E-Commerce Impacts on Regional Travel and Energy Use:

Household Shopping and Parcel Delivery Tradeoffs

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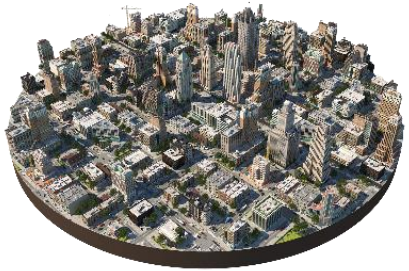
Presented at METRANS I-NUF 2019
Long Beach, California
October 16-18, 2019

Modeling Systemwide Travel for New Metropolitan Challenges…

Traveler decisions & transportation demand

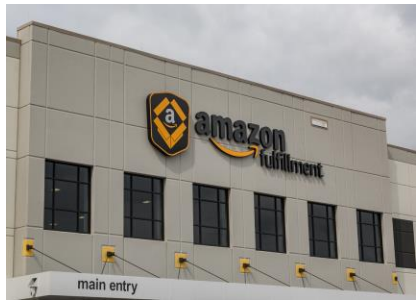
Land use



Metropolitan area with built environment

Transportation supply

…Focusing Today on the Impacts of E-commerce on Regional Travel and Energy Consumption



Research Question

As traditional (physical) shopping trips

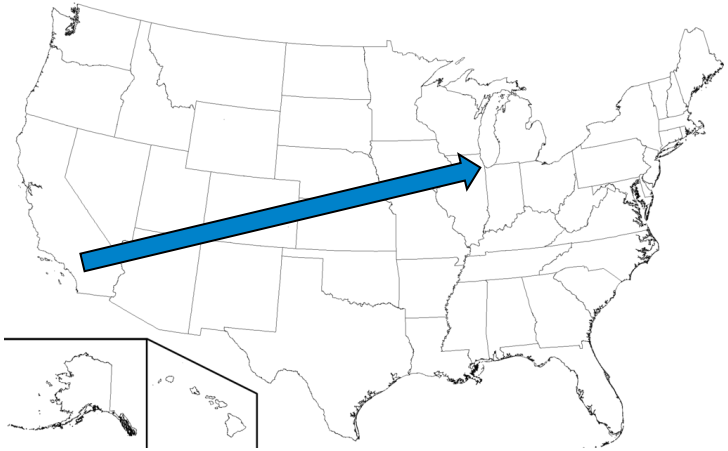
are replaced by

virtual (e-commerce) shopping “events”...

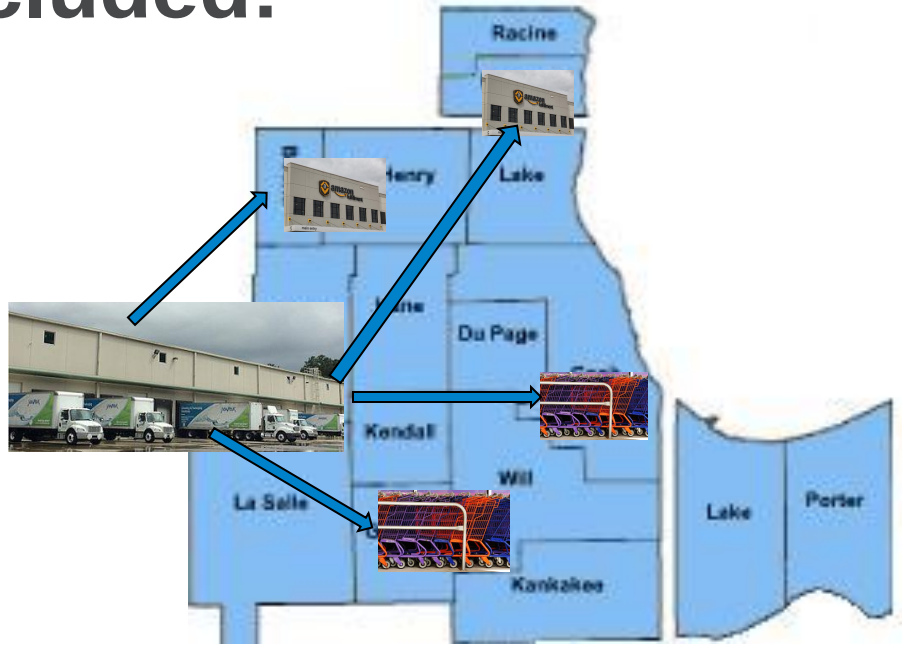
…what will be the net effect on regional Vehicle-Miles Taveled (VMT) and Fuel Use or Total Energy Consumption?

Focus of This Study: Last Leg of the Journey to the Consumer

Not included:



Long-haul freight impacts



Secondary/outer distribution impacts:

APPROACH

ACTIVITY BASED TRAVEL DEMAND AND NETWORK SUPPLY MODELS

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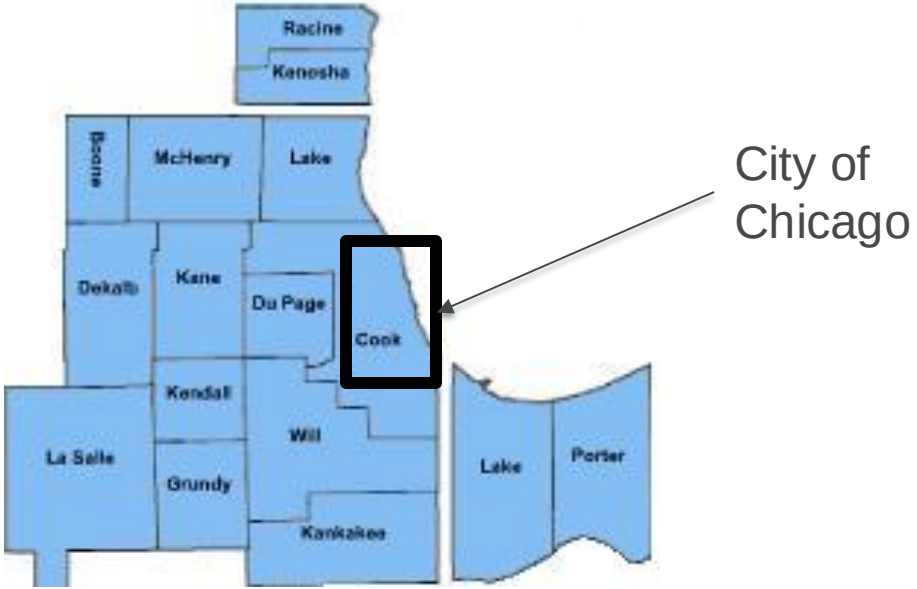
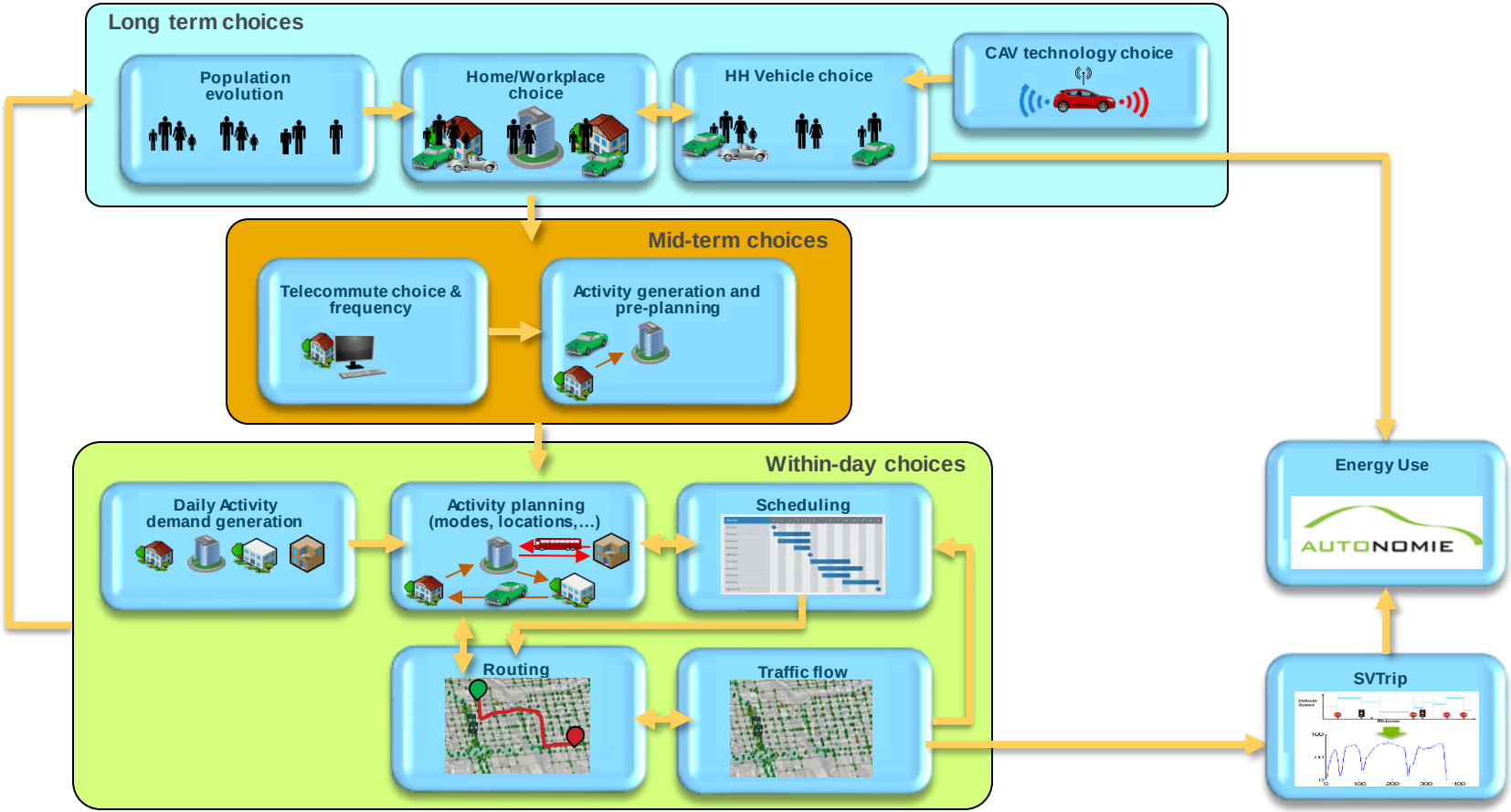
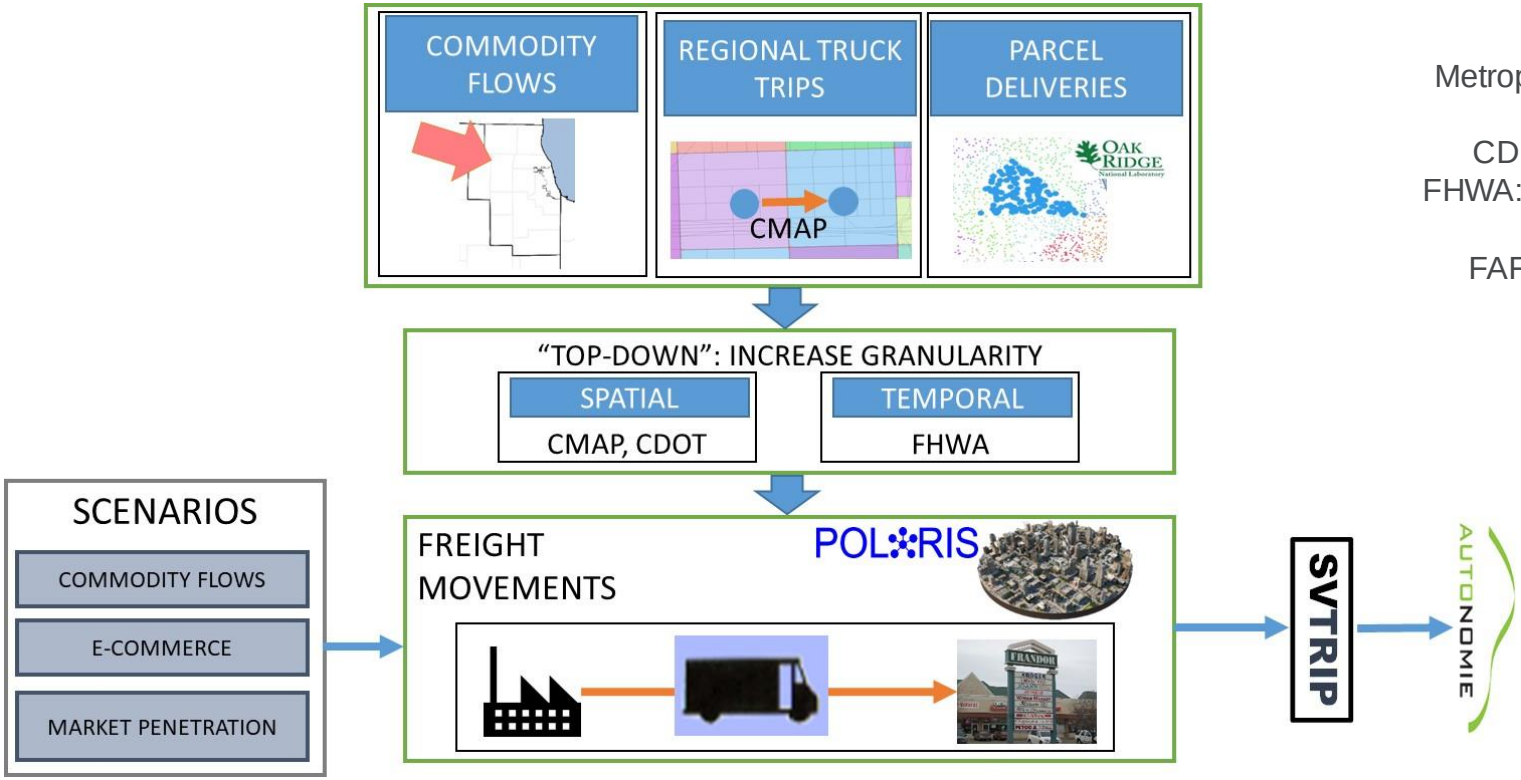
Test Case: the Chicago Metropolitan Region



POLARIS…allows us to explore tradeoffs that individuals make in their travel decisions

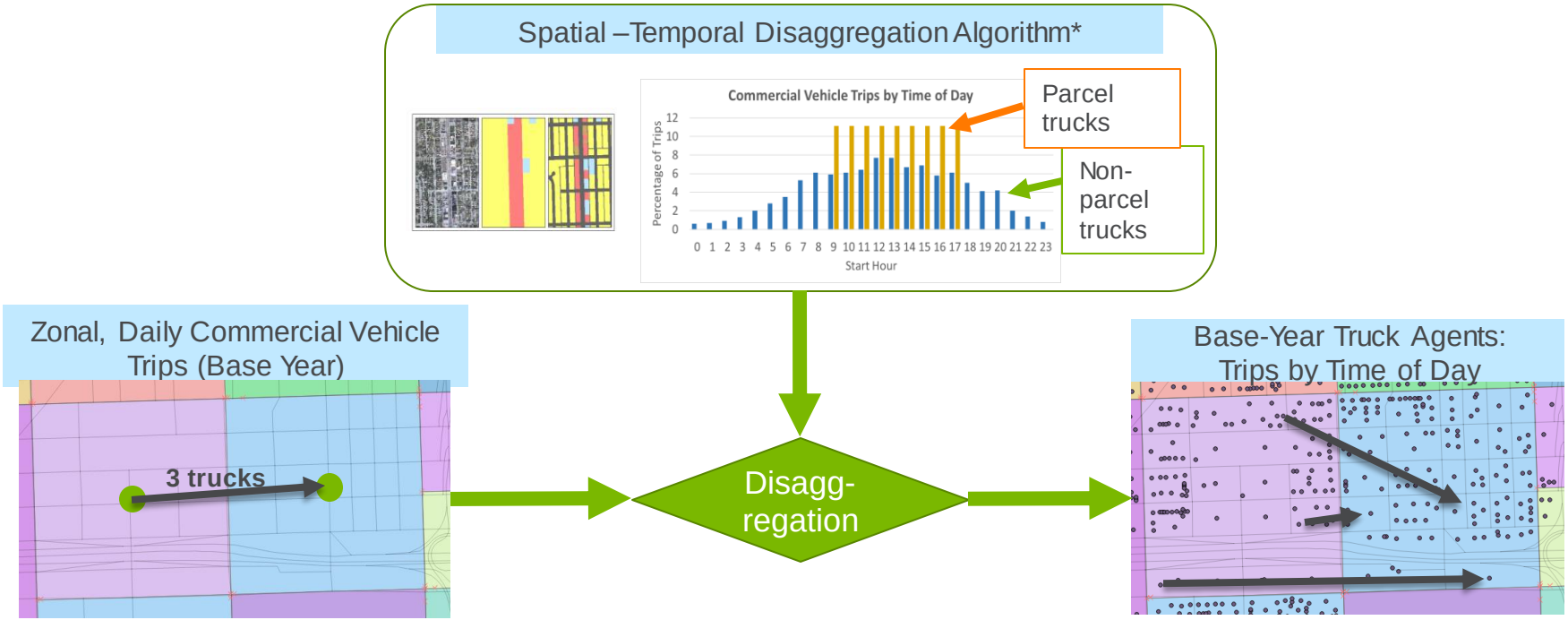


“Top-Down” Freight Model Implemented into POLARIS



CMAP: Chicago Metropolitan Agency for Planning
CDOT: Chicago DOT
FHWA: Federal Highway Administration
FAF: Freight Analysis Framework

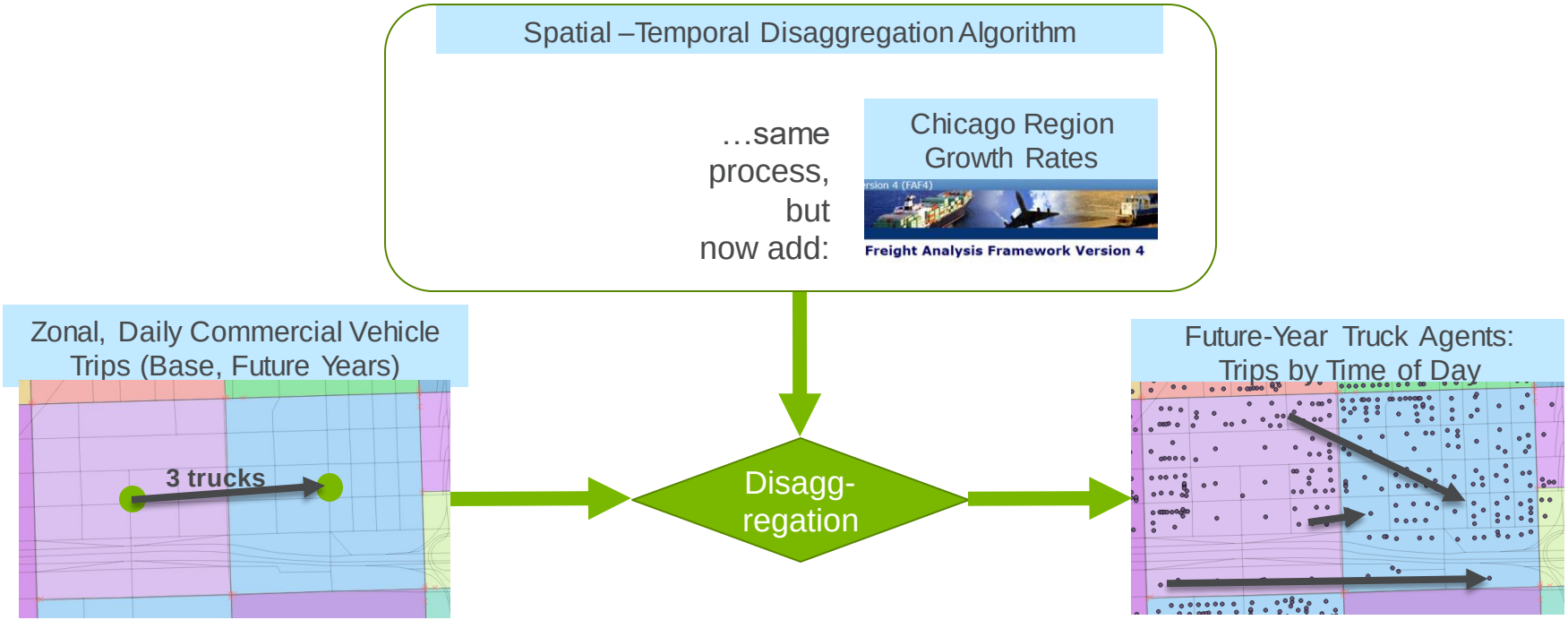
“Top-Down” Freight Model Implemented into POLARIS: Created Baseline Freight Trips



Source: Chicago Metropolitan Agency for Planning or CMAP

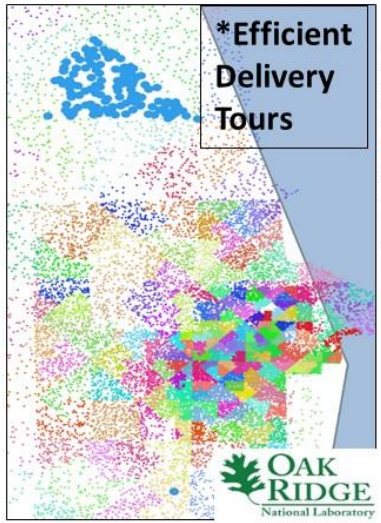
*The algorithm uses data from: Chicago DOT Buildings Data, CMAP Land Use Inventory, and the FHWA Traffic Data Computation Method: Pocket Guide

“Top-Down” Freight Model Implemented into POLARIS: Created Future Freight Trips



Source: Chicago Metropolitan Agency for Planning or CMAP

Freight Analysis: "Top-Down" Approach:
Developed and Implemented Methodology to Assess E-Commerce Impacts



Base year:
Zone-Level: Total Parcel Deliveries
Stop-Level: Random Delivery Locations
->MDT Delivery Tours

WholeTraveler

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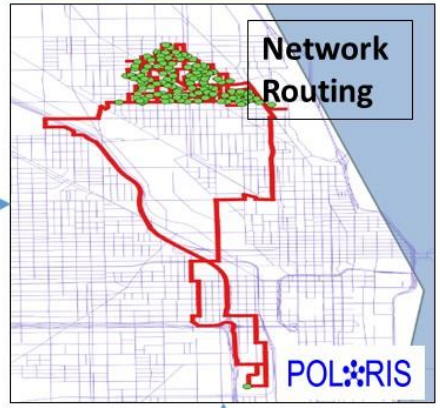
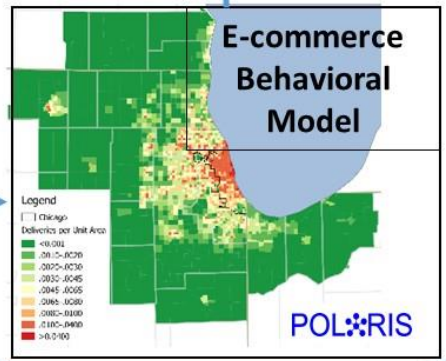
Survey Data





SVTRIP

AUTONOMIE

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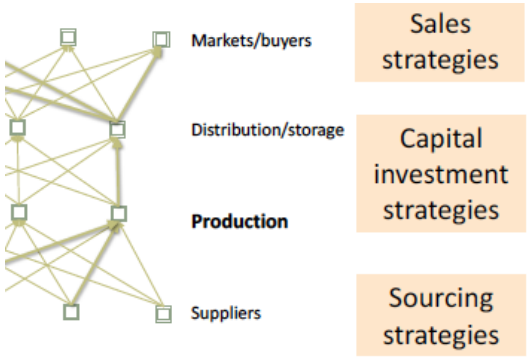
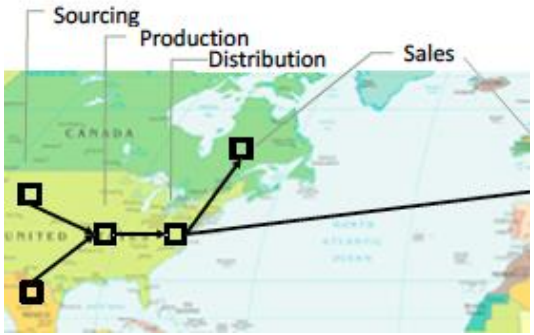
Agent-based Model: “Ground-up” Approach (In Progress)

Conceptual Overview

- **STRATEGIC**
  - B2B collaborations
  - Trade
  - Logistics capacity

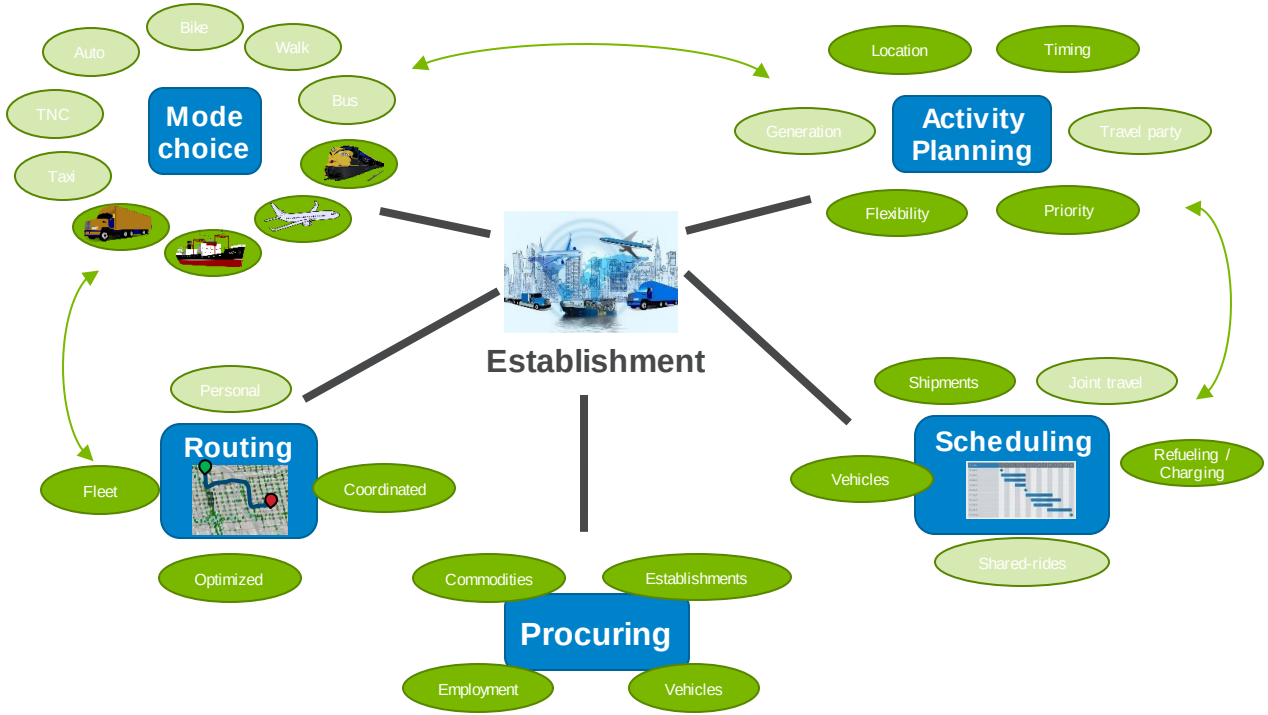


- **TACTICAL**
  - Demand forecasting
  - Production
  - Procurement
  - Logistics preparation



- **OPERATIONAL**
  - Scheduling: vehicles, crews, tours
  - En-route decisions

Decisions and Actions of Individual Firms & Establishments (In Progress)



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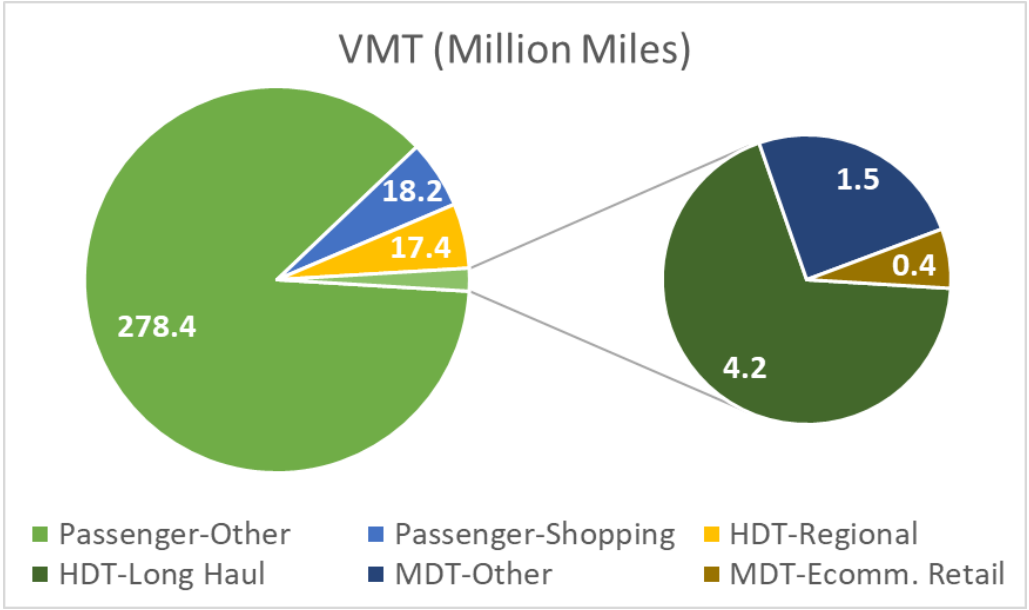
Travel Segments in the Overall Analysis Include: Medium-Duty Trucks (MDT), Heavy-Duty Trucks (HDT) and Passenger-Shopping Light-Duty Vehicles (LDV)

Baseline VMT by Travel Segment



Baseline MDT+HDT Share of VMT, Fuel

MDT+HDT Share	Model Result
VMT	8%
Fuel	36%

- Freight trucks have oversized impacts on regional travel:
  HDT drives high fuel:VMT ratio (3.5:1)

Assumptions in Model Scenarios

Scenario	Year	Commodity Flow Compound Annual Growth Rate (CAGR)	E-commerce Household Delivery Rate (Number of deliveries per week)
Baseline	2020	-	1
C	2040	Optimistic (1.3%)	3
B			7

Additional assumptions regarding **adoption of vehicle electrification technologies** among passenger and commercial fleets

Finally, we focus on **efficient delivery tours only** (non-express)

FINDINGS

Household E-commerce Demand Behavioral Model

More e-commerce demand for households with:

- Higher incomes
- More children (busier parents?)

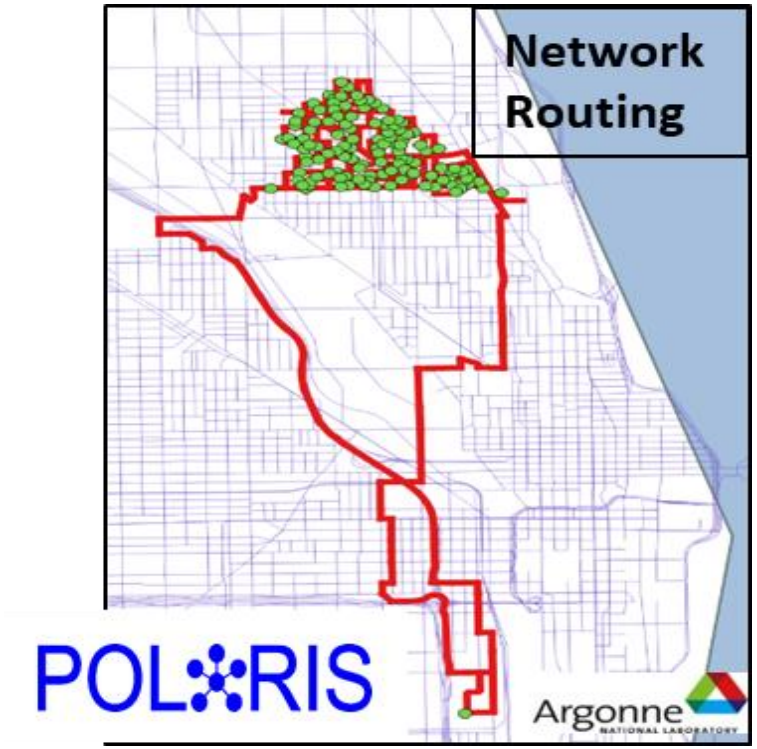
Less e-commerce demand for households with:

- More vehicles
- Fewer adults
- Residence is walkable and/or relatively close to transit (high-density)

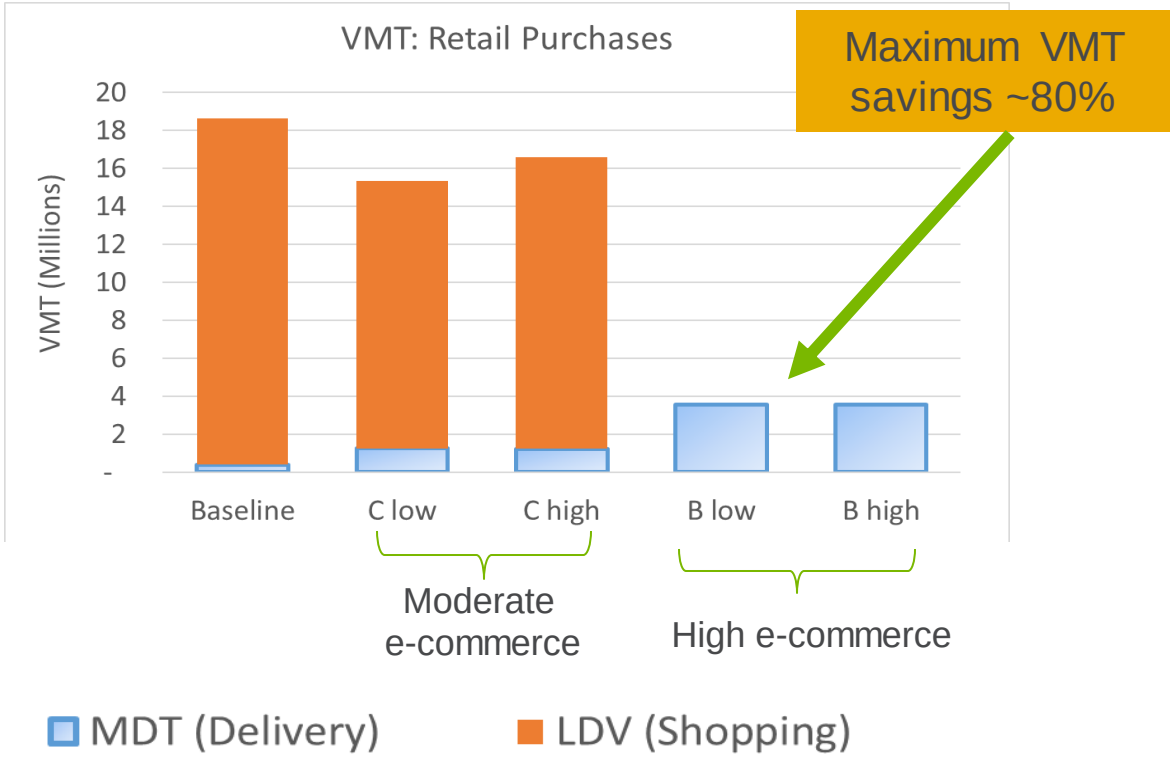
Binary Choice: Whether Participates in E-commerce or not		
Variables	Estimates	t-stat
Constant	-0.103	-1.64
# of HH Children	0.104	1.39
HH income less than 25k	-0.459	-2.33
HH income between 25k and 50k	-0.54	-3.37
HH income between 50k and 100k	-0.154	-1.41
HH income greater than 200k	0.355	3.32
Distance to nearest transit stop from home (in 100th of miles)	0.077	1.18
Ratio of Delivery to Retail Shopping		
Parameters to the latent propensity		
Constant	2.882	11.7
# of HH Adults	-0.146	-2.49
HH income greater than 200k	0.369	3.29
Walk Score (Range 0 to 10)	-0.057	-3
# of HH Vehicle	-0.18	-2.8
Threshold Parameters		
Theta 0	-ve Infinity	Fixed
Theta 1	0	Fixed
Theta 2	1.576	11.86
Theta 3	2.162	15.74
Theta 4	2.738	19.23
Theta 5	3.482	22.34
Theta 6	+ve Infinity	Fixed
Summary		
Number of Observations	971	
Final Log-likelihood	-1362.45	

Example tour after routing in a congested network

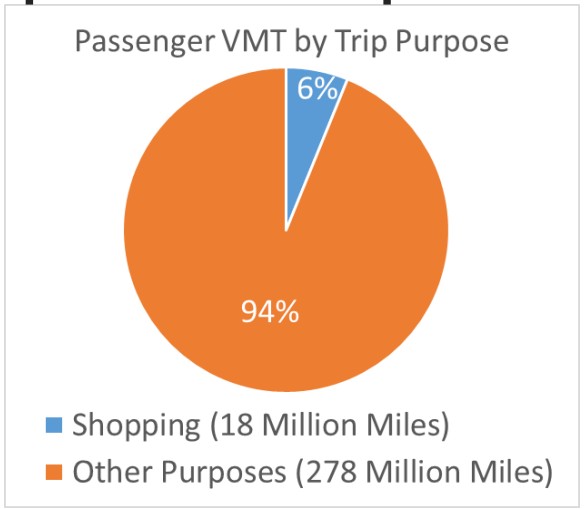
- 120 stops on average per tour
- Freight/delivery, passenger and service vehicles interact in the traffic simulation framework
- Total: 500,000 deliveries (base year) vs. 3.5M in Scenario B



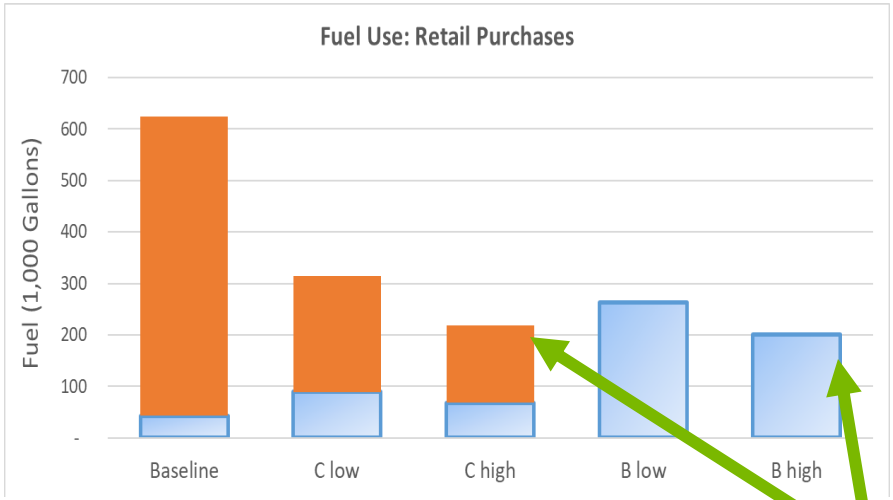
Efficient E-commerce Delivery System Reduces VMT Related to Shopping…

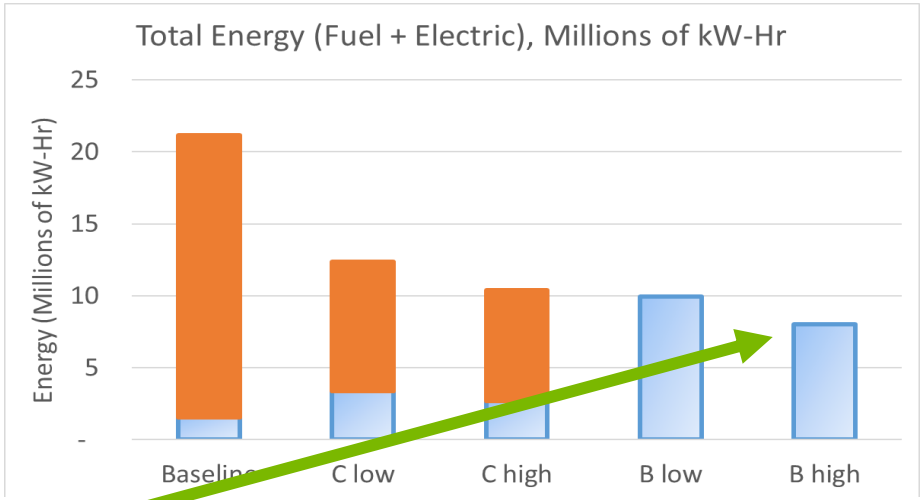


…which is a large portion of the pie:



Likewise, Efficient E-commerce Delivery System Reduces Fuel Consumption Related to Shopping





However, maximum fuel, energy savings ~50-60% → not commensurate with VMT reduction → room to improve truck efficiency

CONCLUSION

Summary of Results

- Investigated net effect of e-commerce on VMT and energy use in the Chicago region
- Focused on efficient delivery tours and the final leg of the retail goods journey
- Based on analysis in the Chicago Metropolitan Area:
  - Efficient delivery tours generate significant savings in VMT over traditional, physical shopping trips
  - Energy savings are also substantial but vary considerably depending on market adoption of vehicle electrification technologies

Next Steps

- In progress
  - Testing additional future scenarios with new technology assumptions, e-commerce utilization rates, and commodity flow growth rates → paint broader picture of possible outcomes
  - Integrate long-haul and outer distribution
- Other extensions
  - Extended survey of e-commerce use among households and businesses
  - Include other last-mile delivery system options (e.g., delivery lockers) in modeling framework

ACKNOWLEDGEMENT

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ACKNOWLEDGMENTS

The submission has been created by UChicago Argonne, LLC, Operator of Argonne National Laboratory (“Argonne") and UT-Battelle, LLC, Operator of Oak Ridge National Laboratory (“ORNL”). Argonne, a U.S. Department of Energy Office of Science laboratory, is funded and operated under Contract No. DE-AC02-06CH11357. ORNL, a U.S. Department of Energy Office of Science laboratory, is funded and operated under Contract No. DE-AC05-00OR22725. The following Department of Energy project managers played a role in guiding this work: David Anderson and Prasad Gupte. The U.S. Government retains for itself, and others acting on its behalf, a paid-up, nonexclusive, irrevocable worldwide license in said article to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government.

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