# An Overview of the California Statewide Freight Forecasting Model (CSFFM)

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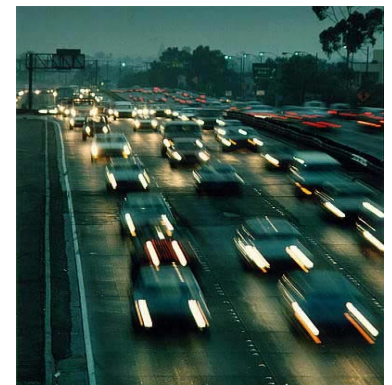
*January 27, 2016*

# Outline

**CSFFM Overview**

**Example Scenarios**

**Follow-up Efforts**

# California Statewide Freight Forecasting Model

## Commodity-based Model

- Forecasts the **flow of commodities** by **transportation mode** as a function of **employment, establishment, land use variables** based on integrated CSTDM and FAF transportation network.
- Based on the 2007/10 Federal *Freight Analysis Framework 3 (FAF 3)* database.
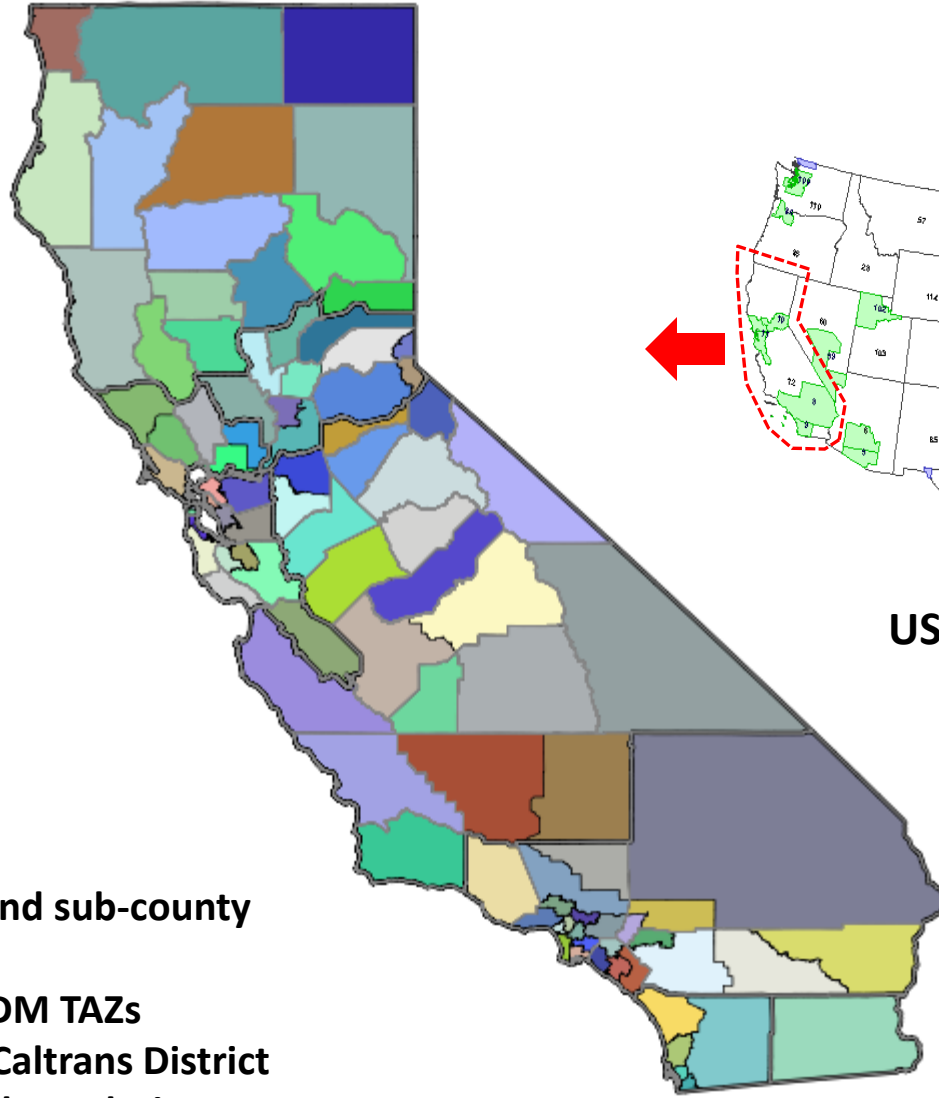
## 15 Commodity Groups (aggregated at the 2-digit SCTG code level)

| CSFFM Commodity Group | SCTG Code* | CSFFM Commodity Group | SCTG Code* |
|---|---|---|---|
| G1 Agriculture products | 1-4 | G9 Chemical/ pharmaceutical products | 20-23 |
| G2 Wood, printed products | 26-29 | G10 Nonmetal mineral products | 31 |
| G3 Crude petroleum | 16 | G11 Metal manufactured products | 32-34 |
| G4 Fuel and oil products | 17,18,19 | G12 Waste material | 41 |
| G5 Gravel/ sand and non metallic minerals | 10-13 | G13 Electronics | 35,38 |
| G6 Coal / metallic minerals | 14-15 | G14 Transportation equipment | 36-37 |
| G7 Food, beverage, tobacco products | 5-9 | G15 Logs | 25 |
| G8 Manufactured products | 24,30,39,40,42,43 | | |

**\* SCTG Code: Standard Classification of Transported Goods Code used in Freight Analysis Framework 3( FAF3)
source: http://2bts.rita.dot.gov/publications/commodity_flow_survey/survey_materials/pdf/sctg_booklet.pdf**

# Freight Analysis Zoning System

*FAF only defines 5 coarse regions in California -* **inadequate resolution for analysis of freight policies and scenarios.**
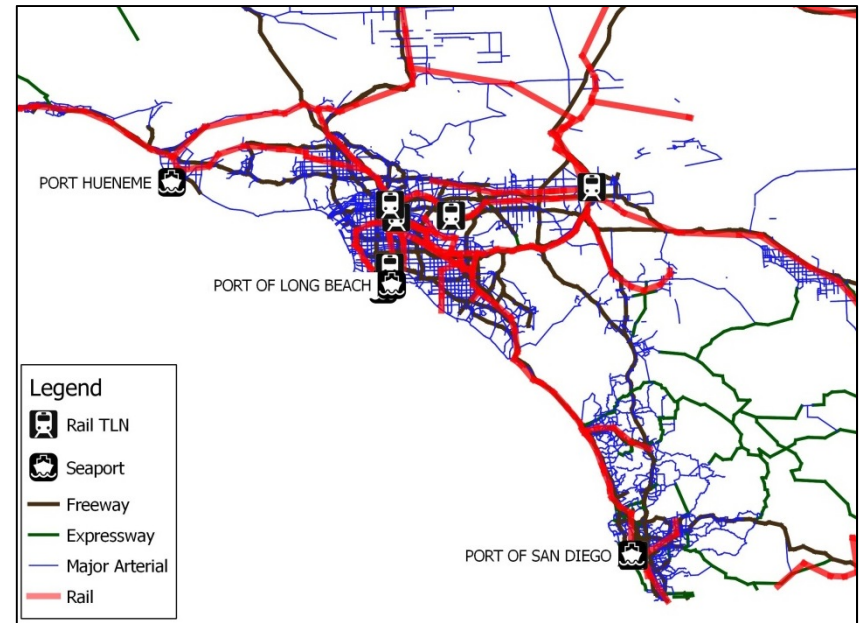
**58 Counties**

**97 CSFFM FAZs**
- **Defined at county and sub-county levels**
- **Aggregation of CSTDM TAZs**
- **Conforms to MPO, Caltrans District and CARB Air Basin boundaries**

**US FAF Zones**

# Freight Analysis Zoning System

## Within California

- **_97 Freight Analysis Zones (FAZs)_**

- **_38 Import/Export Gateways:_**
  - **19 Land Ports (6 in Arizona) US-MEX**
  - **8 Airports**
  - **11 Seaports**

- **_26 Transport Logistic Nodes (TLNs or Transshipment Nodes):_**
  - **13 Airports (8 of these are Gateways)**
  - **13 Rail Terminals (including 4 rail terminals directly connected to seaports)**



Part of _CSFFM network_ for
**Los Angeles, Ventura, and San Bernardino counties**

## Outside California

- **118 domestic FAF regions and 8 international FAF regions**

# FAF3 Overview

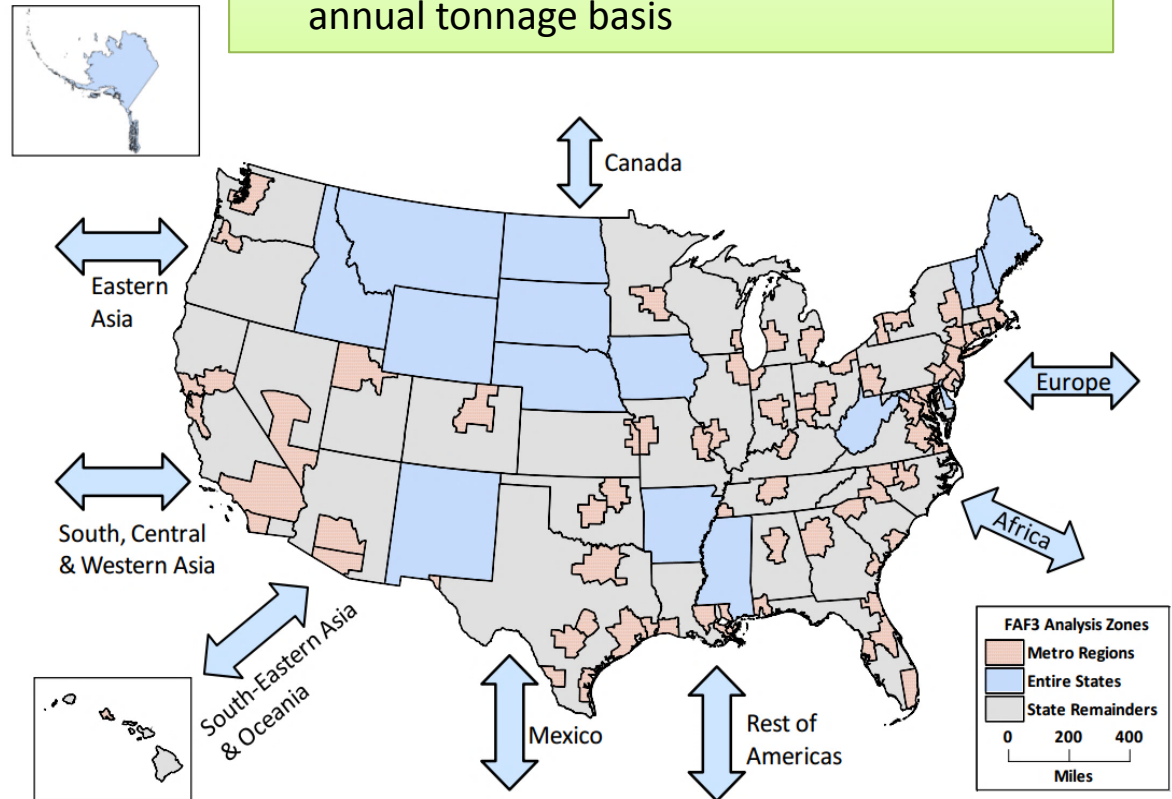## What constitutes this mega OD matrix?
- **CFS freight flows** accounts for 68% of FAF
- Out of CFS scope flows account for 32% of all U.S. freight movements measured on an annual tonnage basis
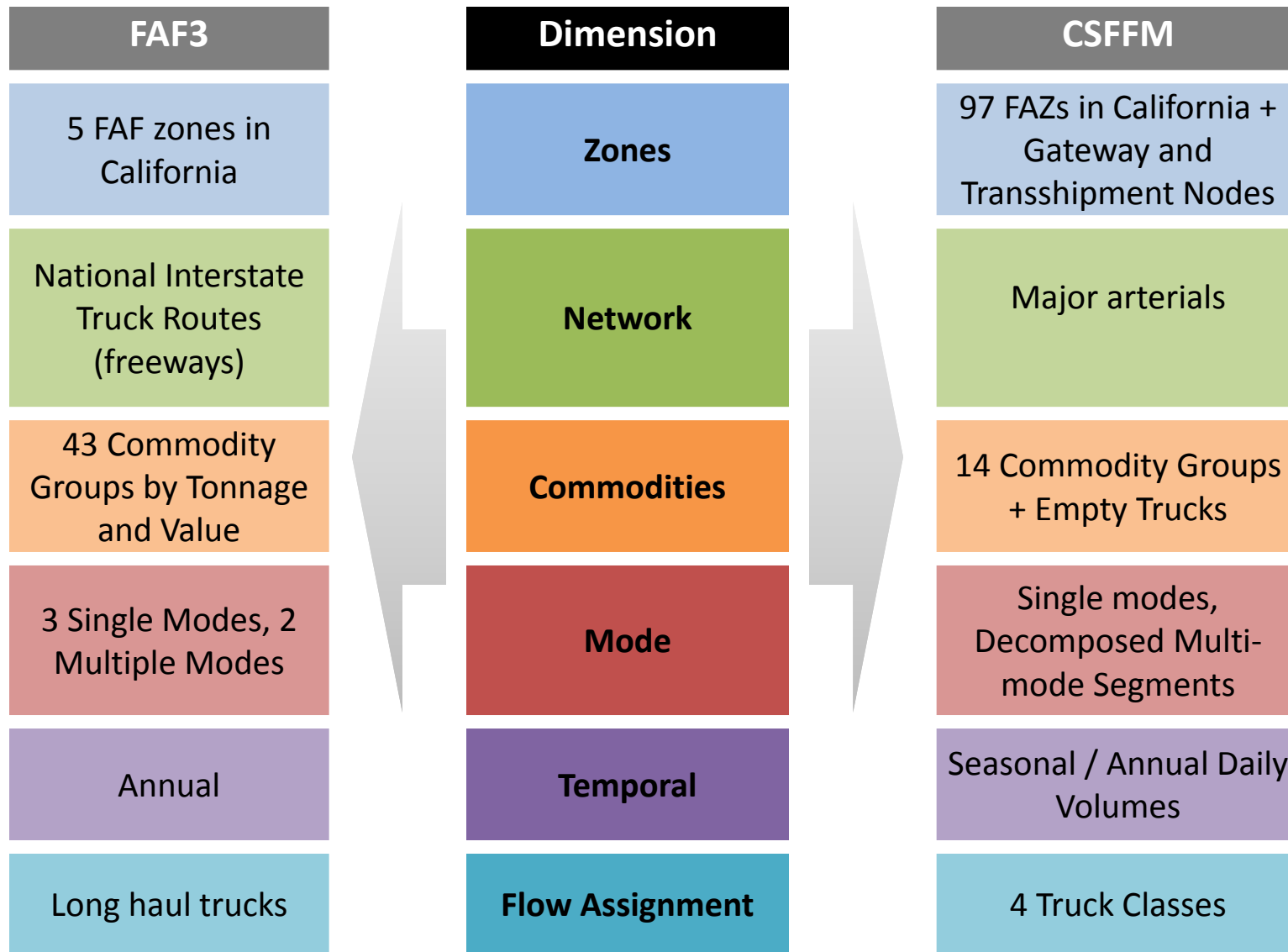
## FAF3 Freight Flow Matrix
- Comprises:
  - 131 **Origins** x
  - 131 **Destinations** x
  - 43 **Commodity Classes** x
  - 8 **Modal Categories**
- Reports <u>Annual Tons</u> and <u>Annual Dollar</u> values.

## CFS data gaps → FAF users challenges
- CFS data suppression and missing values are estimated using other sources
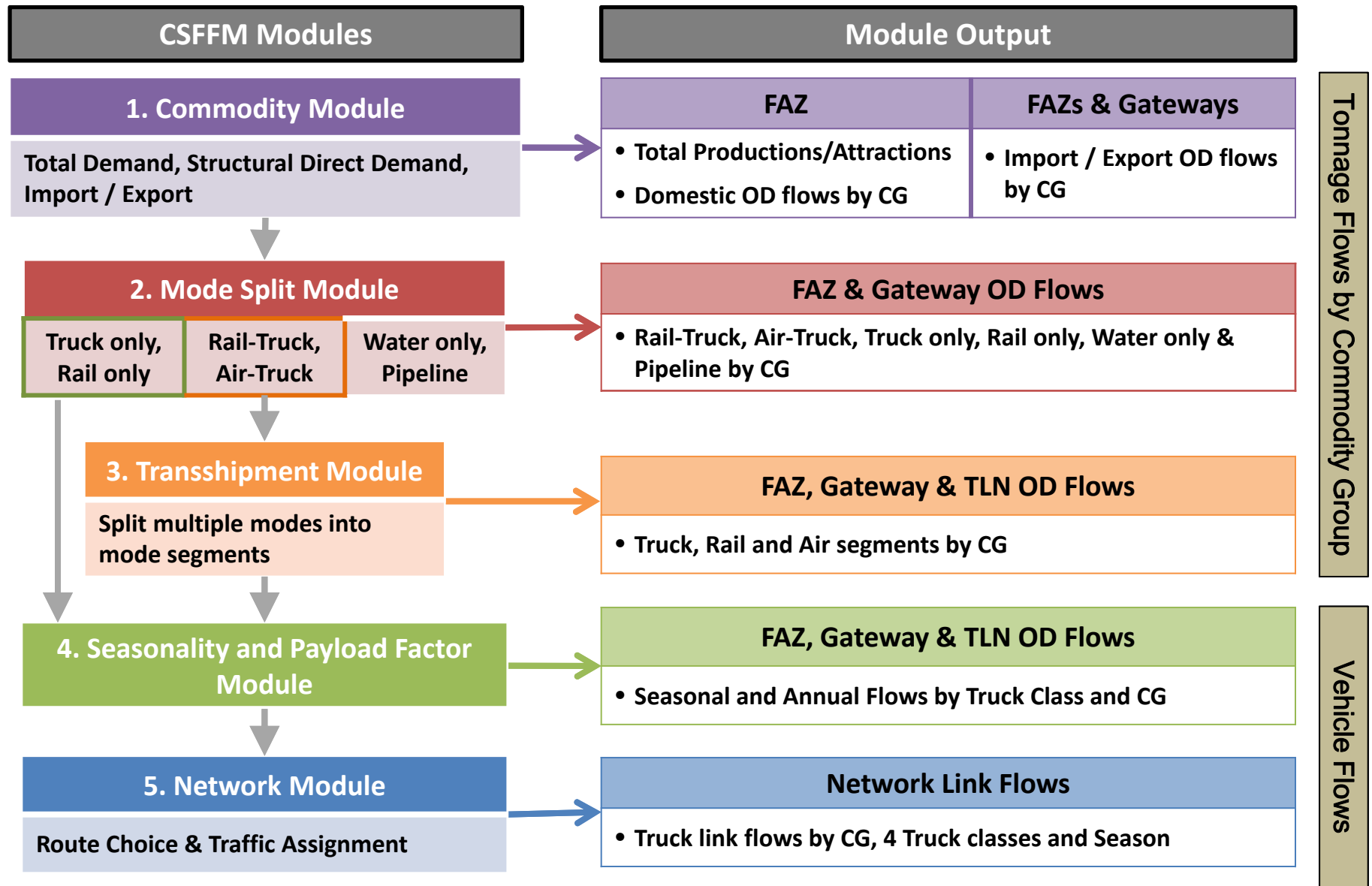- CFS sample size limitations : real zero flows vs. sampling error



Canada

Eastern Asia

South, Central & Western Asia

South-Eastern Asia & Oceania

Mexico

Rest of Americas

Europe

Africa

**FAF3 Analysis Zones**
- Metro Regions
- Entire States
- State Remainders

0   200   400
Miles

CFS: Commodity Flow Survey

# Comparison of Key FAF3 and CSFFM Attributes

| FAF3 | Dimension | CSFFM |
|---|---|---|
| 5 FAF zones in California | Zones | 97 FAZs in California + Gateway and Transshipment Nodes |
| National Interstate Truck Routes (freeways) | Network | Major arterials |
| 43 Commodity Groups by Tonnage and Value | Commodities | 14 Commodity Groups + Empty Trucks |
| 3 Single Modes, 2 Multiple Modes | Mode | Single modes, Decomposed Multi-mode Segments |
| Annual | Temporal | Seasonal / Annual Daily Volumes |
| Long haul trucks | Flow Assignment | 4 Truck Classes |

**CSFFM: California Statewide Freight Forecasting Mode**

# CSFFM Primary Modules

| CSFFM Modules | Module Output | |
|---|---|---|

**1. Commodity Module**

Total Demand, Structural Direct Demand, Import / Export

| FAZ | FAZs & Gateways |
|---|---|
| • Total Productions/Attractions<br>• Domestic OD flows by CG | • Import / Export OD flows by CG |

**2. Mode Split Module**

| Truck only, Rail only | Rail-Truck, Air-Truck | Water only, Pipeline |
|---|---|---|

**FAZ & Gateway OD Flows**

• Rail-Truck, Air-Truck, Truck only, Rail only, Water only & Pipeline by CG

**3. Transshipment Module**

Split multiple modes into mode segments

**FAZ, Gateway & TLN OD Flows**

• Truck, Rail and Air segments by CG

**4. Seasonality and Payload Factor Module**

**FAZ, Gateway & TLN OD Flows**

• Seasonal and Annual Flows by Truck Class and CG

**5. Network Module**

Route Choice & Traffic Assignment

**Network Link Flows**

• Truck link flows by CG, 4 Truck classes and Season

*Tonnage Flows by Commodity Group*

*Vehicle Flows*

**FAZ**: Freight Analysis Zones, **OD**: Origin-Destination, **CG**: Commodity Group, **TLN**: Transportation Logistic Node

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# Truck Assignment Results

## Assignment by CSFFM Truck Categories for 2007
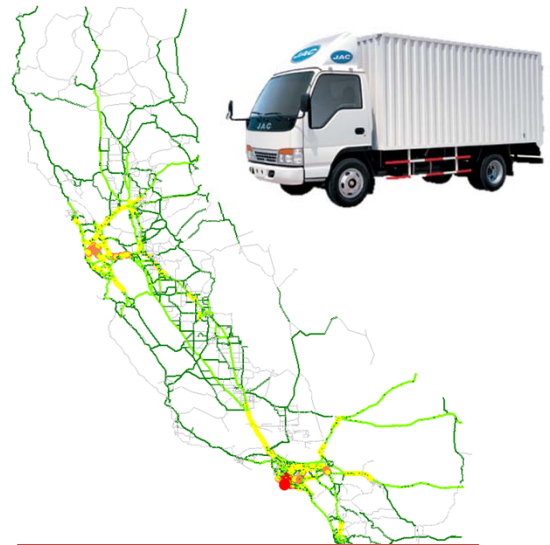


**CSFFM Truck Class 1**
(6-tire single units)

**CSFFM Truck Class 2**
(3+ axle single units)

**CSFFM Truck Class 3**
(Single trailers)

**CSFFM Truck Class 4**
(Multi trailers)

## Assignment of CSFFM Truck Classes 3 and 4 across 48 contiguous states for 2007



### Legend

Daily Directional Link Volumes

— > 6,000 Trucks

— 4,001 – 6,000 Trucks

— 2,001 – 4,000 Trucks

— 501 – 2,000 Trucks

— 101 – 500 Trucks

— 1 – 100 Trucks

# Integration with CSTDM

| Common Master Network | CSFFM and CSTDM networks are generated from the same master network |
| --- | --- |
| | Centroid IDs are consistent. |
| | CSFFM zones are an aggregation of CSTDM zones |

**CSFFM's _Final Truck Matrix_ can be disaggregated using the CSFFM Disaggregation Module to match CSTDM's zoning system**

**CSFFM FAZs**

**CSTDM TAZs**

Legend
☐ Caltrans Districts
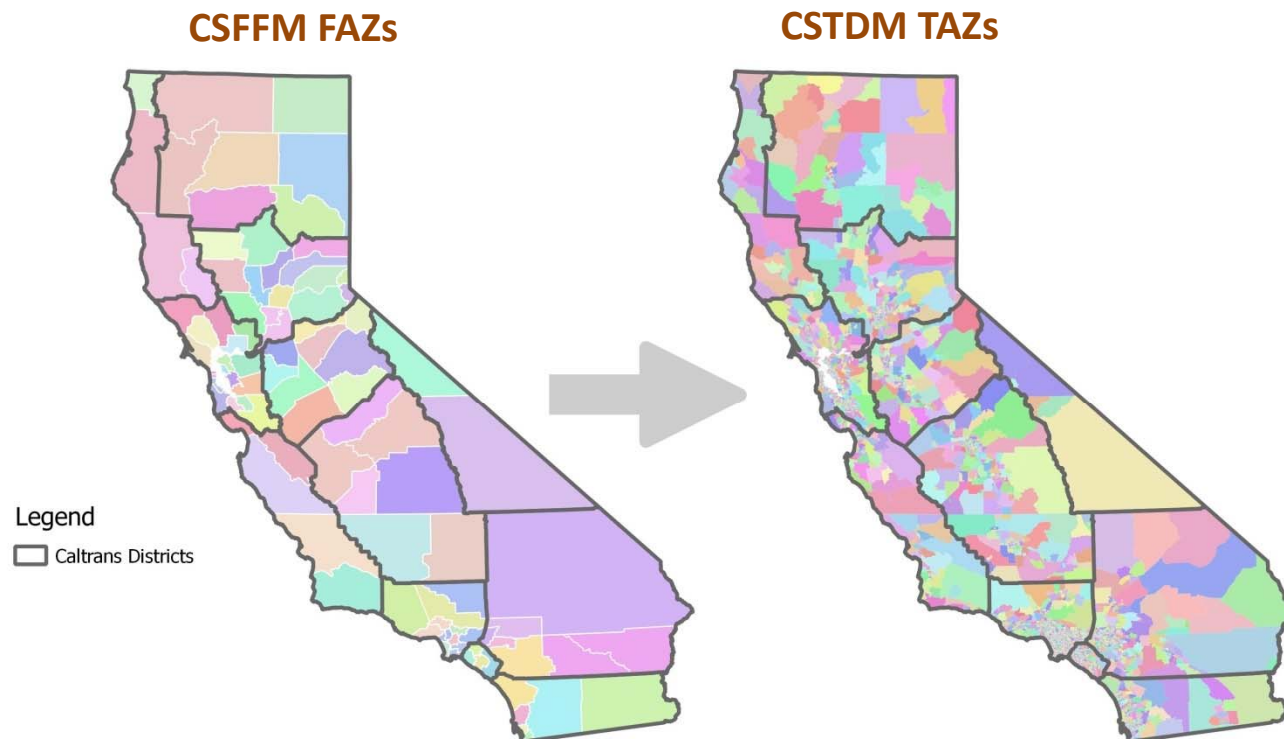
# Some CSFFM Uses

## Stand-alone Applications

- Statewide analysis of demo-economic changes at FAZ level (in and outside of CA)
- Major upgrade of transportation facilities
  - e.g. new corridors or facility type upgrades
- Mode-shift analysis between truck and rail

## Integration with CSTDM or regional models

- Sub-area and Project-level analysis
  - Congestion
  - Capacity upgrades

# Example Scenarios



Oil Prices Increase

Extended Drought

L.A. Metro Transportation Corridor Upgrades

Alameda Rail Corridor Closure

# 25 Percent Oil Price Increase

## Scenario Setup

- 17 percent increase in diesel for truck mode
- 6.4 percent increase in rail operating cost
- 5 percent decrease in all employment sectors and GDP



Legend
base_diesel_17pct_comp
-2096.9395 - -1002.4895
-1002.4895 - -282.9339
-282.9339 - -120.0301
-120.0301 - -33.0300
-33.0300 - 663.2533
OpenStreetMap

Truck Flow Changes in LA Metro Area



Legend
base_diesel_17pct_comp
-2096.94 - -1067.26
-1067.26 - -296.31
-296.31 - -118.29
-118.29 - -31.88
-31.88 - 663.25
OpenStreetMap

Truck Flow Changes in California

13
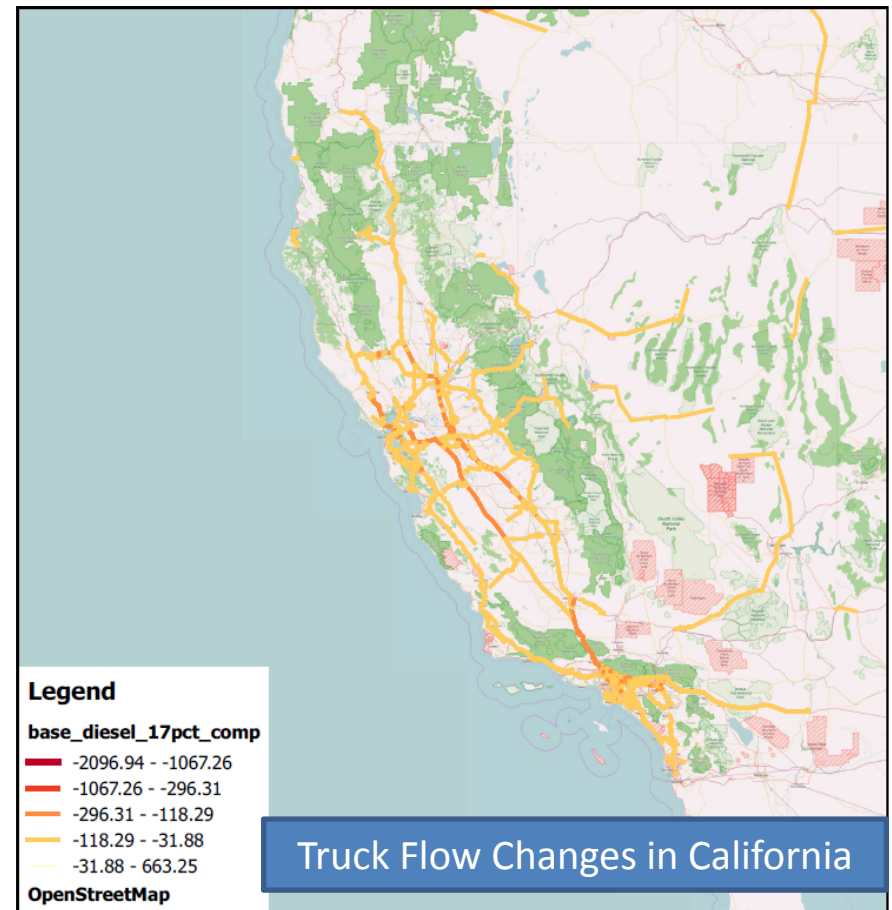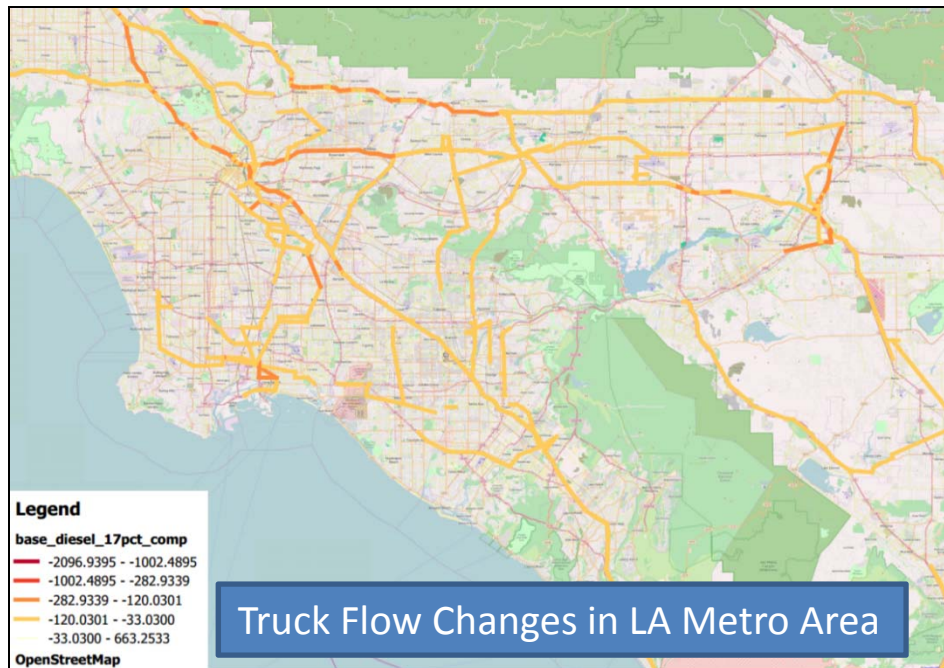
# 2020 Extended Drought

- **30 percent Fallowed Acres**
- **Employment reduction in 7 industry categories**

## Changes in VMT at FAZ Level



**Legend**

**Change in Vehicle Miles Traveled (VMT)**

- □ > 0.0%
- □ 0.0% - -0.5%
- □ -0.5% - -1.0%
- □ -1.0% - -1.5%
- □ -1.5% - -2.0%
- □ -2.0% - -2.5%
- ■ < -2.5%
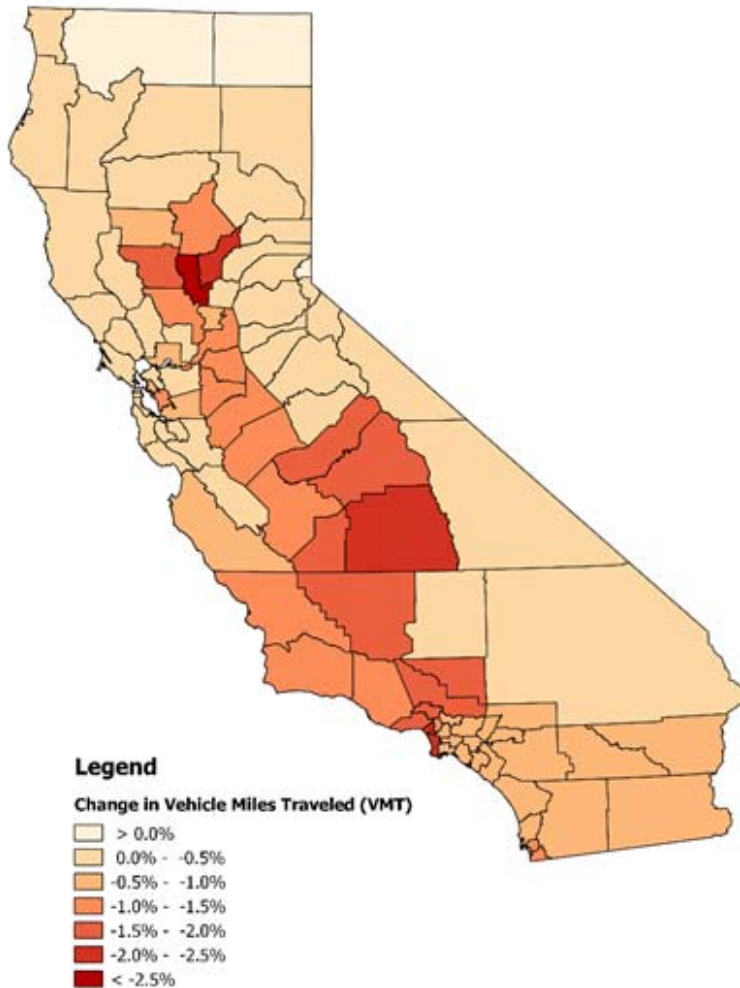
## Changes in Truck Volumes on Highway Network



**Legend**

□ FAZ Boundaries

**Truck Volumes**

- — > 20
- — 20 - -20
- — -20 - -40
- — -40 - -60
- — -60 - -80
- — -80 - -100
- — -100 - -200
- — -200 - -300
- — < -300
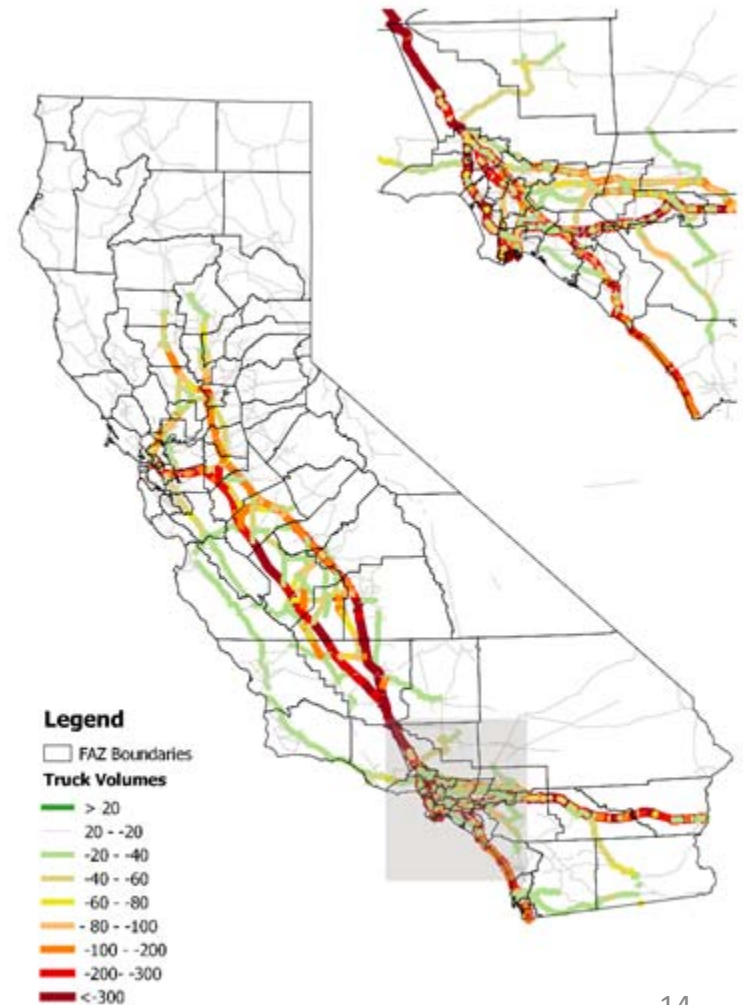
- **Capacity expansion along I-405 and I-710 corridors**
- **Increase in corridor speeds can be obtained from CSTDM**
- **Uniform 10 % corridor speed increase assumed for this example**



Legend

Freeways & Expressways

— Freeway
— Expressway
▭ Caltrans Districts

Truck Volume Difference from Base Scenario

— < -3500
— -3500 - -2000
— -2000 - -1000
— -1000 - -500
— -500 - -200
— -200 - 200
— 200 - 500
— 500 - 1000
— 1000 - 2000
— 2000 - 3500
— > 3500
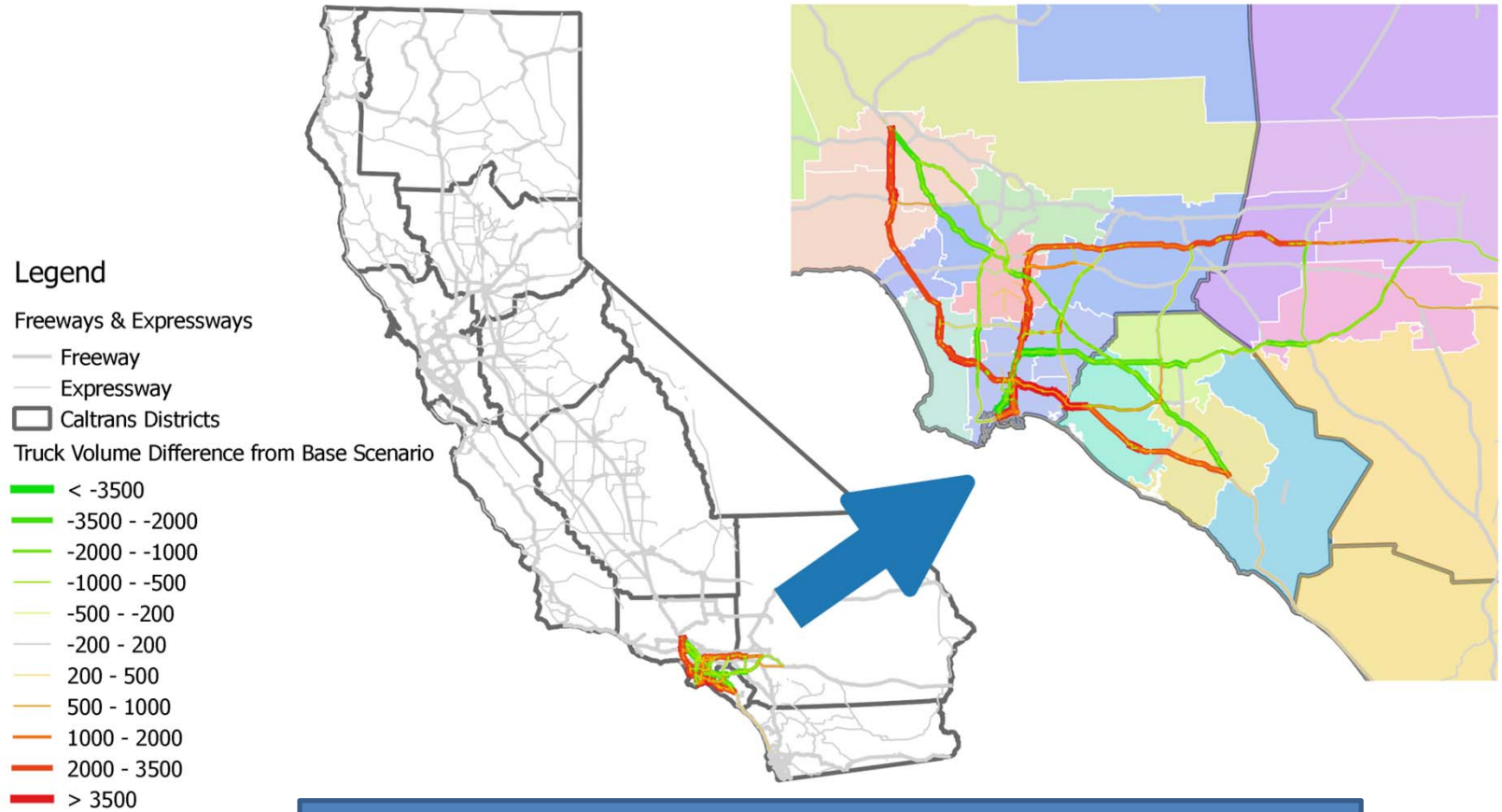
**Model predicts regional network impacts:**
- ➤ **Increased truck volumes on I-405, I-710 & I-10**
- ➤ **Reduced truck volumes on I-5 & SR-91**

# Alameda Rail Corridor Closure

- **Move rail flows from ports to trucks**

**Legend**

**base_alameda_comp**

— -0.5000 - 139.3101
— 139.3101 - 490.1814
— 490.1814 - 973.6003
— 973.6003 - 1513.7035
— 1513.7035 - 2569.5308

**OpenStreetMap**

**Model predicts regional network impacts:**
➢ **Increased truck volumes (to varying degrees) for routes serving the ports**
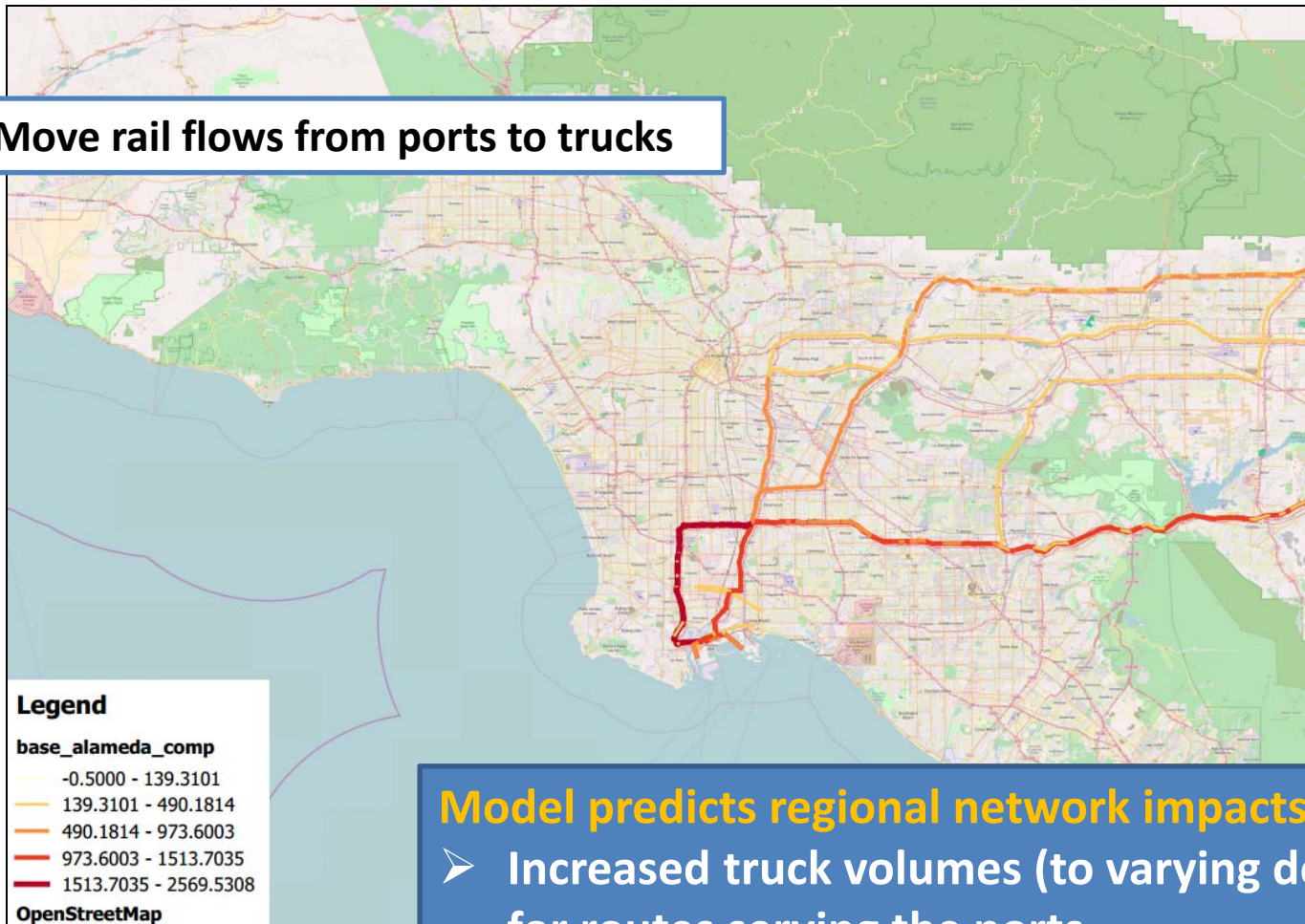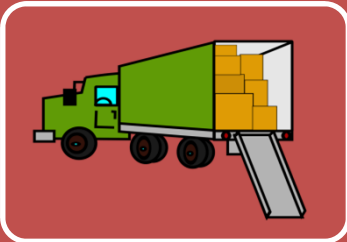
# Follow-up Efforts

 California Vehicle Inventory and Use Survey (Cal-VIUS)

 Truck Activity Monitoring System (TAMS)
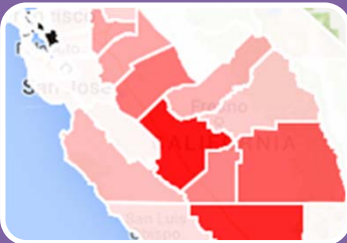
 Online California Freight Data Repository (Cal-FRED) Update

## Follow-up Efforts: California Vehicle Inventory and use Survey (Cal-VIUS) Studies

- Designed to address limitations in 2002 VIUS by providing
  - In-state and out-of-state truck activity
  - Detailed commodity and payload information by truck and trailer configuration
  - Empty factors by truck activity
- Pilot study completed by UCI using web-based platform
- Full study underway
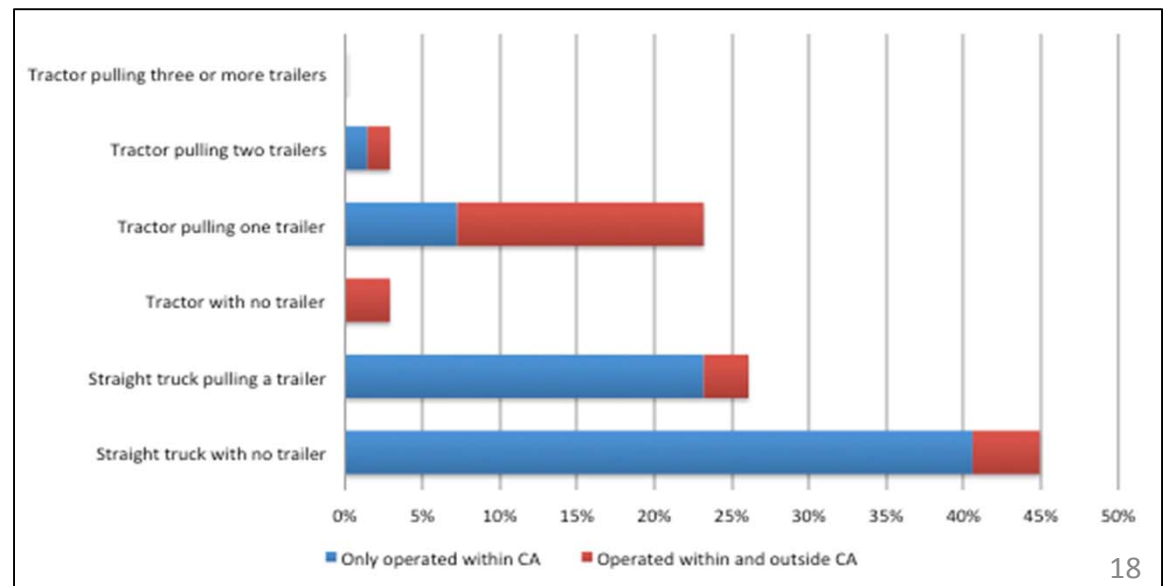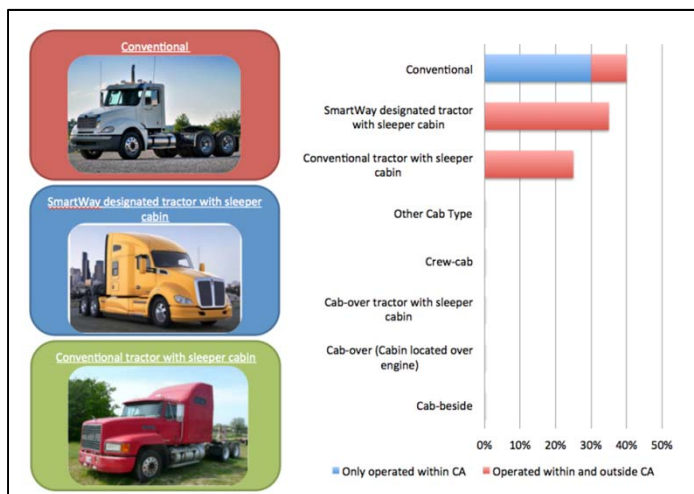
# Follow-up Efforts: Advanced Truck Data Collection



Deployed Locations

- Pilot Study (Completed by UCI in 2015)
  - Detailed classification of **truck and trailer body configurations** at existing WIM and inductive loop only sites using **inductive signature data** (combined with **WIM data** at WIM sites)
  - Pilot study completed by UCI with implementation at **16 locations in San Joaquin Valley**

- Enhancement Study and Extended Implementation by UCI (Started Aug 2015)
  - Model improvements
  - Investigation of new facility types
  - Extended implementation of **76 additional sites throughout CA**



| Site List | Sites ▾ | | | Config |
|---|---|---|---|---|

**REID Monitor for TST103 (SR205_MH)** 2015-06-19 17:26:56 was the last update; waiting for more...

| | | | | |
|---|---|---|---|---|
| DetStaId | 10002 | 10002 | 10002 | 10002 |
| ISTSN | 1031 | 1077 | 1064 | 1022 |
| LaneDir | 3 | 3 | 4 | 4 |
| Lane | 2 | 3 | 2 | 3 |
| timestamp_full | 2015-06-19 17:26:56.279 | 2015-06-19 17:26:51.263 | 2015-06-19 17:26:53.967 | 2015-06-19 17:26:56.450 |
| Samples | 302 | 1034 | 297 | 932 |
| rawSigSamps | 189 | 651 | 210 | 595 |
| VehicleCount | 715 | 563 | 463 | 249 |
| duration | 0.2516666650772095 | 0.8616666793823242 | 0.2475000023841858 | 0.7766666412353516 |
| reserved | 10846 | 5497 | 18388 | 7563 |
| rawsig | | | | |

Screenshot of live signature data streaming from deployed site

Truck Activity Monitoring System (TAMS) showing significant intermodal container traffic along SR-205 Freeway between Port of Oakland and Lathrop rail facility

# Follow-up Efforts:
# Cal-FRED Update and Enhancement

# The End

# Commodity Module



- **Generates <u>Production/Consumption</u> and <u>Distribution</u> based on demo-economic data and impedance information (e.g., travel time and cost)**
- **Estimate import/export freight on gateways in CA**

# Mode Split Module
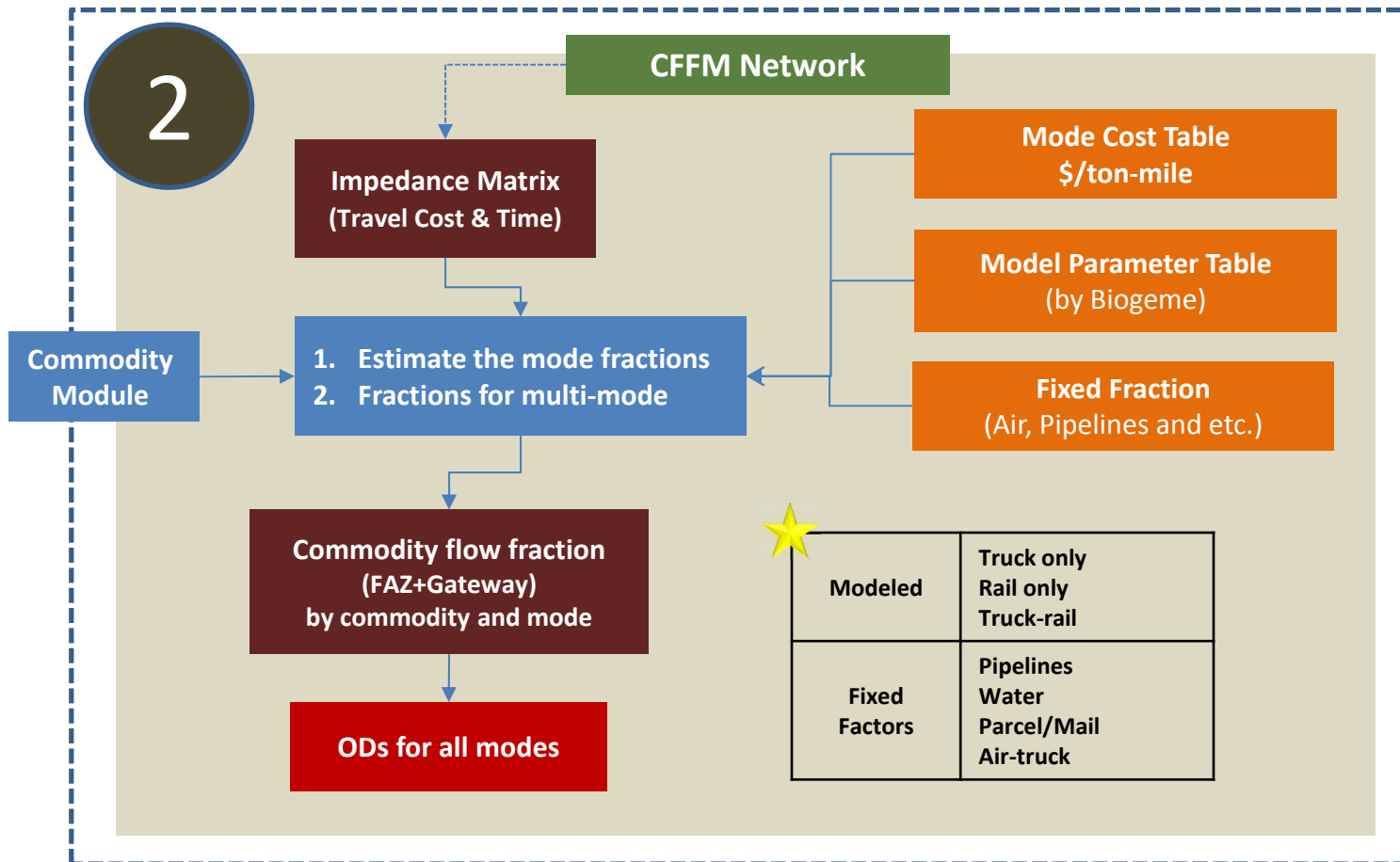


- Determines mode-share for each mode in each OD pair
- Aggregate mode split model estimated using FAF mode data
- Incremental logit models used to evaluate impacts of mode attribute changes

# Commodity Flow ODs for All Modes

**3**

FAZ + Gateway OD Matrices by Mode

OD Flows x Mode Fraction

| Truck Only | Rail Only | Multi-mode: Parcel by Trucks | Multi-mode: Truck + Rail | Truck + Air | Water Only | Pipelines |
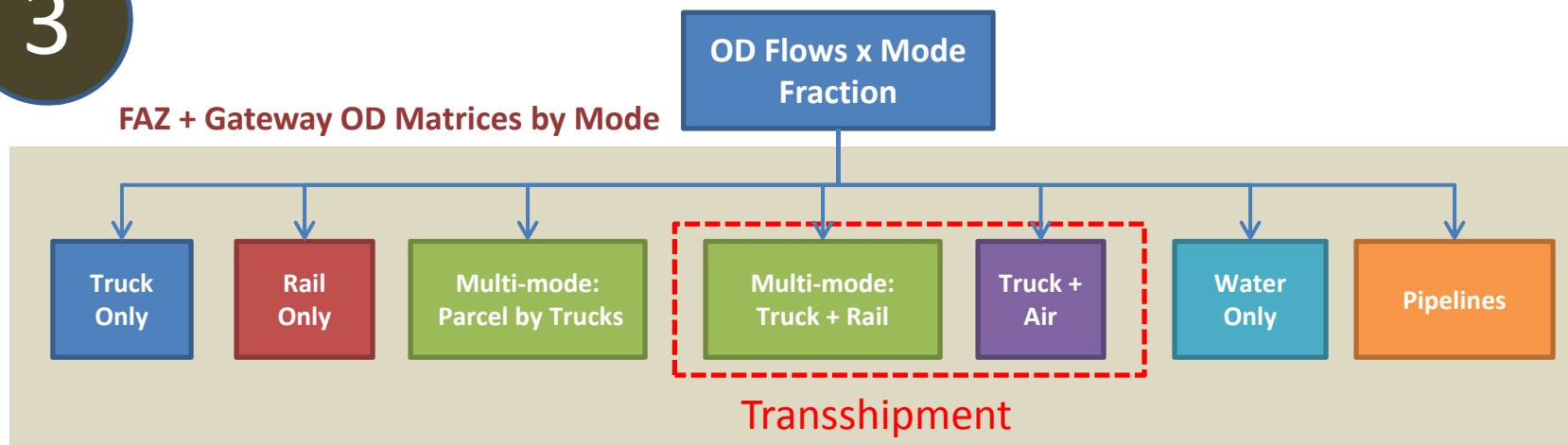
Transshipment

- **Commodity ODs for <u>Water Only</u> and <u>Pipelines</u> are final output for those modes.**

- **Commodity ODs for <u>Truck only</u>, <u>Rail only</u>, and <u>Multiple-mode (parcel by Truck)</u>**
  - **Bypasses Transshipment Module from the model structure**
  - **Procedure: (Commodity ODs) → Conversion from Tonnage to Vehicle → Network Module**

- **Commodity ODs for <u>Truck-rail</u> and <u>Truck-Air</u>**
  - **Procedure: (Commodity ODs) → Transshipment Module → Conversion from Tonnage to Vehicle → Network Module**

# Data Flow of Transshipment Module

**Data Files** | **Modules**
**Parameters** | **Model Output**

**4**

[Module] O/Ds for all modes

Truck only O/Ds

Adjacency matrix
(FAZ+Gateway+TLN)

CFFM Network

**Conversion Module**

**Truck Flows (Tonnage)**

Truck-Rail O/Ds
Truck-Air O/Ds

Capacity at TLN

Transfer Cost at TLN

**Connecting Truck Flows** (from Truck-Rail & Truck- Air)

**Transshipment**

1. Assign commodity flows at TLN
2. Two independent procedures: (Truck - Rail and Truck - Air)

Transport Cost Structure

Performance function

**Rail Flows (Tonnage)**

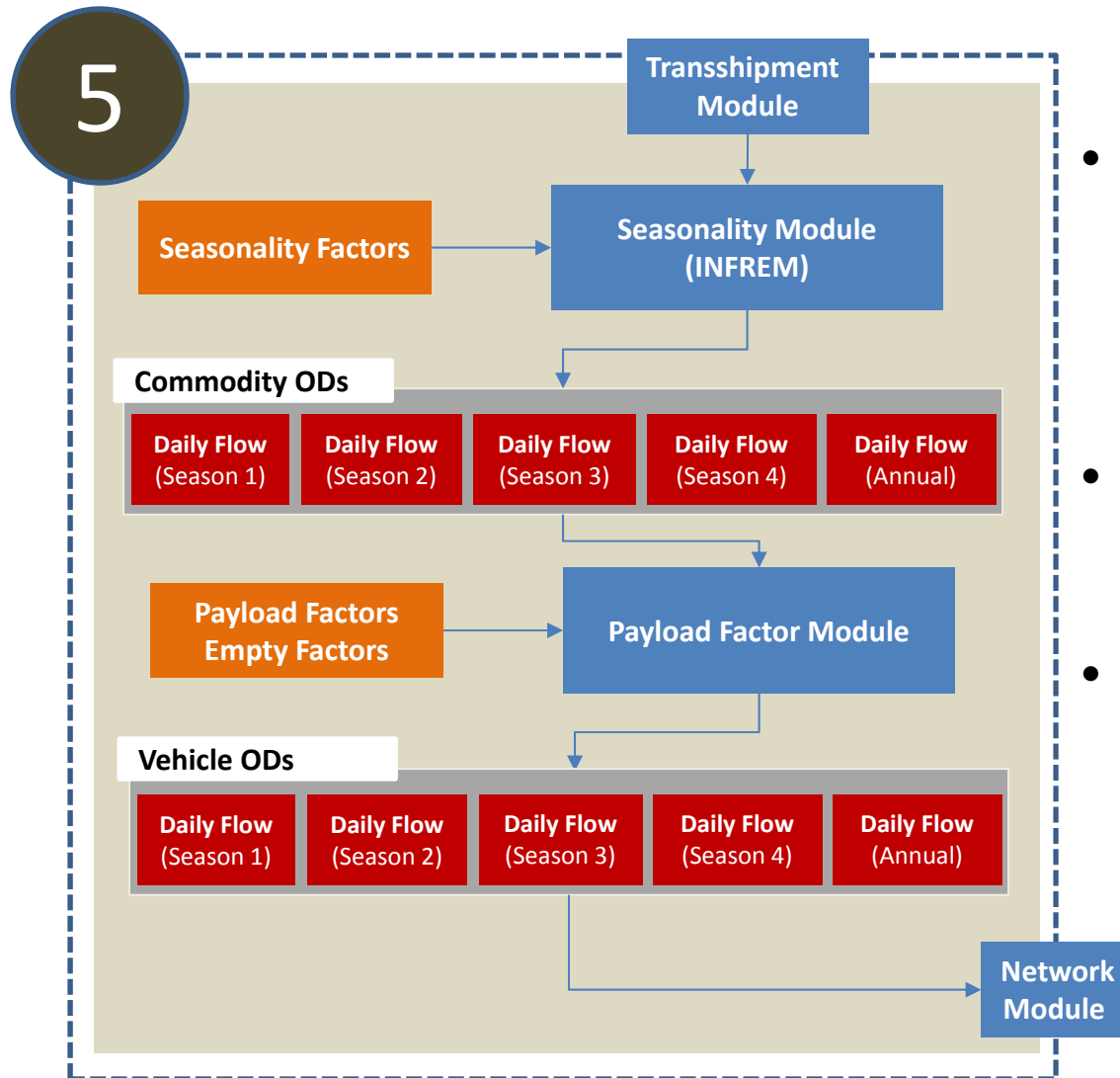**Air Flows (Tonnage)**

- **Decompose inter-modal trips into Truck/Rail/Air segments (Tonnage based)**
- **Determine which TLNs are used for each freight movement**
- **Three major inputs: (1) Truck-Air O/D, (2) Truck-Rail O/D, (3) Facility Data**
- **Three major outputs: (1) Truck, (2) Air, and (3) Rail segment O/Ds at FAZ + Gateway +TLN level**

# Seasonality and Payload Factor Module



**5**

Transshipment Module

Seasonality Factors → Seasonality Module (INFREM)

**Commodity ODs**

| Daily Flow (Season 1) | Daily Flow (Season 2) | Daily Flow (Season 3) | Daily Flow (Season 4) | Daily Flow (Annual) |

Payload Factors Empty Factors → Payload Factor Module

**Vehicle ODs**

| Daily Flow (Season 1) | Daily Flow (Season 2) | Daily Flow (Season 3) | Daily Flow (Season 4) | Daily Flow (Annual) |

Network Module

**Legend:**
- Data Files
- Modules
- Parameters
- Model Output

- **Three major inputs:**
  - Truck tonnage
  - Multi-mode (Parcel by Truck)
  - Truck from Transshipment

- **Seasonality by INFREM**
  - 4 seasons and annual tonnage

- **Tonnage to Vehicles**
  - Daily/Annual truck flows
  - Payload factor
  - FHWA Truck types
  - Empty factor

# Network Module
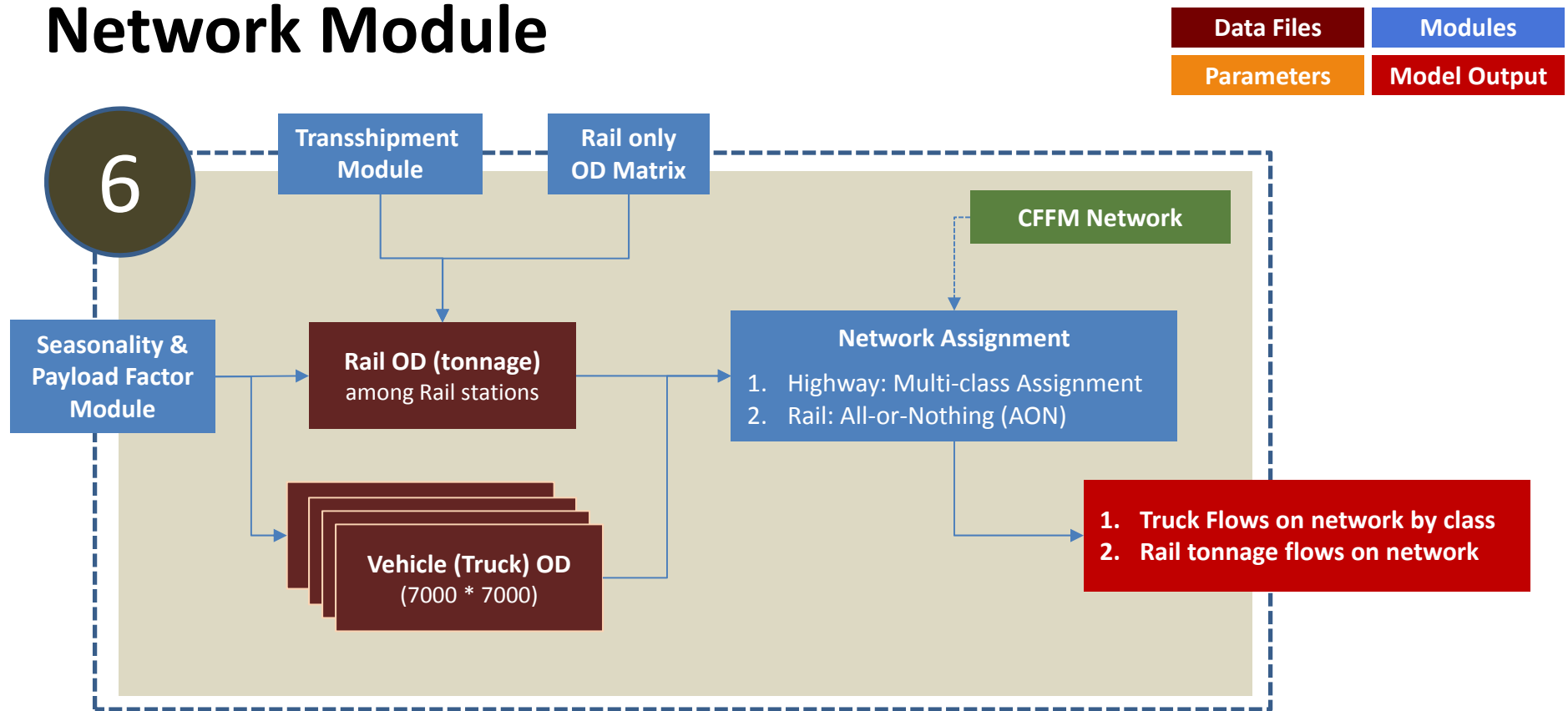


- **Highway Truck Assignment (Multi-class Assignment):**
  - **Multi-class Multi-path static assignment (calibrated with ATRI truck GPS)**
- Rail Assignment:
  - **All-or-Nothing (AON) – tonnage based**