



An Update to SCAG's External Heavy Truck Model using Firm Synthesis and Supply Chain Modeling Techniques

SCAG Modeling Task Force

July 29, 2018

Outline

- Freight and truck modeling concepts
- External model design: introduction to model components
- Software design and visualization
- Discussion of model sensitivity





Design Overview

Behavior-Based Freight Models: 3 Types Emerging

Supply Chain Models

- Tend to be National in scope
- Some examples at State and Regional levels



- Focused on modeling commodity flows
- Includes components such as firm synthesis and supply chain models
- Mode and path selection

Behavior-Based Freight Models: 3 Types Emerging

Supply Chain Models

- Tend to be National in scope
- Some examples at State and Regional levels

Tour-based Models

- Tend to be Regional in scope
- Some examples at State and National levels

- Focused on modeling truck movements
- Includes components such as tour generation, vehicle type models, and time of days models
- Many build tours incrementally



Behavior-Based Freight Models: 3 Types Emerging

Supply Chain Models

Tour-based Models

Hybrid Models

- Combined supply chain and tour-based models
- For Regional/Statewide planning, but with a National component



- Models shipments using the supply chain framework
- Regional pick up and delivery of shipments is handled by touring trucks

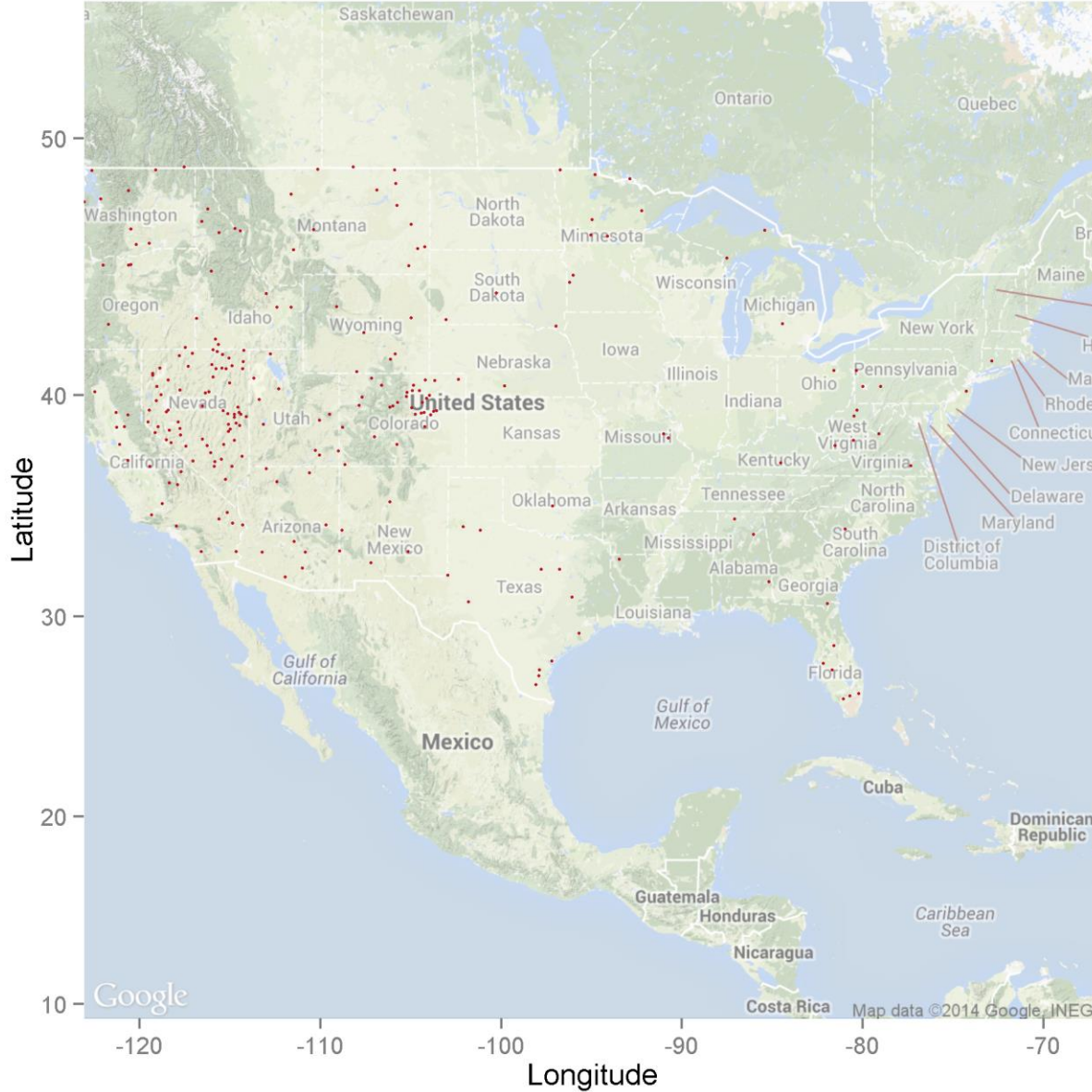
What is Firm Synthesis?

- **A model that creates a complete set of “agents” that represent firms**
- **The model embodies each of those firms with individual characteristics that affect the behavior that we are interested in modeling:**
 - Where are they located?
 - How large is the firm?
 - What industry do they operate in?
 - Which commodities do they consume?
 - Which commodities do they produce?
- **Concept is similar to population synthesis used in activity-based models**
 - In this case, households are the agents that are created
 - They are described in terms of location, size, etc.

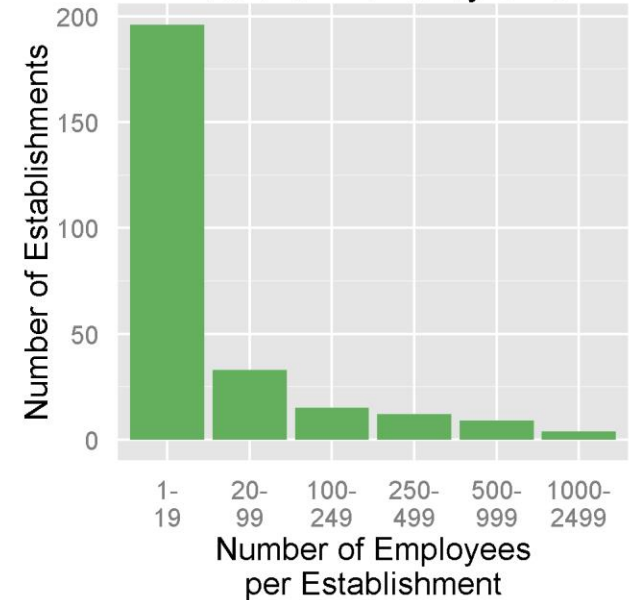


Producer Locations and Characteristics for Commodity 2122A0

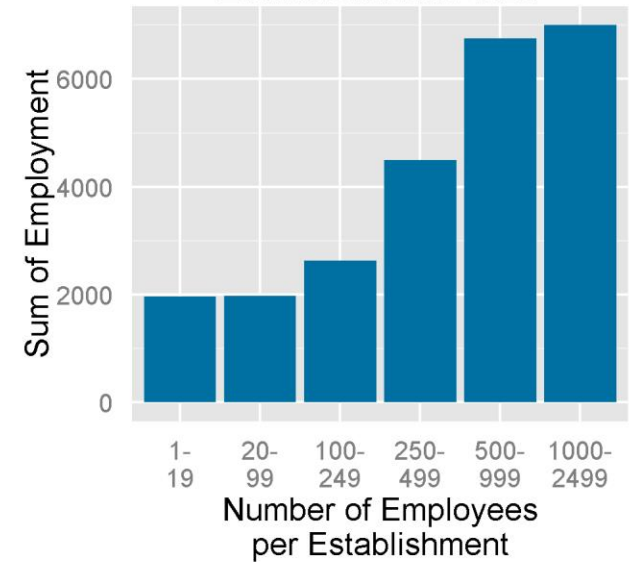
Producer Locations



Establishments by Size



Employment by Establishment Size



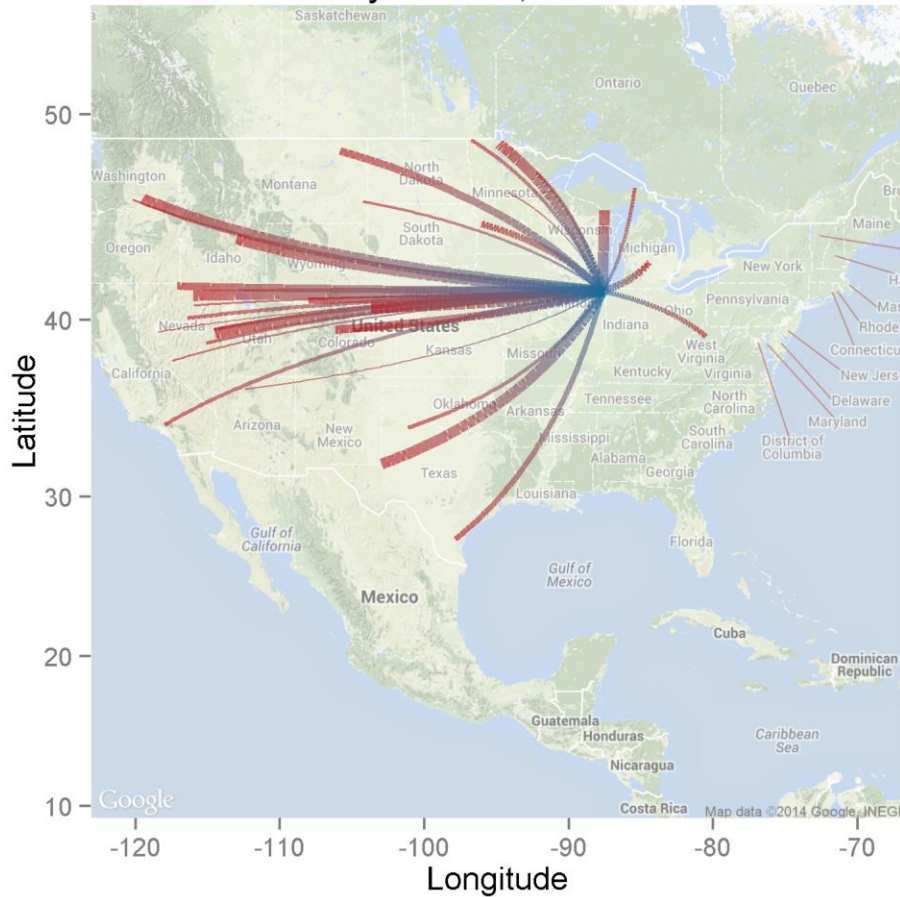
What are Production – Consumption Models?

- Given a set of firms with production capacity and consumption requirements, these models
 - Simulate trading between firms
 - Allow buyers to identify preferred suppliers
 - Estimate the amount (tons and value) of a commodity traded
 - Aggregated results are analogous to commodity flow origin-destination data (e.g. Freight Analysis Framework)
- Several approaches
 - Rule based approach (based on UIC's FAME work)
 - Procurement market games (game theory)

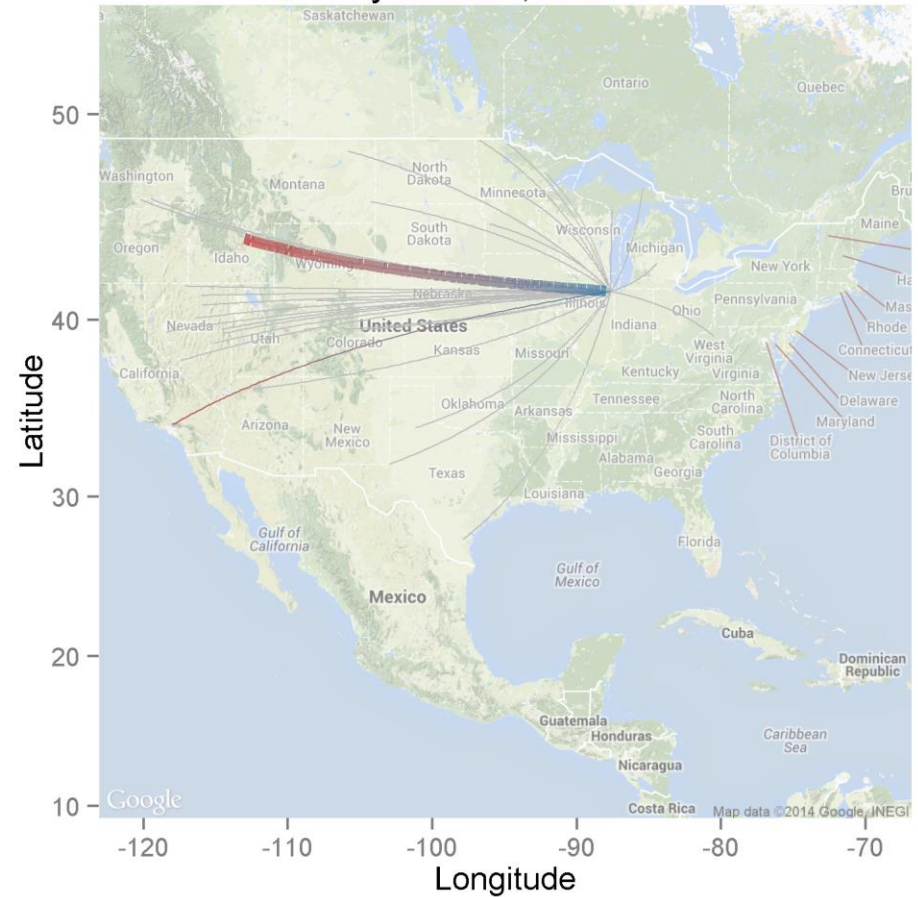


All Attempted Trades and Final Trades for One Buyer

Sellers That Buyer 851828 Attempted to Trade With Quantity Traded, All Iterations



Sellers That Buyer 851828 Attempted to Trade With Quantity Traded, Last Iteration



What are Logistics – Chain Models?

- This family of models simulate decisions made on how to move a commodity between supplier and buyer:
 - How often will shipments be made?
 - How large will the shipments be?
 - Which mode(s) will carry the shipments?
 - Which route will the shipments take?
 - Where will intermodal/within mode transfers take place?
- Model forms include Multinomial Logit Models and logistics cost equations





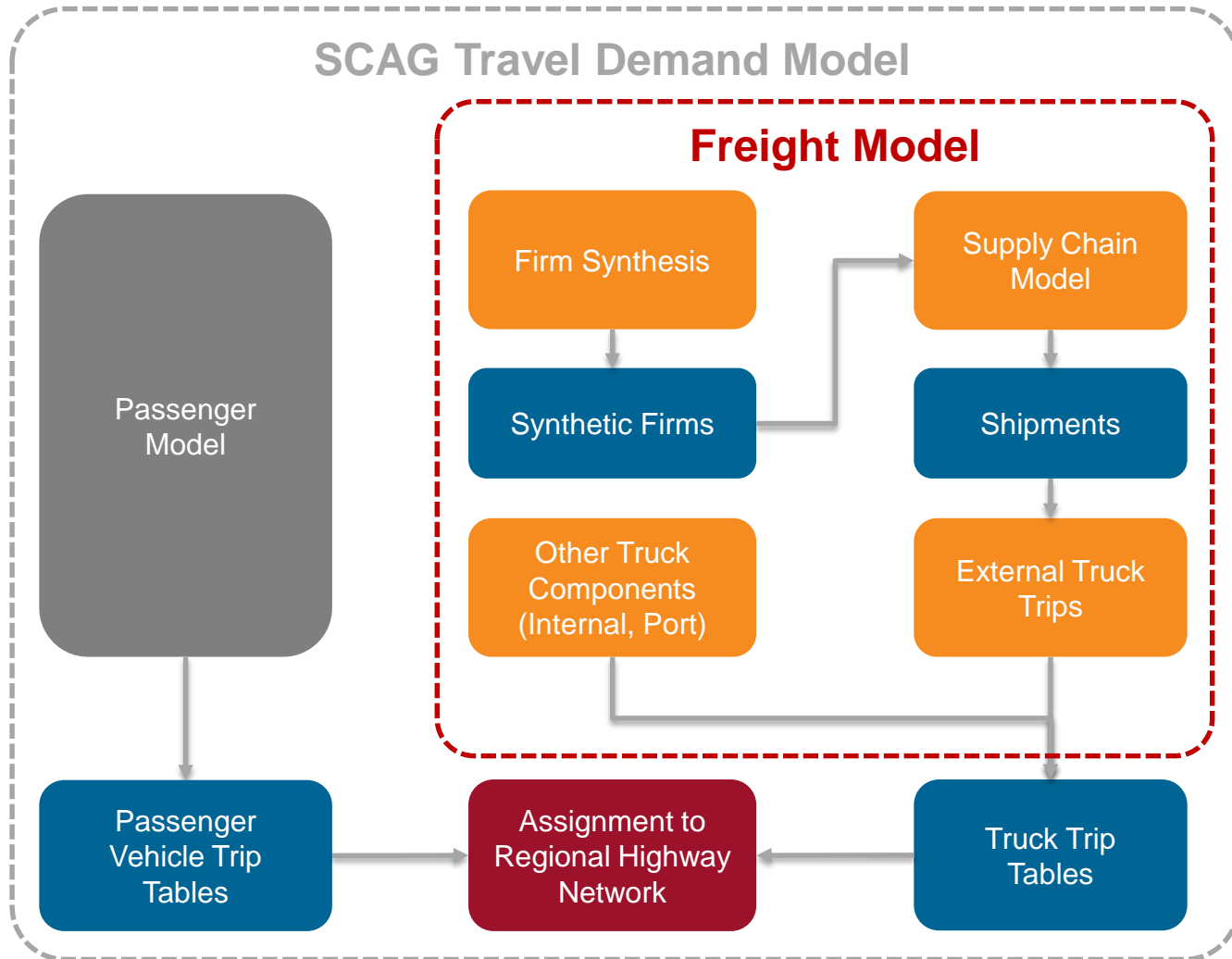
Model Design

Model Design Overview

- **Overall Model Structure**
 - Integrates data from multiple sources
 - Designed for integration within the rest of the SCAG Travel Demand Model
- **Firm Synthesis Model**
 - Synthesizes a set of business establishments that ship and receive freight in the region
- **Supply Chain Model**
 - Models annual commodity movements and shipment flows to and from the region by truck
- **External Truck Trips Model**
 - Allocates shipments to trucks to produce truck trip tables



Overall Model Design



Multiple Geographic Levels

- **National Supply Chain Model**
 - Include all of U.S, Canada, and external foreign zones
 - Uses FAF4 regions as zone system
 - Static travel times and distances (model input) to and from each TAZ to each SCAG external stations
- **California**
 - Use smaller zone system than FAF4 zones, the California Statewide Travel Demand Model TAZs.
 - Static travel times and distances (model input) to and from each TAZ to each SCAG external stations
- **SCAG Model Area**
 - Uses SCAG model network and zones

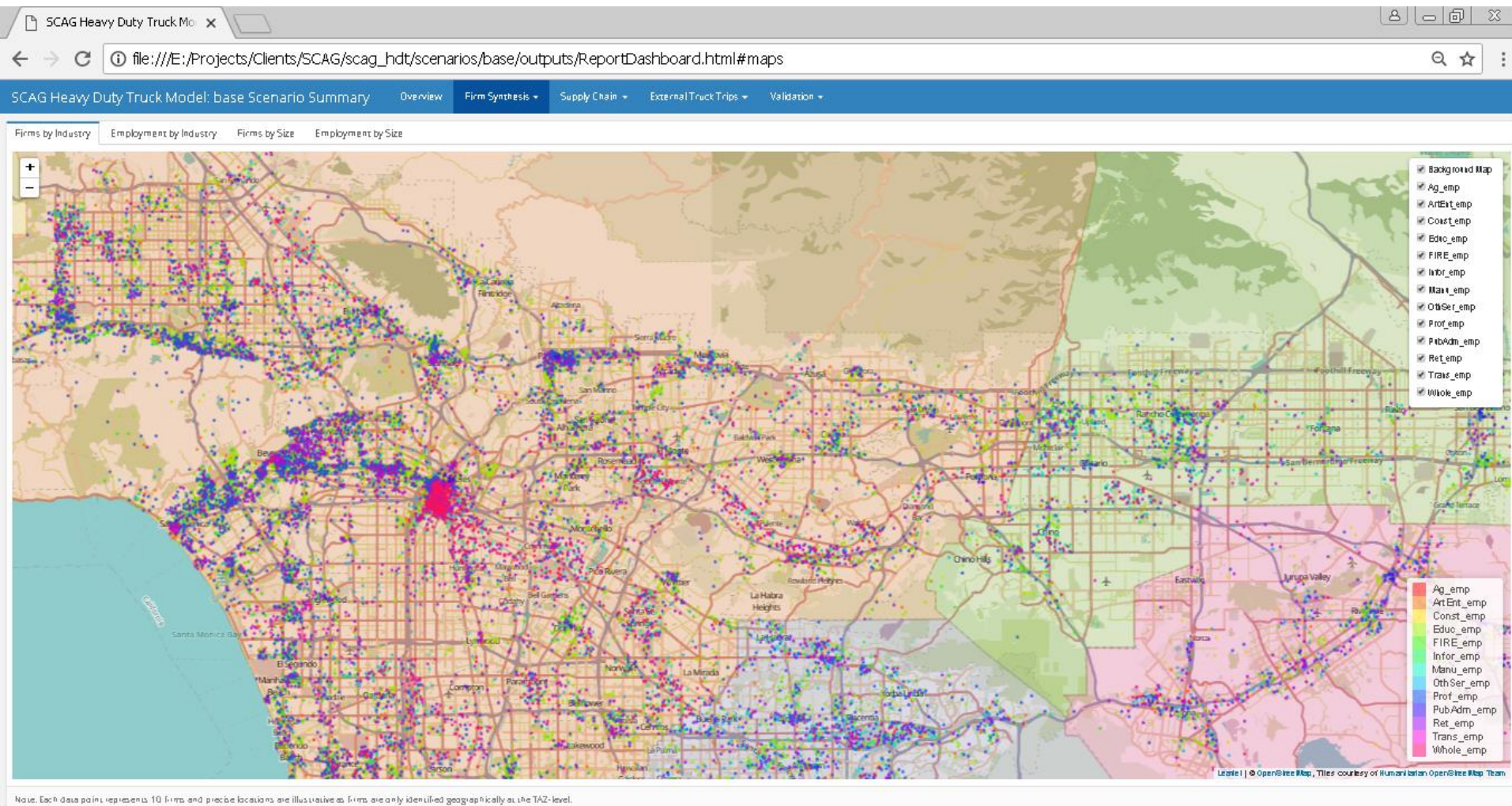


Firm Synthesis Data Needs

- **SCAG Region Data**
 - Point business locations – InfoUSA
 - TAZ control data for base and future years – SCAG model
 - Spatial data – TAZ system
- **Business/Industry Data**
 - BEA input/output data



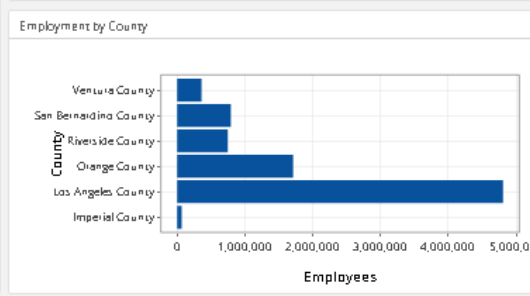
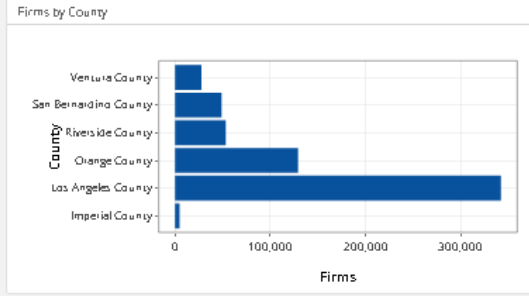
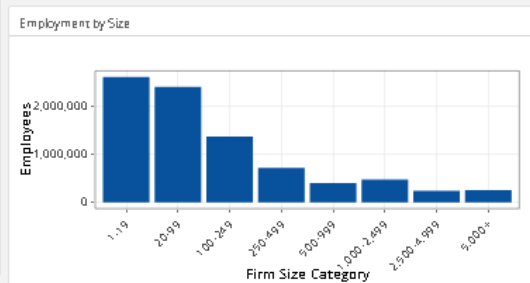
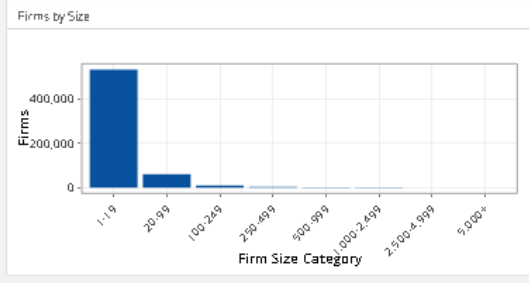
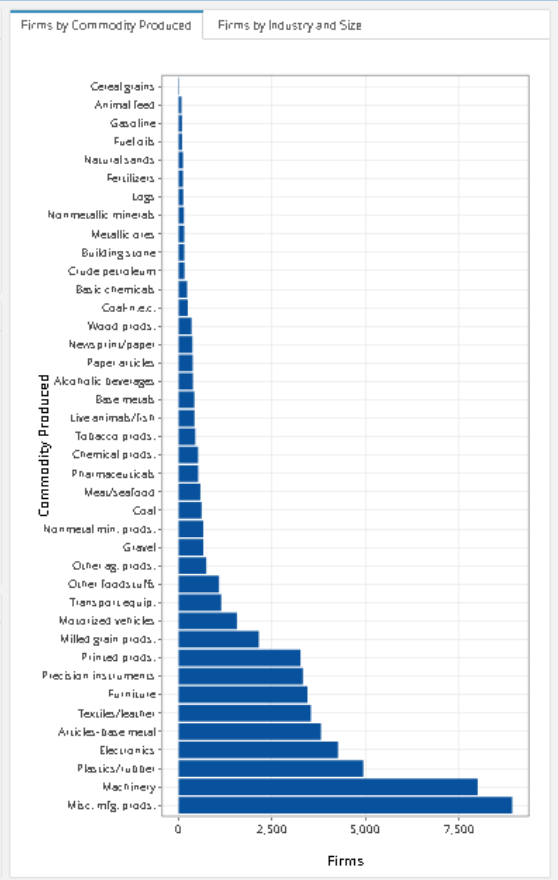
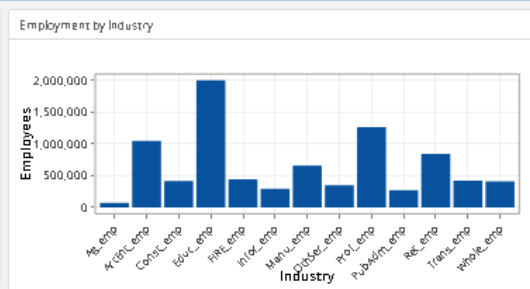
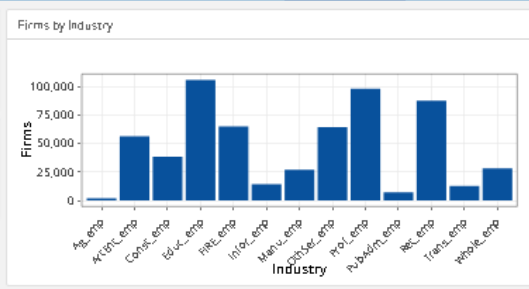
Firm Synthesis Model Outputs



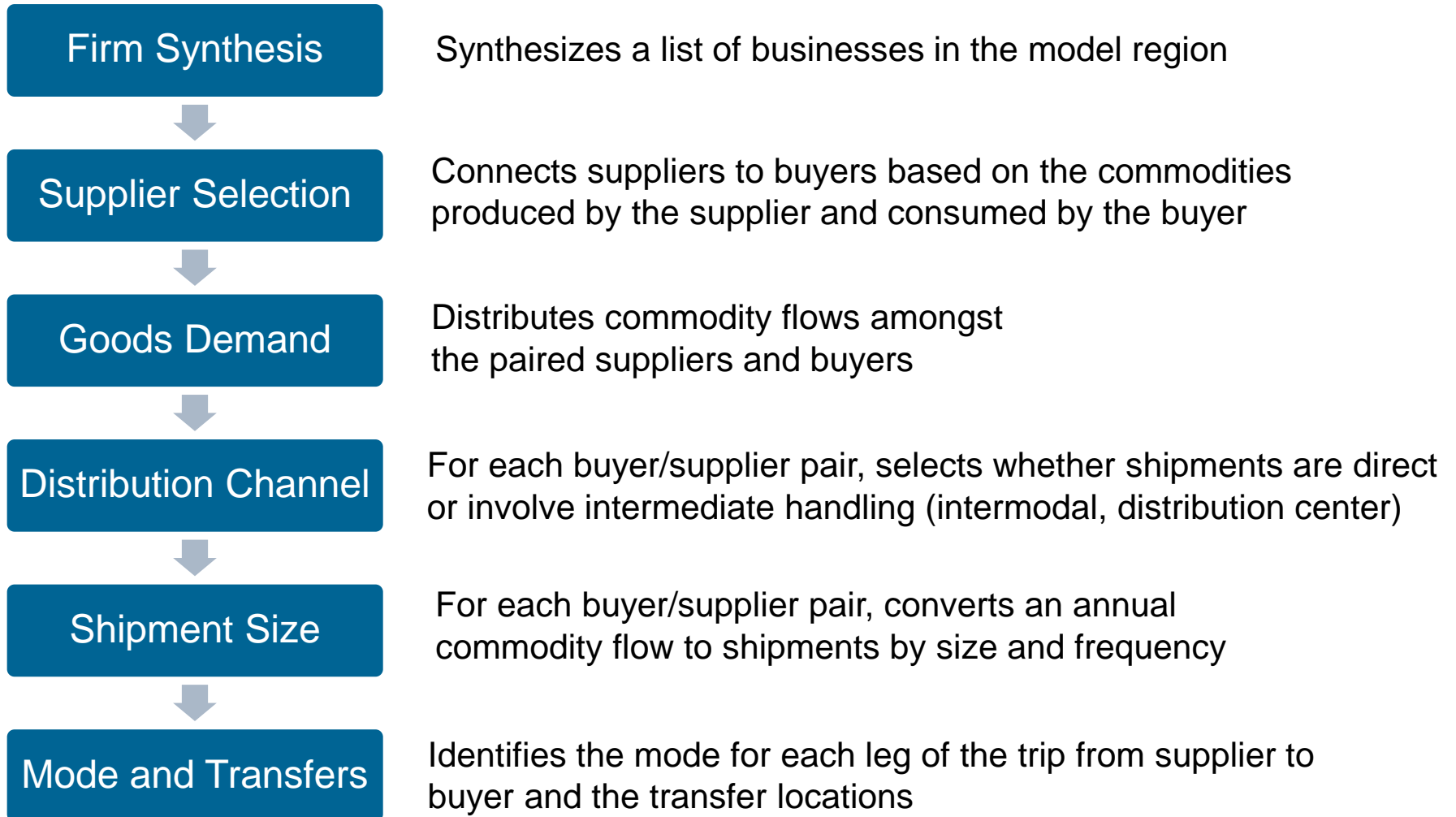
Firm Synthesis Model Outputs

606,148
Synthesized Firms

8,479,827
Synthesized Employees



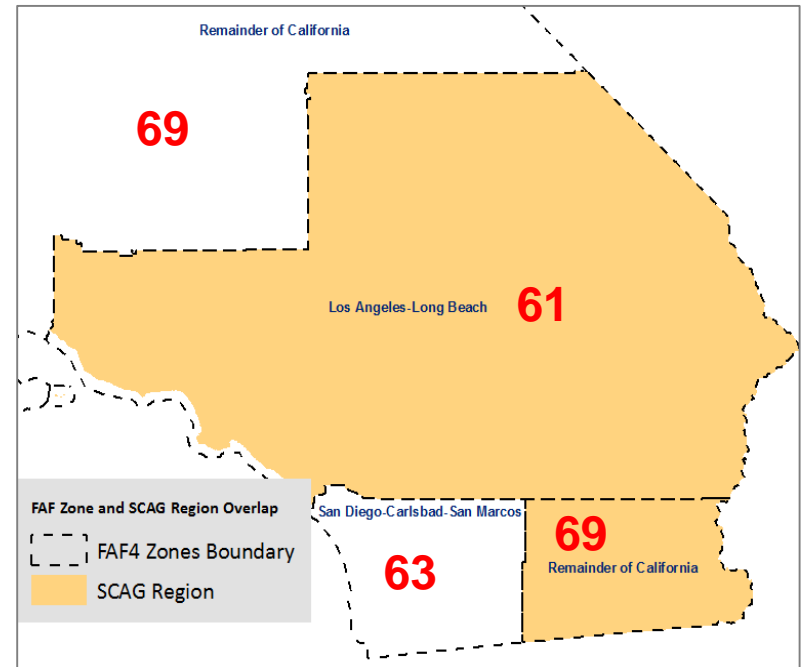
Supply Chain Framework



Supply Chain Data Requirements

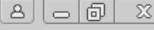
- **Commodity Flow Data**

- Base Year Commodity Flows (Freight Analysis Framework Data)
- Forecasted Commodity Flow Data (Transearch, FAF)
- Shipment Size Data (Commodity Flow Survey)



Supply Chain Model Outputs

SCAG Heavy Duty Truck Mo



file:///E:/Projects/Clients/SCAG/scag_hdt/scenarios/base/outputs/ReportDashboard.html#charts-1



SCAG Heavy Duty Truck Model: base Scenario Summary Overview Firm Synthesis Supply Chain External Truck Trips Validation

1,191,410,361

Annual Shipments

263,897,675

Annual Shipments (IX by Truck)

761,088,166

Annual Shipments (XI by Truck)

180,630,281

Annual Tonnage

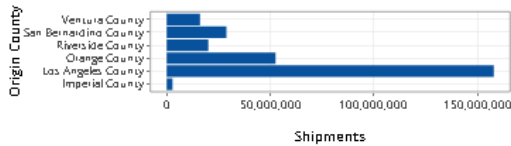
66,873,034

Annual Tonnage (IX by Truck)

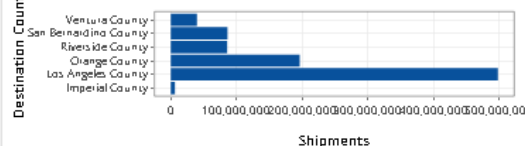
58,630,594

Annual Tonnage (XI by Truck)

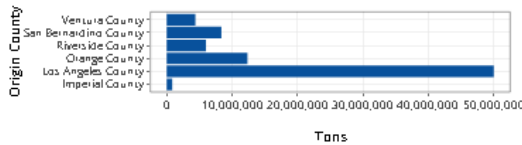
IX Shipments by County



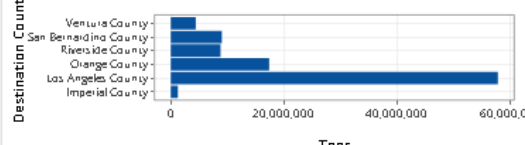
XI Shipments by County



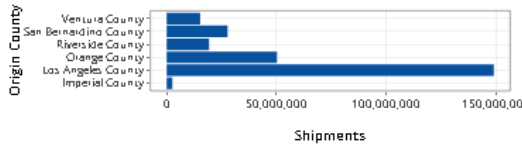
IX Tonnages by County



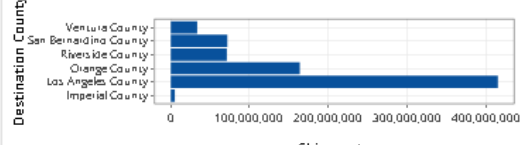
XI Tonnages by County



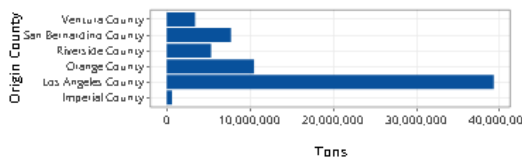
IX Truck Shipments by County



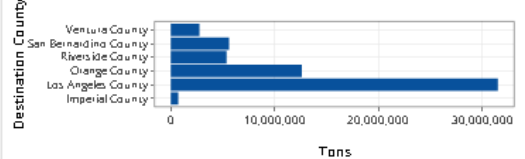
XI Truck Shipments by County



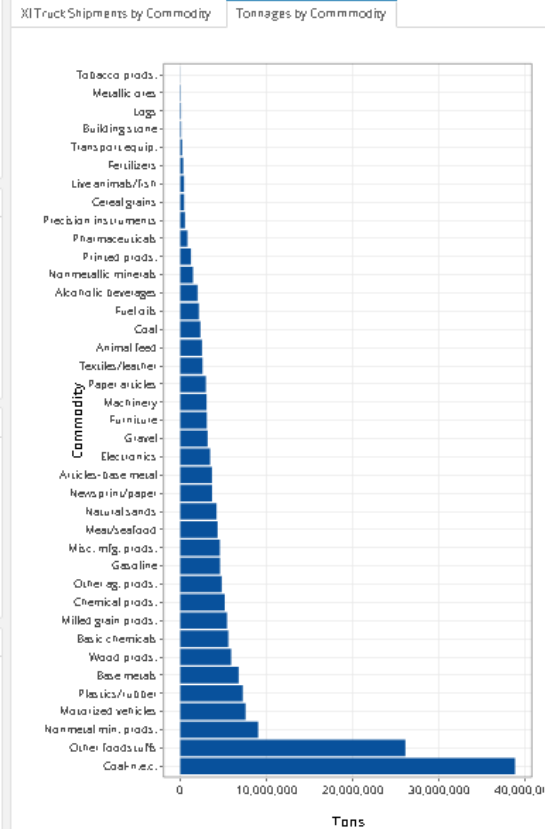
IX Truck Tonnages by County



XI Truck Tonnages by County



Shipments by Commodity IX Truck Shipments by Commodity

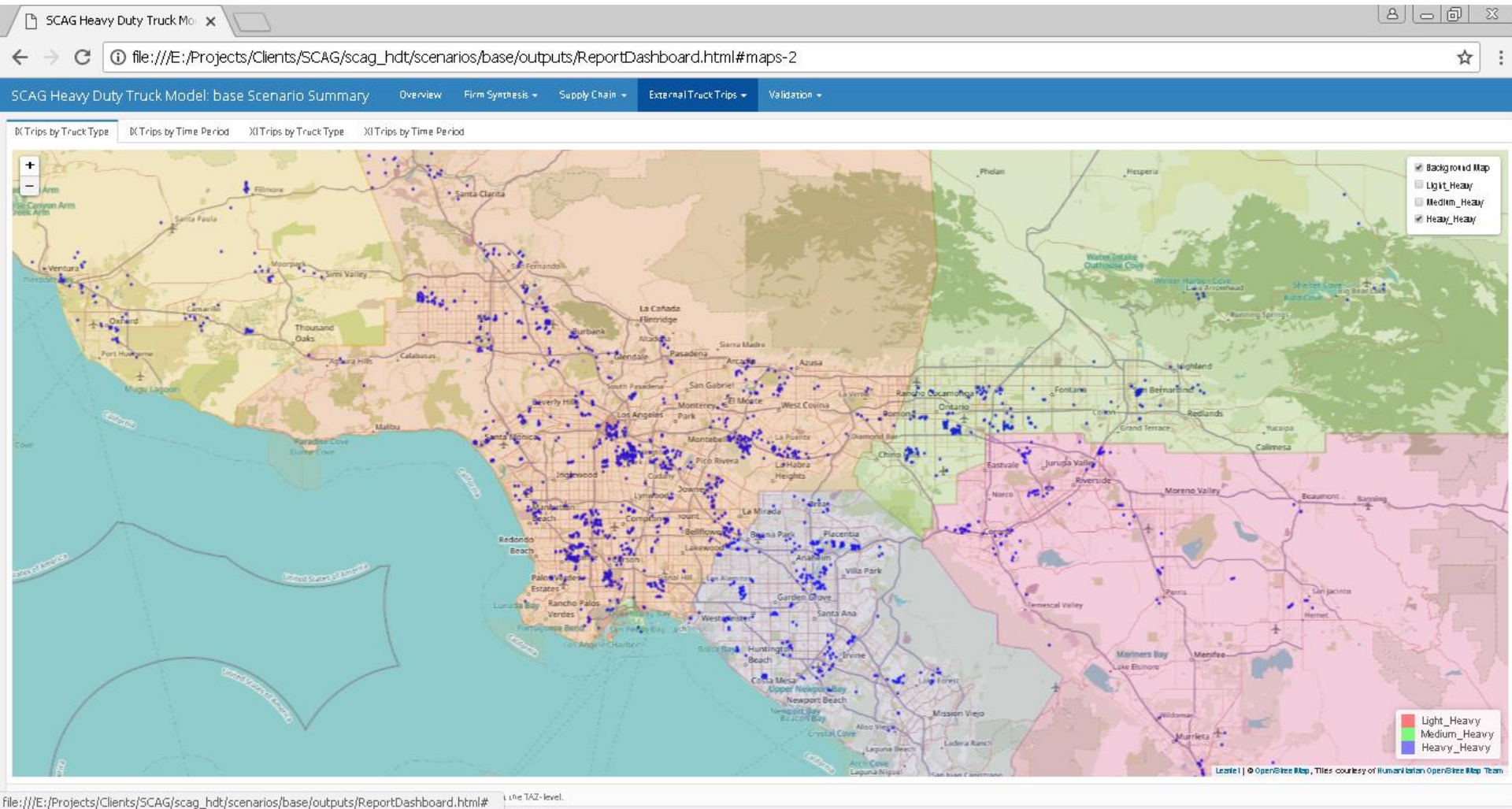


External Truck Trip Data Needs

- **Payload and empty factors**
 - Based on VIUS data by commodity
 - Regional (California) specific where sample supports, national otherwise
- **Calibration**
 - ATRI describing locations served by trucks to/from each external (as well as proportion that is external to external traffic)
 - Count data by truck class and time of day at each external station



External Trip Model Outputs





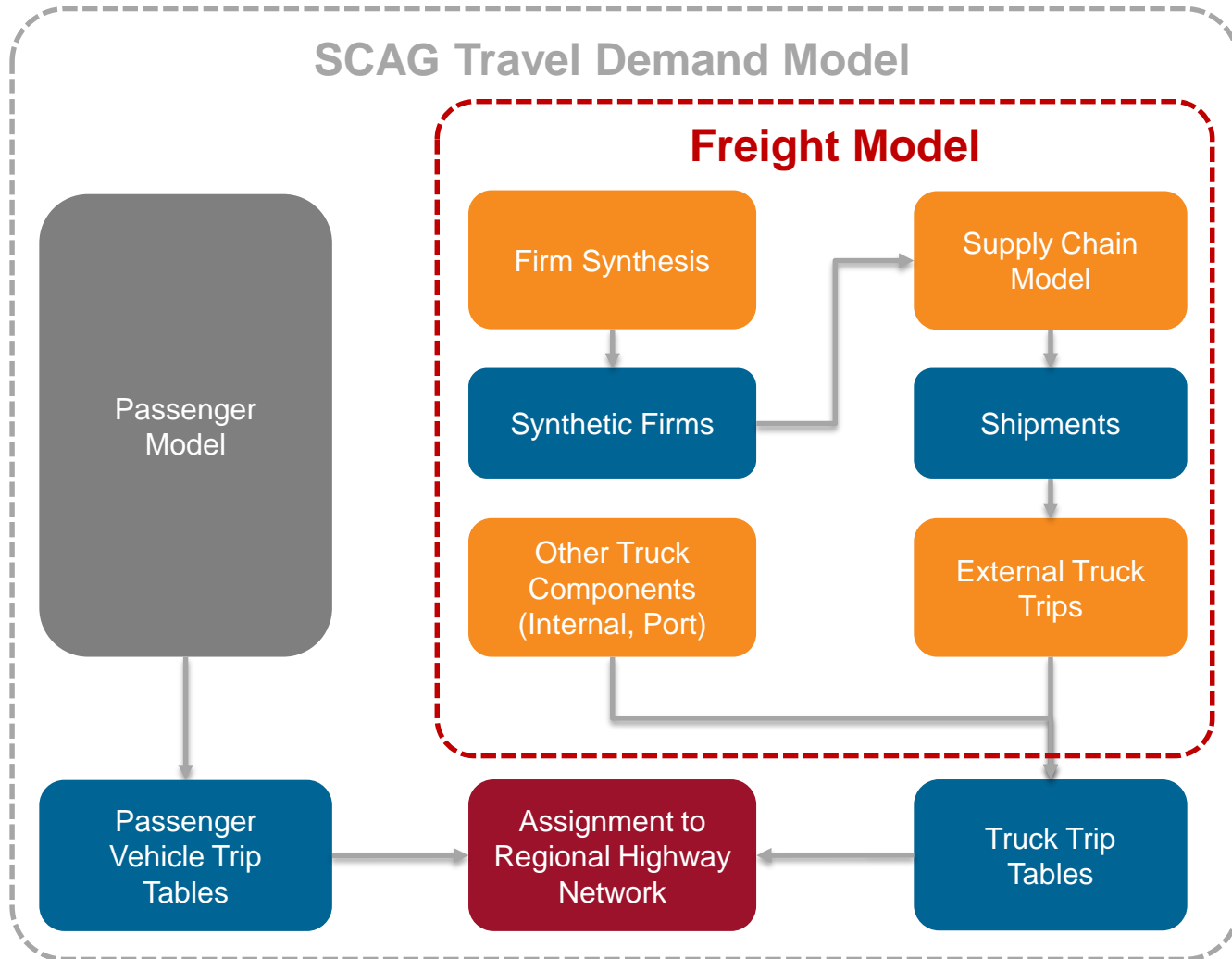
Software Design and Visualization

Software Design

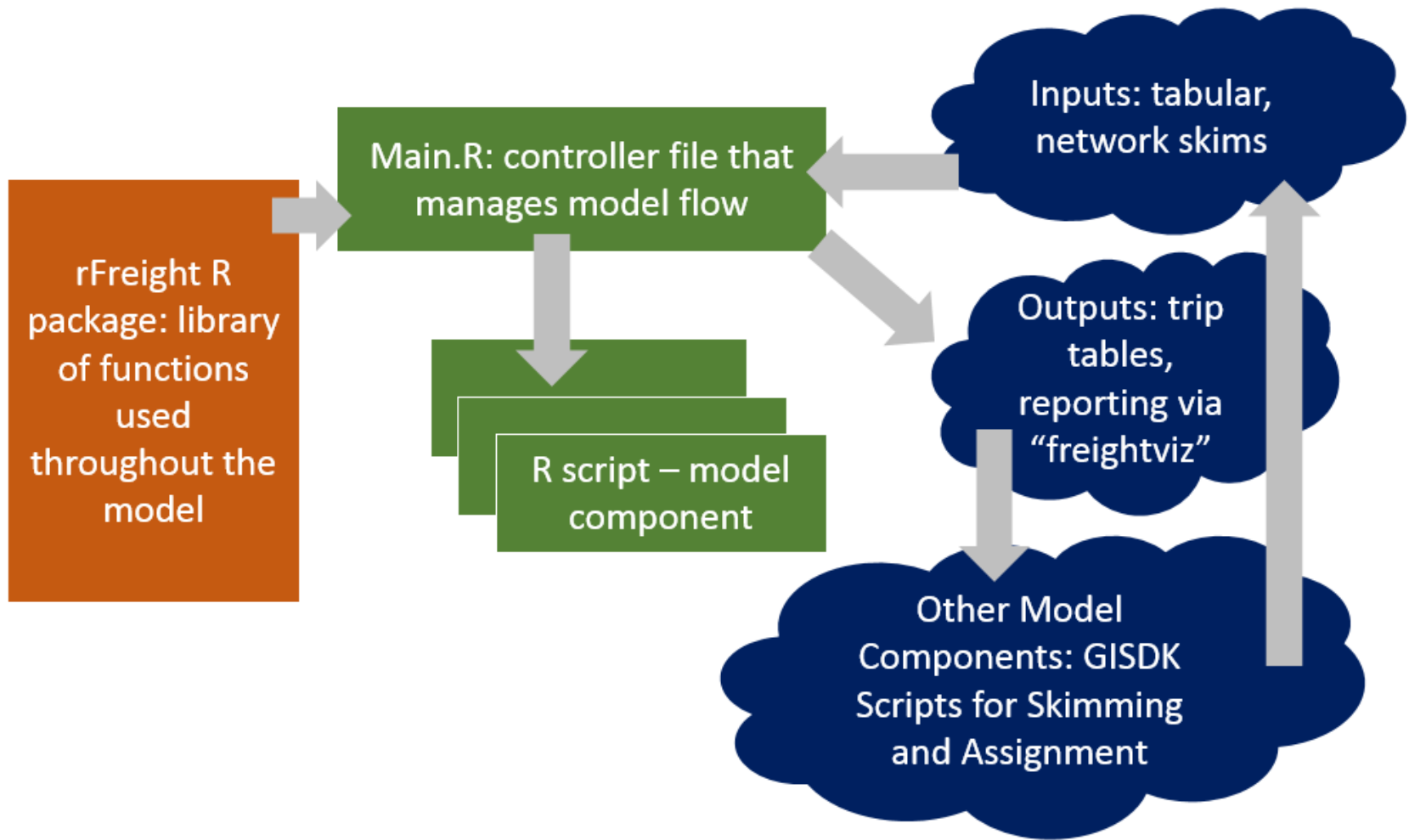
- **Self contained component:** External Heavy Duty Truck model is a self contained model component that reads inputs, simulates the truck trips, and writes outputs (trip lists and summaries)
- **Programming platform:** Written in R, and leverages several R packages to support applying models and visualizing results
- **Non compiled code:** Code is open to read and modify



Overall Model Design



rFreight Application Structure



Visualization Dashboard

- **In one place:** A tool that provides a summary of a set of model results (or data analysis, etc.)
- **Visually Compelling:** Data are presented in a way that is readily digestible
- **Up to date:** Results are updated without work required by the user
- **Interactive:** Users can query, select, filter, pan, zoom, etc.



Dashboard Technology

- **Single HTML file** that is produced at the end of each model run
 - Can be linked directly to a website, or
 - Distributed by email and opened in a web browser
- Interactive tabulations, charts, and maps **embedded directly into the HTML file**
 - Uses client-side interactivity or publicly available web-resources, e.g. Open Street Map.
 - No need for hosting on a webserver



Dashboard Landing Page

SCAG Heavy Duty Truck Model

file:///E:/Projects/Clients/SCAG/scag_hdt/scenarios/base/outputs/ReportDashboard.html#overview

SCAG Heavy Duty Truck Model: base Scenario Summary

Overview Firm Synthesis Supply Chain External Truck Trips Validation

About this Document

This document is stand-alone interactive dashboard viewable from most modern Internet browsers. The dashboard is meant to be a high-level summary of an rFreight scenario. All of the data, charts, and maps viewable in this dashboard are embedded directly into the HTML file, so users are encouraged to share their scenario results with others via this document. An Internet connection is necessary for the best user experience, but is not required.

Users may navigate to different areas of the dashboard using the navigation bar at the top of the page, and may interact directly with most tables, charts, and maps.

This document is best viewed using the most recent versions of the following web browsers:

- Google Chrome
- Microsoft Edge (Must be running Windows 10)

2018-07-11
Model Run Date

5.1
Model Runtime (days)

606,148
Synthesized Firms

Model Region and Traffic Analysis Zone (TAZ) System

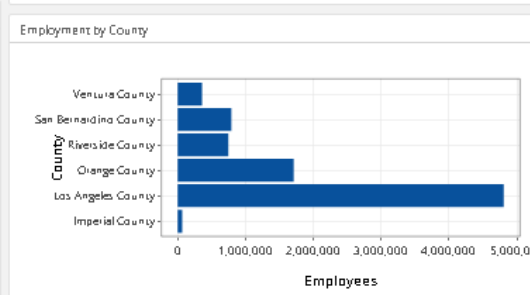
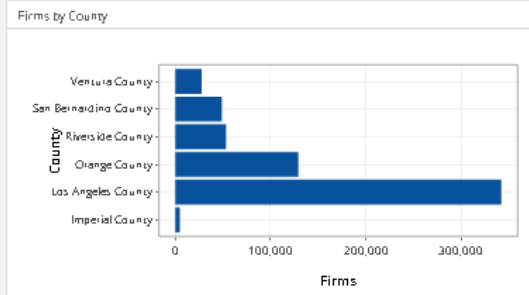
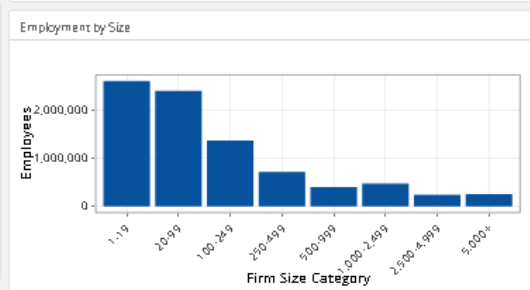
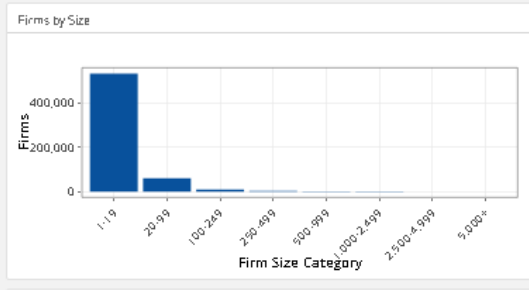
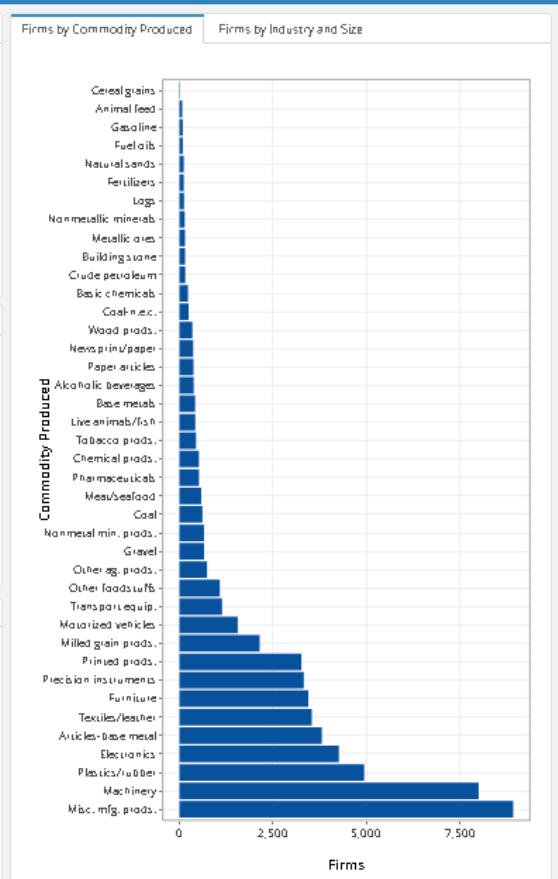
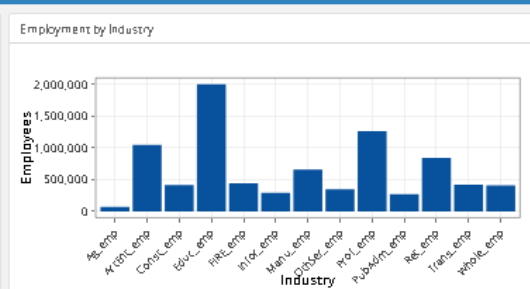
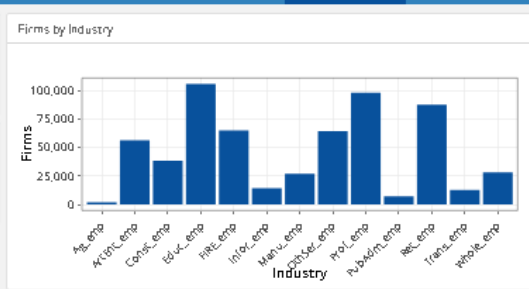
Imperial
Los_Angeles
Orange
Riverside
San_Bernardino
Ventura



Results in Charts, Maps, and Tables

606,148
Synthesized Firms

8,479,827
Synthesized Employees





Discussion of Model Sensitivity

Model Sensitivity

- **Firm Synthesis Model**

- Location and growth of business establishments that ship and receive freight in the region
- Controlled to regional forecasts, but override ability for specific businesses as scenario tests

- **Supply Chain Model**

- Forecasts of annual commodity movements by consumption in the SCAG region and also changes in external production and consumption locations
- Mode choices by commodity and other logistics behavior such as use of distribution and warehousing

- **External Truck Trips Model**

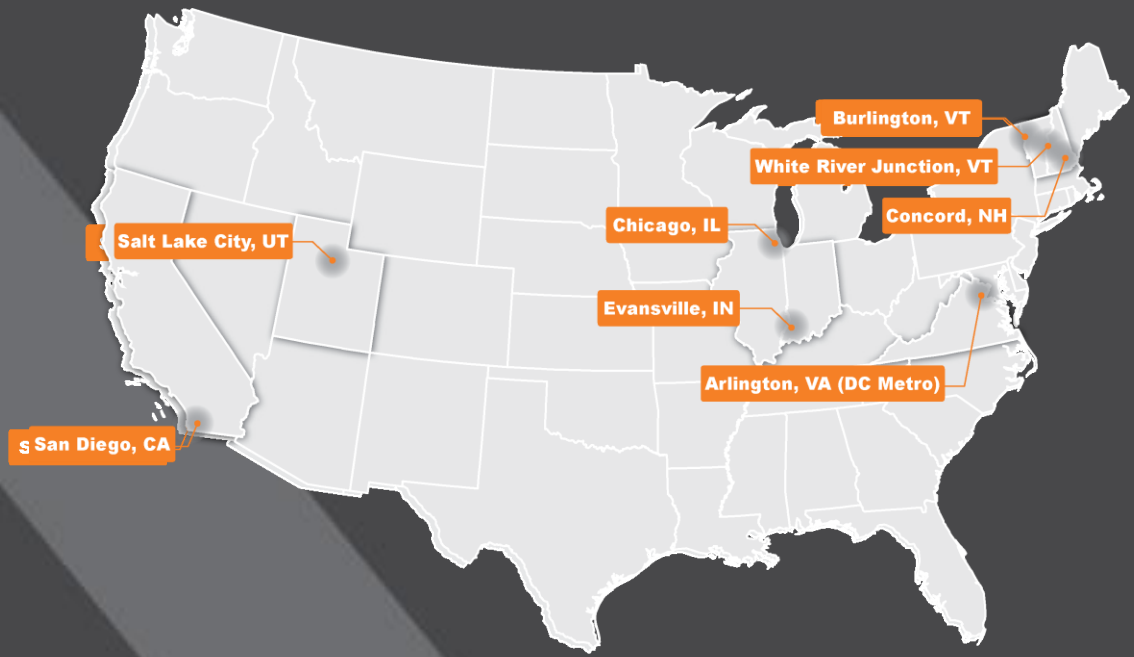
- Travel times within the region (to and from external stations)
- Capacities and loading of trucks
- Diurnal profile of trucks entering and leaving the region



Summary

- **The updated external heavy duty truck model**
 - Incorporates new freight modeling techniques
 - Includes components that simulate firms and supply chains that lead to shipment and truck movements to and from the region
- **Modeling software**
 - Developed as a standalone component for integration with the SCAG travel demand model
 - Includes a visualization dashboard
- **Status**
 - Currently completing the project and transferring final models and documentation to SCAG staff





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