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Think **Forward**

Findings from CA-VIUS

California Vehicle Inventory and Use Survey

presented to
SCAG Modeling Task Force

presented by
Cambridge Systematics, Inc.
Anurag Komanduri

January 23, 2019

Agenda

- Data Collection
- Data Cleaning and Imputation
- Data Expansion
- Expanded Results

Data Collection

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Survey Data Collection

Trucks Registered in California (DMV)

Interstate Trucks Traveling in California (IRP)

GPS Subsample

Retain only from DMV
No Double-Counting

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Data Collection Approach

DMV Large Fleets / IRP	DMV Small Fleets
Telephone recruits	Mail recruits
Online research	Phone follow-ups
Paper survey + Phone Call	Paper Survey + Phone Call
Weekly reminder	Weekly reminder
Incentive	Incentive

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Surveys Completed

California Department of Motor Vehicle (DMV)

Source	Fleet Size	Region	Gross Vehicle Weight (lbs)	Final Target	Completed Surveys	Percent Complete
	Small Fleets (1 – 5 trucks)	Central Coast/Valley	<26,000	980	1,301	133%
			≥26,000	918	781	85%
		LA/Inland/Empire/SD	<26,000	3,000	3,917	131%
			≥26,000	1,700	1,499	88%
		Sacramento/Bay Area	<26,000	1,400	1,771	127%
			≥26,000	526	628	119%
		Rest of State	<26,000	355	453	128%
			≥26,000	180	226	127%
	Subtotal Small Fleets (DMV)			9,059	10,576	117%
	Large Fleets (6+ trucks)	Central Coast/Valley	<26,000	377	238	63%
			≥26,000	200	291	146%
		LA/Inland/Empire/SD	<26,000	708	609	86%
			≥26,000	230	457	199%
		Sacramento/Bay Area	<26,000	380	328	86%
			≥26,000	74	241	326%
		Rest of State	<26,000	200	51	26%
			≥26,000	20	98	490%
	Subtotal Large Fleets (DMV)			2,189	2,313	106%
	Total DMV			11,248	12,889	115%

International Registration Plan (IRP)

Source	Fleet Size	Region	Vehicle Type	Vehicle Model	Final Target	Completed Surveys	Completed Surveys by Target	Percent Complete
	Small (1 – 5 trucks)	Adjacent States	Tractor	2010 and later	55	36	60	109%
			Other			4		
	Large (6+ trucks)		Tractor			18		
			Other			2		
	Small (1 – 5 trucks)		Tractor	Earlier than 2010	50	32	45	90%
			Other			7		
	Large (6+ trucks)		Tractor			6		
			Other			0		
	Subtotal Adjacent States (IRP)				105	105	105	100%
	Small (1 – 5 trucks)	Other States (including Canadian provinces)	Tractor	2010 and later	600	606	646	108%
			Other			40		
	Large (6+ trucks)		Tractor		350	518	518	148%
			Other		30	37	37	123%
	Small (1 – 5 trucks)		Tractor	Earlier than 2010	400	406	430	106%
			Other			24		
	Large (6+ trucks)		Tractor		220	141	141	64%
			Other		35	24	24	69%
	Subtotal Other States (IRP)				1,635	1,796	1,796	110%
	Total IRP				1,740	1,901	1,901	109%
	Grand Total (DMV & IRP)				12,988	14,790	14,790	114%

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Data Cleaning and Data Imputation

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VMT Imputation

```
Reported VMT
<=220,825 Miles
per year
                    GVW, Truck Type, Primary
                    Commodity, Age, Fleet Size
                    Percentage Inside CA

                    Build Regression        Annual VMT =
                    Model                   Reported VMT

Survey Record

                    Apply Regression        Annual VMT =
                    Model                   Imputed VMT
Reported VMT
>220,825 Miles
per year
```

Upper Threshold :
365 days * Maximum
11 hour driving allowed
by law * 55 mph
(average truck speed)
= 220,825 miles/year

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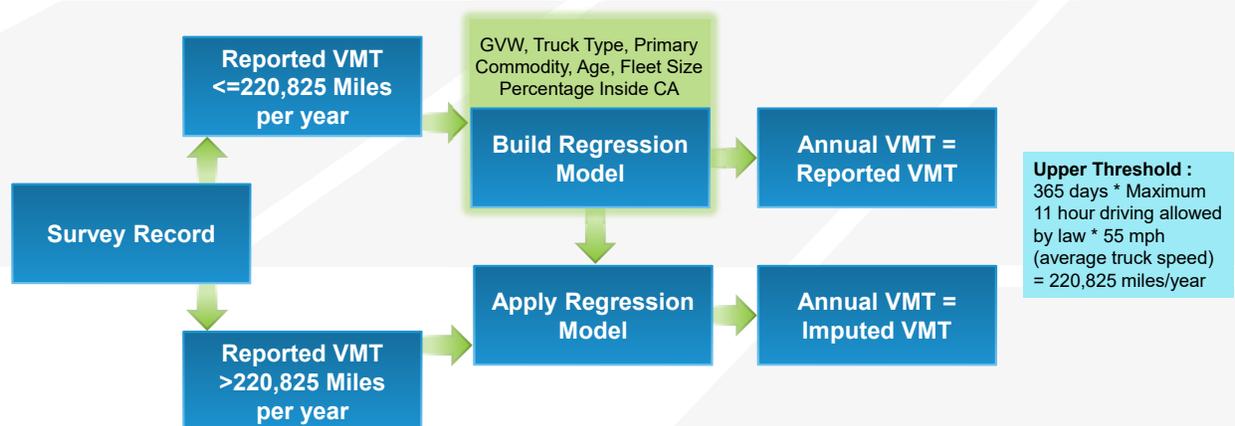
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Payload Imputation

Valid commodity fields reported
(19,718)

Payload = 0 or Missing **(862)**	0 < Payload < 1.05 * Limit OR Payload > Limit and Double Trailer = Yes **(17,848)**	Payload > 1.05 * Limit and Double Trailer = No **(915)**
Fill-in values from lookup table with average payloads (weighted by VMT) by GVW and Commodity	Reported payload	Corrected payloads = Reported payloads - empty vehicle weights 2002 VIUS look-up table with average empty vehicles by GVW
		IF Corrected Payload > Limit, set Payload = Limit

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Data Expansion

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Expansion Approach and Challenges

- ➤ Sample added over time
  - » DMV—new data purchase
  - » IRP—sample received on a monthly basis
- ➤ Who operates in California
  - » Not all IRP fleets travel within California
  - » Not all IRP trucks within fleets travel to California
- ➤ Double-counting fleets in IRP and DMV
- ➤ Tailor expansion to segments in sampling plan
- ➤ Comparing results to external data sources
  - » 2002 VIUS
  - » FHWA's Highway Statistics Tables

Expansion Factors (DMV Trucks)

Region	Fleet Size	Gross Vehicle Weight (lbs)	Truck Database	Adj. Truck Database	Trucks Surveyed	Expansion Weight
LA/Inland Empire/ San Diego	Small (1–5)	<26,000	61,874	46,238	3,917	11.8
		≥26,000	37,892	29,334	1,499	19.6
	Large (6+)	<26,000	92,897	79,586	609	130.7
		≥26,000	103,641	95,113	457	208.1
Central Coast/ Valley	Small (1–5)	<26,000	18,185	13,987	1,301	10.8
		≥26,000	16,067	13,111	781	16.8
	Large (6+)	<26,000	27,126	24,027	238	101.0
		≥26,000	46,461	42,777	291	147.0
Sacramento/ Bay Area	Small (–5)	<26,000	26,797	20,677	1,771	11.7
		≥26,000	11,617	9,579	628	15.3
	Large (6+)	<26,000	47,741	42,876	328	130.7
		≥26,000	42,070	39,911	241	165.6
Rest of State	Small (1–5)	<26,000	4,720	3,741	453	8.3
		≥26,000	2,844	2,529	226	11.2
	Large (6+)	<26,000	4,584	4,180	51	82.0
		≥26,000	6,075	4,765	98	48.6
Total			550,591	472,431	12,889	

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Expansion Factors (IRP Trucks)

Region	Fleet Size	Vehicle Age	Vehicle Type	Truck Universe	Adjusted Truck Universe	Trucks in the Survey	Truck Expansion Factor
Adjacent States	Small (1-5)	2010 or Later	Tractor	1,510	1,191	36	33.1
			Other	304	89	4	22.3
		Earlier than 2010	Tractor	2,597	1,197	32	37.4
			Other	502	1,414	7	201.9
	Large (6+)	2010 or Later	Tractor	5,688	4,867	16	304.2
			Other	1,841	1,034	2	517.2
		Earlier than 2010	Tractor	2,983	1,597	6	266.2
			Other	2,053			
Other States	Small (1-5)	2010 or Later	Tractor	26,672	6,143	605	10.2
			Other	5,981	3,617	40	90.4
		Earlier than 2010	Tractor	52,048	20,503	406	50.5
			Other	6,252	3,548	24	147.8
	Large (6+)	2010 or Later	Tractor	554,862	112,275	517	217.2
			Other	121,877	27,923	37	754.7
		Earlier than 2010	Tractor	189,736	78,652	141	557.8
			Other	35,444	13,124	24	546.8
Total				1,010,351	277,172	1,897	

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Expansion Validation

➤ Total expanded truck population: 759,572
  » Compared to ARB EMFAC 2017 population of 794,272

➤ Total annual California miles: 15 billion
  » Compared to ARB EMFAC 2017 daily miles of
    62.9 million * 260 weekdays = 16 billion

➤ Split of VMT between Single Unit and Combination Unit 39-61
  » According to FHWA, this split should be around 40–60

➤ Split of VMT between DMV and IRP dataset 80–20
  » Based on NHTSA FARS database, this split should be 70–30

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Comparison with 2002 National VIUS

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Comparison with 2002 National VIUS

Trucks Registered in California (DMV)

Interstate Trucks Traveling in California (IRP)

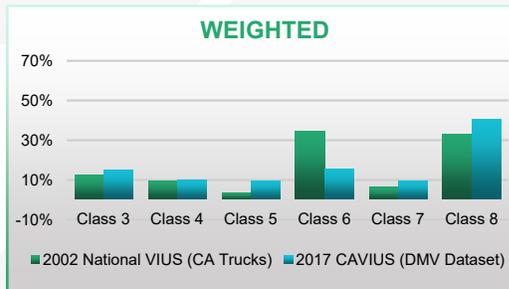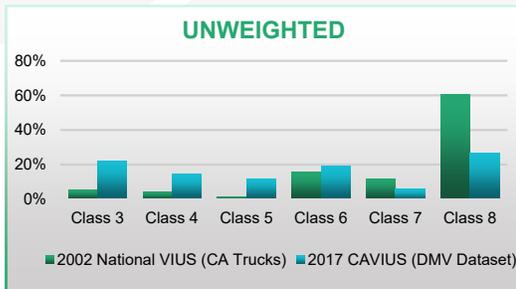**Include only DMV Dataset in Comparison**

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Vehicle Class Distribution
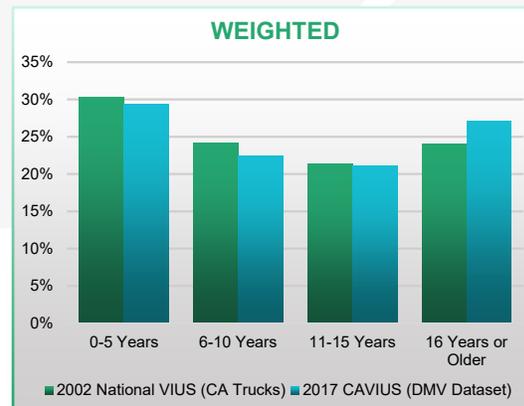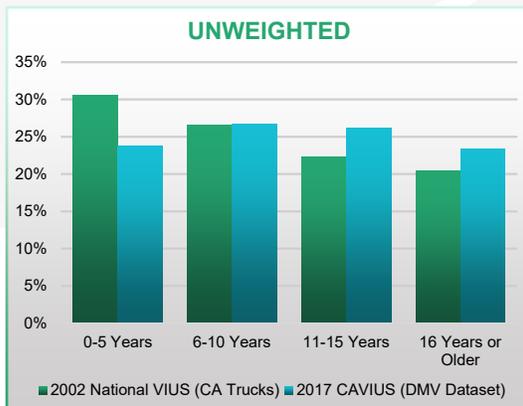
Vehicle Class by GVW	2002 National VIUS (CA Trucks)	2017 CAVIUS (DMV Dataset)
Class 3	85	2,827
Class 4	67	1,857
Class 5	25	1,533
Class 6	240	2,451
Class 7	178	742
Class 8	910	3,479
Total	**1,505**	**12,889**

UNWEIGHTED

WEIGHTED

2002 National VIUS (CA Trucks) 2017 CAVIUS (DMV Dataset)

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Vehicle Age Distribution

UNWEIGHTED

WEIGHTED

2002 National VIUS (CA Trucks) 2017 CAVIUS (DMV Dataset)

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Average VMT by GVW Class

UNWEIGHTED

WEIGHTED

Legend: ■ 2002 National VIUS (CA Trucks) ■ 2017 CAVIUS (DMV Dataset)

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Average VMT by Commodity

AVERAGE VMT BY COMMODITY

Legend: ■ 2002 National VIUS (CA Trucks) ■ 2017 CAVIUS (DMV Dataset)

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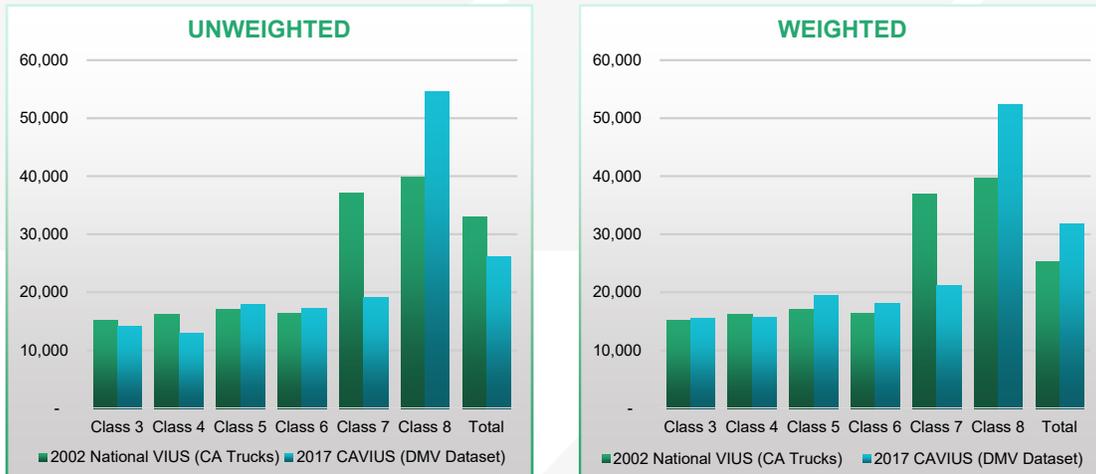
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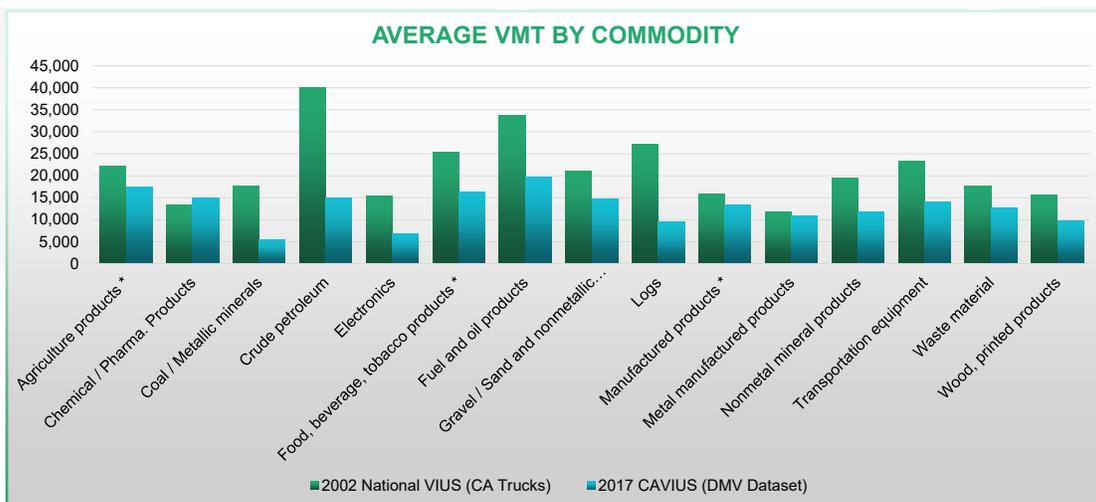
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Key Vehicle Characteristics

Attribute		Dataset		Total
		DMV	IRP	
Fleet Size	Large 6+	333,235	247,650	**580,885**
	Small 1–5	139,196	39,617	**178,813**
Vehicle Type	Straight	310,213	51,812	**362,025**
	Tractor	162,218	235,455	**397,673**
Gross Vehicle Weight	10,001–14,000 pounds (Class 3)	69,723	5,129	**74,852**
	14,001–16,000 pounds (Class 4)	47,505	2,167	**49,672**
	16,001–19,500 pounds (Class 5)	44,914	6,655	**51,569**
	19,501–26,000 pounds (Class 6)	73,170	10,644	**83,814**
	26,001–33,000 pounds (Class 7)	44,822	18,707	**63,530**
	>33,000 pounds (Class 8)	192,297	243,965	**436,261**
Vehicle Age	0–5	139,181	135,849	**275,030**
	6–10	127,877	80,751	**208,627**
	11–15	105,894	47,924	**153,818**
	16 or older	99,479	22,743	**122,222**
Total		**472,431**	**287,267**	**759,698**

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Geographic Distribution
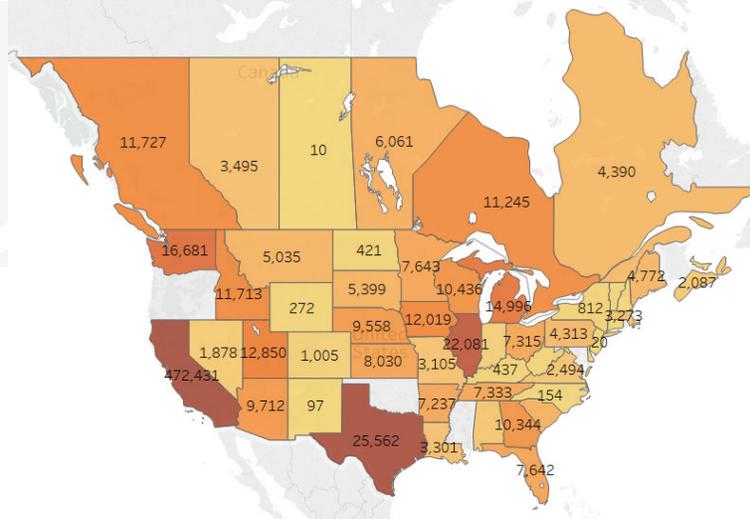
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Fuel Type

Fuel Type	Truck Class						Total
	3	4	5	6	7	8	
Diesel (including biodiesel)	38,445	34,706	44,192	78,554	61,712	433,364	690,974
Gasoline (including gasohol)	36,383	13,556	5,345	4,933	910	273	61,401
Other Fuel (alcohol fuels, electric, natural gas, etc.)	24	1,410	2,032	327	907	2,624	7,323
Total	74,852	49,672	51,569	83,814	63,530	436,261	759,698

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Truck vs. Trailer Axles

Number of Truck Axles	Number of Trailer Axles				Total
	No Trailer	One	Two	Three or More Axles	
Two axles (each axle has 2 tires)	65,595	6,172	9,031	1,497	82,294
Two axles (front 2, rear 4 tires)	211,254	10,561	37,317	18,004	277,136
Three axles	30,456	5,725	310,428	23,438	370,046
Four axles	4,110	86	5,040	7,098	16,334
Five axles	12		10,781	456	11,249
More than five axles	58		11	2,011	2,081
Total	311,505	22,544	373,007	52,643	759,698

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Average Annual VMT

Attribute		Truck Class (GVW)						Combined Average
		3	4	5	6	7	8	
Dataset	DMV	15,461	15,769	19,488	18,171	21,414	52,304	31,856
	IRP	42,508	57,796	83,934	46,415	60,540	93,787	88,461
Vehicle Age	0–5 years	20,187	28,427	34,959	31,405	45,255	88,509	69,491
	6–10 years	22,088	22,999	30,793	24,698	38,432	72,892	58,975
	11–15 years	15,324	17,166	23,116	18,591	24,018	65,869	37,708
	16 years or older	12,196	10,232	14,493	11,342	12,320	47,843	26,554
Combined Average		17,314	17,602	27,861	21,758	32,935	75,502	53,260

ANNUAL VMT BY DATASET

THOUSANDS

DMV	IRP
32	88

ANNUAL VMT BY VEHICLE AGE

THOUSANDS

0 – 5 years	6 – 10 years	11 – 15 years	16 years or Older
69	59	38	27

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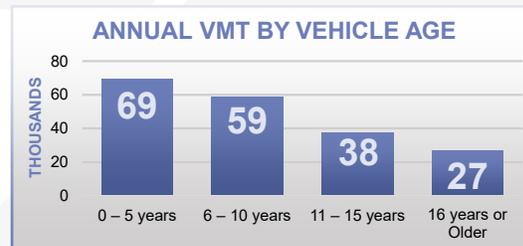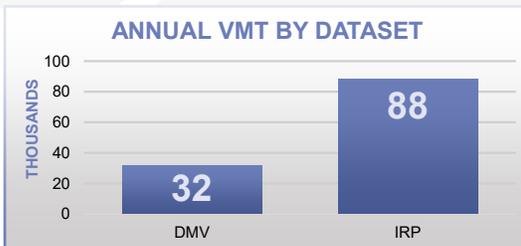
Vehicle Miles Traveled in California

Attribute	Truck Class	Dataset		Combined
		DMV	IRP	
Total Annual California VMT (billions of miles)	Class 3	1.05	0.06	1.11
	Class 4	0.74	0.04	0.78
	Class 5	0.84	0.04	0.88
	Class 6	1.30	0.04	1.34
	Class 7	0.94	0.08	1.03
	Class 8	7.26	2.82	10.09
	Grand Total	12.13	3.09	15.22
Average Annual California VMT (miles)	Class 3	15,078	12,010	14,868
	Class 4	15,515	19,480	15,688
	Class 5	18,610	5,954	16,977
	Class 6	17,806	3,896	16,039
	Class 7	21,055	4,420	16,157
	Class 8	37,758	11,577	23,117
	Combined Average	25,679	10,763	20,039
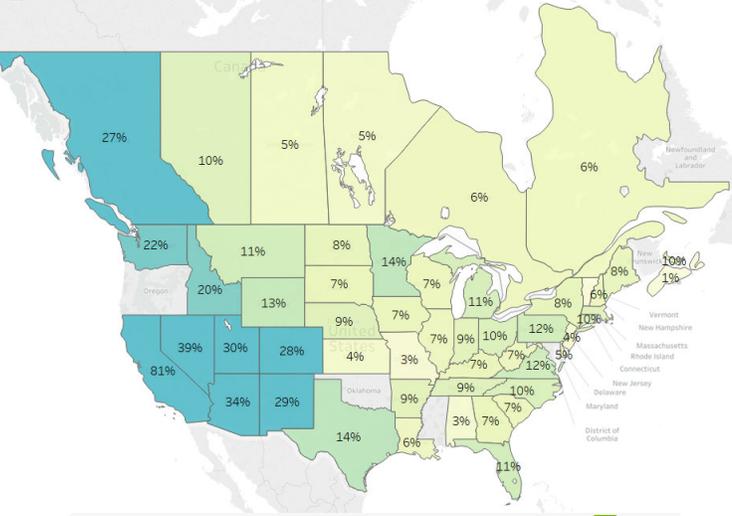
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Loading Pattern

DMV TRUCKS

- Deadheading Bobtail 5%
- Deadheading Empty 22%
- Miles Partially Loaded 25%
- Miles Fully Loaded 48%

IRP TRUCKS

- Deadheading Bobtail 4%
- Deadheading Empty 11%
- Miles Partially Loaded 16%
- Miles Fully Loaded 69%
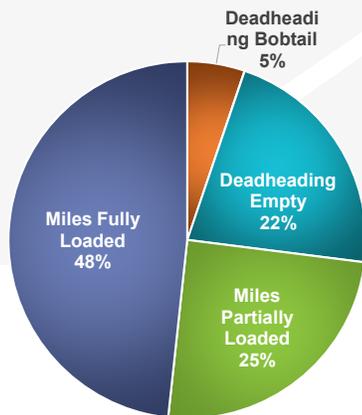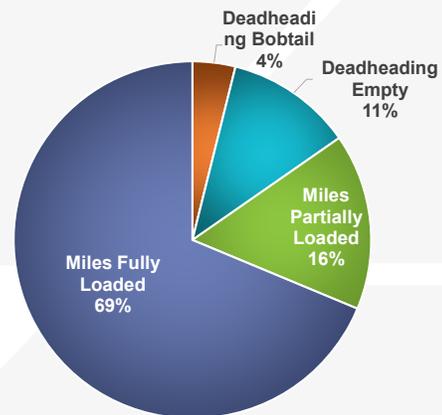
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Payload

Attribute	Dataset		Combined Average
	DMV	IRP	
Commodity			
Agriculture products	26,145	38,747	31,941
Chemical/pharmaceutical products	25,066	24,002	24,615
Coal/metallic minerals	22,420	34,850	29,488
Crude petroleum	34,333	1,646	28,541
Electronics	14,153	24,707	19,013
Food, beverage, tobacco products	26,580	37,493	32,904
Fuel and oil products	21,511	39,569	24,335
Gravel/sand and nonmetallic minerals	26,933	40,869	28,853
Logs	21,873	38,319	24,682
Manufactured products	16,307	29,230	22,608
Metal manufactured products	14,897	35,710	25,545
Nonmetal mineral products	20,232	36,598	30,084
Transportation equipment	16,574	33,976	24,177
Waste material	16,593	30,062	18,393
Wood, printed products	20,053	36,764	27,190
Combined Average Payload (lbs)	**20,162**	**34,001**	**26,361**

Attribute	Dataset		Combined Average
	DMV	IRP	
Truck Class (GVW)			
Class 3	1,835	3,833	1,969
Class 4	2,368	5,194	2,512
Class 5	3,721	8,444	4,492
Class 6	5,266	6,008	5,361
Class 7	11,081	13,932	12,162
Class 8	34,682	37,066	36,069
Combined Average Payload (lbs)	**20,162**	**34,001**	**26,361**

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Applications

➤ Currently being used in the development of the California Statewide Freight Forecasting Model

» Vehicle characteristics such as vehicle-type, GVW and truck-trailer axles combination

» Vehicle miles traveled

» Payload by commodity

» Vehicle loading

➤ Other regional travel and emissions models

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Large Team

Cambridge Systematics, Inc.

Moby Khan, Anurag Komanduri, Jim Brogan, Kimon Proussaloglou, Brent Selby, Pragun Vinayak, Cemal Ayvalik, Dan Beagan, Arun Kuppam, Krishnan Viswanathan, Ron West, Chiru Bhamidipati, Alice Chu, Mary Martchouk, Zhuyun Gu, Mike Fischer

Redhill Group	**Franklin Hill Group**	**Calstart**	**ATRI, Fehr and Peers, Inchecks**
Mark McCourt, Ryan Mak, and crew	Cheryl Stetcher	Jasna Tomic, Kevin Leong, and Chase Lecroy	

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Thank You

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