



SUPERTRUCK 2: EMPOWERING FUTURE TRUCKING

In 2009, The U.S. Department of Energy (DOE) inspired American truck manufacturers by funding the first SuperTruck project to demonstrate a system of new technologies with the goal of greatly improving freight energy efficiency, reducing vehicle operating costs and improving environmental sustainability. This led to DOE funding the even more aggressive SuperTruck 2 program beginning in 2016.

The SuperTruck 2 opportunity to harness the creativity of OEMs and suppliers to push the envelope of vehicle design was embraced by five teams lead by:

- Cummins Inc. & Peterbilt
- Daimler Trucks North America (DTNA)
- Volvo Trucks
- Navistar
- PACCAR Inc.

Each of these five teams succeeded in innovating complete tractor-trailer systems capable of exceeding freight efficiency performance improvements of more than 100% versus each team's Model Year 2009 baseline diesel tractors with standard 53' dry van box trailers. These accomplishments created a watershed of practical engineering and operational information to assist in developing production tractors and trailers to meet the increasingly demanding performance needs of the North American freight industry.

The fundamental basis of these SuperTruck 2 demonstrations is that a systems engineering perspective encompassing the entire tractor-trailer as a single unit can yield significantly better performance improvements than more piecemeal approaches looking at optimizing individual systems.

The North American Council for Freight Efficiency (NACFE) participated in all SuperTruck 2 Annual Merit Reviews as official peer reviewers as well as hosting multiple discussions on the developing technologies and writing thought leadership pieces in industry trade publications.

This report documents the significant technologies investigated, developed and demonstrated by the SuperTruck 2 teams, and the potential for these technologies to influence future production truck designs.

ACKNOWLEDGMENTS

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The starting point for SuperTruck projects was identifying a baseline for comparison. That comparison point is locked in time, but the real world is constantly evolving. In order to judge progress of the SuperTruck technologies and their impact on real-world vehicles, it is necessary to understand both the baseline and the real-world moving target for comparison.

was to demonstrate a 55% brake thermal efficiency (BTE) engine in an engine test stand. The second was to demonstrate a complete tractor-trailer vehicle system that exceeded a 100% improvement in freight-ton-efficiency (FTE) versus their selected 2008 baseline vehicle with a gross vehicle weight of 65,000 lbs. in a representative on-highway long-haul duty cycle of their own choosing. Key Performance Indicators for each team are shown in Figure ES1.

SuperTruck 2 teams had essentially two goals. One

FIGURE ES1

SUPERTRUCK 2 KEY PERFORMANCE GOALS BY TEAM

Factor	Cummins/ Peterbilt	Daimler	Navistar	Volvo	PACCAR
Brake Thermal Efficiency Goal at 65mph	55%	55%	55%	55%	55%
Freight Efficiency Improvement Goal vs 2009 Baseline	125%	115%	100%	100%	100%
Freight Efficiency Improvement Stretch Goal vs 2009 Baseline	170%	125%	140%	120%	140%

A consistent finding with all five SuperTruck 2 teams is that fuel economy performance improvement requires optimizing both the tractor and trailer as a complete vehicle. From an engineering and physics perspective,

improvement is a symbiosis of all the tractor-trailer elements, making the whole greater than the sum of its parts. See Figure ES2.

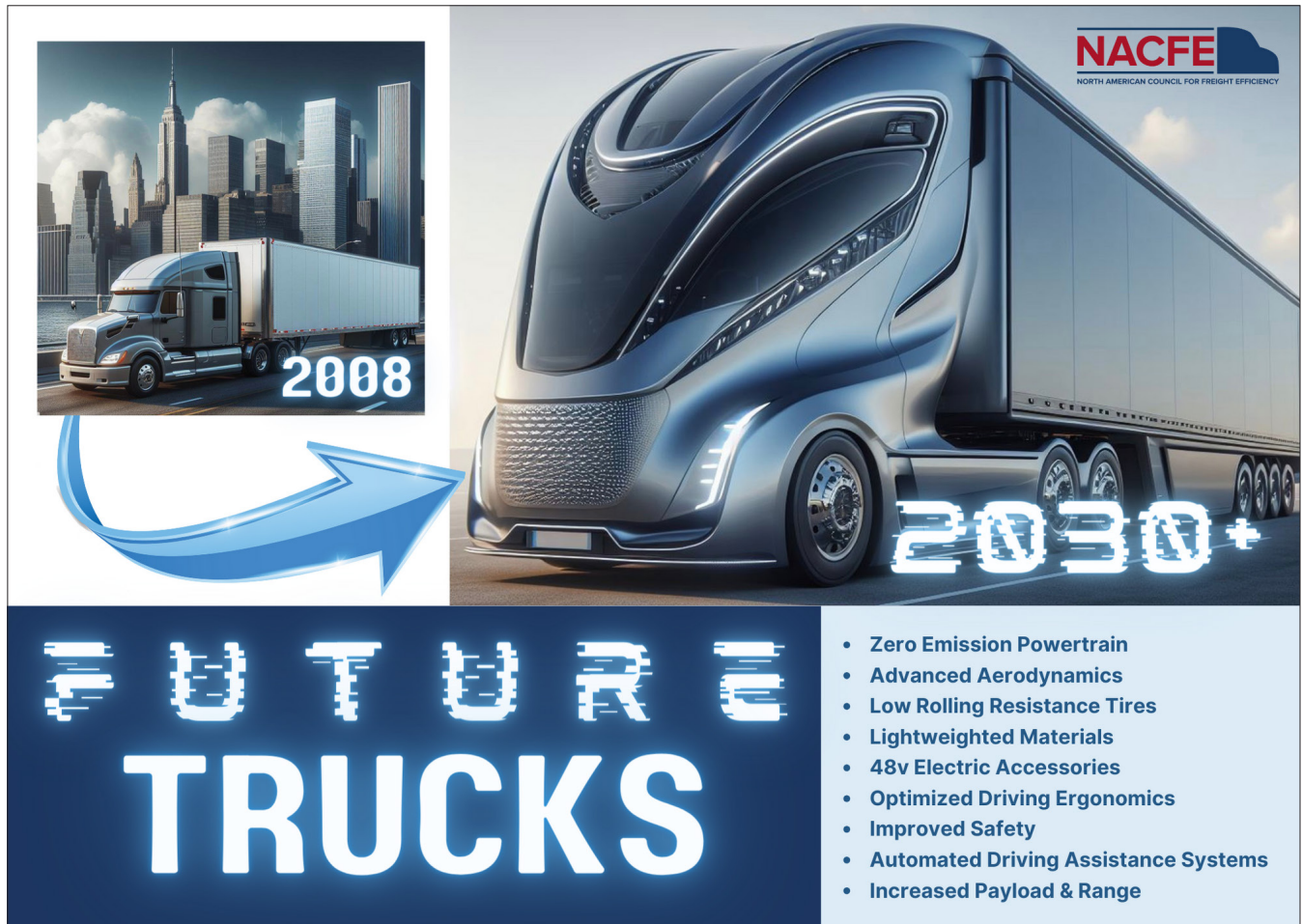
FIGURE ES2

THE SUPERTRUCK 2 DEMONSTRATORS



FIGURE ES3

FUTURE TRUCKS WILL BE INFLUENCED BY SUPERTRUCK INNOVATIONS



The multiple paths to the target demonstrate that there are many ways to improve the net performance of tractor-trailers, but from a physics standpoint, there are some priority technologies that achieve greater gains, irrespective of the chosen power systems. Those are:

- Aerodynamic improvement
- Rolling resistance improvement
- Weight reduction
- Parasitic loss reduction

These four common improvement factors are very pertinent to evolving technologies including battery

electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), alternative fuel vehicles such as renewable natural gas (RNG), compressed natural gas (CNG), hydrogen internal combustion engine (H2 ICE), propane, and all the hybrid permutations of these zero- and near-zero emission technologies. SuperTruck 2 investigations essentially are breeding grounds to propagate innovation well beyond just the subject vehicles.

As future trucks are evolving into zero-emission solutions such as battery electric, the concept of miles per charging event replaces miles per gallon. See Figure ES3. Many of the core technologies developed for the



“At Werner we look for ways to improve our efficiency and emissions reduction goals. We are seeing significant improvements by implementing some of the technologies developed by the truck makers in the SuperTruck projects.”

— Guy Welton, Director of Operations, Werner Enterprises

diesel-based SuperTrucks are helping extend the range of zero-emission vehicles, getting more miles out of each charging event or each kg of hydrogen. For example, a 30% improvement in MPG would make a 300-mile BEV capable of going 400 miles.

NACFE concludes that the SuperTruck 2 teams delivered extraordinary performance against deliverables, were inspired to innovate by the unique SuperTruck program and delivered efficiency technologies to make zero-emission solutions more successful.

1. **Fuel Economy Improvement:** SuperTruck 1 vehicles demonstrated MPGs in the range of 11 to 13 MPG and FTEs greatly exceeding their target 50% improvement versus their 2008 baselines. The SuperTruck 2 technologies had a target of exceeding 100% versus those same baselines and MPGs as much as 16 MPG by further optimizing diesel technologies, and incorporating 48V mild hybridization, and in one case, full high-voltage hybridization. NACFE estimates the equivalent MPG for the emerging battery electric vehicles is starting at 18.5 MPGde. The performance of the SuperTruck 2 demonstrations shows there are significant efficiency gains remaining for diesel-powered vehicles, but it also highlights the complexity required to achieve those gains. SuperTruck 3 and the associated hydrogen programs are innovation solutions for battery electric and fuel cell medium- and heavy-duty trucks in development over the next five years, hopefully with prototype vehicles seen in public as early as 2026.
2. **Innovation Diffusion:** Trucks that exist as ideas, what NACFE terms “paper trucks,” are part of the research and development process, but they are easily debated as they largely lack real-world testing. The SuperTruck vehicles are real-world trucks evaluated strenuously by expert teams that have skin in the game with their own money, resources, and reputations along with

funding from the government. Teams often include participants not typically allowed behind the wall of proprietary development at OEMs, including national laboratories and university researchers. Potentially excellent ideas that normally sit on shelves from lack of management engagement or interest can make it into full system development of vehicles. Development perspectives that may be hamstrung with component-level development are set free to bloom by participating in a complete vehicle system perspective where, for example, performance gains in one area are achieved by weight reductions or simplification in completely unrelated areas of the vehicle. SuperTruck projects empower designers to literally think outside the mental boxes they typically must work within under normal organizational product development.

3. **Universal Ideas:** Many tractor-trailer system efficiency gains are universally applicable to all powertrain choices. Reducing the energy required to move freight over a distance means less operational cost. Another way to view that is that less energy required per mile can translate into greater net range for the same amount of energy, and or greater payload. Improving the tractor-trailer as a system is a key perspective to help emerging zero-emission vehicles to achieve more miles per fill-up. Future trucks will build from technologies demonstrated in SuperTruck 2 to achieve increased range and freight capacity. For example, a 100% scale improvement in FTE easily demonstrated by SuperTruck 2 teams through a range of vehicle technology improvements could make a 300-mile BEV capable of going 600 miles.

SuperTruck has shown that small, engaged and empowered development teams freed from traditional production vehicle mindsets can achieve phenomenal advances in energy efficiency and emissions reduction. These advances are typically done judiciously with available funding.



“DOE’s investment in SuperTruck 1, 2 and 3 has proven to have enormous value as truck manufacturers are putting a great deal of effort into technologies that result in better, more fuel-efficient trucks which will continue to benefit future trucks regardless of fuel source.”

— Austin Brown, Director, Vehicle Technologies Office, US DOE



ABOUT NACFE

The North American Council for Freight Efficiency (NACFE) works to drive the development and adoption of efficiency enhancing, environmentally beneficial, and cost-effective technologies, services, and operational practices in the movement of goods across North America. NACFE provides independent, unbiased research, including Confidence Reports on available technologies and Guidance Reports on emerging ones, which highlight the benefits and consequences of each, and deliver decision-making tools for fleets, manufacturers, and others. NACFE partners with RMI on a variety of projects including the Run on Less demonstration series, electric trucks, emissions reductions, and low-carbon supply chains. Visit NACFE.org or follow us on Twitter [@NACFE_Freight](https://twitter.com/NACFE_Freight).



ABOUT RMI

RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing. More information on RMI can be found at www.rmi.org or follow them on Twitter [@RockyMtnInst](https://twitter.com/RockyMtnInst).

GET INVOLVED

NACFE could use the assistance of fleets, manufacturers and other trucking industry stakeholders in improving freight efficiency. Become a part of this exciting opportunity.

Learn more at www.nacfe.org or contact Mike Roeth at mike.roeth@nacfe.org