Evaluating the Environmental Attributes of Freight Traffic along the U.S West Coast

Geospatial Intermodal Freight Transport (GIFT) Model with Cargo Flow Analysis

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Project Objective

- Quantify environmental impact of containerized freight movement in the West Coast Freight Gateway and Corridor
- Apply a GIS-based model modified to include California-specific inputs

- Demonstrate potential system improvements to achieve GHG reductions and address environmental issues related to freight transport

Discussion Items

- Background on Freight Transport
- Reasons to Model Alternatives
- GIFT Model
- Research Methodology
- Results and Analysis
- Summary

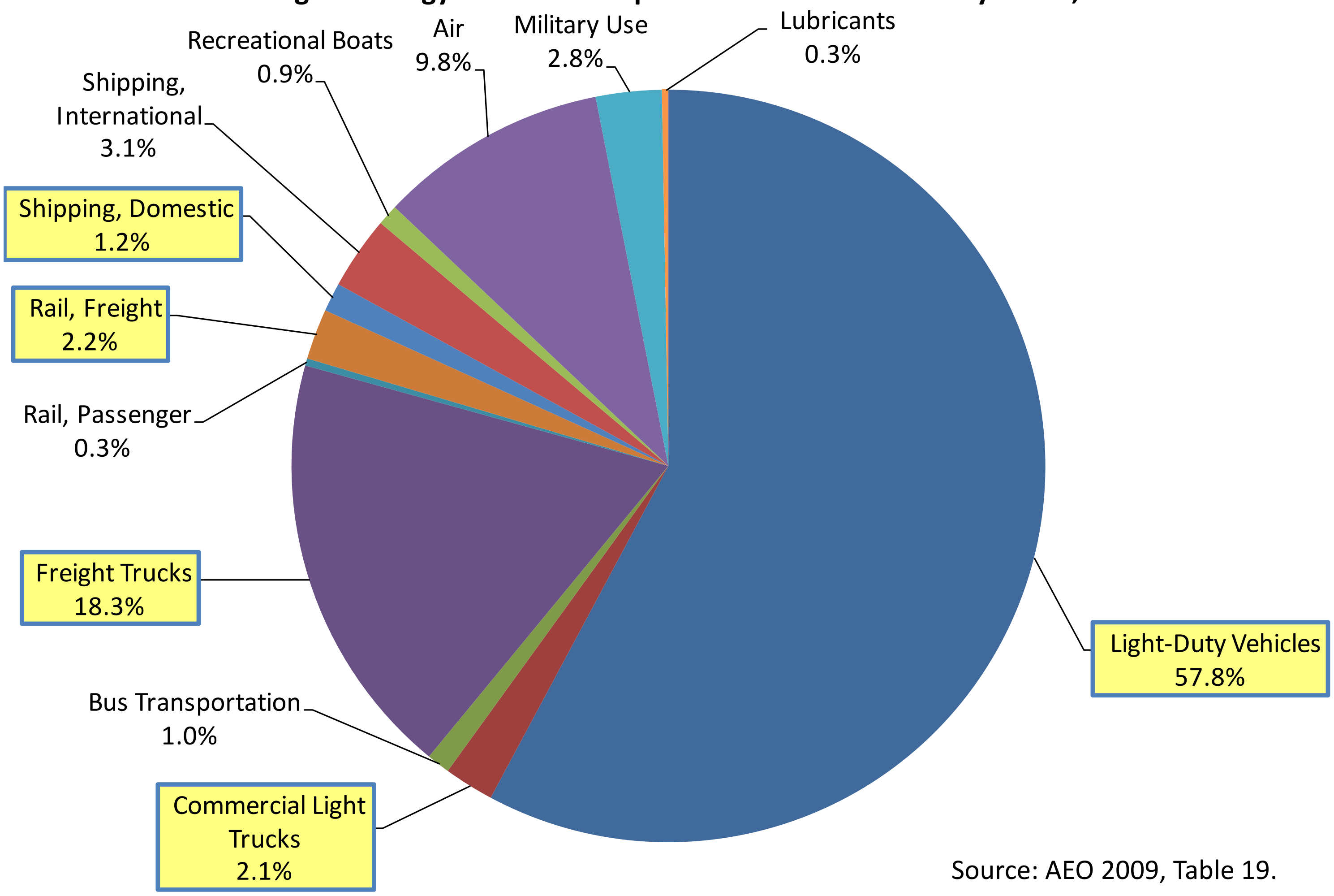
Attributes of Freight Transport

FREIGHT TRANSPORT BACKGROUND

Transportation represents ~35% of GHG in U.S.

~6 Gt CO_2 emissions in U.S.; ~2 Gt transportation

Percentage of Energy-Related Transportation CO2 Emissions by Mode, 2008

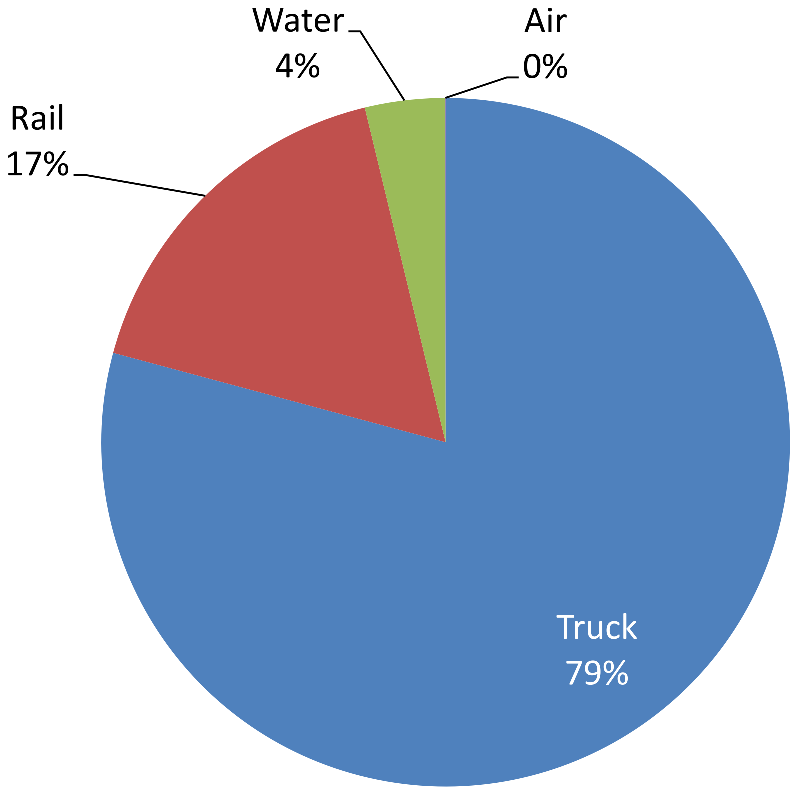


Source: AEO 2009, Table 19.

The U.S. freight industry is dominated by Truck

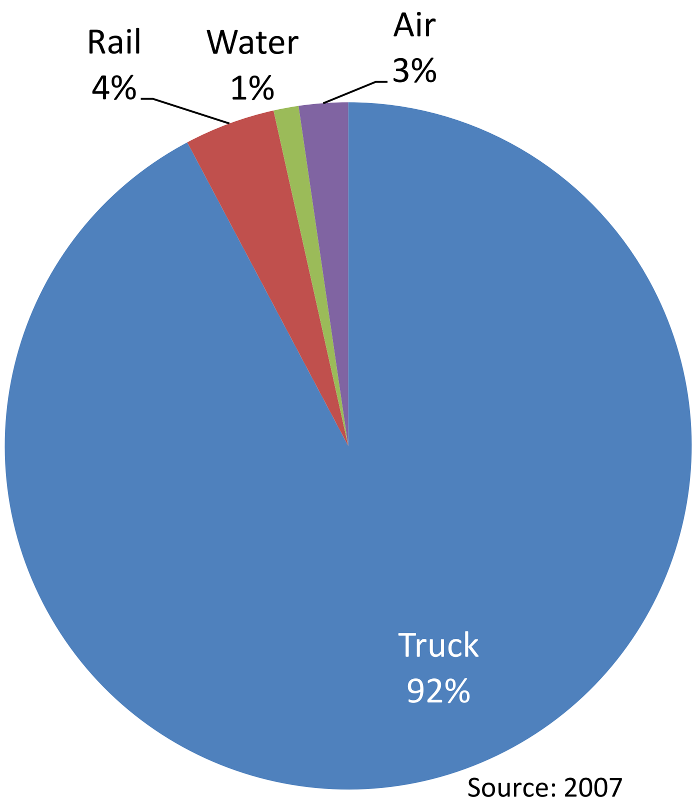
Freight touches energy use, environmental quality, economic growth, congestion mitigation, and national security

Tons of Freight by Mode, 2007



Source: 2007 Commodity Flow Survey Table 1

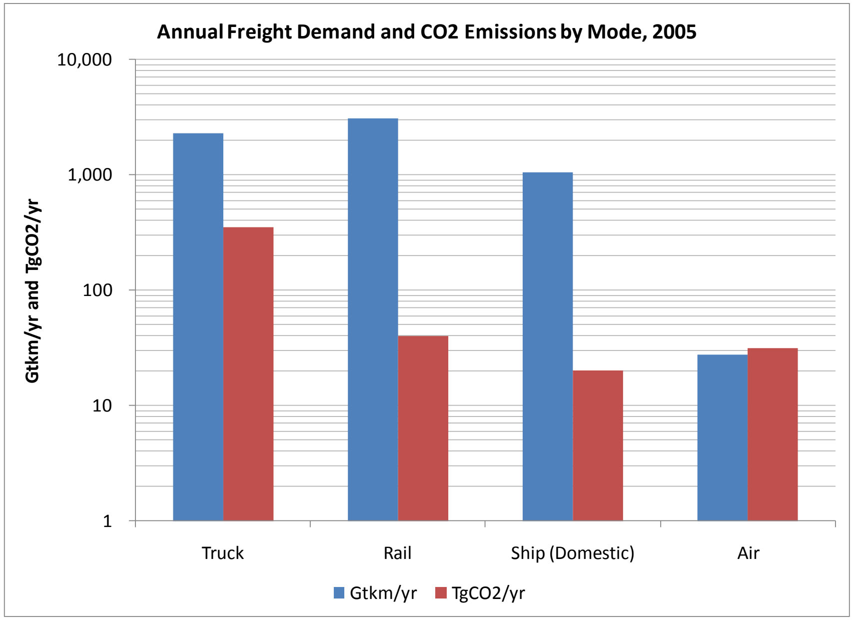
Value of U.S. Freight by Mode, 2007

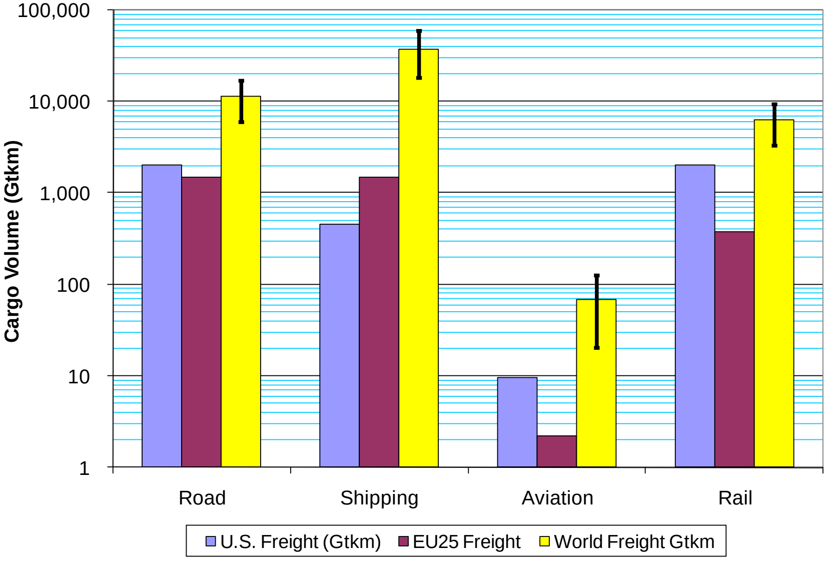


Source: 2007 Commodity Flow Survey Table 1

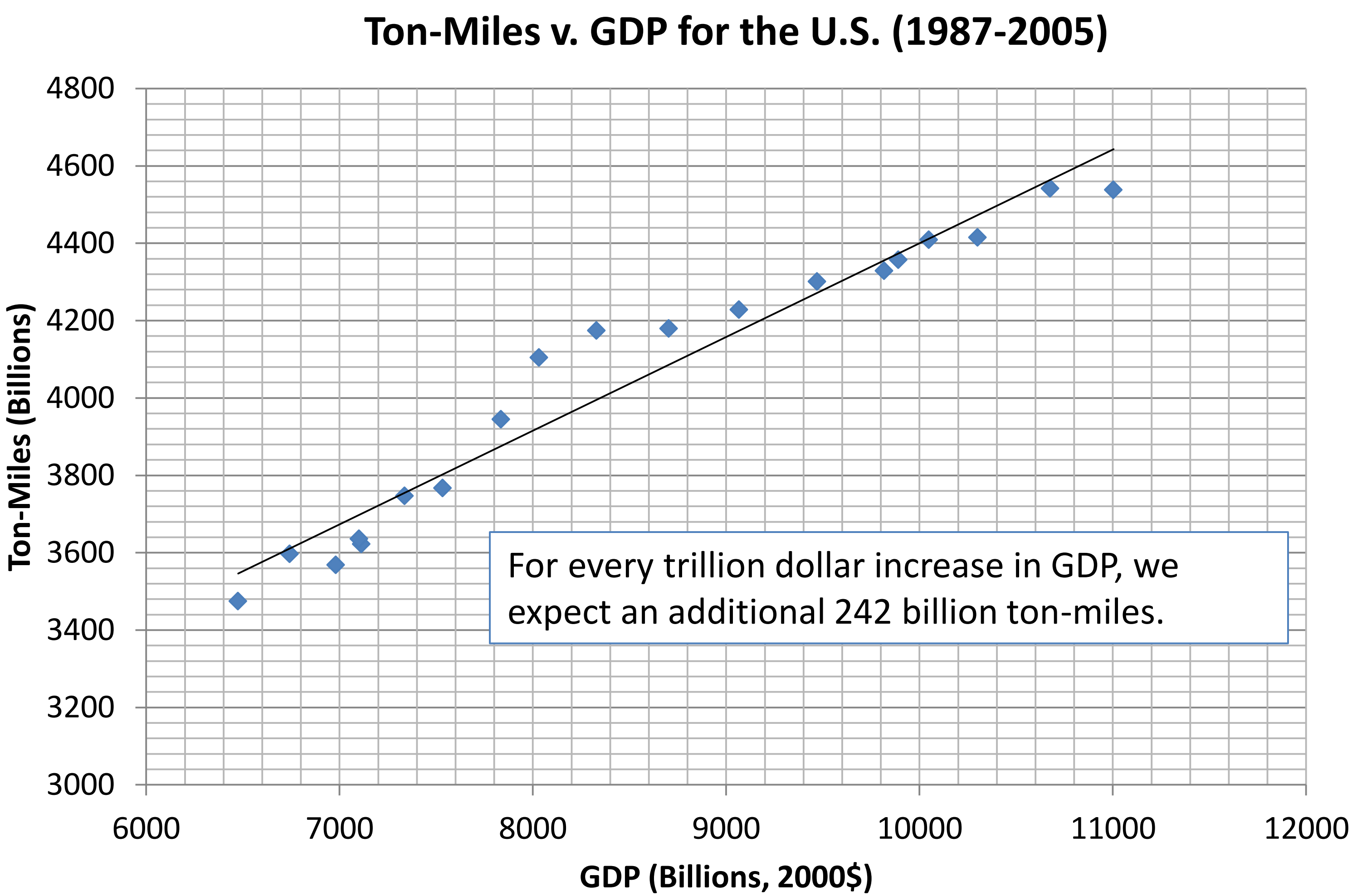
Freight Overview

- Energy use within freight mode is proportional to work done
- Carbon intensity (and other emissions) not symmetric across modes





Goods Movement and GDP



Source: Corbett and Winebrake, 2008.

Calculating Impacts from the Bottom Up

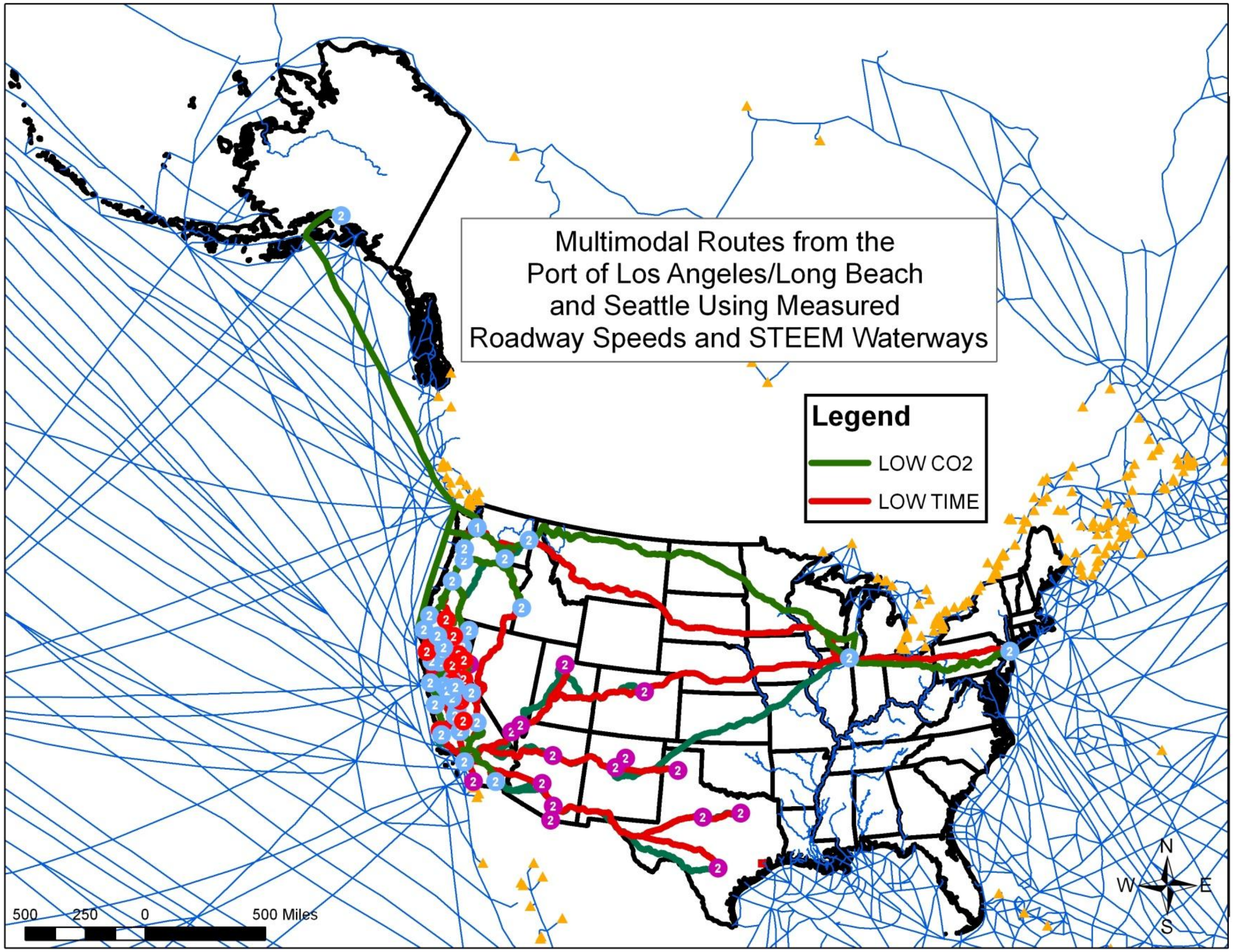
Calculators developed by RIT and the University of Delaware to support research activities under the *Sustainable Intermodal Freight Transportation Research* (SIFTR) program

MODAL MODELING OF POSSIBILITIES

Geospatial Intermodal Freight Transportation Model

THE GIFT MODEL

Geospatial Intermodal Freight Transportation (GIFT) Model



VISUALIZING GOALS
MODELING ALTERNATIVES

Intermodal freight network optimization model to evaluate objective tradeoffs.

Developing resources for “table-top” exercises with industry and agencies.

Evaluates performance against *benchmarks* and optimizes with respect to possible ***targets***

Web-version in development.

How are we using GIFT?

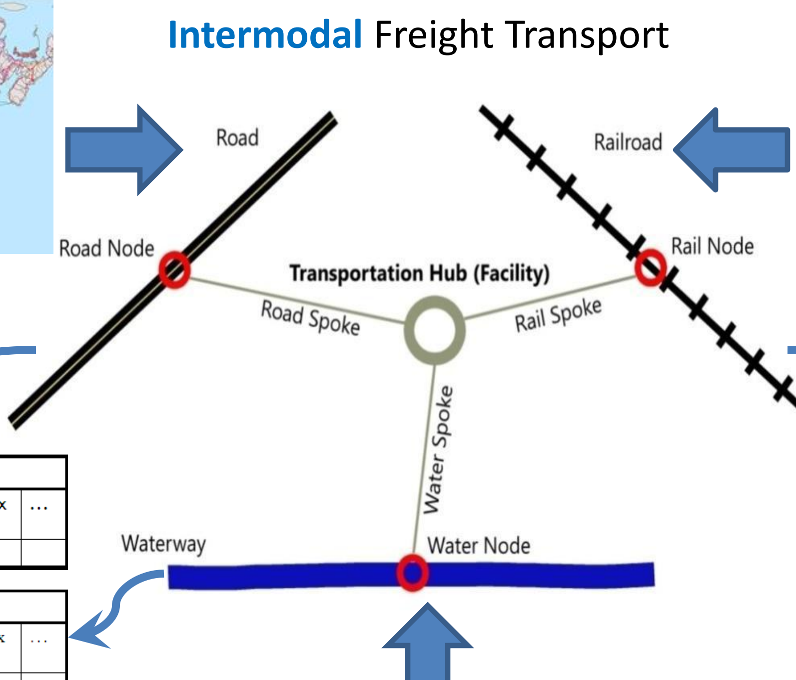
- Table-top exercises with leaders in transportation
  - Modal experts and industry decision makers
  - Public infrastructure planners at regional and national levels
  - Environmental, energy interests in public and private sectors

<u>i</u>nfrastructure
<u>f</u>uels
<u>t</u>echnologies
<u>o</u>perations
<u>l</u>ogistics
<u>d</u>emand

The GIFT Model

Integrating the National Transportation Atlas Database (NTAD) Components

NTAD Road Network



NTAD Rail Network

Truck Segment "Costs"

Distance	Time	Operating Cost	Energy	CO_2	NOx	…

Rail Segment "Costs"

Distance	Time	Operating Cost	Energy	CO_2	NOx	…

Water Segment "Costs"

Distance	Time	Operating Cost	Energy	CO_2	NOx	…

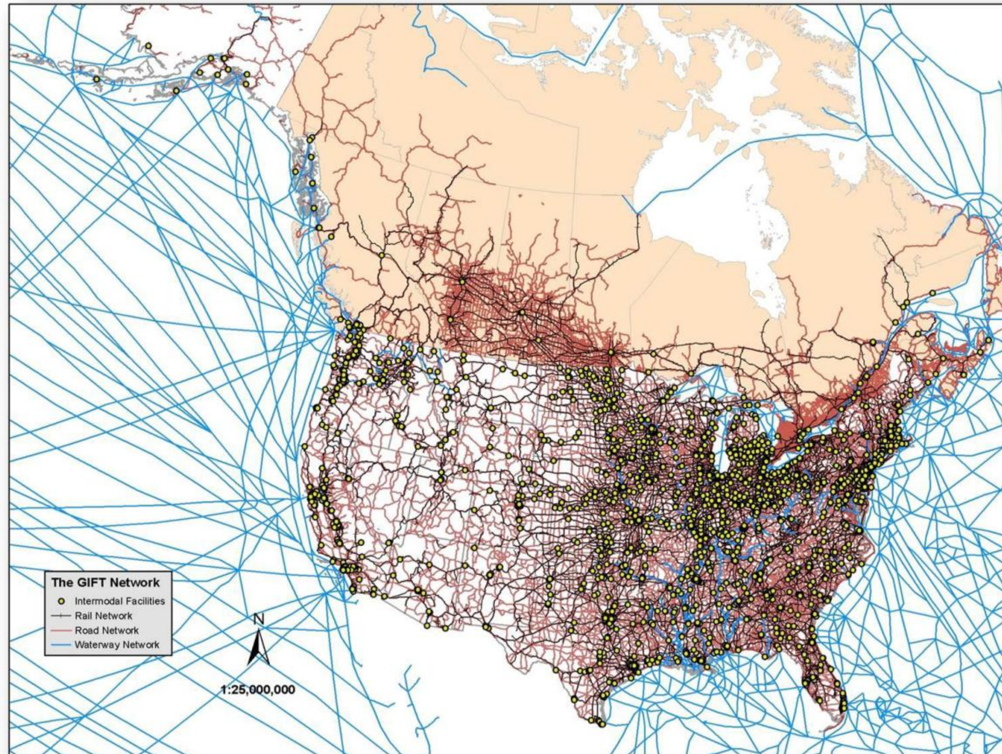
Attribute values used to search for routes that minimize the total "Costs"

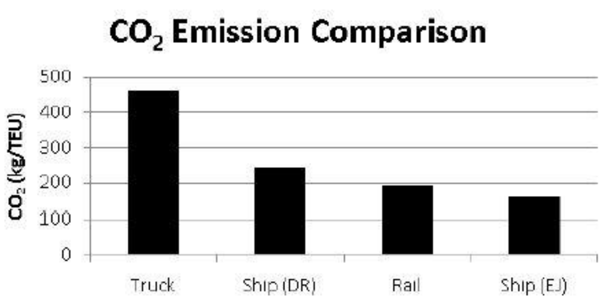
STEEM Water Network

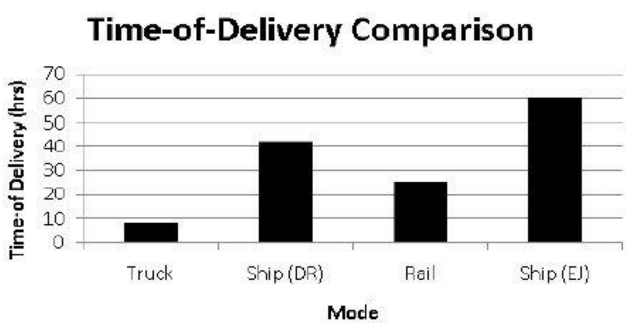
Each segment and spoke of the network contains temporal, economic, and environmental attributes- called "cost factors"

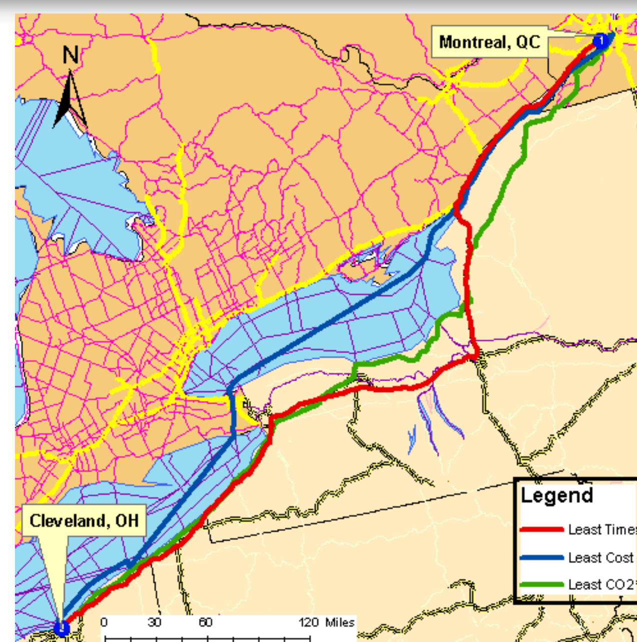
The Geospatial Intermodal Freight Transportation (GIFT) Model

- GIS-based optimization model
- Intermodal network (Road, Rail, Water and Facilities)
- Calculation of least time, least cost , least energy and least emissions (CO2, PM10, NOx, SOx, VOC) routes
- Tool to aid decision makers understand environmental, economic, energy impact of intermodal freight transportation and to compare trade-offs among various policy scenarios









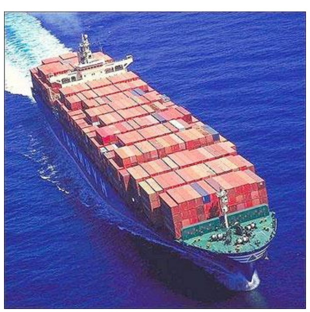
Three Mode Emissions Calculator

Activity-based emissions model (bottom-up emissions calculation) jointly developed by RIT and Univ. of Delaware

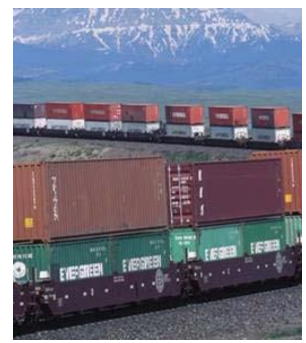
Emissions calculated using basic principles of physics such as energy, materials content in fuels, engine efficiency

$$Emission_{pollutant} = Activity * Emission\ Factor_{pollutant}$$

Truck: *grams per TEU-mile*
- Miles Per Gallon
- TEU Capacity
- Tons Per TEU
- Sulfur Content



Ship: *grams per TEU-mile*
- Speed
- Engine HP
- Load Factor
- TEU Capacity
- Tons Per TEU
- Sulfur Content



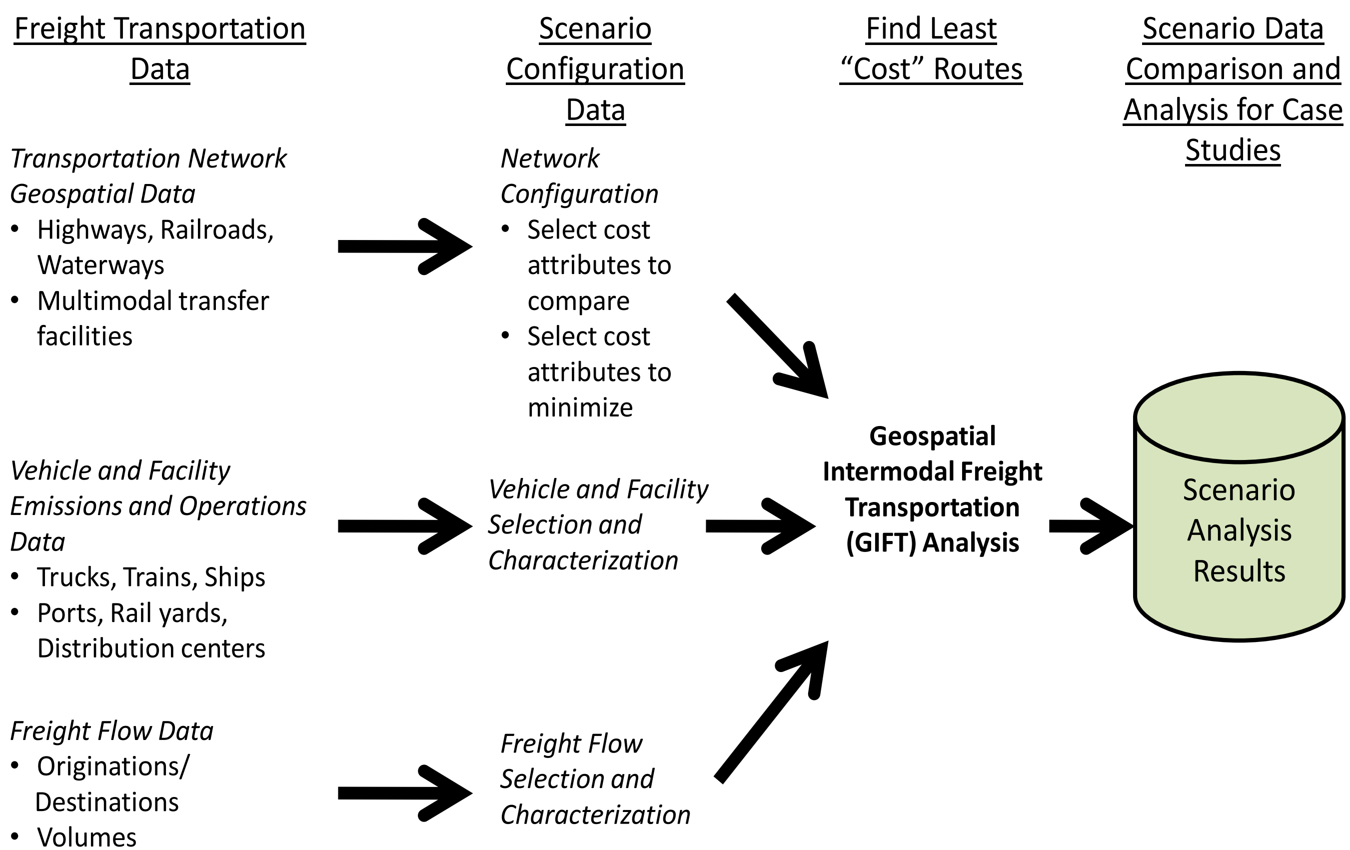
Rail: *grams per TEU-mile*
- Speed
- Engine HP
- Load Factor
- TEU Capacity (Well Cars* Well Car Capacity)
- Tons Per TEU
- Sulfur Content

California-specific application of GIFT

Preparing, importing and processing data in ArcGIS

RESEARCH METHODOLOGY

Structure and use of the GIFT model



Source:(J.S. Hawker, et al., 2010)

Methodology
Gathering Data

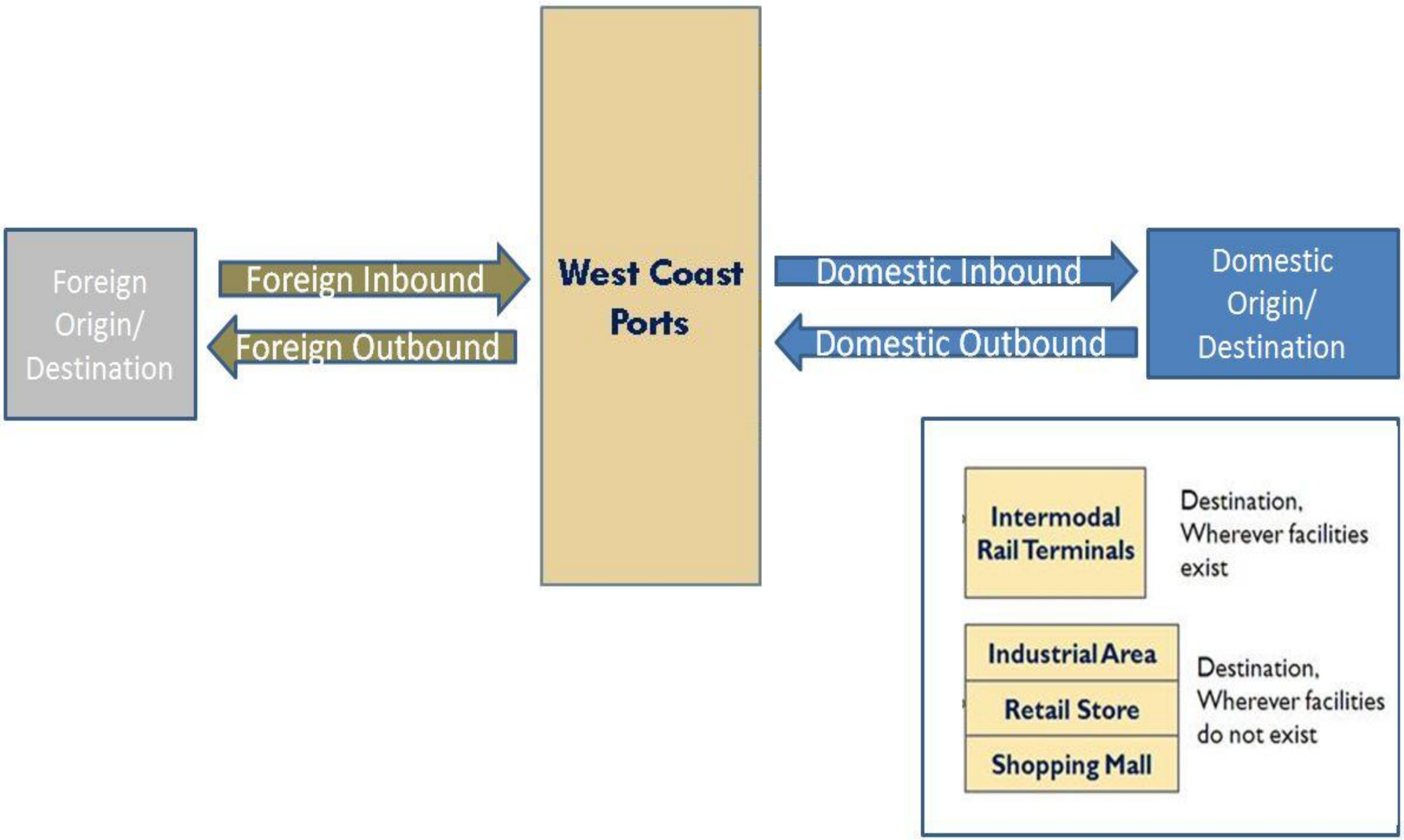
- Commodity Flow Survey 2007
  - National freight flow figures which include estimated shipping volumes (value, tons, and ton-miles) by commodity and mode of transportation at varying levels of geographic detail
  - Lists freight tonnage between the major O-D pairs

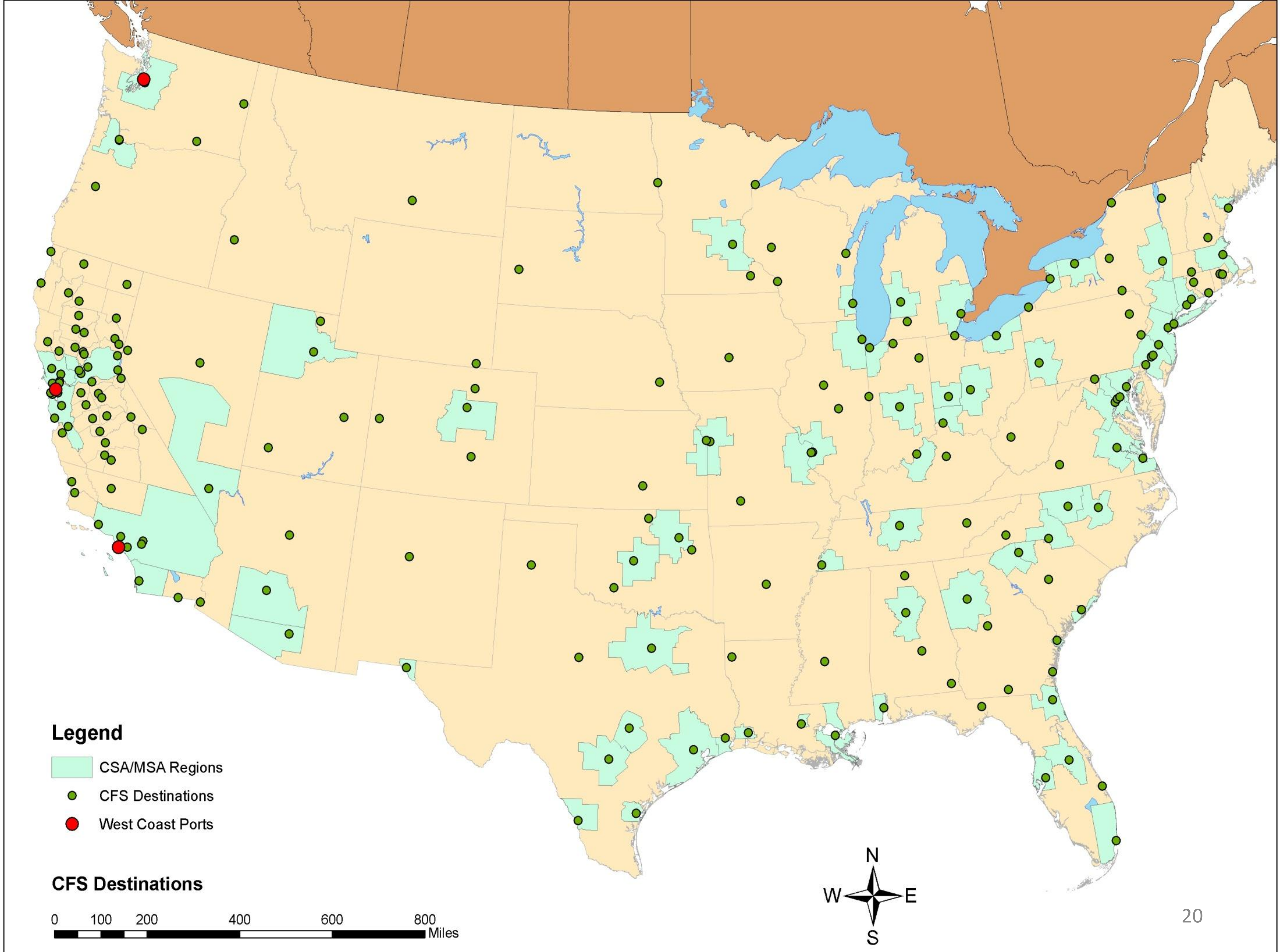
- Port Generated Traffic- US Army Corps of Engineers 2007
  - Waterborne container traffic for US Port/ Waterway 2007

- Cambridge Systematics Origin-Destination (O-D) Database
  - Disaggregated Freight Analysis Framework 2.2 (FAF 2) data at a county level
  - FAF2 data publicly available and built from CFS and other data sources

Route Identification Method

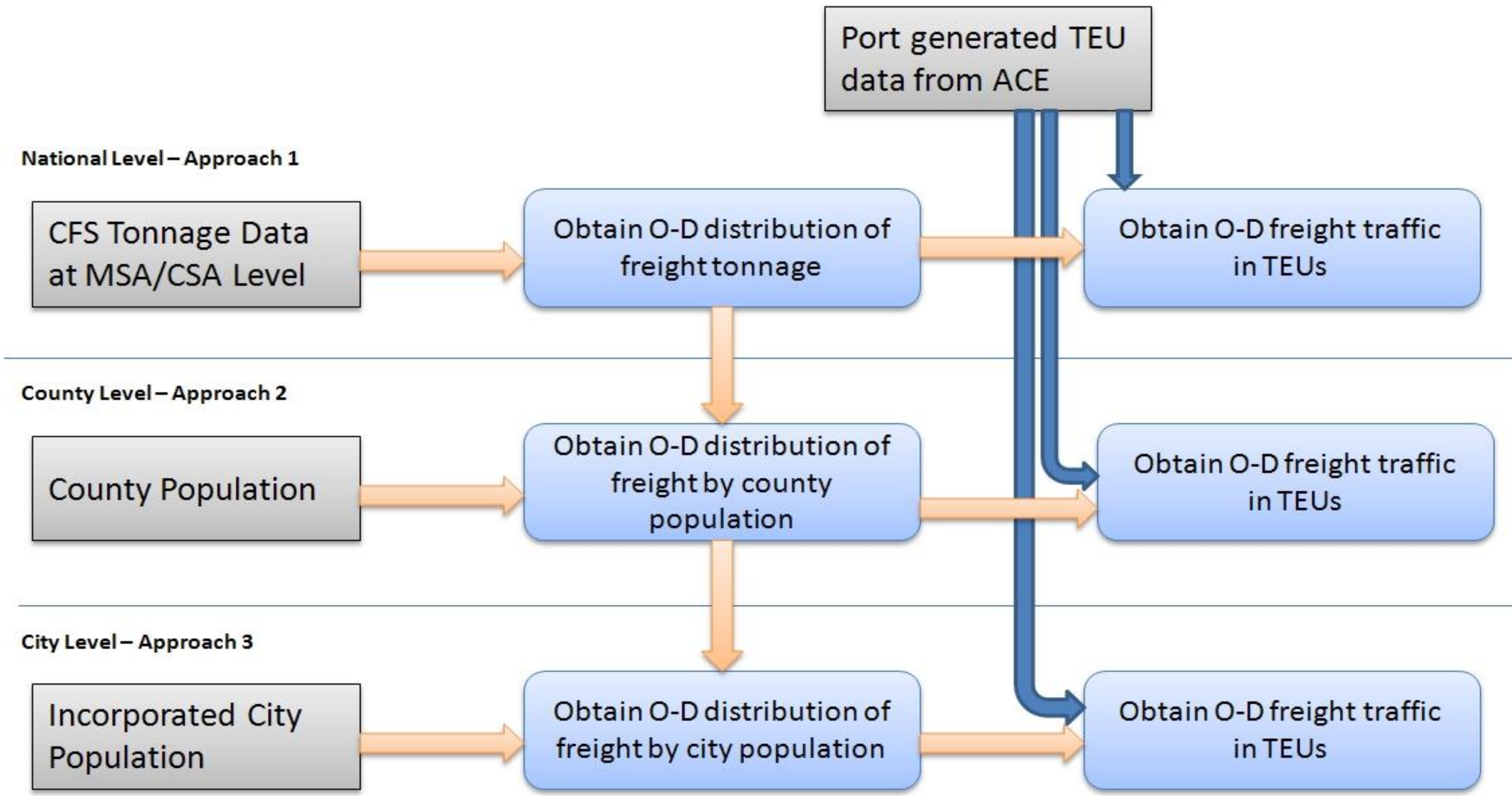
Building a multiple O-D framework




Legend
CSA/MSA Regions
CFS Destinations
West Coast Ports
CFS Destinations
0 100 200 400 600 800 Miles
N
W
E
S

Plural methods for allocating freight flows

Approaches to distributing freight using CFS data



Outside CA, freight split evenly between destinations in the “Remainder of” regions in the states

Methodology

Emissions Assumptions

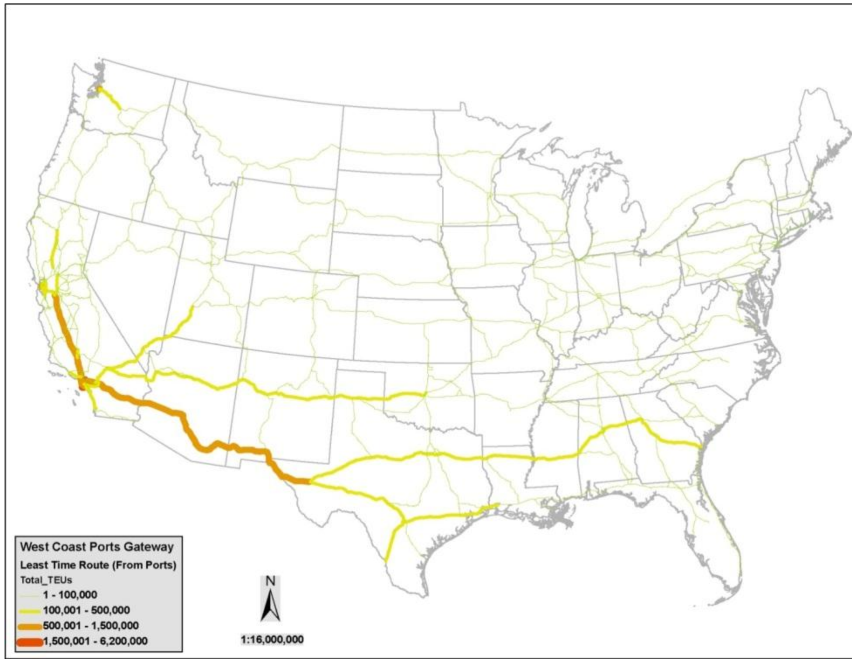
Mode Type/Spoke Type	CO_2 Emissions by Mode Type (g/TEU-Mile)	Intermodal Transfer CO_2 Emissions by Spoke Type (g/TEU)	Mode Attributes
Truck MY 1998-02	830	9200	•Fuel Economy: 6 MPG •TEU Capacity: 2 •Tons Per TEU: 10 •Engine Efficiency: 42% •Fuel Type: Distillate Diesel with 15ppm Sulfur
Rail Tier 1 Line Haul	320	4100	•Speed: 25 mph •Engine HP: 8000 •Load Factor: 70% •Engine Efficiency: 42% •TEU Capacity: 400 •Tons Per TEU: 10 •Fuel Type: Distillate Diesel with 15ppm Sulfur
Ship 'Dutch Runner '	410	2500	•Speed: 13.5 mph •Engine HP: 3070 •Load Factor: 80% •Engine Efficiency: 40% •TEU Capacity: 220 •Tons Per TEU: 10 •Fuel Type: Marine Diesel with 5000 ppm Sulfur

Analyzing the benefits of a Modal Shift in Freight

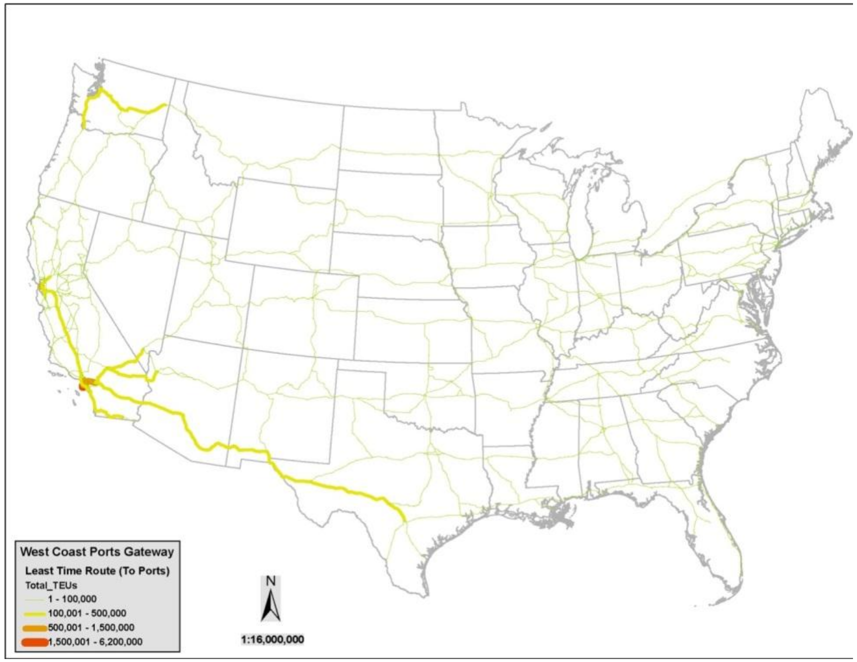
RESULTS AND ANALYSES

Least-Time Freight Flow Results

From Ports

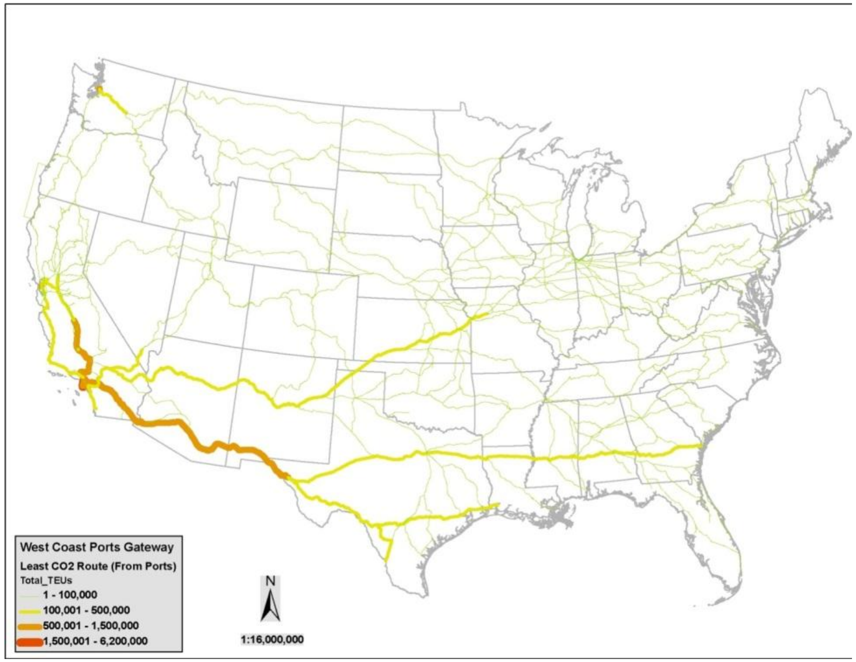


To Ports

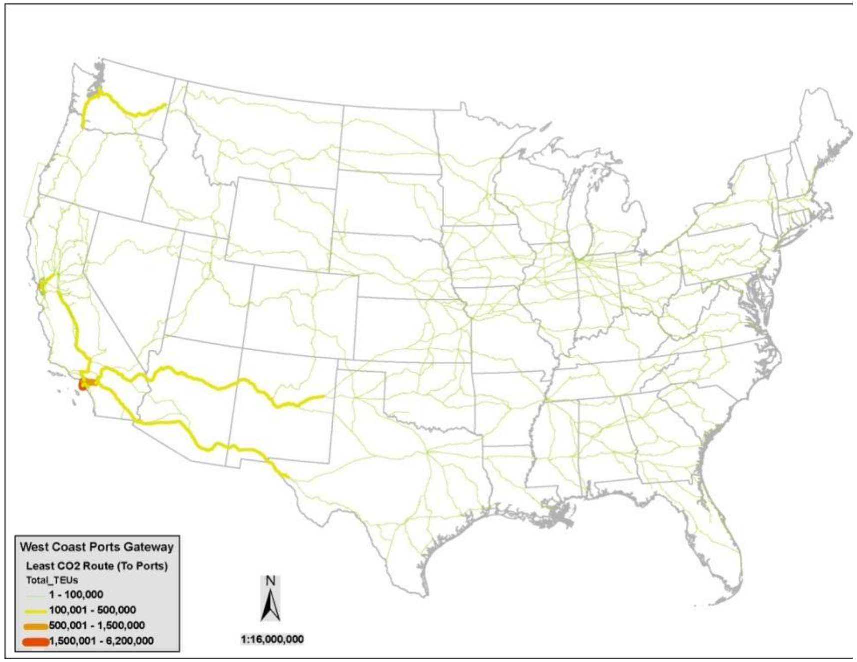


Least-CO_2 Scenario Results

From Ports

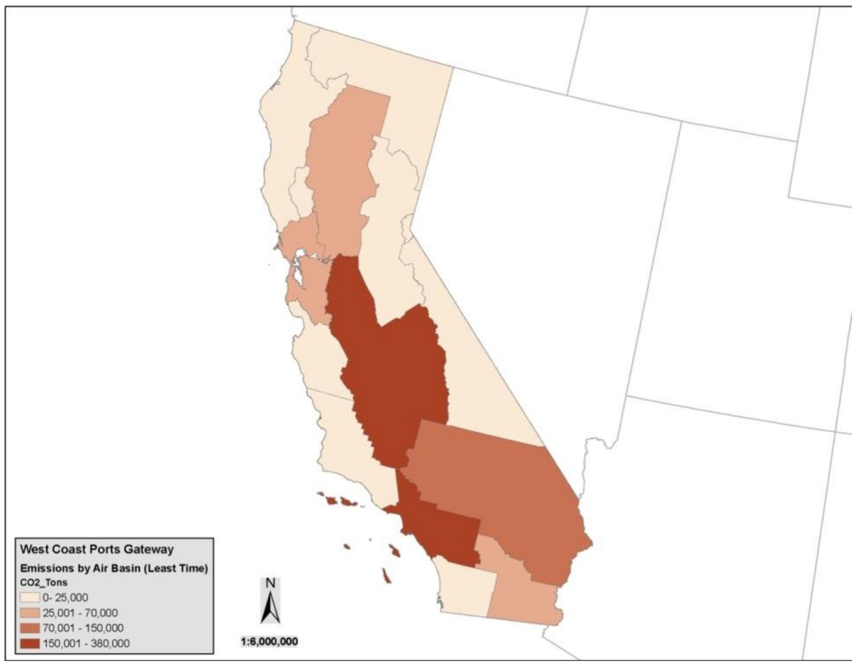


To Ports

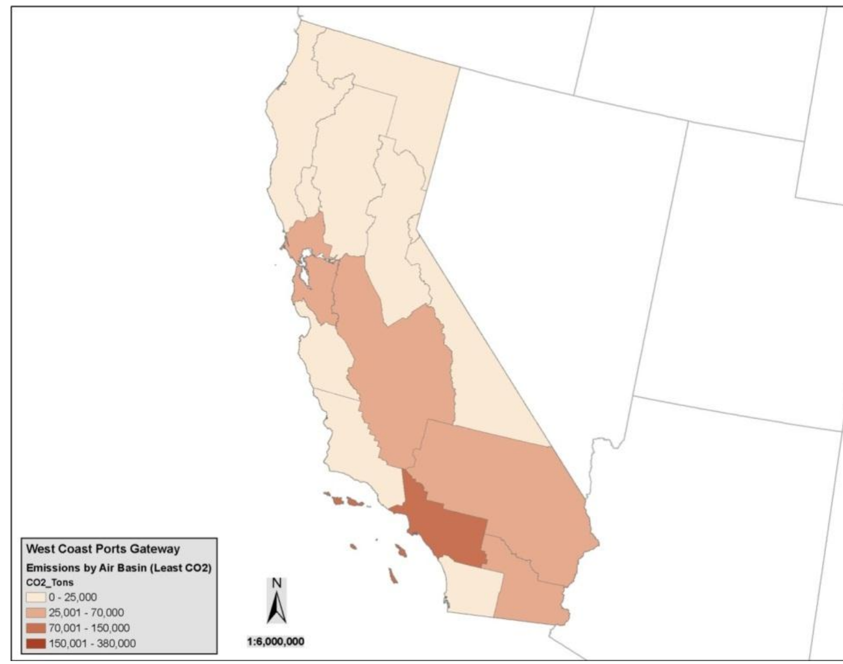


Air Basin Allocation Example

Least Time

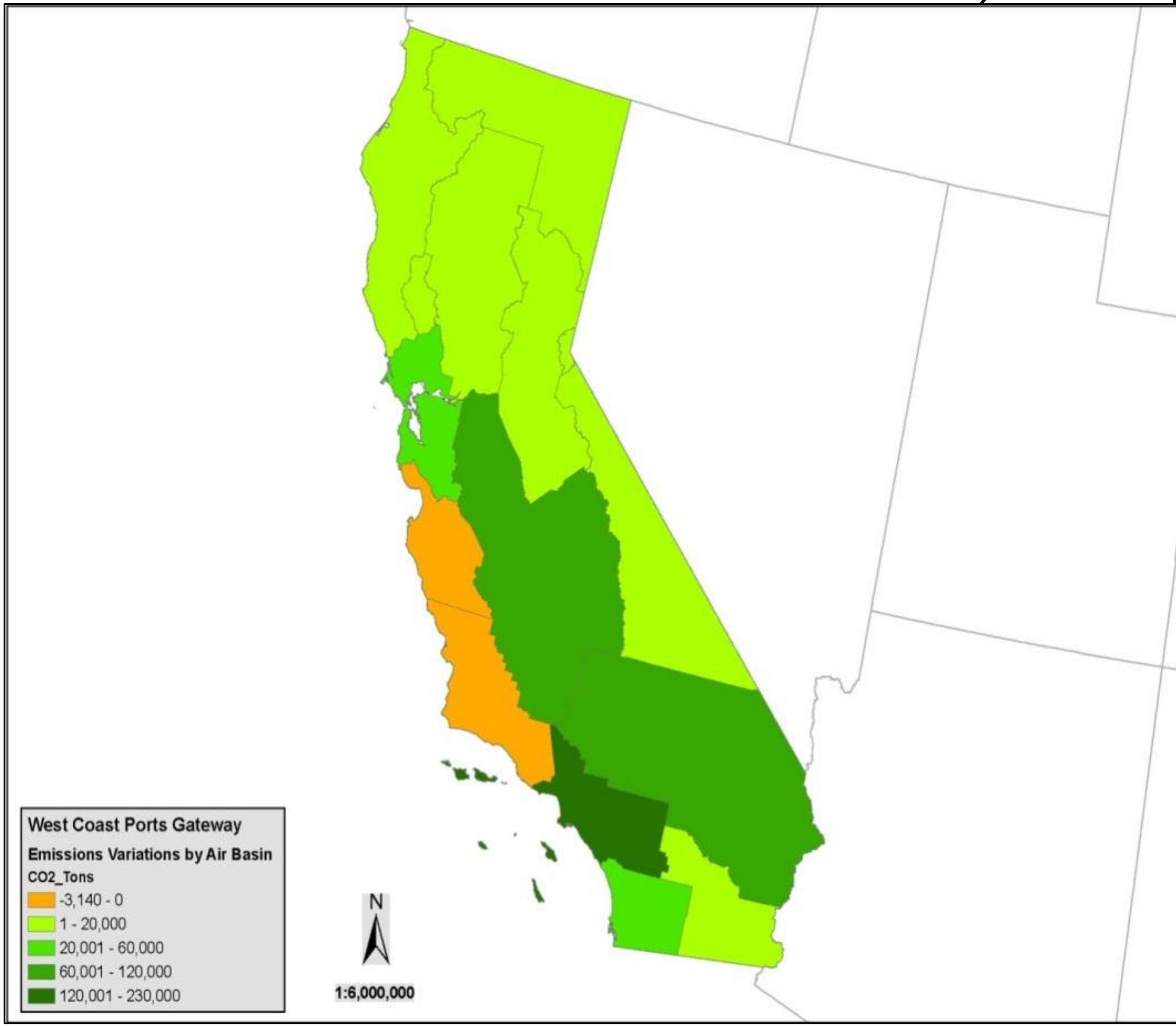


Least CO_2



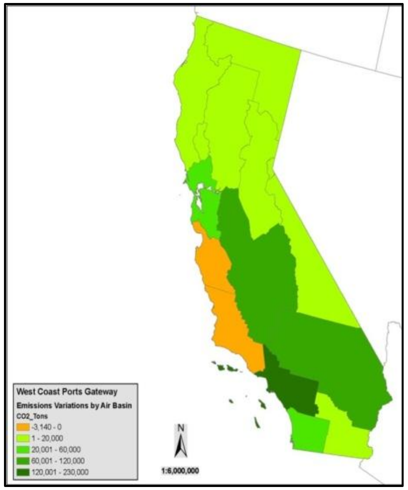
Air Basin Emissions Allocation Change

(difference between “least-time” and “least CO_2” routing in GIFT)



Emissions Variation By Air Basin due to Modal Shift

Air Basin	Total Least-time Scenario CO_2 Emissions (MT)	Total Least-CO_2 Scenario CO_2 Emissions (MT)	Difference in CO_2 Emissions due to Modal Shift (MT)	Percent Change
South Coast	375,866	149,421	226,445	-60%
San Joaquin Valley	178,572	58,690	119,882	-67%
Mojave Desert	120,951	60,908	60,043	-50%
San Francisco Bay	67,983	31,173	36,810	-54%
San Diego County	24,044	3,471	20,573	-86%
Sacramento Valley	34,912	16,948	17,964	-51%
Salton Sea	48,900	41,672	7,228	-15%
Northeast Plateau	8,644	3,994	4,650	-54%
Mountain Counties	6,536	3,517	3,019	-46%
North Coast	814	376	438	-54%
Great Basin Valleys	480	345	135	-28%
Lake County	36	17	19	-53%
Lake Tahoe	23	22	1	-4%
South Central Coast	14,986	17,164	(-2,178)	**15%**
North Central Coast	3,100	6,240	(-3,140)	**101%**
Total in-state	**885,847**	**393,958**	**491,889**	**-56%**



Comparison of Emissions Across Scenarios

Least Time Scenario

Emission Attributes	Total Emissions From All port Traffic (MT)	Total Emissions From Traffic from Port (MT)			Total Emissions From Traffic towards Port (MT)		
		Port of LA-LB	Port of OAKLAND	Port of SEATTLE	Port of LA-LB	Port of OAKLAND	Port of SEATTLE
CO_2	2,885,360	1,707,510	102,759	144,708	597,680	206,560	126,143

Least CO_2 Scenario

Emission Attributes	Total Emissions From All port Traffic (MT)	Total Emissions From Traffic from Port (MT)			Total Emissions From Traffic towards Port (MT)		
		Port of LA-LB	Port of OAKLAND	Port of SEATTLE	Port of LA-LB	Port of OAKLAND	Port of SEATTLE
CO_2	1,182,764	694,997	45,337	56,556	248,031	87,227	50,616

Total Emissions Comparison

Emission Attribute	Least-time Scenario Total Emissions (MT)	Least-CO_2 Scenario Total Emissions (MT)	Total Emission Reduction (MT)	Total Emission Reductions (in percent)
CO_2	2,885,360	1,182,764	1,702,596	59.01%

SUMMARY

Conclusion

- Idealized use of least-CO_2 routing constraints illustrates emissions savings can be achieved through modal shifts.
- Total emissions reductions of 1.7 MMT (~0.5 MMT within California)of CO_2 achievable through a nationwide modal shift of West-Coast ports generated goods movement.
- Results are based on assumption that all port-related goods movement occurs through truck (not adjusted for amount moving through rail and other modes)
- Results have relevance for consideration of system-wide improvements that may achieve energy savings, CO_2 reductions, and associated benefits for air quality.

Summary

- GIFT can be used for systems analysis to model energy and environmental attributes of freight flow
- Model parameters can be changed to represent real-world policy scenarios
- GIFT can provide an estimate of the emissions saved through goods movement system improvements

- FUTURE IMPROVEMENTS
  - Utilize Multi-Criteria Optimization Approaches
  - Incorporate real-world speeds
  - Inclusion of geospatial gradient data
  - Better emissions calculations
  - Account for Delays in networks

Questions?