2020 Webinar Series

HTUF
High-Efficiency Truck Users Forum

The Forum for Action in High-Efficiency Commercial Vehicles

Steven Sokolsky
Program Manager
AGENDA

• CALSTART commercial vehicle activities and relationship to HTUF program
• HTUF background and current activities
• Panel Discussion: connecting the military to commercial vehicle developments
  – Mihai Dorobantu, Eaton
  – Dean McGrew, U.S. Army GVSC
  – John Szafranski, U.S. Army GVSC
• Working group opportunities
• HTUF future direction
A GLOBAL ORGANIZATION WITH REGIONAL FOCUS

- San Joaquin Valley Clean Transportation Center (Fresno, Stockton)
- Nor Cal/ Bay Area
- Colorado
- Wisconsin
- Michigan/ Midwest
- New York- Northeast
- Washington, DC
- Florida
- So Cal/HQ Pasadena
Over 250 Members
### CALSTART Overarching Strategy:

**Speed commercialization of clean transportation technologies**

These are our focus areas:

*This is the work we do:

<table>
<thead>
<tr>
<th>Commercialization Activities Areas</th>
<th>CARS &amp; MOBILITY</th>
<th>BUSSES &amp; TRANSIT</th>
<th>TRUCKS &amp; OFF-ROAD</th>
<th>FUELS &amp; INFRA</th>
<th>Maritime</th>
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<tbody>
<tr>
<td>Development, Demonstration &amp; User Connection</td>
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<td>Performance Validation &amp; Assessment</td>
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<td>Market Acceleration (Incentives)</td>
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<td>Policy Development &amp; Support</td>
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<td>Industry Service</td>
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CALSTART DRIVES COMMERCIALIZATION

Commercialization Activities Areas

Development, Demonstration & User Connection
- Identifying, assembling and managing real world tech demonstrations to meet user needs.

Performance Validation & Assessment
- Validating the performance and business case of technology to inform user, developer and policy.

Market Acceleration
- Developing and managing effective, streamlined incentives for new tech.

Policy Development & Support
- Developing and supporting smart, effective policies to drive clean technology

Industry Service
- Supporting company success via information, partnering, identifying opportunities.
Commercializing Next Gen Trucks & Equip
Multiple demos and pilots with OEMs for M/HD delivery, drayage and cargo handling equipment

Demonstrating Advanced Engine Technologies
Achates opposed piston Class 8 engine; 15% better FE; 90% reduced emissions

Commercialization Roadmapping
Developed “beachhead strategy” with CARB for investing in key success applications for ZEV and Low NOx

Market/Technology Acceleration
Global Drive to Zero Program, Vehicle Incentive Programs
CALSTART DESIGNS AND MANAGES SMART INCENTIVES FOR LEADING REGIONS

- **NEW**: CORE – Clean Off Road Equipment program. $44M for ZE off road goods movement
- California has invested nearly >$500M for hybrid and electric trucks and low NOx engines – CALSTART helped create/design; managed for 10+ years
- New York $15M voucher program for hybrid, electric and NG trucks
- Chicago initial $11.295M electric truck voucher sold out all funds; New funding coming soon
Global Drive to Zero
An international multi-stakeholder initiative to accelerate the growth of zero-emission commercial vehicles

2025
Near- and zero-emission MHDVs are commercially viable and cost-competitive in beachhead applications and first-mover regions by 2025.

2040
Zero-emission MHDVs achieve 80% of new vehicle sales in first-mover regions by 2040.
Global Drive to Zero Theory of change: from activities to outcomes

<table>
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<tr>
<th>ACTIVITIES</th>
<th>PRODUCTS</th>
<th>BARRIERS</th>
<th>ACTIONS</th>
<th>OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>CALSTART and partners undertake activities to connect, inform, and influence key stakeholders.</td>
<td>These activities will lead to specific products.</td>
<td>These activities and products will minimize institutional, technical, and economic barriers.</td>
<td>With barriers minimized, key stakeholders will be influenced/supported and take a series of actions.</td>
<td>These actions will lead to outcomes.</td>
</tr>
</tbody>
</table>

**RECRUIT** strategic new partners and strengthen engagement with current partners.

**MOBILIZE** stakeholders networks and integrate the Drive to Zero strategy into existing networks.

**COMMUNICATE** materials, tools, and expertise to carry the message of change to audiences that can leverage and support action.

**DEVELOP** and refine tools and materials to enable partners to take action.

**SUPPORT** and grow the capability of partners in key segments and regions.

**MEASURE** progress toward 2025 outcomes.

- **ZETI**, recruitment of priority partners, annual publication, newsletters, events, webinars
- **PAT**, recruitment of priority cities, newsletters, events, webinars
- **Infra planning guide**, working group, newsletters, events, webinars
- **TCO calculator**
- **Synthesis reports**, working group, newsletters, events, webinars
- **Case studies**, **Investor Council**
- **Lack of model availability**
- **Lack of enabling policies**
- **Lack of fitting infrastructure**
- **Negative TCO**
- **Lack of fleet awareness and buy-in**
- **Lack of user awareness and buy-in**

**2025**

Near- and zero-emission MHDVs are commercially viable and cost-competitive in beachhead applications and first-mover regions by 2025.

**2040**

Zero-emission MHDVs achieve 80% of new vehicle sales in first-mover regions by 2040.
Zero-emission vehicles will come in waves, and our “beachhead” strategy targets applications where zero-emission technology is likely to succeed first.

**Wave 1**
- **Transit:** ZE transit buses
  - Chanje Class 5 Delivery Van: Available now
  - ZE industrial lifts: Available now

**Wave 2**
- **Delivery:**
  - Chanje Class 5 Delivery Van: Available now
  - Fuso ECanter: Available now
  - Orange EV yard tractor: Available now

**Wave 3**
- **Medium Freight:**
  - E-Fuso Vision One: Announced 2021
  - Freightliner eM2: Demo now; Announced 2021

**Wave 4**
- **Heavy Regional Freight:**
  - Freightliner e-Cascadia: Demo Now; Announced 2021
  - Volvo VNR: Demo now; 2019 Europe; 2021 NA?
  - Tesla demo: Coming 2021?
  - Mack e-Refuse: Demo 2020; Coming 2022?

**Corridor Longhaul**
- **Freightliner eM2:** Demo now
- **E-Fuso Vision One:** Announced 2021

Similar drivetrain and component sizing can scale to early near applications.

Expanded supply chain capabilities and price reductions enable additional applications.

Steadily increasing volumes and infrastructure strengthen business case and performance confidence.

<table>
<thead>
<tr>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
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</table>
Global Drive to Zero: Tools to Drive Market Success

POLICY AND ACTION TOOLKIT

ZE TECH INVENTORY (ZETI)

INFRA PLANNING GUIDANCE

TCO CALCULATOR

Resources for Transformation: https://globaldrivetozero.org/tools/
HIGH-EFFICIENCY TRUCK USERS FORUM

• Funded and supported by U.S. Army-Ground Vehicle Systems Center at Detroit Arsenal

• Primary objectives:
  – Foster commercial vehicle industry collaboration with military
  – Identify cross-cutting issues & technologies that improve efficiency of commercial & military vehicles
  – Support research & demonstration activities centered on vehicle electrification, cybersecurity, connected/automated vehicles

• Program operating since 2002 - ~$20M funding leveraged 15X with industry match
CALSTART is bringing industry and the military together to deliver dual-usage efficient powertrain, connected and automated, and cybersecurity solutions and opportunities.

Mutually Beneficial Goals:

- Promoting and expanding commercial truck market opportunities for advanced technologies
- **Driving down the cost** of developing new technologies for the military
- Bringing leap-ahead technology solutions to the military through continuous outreach and engagement
## DRIVING DUAL-USE TECH CAPABILITIES

<table>
<thead>
<tr>
<th>Military Activities</th>
<th>Commercial Activities</th>
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<tbody>
<tr>
<td>CCDC Ground Vehicle Systems Center Vehicle Electrification Forum</td>
<td>Electric Truck (eTruck) Task Force, Global Drive to Zero</td>
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<td><strong>Electrification:</strong> DOD-DOE fuel cell vehicle initiative support</td>
<td>Fuel cell truck and bus testing and deployments In Calif., Ohio</td>
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<td><strong>Automation:</strong> Connected vehicle (leader-follower) demo support</td>
<td>Connected &amp; Automated Vehicle Users Forums</td>
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<td><strong>Cybersecurity:</strong> CCDC Ground Vehicle Systems Center Cyber Lab build-out; Cyber truck Challenge</td>
<td>Ground Systems Cyber Information Sharing &amp; Analysis Org.</td>
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<td><strong>Efficiency:</strong> Opposed-piston combat engine commercialization study</td>
<td>CARB-funded demo of HD opposed-piston OTR engine</td>
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<tr>
<td><strong>Electrification:</strong> CCDC Ground Vehicle Systems Center-Eaton microgrid program support</td>
<td>DOE-ORNL-UPS bi-directional wireless charging project</td>
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</table>
CALSTART supported collaboration events to bring the U.S. Army Ground Vehicle Systems Center (GVSC) together with industry partners:

**Vehicle Electrification Forums**
- 5 events - each attracted ~100 attendees
- Goal to introduce the clean transportation technology community to GVSC and to solicit the community’s input to GVSC’s vehicle electrification strategy
- Activity led to RFI/RFP process
2019/20 HTUF PRIORITIES

- **Microgrid** technology working group
- Advanced vehicle technology **supply chain study**
- Vehicle cybersecurity supply chain working group
- **Opposed-piston engine** demonstration planning
- Advanced powertrain demonstration planning
- Technology readiness analyses for military end-users
- Advanced planning for GVSC **Cyber & Automated Vehicle Innovation Center**
- Working group for **fleet electrification** planning
CALSTART is accelerating connected and automated transportation by engaging and working with transit authorities, bus OEMs, fleet owners, and suppliers.

Meeting the needs of the users community focusing on 3 Key Areas:

- **Policy and infrastructure**
- **Evolutionary strategies for CAV adoption**
- **Performance parameters & requirements**
  - Crashworthiness
  - ADA
  - Beyond Human Machine Interface (HMI)
CALSTART CATUF NEXT GENERATION, PURPOSE-BUILT, TRANSIT AV COHORT
CALSTART is accelerating the connected and automated movement of goods by engaging and working with MD/HD truck OEMs, fleet owners, and suppliers.

From long-haul freight and warehouse logistics, to home deliveries, stakeholders are looking to Automated Driving Systems (ADS) to improve operations, safety and security.
KEY ACTIVITIES ACROSS REGION

- ZE Bus Deployment Support
- Maintenance/Safety SOPs
- ZE Bus Deployment Support
- Northern Light and Electric utility rate-case
- Utility Rate-Case Support (DTE/CMS)
- Supply Chain Study
- Technology Readiness Study
- Vehicle Electrification/Export Power/Cyber WG
- HTUF 2020
- CATUF
- ZE Bus Deployment Support
- Commercial Vehicle Readiness Guidelines
- Chicago EV Ordinance
- DOE Data Collection (CTA/CCC)
- Drive Clean Chicago
- On-Site H2 Generation Report
- MI/Ohio H2 Demand Study
- Midwest ZEB 3 WG meetings
- Microgrid Study
- H2 Bus Analysis
- SARTA NEORide FTA IMI
PANEL DISCUSSION

Mihai Dorobantu - Director, Vehicle Technology Planning and Government Affairs, Eaton Vehicle Group

John Szafranski – Division Chief, Vehicle Electrification, Ground Vehicle Power & Mobility, U.S. Army Combat Capabilities Development Command, Ground Vehicle Systems Center

Dean McGrew – Branch Chief - Powertrain Electrification Team, Ground Vehicle Power and Mobility, Ground Vehicle Systems Center, US Army - Army Futures Command – DEVCOM
Commercial vehicle electrification
Dr. Mihai Dorobantu
June 2020
Eaton and HTUF: A Twenty Year Journey

2002: Sen. Orrin Hatch (R-Utah) congratulates FedEx, EDF and Eaton for 1st MD HEV: "a bellwether for the rest of the nation and the world."

Over 15 years and 2 billion miles of safe, reliable HEV and PHEV service

2020: Eaton and Green Motion to Integrate EV Chargers in Buildings with Energy Storage
Eaton is helping to evolve EV technology at our sweet spot: the convergence of electrical and mechanical power.

- Vehicle dynamics
- System integration
- Safety standards
- OEM relationships

- Circuit protection
- Power electronics
- R&D resources
- Current scale
Eaton specializes in power electronics, systems, distribution and protection

- **Power Electronics**: Managing electrical power
- **Power Systems**: Managing mechanical power
- **Power Distribution and Protection**: Safely and reliably distributing power
- **HVAC/Thermal Management**: Heating and cooling electronics and the passenger
- **Energy Storage**: Storing electrical energy
- **Traction Motor**: Electric motor creating mechanical power

Eaton products

Integrated areas

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All-new heavy duty EV transmission

- **Purpose-built design** for electrified commercial vehicles
- **Engineered with industry leading expertise**
- Improves **vehicle performance**
- **Uncompromised gradeability**
- Flexible **shift schedules**
- **Efficient** motor use, extended range and/or reduced battery size
Electric power distribution for CVs

Similar to how a home service panel is fully-customized for a home’s specific loads...

Primary

Kitchen
Air conditioning
Garage
Electric water heater
Etc.…

Eaton’s solution is fully-customizable for a commercial vehicle’s specific requirements, by assembling the elements.

Primary

Electric motor
Power Steering
HVAC
Infotainment

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High-voltage FLEX Power Distribution Unit (PDU) for electric commercial vehicles

Safely and efficiently monitors and manages all electric power distributed in an electric vehicle

Intelligent software integration for complete programmable control of system components, communicating operational status and diagnostics

Fully-customizable based on a vehicle’s power level, number of electric auxiliaries and battery packs
# Power Electronics: Beyond EVs

## Electrical components for vehicles and grid connect

<table>
<thead>
<tr>
<th>Component</th>
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<tbody>
<tr>
<td>Low and High voltage DC/DC converters</td>
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<tr>
<td>120-225 kW inverters</td>
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<tr>
<td>Vehicle PDM</td>
</tr>
<tr>
<td>Battery equalizer, sensor, disconnects</td>
</tr>
<tr>
<td>On-board chargers</td>
</tr>
<tr>
<td>Circuit protection: fuses &amp; contactors</td>
</tr>
<tr>
<td>Micro-Grid controllers</td>
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</table>

Customers include military applications
Thank you
U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – GROUND VEHICLE SYSTEMS CENTER

Ground Vehicle Power & Mobility – June 18, 2020

John Szafranski
Division Chief, Vehicle Electrification

DISTRIBUTION A. Approved for public release; distribution unlimited. OPSEC# 4109
Ground Vehicle Power & Mobility (GVPM)

“We power and move the Nation's military ground systems”

Power & Mobility Technology

Powertrain

Real Time Control Systems

Track & Suspension

Vehicle Electrification

Powertrain Electrification

Energy Storage

Fuel Cell Technology

Testing & Evaluation

Propulsion System Laboratory

Ground Systems Power & Energy Laboratory

DISTRIBUTION A. See first page.
TECHNOLOGY GAPS
PRODUCT, CRADA, SBIR OPPORTUNITIES

**Powertrain**
- Thermal Management (Heat Exchangers, Fans)
- High efficient, compact transmissions for wheeled & tracked vehicles
- Power Dense, Multi-Fueled Engines
  POC: Constantine.Panagos.civ@mail.mil

**Energy Storage**
- Scalable HV Battery Architecture
- High Energy Density Cell/Batteries (>400Wh/kg)
- Battery Safety
- Thermal Management technologies
  POC: Laurence.M.Toomey2.civ@mail.mil

**Fuel Cell Technology**
- Metal Supported Solid Oxide Fuel Cells
- Multi-fuel reformation Technology
- High Temperature Proton Exchange Membrane (PEM) fuel cells
  POC: Kevin.S.Centeck.civ@mail.mil

**Real Time Control Systems**
- System/Vehicle Models
- Automated Testing and Software Documentation Tools
- Smart, Combustion Controls with Real Time Algorithm for Vehicle Applications
  POC: Kevin.T.Sharples.civ@mail.mil

**Track & Suspension**
- Segmentation of composite track systems at weights above 45T
- Combat vehicle suspension units.
- Electric height management capability
- Running gear conversion systems (Convert from tracked and wheeled systems)
  POC: Jason.T.Alef.civ@mail.mil

**Powertrain Electrification**
- High Temperature, Power Dense Motors and Generators
- High Temperature, Power Dense Inverters
- Embedded Motor Controls Software
  POC: Dean.Z.McGrew.civ@mail.mil

DISTRIBUTION A. See first page.
Extreme operating environments

Military Requirements:
- Operating Temperatures: -46°C to 71°C
- Storage Temperatures: -54°C to 88°C
- Nuclear & EMI: MIL-STD-461F
- Ballistic Shock: MIL-STD-810G
- Live Fire: MIL-STD-810G
- Explosive Environment: MIL-STD-810G
- Altitude to 60,000ft: MIL-STD-29595
- Explosive Decompression: MIL-STD-810G
- Salt fog: MIL-STD-810G
- Sand and Dust requirements: MIL-STD-810G

Additional Military Focus:
- NATO Standardized Form Factors (i.e. 6T)
- Maximized Power AND Energy density
- Sustainability and Logistics issues
- Silent Watch/Silent Mobility
- On-board Electric Power

Distribution A. See First Page.
U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – GROUND VEHICLE SYSTEMS CENTER

Vehicle Electrification – June 18, 2020

Dean McGrew
Branch Chief,
Powertrain
Electrification Team
ELECTRIFICATION MOTIVATION

**Improved System Efficiency**

- Vehicle Controller
- DC-DC
- 24 VDC
- 600 VDC

**Advanced Systems**

- Energy Weapons System
- Wireless Energy Beaming
- Missile Systems
- High Voltage Energy Storage
- High Power Jamming
- Vehicle-to-Grid & V2V
- Electronic Armor
- High Power Comms

**Advanced Capabilities**

- C-RAM, C-UAV, & Non-lethal
- Sustained UGV/UAV operation
- Offensive & Defensive
- Silent & Enhanced Mobility
- IED & Other defeat
- Expeditionary Power
- Lighter Weight Armor
- Improved communications

**Legend:**

- Existing Architecture
- Mechanical
- 28VDC
- 600VDC

AC and VAC = Alternating Current
C-RAM = Counter Rocket, Artillery and Mortar
C-UAV = Counter Unmanned Arial Vehicle
DC = Direct Current
DC-DC = HV/LV DC Power Conversion
HV = High Voltage
HVAC = Heating Ventilation and Cooling
HVPC = High Voltage Power Control
ISG = Integrated Starter Generator
LV = Low Voltage (24 VDC)
UAV = Unmanned Arial Vehicle
UGV = Unmanned Ground Vehicle
VDC = Volts Direct Current
V2G = Vehicle to Grid
V2V = Vehicle to Vehicle

Advanced Systems/Capabilities Enabled by 600 VDC Backbone

DISTRIBUTION STATEMENT A. Approved for public release; distribution unlimited.
**FMTV OBVP**
**PM THAAD & CPI2**

**Equipment**
- **PM TS**
  - Electronics Cooling
  - Relocated NATO Plug
  - 600/28 VDC DCDC
  - 600 VDC PDU
  - Generator Inverter
  - Supervisory Control

- **PM E2S2**
  - V2G Inverter
  - 600 VDC Ring Bus Manager
  - Host Nation & Hydraulics inverter
  - Host Nation Line interface Unit

**HEMTT OBVP**
**PM THAAD only**

**Equipment**
- Expansion Tank
- Heat Exchanger
- 6T Lion Batteries
- 3kW DCDCs
- Generator Inverter
- HV PDU
- Coolant Manifold
- Supervisory Controls
- 600/28 VDC DCDC

NOTE: Other components (hidden for visual purposes)
ELECTRIFICATION INTEGRATION HIGHLIGHTS NEED FOR POWER-DENSE/HIGH TEMPERATURE POWER ELECTRONICS

Silicon Carbide Enables Electrification in Combat Systems

Phase I

Current Generator Tech w/ electrified systems – cooling fan, DCDC, pumps

Weight Delta, (lb) | +466
Volume Delta, (L) | +220
Ave. Fuel Reduction, % | 10%
Speed on Grade, % | 10% better
0-60 mph Accel, % | 10% improved

Phase II VMD

Replaced hydraulics or local hydraulic supply + Li-Ion 6T batteries. **Advanced SiC power electronics** + ISG starting capability

Weight Delta, (lb) | ~0 lb
Volume Delta, (L) | ~0 lb
Ave. Fuel Reduction, % | 25%
Speed on Grade, % | 15% better
0-60 mph Accel, % | 15% improved

---

**Stryker Electrification**

**Phase I**

- **Description:** Current Generator Tech w/ electrified systems – cooling fan, DCDC, pumps
- **Weight Delta:** +466 lb
- **Volume Delta:** +220 L
- **Ave. Fuel Reduction:** 10%
- **Speed on Grade:** 10% better
- **0-60 mph Accel:** 10% improved

**Phase II - VMD**

- **Description:** Replaced hydraulics or local hydraulic supply + Li-Ion 6T batteries. **Advanced SiC power electronics** + ISG starting capability
- **Weight Delta:** ~0 lb
- **Volume Delta:** ~0 lb
- **Ave. Fuel Reduction:** 25%
- **Speed on Grade:** 15% better
- **0-60 mph Accel:** 15% improved
Power Export and Microgrid Working Group

CALSTART - HTUF

June 18, 2020
Power Export and Microgrid Working Group

- Focus on grid resiliency at Military bases
- Identify key vehicles ideal for electrification which will not hinder operations and can be used for power export
- Develop protocols for power export
  - Volt/VAR Power Factor Improvements
  - Fast Frequency Power Regulation
  - Peak Load Shedding
  - Short-term power outage (Brown Out)
  - Long-term power outage (Black Out)
- Microgrid integration planning and analysis roadmap development
Working Group Participants

• OEMs
• Engineering Firms
• Relevant Component Suppliers
• Military Base personnel
• Utilities
FIRST MEETING

• June 22, 2020 – 13:00 CST
• Location: Web-based

For more information or requests to participate, please email Jared Schnader:

jschnader@calstart.org

Thank you!
CALSTART’s Truck Initiative team is pleased to announce they are growing not only in numbers but in expertise.

Maureen Marshall
Midwest Regional Director
CALSTART
mmarshall@calstart.org

Kevin Walkowicz
Senior Director – Truck Initiative
CALSTART
kwalkowicz@calstart.org
VISION: HTUF enables targeted commercialization of MD/HD clean transportation technologies through strong participation across industry, military, fleet owners and key stakeholders.

2025
Commercially viability and cost-competitiveness for MD/HD near-zero and zero emission technologies

2040
Zero emission technologies dominate sales across MD/HD vehicle platforms
PRIORITY FOCUS: Beach head applications with key technology enabled for both private and military fleets:

- Class 7-8 Trucks
- Off-Road Vehicles
- Class 3-6 Delivery

- Economy of Scale for manufactures across applications/users
- Maximize leverage across local, state and federal incentive and regulatory programs
- Shared learning, specification and demonstration opportunities

Enabling Electrification (BEV/FCEV)

Connectivity and Automation (Efficiency and Safety)

High-Efficiency Enablers (Ton-mile/gal, Powertrain, and ICE)

Fleet Readiness (TCO, Training, Service Networks)

Strategic Transformation (Specifications, costs, standardization)

Cyber Security (Vehicles and EVSE)
UPCOMING HTUF WEBINARS

July 23rd 1:00pm Eastern: Vehicle electrification and shared lessons from the military and commercial industry

August 20th 1:00pm Eastern: How vehicle electrification contributes to microgrids in military and commercial applications

September 17th 1:00pm Eastern: Vehicle cybersecurity and its role in commercial and military technology development
THANK YOU

Send us your comments and suggestions

Steven Sokolsky
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ssokolsky@calstart.org