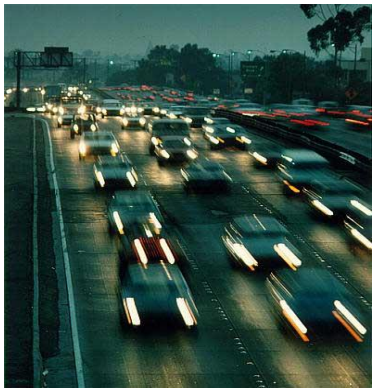
Classifying California Truck Activity Using Loop Sensors

UCIrvine
University of California, Irvine

Innovations in Freight Data Workshop:
Technologies for Monitoring, Tracking, and Data Collection

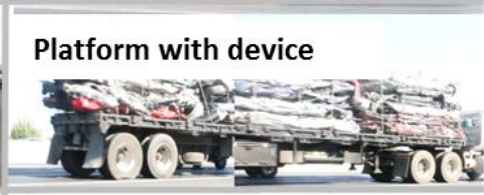
ITS University of California Irvine

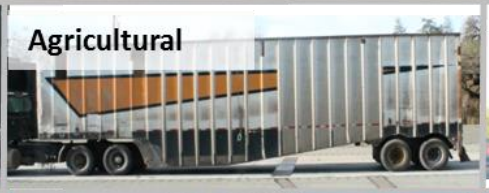


Andre Tok

May 17th, 2017

Trailer Configurations





Trivia #1

Which of the following corridors has seen 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

Which of the following corridors has seen the highest volume of double belly dump trailer trucks in 2017?

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

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

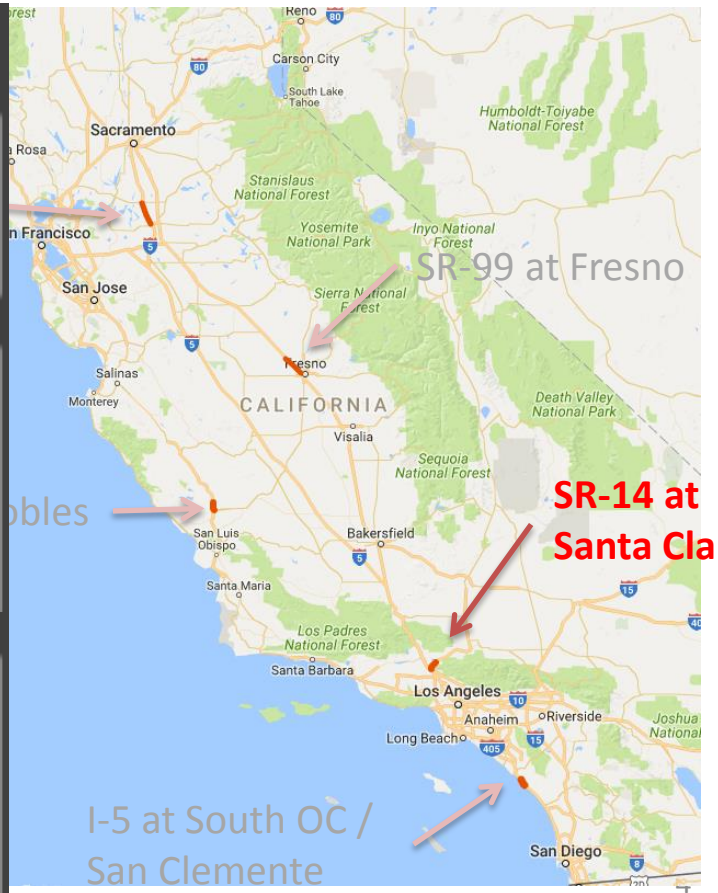
Vehicle Category	NB (Truck Lanes Only)	SB (Truck Lanes Only)
Passenger Vehicle	21173	15512
Single Unit Truck	3619	2495
Truck with Single Trailer	585	534
Tractor with Semi-Trailer	1815	1583
Tractor with Multuiple Trailers	673	660

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
Agricultural Van				1																					1
Bottom/Belly Dump	2	12	13	15	5	7	14	13	29	32	33	35	35	39	36	13	9	6	6	10	2	8	6	5	385
Enclosed Van	5	2	1	2	4	1					1	2	2					2	2			3	9	5	41
End Dump																	1								1
Hopper			1		1				2	3	1	2	1	2	3	1	1								18
Platform/Tank	6	8	7	7	4	16	10	9	12	13	10	10	17	11	10	17	5	7	8	2	7	7	10	4	217
Van/Platform (Low Chassis)	1							1	1		1			2	2		1	1							10

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

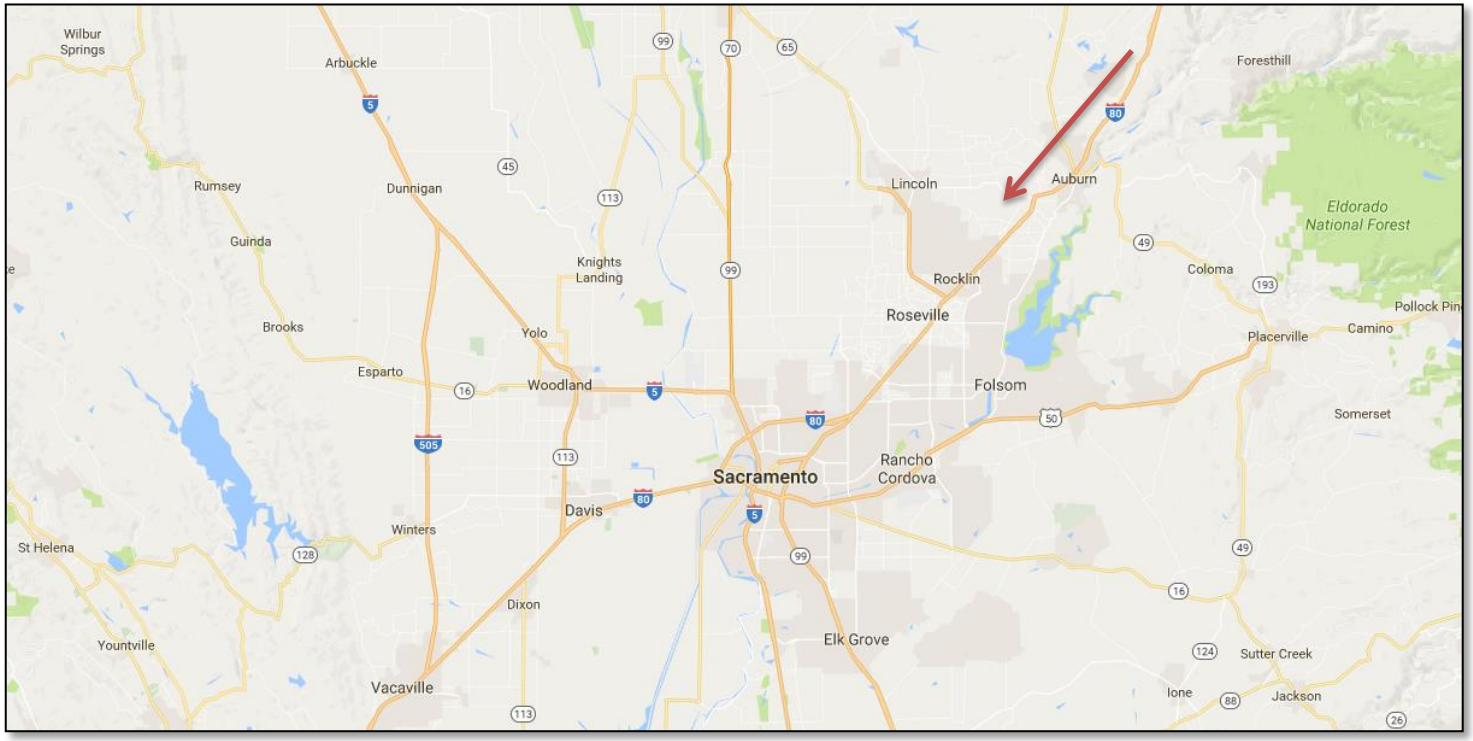
Body Class	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Agricultural Van								1																	1
Bottom/Belly Dump	11	1	4	8	11	35	25	23	26	22	29	23	34	23	16	5	7	14	19	10	13	5	3	12	379
Enclosed Van		1		3	3	7	3	5	2	3	1	1	1	2			2		1	1	1				37
End Dump				1																					1
Hopper	1				1		1	3	5	2	3	1	3	1	3					1	2			1	28
Platform/Tank	8	4	4	9	20	13	11	12	12	10	10	12	12	6	6	3	4	5	8	7	8	11	6	3	204
Van/Platform (Low Chassis)					1			1	1	1			1			2	1	1				1			10



Trivia #2

What is the approximate daily weekday volume of logging trucks on I-80 heading from the Sierra Nevada east bound towards Sacramento in November 2016?

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



Trivia #2

What is the approximate daily weekday volume of logging trucks on I-80 heading from the Sierra Nevada east bound towards Sacramento in November 2016?

a. 30

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c. 100

d. 200

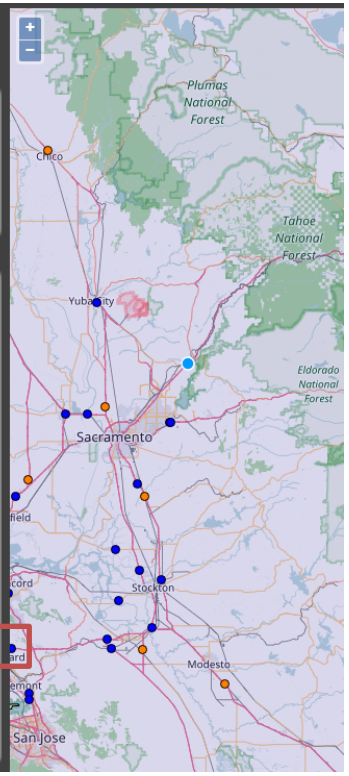
I-80 @ Webber Ln (ILD), ILD site
Summary Data for Tuesday, Nov 15 2016

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

Vehicle Category	EB (Truck Lanes Only)	WB (Truck Lanes Only)
Passenger Vehicle	35326	35989
Single Unit Truck	3412	3217
Truck with Single Trailer	565	656
Tractor with Semi-Trailer	3073	3075
Tractor with Multuiple Trailers	252	275

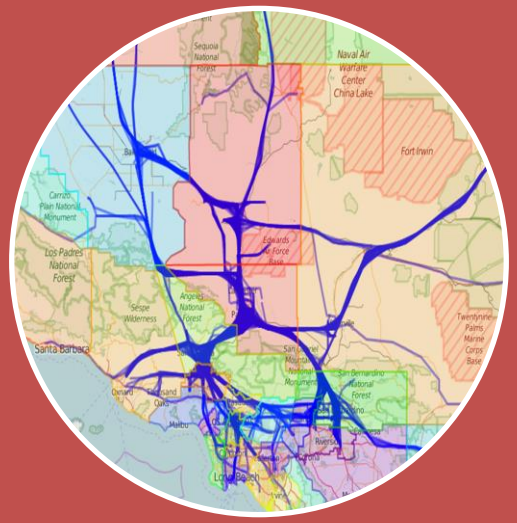
I-80 @ Webber Ln (ILD): WB (Truck Lanes Only), Tier 2 Class Semi: Breakdown by Hour of Day

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
20ft Container	4		2	3	4	1	4	5	2	1	5	4	9	4	5	3		1		2		1	2	1	63
40ft Container		3	7	7	8	9	7	8	10	4	5	3	13	11	4	5	7	2	2	3	2	1	1	1	123
40ft Container Reefer			3	3	3		4	2	5	9	1	2	2	1		2	1	1					1		40
53ft Container	3	1			1	2	2		1	3	9	6	12	8	3	6	12	6	3	2	3	2	2	3	90
Agriculture		1		2					4		1		1	2	1	1									13
Auto					1		3	1	1	1	3	3	5	6		2	3	6	4	1	2	1	1		44
Beverage	1					1		1			1		6	1	1	3	1	2	1	1	1				21
Bulk Waste							1					2	2			1			2	4	1				13
Drop Frame Van		1		1	1		5	3	5	7	5	5	8	6	3	1	5	1	2	4	3	2	5	1	74
Dump		2				1		4	2	6	3	3	3	1	1	1	1				1				29
Enclosed Van (FHWA 8)		1	1	1	1		2		2	4	2	2	3	6	9	4	8	3	3		1	1			54
Enclosed Van (FHWA 9)	26	25	19	19	36	24	39	31	36	36	45	44	55	70	60	53	61	40	40	37	29	24	42	28	919
Enclosed Van Reefer (FHWA 8)									2					1	1	1	2	1							8
Enclosed Van Reefer (FHWA 9)	21	27	22	26	25	32	25	30	32	22	38	43	32	57	37	43	25	30	23	24	31	12	29	16	702
Livestock	3	3	3	7		3	5	4		3	3	4	4		4	3	3	3	3	3	4		7	4	59
Logging					14	15	13	15	11	19	20	12	12	14	28	19	4	3	3			2	1		205
Low Boy Platform	2	2	2	2	2	3	4	7	10	11	10	12	14	8	8	7	4	5	4	4	11	2	2	2	142
Open Top Van	1	2		4	6	10	5	2	7	3	6	3	3	9	4	5	3	1	1	1	1	1	3	2	83
Platform	1	2	3	6	6	9	11	15	20	9	22	22	28	18	17	19	14	16	12	11	5	6	6	10	288
Tank	2	4	3	4	3	3	6	6	4	4	7	4	9	8	4	6	8	4	3	3	1	3	4	2	105



Existing Truck Activity Data Sources

Mobile



- GPS
- Telematics

Static / Count Data

- Weigh-In-Motion (WIM)
- Automatic Vehicle Classifier (AVC) System

Surveys

- 2002 National Vehicle Inventory and Use Survey (VIUS)
- 2016/17 California VIUS
- Regional Intercept Surveys

The Research Question

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

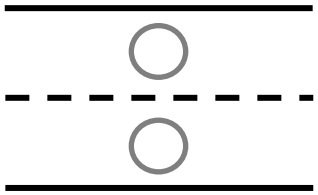
Our Solution

Develop comprehensive cutting-edge classification models that

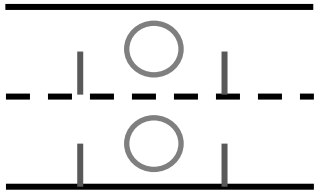
- can be implemented at existing traffic detector sites
- to provide truck activity data by industry-affiliated configuration
- using advanced inductive signature technology

Loops are out there!

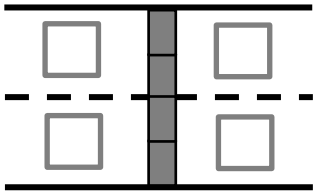
Common In-Pavement Detection Systems:



Standalone Inductive Loop Detector System



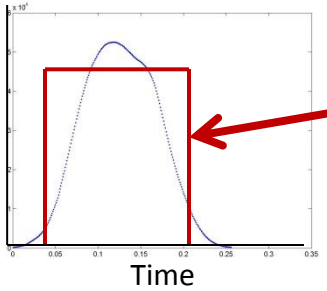
Automatic Vehicle Classifier (AVC) System with Piezo Sensors

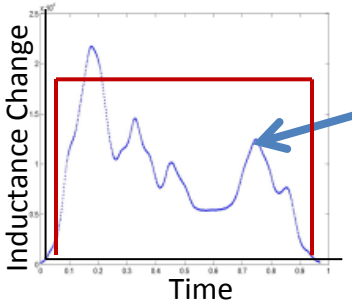


Weigh-In-Motion (WIM) System

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

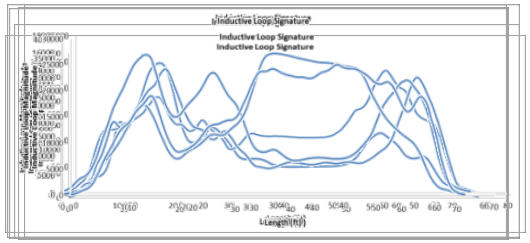
Inductive Signature
Inductive magnitude changes at up to 1200 samples/sec

How Distinctive Are Inductive Signatures?

Enclosed Van

Livestock

Low Boy Platform



Drop Frame Van

Basic Platform

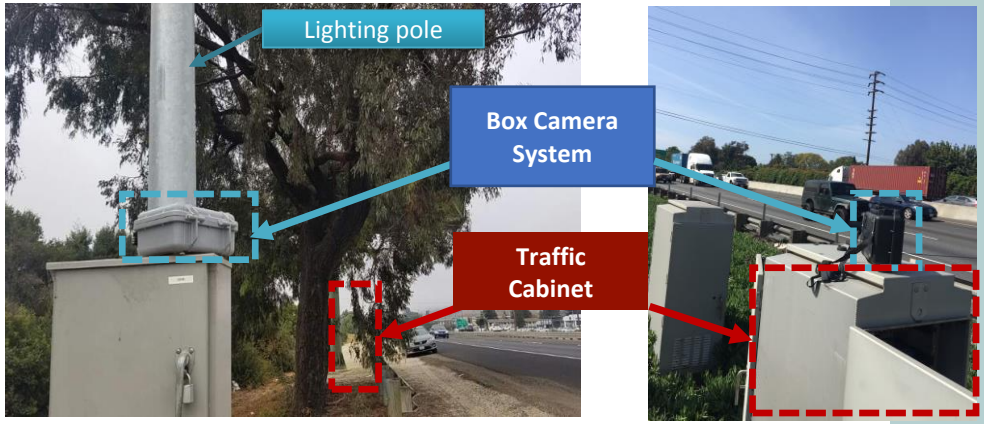
Tanks

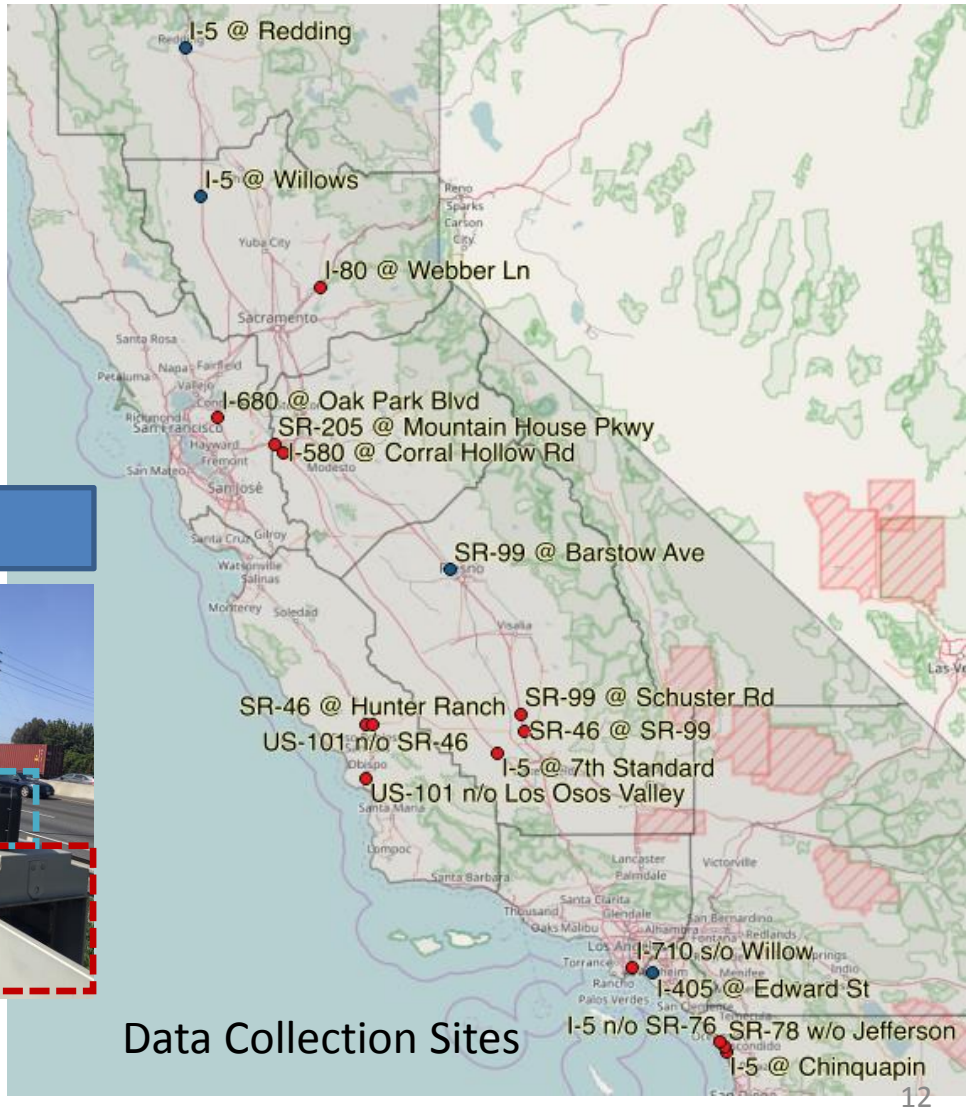
Sample FHWA Class 9 (5- Axle Semi-Trailer) signatures by trailer configuration

Data Collection Effort for Model Development and Validation

- 18 sites across California
- Over 140 hours of data with more than 40,000 truck records captured and processed

Data collection setup





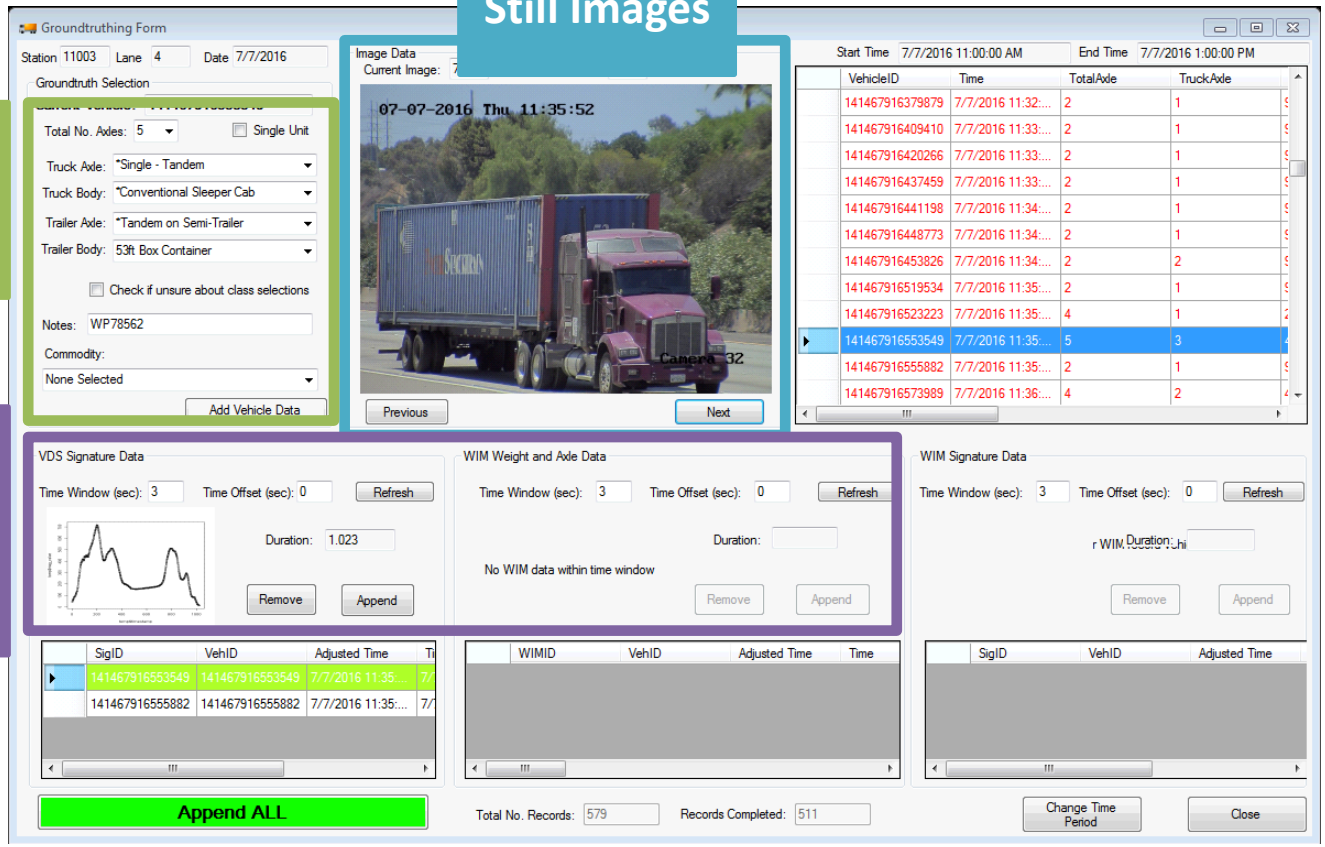
Data Groundtruth Process

Vehicle axle and body configuration entries, and inductive signature and WIM data are manually linked in a database through a custom groundtruth interface

Still Images

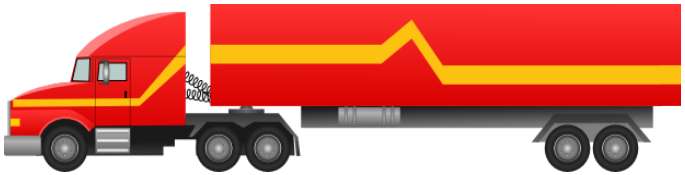
Vehicle axle and body configuration data entry form

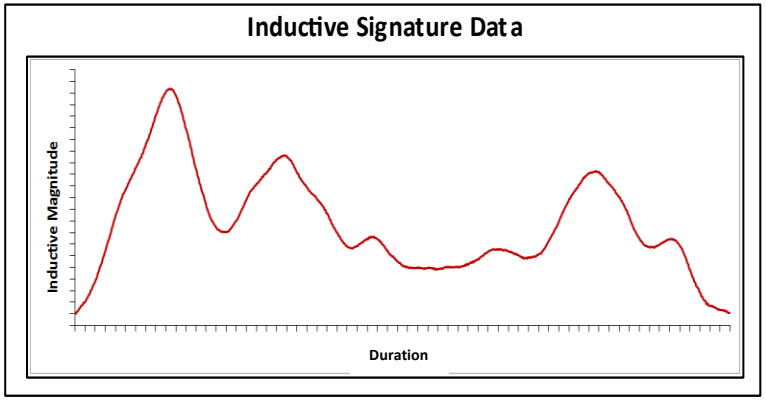
Inductive Signature and WIM Data (where applicable)

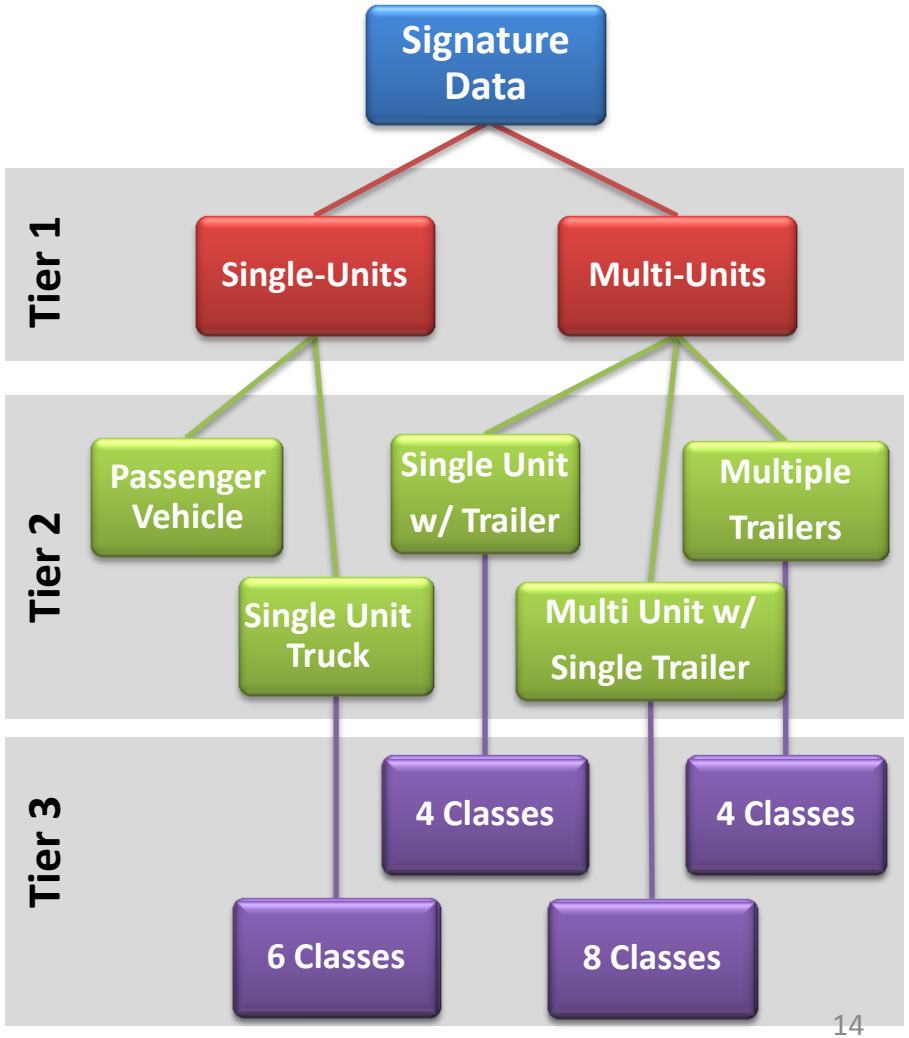


Body Classification Model Architecture

Inductive Signature **Model**







Selected Body Classification Model Results

Tier 3 Multi-Unit Single Trailer Results by Body Type

- Enclosed van
- Open top van
- Agriculture
- 53ft Container

- Platform
- Container Chassis
- Low boy platform
- Drop frame van

	Training		Common Site Validation		Independent Site Validation	
Body Type	CCR	Samples	CCR	Samples	CCR	Samples
Enclosed Van Group	97%	8762	95%	3548	92%	950
Tank/Dump	78%	780	64%	340	77%	130
Platform Group	84%	2071	77%	835	75%	197
40ft Container	79%	536	80%	247	84%	123
20ft Container	77%	124	68%	50	44%	43
Auto	94%	93	75%	40	54%	13
Livestock	97%	74	83%	30	80%	5
Logging	91%	81	100%	12	-	-
Overall CCR	**93%**	**12521**	**89%**	**5102**	**85%**	**1468**

CCR: Correct Classification Rate

Signature Implementation at ILD Sites

- Upgrading hardware at 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 requiring traffic closures
  - Existing traffic operations are not compromised

Conventional Detector Cards

Solid-State Field Processing Unit

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

Advanced Signature Detector Cards

Before **After**

Hardware setup at I-15 freeway in Fallbrook

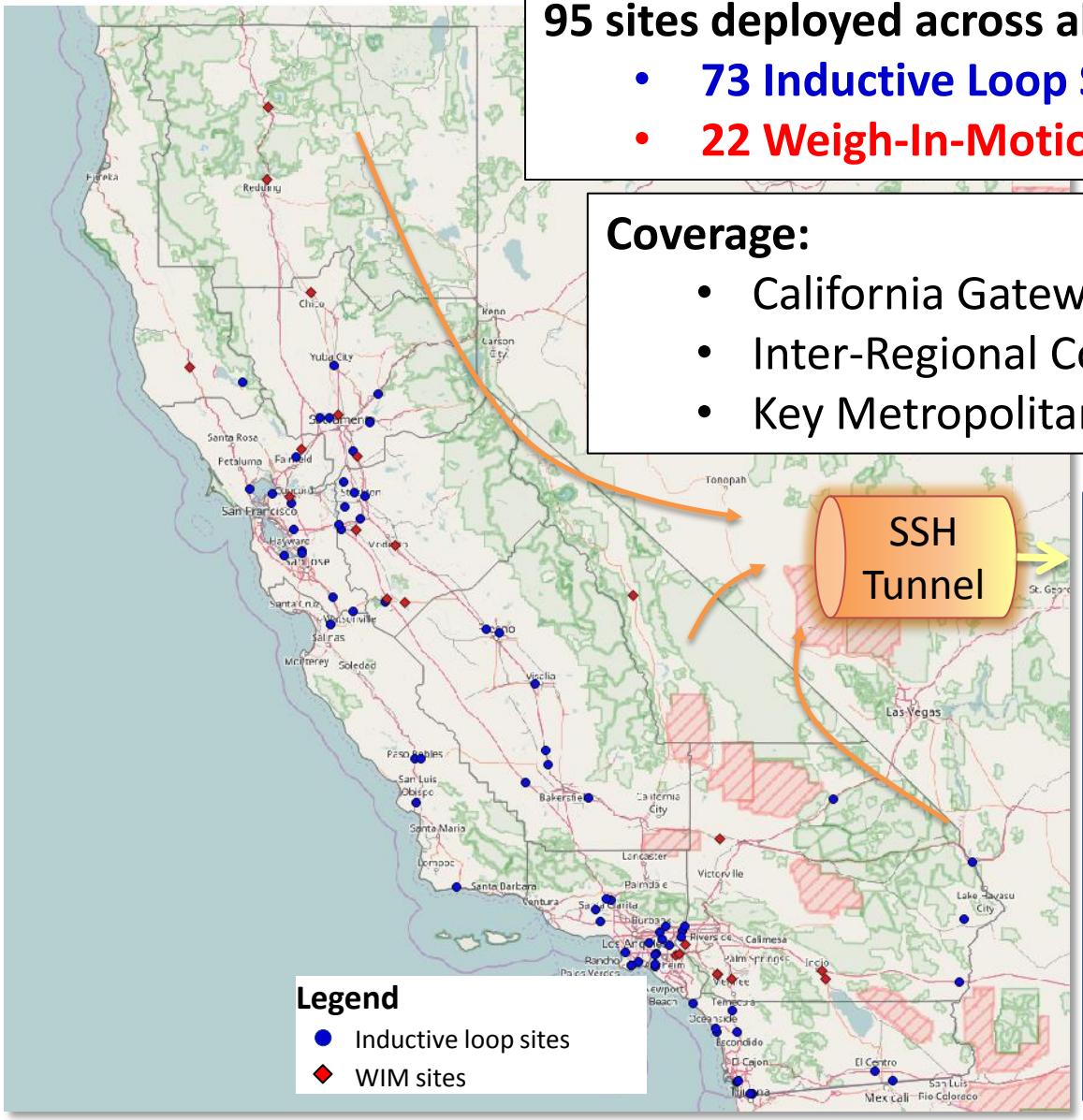
Total Currently Deployed Sites

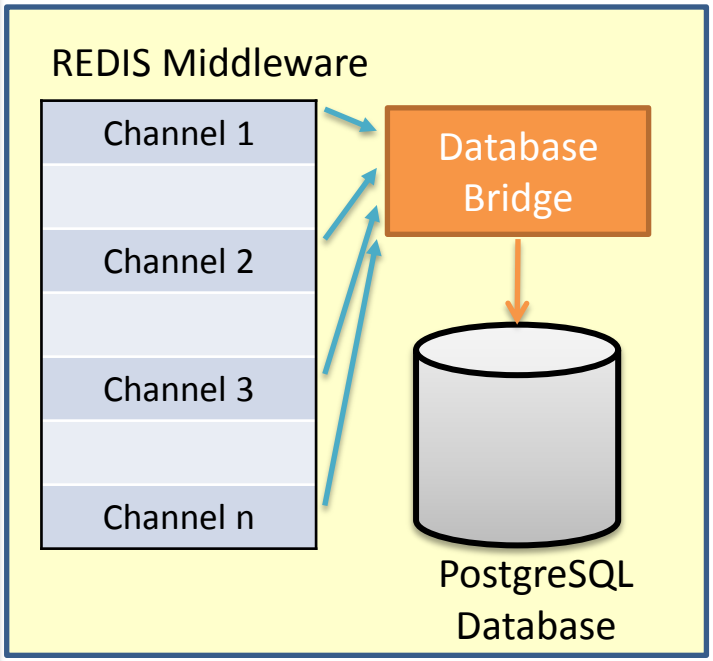
95 sites deployed across all 12 Caltrans districts

- **73 Inductive Loop Sites**
- **22 Weigh-In-Motion sites**

Coverage:

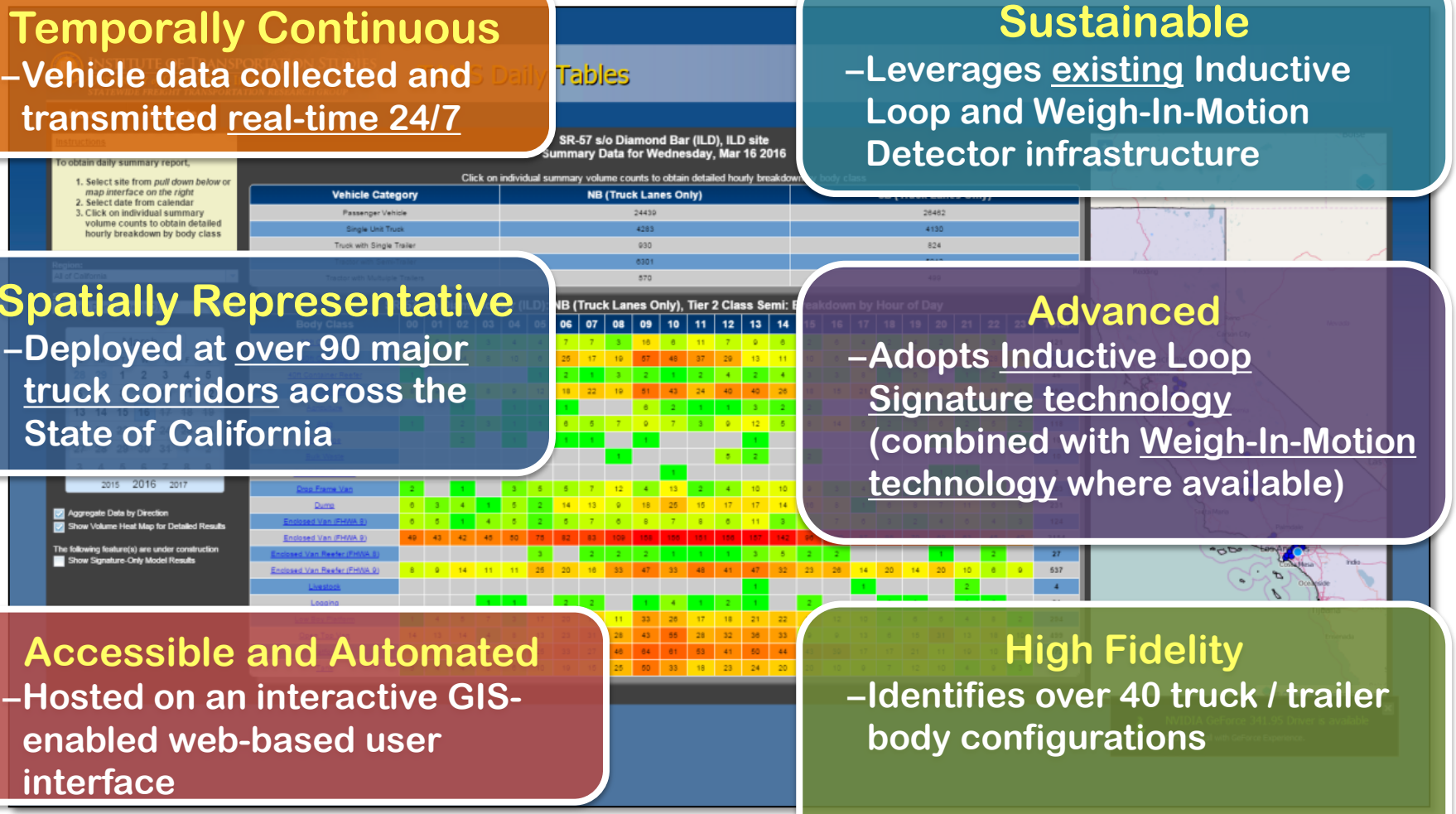
- California Gateways
- Inter-Regional Cordons
- Key Metropolitan Corridors





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 an interactive GIS-enabled web-based user interface

High Fidelity

–Identifies over 40 truck / trailer body configurations

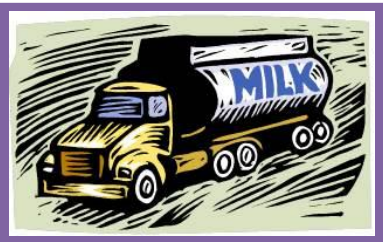
LIVE DEMO

1. Walk Through TAMS Web Interface
2. Live Classification Demo

Estimate proportions of freight and non-freight truck movements

Analysis of empty movements in freight trucks

Applications



Determine temporal and spatial travel patterns of trucks by industry

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

Just Getting Started: *A platform for future research and applications*

- Analysis of archived raw signature data
- Identify alternative energy trucks?
- Profile overloaded trucks?
- Improved models for traffic census
- State-wide self-learning truck classification system
- Improved tracking through integration with other data sources such as Bluetooth / GPS