

# Emerging Trends in Freight

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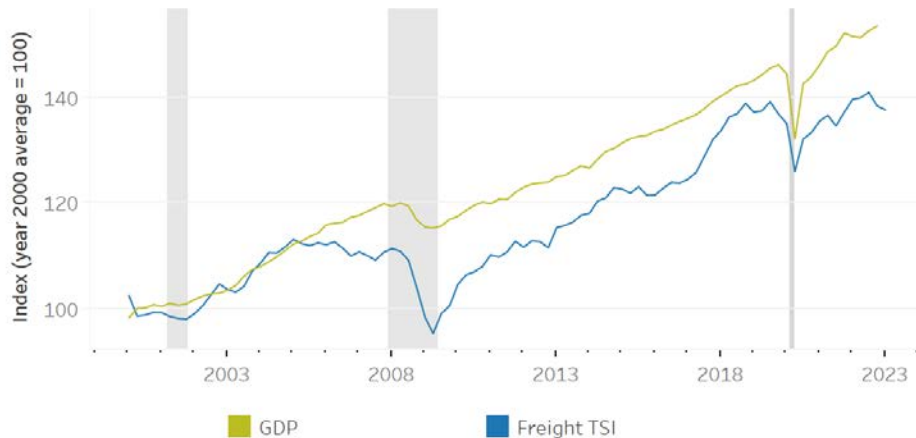
# State-of-the-Art



# Freight Facts

Minority of the traffic flow in the mobility system, but significant contributor to energy consumption and emissions

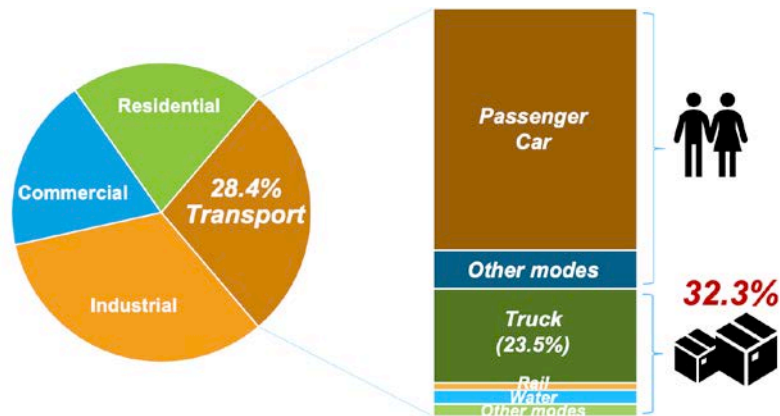
## US Freight Trend (2000 – 2023)



Note: Shaded area= economic recessions

Source: Bureau of Transportation Statistics

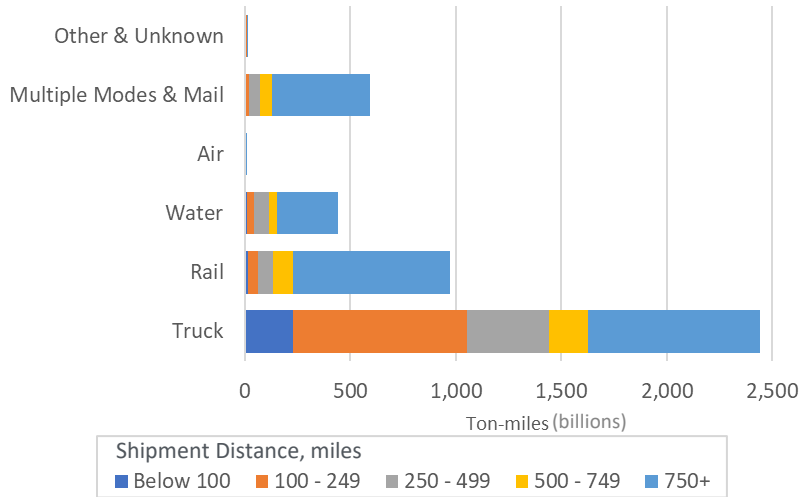
## US Freight Energy Consumption (2019)



Source: Transportation Energy Data Book: Edition 40 (Davis and Boundy, 2022)

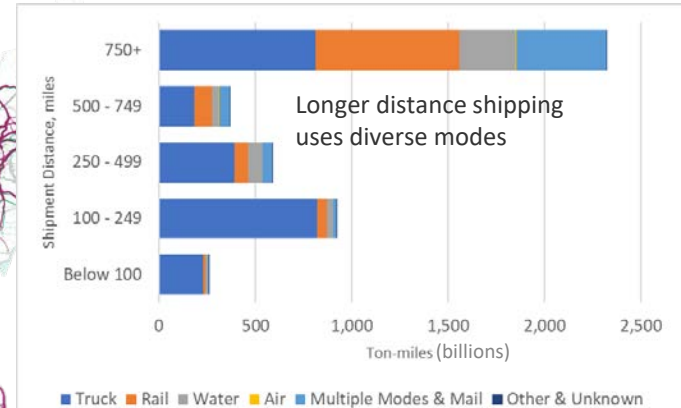


# Multi-Modal Freight System



- Trucking accounts for the largest share of freight movement
- Rail is ~40% as large as trucking
- 57% of all freight ton-miles are shipped more than 500 miles
  - 41% of truck ton-miles > 500 miles
  - 86% of rail ton-miles > 500 miles

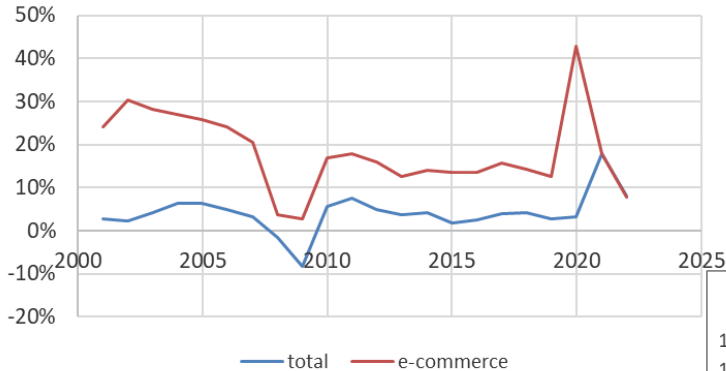
Source: Freight Analysis Framework, Freight Facts and Figures (pipeline excluded)



Longer distance shipping uses diverse modes

# E-Commerce: Why is everyone talking about it?

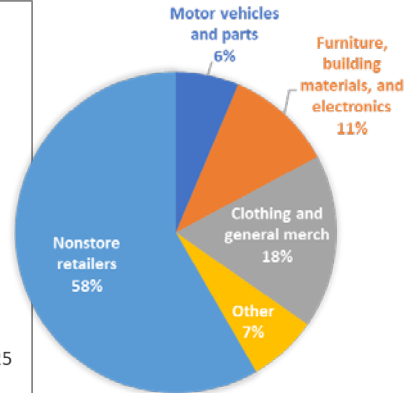
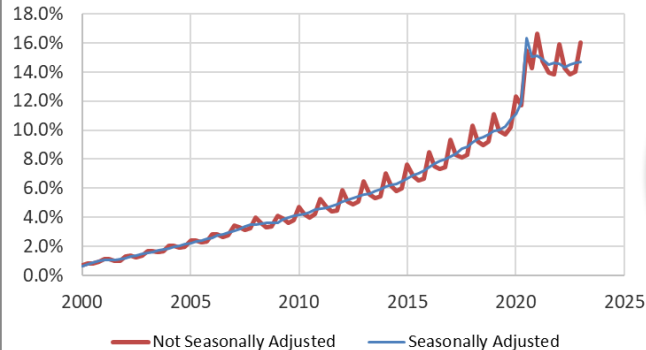
Annual Change in Retail Sales



- Since 2000, e-commerce has grown an average of 16.5% per year compared to 3.9% for retail sales overall
- E-commerce average annual growth rate since 2019 is ~23%
- E-commerce is ~15% of retail sales by value – up from 11% in 2019
- Non-store retailers (no brick and mortar channel) account for 58% of e-commerce retail sales by value – down from 87% in 2017

Source: U.S. Census Bureau, Monthly Retail Trade Survey  
<https://www.census.gov/retail/index.html#ecommerce>

Quarterly E-commerce Retail Sales as % of Total



***E-commerce has fundamentally changed freight logistics - What does continued growth mean for freight mobility, energy demand, emissions, and future technology solutions?***

# FREIGHT RESEARCH



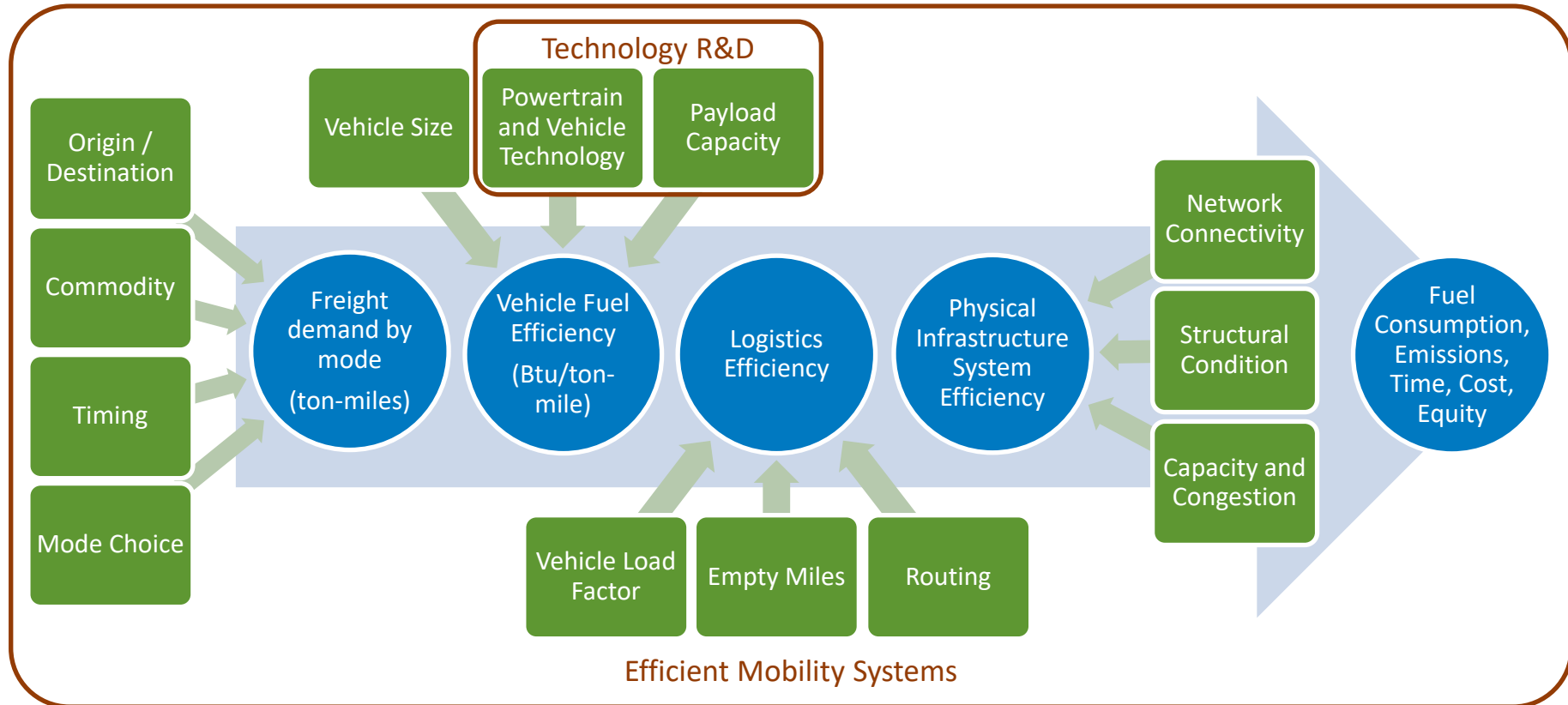
## Business Trend

- Increase in online-shopping
- Just-in-time supply chain
- Instant delivery
- Crowdsourcing
- Omnichannel logistics

## Vehicle Technology

- Digitalization
- Automation
- Connectivity
- Alternative powertrains and fuels
- New delivery modes

# Freight Research: a Systems Perspective



# NREL's Freight Research & Tools

A first-person perspective from the driver's seat of a car on a highway. The dashboard and steering wheel are visible in the foreground. In the distance, a semi-truck is driving away in the same lane. To the right, the side of another semi-truck is visible, partially cut off by the frame. The sun is low on the horizon, creating a bright, golden glow and lens flare effects across the scene. The sky is a clear, pale blue.



# Simulation and Analysis for Regional Freight Mobility

## Freight Activity **MO**bility Simulator (FAMOS)

- Agent-level modeling of the multi layer of freight activities and their interactions and infrastructure impact
- Focus on simulating road-freight vehicle movements in a region while generating mode-specific business-to-business flows across the nation
- Integration with a passenger model, enabling comprehensive regional mobility system analyses
- Scenario analysis capability (e.g. vehicle electrification, charging sighting, demand growth, last-mile delivery innovations, etc.)

### SynthFirm

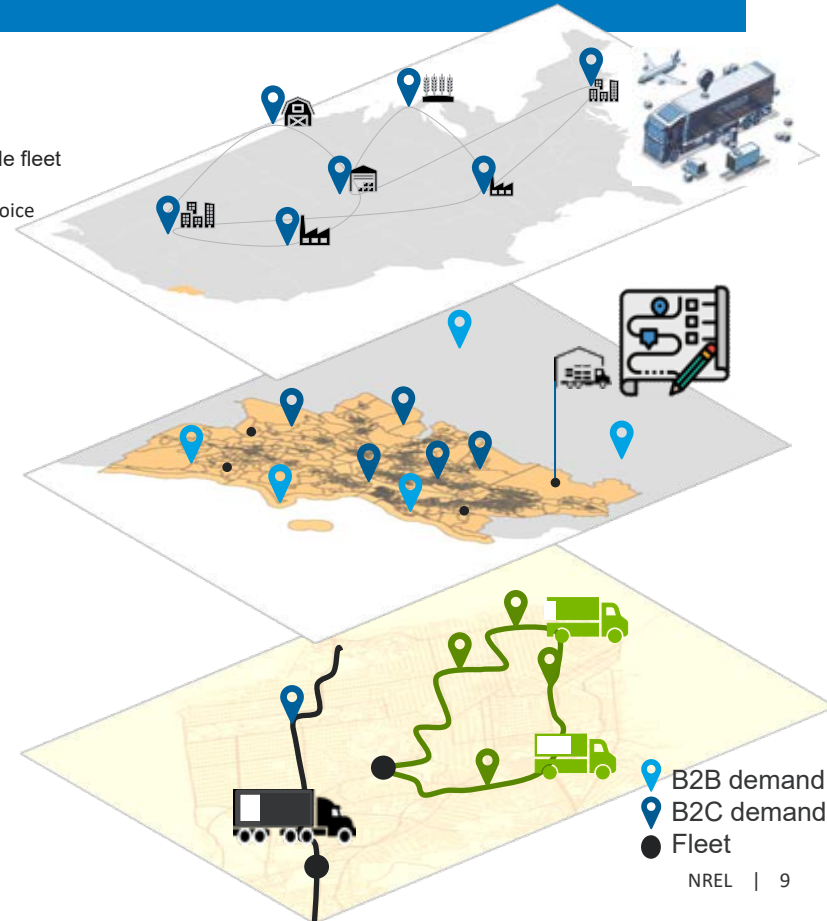
Synthesis of firm & vehicle fleet  
Supply-chain logistics  
Shipment size & mode choice

### FRISM

Online-shopping demand  
Daily shipments  
Fleet operation plan

### BEAM-Freight

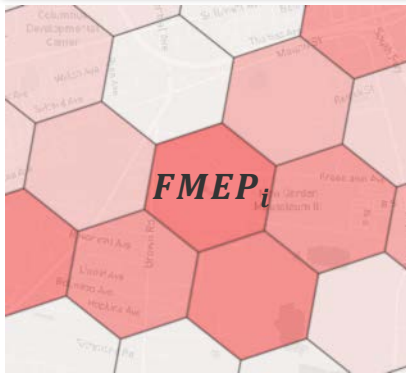
Vehicle routing  
Traffic assignment  
Infrastructure use



# Quantification of Freight Mobility Efficacy

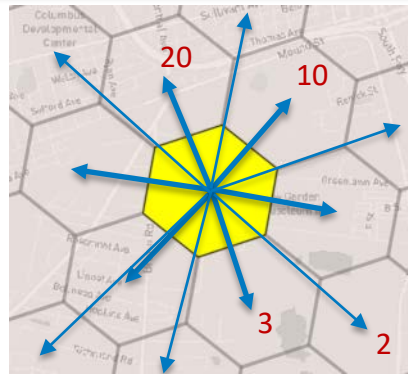
## Freight Mobility Energy Productivity (F-MEP)

- Quantify freight productivity of current as well as future freight systems, accounting for various expenditure associated with freight transport
- Enables between-city and within-city freight system analysis



F-MEP score for  $i$

=



Freight Mobility Benefits\* Impedance of time+ money + energy  
for a given location  $i$

+



Modes  
Opportunities  
Destinations



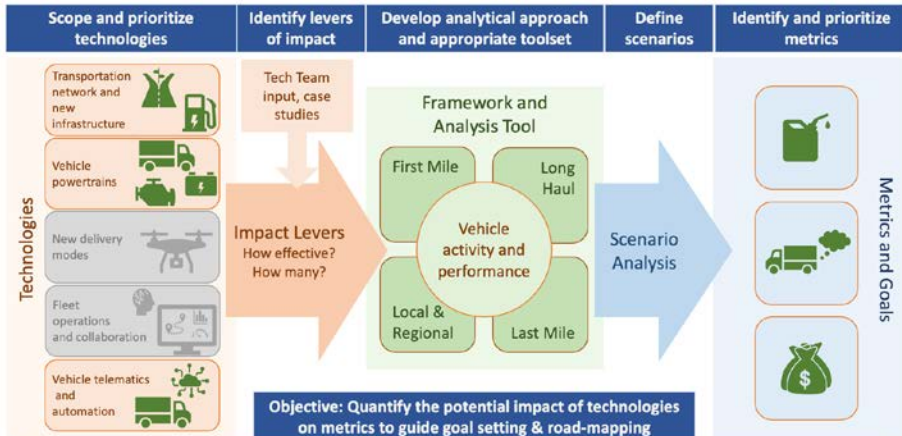
Comprehensive attractiveness to freight transport for delivery purpose to various location types

# Impact of emerging technologies on operational efficiency

## Freight Operational Efficiency Metrics (FOEM)

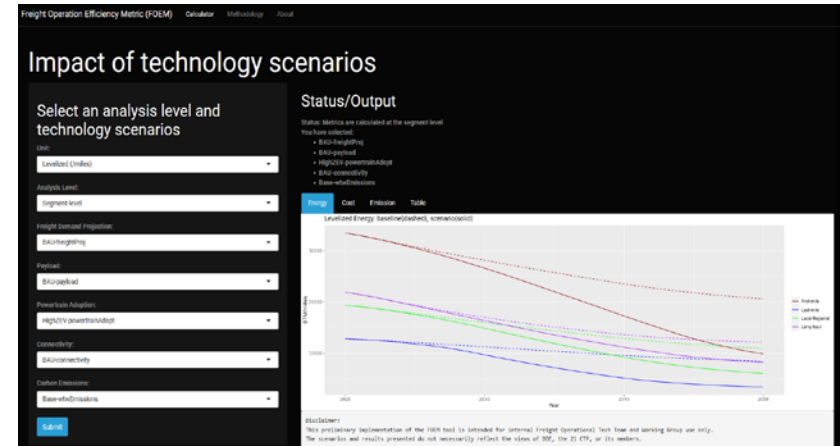
- Develop an analytical tool that allows for quick exploration of the operational efficiency space
- Apply the tool to estimate baseline performance metrics and the impact of emerging technologies on these metrics
- Enable providing segment-level analysis with national scope

### Analysis Framework

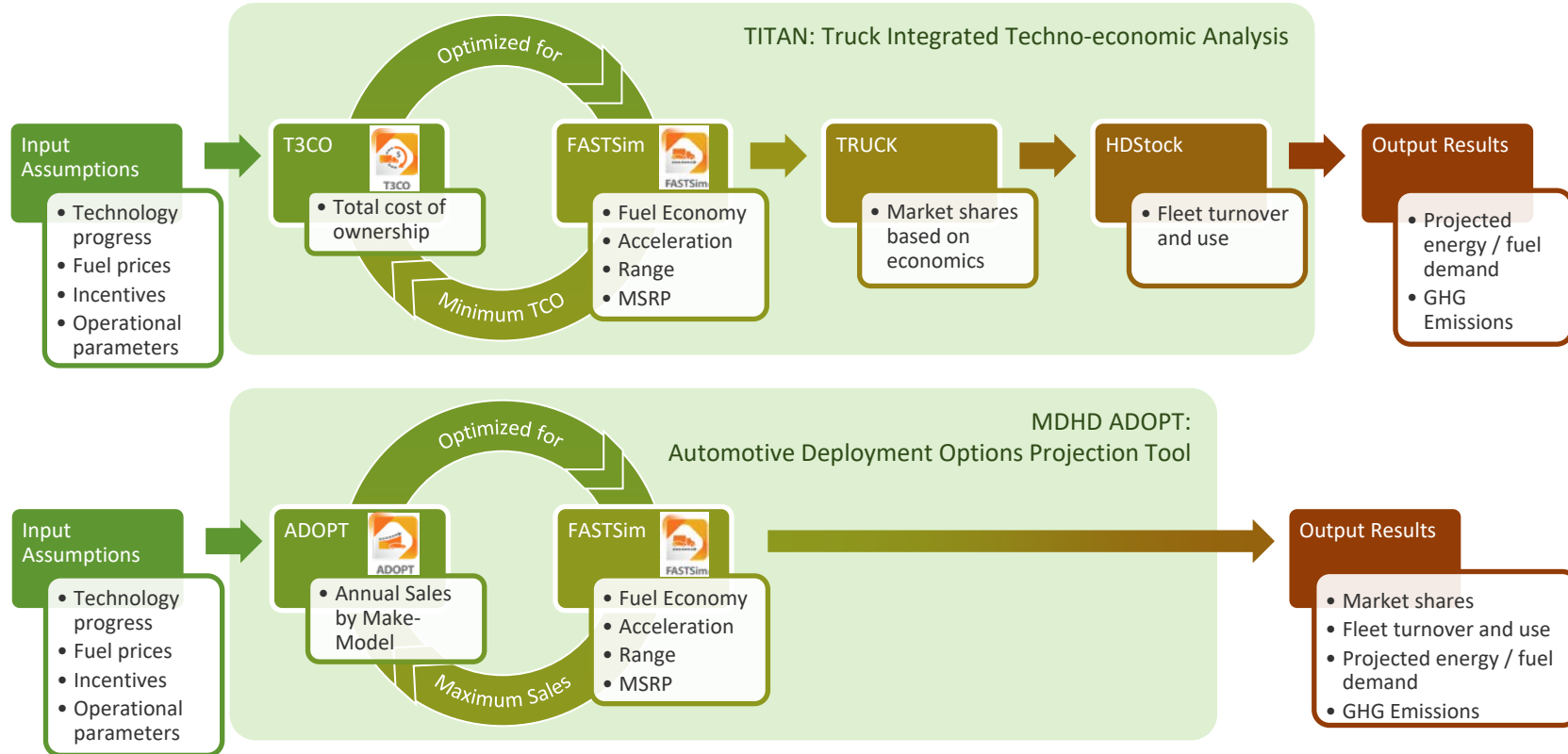


The FOEM provides a framework to aggregate the impact of freight efficiency technologies at the segment and system levels.

### Web-Interface



# Techno-economic Analysis of Commercial Vehicles

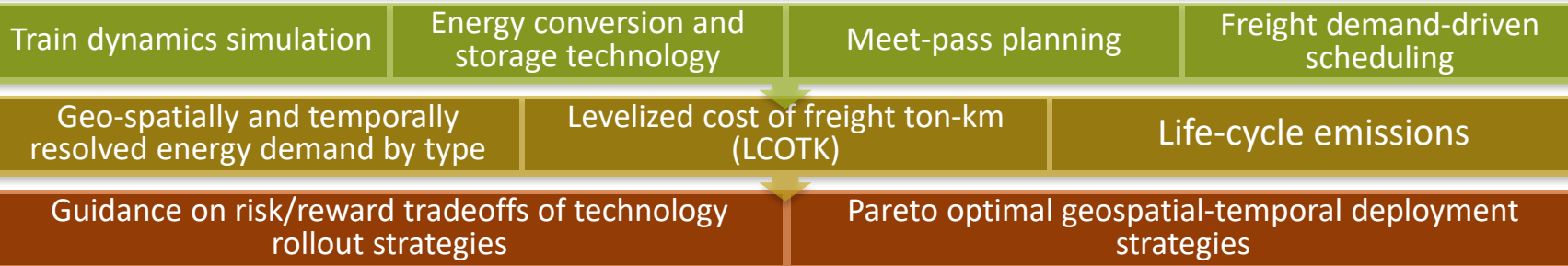




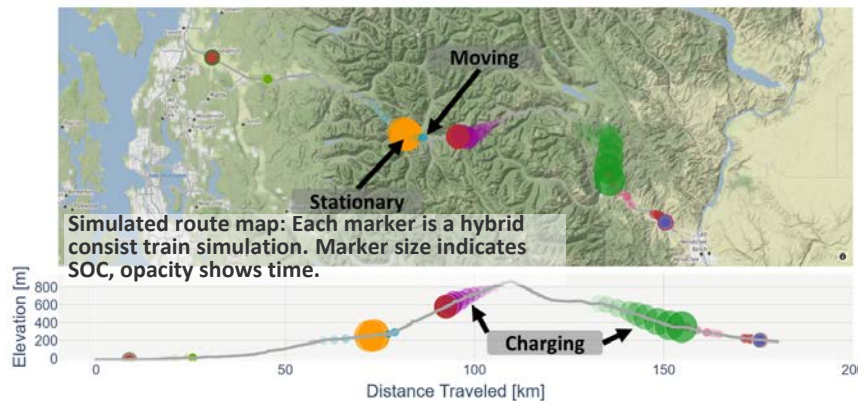
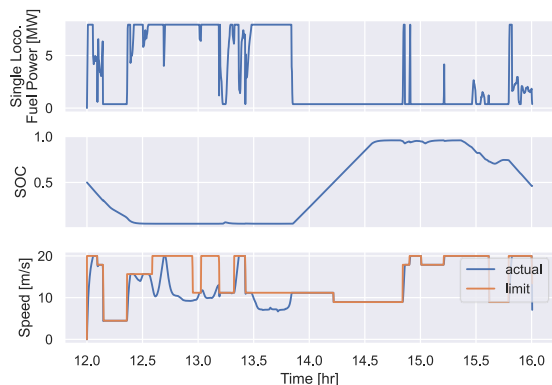
# ALTRIOS - Advanced Locomotive Technology and Rail Infrastructure Optimization System



Open-source software tool to evaluate strategies for deploying advanced locomotive technologies and associated infrastructure for cost-effective decarbonization.



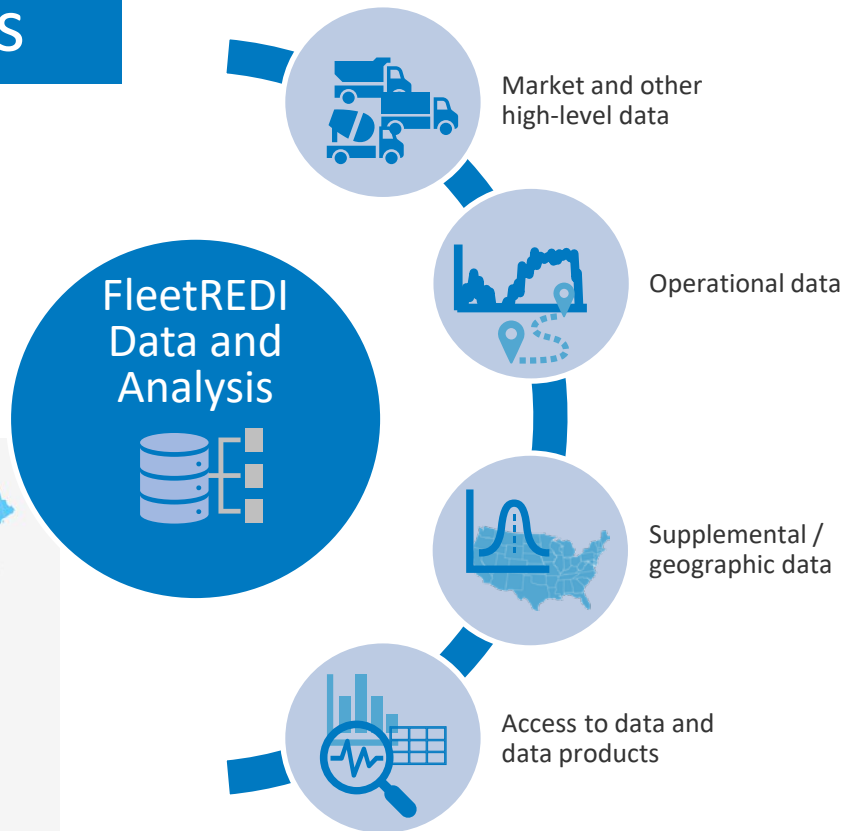
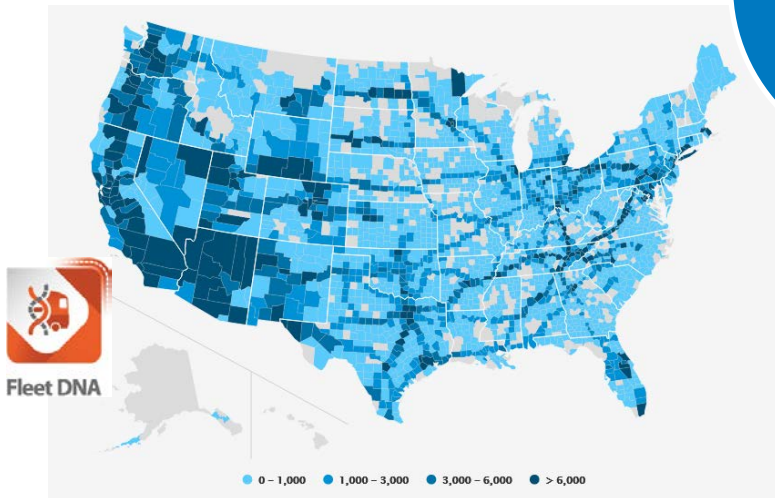
*Fuel, SOC, and Speed for 1 of 100 conventional locomotive trips*



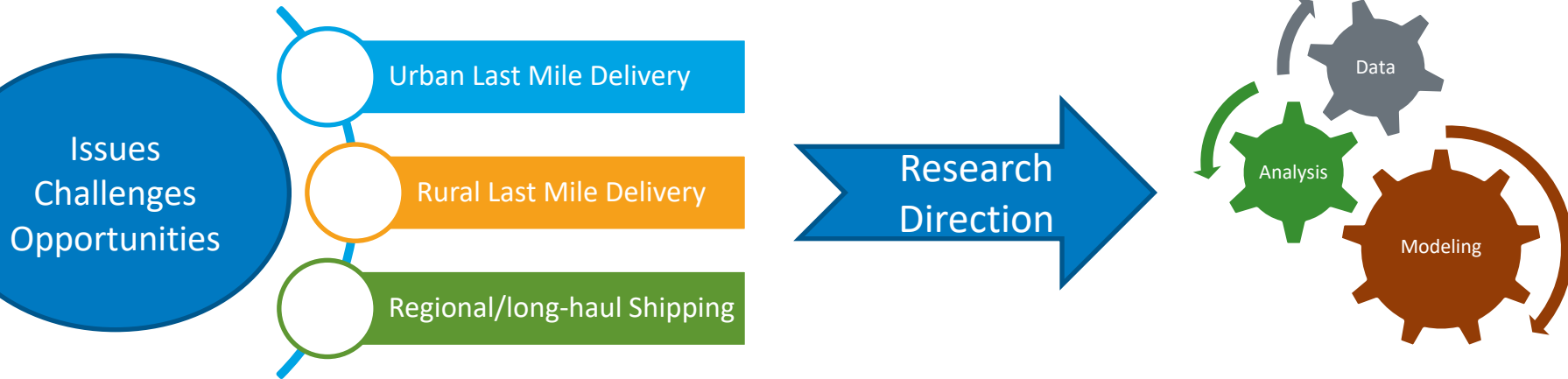
# FleetREDI – Fleet Research, Energy Data, and Insights

## GOAL

Provide research community with *updated, integrated, and comprehensive commercial vehicle data and intelligence* for strategic planning, R&D portfolio development, and current and future R&D projects.



# Breakout Discussion



- Existing and expected issues
- Challenges and opportunities to freight system efficiency and decarbonization
- How to resolve the issues
- Equity in the freight mobility

# Thank You

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[www.nrel.gov](http://www.nrel.gov)

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