

Advanced Statewide Truck Activity Data through Existing Detector Infrastructure

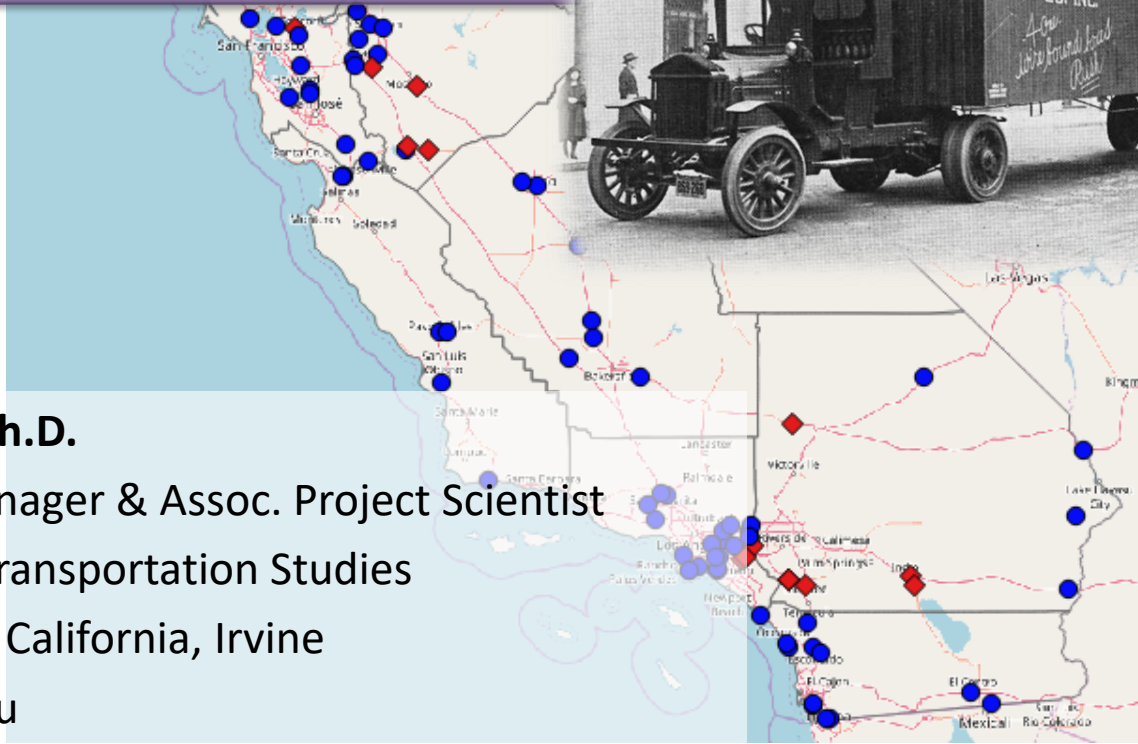
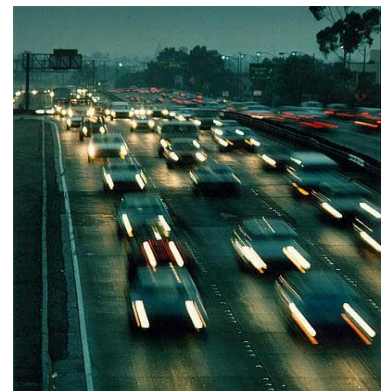
OCTEC Luncheon
Sep 26 2019



UCIrvine
University of California, Irvine



ITS
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Irvine



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Research has shown that truck volumes like car volumes, vary by time of day, day of week, and season, but *truck volumes follow patterns that are significantly different than those of passenger vehicles.*

FHWA Traffic Monitoring Guide, 2001

No such thing as a “typical” truck!



Transportation loop infrastructure in California ...

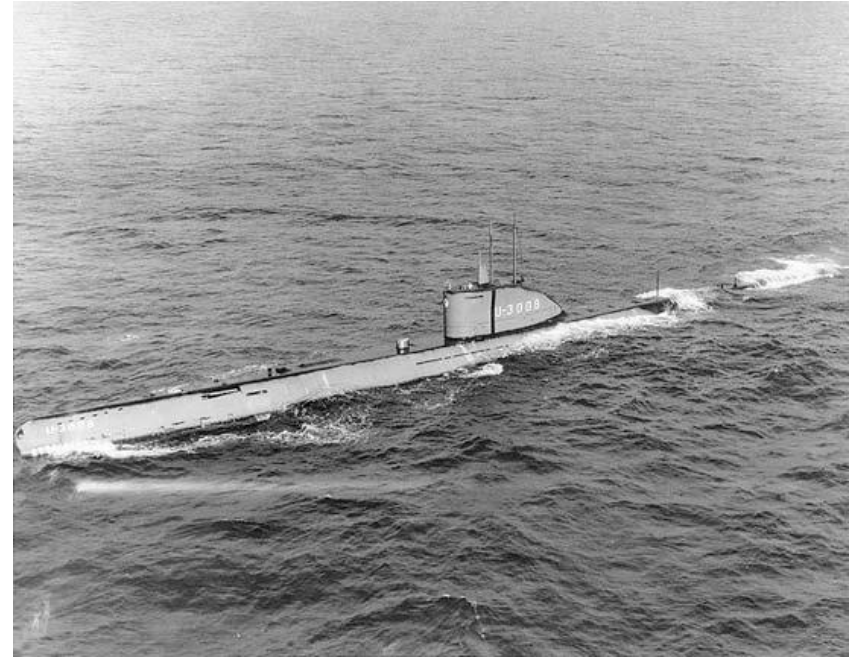


The inductive loop sensor or "Road" loop

Tehachapi Loop

So yesterday ... 🙄

- 2018 marked the **centennial of inductive loop detector** application in “vehicle detection”
- First deployed in mid-1918 to detect submarines (a.k.a. U-boats) entering harbors



Model Ts were still in production!!

Trivia #1: Do you know...

Of the following five corridors, which one has experienced the highest volume of double belly dump trailer trucks in 2017?



I-5 at Stockton

SR-99 at Fresno

US-101 at Paso Robles

SR-14 at Santa Clarita

I-5 at South OC /
San Clemente



Trivia #1: Do you know...

Of the following five corridors, which one has experienced the highest volume of double belly dump trailer



SR-14 @ Newhall Ave (ILD), ILD site
Summary Data for Tuesday, Apr 25 2017

Click on individual summary volume

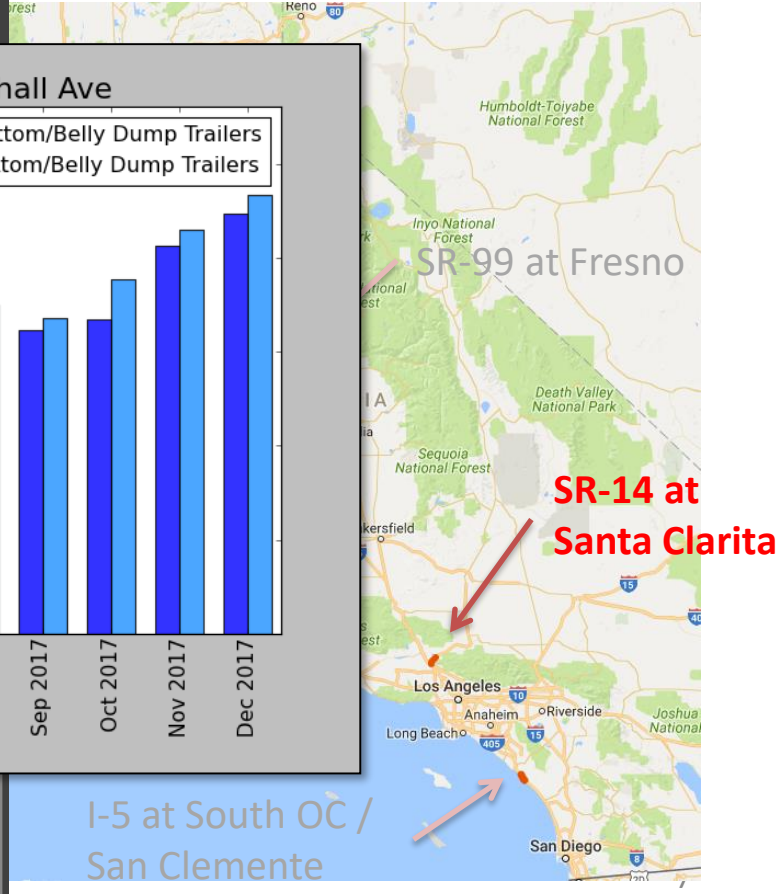
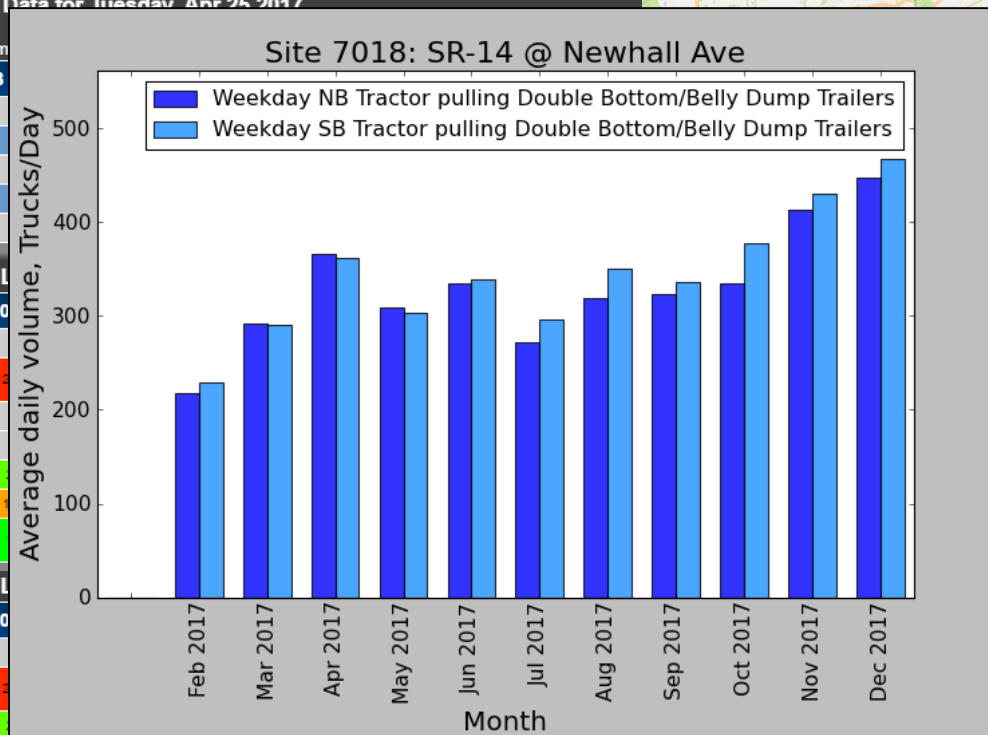
Vehicle Category	NB
Passenger Vehicle	
Single Unit Truck	
Truck with Single Trailer	
Tractor with Semi-Trailer	
Tractor with Multiple Trailers	

SR-14 @ Newhall Ave (ILD): NB (Truck L

Body Class	00	01	02	03	04	05	06	07	08
Agricultural Van				1					
Bottom Belly Dump	2	12	13	15	5	7	14	13	3
Enclosed Van	5	2	1	2	4	1			
End Dump									
Hopper			1		1				
Platform/Tank	6	8	7	7	4	16	10	9	3
Van/Platform (Low Chassis)	1							1	

SR-14 @ Newhall Ave (ILD): SB (Truck L

Body Class	00	01	02	03	04	05	06	07	08
Agricultural Van								1	
Bottom Belly Dump	11	1	4	8	11	35	25	23	3
Enclosed Van		1		3	3	7	3	5	
End Dump				1					
Hopper	1			1	1	3	5	2	3
Platform/Tank	8	4	4	9	20	13	11	12	10
Van/Platform (Low Chassis)				1	1	1	1	1	1



Double Trailer Activity in Santa Clarita



Time-of-day hourly directional volumes of double trailers on Feb 14 2017

SR-14 @ Newhall Ave (ILD), ILD site
Summary Data for Tuesday, Feb 14 2017

Click on individual summary volume counts to obtain detailed hourly breakdown by body class

Vehicle Category	NB (Truck Lanes Only)	SB (Truck Lanes Only)
Passenger Vehicle	21056	16230
Single Unit Truck	3811	2598
Truck with Single Trailer	559	509
Tractor with Semi-Trailer	1649	1393
Tractor with Multiple Trailers	543	520

SR-14 @ Newhall Ave (ILD): NB (Truck Lanes Only), Tier 2 Class Multi: Breakdown by Hour of Day

Body Class	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Bottom/Belly Dump	7	17	7	12	6	7	11	30	15	11	13	17	13	16	18	18	5	4	2	12	6	6	8	4	298
Enclosed Van	5		1	3	4	1				1	2	1				1		1		1		5	8	2	36
End Dump																									2
Heaper				3				1	2	1	4	1	1	1	1	2			1	1	1			1	19
Platform/Tank	9	2	6	1	2	6	8	11	13	11	13	15	5	12	21	2	3	5	3	11	6	2	8	3	180
Van/Platform (Low Chassis)	1					2		2								1	2								8

SR-14 @ Newhall Ave (ILD): SB (Truck Lanes Only), Tier 2 Class Multi: Breakdown by Hour of Day

Body Class	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Agricultural Van																1									1
Bottom/Belly Dump	5	2	2	3	9	26	34	25	14	20	21	10	26	16	7	6	1	1	26	13	15	7	4	11	310
Enclosed Van	1			1	5	2	7	4	3		1	2	2			2			3	2			1	1	37
End Dump			1																1						2
Heaper				1	1			1	4	3			3	3					1	1	2				22
Platform/Tank	4	3	2	5	8	6	11	8	6	8	15	5	6	9	3	5	2	2	6	8	3	4	5	3	137
Van/Platform (Low Chassis)						1	1				1	1	1	1		1					1	2	1		11

SR-14 freeway corridor



Double Enclosed Van

I-5 @ Sagecrest (ILD), ILD site
Summary Data for Tuesday, Feb 14 2017

Click on individual summary volume counts to obtain detailed hourly breakdown by body class

Vehicle Category	NB (Truck Lanes Only)	SB (Truck Lanes Only)
Passenger Vehicle	27832	24457
Single Unit Truck	4612	4319
Truck with Single Trailer	833	879
Tractor with Semi-Trailer	9721	9468
Tractor with Multiple Trailers	970	998

I-5 @ Sagecrest (ILD): NB (Truck Lanes Only), Tier 2 Class Multi: Breakdown by Hour of Day

Body Class	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Bottom/Belly Dump						5	6	27	27	22	26	26	17	28	3	8	3	2	1		2	1			221
Enclosed Van	81	37	28	23	26	23	13	2		3	2	2	5	2	5	5	9	2	4	4	12	18	24	11	422
End Dump				1	2	1	2			1	1														11
Heaper					1	3				2			1		2	1			2	1	2	1		1	17
Platform/Tank	5	5	9	9	11	13	11	6	8	16	8	12	17	9	15	7	3	4	8	2	3	4	10	5	200
Van/Platform (Low Chassis)	8	4	4	6	8	4	2	5	2	2	6	9	6	5	5	3		3		1	6	6	2		55

I-5 @ Sagecrest (ILD): SB (Truck Lanes Only), Tier 2 Class Multi: Breakdown by Hour of Day

Body Class	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Bottom/Belly Dump	1			1	6	1	11	17	7	28	18	24	38	32	22	25	1			1	1				234
Enclosed Van	25	15	13	21	17	16	39	38	17	13	10	15	7	7	2	4	2	3	5	6	7	13	23	21	414
End Dump				1		1					3				1					3	2	2			14
Heaper							2		2	2	3	5	7	1	1	1		5	3	2	3	2			37
Platform/Tank	7	7	2	10	8	19	15	10	6	18	17	22	11	9	8	9	5	8	5	7	7	6	4		220
Van/Platform (Low Chassis)	6	1		1	4	6	1		1	2	4	4	1	9	4	3	1	6	6	3		6	5	5	75

I-5 freeway corridor

Double Belly Dump

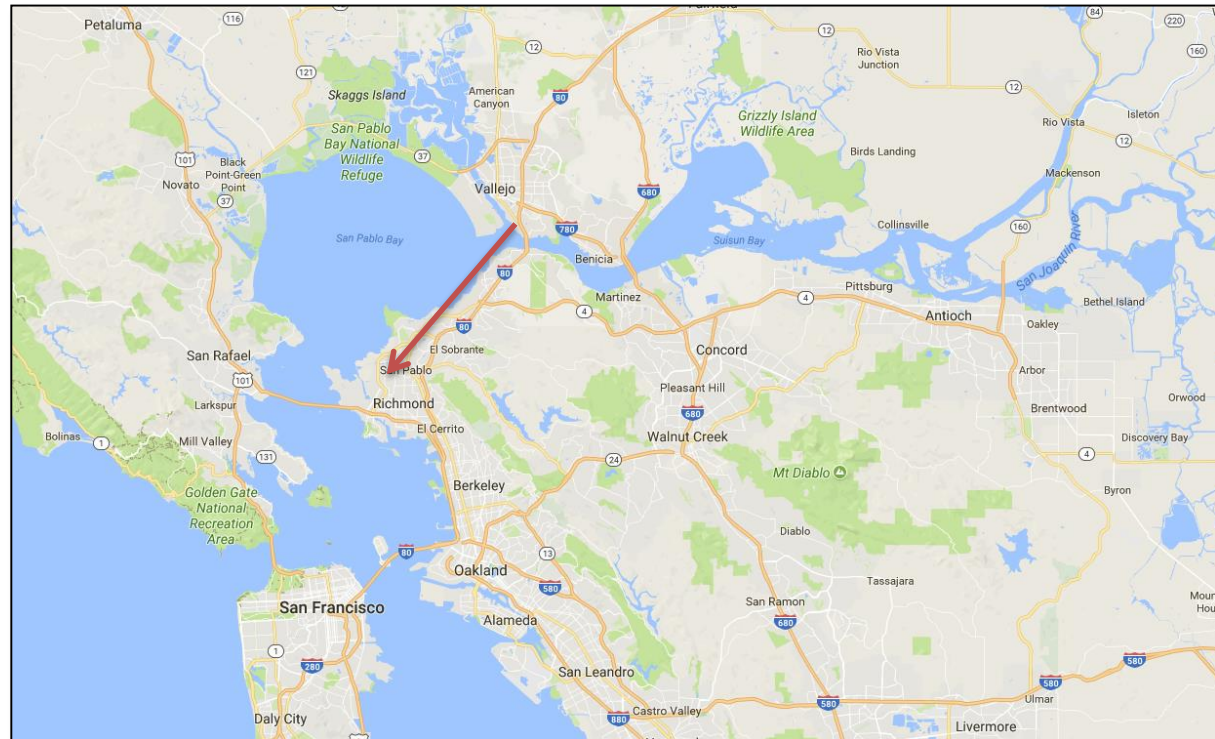


Trivia #2: Do you know...

What was the approximate weekday volume of logging trucks traveling westbound on the I-80 in the San Francisco East Bay in Sep 2017?



- a. 30
- b. 50
- c. 100
- d. 200



Trivia #2: Do you know...

What was the approximate weekday volume of logging trucks traveling westbound on the I-80 in the San Francisco East Bay in Sep 2017?



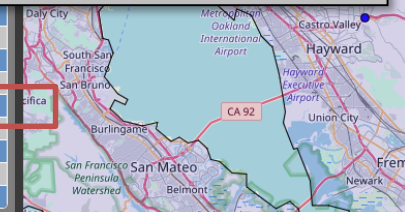
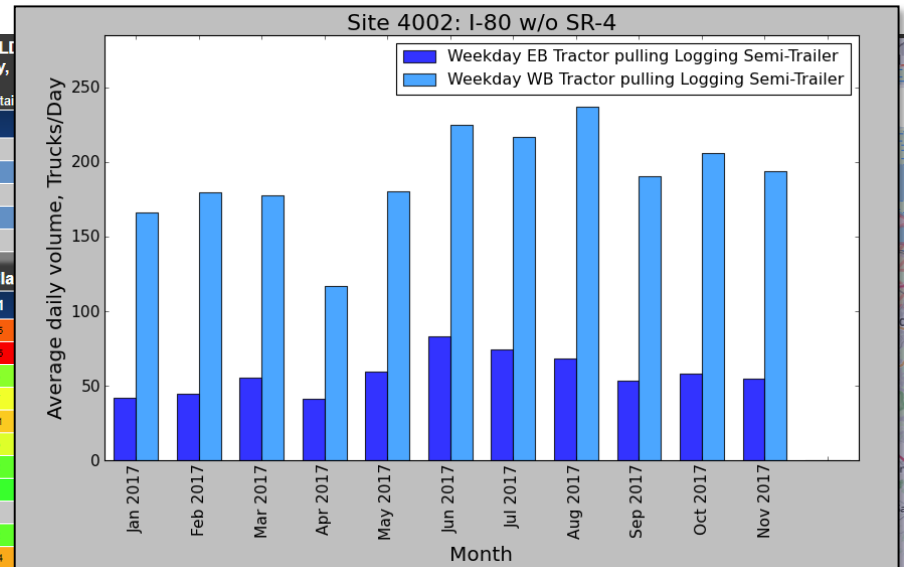
- a. 30
- b. 50
- c. 100
- d. 200**

I-80 w/o SR-4 (ILD), ILI Summary Data for Thursday,
 Click on individual summary volume counts to obtain details

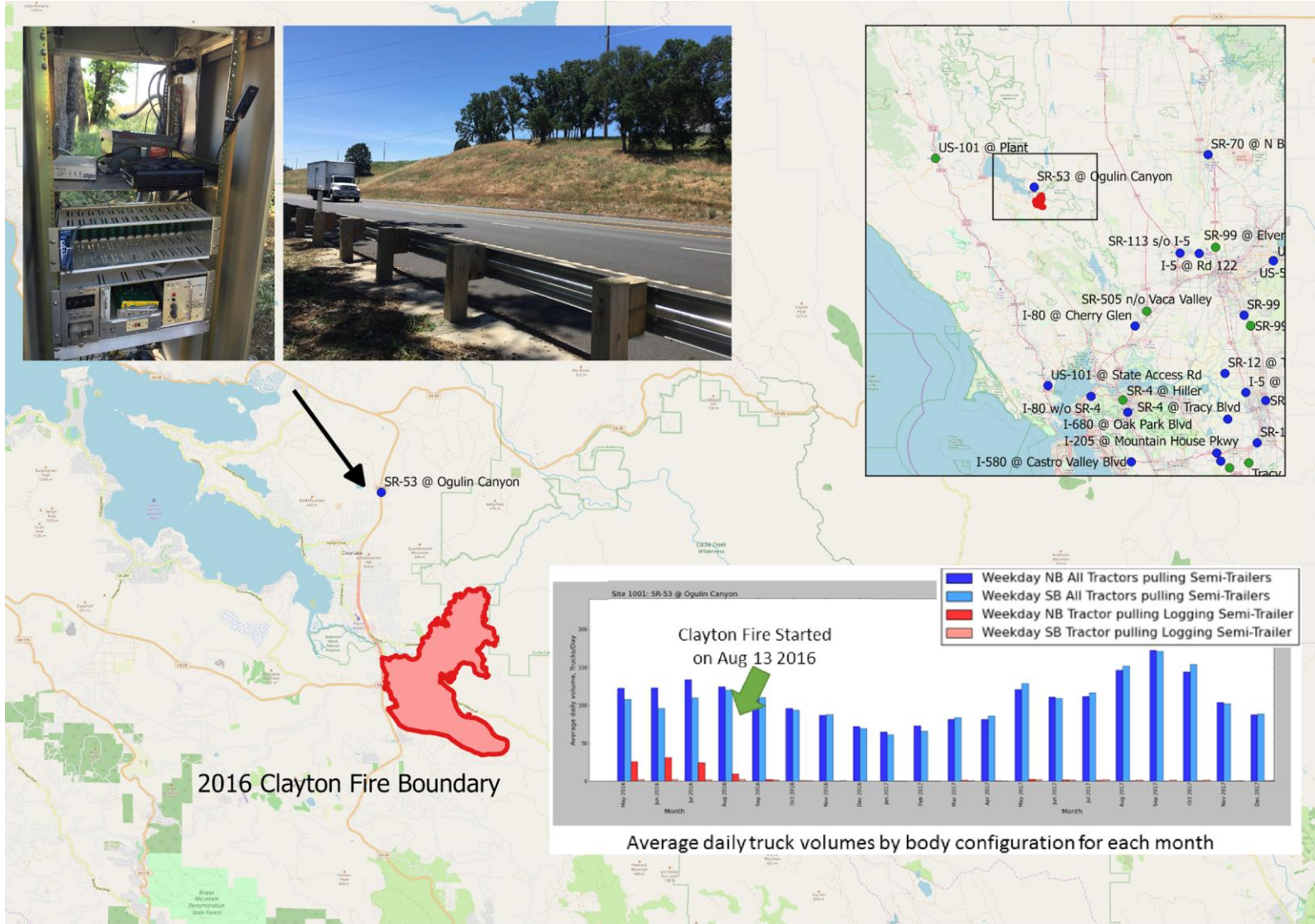
Vehicle Category	EB (Truck Lanes Only)
Passenger Vehicle	42507
Single Unit Truck	4349
Truck with Single Trailer	630
Tractor with Semi-Trailer	3299
Tractor with Multiple Trailers	178

I-80 w/o SR-4 (ILD): WB (Truck Lanes Only), Tier 2 Classification

Body Class	00	01	02	03	04	05	06	07	08	09	10	11	Total
20ft Container	3		2	3	6	12	14	3	9	17	21	25	100
40ft Container		2		8	15	20	19	24	21	36	37	55	200
40ft Container Reefer		1		1	1	1	2	1		3	1	3	14
53ft Container		4	2	2	1	2	1	3	3	2	6	7	31
Agriculture	1	10	5	1	3	4	5	1	4	6	7	11	62
Auto	3	2		3	3	1	3		4	7	8	6	47
Beverage			1	1	1	1	2	1				1	10
Bulk Waste				1					1	1		1	4
Container Chassis											1	1	2
Drop Frame Van	3	1	1	1	3	6	5	1	6	5	5	2	41
Dump	4	2	1	6	9	14	12	14	18	23	27	14	137
Enclosed Van (FHWA 8)		1	1	2	5	7	5	5	5	7	13	11	69
Enclosed Van (FHWA 9)	28	27	18	37	47	48	36	22	32	48	47	44	444
Enclosed Van Reefer (FHWA 8)		1			1	1	1		1	1	1	1	8
Enclosed Van Reefer (FHWA 9)	6	10	7	15	19	25	18	7	13	20	24	12	137
Logging	2	2	5	16	21	8	7	8	8	12	7	7	102
Low Boy Platform													0
Open Top Van	6	3	6	6	9	18	15	12	10	19	23	22	118
Platform	5	5	4	10	19	30	22	10	20	27	17	26	181
Tank	5	5	6	8	17	22	16	9	23	14	21	32	155



Impact of Clayton Wildfire on Logging Activity in Clear Lake



Finding: Average monthly weekday truck volumes show that logging truck activity on SR-53 did not recover in the year following the 2016 Clayton Fire

California Statewide Freight Forecasting Model

1. Commodity Module

Total Demand, Structural Direct Demand, Import / Export

2. Mode Split Module

Truck only,
Rail only

Rail-Truck,
Air-Truck

Water only,
Pipeline

3. Transshipment Module

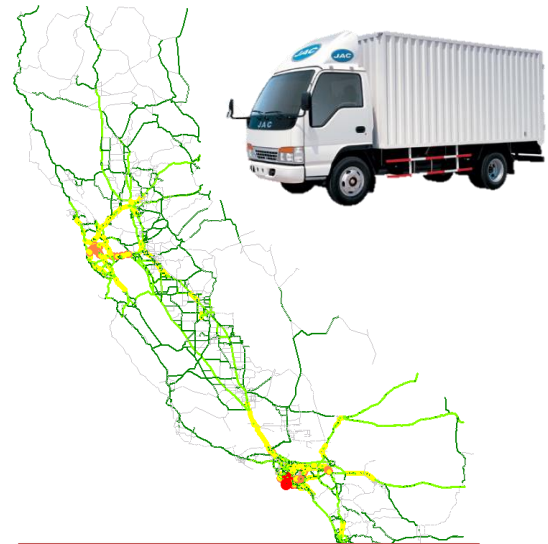
Split multiple modes into mode segments

4. Seasonality and Payload Factor Module

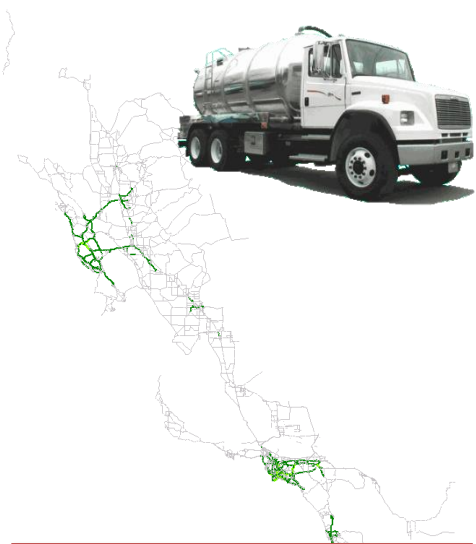
5. Network Module

Route Choice & Traffic Assignment

Assignment by CSFFM Truck Categories for 2007



CSFFM Truck Class 1
(6-tire single units)



CSFFM Truck Class 2
(3+ axle single units)



CSFFM Truck Class 3
(Single trailers)



CSFFM Truck Class 4
(Multi trailers)

The Research Question

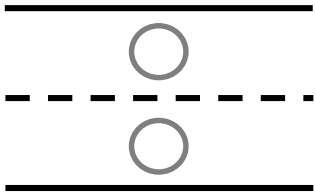
Can we leverage **existing infrastructure**
to provide **detailed truck activity data**
at the **statewide level**
to meet **freight data and modeling needs?**

Our Solution

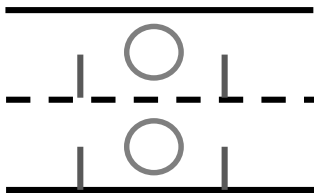
- Develop comprehensive cutting-edge classification models that
- can be implemented at existing traffic detector sites
 - to measure truck activity by facility/industry-affiliated (and to some degree freight-specific) configuration
 - by enhancing already invested detector infrastructure

Loops are out there!

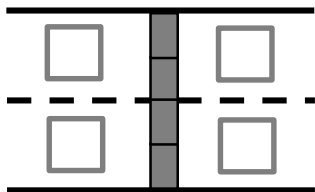
Common In-Pavement Detection Systems:



**Standalone Inductive Loop
Detector System**



**Automatic Vehicle
Classifier (AVC) System
with Piezo Sensors**



**Weigh-In-Motion (WIM)
System**



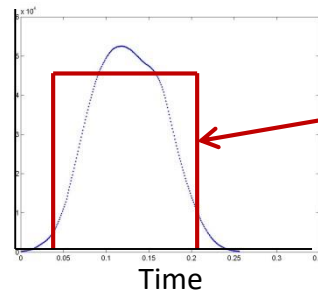
Piezoelectric Axle Sensors



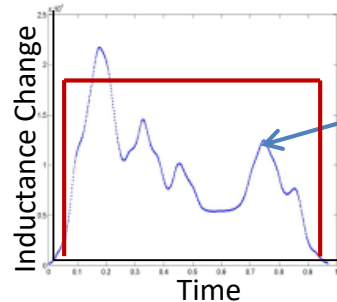
**Bending Plate
WIM Sensors**

Inductive Signature Technology

- **Conventional ILD measure bivalent outputs**
 - Produce traffic counts, not truck counts
- **Advanced ILD measure inductance changes**
 - **‘Inductive Signature’**
 - Inductive signatures are indicative of body configuration



Conventional Measurement
[0,1] Binary output



Inductive Signature
Inductive magnitude changes at up to 1200 samples/sec

How **Distinctive** Are Inductive Signatures?

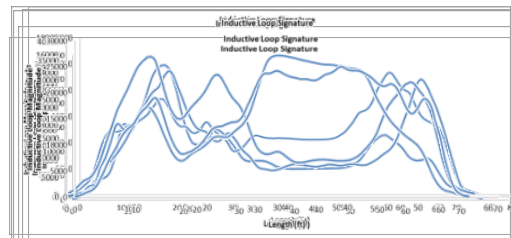
Enclosed Van



Livestock



Low Boy Platform



Drop Frame Van



Basic Platform



Tank

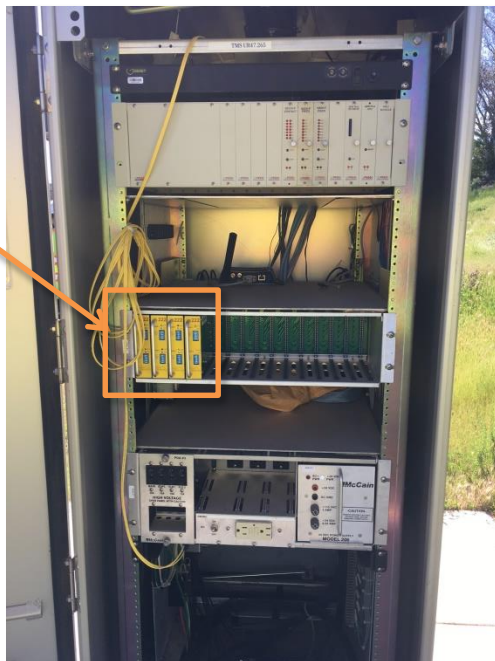


Sample FHWA Class 9 (5- Axle Semi-Trailer) signatures by trailer configuration

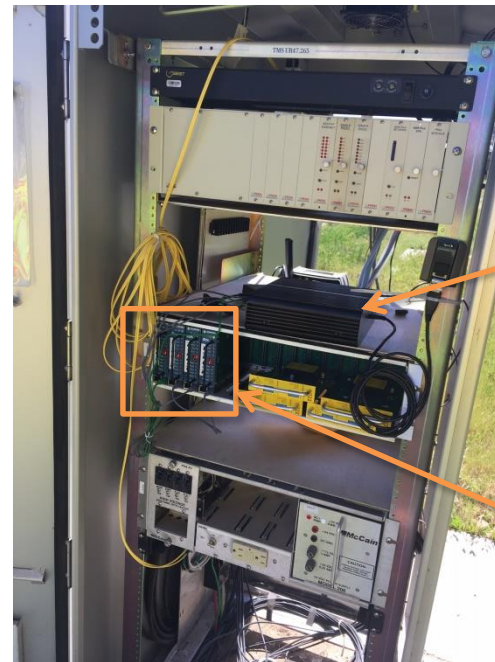
Signature Implementation at ILD Sites

- Upgrading hardware at Inductive Loop Detector (ILD) sites is straightforward
 - Simple swapping of advanced detector cards in roadside traffic cabinet
 - Installation of field processing unit
 - Setup configuration of advanced detector cards
 - No need for in-pavement installation → no traffic closures
 - Existing traffic operations are not compromised

**Conventional
Detector Cards**



Before



After

**Solid-State Field
Processing Unit**

- Independent wireless communications
- Receives and processes signature data from detector cards via USB

**Advanced Signature
Detector Cards**

Field system setup at I-15 freeway in Fallbrook

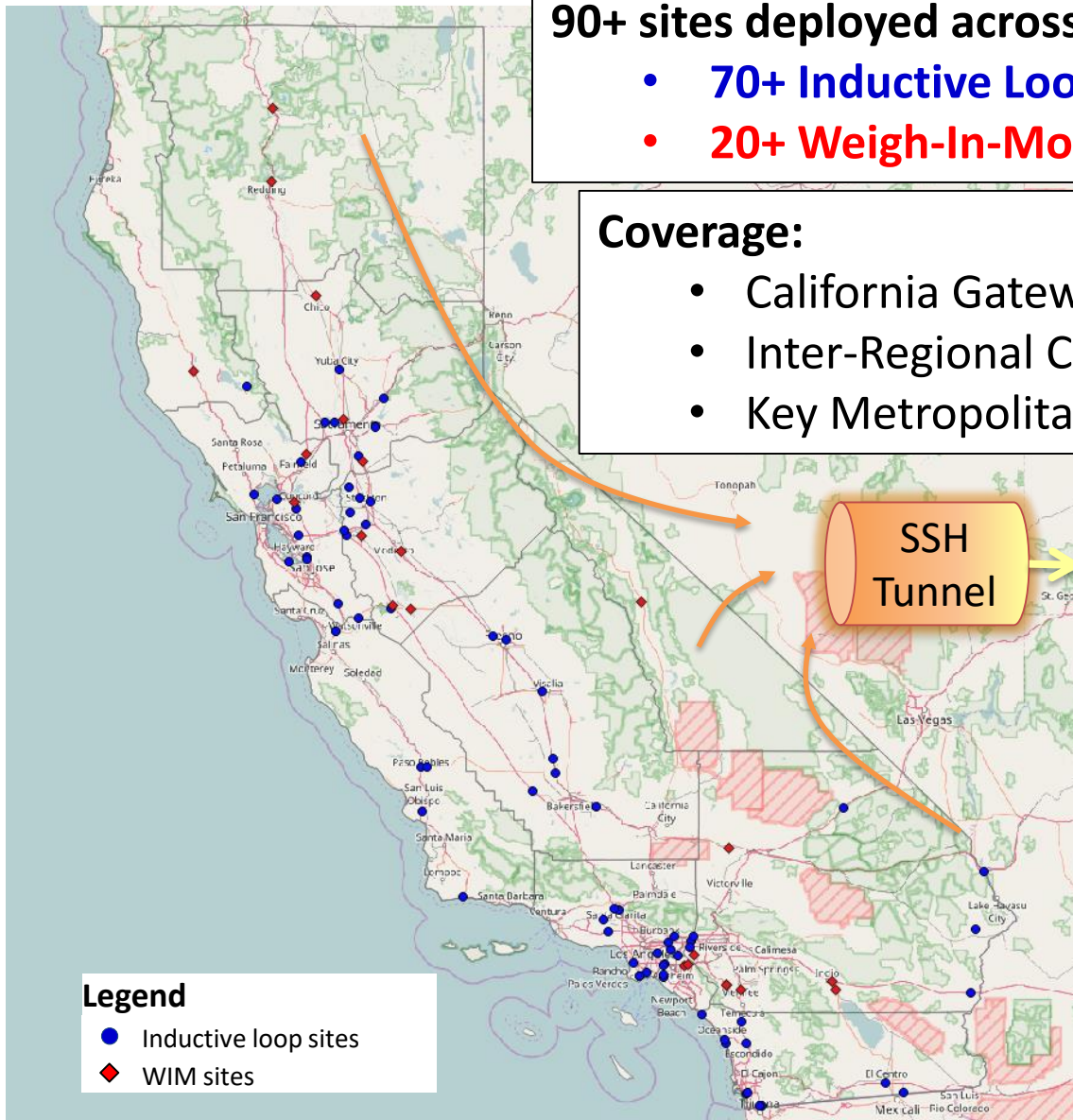
Total Deployed Sites

90+ sites deployed across all 12 Caltrans districts

- 70+ Inductive Loop Sites
- 20+ Weigh-In-Motion sites

Coverage:

- California Gateways
- Inter-Regional Cordons
- Key Metropolitan Corridors



Legend

- Inductive loop sites
- WIM sites

UC-Irvine ITS

REDIS Middleware

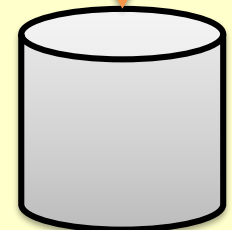
Channel 1

Channel 2

Channel 3

Channel n

Database Bridge



PostgreSQL Database

The Outcome: *Truck Activity Monitoring System (TAMS)*

A truck counting system that is...

Temporally Continuous

– Vehicle data collected and transmitted real-time 24/7

Sustainable

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

Spatially Representative

– Deployed at over 90 major truck corridors across the State of California

Advanced

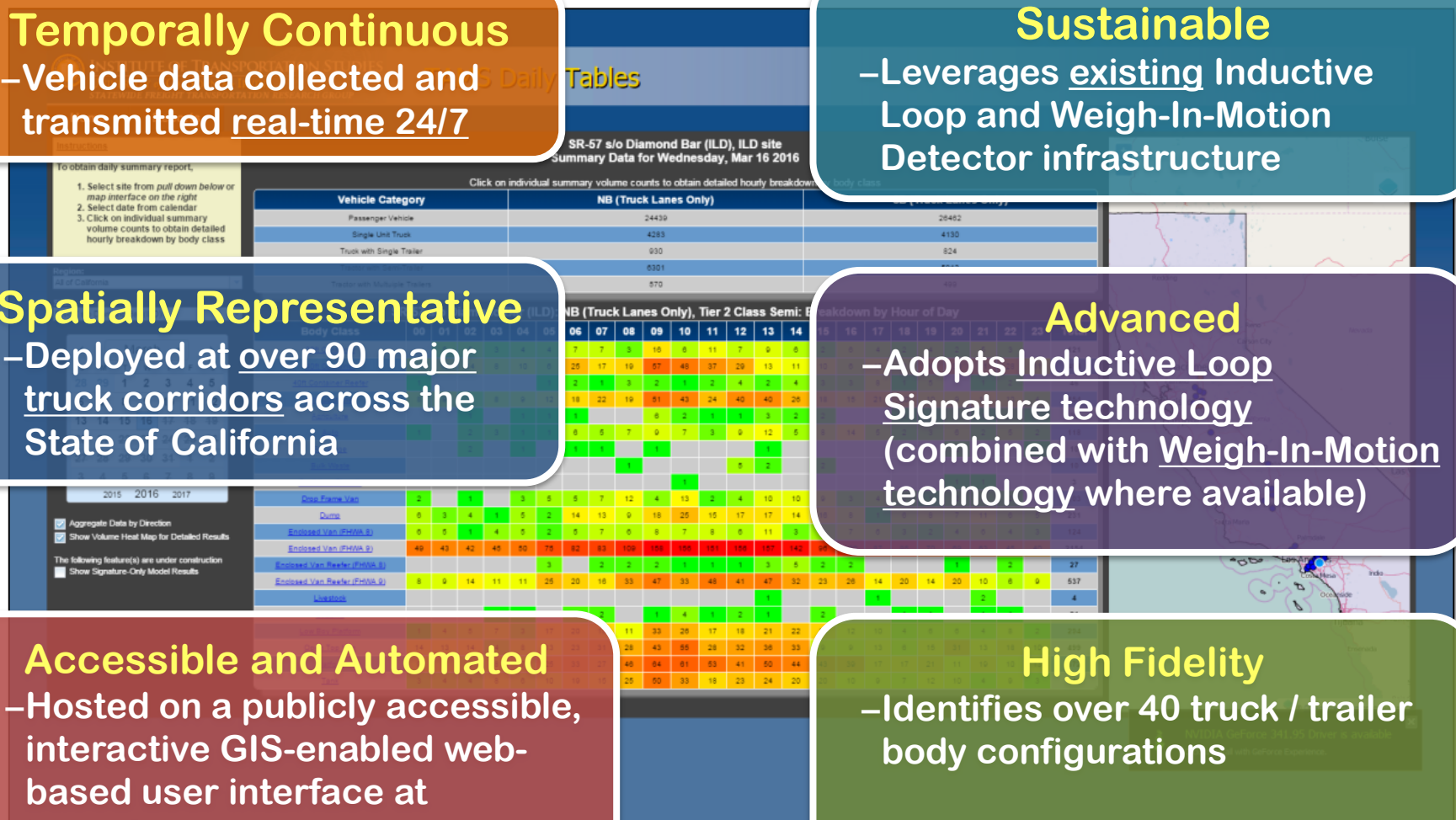
– Adopts Inductive Loop Signature technology (combined with Weigh-In-Motion technology where available)

Accessible and Automated

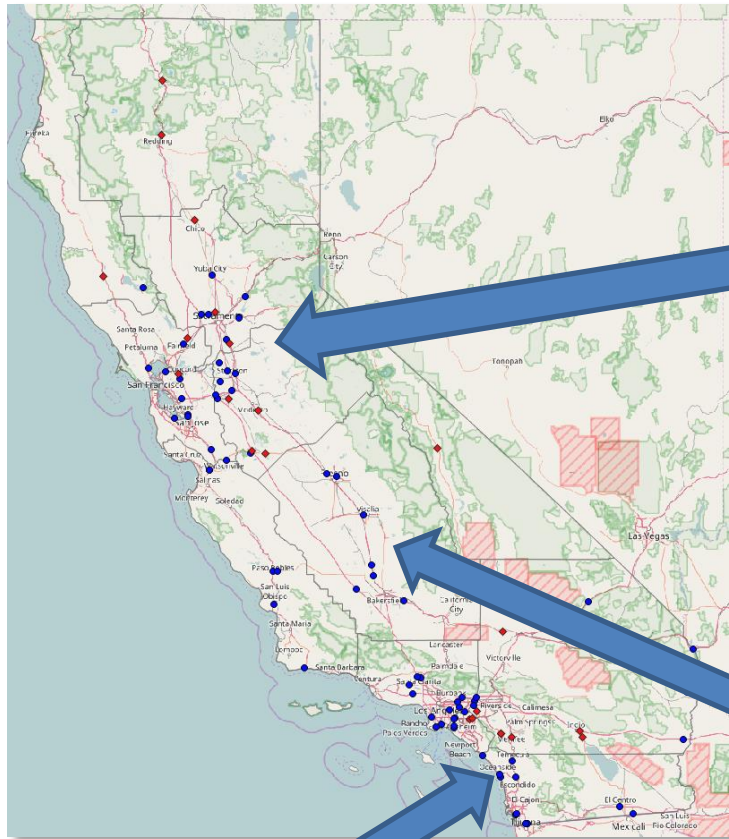
– Hosted on a publicly accessible, interactive GIS-enabled web-based user interface at <http://freight.its.uci.edu/tams>

High Fidelity

– Identifies over 40 truck / trailer body configurations



Snippets of Field Staff Testimonials



- Great to see how using only **existing loops and software and installed cards in our cabinets from the study actually can classify 32 types of trucks and or vehicles**
- Greatly impressed at a recent location on highway 50 in Eldorado county Folsom Blvd ...
- Fantastic to see it implemented how accurate one can categorize the type of Truck Vehicle from a signature from a loop....
- With my actual presence Andre determined the TypeMy reaction... Very impressive...
- **This technology and study can save the state thousands of dollars and keep staff safe...**
- Basically **Piezo installation is expensive and exposing many a worker to dangers**
- Hope to see more of this UC Irvine Study has to offer and when can a finished Product be deployed in our District?

- Caltrans District 3



Loop and Piezo sensors



Damaged traffic cabinet from collision along SR-91 Freeway

- Thank you for your help on route 15, piezo site #969, located just north of route 76 Jct
 - Getting only the south detection before.
 - The **NB ML#4 piezos need replacement**
 - With your loop-signature system the **problem was easy to fix, within 30 minutes**, and now we are getting vehicle classification data at this location.
- For some of the sites deployed in our district, we have **very old data**
 - But now with this technology we have the opportunity to update these old truck AADT without having to **wait for the construction of a piezo site, which sometimes takes years.**

- Caltrans District 11

- **Setting hoses across a highway exposes workers to traffic**
- **Piezos have a very limited life span**
- The single loop vehicle classification system has the following advantages:
 - use of **existing loops**
 - use of **existing cabinets**
 - and more concise classification of vehicles, e.g. we can tell the difference between a class 9 refer box van and a class 9 flat bed.
- Great potential for **better data, longer system life, and less traffic exposure for census workers.**

- Caltrans District 6