

California Truck Count Project

Development of the Truck Activity Monitoring System (TAMS)

Sponsored by:
California Department of Transportation

Presented by:
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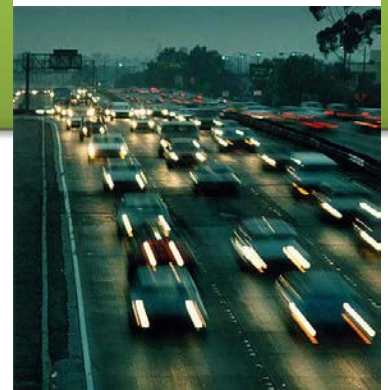
May 3rd, 2016



UCIrvine
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ITS
Irvine



Truck Configurations

Logging



Conventional cab



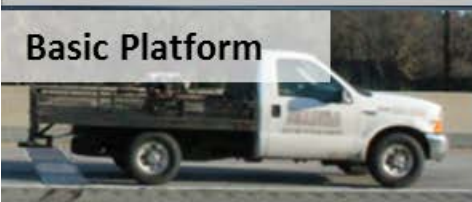
Wrecker



Sleeper cab



Basic Platform



Dump



Reefer Enclosed van



Utility



30ft bus



Light van



Beverage



Service



Multi stop



Low loading



Garbage



Tank



Conventional Enclosed van



Cab over Enclosed van



Cab over cab



RV



Dumpster transport



Concrete mixer



20ft bus



Crane



Trailer Configurations



Project Team from UC Irvine

Principal Investigator:
Professor Stephen Ritchie



Asst. Research Scientist:
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Asst. Research Scientist:
Dr. Craig Rindt



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Kyungsoo Jeong



Kate Hyun



Outline

Part 1. Overview

1. Background
2. What is TAMS?
3. Importance of Truck Body Class Data
4. Expected Contributions
5. Detector Technologies Behind TAMS

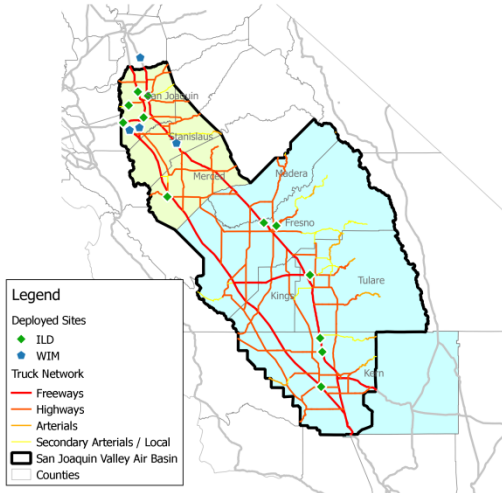
Part 2. System Development

1. Data Collection and Processing Efforts
2. Model Design
3. Site Deployments
4. Data Flow Architecture

Part 3. Live Demo & Wrap-up

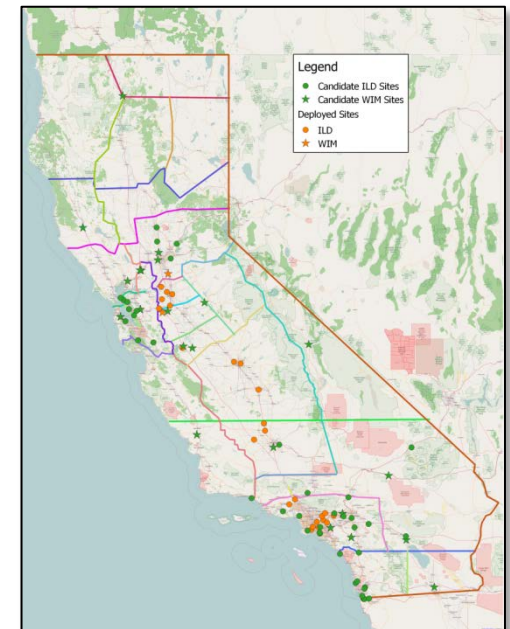
1. Live Signature Transmission
2. Walk Through TAMS Web Interface
3. Collateral Benefits

Background



- Pilot study funded by California Air Resources Board in 2012
 - Initial development of inductive signature-based truck body classification models
 - Deployed at 16 weigh-in-motion (WIM) and inductive loop detector (ILD) sites in the California San Joaquin Valley

- Current study funded by Caltrans in 2015
 - Improved Validation and Calibration of the California Statewide Freight Forecasting Model (CSFFM)
 - Enhancement of truck classification models
 - Expand deployment to over 90 locations along major truck corridors in California, encompassing
 - state borders,
 - regional cordons, and
 - metropolitan areas



What is the *Truck Activity Monitoring System (TAMS)*?

A truck counting system that is...

Temporally Continuous

– Data collected and transmitted real-time 24/7

Cost Effective

– Leverages existing Inductive Loop and Weigh-In-Motion Detector infrastructure

Spatially Comprehensive

– Will be deployed at over 90 major truck corridors across the State of California

Advanced

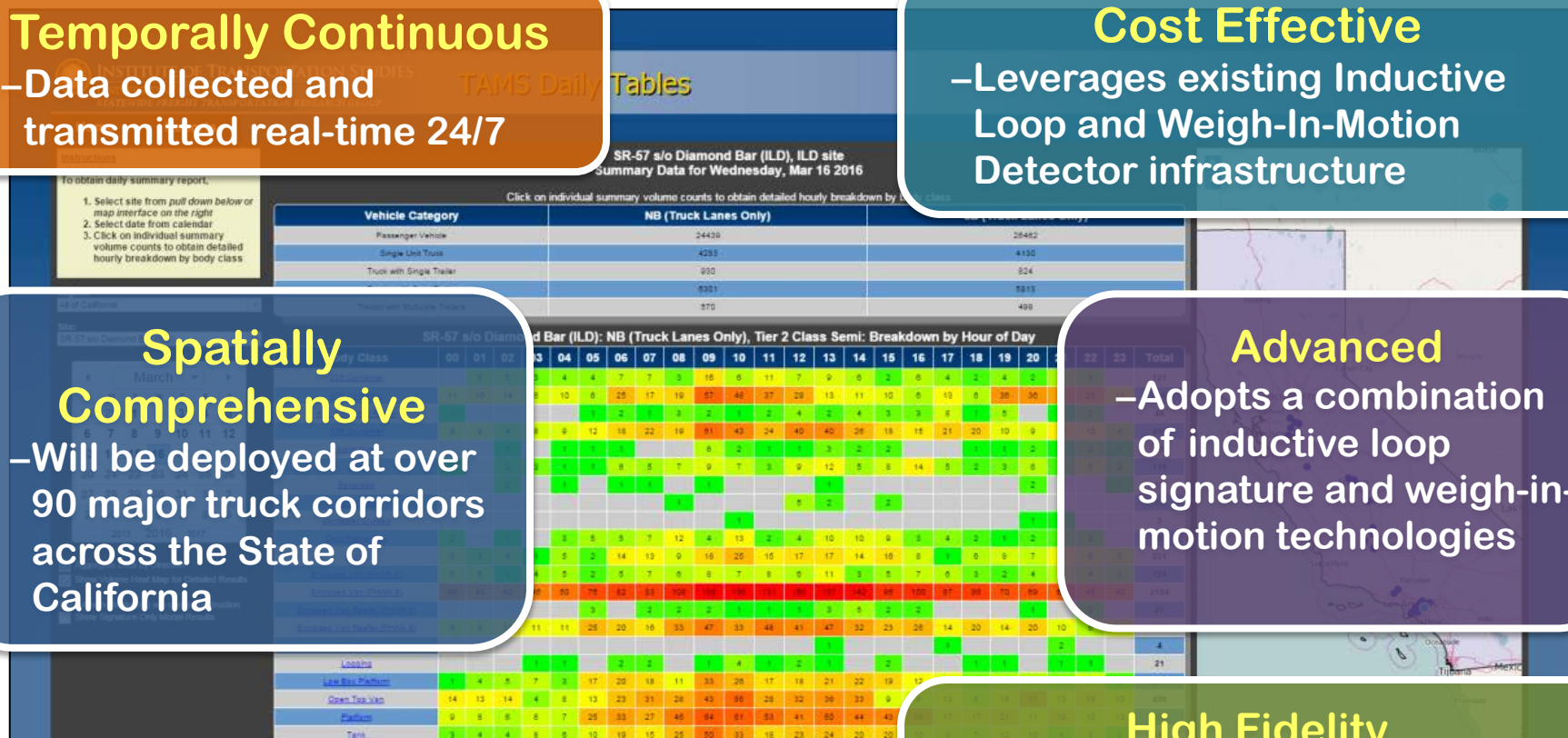
– Adopts a combination of inductive loop signature and weigh-in-motion technologies

Accessible

– Hosted on an interactive GIS-enabled web-based user interface

High Fidelity

– Identifies 40 to 60 truck / trailer body configurations



Potential Applications

Estimate proportions of freight and non-freight truck movements



Statistics relating to empty movements in freight trucks



Better understanding of truck travel patterns and behavior



Temporal and spatial travel behavior of trucks by industry

Estimations proportions of long and short haul trips along major and restricted truck corridors

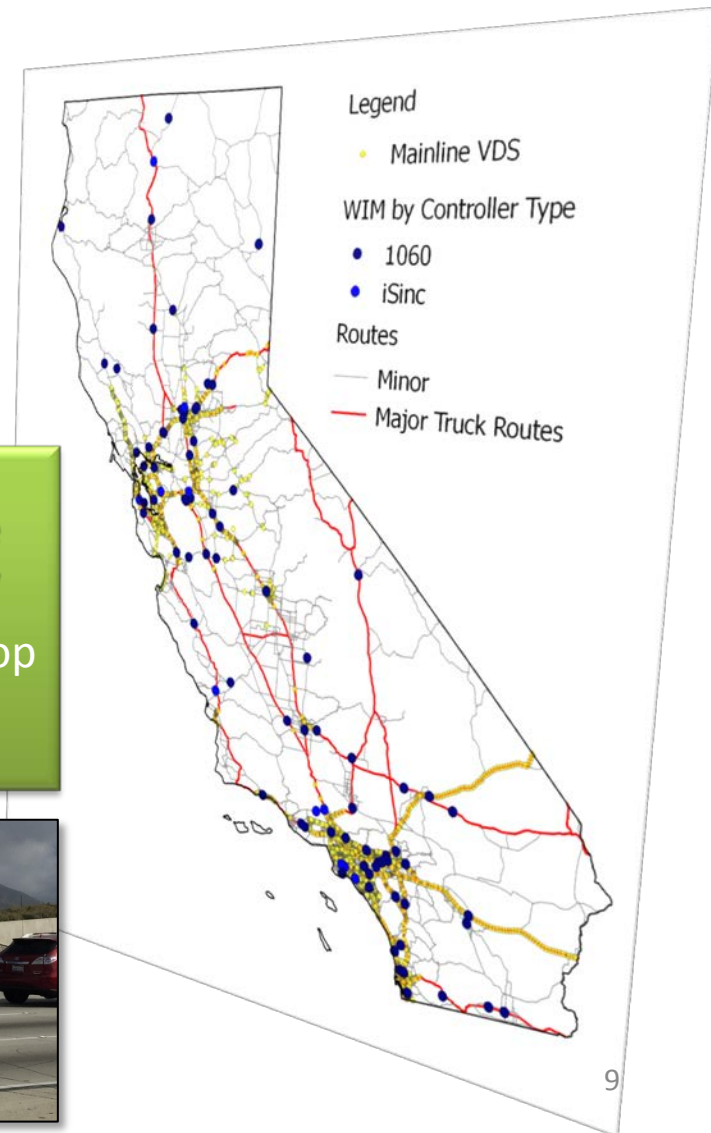


Detector Technologies Behind TAMS

Two Types of Detector Solutions:

Combination of Weigh-In-Motion (WIM) and Inductive Loop Signature Technology at existing WIM sites

Standalone inductive signature technology at existing Inductive Loop Detector sites



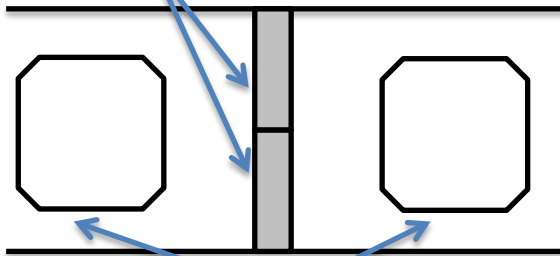
Weigh-In-Motion Technology

Components

Bending Plates

- Measure Wheel/Axle Weights

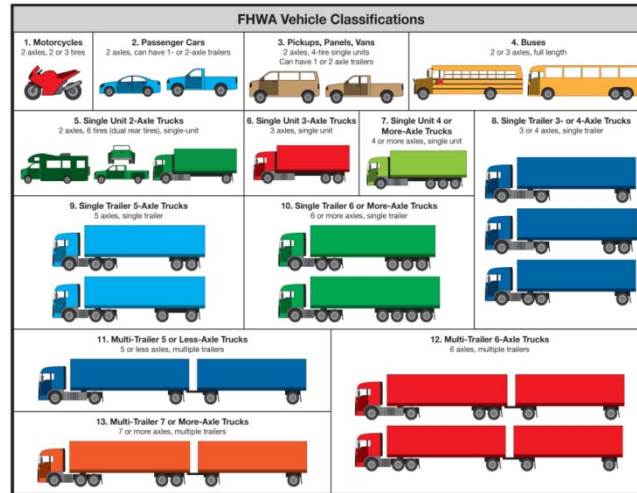
Bending Plates



Inductive Loop Sensors
Traveled lane on freeway

Inductive Loop Sensors

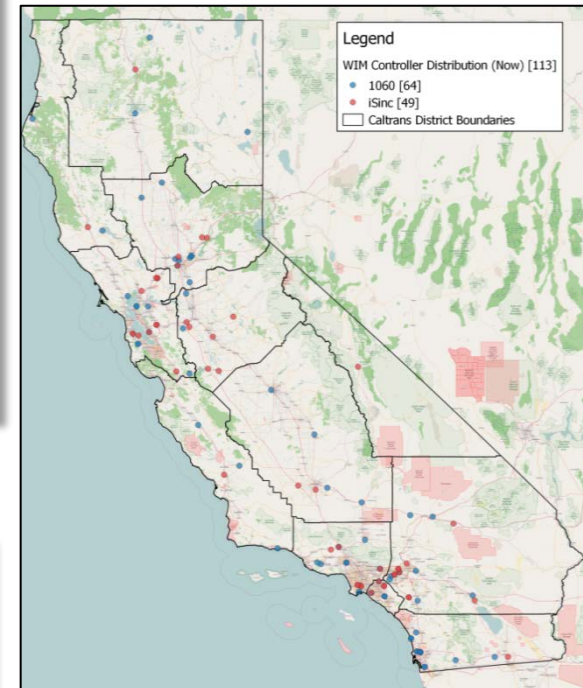
- Presence detection
- Speed measurement
- Transform temporal gap in axle measurements into axle spacing



Provides 13 axle-based classifications (14 in California)



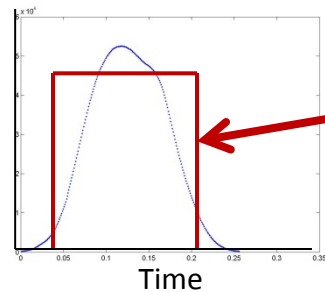
Weigh-In-Motion sensors located along a freeway



Over 100 Data WIM sites in California located along Major Truck Corridors

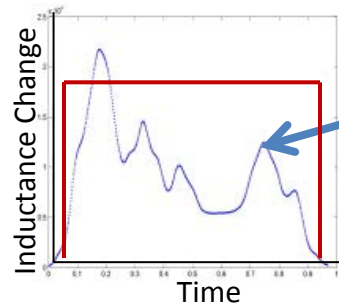
Inductive Signature Technology

- Conventional ILDs produce bivalent outputs
 - Generate traffic counts, not truck counts
- Advanced ILDs measure inductance changes → ‘Inductive Signature’
 - Inductive signatures are indicative of body configuration



Conventional Measurement

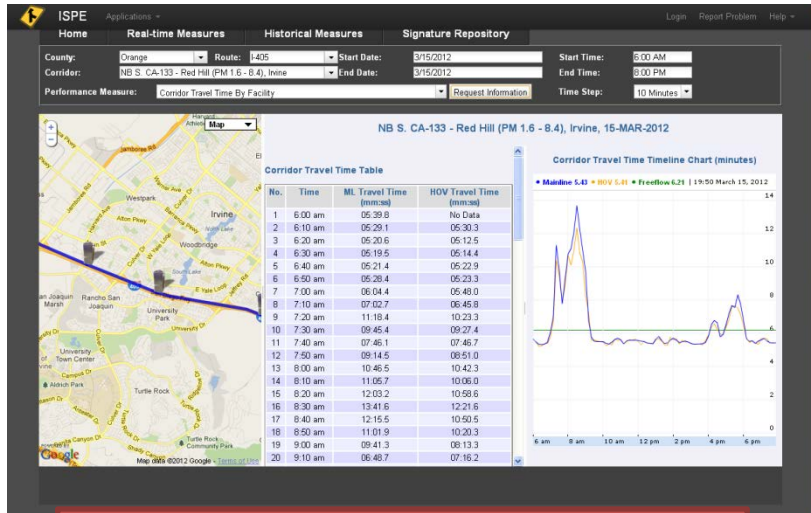
[0,1] Binary output typically sampled at 30 samples/sec



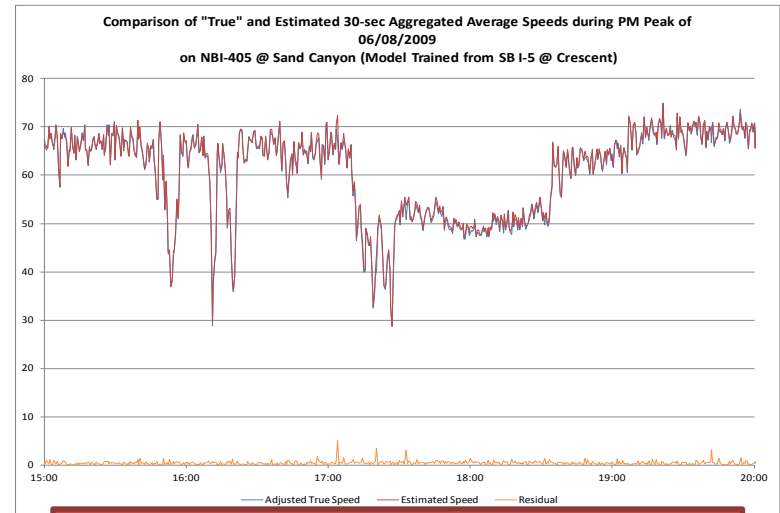
Inductive Signature

High resolution inductive magnitude changes at up to 1000 samples/sec

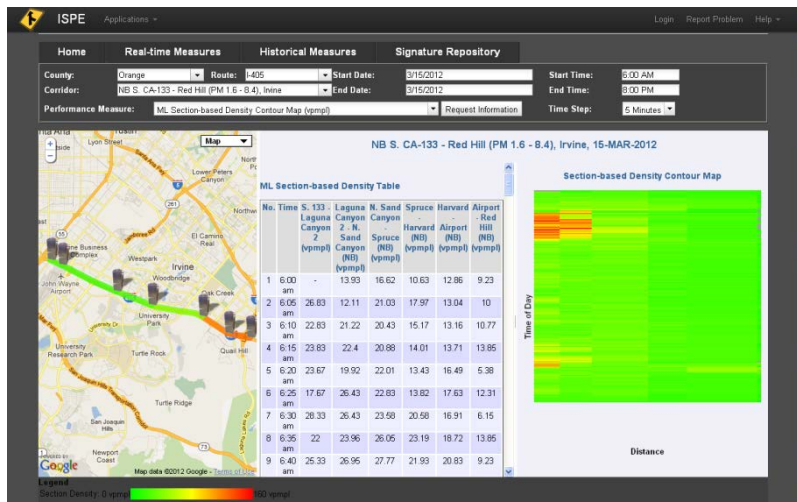
Inductive Vehicle Signature Applications



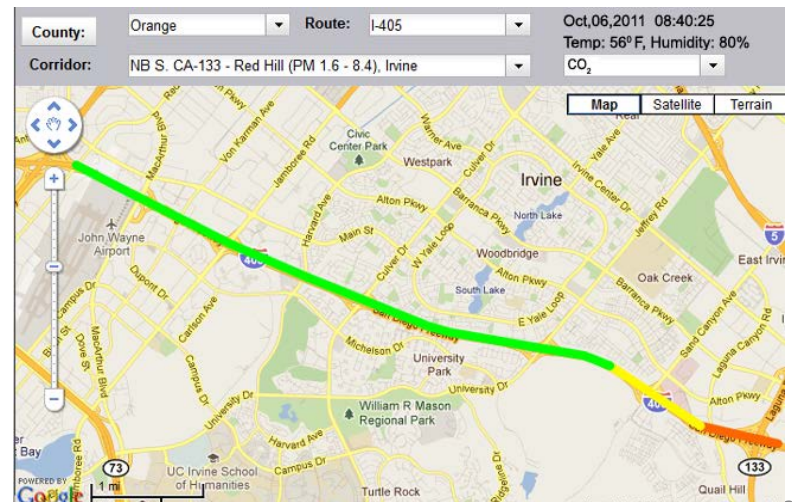
Real-time Section Travel Time and Speeds



Single Loop Point Speed Estimation



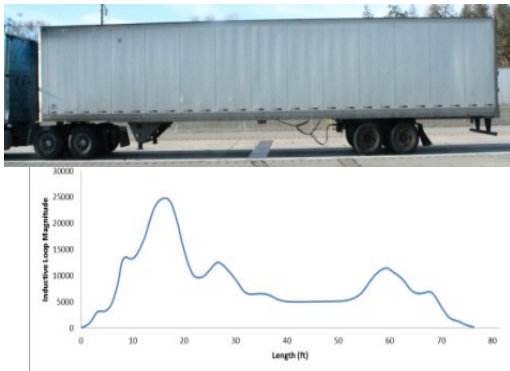
Section-level Density



Section-level Emissions Estimation

Sample FHWA Class 9 truck signatures by trailer configuration

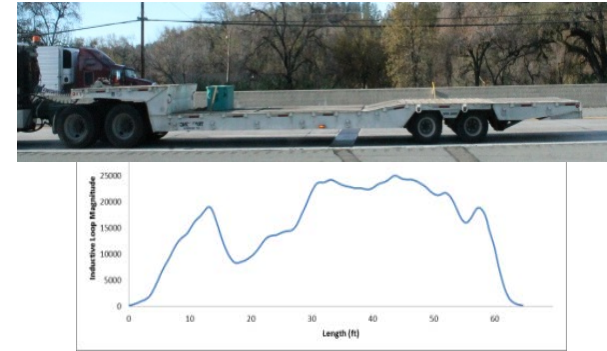
Enclosed Van



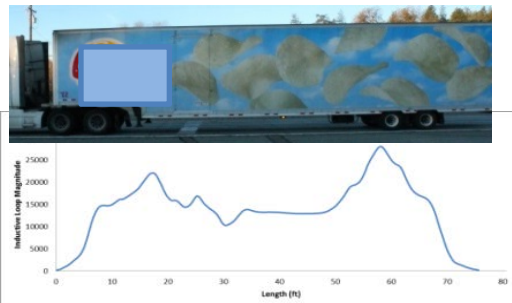
Livestock



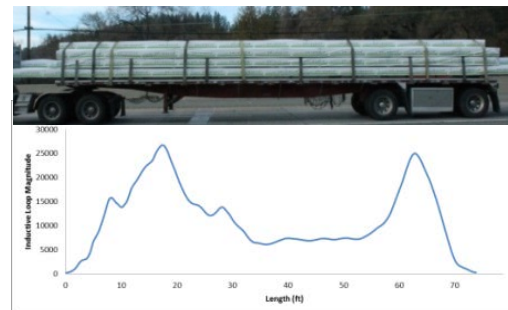
Low Boy Platform



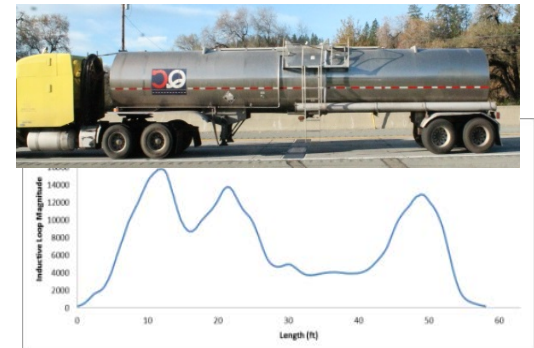
Drop Frame Van



Basic Platform

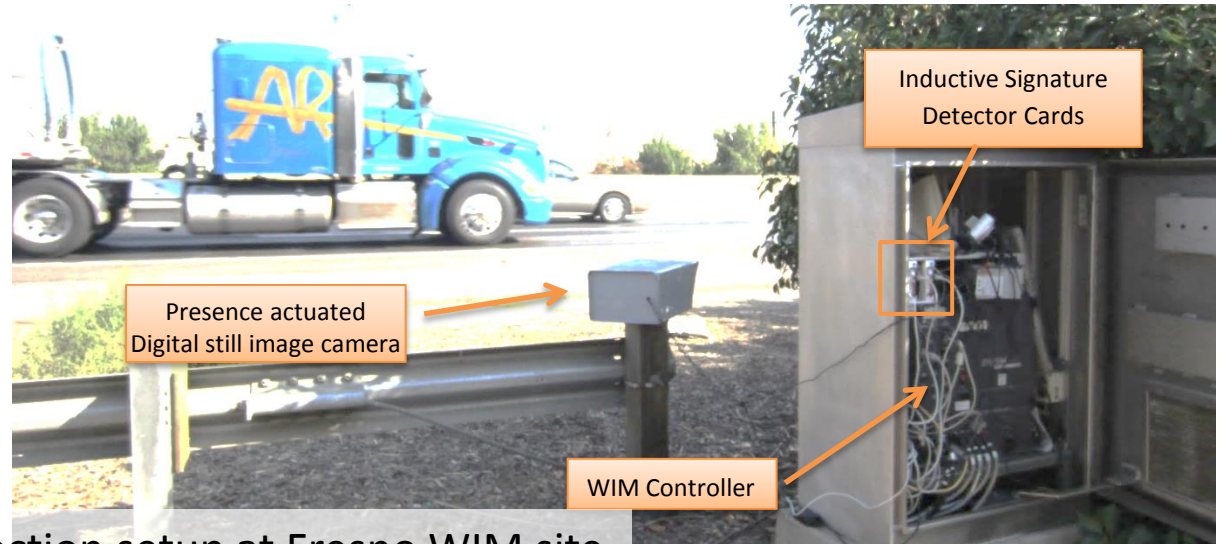
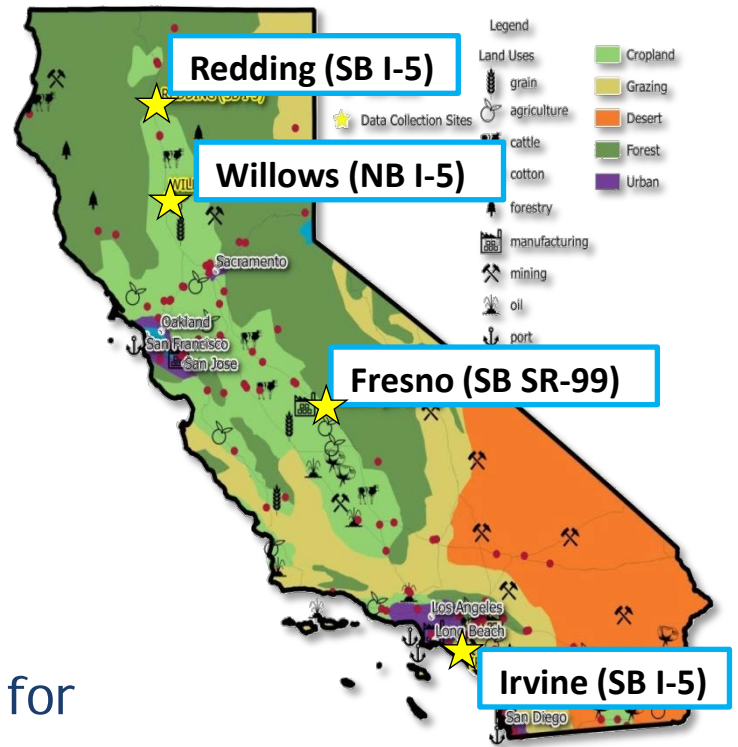


Tanks



Data Collection Sites

- Land use variation: four sites with differing land use characteristics
- Comprehensive data: still image photos, WIM data, and inductive signatures
- Temporal variation: multiple times of day, days of week, and seasons included
- 97 hours of data collected, with 35,000 vehicle records (mostly trucks) processed for model development and testing



Data collection setup at Fresno WIM site

Data Groundtruth System

Station 501 Lane 5 Date 10/2/2012

Groundtruth Selection

Current Vehicle: 151349224254070

Total No. Axles: 2 Single Unit

Truck Axle: Single - Single 4 Tire

Truck Body: 30ft Bus


Trailer Axle: No Trailer

Trailer Body: No Trailer

Unsure? Add Vehicle Data

Image Data

Current Image: 1 No. Images: 3



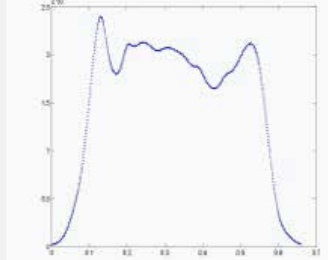
Previous Next

Start Time 10/2/2012 5:30:00 PM End Time 10/2/2012 6:00:00 PM

VehicleID	Time	TotalAxle	TruckAxle	TrailerAxle
151349224223870	10/2/2012 5:30:23 PM	5	3	4
151349224254070	10/2/2012 5:30:54 PM	2	1	99
151349224348080	10/2/2012 5:32:28 PM			
151349224356450	10/2/2012 5:32:36 PM			
151349224365250	10/2/2012 5:32:45 PM			
151349224369780	10/2/2012 5:32:49 PM			
151349224456900	10/2/2012 5:34:16 PM			
151349224511480	10/2/2012 5:35:11 PM			
151349224653050	10/2/2012 5:37:33 PM			

VDS Signature Data

Time Window (sec): 3 Time Offset (sec): 0 Refresh



Duration: 0.659

Remove
 Append

SigID	VehID	Adjusted Time	Time
151...		10/2/2012 5:30:51 PM	10/2/2012 5:30:...
151	1513	10/2/2012 5:30:53 PM	10/2/2012 5:30:...
151...		10/2/2012 5:30:55 PM	10/2/2012 5:30:...
151		10/2/2012 5:30:56 PM	10/2/2012 5:30:...

WIM Weight and Axle Data

Time Window (sec): 3 Time Offset (sec): 47.5 Refresh

Start X: 44 Start Y: 0 Select Region

Width: 1192 Height: 760 Select Window

When recording:

- Show rectangle around recorded area
- make this rectangle blink
- Leave HyperCam Window Opened
- Iconize HyperCam Window to the Task Bar
- Hide HyperCam Window
- Capture layered/transparent windows (may slow down performance)

Duration: 0.642

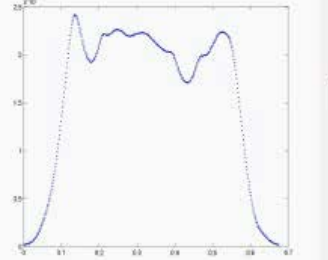
Last Record Status: Total frames: 184, skipped: 0

Stop Rec. Pause Rec. Play Default Help

WIMID	VehID	Adjusted Time	Time	2
9494	1513	10/2/2012 5:30:54 PM	10/2/2012 5:30:...	

WIM Signature Data

Time Window (sec): 3 Time Offset (sec): 2.31 Refresh



Duration: 0.675

Remove
 Append

SigID	VehID	Adjusted Time	Time
241...		10/2/2012 5:30:53 PM	10/2/2012 5:30:...
241	1513	10/2/2012 5:30:56 PM	10/2/2012 5:30:...

Append ALL

Total No. Records: 34 Records Completed: 2 Change Time Period Close

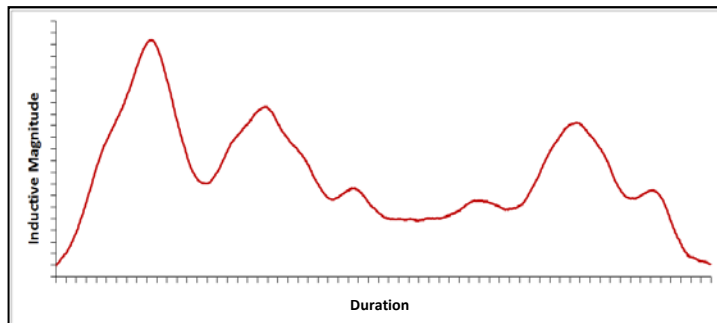
Model Design

Two Types of Body Classification Models Developed:

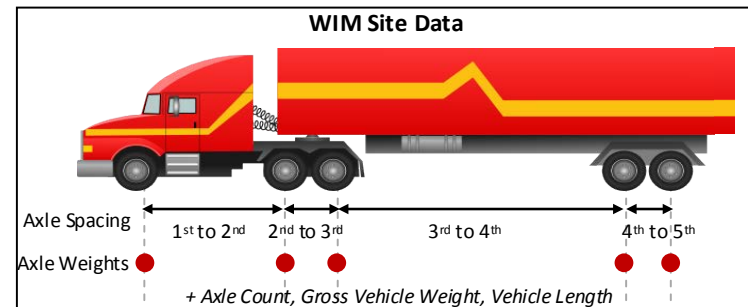
Inductive Signature only
Model
(for existing ILD sites)



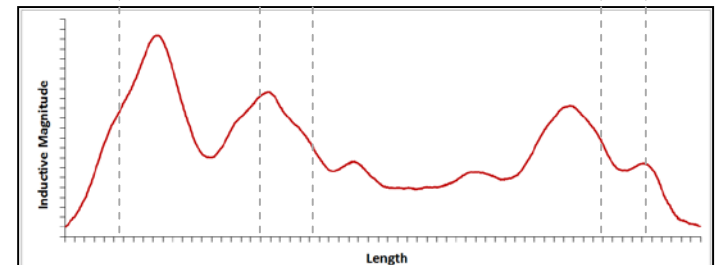
Inductive Signature Data



Integrated *WIM and*
Inductive Signature Model
(for existing WIM sites)



Inductive Signature Data



Body Classification Architecture: Two Systems of Models

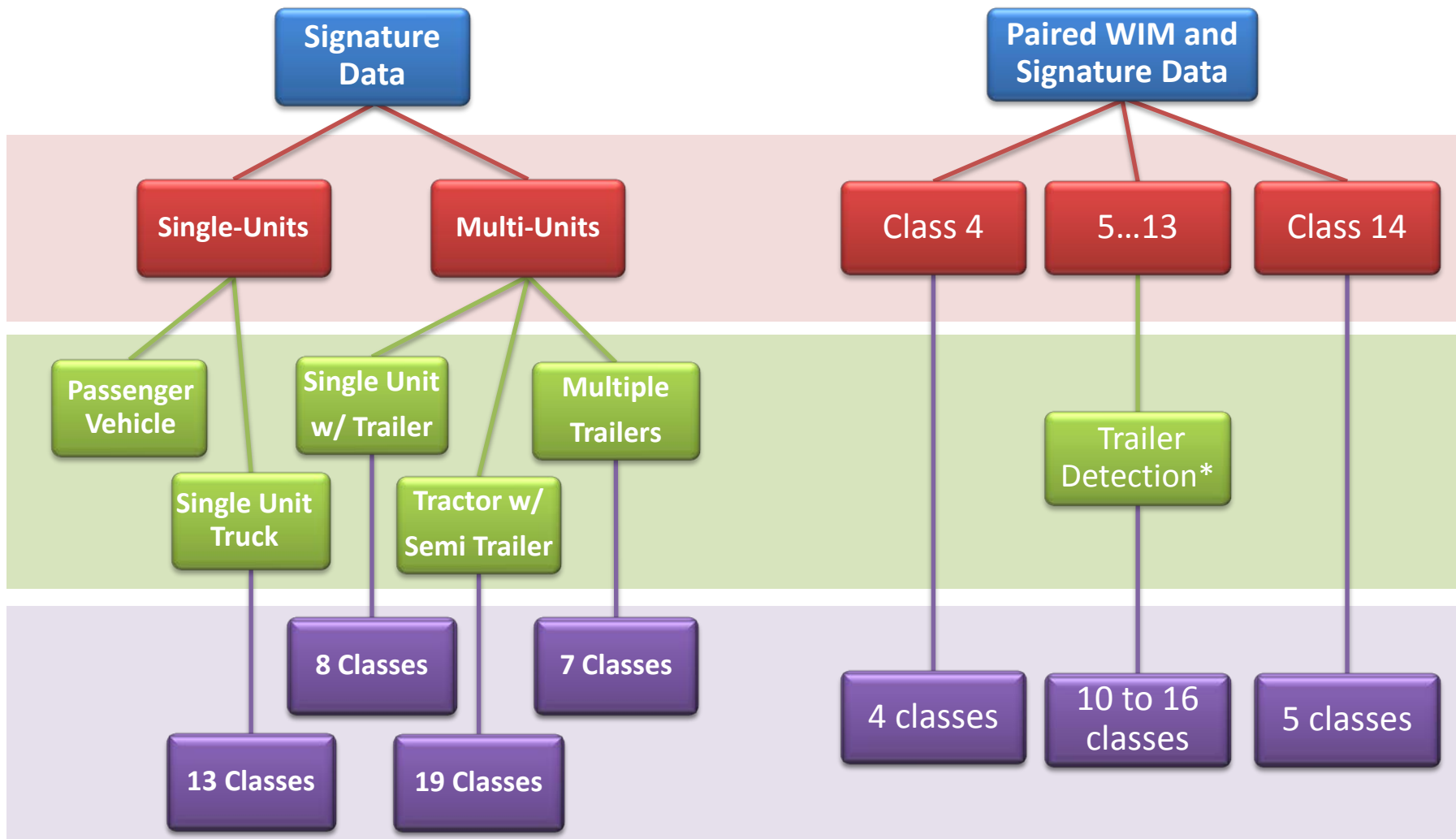
Signature Only Model System

WIM and Signature Model System

Tier 1

Tier 2

Tier 3












Signature Only Model Results

- Body class model results summary
 - 4 categories incorporating 47 truck body classes
 - 34 classes with classification accuracy > 70%
 - 27 classes with volume error < 10%

Sub-Model	Classes	Accuracy (%)	Volume Error (%)
Passenger Vehicles	1		
Single Unit Trucks	13	72.3	15.4
Single Unit w/ Trailers	8	94.2	8.2
Single Semi-Trailers	19	74.2	11.3
Multiple Semi-Trailers	7	90.4	7.0

Integrated (WIM + Signature) Model Results

- System of 9 sub-models with 63 body classes
- 52 classes with classification accuracy > 70%
- 37 classes with volume error < 10%

	Model	Classes	Accuracy (%)	Volume Error (%)
	FHWA 4	4	95.2	9.7
	FHWA 5	10	75.3	6.8
	FHWA 6	8	80.5	9.2
	FHWA 7	4	100.0	0.0
	FHWA 8	5	90.9	4.2
	FHWA 9 Semi Tractors	16	75.4	12.2
	FHWA 9 Single Trailers	5	96.7	1.7
	FHWA 10	4	92.3	7.7
	FHWA 11 and 12	7	92.7	8.0

Hardware Components



**Advanced Detector
Cards**

(Acquire Inductive
Signature Data)



**Fan-less Field
Processing Unit**
(Data Processing)



Wireless Modem
(Communications
to Server)



Types of Site Deployments

WIM-Signature Integration



WIM Site
on SR-99 between
Stockton and
Sacramento

Inductive Signature Only



Ramp Metering ILD
Site
on SR-91 in LA



Traffic Monitoring Site
on CA-4 near Stockton

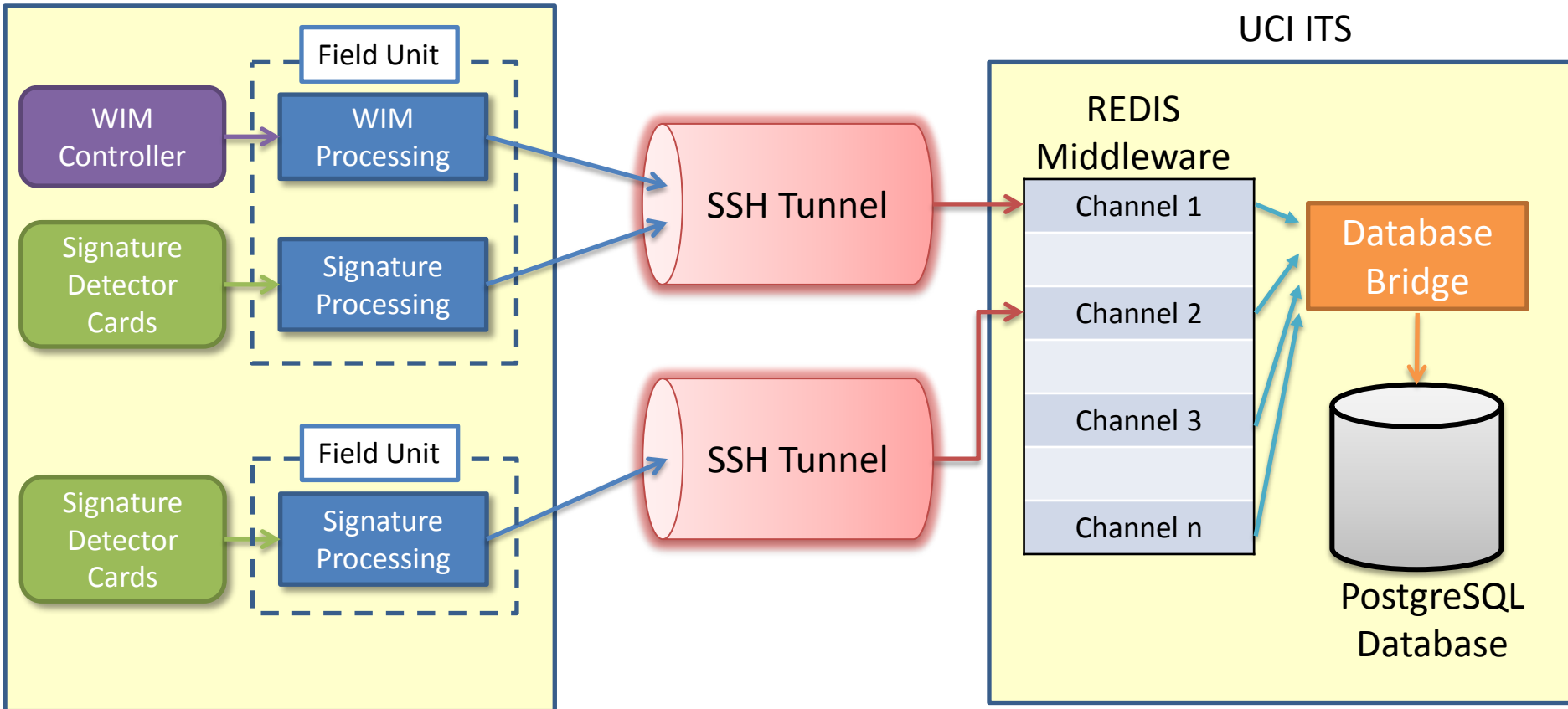


Census AVC Site
on I-15 in Escondido

Data Flow Architecture Overview

Field

UCI ITS



LIVE DEMO

1. **Live Signature Transmission**
2. **Walk Through TAMS Web Interface**

Collateral Benefits

Policy Evaluation

- PierPass: Monitoring truck port activities

Enforcement

- Monitor truck lane violations
- Monitor unauthorized travel along restricted routes

Impact Assessment of Non-recurrent Events

- Determine the impacts of port strikes, freeway closures, etc.

Understand Industry Impacts on Traffic, Infrastructure and Emissions

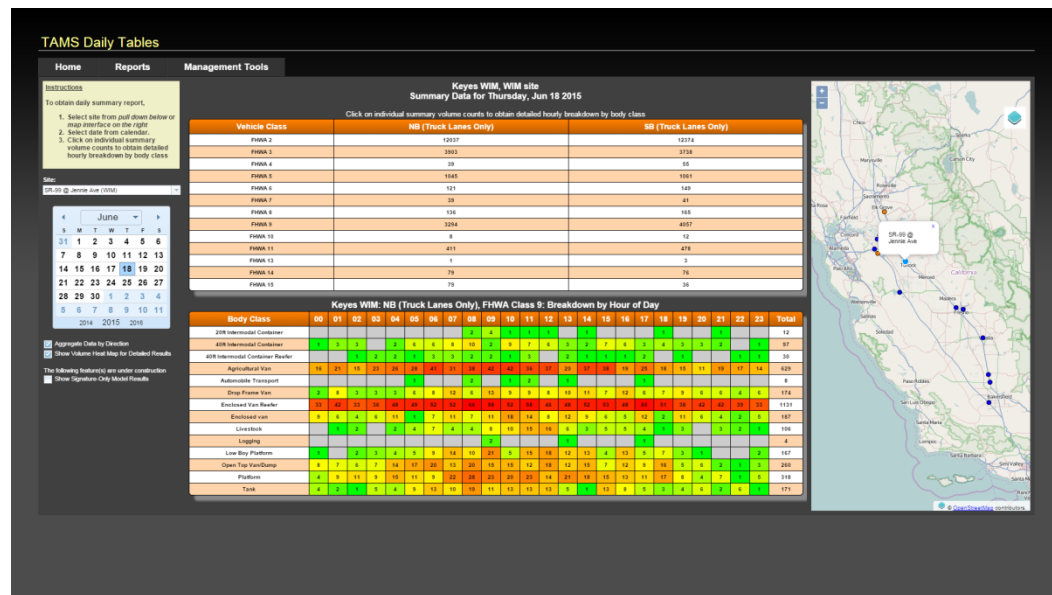
- Ability to analyze temporal and seasonal variations of truck activity by industry

Anonymous Truck Tracking

- Towards improved truck VMT estimates

QUESTIONS

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Truck Activity Monitoring System, <http://freight.its.uci.edu/tams>