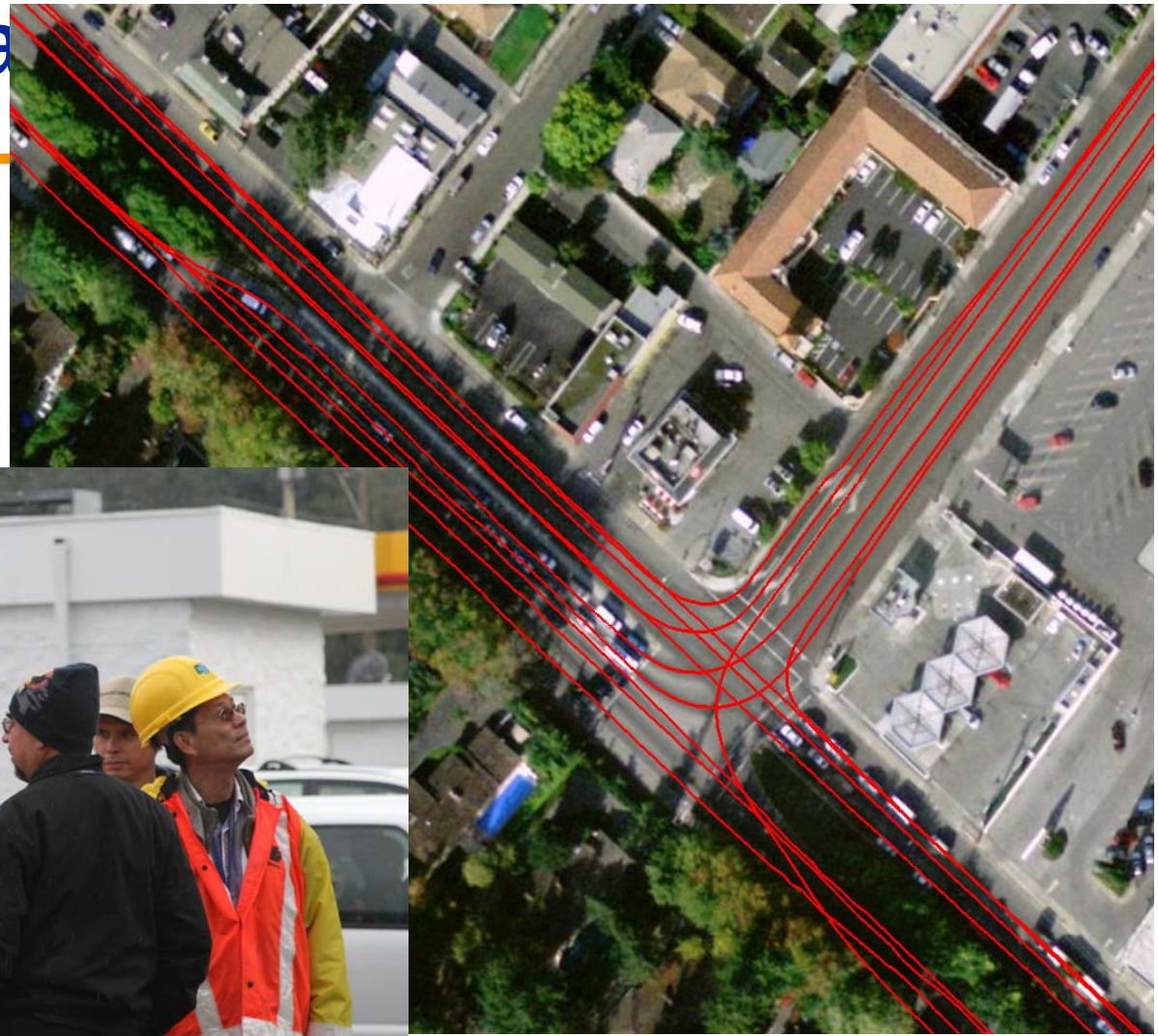
System Features

- On-board curve prediction and dynamic curvature estimation using
- [redacted] munication
- [redacted] er vehicles through
- [redacted]



O [redacted] estimates using existing

5th and El Ca



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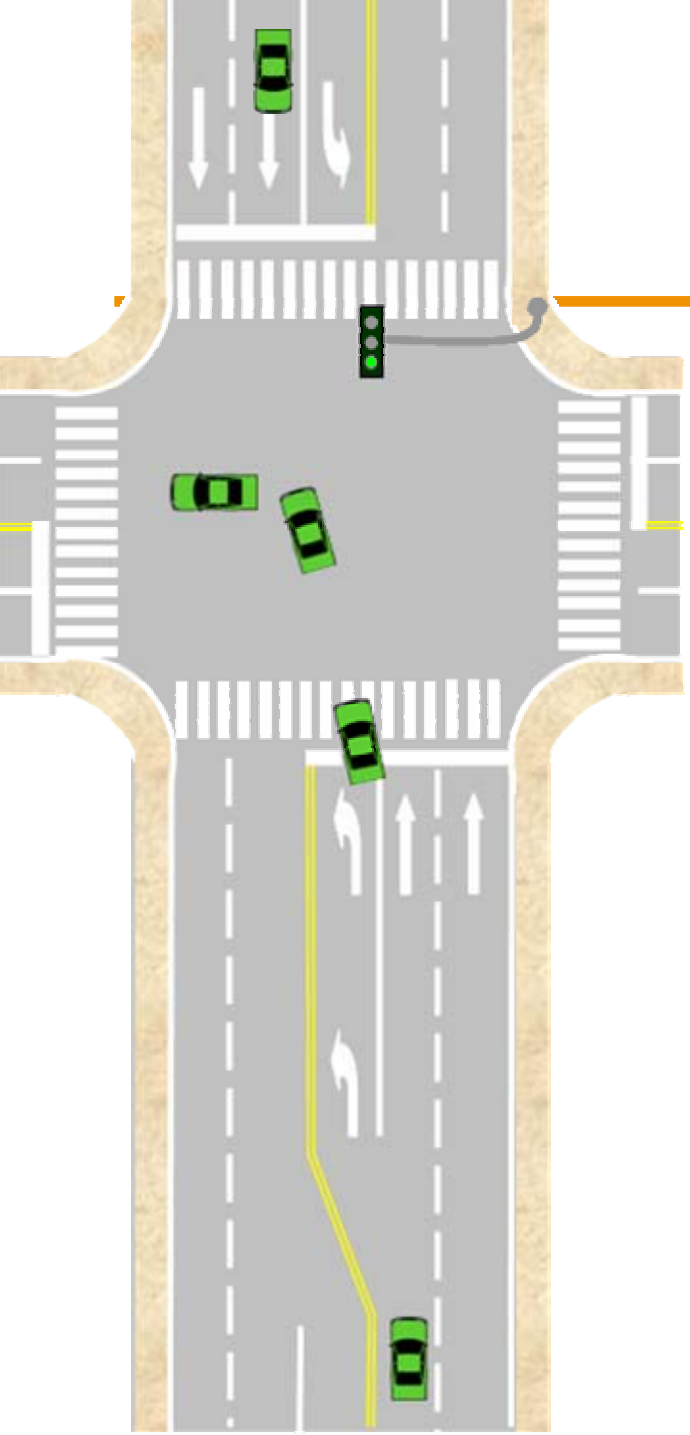
Caltrans/PATH Signal Phase Software: History

- 170
  - AB3418 (TSP Project, 2002)
  - Sniffer (Page Mill, 2006)
  - Current work with Kai Leung / BMW
- 2070
  - NTCIP serial (Turner Fairbank, 2003; RFS, 2004)
  - AB3418 (ECR/Fifth, 2007)
- Econolite ASC/3-2100
  - NTCIP ethernet (World Congress, 2005)

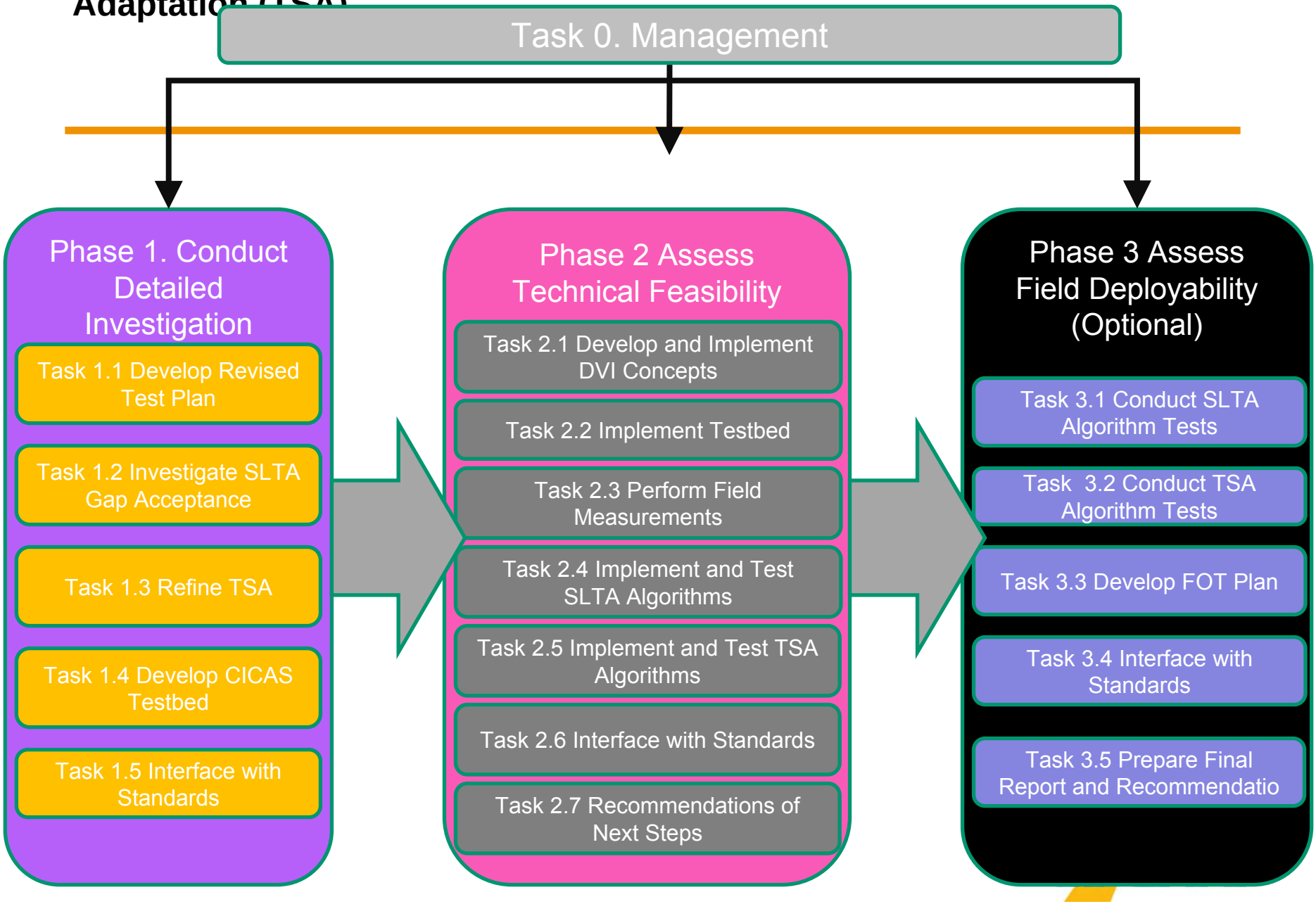


CICAS-SLTA (and –TSA)

Intersection Safety

- **Intersection Decision Support: 2002 – 2005**
- **Cooperative Intersection Collision Avoidance Systems – Signalized Left-Turn Assistance (CICAS-SLTA)**

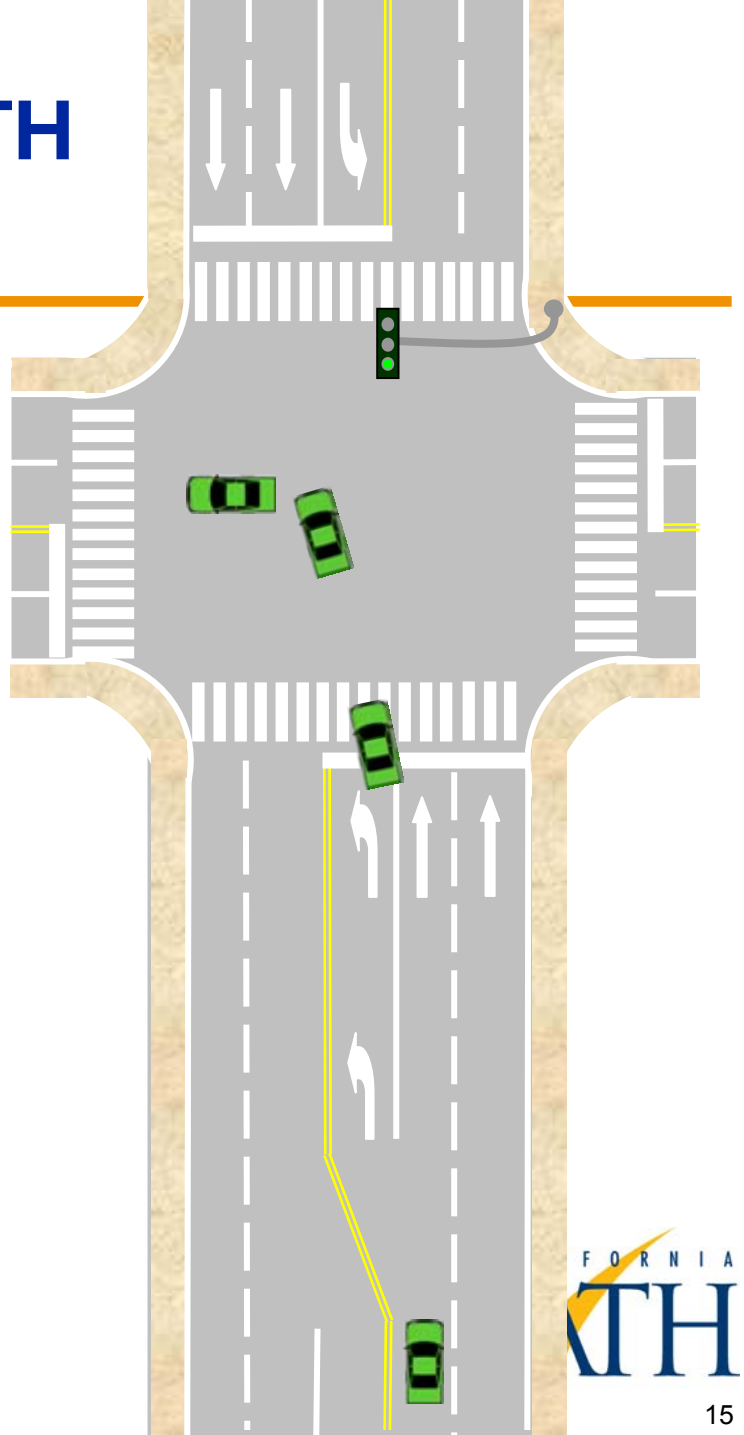
CICAS SIGNALIZED LEFT TURN ASSISTANCE (SLTA) and Traffic Signal Adaptation (TSA)



A Project Focus at PATH - Unprotected SLTA

- **Support driver making a left turn**
- **27% of intersection crashes**
- **Type of Crashes**
  - **Head-On**
  - **Sideswipe**
  - **Other roadway users (pedestrians & bicyclists)**

- **Integration of CICAS within VII, emphasizing a vehicle-based solution**



Signalized Left Turn Assist

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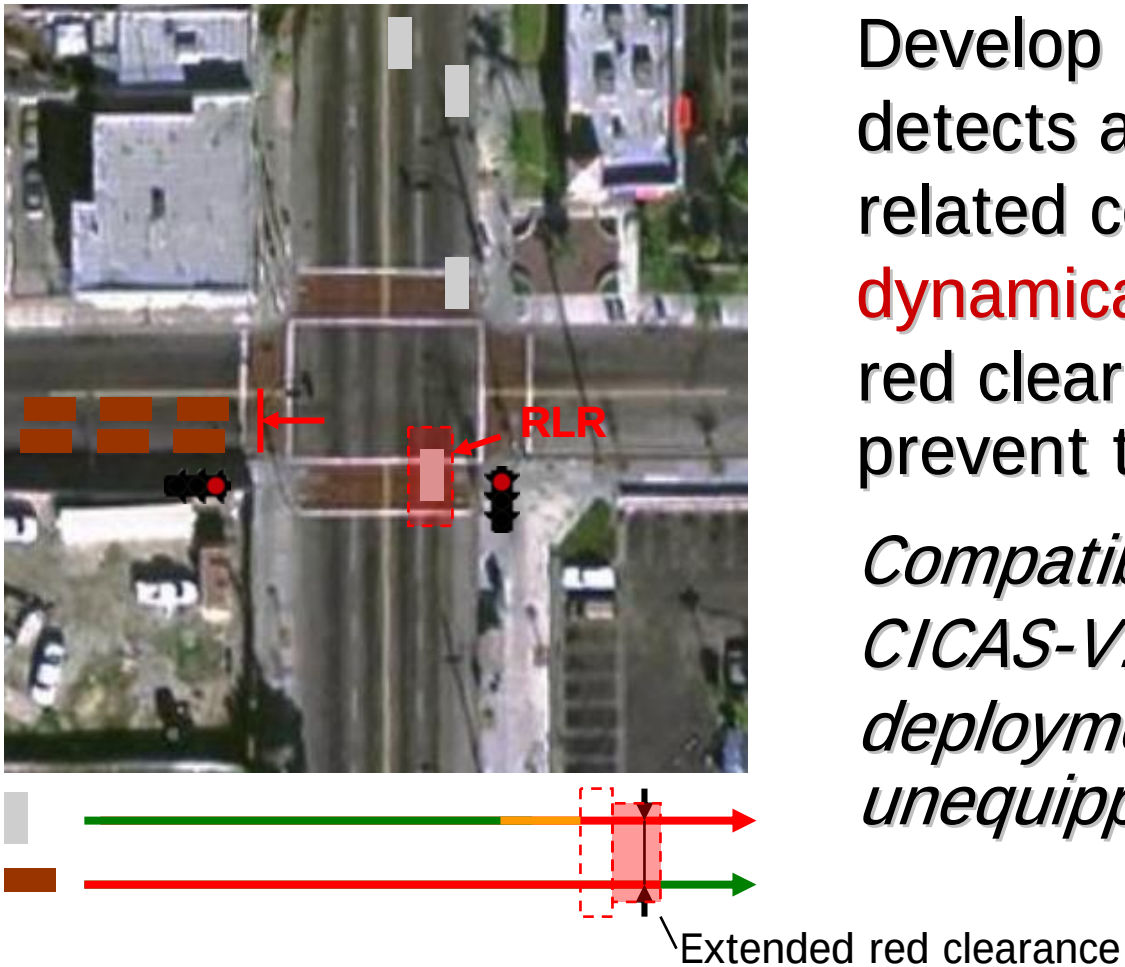
CICAS-TSA Objective



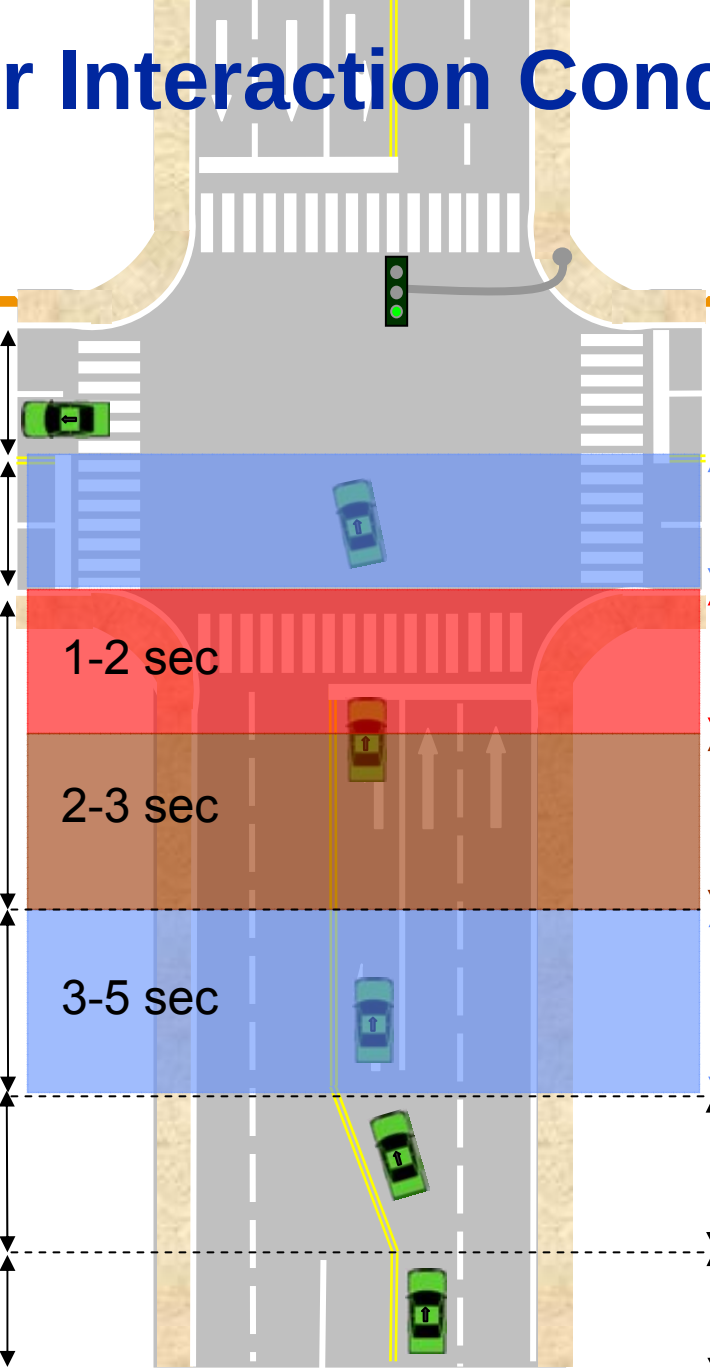
Develop a system that detects a potential RLR-related conflict and dynamically extends the red clearance phase to prevent the collision

Compatible with CAMP CICAS-V: Addresses deployment and/or unequipped cars

SLTA Driver Interaction Concept

SV Maneuver Stage

Potential Interaction Between DVI-Driver



Execute turn

Wait for POV to clear

Deceleration for intersection crossing

Initial decision zone

Deceleration for entering turn lane

Approach

Can't Use System for Collision Warning for Stopped SV

Decision Support for Stopped SV

Reactive Warning (SV Not Stopping)

Preemptive Warning (Late Decision Support)

Decision Support (Provided Before Braking)

Too Early to Predict Vehicle Interactions Reliably?

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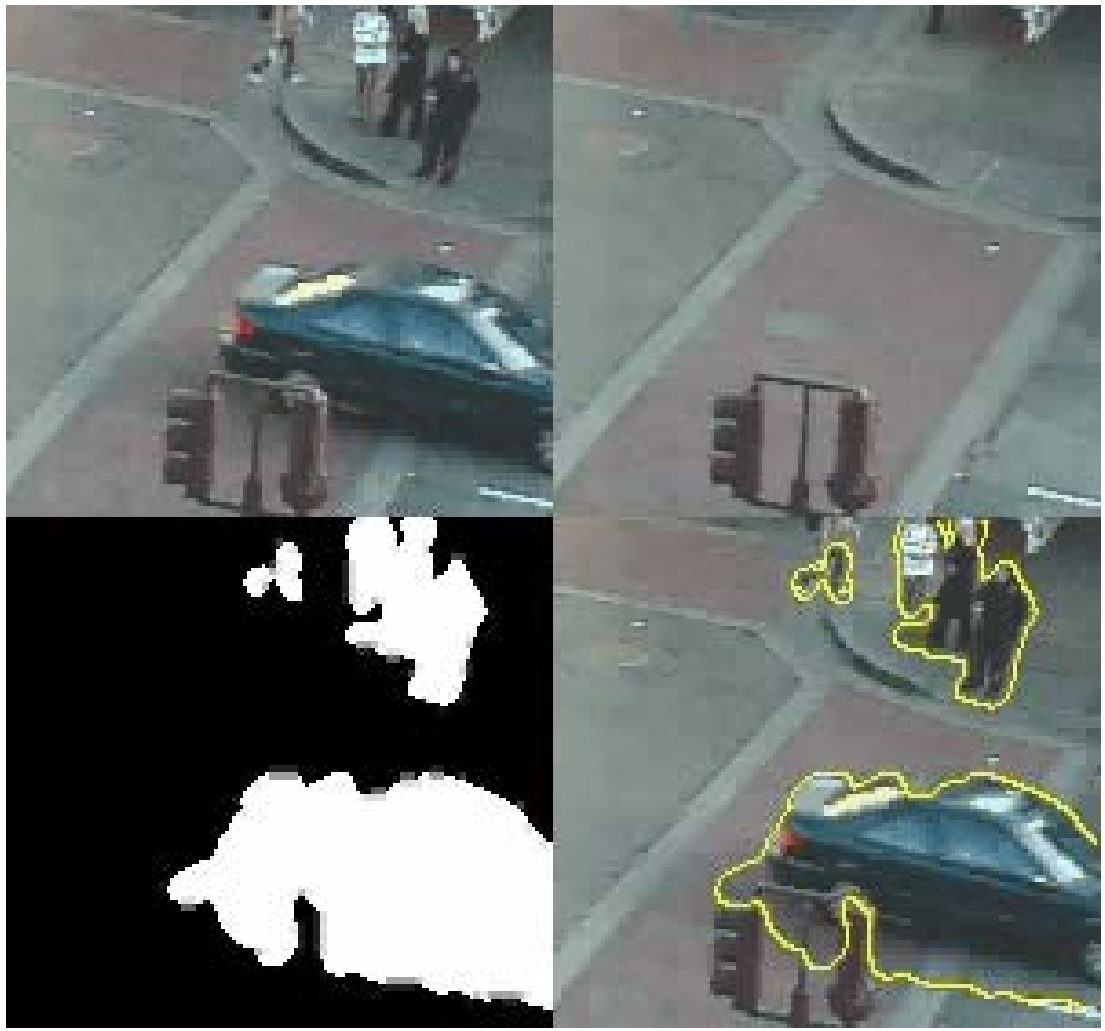
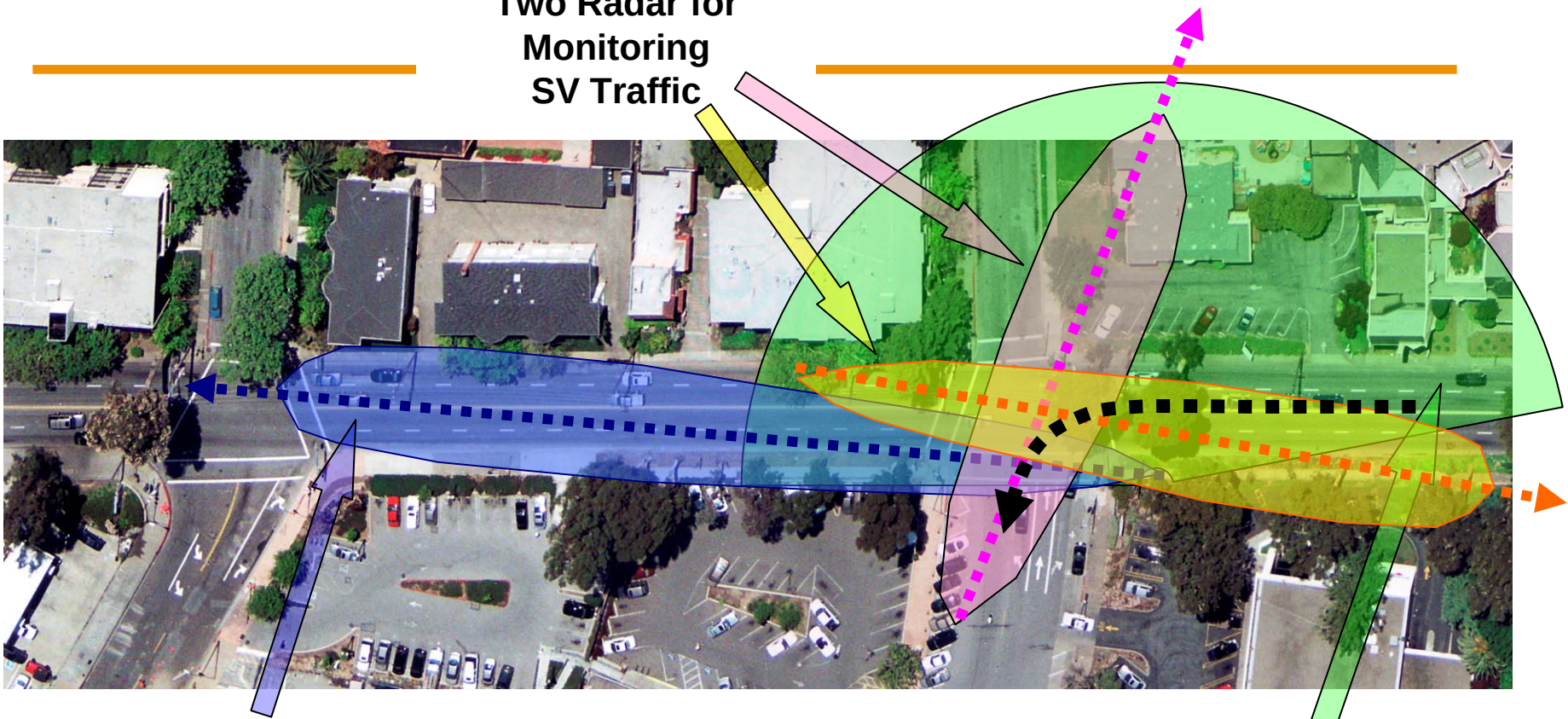
Computer Vision-Based Pedestrian & Bicycle Detection and Tracking



Instrumentation Plan for Field Observation

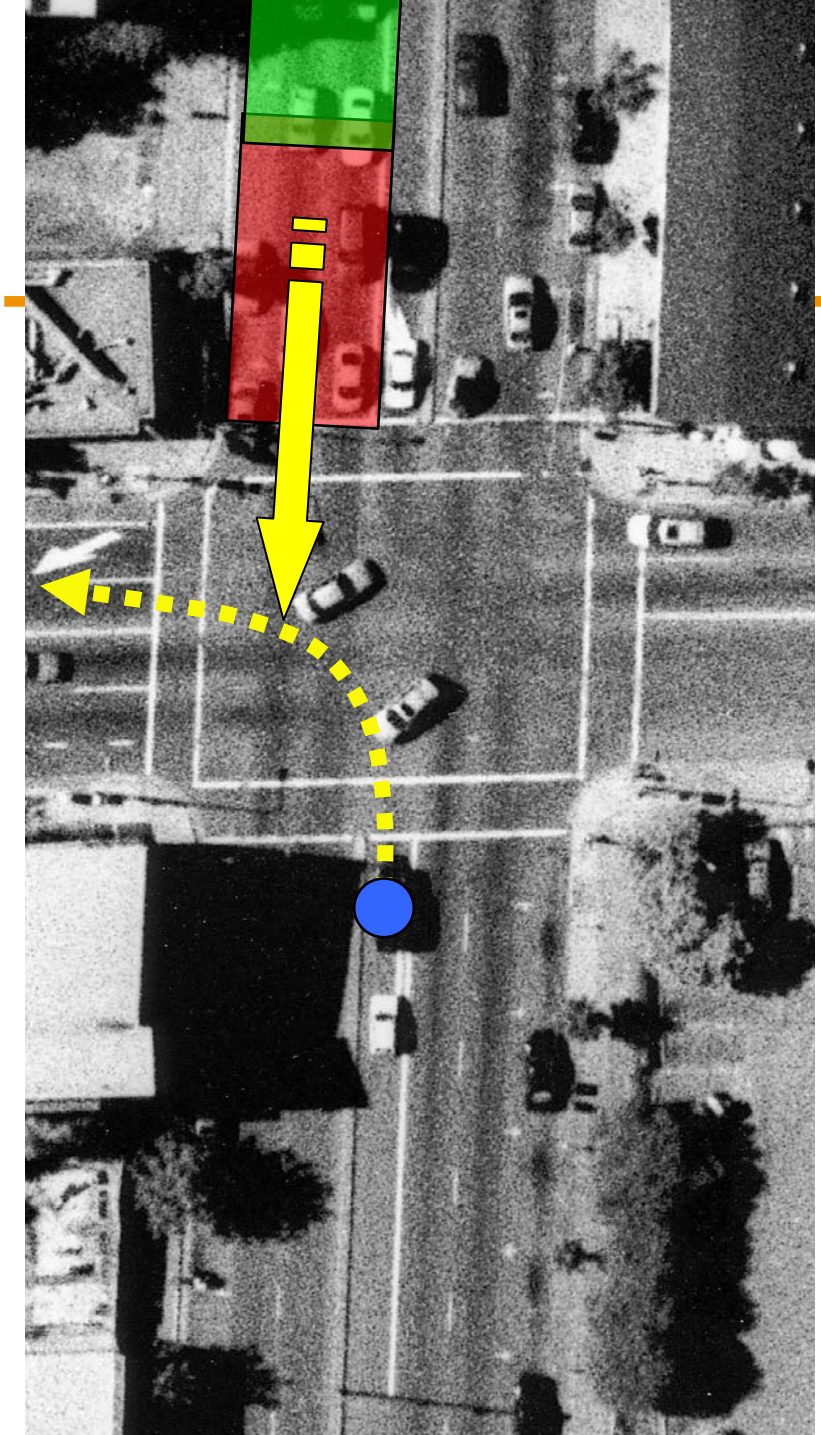
Two Radar for Monitoring SV Traffic



Long-range Radar POV Traffic Monitoring

Additional Equipment
- Video Image Capture
- GPS
- Data Acquisition Computer
- Infrared Camera

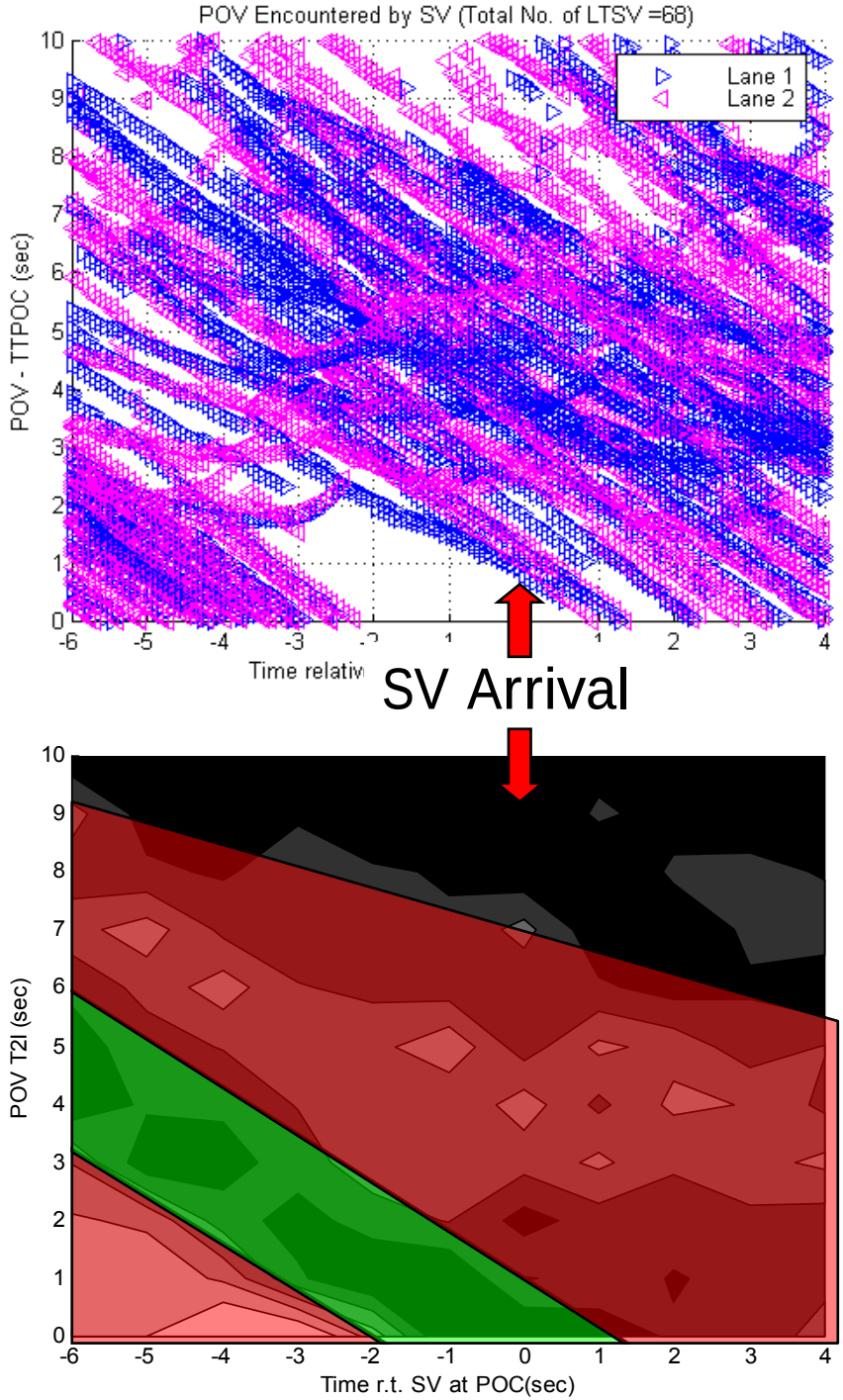
160° Laser Scanner In-the-Box + All-direction Monitoring



Warning Algorithms Based on Trailing Buffer

- **Trailing buffer is the time difference between**
  - **SV departure from POC (point of conflict), and**
  - **POV arrival at POC**

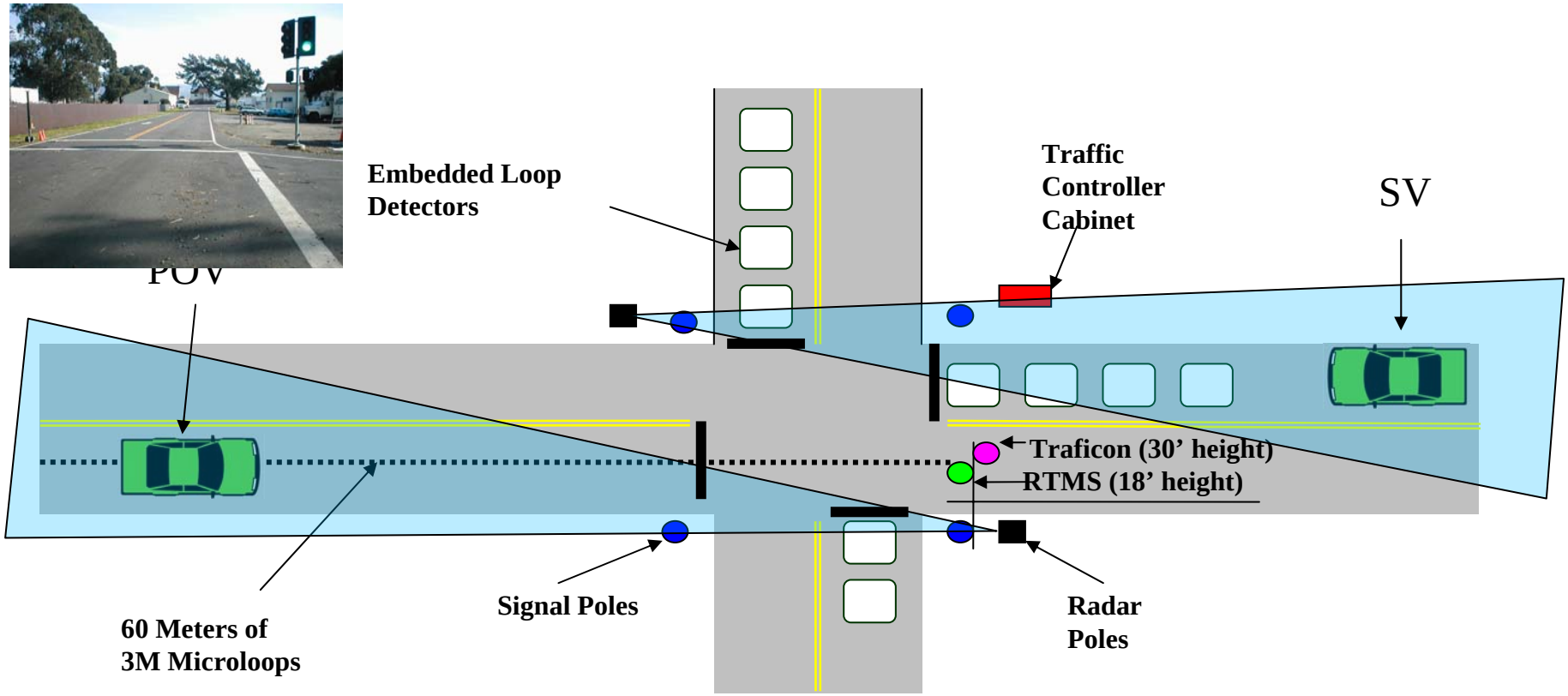
- **Trailing buffer is**
  - **A dynamic value that varies over time**
  - **A meaningful measure of "closeness to a crash"**
  - **A candidate criteria for warning algorithms**



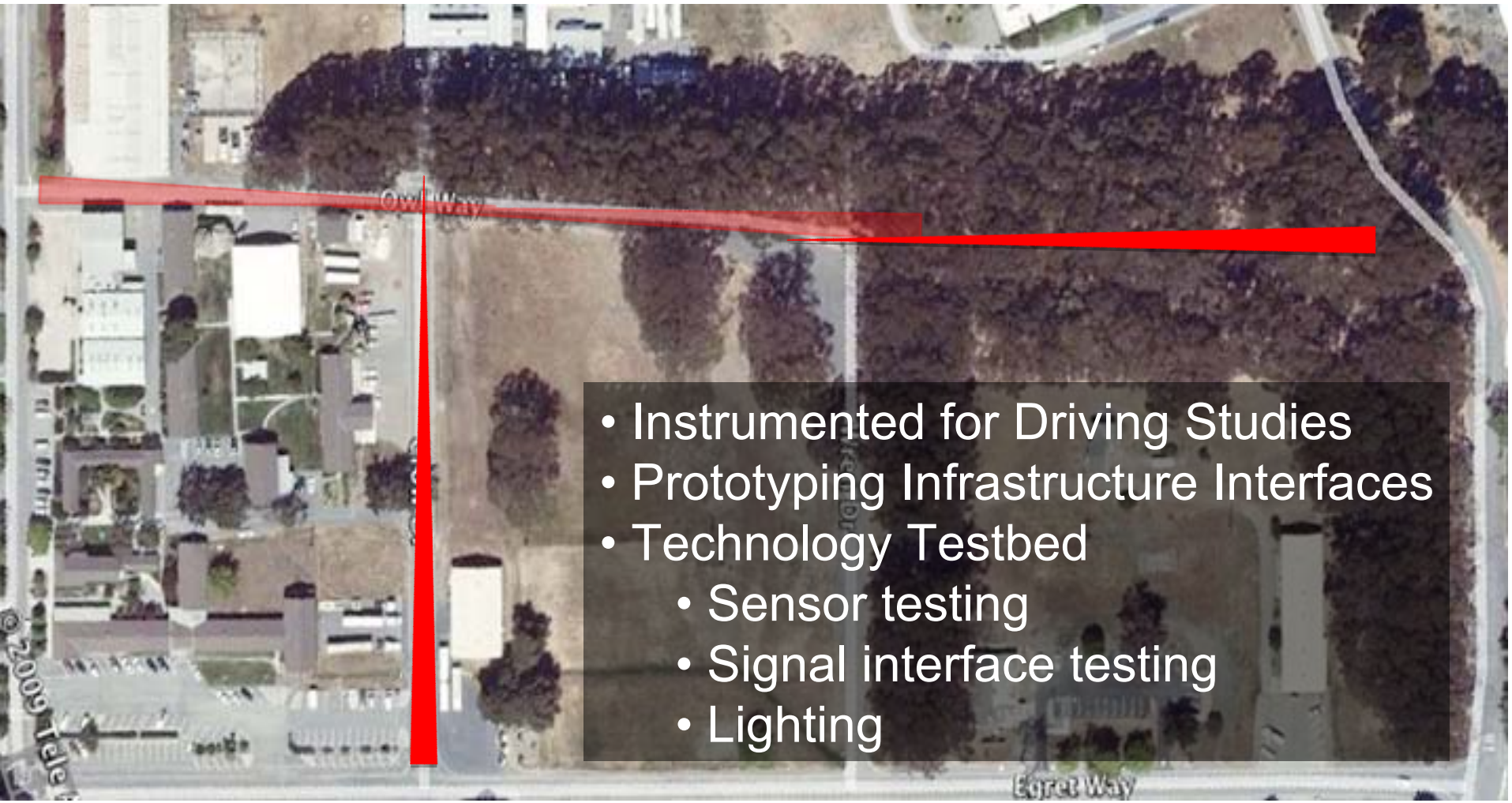
Representation of Time Gap Acceptance in LTAP-OD Scenarios

- **Analysis of SV-POV interactions helps the understanding of driving behaviors and allows the estimation of gap/lag acceptance.**

PATH Intelligent Intersection Facility



RFS Instrumented Intersection



- Instrumented for Driving Studies
- Prototyping Infrastructure Interfaces
- Technology Testbed
  - Sensor testing
  - Signal interface testing
  - Lighting

IDS RFS Intersection Experiments

DII

Off

Low Cycle

High Cycle

Driver Infrastructure Interface

From Driver's Perspective

DVI

Pretrial

Trial Start

Warning On

Driver Vehicle Interface

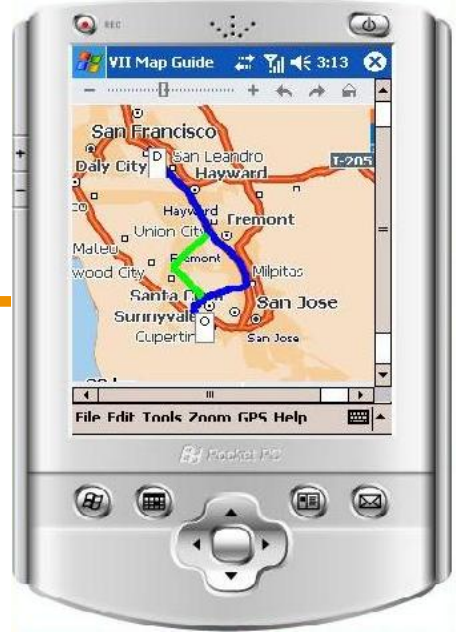
SafeTrip-21: The Connected Traveler

SafeTrip-21

Innovation for a Nation on the Move

Networked Traveler Services

We demonstrated these in NYC



- **Tell me about my trip**
  - *Trip Planner (cell phone with Internet connectivity; multimodal services*
  - *Dynamic Route Advisory*
- **Tell me about the road**
  - *Traffic Signal Countdown (as a safety and information enabler)*
  - *Public Signage – Situational Awareness*
  - *Pedestrian Assistant (location and other apps)*
- **Watch out for me!**
  - *Heartbeat/watch out for me (confederate driver near the bus; situational awareness, left/right?)*
  - *Pedestrian Assistant (safety apps)*
- **System Operator / Agency Application**
  - *Transit Signal Priority (LCD on bus with signal phase countdown)*
  - *Dynamic Passenger Information (On-board display, arrival countdown, and bus station, arrival time)*

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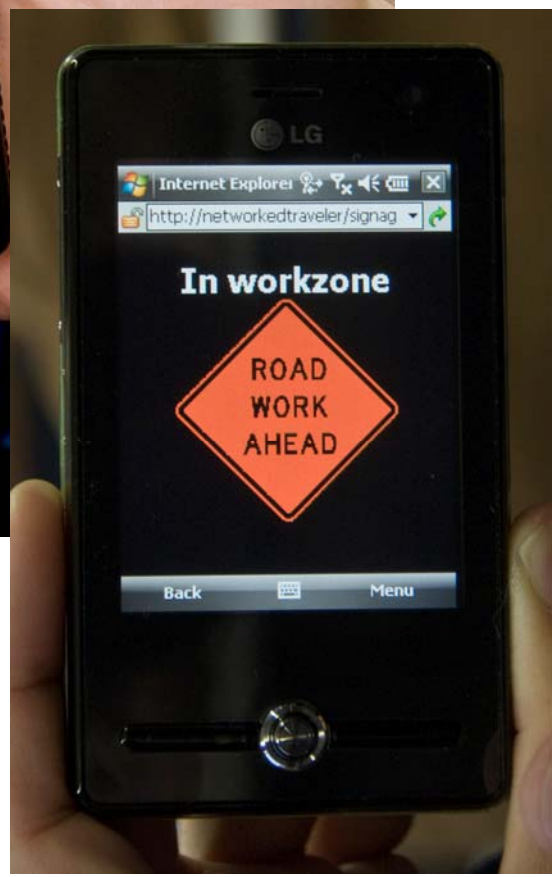
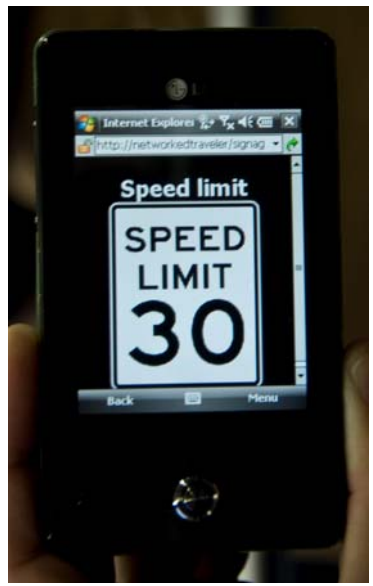
Milestones

- **Demonstration at ITS World Congress November 2008**
- **Field Test**
  - **San Francisco Bay Area**
  - **Beginning in October**

Safety

Situational Awareness is Key





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Application 1. Situational Awareness

Concept of Advisory Services

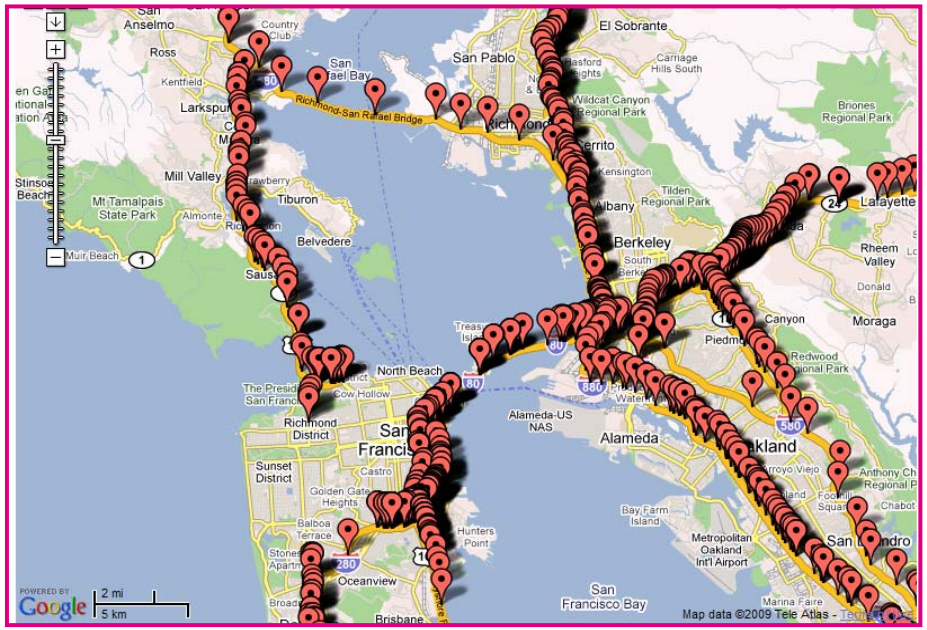
Active Safety	**Situational Awareness**	**Trip Advisory**	
< 1 sec.	10-60 sec.	2-30 minutes.	**Alert Latency**

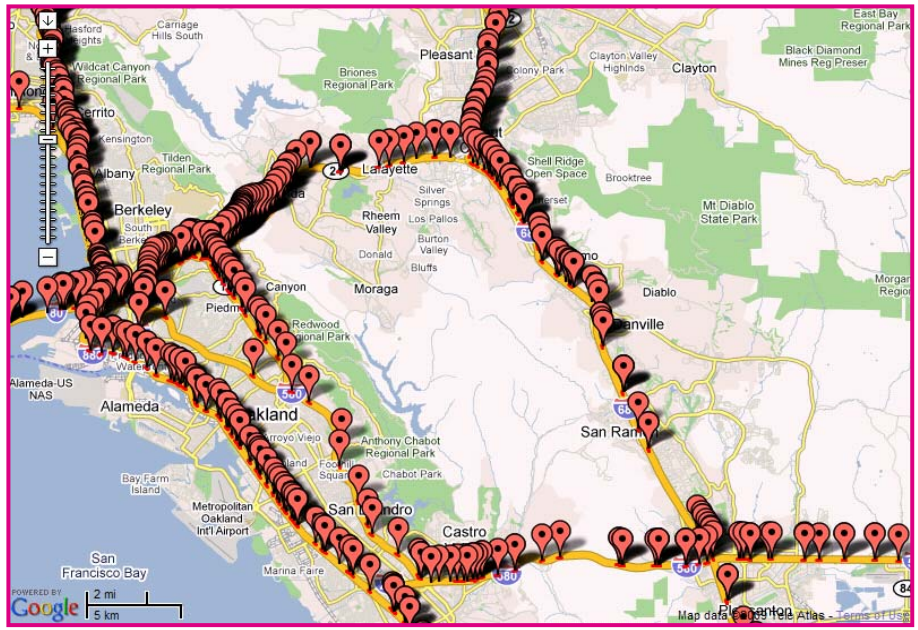
Mapping to the Classic Driving Model Taxonomy

- **Strategic**
  - **Safety Route Advisory**
- ***Tactical (Primary Focus)***
  - ***Situational Awareness Advisory***
- **Control**
  - **"Watch out for me!" Active Safety**

Coverage Map (1/2):

About 1650 NAVTEQ triggers and more than 520 SpeedInfo triggers in Bay Area.





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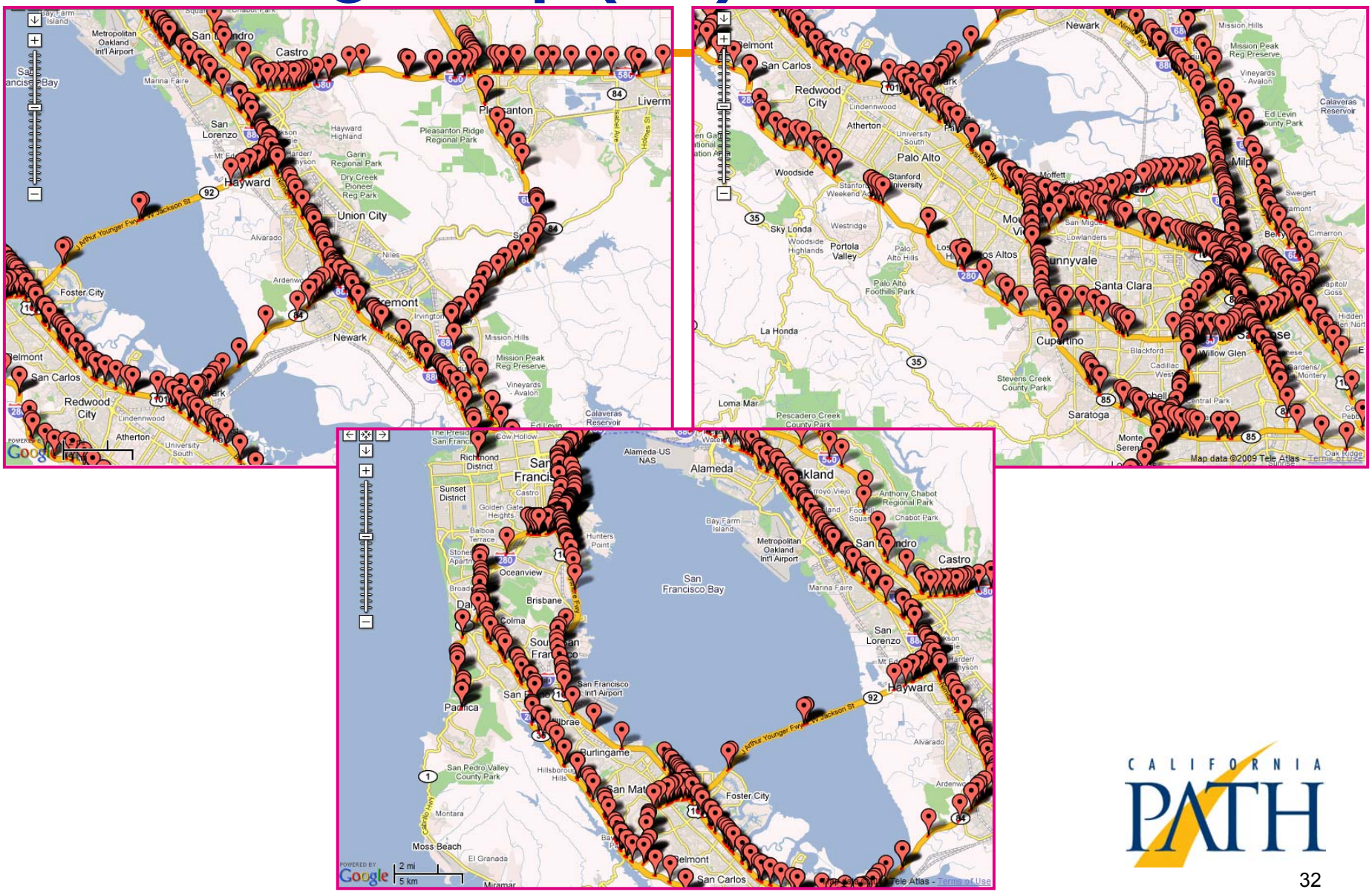
Coverage Map (2/2):



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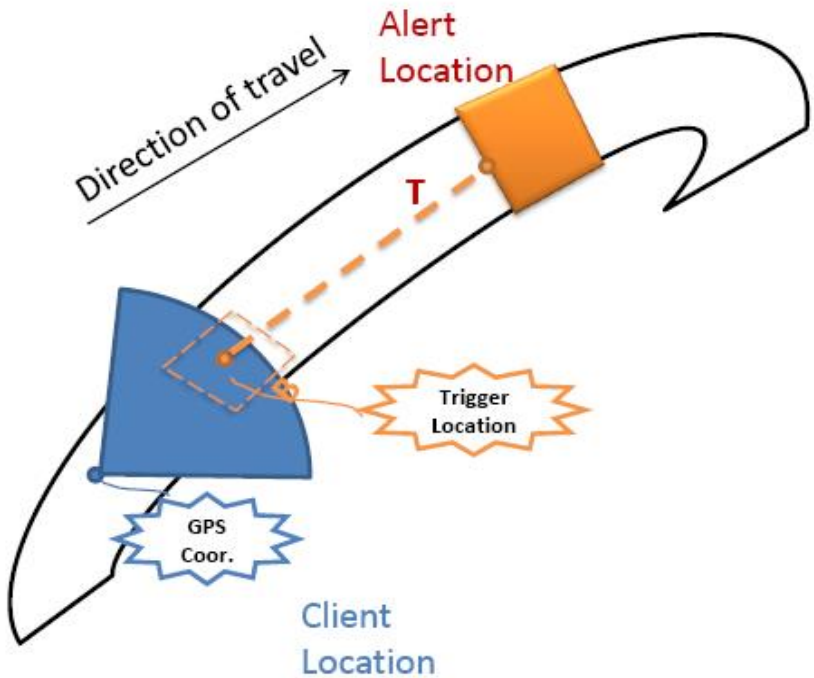
Alert Algorithm



Definitions:

Subject vehicle: Vehicle whose driver receives slow traffic ahead alert

Alert location: Upstream location where traffic is slow

Trigger location: Represented by GPS lat, long, and heading; about one mile (60 seconds of free flow speed) before the alert location

Suppose:

Vs = Speed of the subject vehicle

Vf = Speed of the vehicles at the alert location

Alert is issued if:

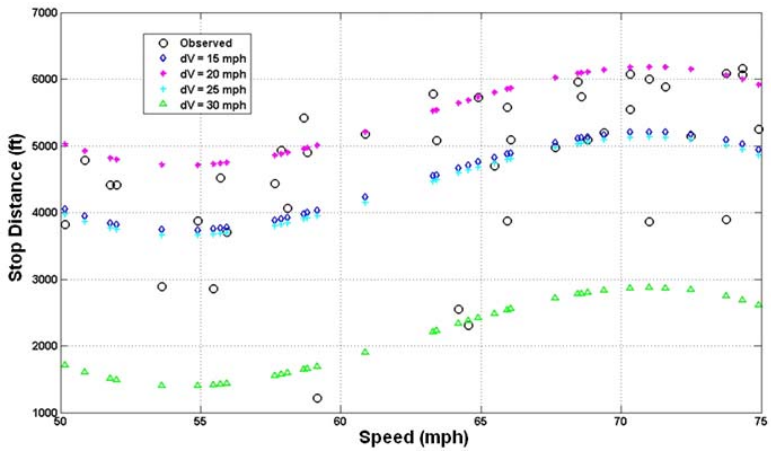
1)Vf ≤ 50 mph and

2)Vs – Vf ≥ 15 mph and

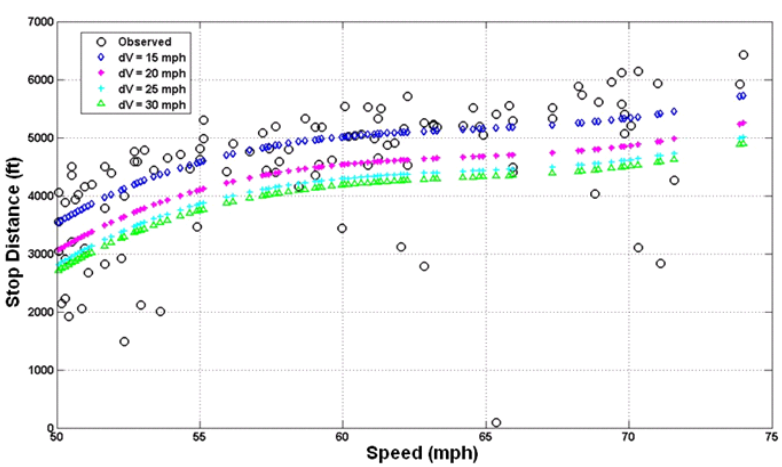
3)Distance between trigger location and subject vehicle location ≤ 500 ft

4)Difference between trigger location's heading and vehicle's heading ≤ 50 deg

Validating End of Congestion Queue Algorithms (in progress)



Observed and fitted slowing distance versus speed for several values of Δv for user 1



Observed and fitted slowing distance versus speed for several values of Δv for user 2.

- **3000 miles of late summer, early fall "shakedown" testing**
  - **7 drivers**
  - **Analyzed GPS traces**
    - **Time (s)**
    - **Latitude (deg)**
    - **Longitude (deg)**
    - **Speed (mph)**
    - **Heading angle (deg)**
    - **Altitude (m)**
    - **Number of satellites**
    - **PDOP[**
- **Isolated soft braking events**
  - **Braking (slowing distance)**
  - **Speed before slowdown**
  - **Speed differential (post facto speed data),**
- **Modeled the slowing distance as a third order polynomial**
  - **Speed and speed differential.**
  - **Calculated coefficients of the polynomial**
    - **f(driver, traffic, location)**

Location of Top-Deck S-Curve Trigger Point

The ‘Onboard Monitoring System for Commercial Vehicle Safety’ (OBMS) System Prototype

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Goal

Effective and lasting behavior change to safer driving behaviors for CMV drivers

- **What is unsafe?**
- **How can feedback best be provided?**

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Core Behavioral Monitoring Categories

1. Speed Selection
2. Following Behavior
3. Attention (Inattention)
4. Fatigue
5. General Safety (Good Driving Practice)

Monitoring Apps: Speed

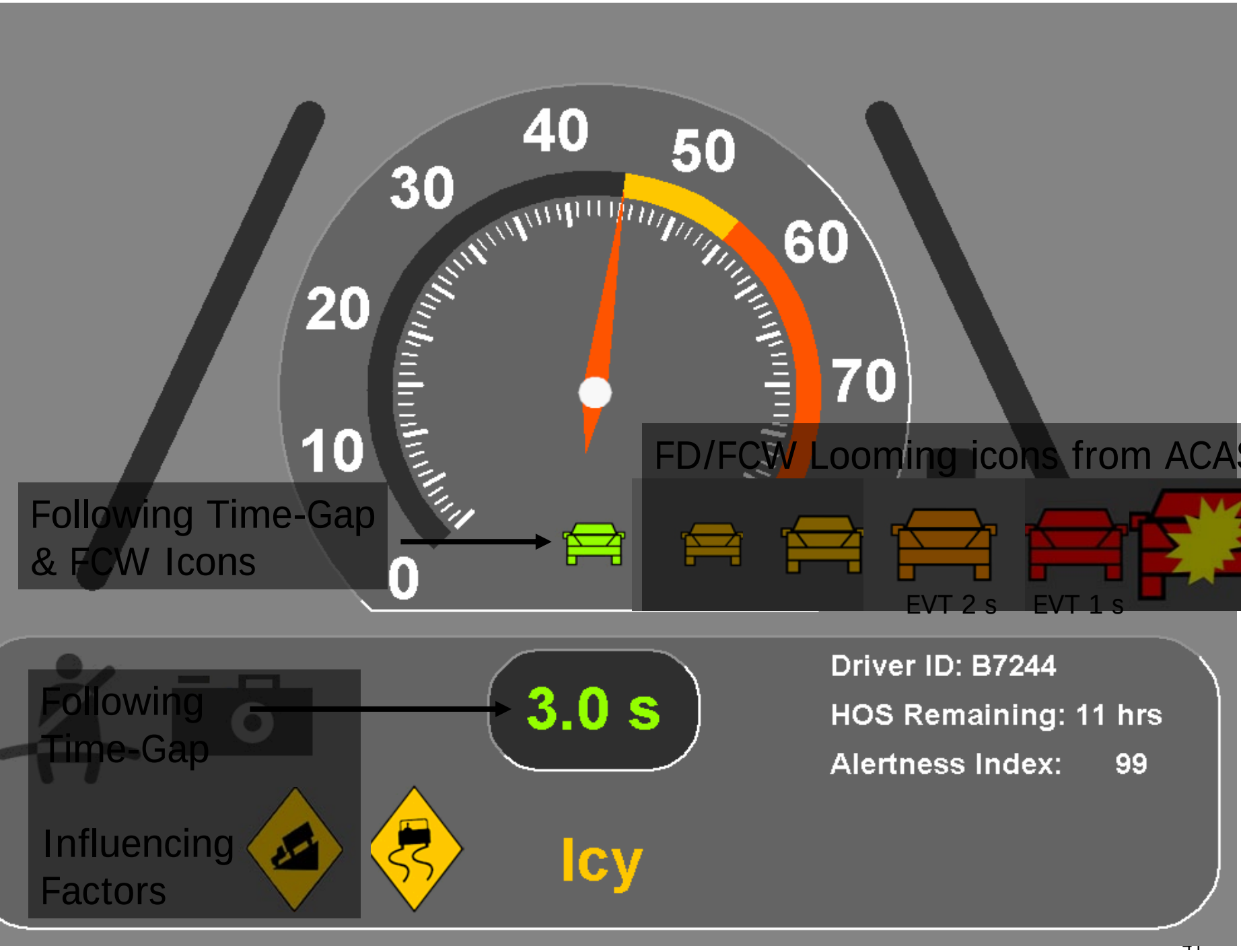
Speed vs.

1. Speed Limit (Violation)
2. Traffic Flow
3. Curve Speed (Curves Speed & Rollover Warning)
4. Road Surface
5. Grade
6. Hard Acceleration

Real-Time Driver Feedback Elements

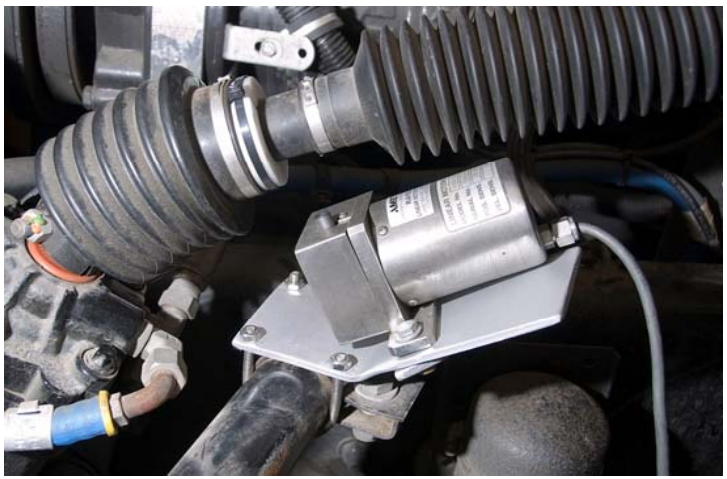
1. Current Speed
2. Recommended Speed
3. Risk Factors (Why is that speed recommended?)
4. Event Recording in Progress (LED/Icon)

HHDD Warning
Recommend 45 mph
Recommended Speed
Speed Limit
0
10
20
30
40
50
60
70
80
Factors that may be influencing the recommended speed
-- S
Driver ID: B7244
HOS Remaining: 11 hrs
Alertness Index: 99
Icy


0
10
20
30
40
50
60
70
FD/FCW Looming icons from ACAS
Following Time-Gap & FCW Icons
EVT 2 s
EVT 1 s
Following Time-Gap
3.0 s
Driver ID: B7244
HOS Remaining: 11 hrs
Alertness Index: 99
Influencing Factors
Icy

Components:

Camera Enclosure, Radar & Lidar, Road Surface Condition Monitor, Wheel Angle Sensor (String Pot), Gyro & Accelerometer



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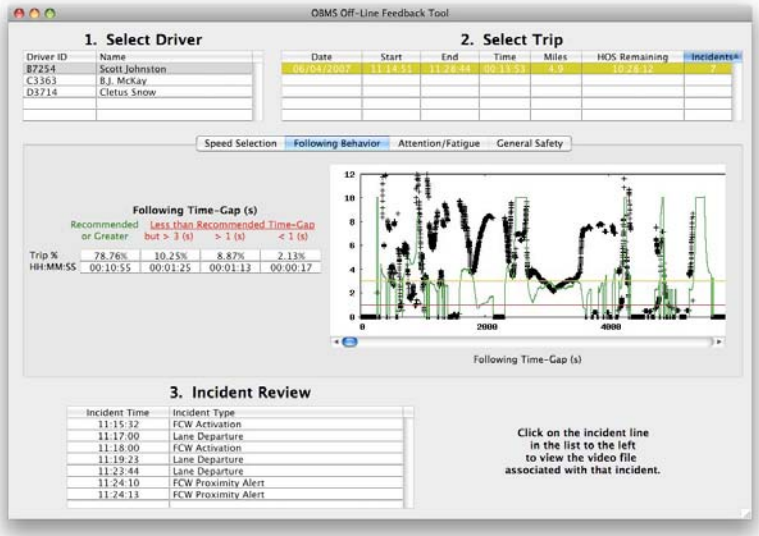
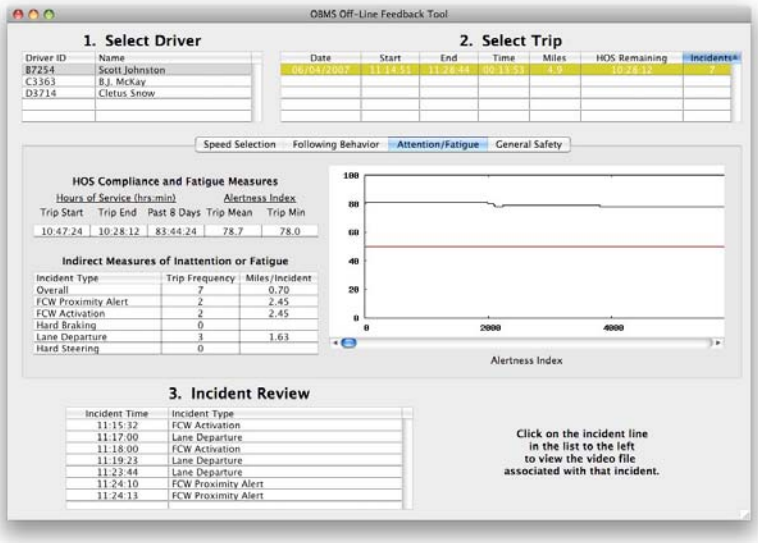
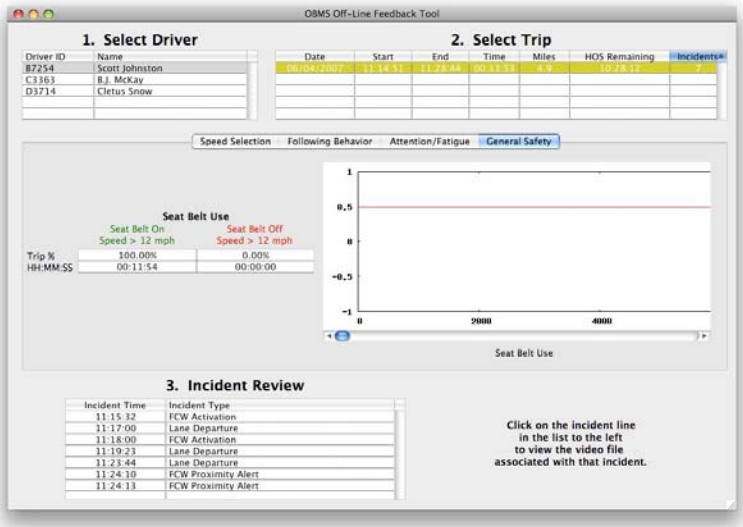
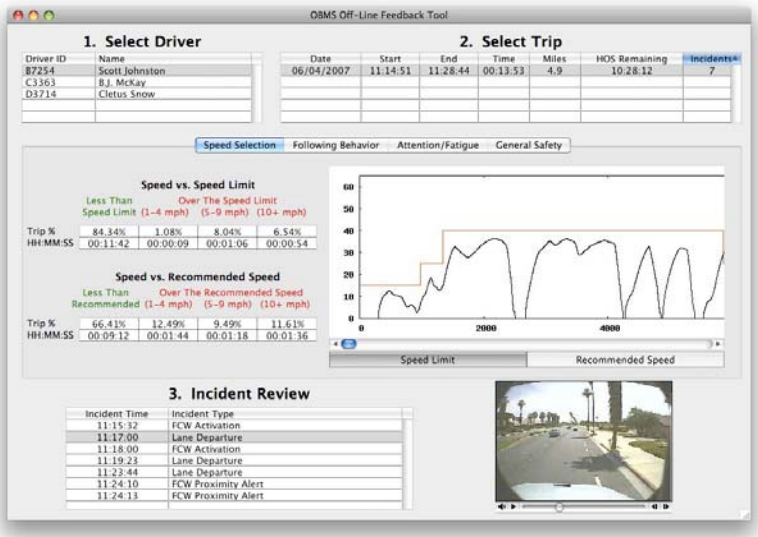
Prototypical Offline Feedback Format









Recap

- **Summary**
  - **Vehicle-Infrastructure Integration (VII) → IntelliDrive (in California)**
  - **Intersection Safety**
  - **Networked Traveler – Situational Awareness**
  - **(Onboard Monitoring for Trucker Safety)**
- **We have been on the vanguard**
  - **Innovation**
  - **National spotlight**
- **Bridges near-term safety problems with potential mid-term safety solutions**

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Thank You

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