Connected and Learning Based Optimal Freight Management for Efficiency

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Cummins Inc.

June 24, 2021

Project ID # eems109

DOE Vehicle Technologies Office Annual Merit Review (AMR), June 21-25, 2021

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Overview

Timeline

- Project Start Date: 10/01/2020
- Project End Date: 12/31/2023
- Percent Complete: 10%

Budget

- Total Project Budget: $3,177,151
  - Total recipient share: $1,177,151
  - Total federal share: $2,000,000
  - Federal share of expenditures*: $74,182
  - Recipient share of expenditures*: $50,517

* As of 03/31/2021 (does not include federal lab spending)

Barriers

- Uncertainties in future truck fleet composition with electrification, connectivity and automation trends
- System of Systems (SoS) modeling for trucking freight operations (short/long haul + P&D) to assess emissions, cost, and energy impact
- Large scale optimization of truck fleet management for technology adoption and optimal operation
- Limited high quality fleet scale operation data

Partners

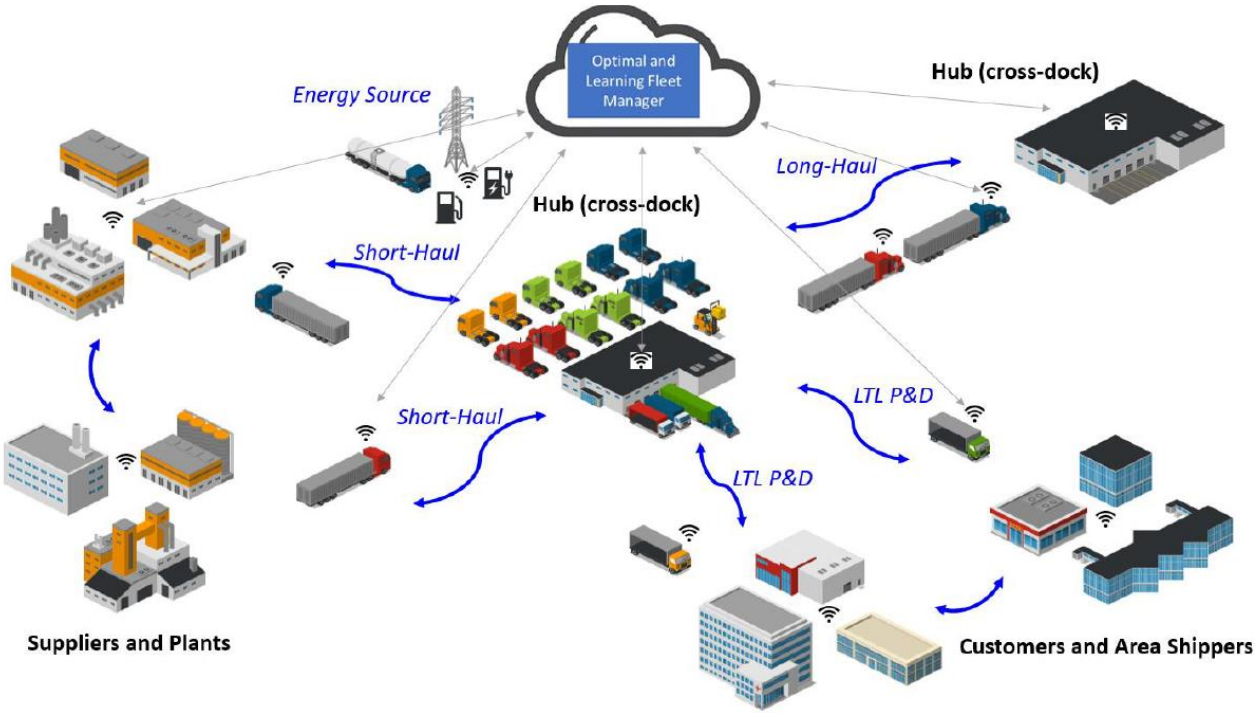
- Cummins (lead)
- Venture Transport
- Argonne National Laboratory
- University of California, Berkeley
- Michelin North America

Relevance

Objective

Demonstrate ≥ *20% fleet level W2W CO2 reduction (per unit of load-distance)* over a baseline fleet through

1) optimal adoption of
   - Advanced powertrain technologies
   - Connectivity features: V2I, V2V, V2X
   - Automation: Partial (L1/L2), ADS (L3+)
2) optimal operation using connected and learning fleet management algorithms e.g.
   - Truck dispatching
   - Routing/scheduling
   - Charge/fueling management



This will result in

- Assessment of pathways to reduce W2W CO2 emissions for trucking freight transport
- Cost/TCO minimum path to ≥ 20% fleet level W2W CO2 reduction
- SoS modeling for trucking freight operations with electrification, connectivity and automation impact
- Learning and optimal fleet management for future fleet efficiency

Trucking freight transportation

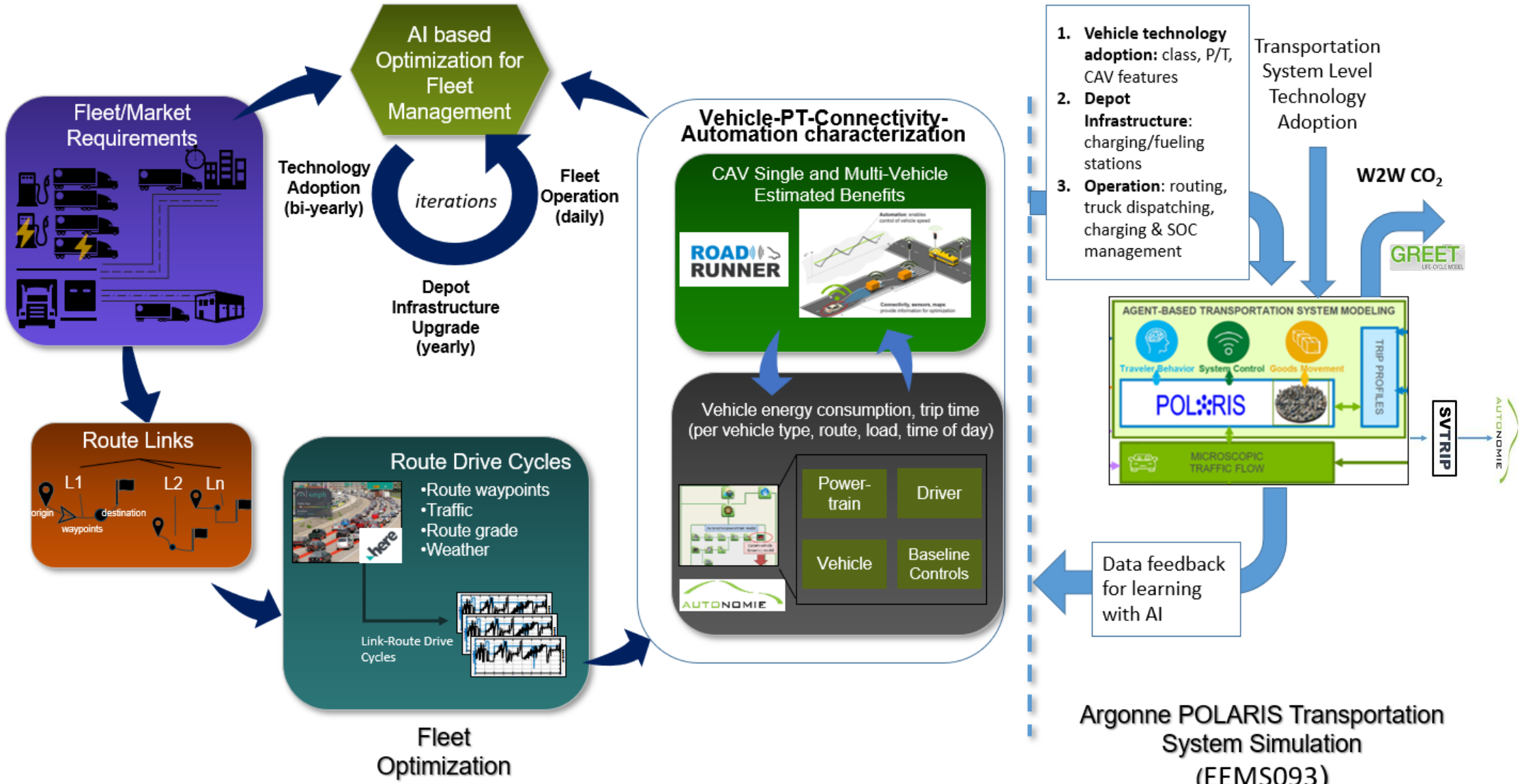
- is dominant mode of freight shipping in U.S.
- accounts for >25% of transportation energy consumption & GHG emissions.
- projected to grow and adopt electrification, connectivity and automation technologies.

Key Milestones*

Budget Period	Start/End Date	Milestone	Type	Description
1	10/01/2020 – 12/31/2021	Complete Baseline Freight System Simulation Model Development and Validation with the Fleet Operation Data	Go/No Go	The baseline freight operation has been successfully evaluated in the freight system simulation model.
2	1/01/2022 – 12/31/2022	Demonstrate ≥20% Freight Operation Efficiency in Simulation	Go/No Go	The ≥20% improvement in freight efficiency has been demonstrated and the conditions under which the improvement is feasible are documented. This includes quantifications of the required targets for penetration of alternative powertrains, powertrain to route matching, and automation/connectivity technologies.
3	1/01/2023– 12/31/2023	Demonstrate ≥20% Efficiency Improvement on the Fleet with a Mix of Micro Simulation and Actual Fleet Operation	Technical	A ≥20% improvement in freight efficiency is demonstrated under real-world fleet conditions by the aggregate of all the technologies embodied in the project.

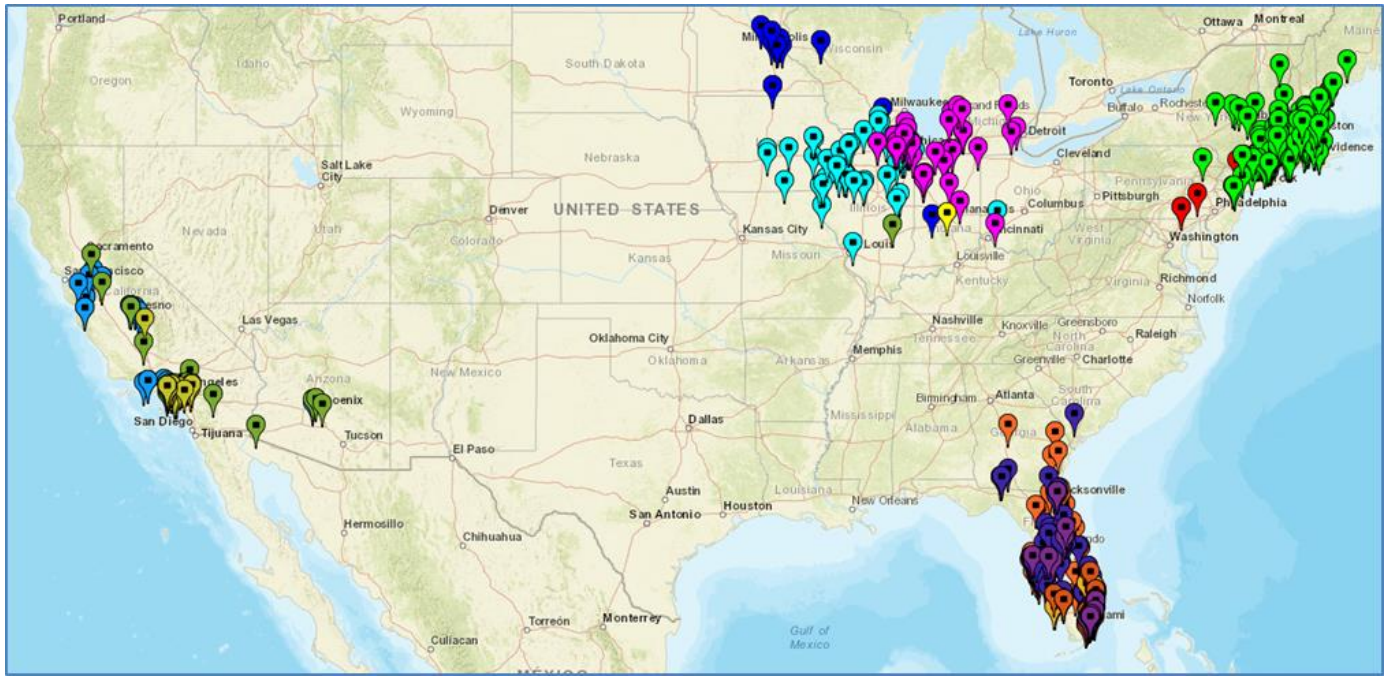
**Interim Milestones are defined in the SOPO and PMP*

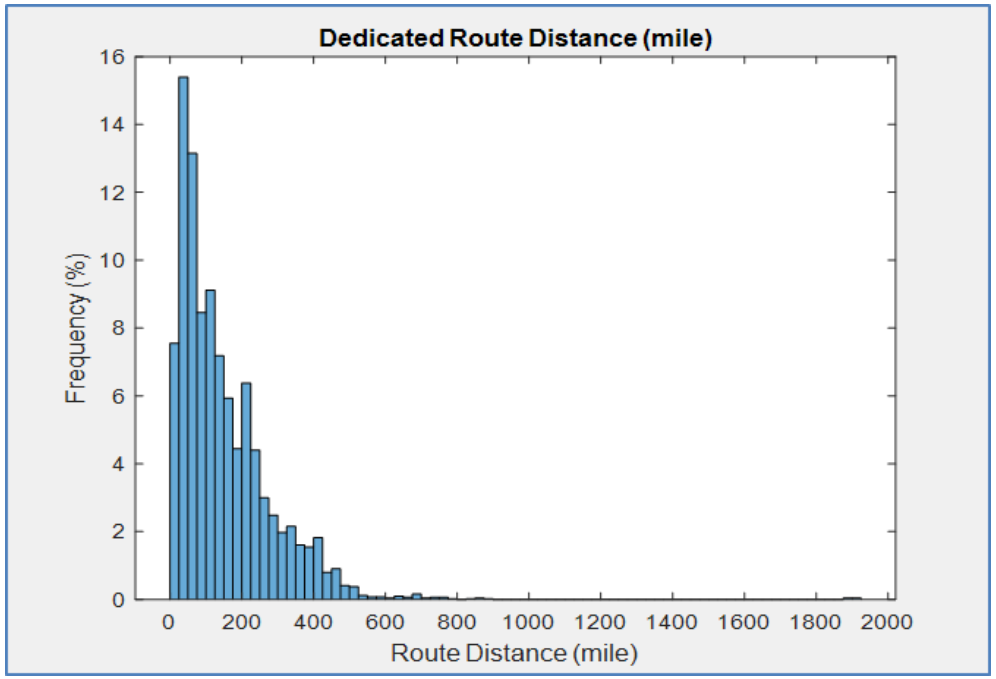
Approach: SoS Simulation



Technical Accomplishments and Progress

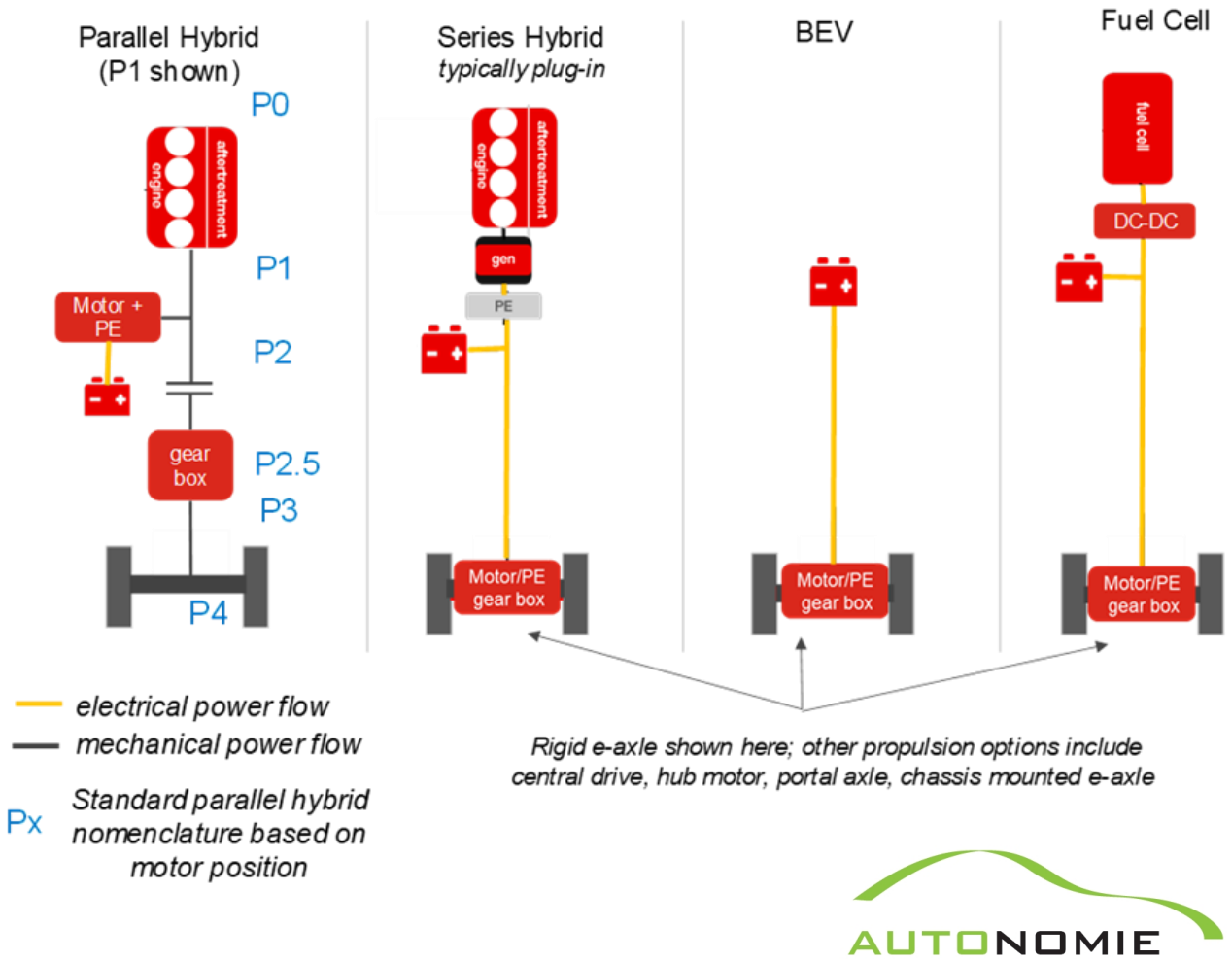
- Fleet operation requirements and network data acquired and analyzed with the project fleet partner collaboration (Task 1.2).





Technical Accomplishments and Progress

- Relevant powertrain technologies identified and mapped to truck classes (4-8)
- Truck models' development ongoing with Argonne Autonomie(1) to characterize the impact of advanced powertrain technologies for fleet optimization and SoS modeling (Milestone 1.3)



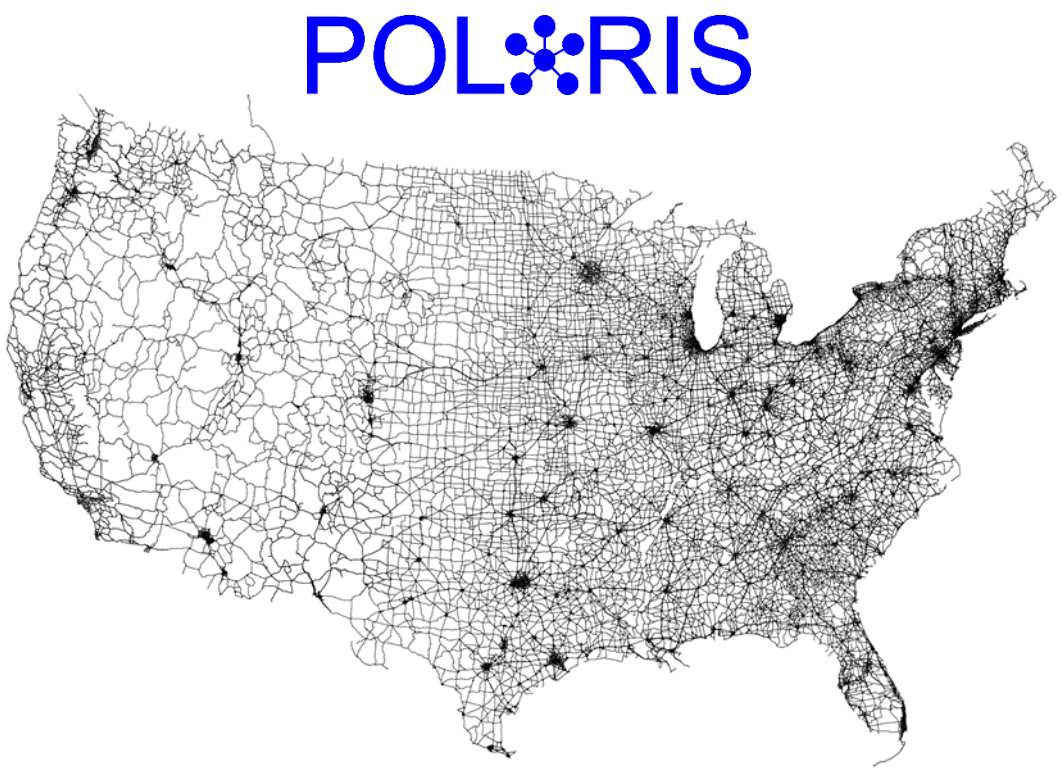
AUTONOMIE

(1) EEMS013, VAN032

Technical Accomplishments and Progress

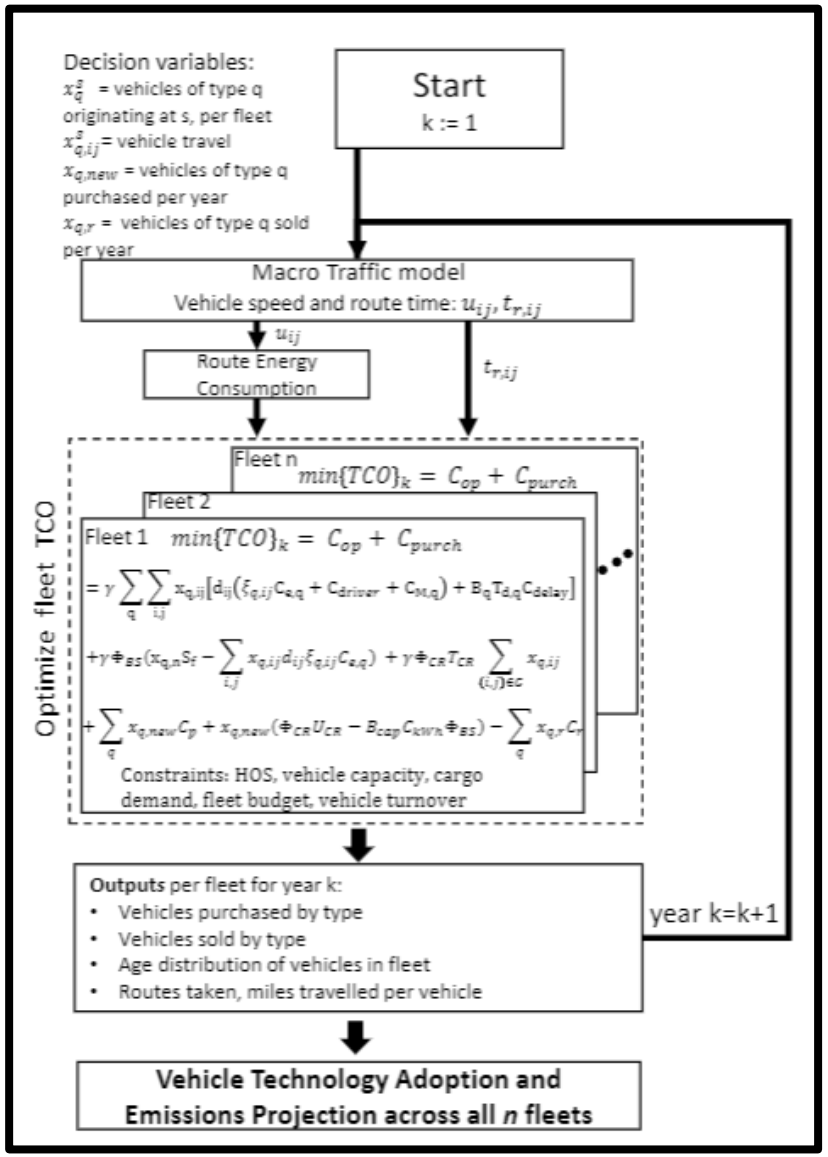
- Argonne has developed a national network in POLARIS to support the baseline freight operation simulation across U.S. (2021 Go/No-Go milestone).

- POLARIS is upgraded with road grade (including bridges and tunnels data) that is an important factor in energy consumption of MD/HD trucks.



Technical Accomplishments and Progress

- Fleet management is formulated as an optimization problem.
  - Large scale
  - Multi objective
  - Multi time scale
  - Stochastic
- Learning algorithms combined with optimization are being developed with University of California, Berkeley team.



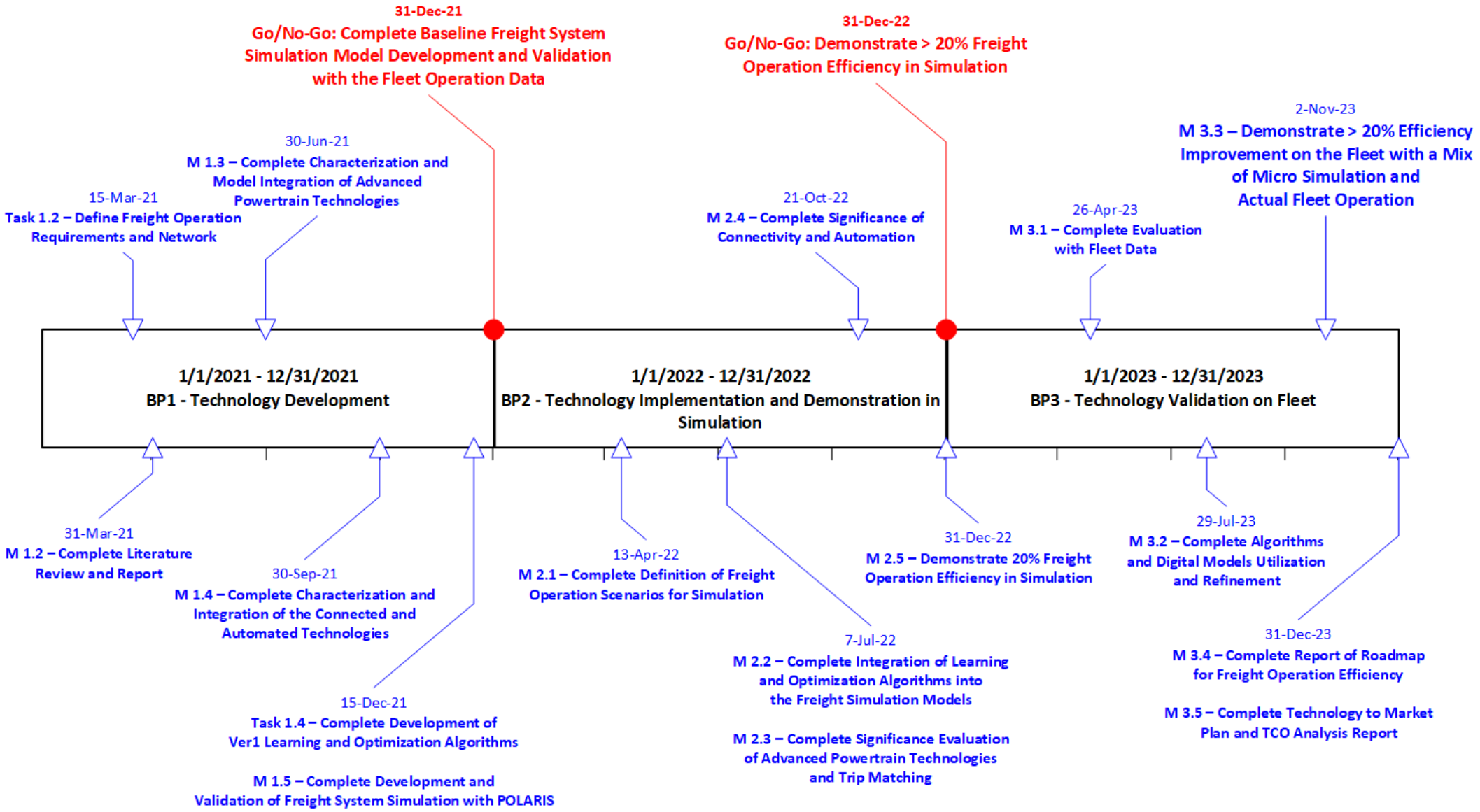
Collaboration with Other Institutions

- **Venture Logistics**, Support with insights on fleet logistics and operation, constraints and requirements for optimization and data collection to characterize the fleet operation and testing of the algorithms.
- **Argonne National Laboratory**, Support with the POLARIS-SVTrip-Autonomie simulation system for transportation modeling. Furthermore, Argonne will be working to integrate reinforcement learning methods to support the development of a complete optimal fleet operation system.
- **University of California Berkeley**, Develop and integrate stochastic and learning optimal fleet management algorithms.
- **Michelin North America,** Quantify the improvements in fuel savings when accounting for information about tire inflation pressure, temperature, and adherence capabilities through tire connectivity.

Remaining Challenges and Barriers

- Complete development and validation of the baseline MD/HD fleet operation in POLARIS with interface to fleet optimization.
- Large scale optimization of the fleet management for vehicle & P/T technology adoption, depot infrastructure upgrade and fleet operation.
- Connectivity and automation characterization of energy benefits for MD/HD truck applications.
- Analyzing fleet telematics data for baseline model development, validation and improved inputs to learning algorithms.
- Developing Machine Learning models for MD/HD energy consumption for use in Y2/Y3

Proposed Future Research*



**Any proposed future work is subject to change based on funding levels.*

Summary

- Fleet operation requirements and network data are acquired for baseline freight operation simulation.
- POLARIS is upgraded to model:
  - baseline regional and long-haul freight operation simulation across U.S.
  - road grade in addition to passenger & truck traffic flows
- MD/HD future powertrain technologies identified and mapped to the applicable truck vehicle classes.
- Modeling and characterization of the trucks with advanced powertrain technologies, connectivity and automation ongoing.
- Development of learning and optimization algorithms for freight operation efficiency ongoing.

Thank You!

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