Volvo SuperTruck 3

A Zero Emission Freight Future

Project ID: ELT286

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Volvo Group North America

VTO Annual Merit Review

June 13, 2023

Project Overview

Objectives

Develop and demonstrate a Class 8 battery electric vehicle (BEV) capable of 400-mile range on a single charge.

Demonstration of Megawatt Charging System (MCS).

Assess Greenhouse Gas (GHG) emission reduction potential and Total Cost of Ownership (TCO) impact.

Barriers

Balancing battery weight / energy capacity with range requirements for heavy-duty long haul commercial vehicles.

Managing technology trade-offs during complete system integration.

Developing complex systems concurrently.

Timeline

10%

August 2022 — July 2026

Funding

- Total project cost: $36 M
    - DOE funds: $18 M
- FY2022 funding: $470,584
- FY2023 funding: $3,497,606

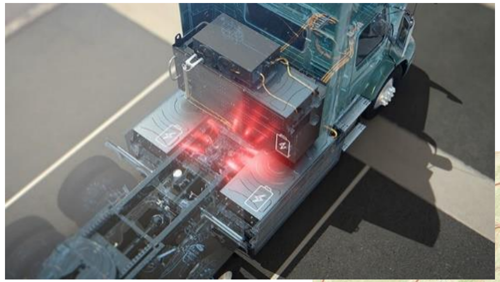
Project Lead: *Volvo Group North America*

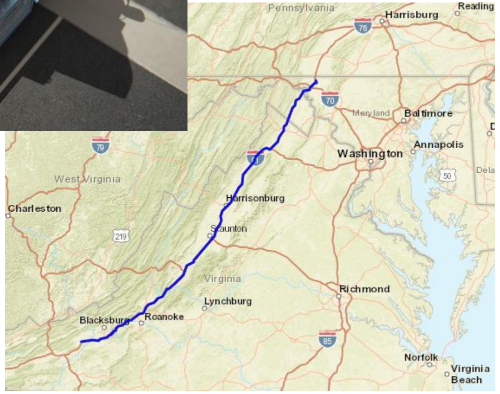
Project team members:

Michelin Tire
Oak Ridge National Laboratory
Electrify America
Fleet partner / customer (TBD)
Rensselaer Polytechnic Institute
Pennsylvania State University
Bluefield State University

Relevance

Goals and Objectives





- ➢Develop and demonstrate a Class 8 battery electric vehicle (BEV).
  - ➢ Capable of 400 miles with a representative payload.
  - ➢ Correlated to defined freight corridor and urban area freight models.

- ➢Demonstration of Megawatt Charging System (MCS).

Impact:

- ➢Improved zero-emission solutions for heavy-duty long-haul trucks.

- ➢Reduced Greenhouse Gas emissions and better air quality along commercial freight corridors and urban areas.

Challenges:

- ➢Achieving the full range and payload requirements of a heavy-duty long-haul application.

- ➢Improving the total cost of ownership.

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Project Phases and Milestones

2022	2023	2024	2025	2026

Simulation & Analysis	Design	Vehicle Integration	Vehicle Demonstration

Project Management Plan / Diversity Equity & Inclusion Plan

- Submit plans
- Review / update
- Review / update
- Review / update

Freight Modeling & Simulations

- Logistics Use Cases Defined
- Freight Corridor Scenarios Defined
- Freight Model Validated
- Freight Corridor Model Developed
- Advanced Concept Showcase
- Fuel Cell Model Developed
- Fuel Cell Model Available
- Freight Model Report

Vehicle Development

- Requirements Documented
- Truck Build Complete
- Preliminary Design Simulated
- SuperTruck 3 Demonstration
- Vehicle Demonstrator Design Complete

Charging Demonstration

- Charge Site Details Prepared
- Megawatt Charger Installed
- Initial Charge Site Planning Complete
- Charging Demonstration

Approach

Learnings to be applied from SuperTruck 1 (ST1) and SuperTruck 2 (ST2)

ENERGY EFFICIENCY IS THE MAIN DRIVER FOR THE SUCCESS OF ALL 3 PROGRAMS

SuperTruck 1: 50% (88% achieved) Freight Efficiency improvement.

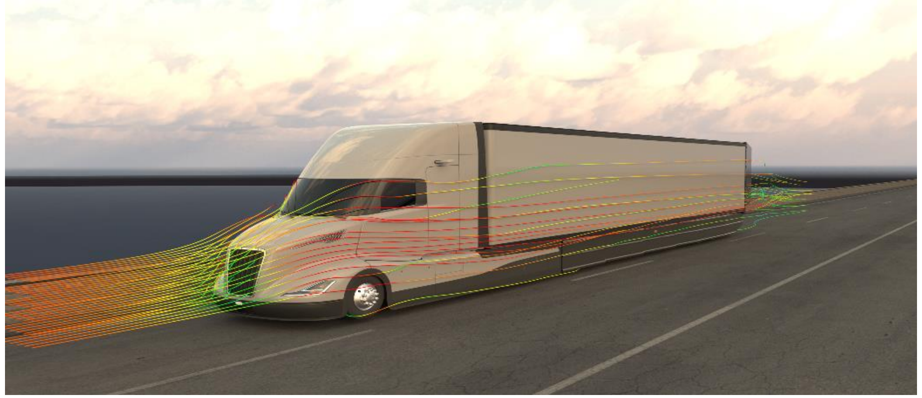
SuperTruck 2: 100% (stretch 120%) Freight Efficiency improvement.

Approach: Engine, driveline, and vehicle efficiency improvements - internal combustion engine (ICE) platform.

SuperTruck 3 (ST3): Battery Electric Vehicle (BEV) capable of a 400-mile range on a singe charge.

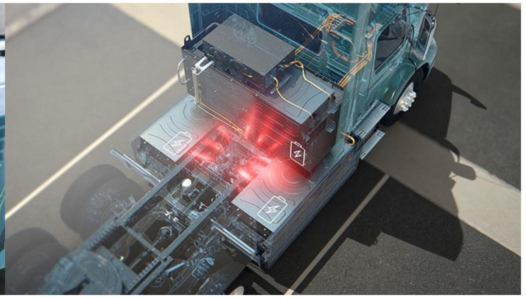
Approach: Energy storage solution, eAxle optimization, and vehicle efficiency improvements - battery electric vehicle (BEV) platform.

Approach



Energy storage solution
Battery capacity
- High energy density
- Chemistry
- Cell type

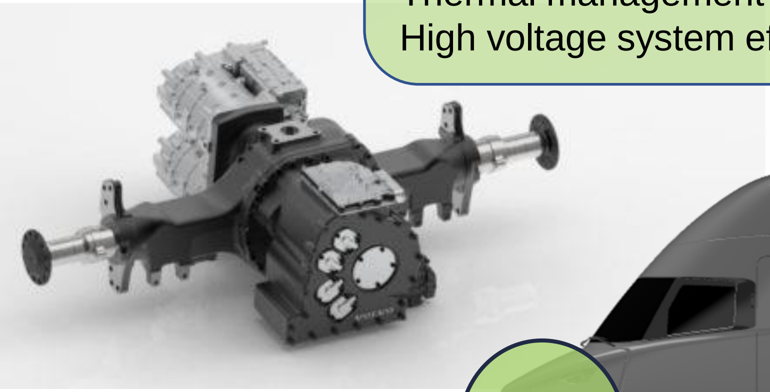
Battery management
Megawatt charging



Efficiency improvements
Aerodynamics
Low rolling resistance tires
Electric drive axles (eAxles)
Thermal management
High voltage system efficiency

ST3 Demonstrator
targeting a 400-mile range and payload equal to ST2

Payload
Balanced architecture
Axle loading
Light weight components
Light weight trailer



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Technical Accomplishments and Progress

Use Cases Defined

Route 1 (~150 mile each way).

Hagerstown to Lehigh Valley Operations.

Route 2 (~420 mile each way).

New River Valley to Lehigh Valley Operations.

Route 3 (~275 mile each way).

Hagerstown to New River Valley.

Payloads up to 44,500 lbs.

Routes to be used for simulation, not vehicle demonstration.

Technical Accomplishments and Progress

Data architecture under development

Data Engineering

- Preparation of the cloud environment (sandbox) to collect data following privacy and cybersecurity guidelines.

  - Provide scalable solution for data collection and processing.

  - Ability to process volume of data.

Data Segmentation

- Development of algorithm to collect telematics data of vehicles operating in target corridor.
- Verify data integrity for assets operating in corridor.

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Technical Accomplishments and Progress

Complete Vehicle Architecture Study

Drivers for platform change from ST2 to ST3

- Transition from ICE to BEV architecture.
- Frame space needed for battery packaging.
- Shifting of weight from front axle to between the wheelbase.
- Updated chassis / frame system to accommodate energy storage system.
- Tandem axles needed to support wheelbase / battery weight.
- Larger tires required for front axle loading.
- Maintain ST2 payload – 40k lbs.

Significant changes in vehicle architecture / chassis configuration required!

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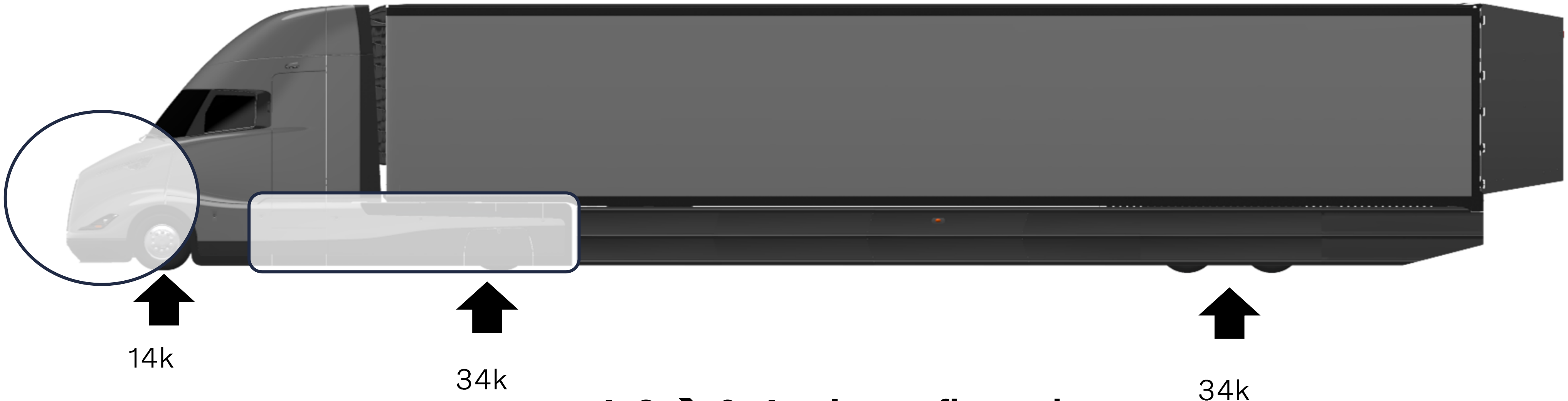
Technical Accomplishments and Progress

Complete Vehicle Architecture Defined



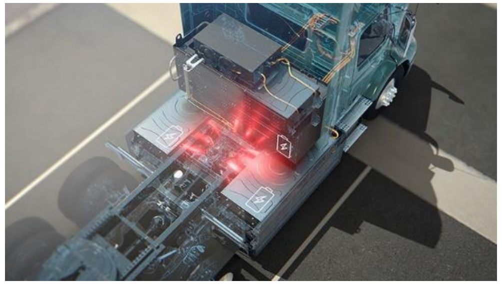
- **4x2 ➔ 6x4 axle configuration.**
- **Longer wheelbase.**
- **11k/20k/34k ➔ 14k/34k/34k axle loading.**
- **19.5” ➔ 22.5” wheels and tires.**
- **Aluminum ➔ steel frame rails.**
- **65k ➔ 82k Gross Combination Weight.**

Technical Accomplishments and Progress

Progress in System Selection

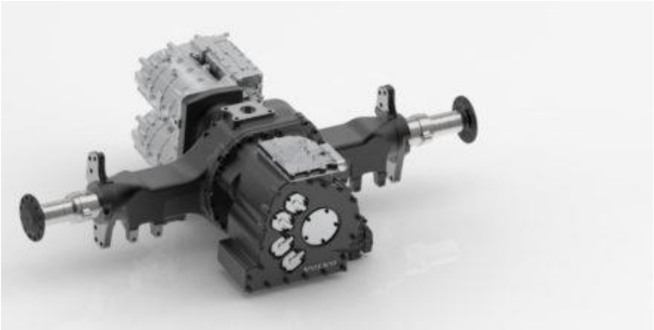
Energy Storage Solution

- Requirements established.
- Investigation of solution in process.
    - Cell type.
    - Cell chemistry.
    - ESS configuration.
    - Mounting.



eAxles

- Requirements defined.
- Multiple options under consideration.
    - Motor types.
    - Transmission/ratios.



Initial system topologies created

- Thermal management.
- Pneumatics.
- Electrical.

Technical Accomplishments and Progress

Aerodynamics

- Redesigning hood and chassis front to optimize for BEV.
- Trailer modifications due to increase in wheel/tire size.

Tires

- Compromise between tire rolling resistance and tire wear.
- Increased load carrying capacity on steer axle.
- 25% reduction in combination vehicle rolling resistance.
- 25% improvement in steer tire life.

ST3 – 82K lbs. GCW	Steer Axle	Drive Tandem	Trailer Tandem
Loads (lbs.)	14,000	34,000	34,000
22.5'' Sizes	315/70R22.5	445/50R22.5	445/50R22.5
ST3 Tires	**No Tire Development (Tires Imported from Europe)**	**New Tire Development**	**New Tire Development**

Collaboration and Coordination with Other Institutions

Organization	Key Contributions
Volvo	Project lead, simulations, powertrain development, complete vehicle integration, testing.
Oak Ridge National Lab.	Freight analysis, modeling, and simulation development.
Rensselaer Polytechnic Institute	Freight analysis and modeling of activity in the corridor.
Michelin	Tire technology developer and manufacturer.
Electrify America	Charging infrastructure provider.
Bluefield State University	STEM-related outreach thru university relations.
Pennsylvania State University	STEM-related outreach thru university relations.
Fleet Partner / Customer (TBD)	Provide operational input and feedback to goals and deliverables.

Remaining Challenges and Barriers

Balance between range, payload, and product cost is much more complex for a heavy-duty long-haul BEV solution.

ESS occupies much of the chassis space.

- Challenging to package high-voltage, pneumatic, HVAC, and other systems.

Battery Technology

- Energy density vs. weight.
- Structural integrity and safety.

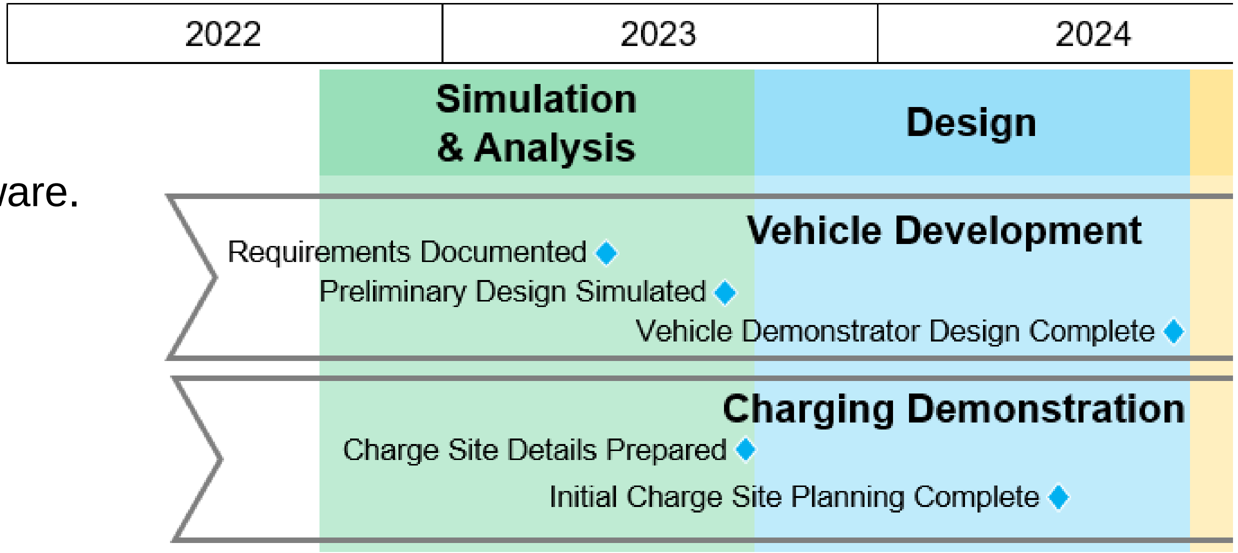
Thermal management – maintain battery temperature and driver comfort.

Operating voltage (to enable higher rate of charging and system efficiency) may be limited by the availability of high voltage components.

Proposed Future Research

Demonstrator system and component definition and development

- Finalize topologies.
  - Thermal management.
  - Pneumatics.
  - Electrical.
- Complete Bill of Materials (BoM) – hardware and software.
- eAxle optimization.
- ESS definition.
  - Energy density and chemistry considerations.
- System integration.



MCS charge site – prepare details and finalize planning.

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

Proposed Future Research

Data Cleansing and Segmentation

- Validate data integrity and consistency for analytics for the period of the analysis.
- Segment data sets on the three logistic use cases (limited to specific, defined routes).
- Create customer profiling in NA markets based on results.
- Data anonymization for privacy of customer telematics data.
- Review data sample with RPI/ORNL to ensure compatibility with existing models.

Data Delivery

- Preparation for data handover to RPI / ORNL for Freight Corridor Model Development.

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

Summary

- **Relevance**

  The goals of this project are aligned with the key objectives to provide a long-haul, zero emissions transport solution, reduce greenhouse gas emissions, and improve air quality along the freight corridor and urban areas.

- **Approach**

  Volvo's SuperTruck 3 program is in the first phase, with a focus on identifying the technical solutions required to develop a heavy-duty long-haul BEV. Design and development activities will continue through FY2024.

- **Milestones & Technical Accomplishments**

  In this reporting period, the vehicle platform was defined, topologies for the thermal, pneumatic, and electrical systems were created, and development work began for the ESS and eAxles. The direction for tire development was also decided. The freight corridors that will be used for simulation activities were identified, and data collection for those corridors has begun.

- **Future Work**

  Finalize the design direction for the ESS and eAxles. Continue to develop, integrate, validate the technologies selected for the BEV platform, and prepare for system integration. Complete data collection and begin simulation activities.