

Emerging Trends in Freight

Kyungsoo Jeong

Alicia Birky

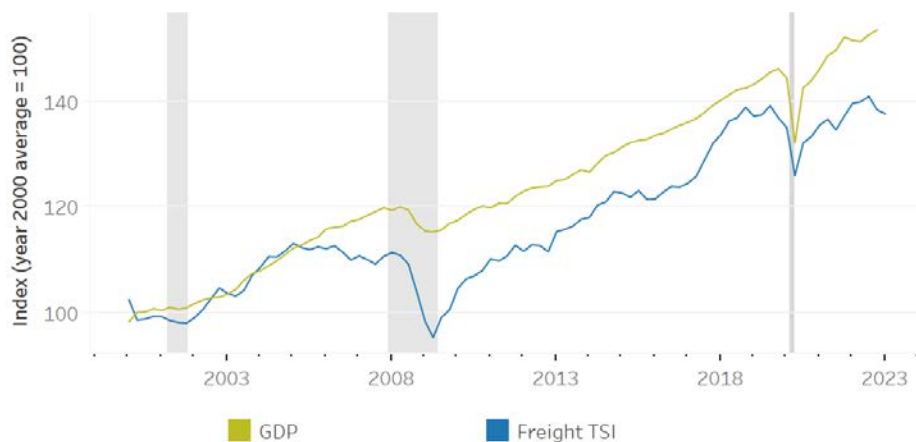
State-of-the-Art



Freight Facts

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

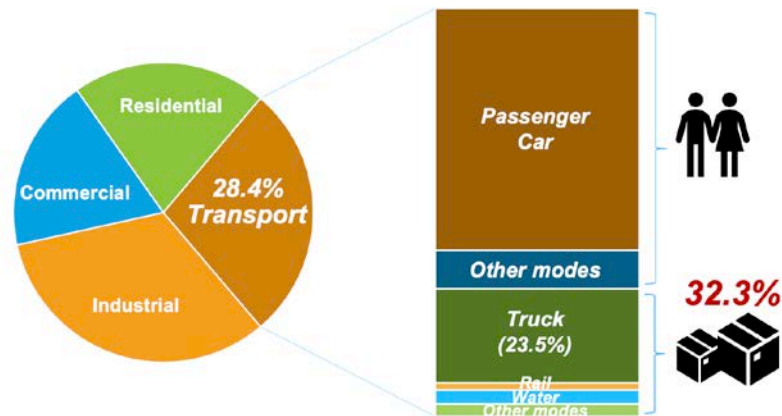
US Freight Trend (2000 – 2023)



Note: Shaded area= economic recessions

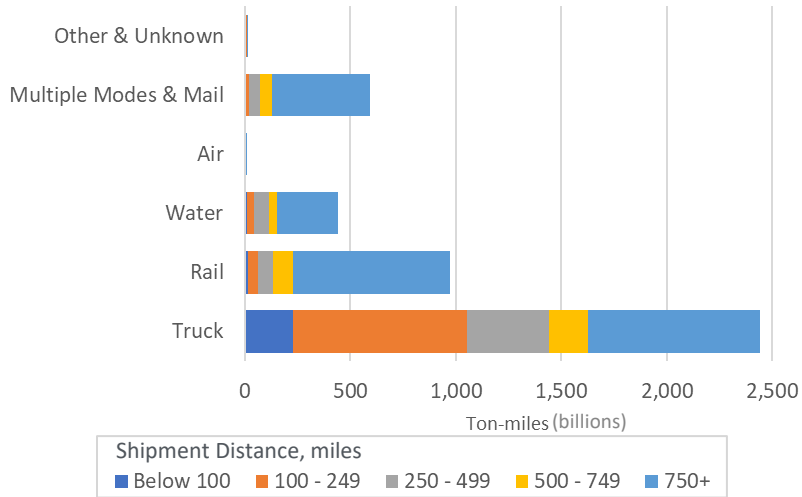
Source: Bureau of Transportation Statistics

US Freight Energy Consumption (2019)



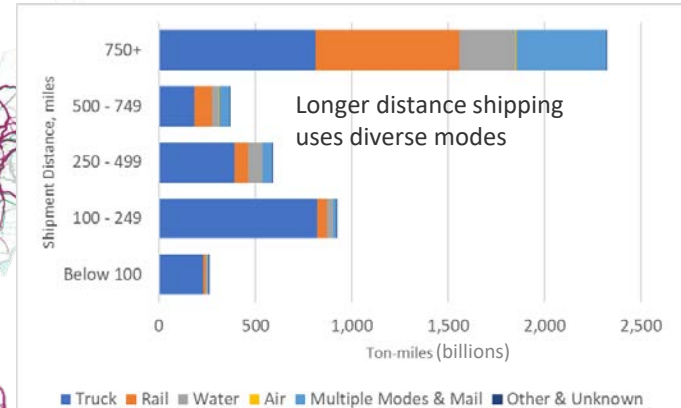
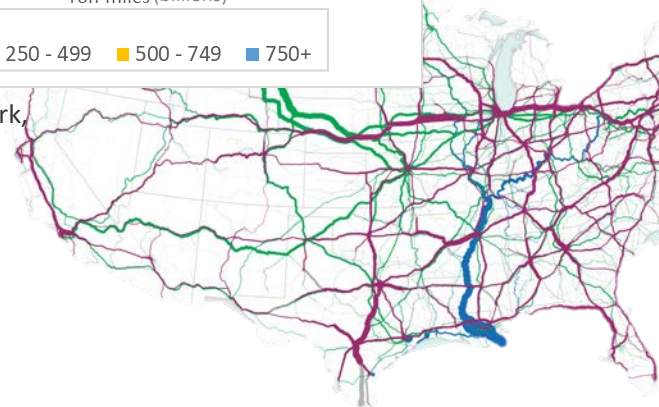
Source: Transportation Energy Data Book: Edition 40 (Davis and Boundy, 2022)

Multi-Modal Freight System



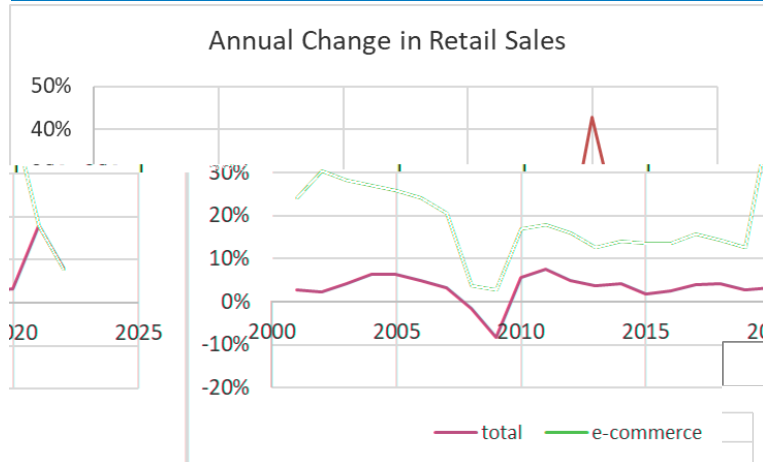
- Trucking accounts for the largest share of freight movement
- Rail is ~40% as large as trucking
- 57% of all freight ton-miles are shipped more than 500 miles
 - 41% of truck ton-miles > 500 miles
 - 86% of rail ton-miles > 500 miles

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



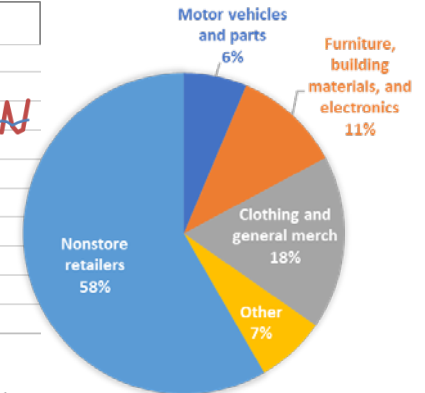
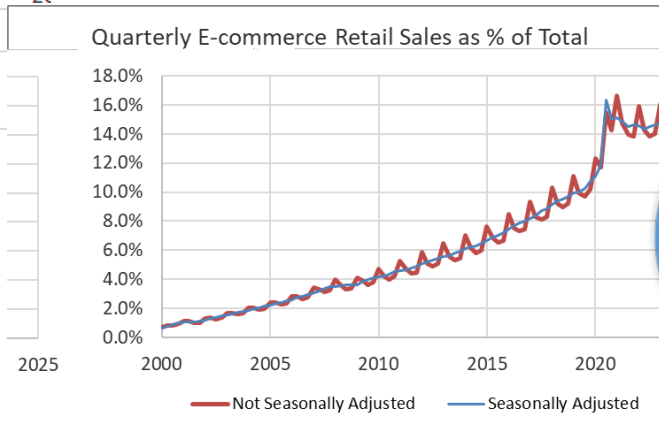
Longer distance shipping uses diverse modes

E-Commerce: Why is everyone talking about it?



- 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>



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

FREIGHT RESEARCH



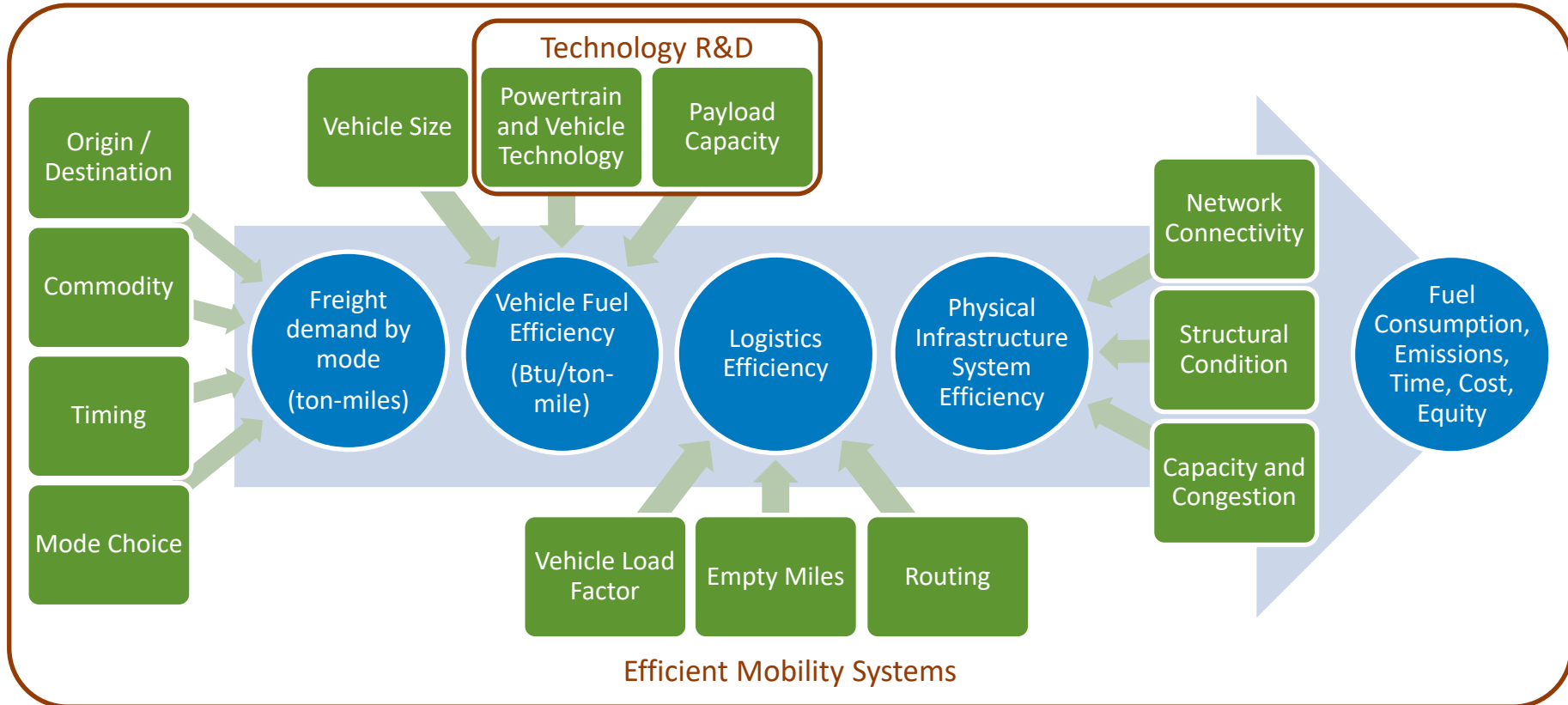
Business Trend

- 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



A first-person perspective from the driver's seat of a car on a multi-lane highway. The sun is low on the horizon, creating a bright, golden glow and lens flare effects across the scene. In the right lane, a large white semi-truck is driving away. In the distance, another truck is visible in the center lane. The dashboard of the car is visible in the foreground, and the road ahead is flanked by green fields and a clear blue sky.

NREL's Freight Research & Tools

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

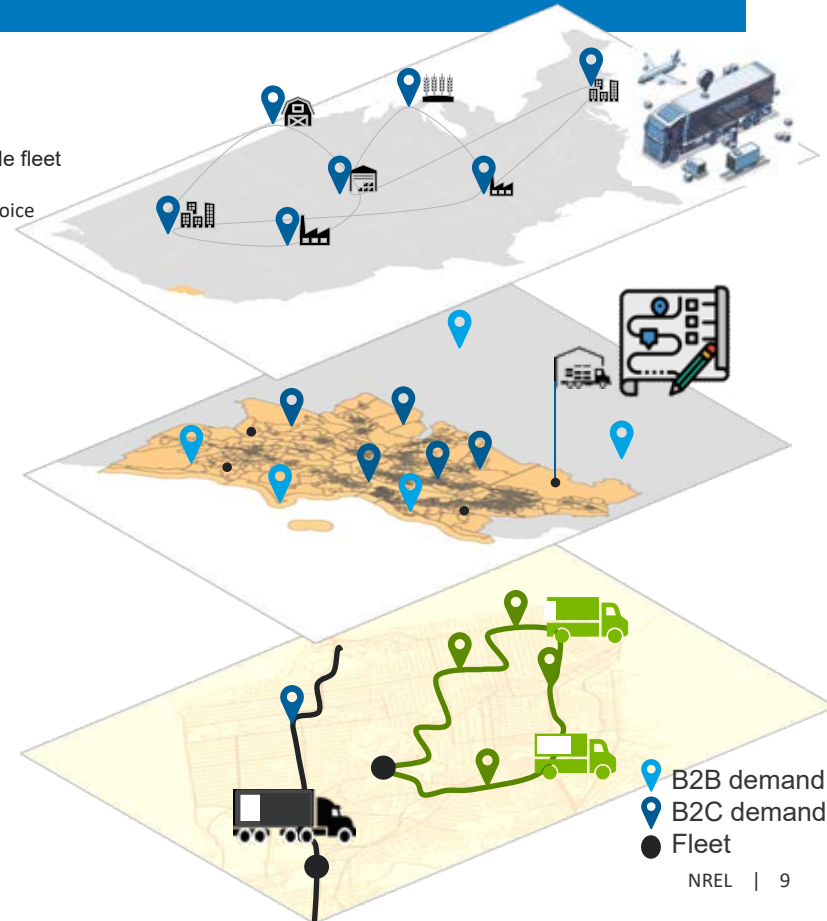
Synthesis of firm & vehicle fleet
Supply-chain logistics
Shipment size & mode choice

FRISM

Online-shopping demand
Daily shipments
Fleet operation plan

BEAM-Freight

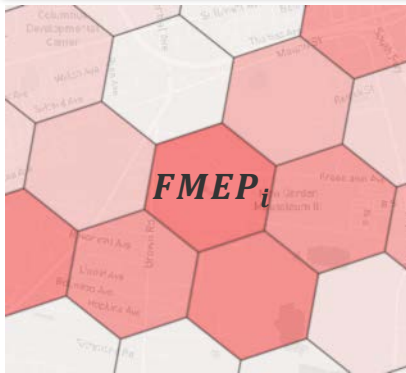
Vehicle routing
Traffic assignment
Infrastructure use



Quantification of Freight Mobility Efficacy

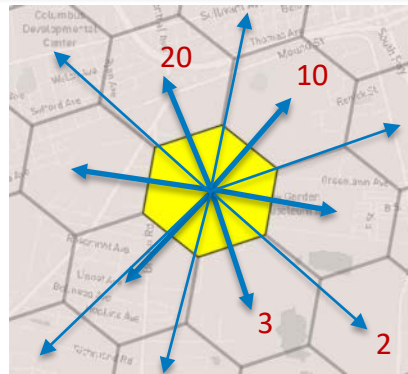
Freight Mobility Energy Productivity (F-MEP)

- 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



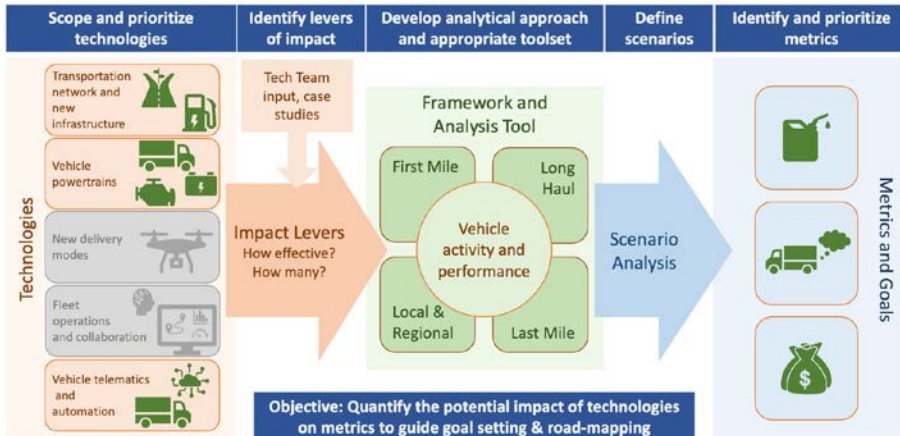
Comprehensive attractiveness to freight transport for delivery purpose to various location types

Impact of emerging technologies on operational efficiency

Freight Operational Efficiency Metrics (FOEM)

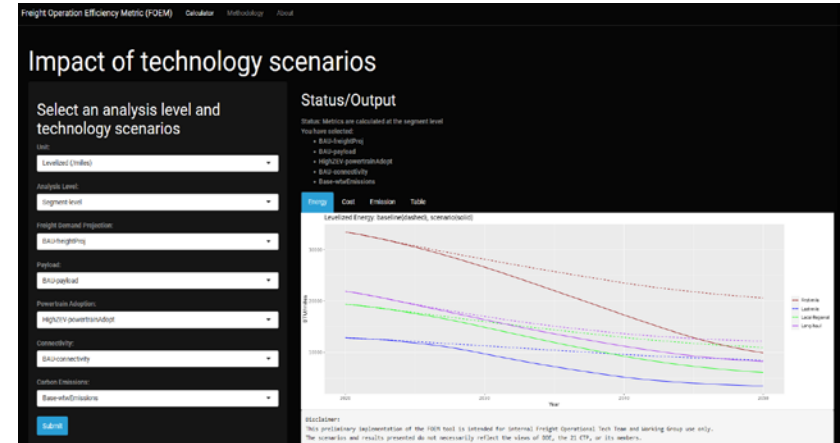
- Develop an analytical tool that allows for quick exploration of the operational efficiency space
- Apply the tool to estimate baseline performance metrics and the impact of emerging technologies on these metrics
- Enable providing segment-level analysis with national scope

Analysis Framework

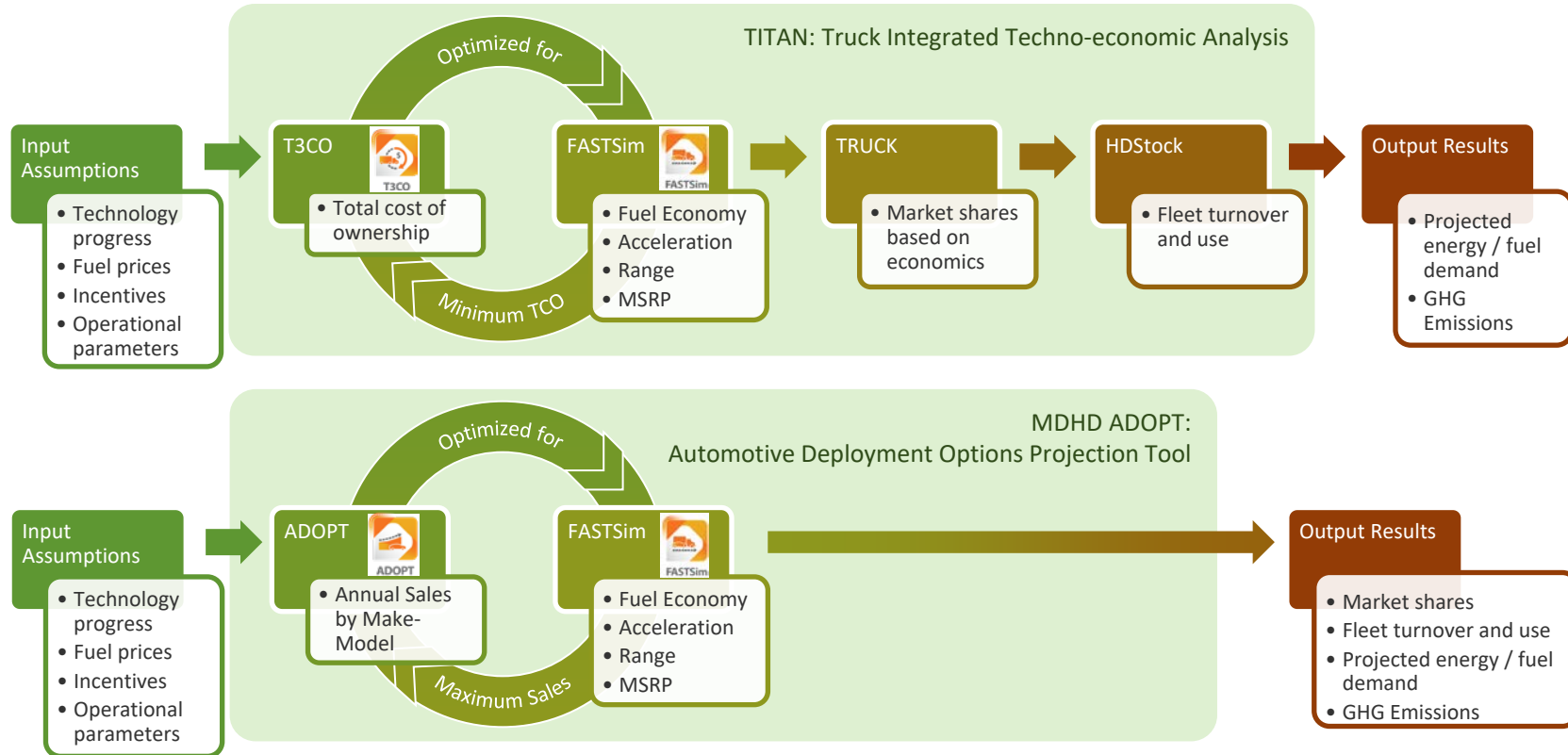


The FOEM provides a framework to aggregate the impact of freight efficiency technologies at the segment and system levels.

Web-Interface



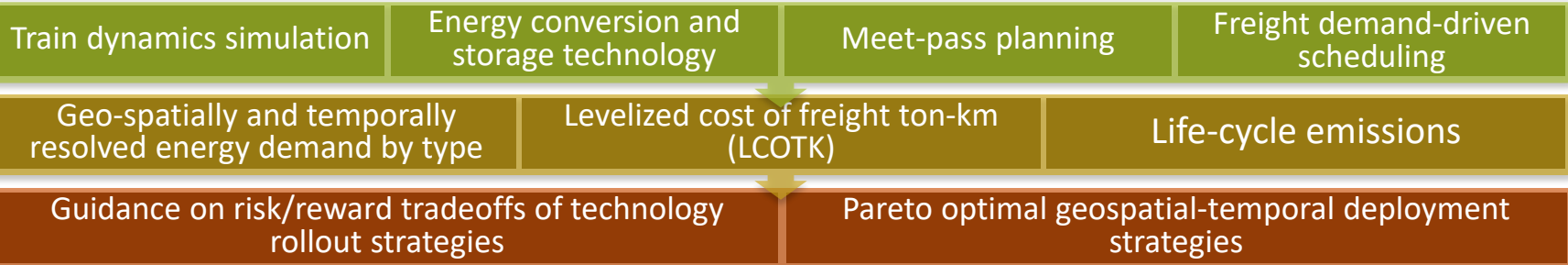
Techno-economic Analysis of Commercial Vehicles



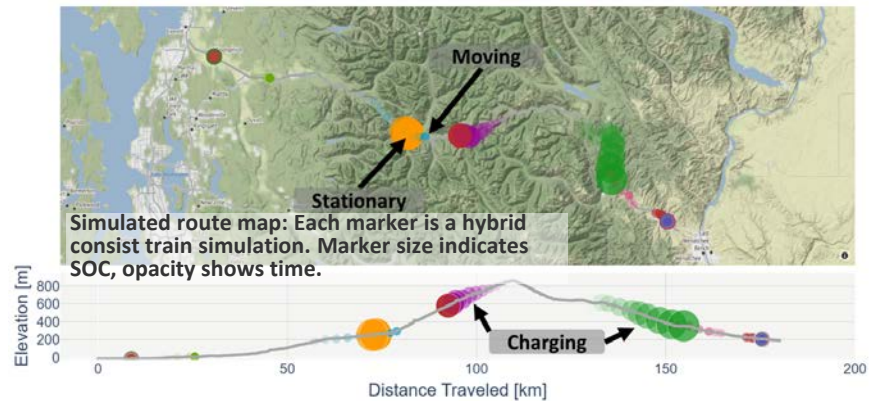
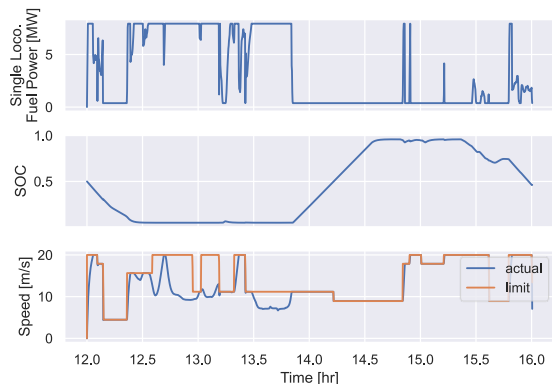
ALTRIOS - Advanced Locomotive Technology and Rail Infrastructure Optimization System



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



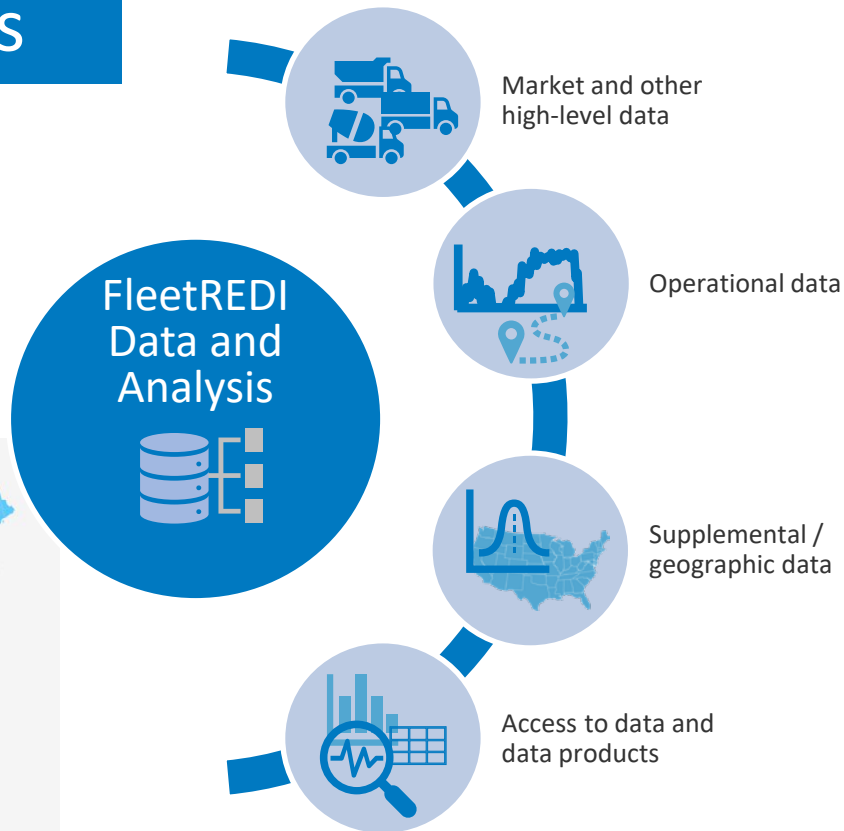
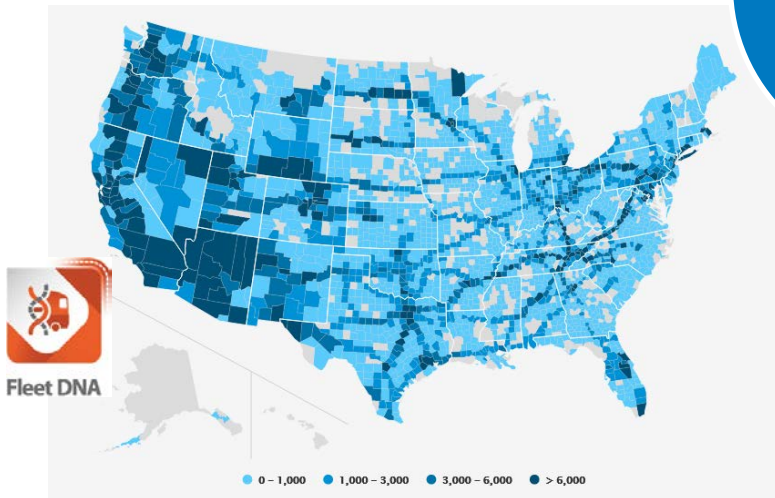
Fuel, SOC, and Speed for 1 of 100 conventional locomotive trips



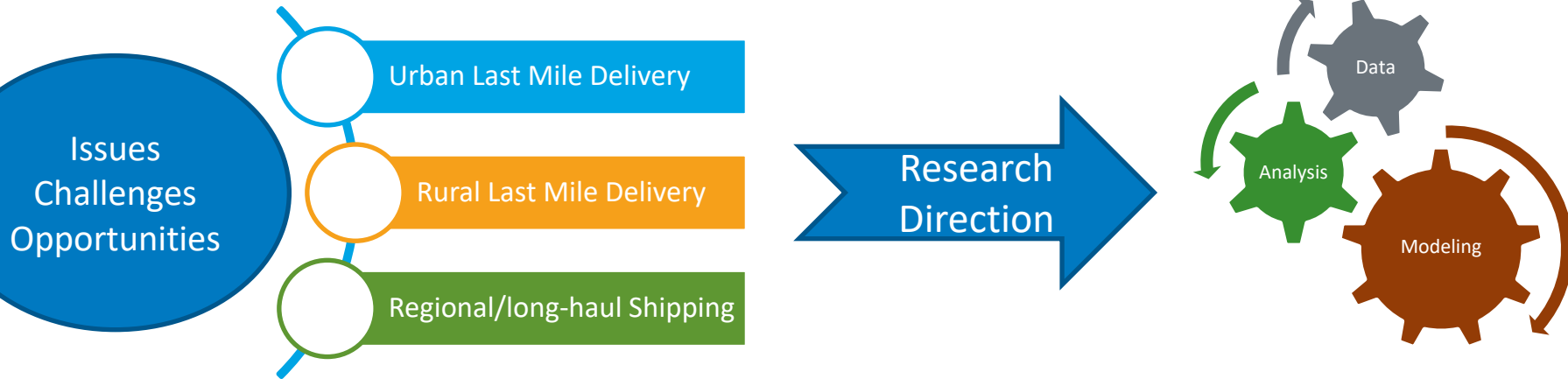
FleetREDI – Fleet Research, Energy Data, and Insights

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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