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Behavioral/Agent-Based Supply Chain Freight Modeling Synthesis and Guide

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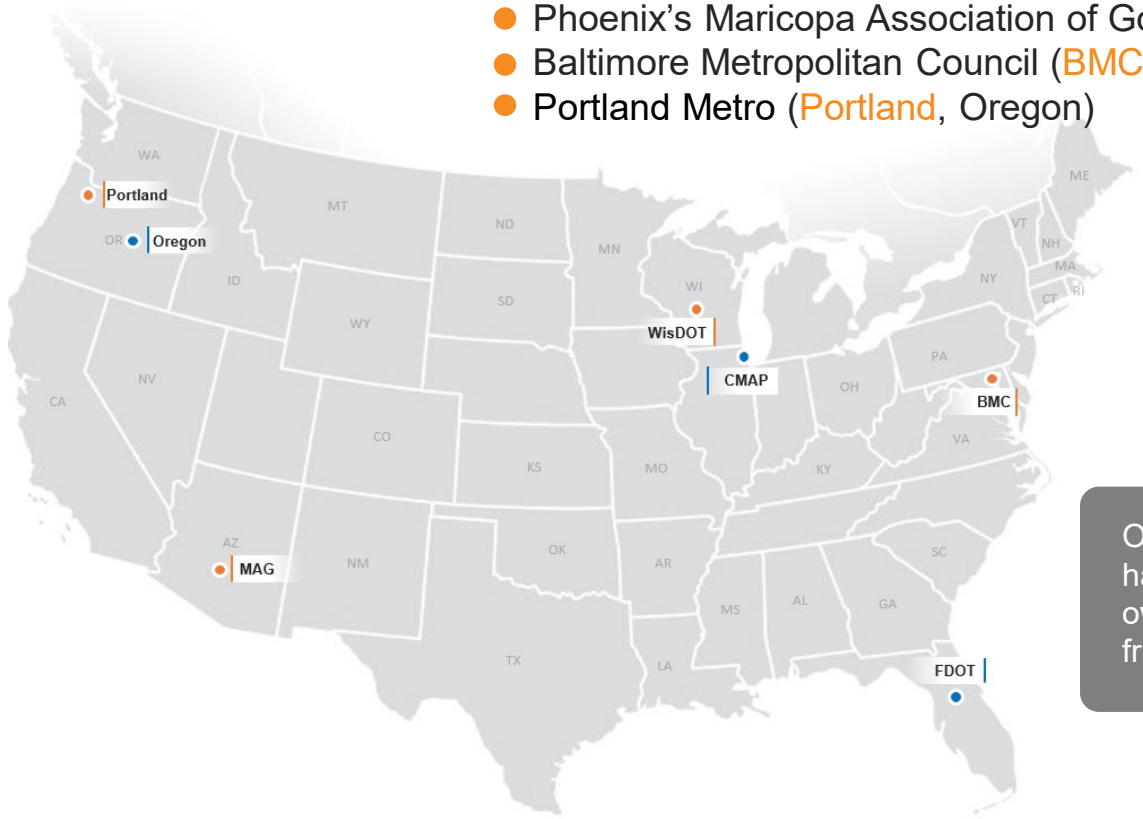
Guidance on Supply Chain Modeling

- Introduction
- Behavioral/Supply Chain Modeling Needs
- Freight Modeling Data
- Agency Experiences
- Freight Model Assessment
- Performance Measures
- Data Sharing

Funding from SHRP2 C20 has enabled agencies to build behavioral freight models

- Wisconsin Department of Transportation (WisDOT)
- Phoenix's Maricopa Association of Governments (MAG)
- Baltimore Metropolitan Council (BMC)
- Portland Metro (Portland, Oregon)



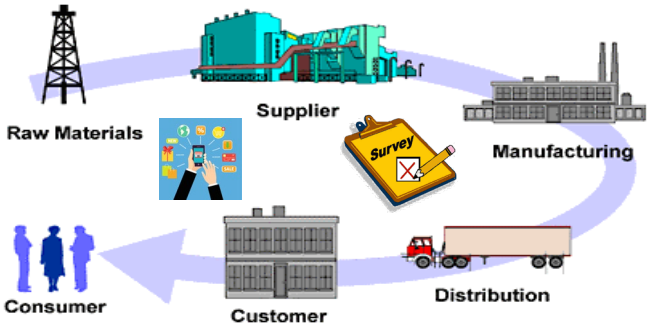
Other agencies have funded their own behavioral freight models.

- Chicago Metropolitan Agency for Planning (CMAP)
- Florida Department of Transportation (FDOT)
- Oregon Department of Transportation (ODOT)

Each model is reviewed across several dimensions

METHODOLOGY

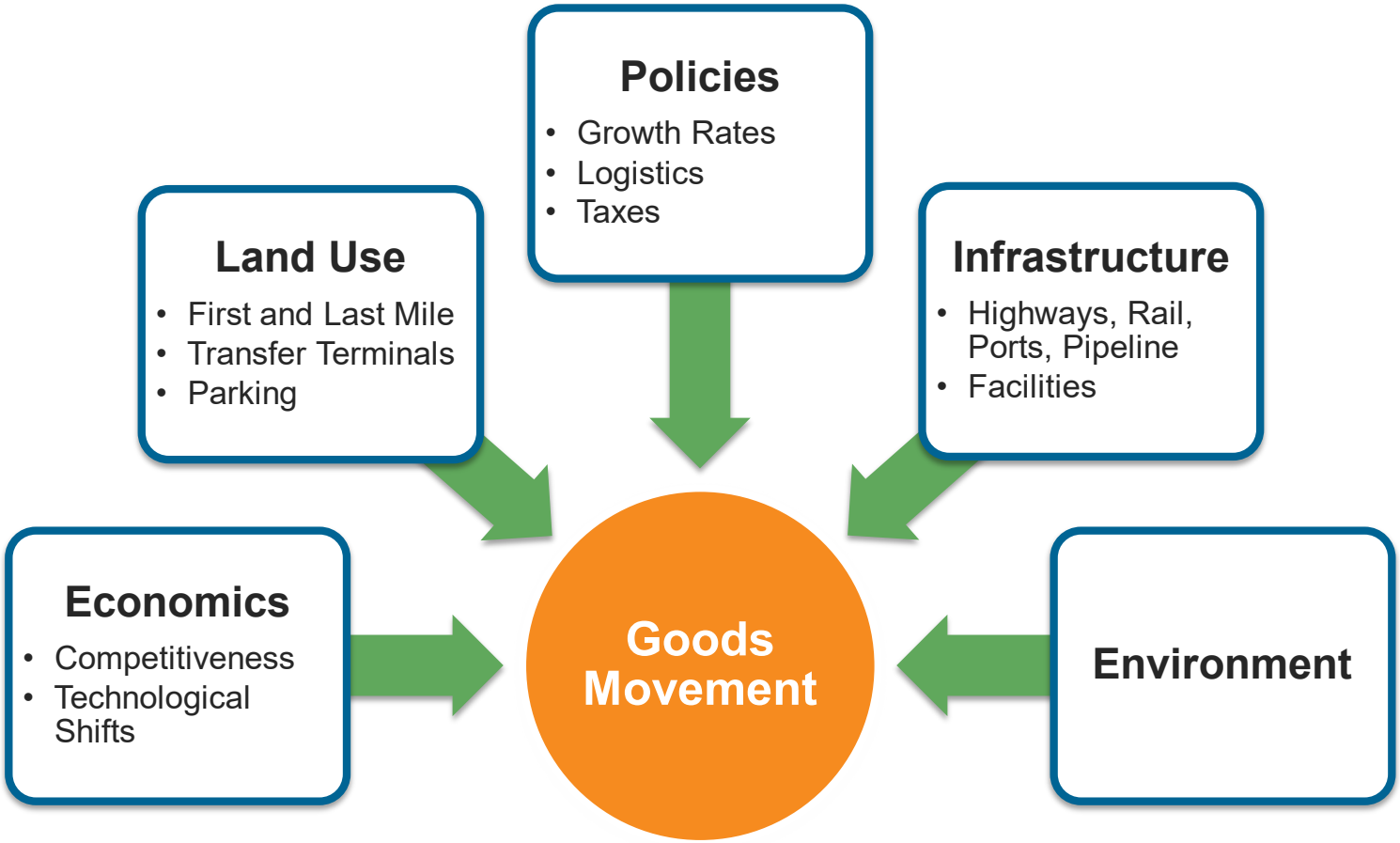
- Supply chain modeling needs
- Model structure, component interactions, and segmentation
- Market segmentation (commodity, mode, etc.)
- Modeled performance measures
- Approach to forecasting
- Types of applications



DATA

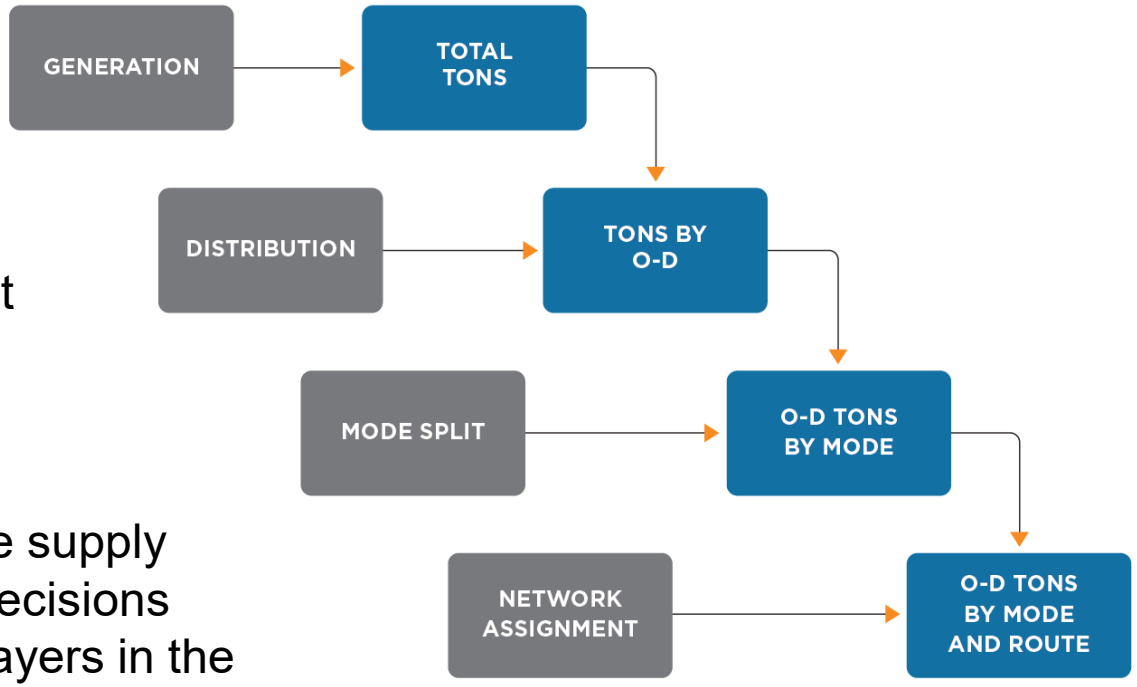
- Geographic scope
- Data inputs
- Data used for parameters estimation, calibration/validation
- Data desired, but not found

Agencies are faced with more complex policy and planning questions

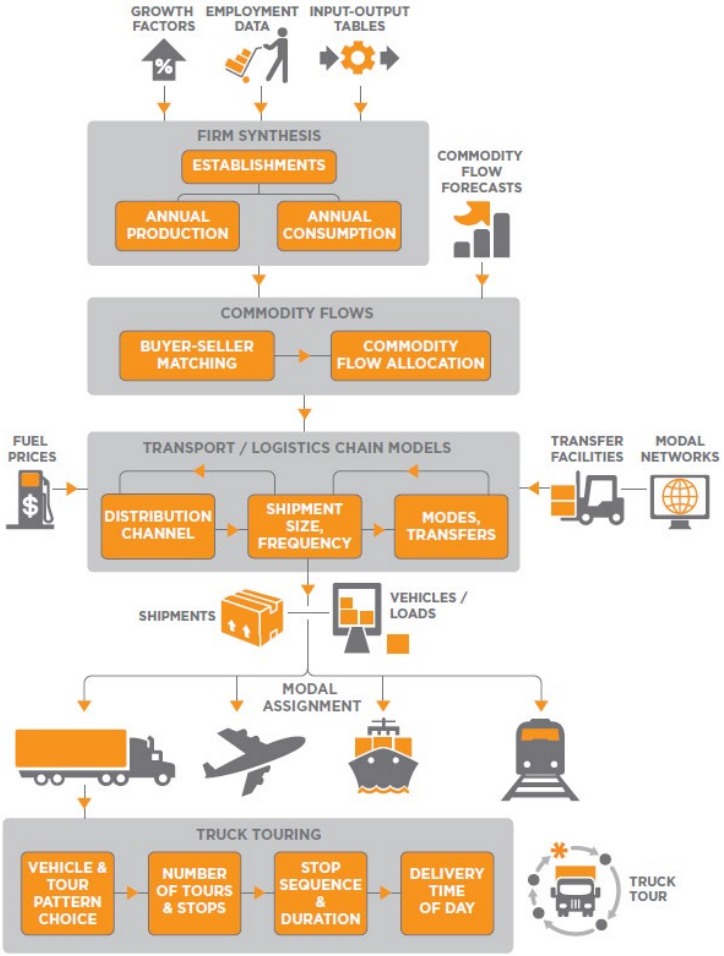


Trip-based models have limitations for understanding goods movement

- Lacking economic behaviors
- Not sensitive to freight policies of interest
- Failure to replicate the supply chains and logistics decisions made by individual players in the freight supply chains



Supply Chain Modeling Approaches



- Firm synthesis
- Buyer-supplier matching
- Commodity flow allocation
- Distribution channel
- Shipment size and frequency
- Modes and transfers
- Truck touring models

Behavioral freight models can support a wide range of applications

Modal Alternatives
- Infrastructure investments
- Ports and terminal facilities
- Congestion

Pricing
- Manage demand
- Raise revenues

Economics
- Global
- Domestic
- Regional

Environmental
- Fuel standards
- Taxes

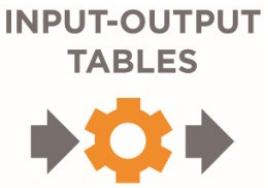
Safety
- Technologies
- Hours of service
- Emergency management

Regional
- Policies
- Pricing
- Planning

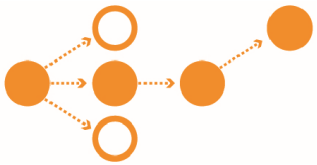
Common Data Sources

- **Employment data**
  - County Business Pattern (CBP)
  - Longitudinal Employer-Household Dynamics (LEHD)
  - Quarterly Census of Employment and Wages (QCEW)
  - US Department of Agriculture (USDA) Census of Agriculture

- **Economic data**
  - US Bureau of Economic Analysis (BEA) Input-Output (IO) Make and Use Tables



- **Commodity flow data**
  - Commodity Flow Survey (CFS)
  - Freight Analysis Framework (FAF)

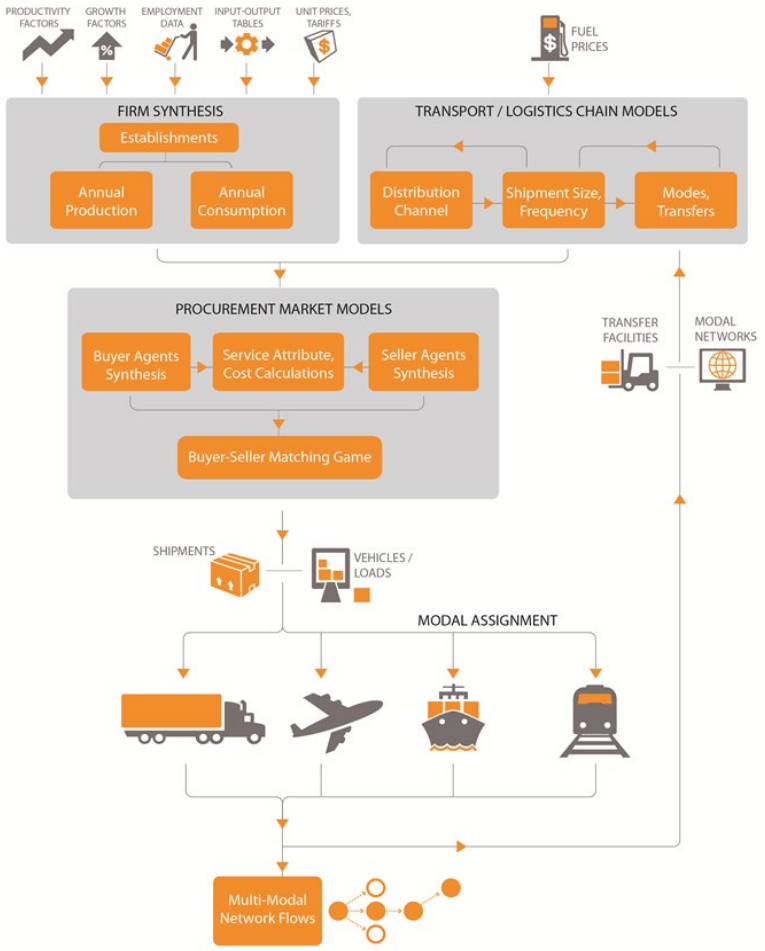


Compare Details of the Common Data Sources

Data Source	Availability (latest available)	Spatial Detail	Temporal	Modes	Industry Detail	Commodity Code
County Business Pattern (CBP)	Public, 2016	County	Annual	N/A	Six-digit NAICS codes	N/A
Bureau of Economic Analysis (BEA) Input/Output Accounts	Public, 2012	National	Annual	N/A	Two to six-digit NAICS codes	N/A
Freight Analysis Framework (FAF)	Public, 2017	FAF Zone	Annual	All modes	N/A	Two-digit SCTG Commodities
Commodity Flow Survey (CFS)	Public, 2012	BEA Zone	Every five years	All modes	N/A	Two-digit SCTG Commodities
Vehicle Inventory and Use Survey (VIUS)	Public, 2002	State	Every five years	Truck	N/A	Two-digit VIUS Commodities
Transearch	Private, 2018	County	Annual	All modes	N/A	Four-digit STCC Commodities
Surface Transportation Board Waybill	Public, 2017	BEA Zones	Annual	Rail	N/A	Four-digit STCC Commodities

EXAMPLE 1

Chicago Metropolitan Agency for Planning

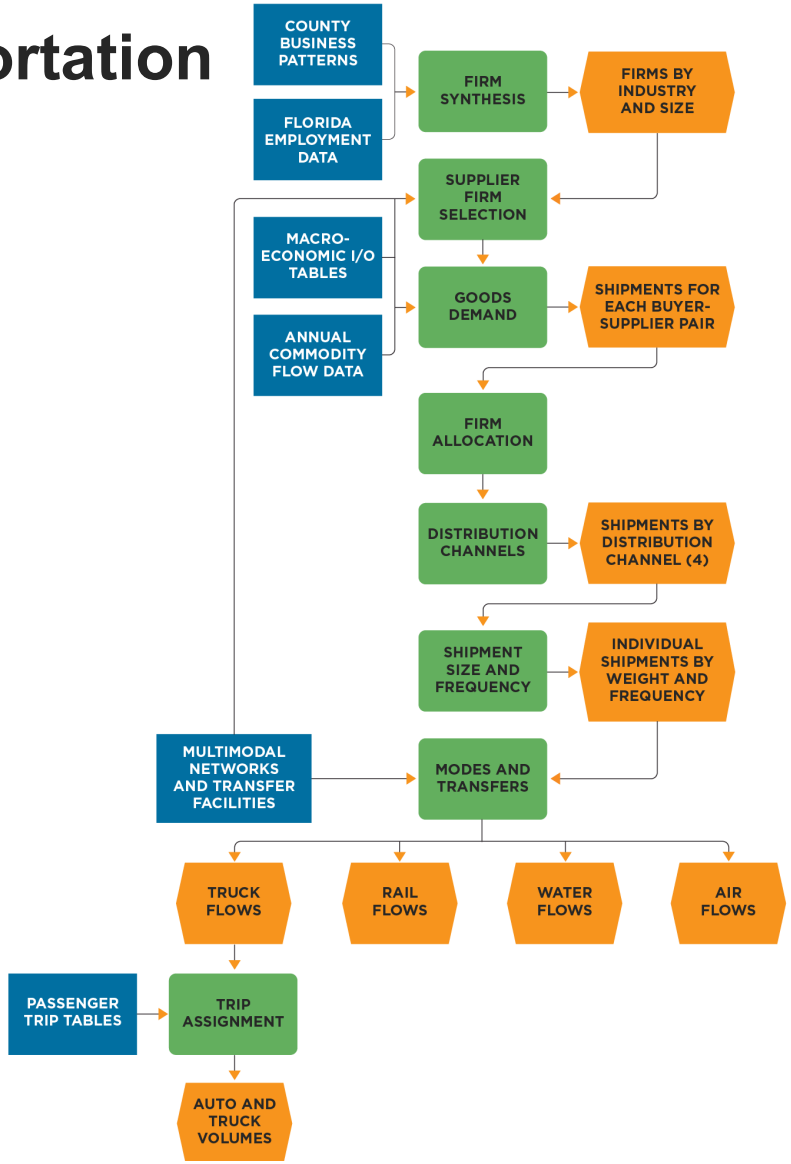


- Firm synthesis, supplier selection, and mode choice elements developed in 2011
- Supply chain and logistics elements and truck-touring models added in 2012
- Developed an extension to the mesoscale model in 2017
- Incudes an iterative procurement market game (PMG) for each commodity market

EXAMPLE 2

Florida Department of Transportation

- Integrated into the Florida Statewide Model (FLSWM)
- Utilizes detailed employment data (infoUSA) along with the CBP data
- Uses “Total Logistics Costs” and supply chain related concepts to estimate path cost parameters.
- Utilizes ATRI truck GPS data to support calibration of the model



Compare Methods of Existing Advanced Models

Model	Firm Synthesis (model type)	Buyer-Supplier Matching (model type)	Supply Chain Allocation (model type)	Mode and Shipment Size (model type)	Tour-based Truck (model type)
Chicago	Establishment enumeration	Game theory	MNL model	Ben-Akiva and de jong utility equation, MNL model	MNL models, greedy algorithm
Florida	Establishment enumeration	Fuzzy logic	MNL model	Ben-Akiva and de jong utility equation, MNL model	N/A
Baltimore/ Maryland	Establishment enumeration	Fuzzy logic	MNL model	Ben-Akiva and de jong utility equation, MNL model	MNL models, TSP algorithm, hurdle/count models
Portland	Establishment enumeration	Fuzzy logic	MNL model	Ben-Akiva and de jong utility equation, MNL model	MNL models, TSP algorithm, hurdle/count models
Phoenix	Establishment evolution	ACE	ACE	Nested Logit	MNL models
Oregon	N/A	N/A	N/A	Monte Carlo process	TSP algorithm
Wisconsin	Establishment enumeration	Fuzzy logic	Ben-Akiva and de jong utility equation	Ben-Akiva and de jong utility equation	Gravity models

Staff Resources for Data Processing and Model Maintenance

- Requires training and experience to maintain and apply
- Ideally, one or two full-time staff, but many transportation agencies will begin with 0.5 full-time equivalent staff resources

COLLABORATION OPPORTUNITIES

(public sector partnerships)

- Sharing data, software, and computing resources, as well as joint funding of model development or maintenance activities (e.g., MAG and PAG shared data and modeling resources)

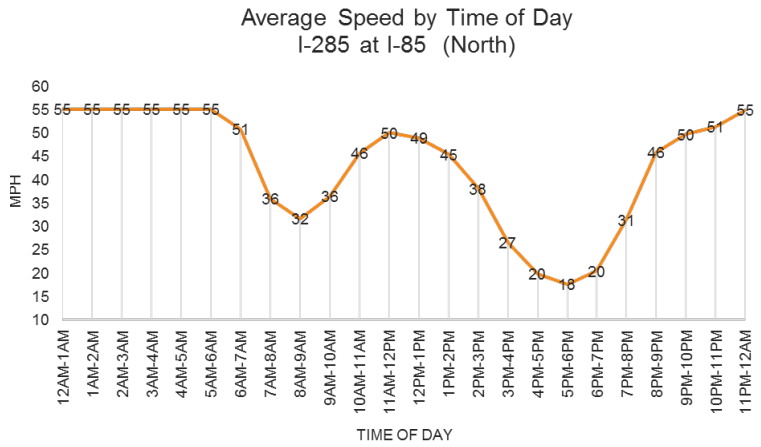
Freight Performance Measures

PUBLIC SECTOR PERFORMANCE METRICS

- Transportation system performance (efficiency and reliability)
- Safety
- Environmental sustainability
- Economic indices
- System preservation

PRIVATE SECTOR PERFORMANCE MEASURES

- Operations
- Financial
- Safety

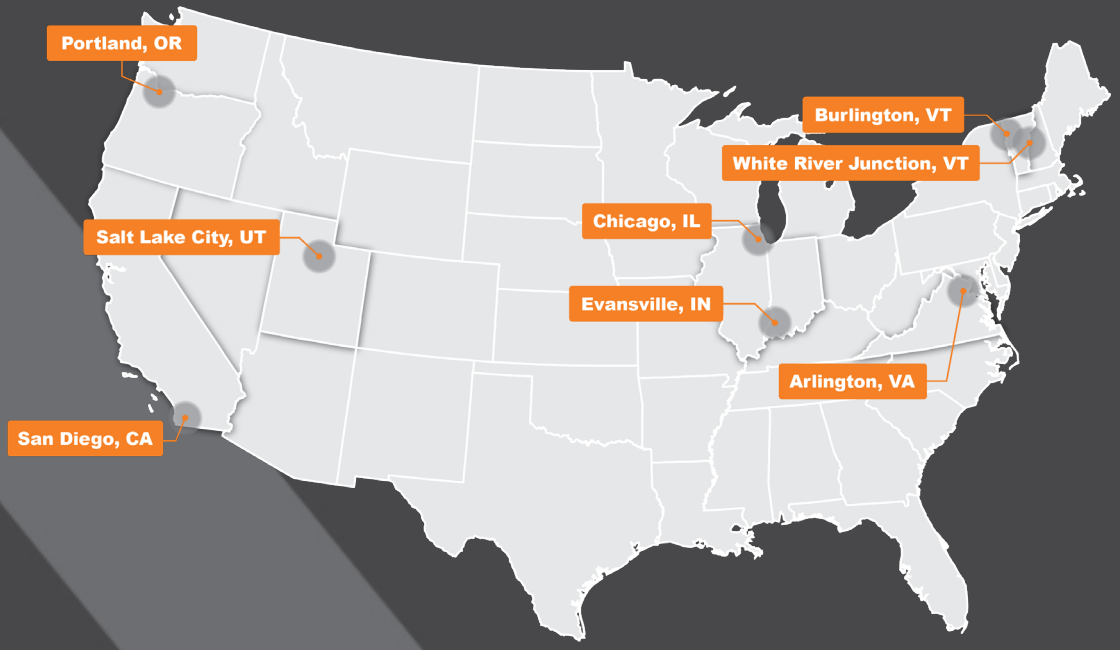


Freight Data Sharing

- Freight data is a firm's most valuable IP
- Considered highly sensitive and proprietary
- Most data is now electronic – which makes data protection more important than ever – and more difficult than ever
- Industry hacking and cyber crimes reflects data value
- Public transportation agencies and private data firms can share data needed for behavioral supply chain freight models

Behavioral supply chain freight models have been successfully developed in the U.S.

- This guidance offers efficiency and confidence to implement supply chain models
- Many models leverage existing research on methods (mode choice, buyer-supplier matching)
- Some models continue to innovate (firm evolution, buyer-supplier game)
- There are opportunities to share data while still protecting data privacy



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