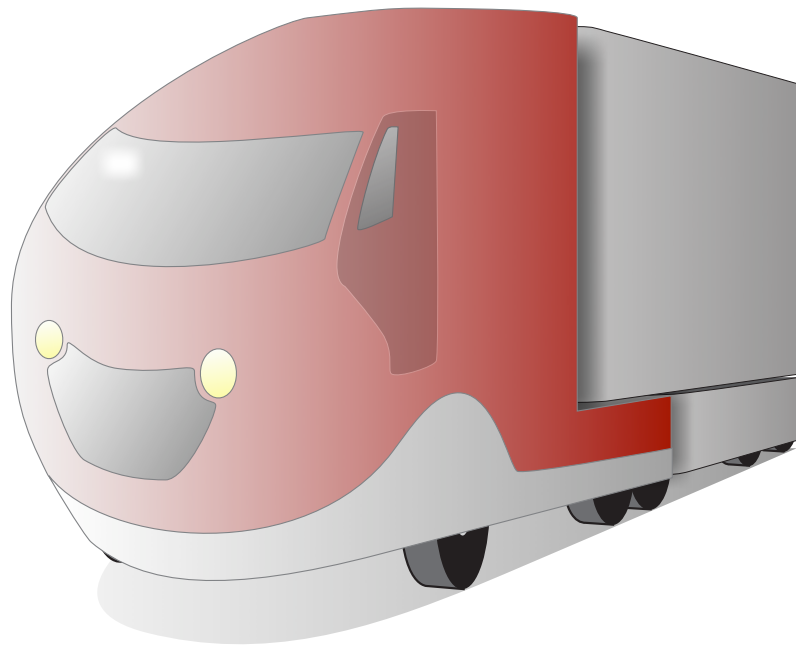


Rocky Mountain Institute®

Transformational Trucking Initiative *Report*



Transformational Trucking Initiative Team:

Amanda Sahl, Mike Simpson

Program Lead: Hiroko Kawai, Principal

Team Advisor: Kristine Chan-Lizardo

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Thanks to those companies that participated in the Transformational Trucking Charrette (see Appendix A) that generated this document. Special thanks to the Robertson Foundation for its generous support of the Transformational Trucking Initiative and to others who continue to support RMI's efforts.

Introduction

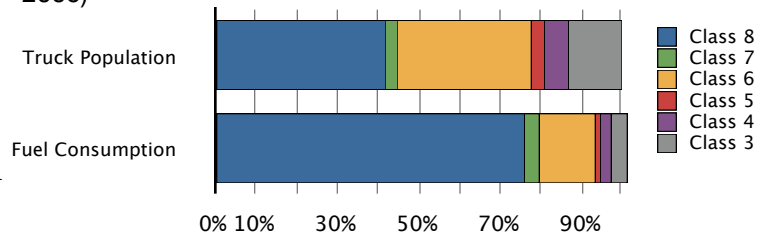
The American trucking industry moves 60 percent¹ of America's goods using 3.5 million tractors and 5.3 million trailers.² Yet despite their ubiquity, tractor-trailer designs have remained fundamentally unchanged for fifty years. They remain, in the words of Andrew Smith, CEO of ATDynamics, "the worst shape to move down the highway at 55 miles per hour...a big rectangular box."

Within the trucking industry, long-haul heavy-duty (Class 7 and 8) trucks offer particularly great efficiency potential. Despite accounting for less than half of the nation's trucks, Class 7 and 8 trucks account for

almost 80 percent of trucks' fuel consumption. Their size, speed, and poor aerodynamics mean Class 7 and 8 trucks are laden with "low-hanging fruit" (cost-effective efficiency and retrofitting opportunities). The complexity of the industry and its culture have been the primary barriers to realizing this efficiency. The industry has found efficiency improvements difficult to invest in, and when OEMs (original equipment manufacturers), fleets, and owner-operators have been able to, they've been reluctant because they don't trust efficiency data (nor projected payback). Regulations have also discouraged the greater use of high productivity vehicles (HPVs;³ due primarily to concerns about safety and infrastructure) and diverted resources from efficiency.

The time is ripe for change. According to a recent analysis by Rocky Mountain Institute (RMI), the technology already exists to double trucking efficiency.⁴ Furthermore, the trucking industry would benefit from increased efficiency through reduced and more predictable fuel costs as well as from reduced regulatory pressure.

Figure 1: Fuel Economy and Mileage Outweigh Population (RMI 2009)



¹ Hoover's, Inc. 2009

² Transport Topics 2009

³ HPVs are commonly referred to as long-combination vehicles (LCVs) within the industry; however, at the University of Michigan MagicTrucks conference (June 15-17, 2009), industry participants discussed using more accurate terminology. Other terms discussed included high efficiency vehicles and high capacity vehicles. This report will use the term high productivity vehicles as it conveys capacity and efficiency factors.

⁴ Ogburn et. al. 2008; RMI 2009

But these same conditions that can encourage efficiency, can also discourage it. For example, while the industry and individual players could improve their financial situation through efficiency, their current financial situation prevents them from investing in the necessary improvements. Similarly, while volatile fuel prices have made the industry's sensitivity to prices clear, companies often cannot afford to invest given such uncertainty.

RMI convened industry leaders at a Transformational Trucking Charrette in April 2009 to identify the barriers to efficiency and create an industry action plan for doubling trucking efficiency.

Transformational Trucking Charrette

Rocky Mountain Institute (RMI) recognized the potential for transformation in the trucking industry due to the industry's high fuel use (8 percent of U.S. oil consumption)⁵ paired with high efficiency potential (2–3 times existing efficiency using existing technology). Based on extensive analyses of both existing technologies and system-wide efficiency potential, RMI set a goal of doubling trucking efficiency.

From 14 to 16 April, 2009, RMI held the “Transformational Trucking Charrette,” which convened roughly forty-five of the trucking industry's leaders. A charrette is an intensive, highly integrative, transdisciplinary, roundtable workshop that brings together stakeholders and experts at the outset of a design or problem-solving process. Participants represented suppliers, OEMs, private and public fleets, and key government agencies, among others (see Appendix A). The best-represented stakeholder groups were technology developers, component suppliers, and industry consultants (in order from most to least participants), followed by government, research organizations, and end users. Tractor and trailer OEMs were the least represented in absolute numbers; however, there are only a handful of major tractor and trailer OEMs nationwide (compared to hundreds of thousands of fleets).

RMI defines trucking efficiency as: delivering what you want with the least energy.

The charrette was a rare opportunity for key stakeholders to discuss barriers and solutions. The top barriers identified at the charrette stemmed from customer requirements, information, and regulations and infrastructure (see the “Ten Key Barriers” section, p. 13). Technology was recognized as a barrier that will be particularly important later, as the industry reaches and exceeds doubled efficiency.

This report examines current industry and environmental conditions relevant to doubling efficiency, the conditions that drive efficiency, the barriers to doubled efficiency, how doubled efficiency can be achieved using existing technology, as well as novel approaches to doubled efficiency. These novel approaches are encapsulated in three projects proposed by charrette participants: 1) the **U.S. Council for Freight Efficiency (USCFE)**, a non-biased certification body that would test and certify efficiency technologies; 2) **“Freight Without Borders: A National Freight Strategy,”** a cohesive, science-based industry vision centered around an industry blue-ribbon panel and a government committee; and 3) **Transformational Truck Demonstration**, a project that would combine, demonstrate, and test existing efficiency technologies in a single

⁵ M.J. Bradley & Associates 2009

vehicle that maximizes not only technological platform efficiency, but also process and operational efficiency. By identifying and addressing key barriers stakeholders face to implementing efficiency, the trucking industry can double its efficiency, save fuel costs, help protect the environment, and enjoy a brighter, more certain future.

The Trucking Industry: A Fragmented Value Chain

The trucking industry is neither concentrated nor cohesive (the top fifty companies account for only 30 percent of the market)⁶. The market is also fragmented, with many stakeholder types involved in portions of production or operations as well as poor communications and collaboration between stakeholder groups and specific companies (see Figure 2, stakeholder map that follows). The market's fragmentation has embedded system-wide inefficiencies—inefficiencies such as empty backhauls, fleets and owner-operators who decide against efficiency improvements, and drivers idling their trucks overnight to stay warm. Doubling trucking efficiency will require an in-depth understanding of the trucking industry and its stakeholders as they form the basis for many efficiency drivers and barriers.

Tractor and Trailer Production

More than a dozen key stakeholder groups are involved in the design, manufacture, operation, logistics, and maintenance needed to get freight from Point A to Point B. A new tractor-trailer is designed with input from component suppliers; engine, tractor, and trailer OEMs; technology entrants and design firms; dealerships; and bodybuilders. In the North American market, many of the equipment purchasers are involved; typically mega-fleets⁷ specify their truck configurations, and have influence even during the OEM's product development phase. Owner-operators typically buy their tractors second-hand from large fleets after 3–6 years.

Research and Development. OEMs have traditionally been the ones to undertake new research and development (R&D). They develop new equipment with input from component suppliers and key end customers, and in response to regulatory requirements. However, in recent years, more and more technology entrants and design firms have become the source of efficiency improvements. The fragmentation of R&D has meant some efficiency technologies have come from OEMs and been integrated into new vehicles while other technologies have been used more for customization and aftermarket retrofits. New, whole-system efficiency improvements will require collaboration between design firms, OEMs, component suppliers, outside influencers, and customers.

Orders and Manufacturing. Due to their size, mega-fleets exert considerable influence on the industry. They are able to order their vehicles directly from OEMs,⁸ often during or

⁶ Hoover's, Inc. 2009

⁷ For the purpose of this report, mega-fleets are fleets with greater than 1,000 vehicles

⁸ There are four main OEMs in the U.S.: Paccar, International Navistar, Volvo NA, and Daimler Truck NA.

even before production, rather than going through an intermediary dealership. Most mega-fleets special order their vehicles to match operational requirements, such as duty cycle. While most OEMs are beginning to vertically integrate engine and highly engineered component manufacturing, mega-fleets still have the power to influence truck specifications. These orders—and orders from dealerships—go to tractor and trailer OEMs who in turn order their components from component suppliers and engine OEMs.

Customization. When a small- or medium-sized fleet purchases new equipment, it will typically purchase basic equipment from a dealership and then, through that dealership, have a bodybuilder customize the new equipment. This customization ranges from chrome lighting and satellite television to more efficient tires. At this stage in production, a new tractor-trailer⁹ can be retrofitted for efficiency using commercialized products from an after-market supplier and/or products from a technology entrant or design firm. Fleets can also purchase more efficient models directly from OEMs or dealerships.

Retrofits. Through a process similar to customization, tractor and trailer owners can retrofit their equipment later in life. Here, external stakeholders have stepped in to encourage efficiency improvements. Particularly notable are the U.S. Environmental Protection Agency's (EPA) SmartWay program,¹⁰ which tests and certifies efficiency equipment, and Cascade Sierra Solutions,¹¹ a non-profit that helps owner-operators understand, choose, and finance efficiency improvements.

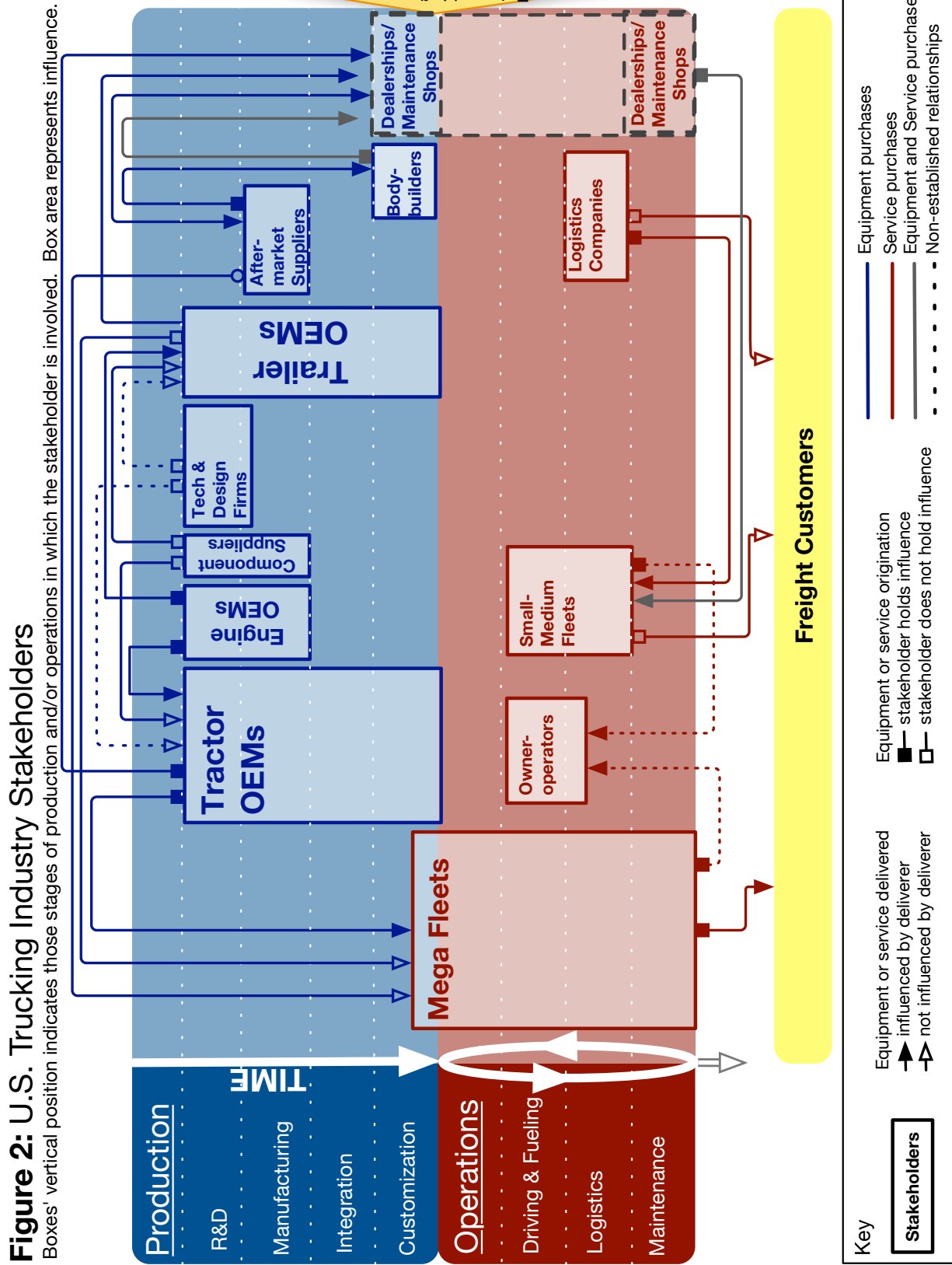
The retrofit process is simpler for mega-fleets, which once again sidestep dealerships and go directly to the source. (Mega-fleets handle almost all maintenance internally, eliminating any regular interactions with dealerships.) Should they choose to retrofit their equipment, mega-fleets prefer to interact with the primary equipment source.

External Regulatory Influence. Throughout this production process, outside stakeholders yield influence. The U.S. Department of Energy (DOE) influences certain research and development efforts through grants, while EPA sets tractor emissions standards. Air resource boards (ARBs), particularly California's, play a key role in setting state emissions requirements, thus influencing fleets' equipment purchases and logistics.

⁹ While this discussion describes the lifetime of tractors and trailers in tandem, most tractors and trailers are purchased separately and trailers have a significantly longer lifetime than most tractors.

¹⁰ SmartWay testing methodologies are currently being updated to better reflect duty cycles and include greenhouse gas information. www.epa.gov/smartway/

¹¹ www.cascadesierrasolutions.org/



Operations and Maintenance

During operations, mega-fleets prefer in-house fueling and logistics over third-party options. Owner-operators and small- to medium-sized fleets, on the other hand, regularly use public truck stops and maintenance shops for fueling and maintenance. Many also turn to third-party logistics companies. These companies, thanks to their size and specialization, can typically reduce empty backhauls (“deadheads”) and thus increase efficiency for their customers. Some logistics companies also provide group benefits—such as group insurance and discounted fuel prices—to owner-operators and small fleets.

External Influence. Throughout tractors’ and trailers’ lifetimes, external influencers—such as truck stops, the EPA, the U.S. Department of Transportation (DOT), state departments of transportation (DOTs), and non-governmental organizations (NGOs)—are never far from operators’ thoughts and decisions. Infrastructure (roads, bridges, truck stops, etc.); future emissions and efficiency regulations; and size, weight, and length limits all impact decisions made during equipment development and

“Fleets won’t invest in new technologies and new trucks unless those potholes are fixed and they are certain to reap the benefits of their investments.”

-Charrette Participant

production. The influence of road and bridge conditions, maintained by DOT and state DOTs, have a significant, but often-overlooked role. Road conditions influence traffic conditions, wear and tear on vehicles, and ultimately the decision to invest (or not) in efficiency technologies.

Government funding decisions also play a role. Indiana DOT, for example, is leading a \$5 million USDOT-funded effort to conduct an economic feasibility study on creating dedicated truck-only lanes on Interstate 70 through Missouri, Illinois, Indiana, and Ohio. When completed, this project will encourage more fuel-efficient vehicle combinations, illustrating how government funding decisions can influence infrastructure investments, allowable vehicle combinations, and their resulting fuel use. Anticipation of future regulations also weighs heavy on the minds of OEMs and fleets. The role of regulations and regulatory agencies in driving and discouraging efficiency will be examined in greater depth later in this report.

Drivers of Efficiency

Volatile fuel prices, current and future regulations, and the industry's razor-thin margins in an uncertain economy will all drive transformational changes in efficiency. Early movers will be able to capture market share and financial benefits. In the trucking industry, the business-as-usual path spells disaster.¹²

An Industry on the Brink. With small profit margins, rising fuel prices, driver shortages, decreasing freight volumes, and increased competition (particularly from rail), the trucking industry faces tough times. Of the top six (ranked by 2007 revenues) carriers, profit margins dropped as low as -0.3 percent.¹³ The recent recession has not helped, particularly since U.S. gross domestic product (GDP) changes are often correlated with increases or decreases (depending on the GDP change) in the transportation market.

Changes in GDP have affected the transportation market by as much as 500 percent.¹⁴

*"The impact of the current recession on this industry will be disaster."
-IBISWorld Inc. 2009*

Fuel prices are not helping matters. Standard & Poor's estimates that fuel prices account for about one-third of a typical carrier's operating expenses. As fuel prices rise, this share will likely increase unless carriers take action now to improve efficiency. Another third of a typical carrier's operating expenses is labor (including driver wages and benefits).¹⁵ While driver shortages have eased recently, driver turnover remains an issue, especially

*"Owners of trucking fleets, who had struggled to attract drivers while freight markets were rising, appeared to be working just as hard to retain those drivers as the market weakened."
-Standard & Poor's 2009*

because it costs an average of \$3,000 to replace a driver and up to \$24,000 to replace a profitable senior driver. Given these historic pressures, carriers have not been able to ease up on their costly efforts to retain drivers.¹⁶

As they deal with rising fuel prices, low profit margins, and decreasing freight volumes, many carriers are lowering prices to stay competitive. Hoover's found that "producer prices for U.S. truckload freight carriers decreased almost 4 percent in January 2009 compared to the same month in 2008."¹⁷ Freight carriers' challenges reverberate

¹² IBISWorld Inc. 2009

¹³ Standard & Poor's 2009

¹⁴ *ibid*

¹⁵ *ibid*

¹⁶ *ibid*

¹⁷ Hoover's Inc. 2009

throughout the industry, affecting demand for services and equipment, both new and used.

Paradoxically, the poor financial state of the industry has prevented widespread investment in the very technologies that could ease operating expenses and help profit margins.

Volatile Diesel Prices. Average diesel prices peaked in 2008 at \$4.67.

Already in 2009 (Jan–June), diesel prices have averaged 42 percent less than in 2008.¹⁸ Price increases stress the tight profit margins within the trucking industry, while volatile prices inhibit research and development and discourage truck owners from investing in efficiency technologies. For example, in 2008, an aerodynamic trailer-tail (\$2,800) that increased an average truck's efficiency by 6 percent would have paid for itself in two years. In contrast, diesel price averages in the first five months of 2009 would have meant a three-year payback for the same trailer-tail. High diesel prices have made the industry acutely aware of its inefficiency, but volatility has prevented the necessary investments.

Figure 3: Weekly U.S. No. 2 Diesel Sales by All Sellers (US EIA 2009)

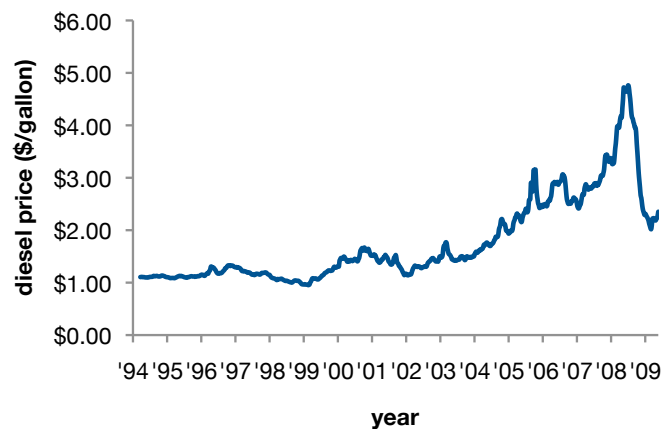
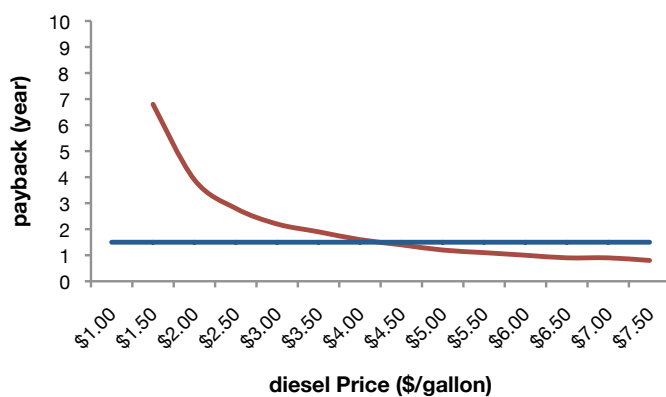


Figure 4: Effect of Diesel Price on Payback (assuming a \$6,300 upfront cost and 10 percent efficiency gains, consistent with costs and minimum savings for implementing a range of aerodynamic improvements)



Uncertain and Increasing Regulations. Increasing and uncertain regulation has also affected bottom lines in the trucking industry. Existing industry regulation focuses primarily on emissions, but bills in Congress and recent announcements from the Obama Administration suggest that efficiency legislation is on its way. The

¹⁸ EIA 2009

Congressional majority is also hoping to pass climate-change legislation this year.¹⁹

How it will affect the trucking industry is uncertain, but as the source of 78 percent of freight greenhouse-gas emissions,²⁰ trucking will not escape the attention of regulators.

*“the profitability of truck manufacturers has been constantly challenged by rising costs of production and legislative changes”
-IBISWorld 2009*

California, a key regulatory player, recently passed regulations that apply to new tractors and trailers starting with model year 2011. These regulations will be phased in to retroactively apply to existing equipment, requiring truck owners to retrofit less efficient tractor-trailers at their own expense.²¹ By doing so, these regulations place proactive truck owners at a competitive advantage, as may future regulations. In the face of uncertain regulations, the trucking industry has been reluctant to invest in the wrong technology, yet a proactive approach could prove competitively advantageous and/or forestall prescriptive regulation undesirable to the industry.

¹⁹ Allen 2009

²⁰ M.J. Bradley & Associates 2009

²¹ UCS 2009

Ten Key Barriers

Charrette participants recognized that existing, commercialized technologies could themselves encourage significant transformation in the industry. As one participant put it, *“the future [of trucking efficiency] is already here, it’s just not well distributed.”*

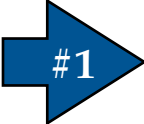
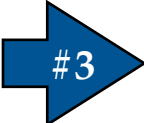
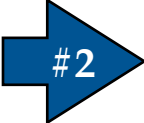
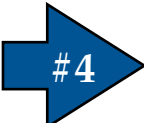

Participants identified ten key barriers to the successful distribution and adoption of efficiency technologies (see Table 1), grouped into four types: customer requirements, information, regulations and infrastructure, and technology. These primarily cultural barriers stem from the industry’s fragmentation and small profit margins (see the “Industry” section). Customers require short (e.g., 18-month)²² paybacks on equipment investments, but most efficiency improvements have paybacks ranging from two to ten years. A lack of trustworthy information and skepticism surrounding efficiency claims also bars technology adoption. *“Anything longer than 18 months payback is hard to swallow.”* Manufacturers might claim two-year paybacks, but customers might not believe the technology would save them any money. *Charrette Participant* Even if they believe the after-market technology is more efficient, customers worry that it will require maintenance (and downtime) or that they will not be able to find somebody to repair it at all.

There are also important regulatory barriers to efficiency. Tractor owners, for example, must meet emissions standards, often requiring additional equipment purchases. The emissions equipment does not generally improve efficiency, and its purchase diverts funds from efficiency equipment purchases. Inconsistent regulations between states also impact efficiency. In the case of length and weight, they have encouraged many truckers and fleets to adopt the lowest common denominator: short and light loads that are less efficient to transport than long and heavy loads (on a ton-mile / gallon basis).

While participants did not identify technology as one of the top barriers of the moment, they recognized that the broken research and development process and lack of long-term vision for research and development funding would inhibit efficiency improvements beyond a certain point.

²² RMI research

Table 1: Industry Barriers to Trucking Efficiency, numbered arrows represent the order of importance, as voted by Charrette Participants

	Top Barriers	Solution Strategies	Next Step Project
	Customer Requirements 1.Short-term payback expectations outweigh competing priorities 2.Large variety of customer requirements prevents manufacturing economies of scale 3.Limited access to capital funds and financing inhibits investment 4.Impacts to trucking business (industry inertia) other than cost inhibit investment	<ul style="list-style-type: none"> •Create a finance model to fund the upfront costs of efficiency improvements •Set standards for lifetime cost calculations •Fix a price floor for diesel 	U.S. Council for Freight Efficiency and existing Cascade Sierra Solutions
			
	Information 1. Lack of trustworthy, targeted information and sources inhibits investment 2.Lack of credible testing methodology reinforces lack of trust in performance	<ul style="list-style-type: none"> •Create standard testing methodology for multiple drive trains •Create an independent source for efficiency information, Consumer Reports for trucking •Demonstrate a transformational truck 	U.S. Council for Freight Efficiency and Transformational Truck Demonstration
	Regulations and Infrastructure 1. Inconsistent state-to-state regulations create many sets of requirements for efficiency 2. Competing policies divert resources 3.People and freight share infrastructure in sub-optimal configurations for both	<ul style="list-style-type: none"> •Create a national freight strategy with which key industry stakeholders agree •Harmonize state regulations with federal minimums beginning with western states per ATA proposal²² •Create freight corridors and truck lanes addressing system preservation 	Freight Without Borders
			
	Technology Sparse and fragmented research and development operations move slowly	<ul style="list-style-type: none"> •Develop joint R&D programs that combine multiple stakeholders •Demonstrate a transformational truck 	Transformational Truck Demonstration

²³ ATA 2009

Doubling Trucking Efficiency

Recent research indicates that a diesel fuel economy exceeding 10 miles per gallon (versus the current average of 5.5 mpg) is feasible with currently available technologies.

Doubling trucking efficiency will require the optimization of three major elements in harmony: truck platform efficiency, operational efficiency, and regulatory efficiency (see Table 1).²⁴ Harmonizing regulation with platform and operational efficiencies is especially important because regulations determine system constraints, such as allowable lengths, sizes, and weights. For example, a high productivity vehicle (which has multiple trailers) with a right-sized powertrain can realize substantial efficiency gains, but only if operational efficiencies ensure the trailers are weighed-out or cubed-out and if regulations allow HPVs along the most efficient route.²⁵ Similarly, regulatory and operational efficiencies cannot be optimized unless harmonized with vehicle platform efficiencies.

Figure 5: From Traditional to Transformational, How to Double Trucking Efficiency

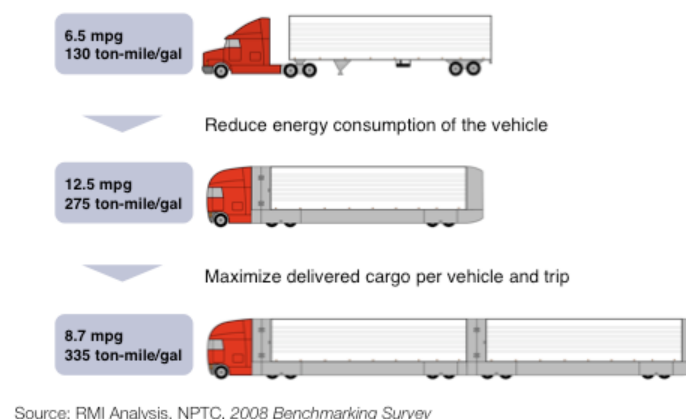


Table 2: Mechanisms to Increase Trucking Efficiency

TRUCK PLATFORM EFFICIENCY: Technologies and Equipment	OPERATIONAL EFFICIENCY: Logistical and Operational Processes	REGULATORY EFFICIENCY: Regulations and Infrastructure
<ul style="list-style-type: none"> • Aerodynamics Streamlining • Rolling Resistance Reduction • Auxiliary Power Efficiency (APUs) • Engine Idle Reduction • Powertrain “Right-sizing” • Heat Recovery • Powertrain Hybridization • Equipment Lightweighting 	<ul style="list-style-type: none"> • Load Optimization (TL vs. LTL)²⁵ • Hub-Spoke Distribution Network • Warehouse/Inventory Management • Streamlined Routing • Driver Education and Incentive Metrics • High Productivity Vehicles 	<ul style="list-style-type: none"> • GHG and PM Emissions Limits • Anti-idling Mandates • Congestion Solutions • Weight/Length Limits • Roadway Tolls • State and Federal Fees

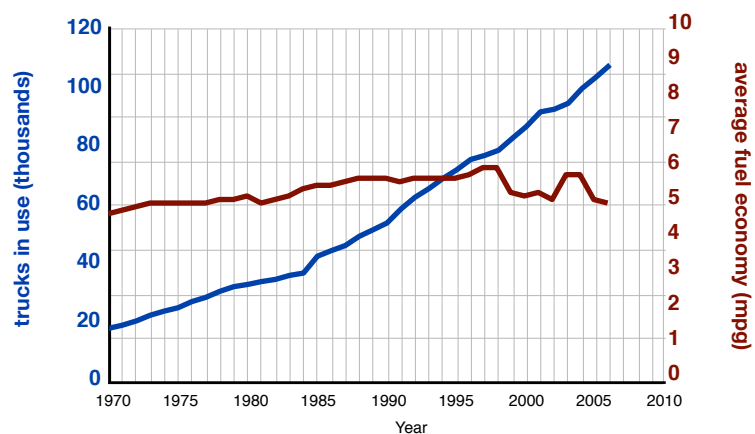
²⁴ “Harmony” in this context refers to elements that do not work against each other

²⁵ A load “cubes-out” when all available transport volume is utilized; a load “weighs-out” when it reaches maximum allowed weight. A load that cubes out is likely underweight whereas a load that weighs out tends to have excess volume capacity.

Vehicle Platform Efficiency. Average fuel economy (miles per gallon (mpg)) of heavy-duty trucks has increased only slightly since 1970, and it has actually decreased in recent years (see Figure 5). This decline in fuel economy has occurred despite the commercial availability of many after-market efficiency products. For example, multiple manufacturers now offer wide base single tires to replace duals and thereby reduce rolling resistance. Other companies offer tire inflation monitoring devices and products that improve aerodynamics. Each of more than a dozen products can increase efficiency 1–10 percent. While not all efficiencies can be captured in a single vehicle, many can (see RMI Transformational Trucking Charrette Pre-Read Appendix).²⁷

Figure 6: Heavy Duty Trucks' Average Fuel Economy

With less ground and air friction, the truck now has smaller power requirements and can use a smaller, more efficient powertrain to match the performance of a conventional truck; this can increase efficiency by 4.5 percent.²⁸ Downsized equipment can decrease weight, allowing for either a still smaller, more efficient engine, or for greater load weight capacity. These cascading efficiencies, which could be achieved by whole-system integration, have not yet been fully captured by the fragmented trucking industry; they could, however, be combined and demonstrated in a transformational truck design.



Process and Operational Efficiency. Though critical to energy independence and overall financial robustness, better fuel economy should not be the trucking industry's only goal. A truck's productivity is directly related to the amount of freight it delivers. For example, a pickup truck achieves roughly three times the fuel economy of a Class 8

²⁶ TL stands for "truck load," which refers to the practice of using one truck for a single customer; LTL stands for "less than truck load" and refers to the practice of shipping less than a full truck load for a customer; thus, multiple customers' freight comprises a typical load.

²⁷ RMI 2009 (www.move.rmi.org/files/capabilities/transformationaltrucking/TTC_PreReadApx_090406_RMI.pdf)

²⁸ Peterbilt Motors Company 2008

truck, but can only transport a small fraction of the freight. Thus, the second step of the Transformational Truck equation must incorporate maximized freight delivered during each trip, incorporated in the metric ton-miles/gallon.²⁹

Lack of coordinated logistics across the system hinders productivity and increases operational costs for truck fleets and drivers.

Total vehicle miles traveled (VMT) must also be considered when seeking to reduce fuel consumption. Logistics and route optimization are key levers for reducing both miles and gallons of fuel. A truck returns empty (termed an empty backhaul or a deadhead) almost 30 percent of the time. Still more trips are spent hauling less than full trailers. Loads that neither cube-out nor weigh-out are sub-optimal, and thus waste energy. Companies can reduce VMT by reducing “empty” miles (empty backhauls, for example) whenever possible, reducing required trips (by increasing load per delivery), and appropriately distributing miles (to account for traffic and weather). While achieving maximum efficiency in all operations is quite difficult, intelligent logistics can begin to close that gap. Using HPVs further improves efficiency, because a tractor uses only slightly more energy to haul a second trailer. While fuel economy of a HPV is lower, the productivity (ton-miles/gallon) is much higher.

Regulatory Efficiency. Individual states set their own size, weight, and length restrictions. The unintended result is a poorly coordinated and inefficient road network that favors the lowest common denominator

Without industry leadership, regulations threaten to determine the future of trucking.

*“in many ways the EU is more cohesive in transportation regulations than the U.S.”
-Don Baldwin, Michelin*

for efficiency: single-trailer tractors weighing less than 80,000 pounds. High Productivity Vehicle use has also been hindered by federal regulations. In 1991, Congress froze the maximum weight and length of HPVs. Set in the name of preserving road conditions and safety, these restrictions have inadvertently encouraged a greater number of smaller trucks, thus increasing overall road wear (using two or three trailers moves the same amount of goods in fewer loads, reducing not only fuel use, but road wear).³⁰

Restricting vehicle lengths and weights has also affected congestion, which costs the trucking industry at least \$6.5 billion a year in lost revenue.³¹ Depending on its size, one HPV can replace two or more conventional tractor-trailers. Reducing the number of

²⁹ the metric of ton-miles/gallon refers to the amount of freight (in tons) the vehicle can transport over a distance of one mile with each gallon of fuel

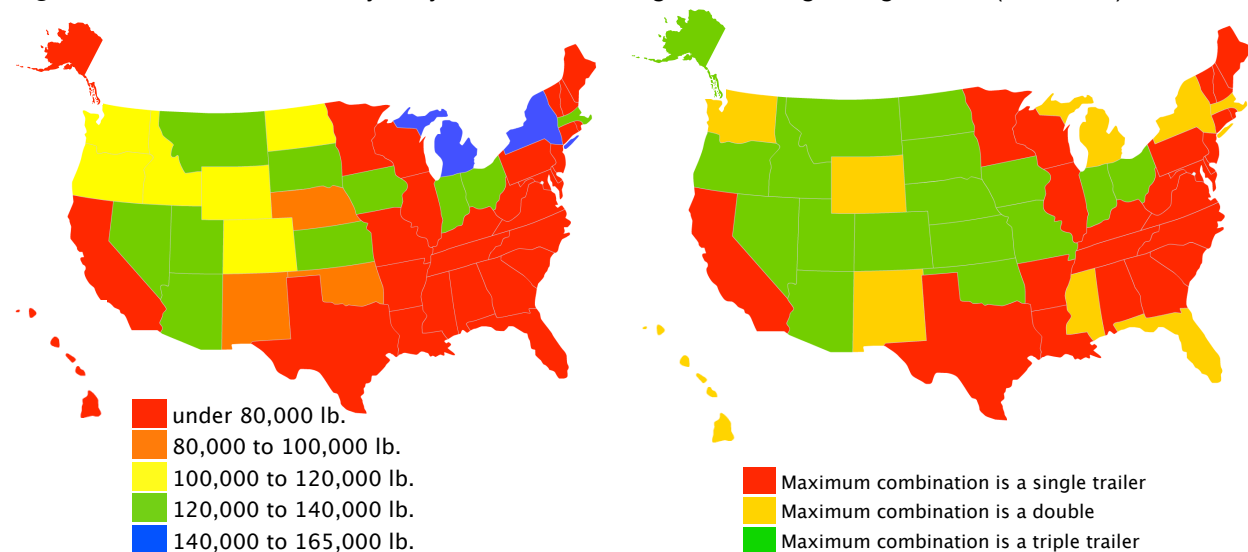
³⁰ Ogburn et al. 2008

³¹ DOT 2008

vehicles on the national highway system could ease congestion along major freight roads, decreasing emissions per ton transported and road wear.

Emissions regulations also impact efficiency. While these regulations have succeeded in lowering truck emissions, some have indirectly lowered efficiency by requiring tail-pipe emissions reductions systems that cause trucks to burn more fuel. Harmonized regulations could emphasize efficiency and prompt steps such as creating road corridors for HPVs. After all, more efficient vehicles use less fuel, and thus release fewer emissions per ton-mile.

Figure 7: United States' Heavy Duty Trucks' Size, Length, and Weight Regulations (RMI 2009)



In a sector such as the trucking industry, every decision counts. Unfortunately, the short-term payback requirements and poor credit of many in the trucking industry discourage wise investments in efficiency improvements. These and other cultural barriers have prevented any significant fuel economy improvement within the trucking industry for the last 30 years. Trucking efficiency cannot be increased, let alone doubled, without addressing them head on. Rocky Mountain Institute chose to do so by convening industry leaders at the Transformational Trucking Charrette. The barriers and solutions that participants uncovered there could revolutionize the trucking industry.

Busting Barriers: Projects to Double Trucking Efficiency

During the Charrette, participants worked in interdisciplinary groups to identify key barriers to transforming the trucking industry's energy efficiency and devised ways to tackle them. The group has initiated three projects to transform the trucking industry:

1. **U.S. Council for Freight Efficiency** (modeled on the U.S. Green Building Council)—a technology value assessment, demonstration, and certification program;
2. **Freight Without Borders: A National Freight Strategy**—creating a united front for industry stakeholders to connect with policy makers on a trucking efficiency agenda; and
3. **Transformational Truck Demonstration**—demonstrating and testing whole-system design for an intermodal tractor-trailer at least twice as efficient as conventional tractor-trailers.

These projects are in the early stages; we are currently seeking funding champions and creating organizational frameworks. The groups have identified actionable short-term goals in addition to mid- and long-term steps and goals.

U.S. Council for Freight Efficiency

Charrette participants proposed the formation of the U.S. Council for Freight Efficiency to advocate increased adoption of and investment in various efficiency technologies. The Council will address the lack of trustworthy, targeted information within the industry. Each end-user believes his duty cycle is unique, and doubts the technology benefits claimed by the technology provider due to its source and bad past experiences. The proposed USCFE is an excellent step towards demonstrating efficiency technology and offering credible information.

Business Overview. USCFE is a start-up, non-profit certification body for green (fuel-efficient) freight transportation. Led by a board of directors composed of diverse members, USCFE's first project will be an efficiency rating system for tractors and trailers, and their components.

USCFE will promote the adoption of and planning for fuel-efficient freight technologies by providing credible information on efficiency gains through its rating system. It will leverage the adoption of fuel-efficient technology with internal financing, thus addressing customer requirements for short-term payback. Initially it will focus on the trucking industry, but by year five the Council will expand to address intermodality.

Product Offerings. USCFE will offer a range of products, released in stages:

Stage	Product	Customer (who will pay USCFE to be rated)	Market (Who will pay for the rated product)
1a Months 0-6	ELITE* Component rating	Technology developers (OEMs, suppliers, etc.)	Owner-operators Fleets OEMs
1b Months 6-12	ELITE Tractor and Trailer Ratings	OEMs Dealerships Bodybuilders	Owner-operators Fleets Freight customer
1c Months 8-15	ELITE Authorized Dealers and Installers	Dealerships Bodybuilders	Owner-operators Small-medium fleets
2 Months 10-18	Financing	Owner-operators Small-medium fleets	
3 Months 18-40	Driver Education and Accreditation	Drivers Owner-operators Fleets	Fleets Freight customers Logistics companies
4 Year 5	Infrastructure Certification (roads, truck stops, etc.)	DOT, State DOTs, Private road owners, Rail track owners	Fleets Logistics companies

*ELITE stands for Exemplary Leadership In Trucking Efficiency

Operations. The primary functions of the Council will be organizing membership, arranging financing, designing rating and certification systems, and approving independent third-party certifiers.

Sales and Marketing. The Council's sales and marketing strategy is focused on:

- Advertisement through members,
- Education and accreditation programs, and
- Conferences and conventions.

Strategic Overlap. EPA's SmartWay program is the only established rating system for the trucking industry. The Council will build on SmartWay's existing efforts, expanding testing methodology to include multiple drive cycles.

Table 3: ELITE Product Benefits for Technology Developers

	USCFE's ELITE	SmartWay	No Rating
Credible efficiency rating	✓	✓	✗
Rating for multiple drive cycles	✓	✗	✗
Distribution through ELITE Authorized dealers	✓	✗	✗
Discounted financing available	✓	✗	✗

Finance Strategy. The Council plans to raise \$500,000 in its initial round of fundraising. This will support startup and operations for the first year. Initially, USCFE's revenue will come from membership fees (initiation and annual fees). Beginning in year two, additional revenue will come from a larger membership base, certification fees, and authorized dealership fees. By year three, membership fees will make up only a small portion of the Council's revenue, with funds coming primarily from education and financing.

Freight Without Borders: A National Freight Strategy

While the USCFE addresses technology efficiency, the second project “Freight Without Borders: A National Freight Strategy,” will address the issues of inconsistent, discordant, and often competing policies between states and the need for a long-term, system-wide (i.e., intermodal) freight strategy. Some policies have been very successful in addressing emissions, but often at the expense of efficiency.

Industry representatives were adamant about the need for regulatory certainty and consistency, calling for additional federal legislation to harmonize weight and size regulations, infrastructure upgrades, and idling standards.

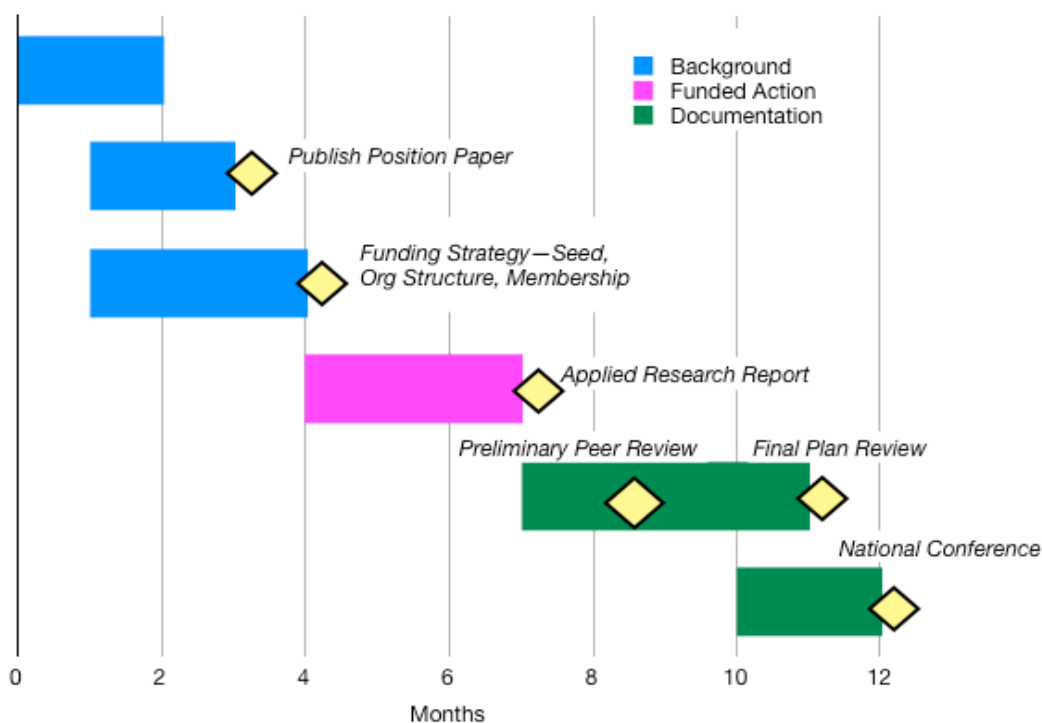
Freight Without Borders will also address an issue of considerable importance to participants: intermodality. Although they represented the trucking industry, participants agreed that the future of freight lies in efficient intermodal systems that move goods seamlessly from ship to rail to truck. While efficient technologies and HPVs will help the industry double efficiency, it will take a whole-system approach to push the envelope still further, and, arguably, by doing so create a more resilient and profitable freight industry. Freight Without Borders will create a range of benefits, including: increased job opportunities in efficient technology sectors, reduced oil dependence, a reduced environmental footprint, and increased profits in the freight transport industry.

Objectives. Freight Without Borders involves forming an industry blue-ribbon panel that can connect with policy makers, create a forum in which policy makers can review policies, and advance the national freight agenda. This will set the stage for efficient intermodal freight in the future.

Risks and Opportunities. Some freight stakeholders may not be interested in creating a national freight strategy. A significant challenge for Freight Without Borders will be attracting rail-sector officials, who are currently at odds with trucking, on board. Similarly, individual organizations risk losing current funding to a national freight effort. Dealing with government departments and on such a large scale will also be a challenge. But many of these challenges also bring opportunities. Freight Without Borders offers an opportunity to break down cultural and physical barriers between rail and trucking and to demonstrate how the freight industry as a whole can realize a win-win situation. Also, working with government offers an opportunity to reinvigorate the 21st Century Trucking program and influence upcoming legislation, such as the 2009 Transportation Bill. Freight Without Borders’ operations will mitigate these risks and attempt to capture these opportunities.

Operations. Freight Without Borders will start by focusing on trucking, but it will also set the stage for intermodal freight by including a rail constituency. Efforts will build on the lessons learned by the 21st Century Trucking Program, as well as from prior National Academy of Sciences reports. The initiative will identify a champion and develop a funding strategy and membership model. Stage two of operations (see chart below) will include publishing and distributing a position paper. Next, the champion and key members will develop a business plan and share it with existing trucking industry organizations such as ATA³² and OOIDA.³³ The group will write applied research reports at the start of the process. It will then have peers review the report and develop a final plan in time for the first national conference at month twelve. Following the first national conference, the group will choose a policy recommendation in the business plan to adopt as a pilot over two to three years.

Figure 8: Operations Plan for First Year of Freight Without Borders: A National Freight Strategy



Funding Strategy. Freight Without Borders seeks to raise \$568,000. This will support four full-time employees while they promote the initiative, manage the program, and do the research necessary during the first year of operations.

³² American Trucking Association, www.truckline.com

³³ Owner Operator Independent Drivers Association, www.ooida.com

Transformational Truck Demonstration

Doubling trucking efficiency will not be easy. While many of the technologies already exist, they have yet to be demonstrated and tested together over multiple duty cycles. Furthermore, doubling the efficiency of the trucking system requires more than adopting the existing technologies. It will also require improved logistics and increased inter-modality. Perhaps most importantly, it will require consumer confidence in and adoption of these technologies and methods. A Transformational Truck Demonstration will build on the efforts of the USCFE. But it will also go a step further.

Objectives. The Transformational Truck Demonstration will develop, demonstrate, and test a transformational truck that achieves at least double the efficiency of a traditional truck. In doing so, the demonstration aims to accelerate the development of efficient vehicles, their components and systems, and their profitable commercialization.

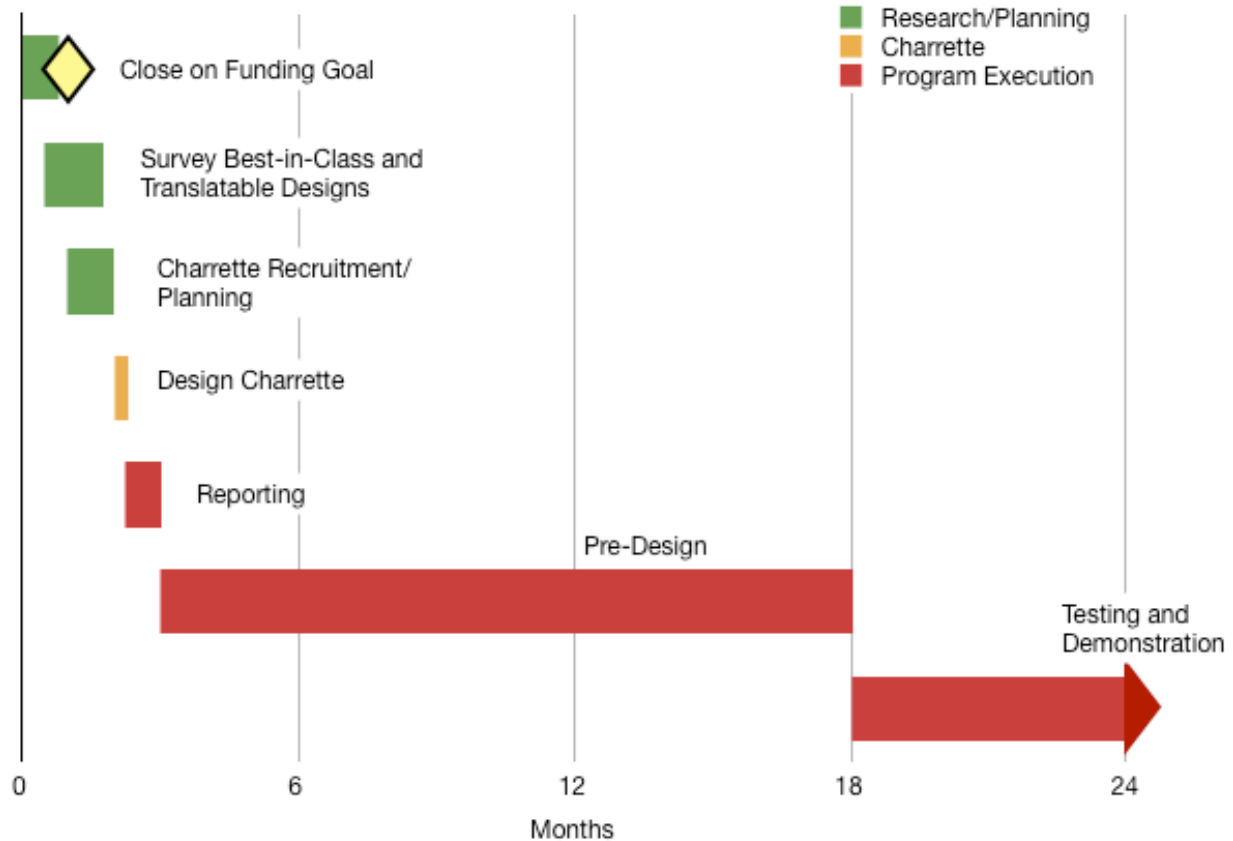
This project will establish the true efficiency limits for long-haul Class 8 trucks using USCFE testing methodologies that collect application-specific, duty-cycle-specific efficiency data. The Transformational Truck Demonstration process will leverage the research and networks from Freight Without Borders and USCFE while providing a test platform that can support the validation of new concepts from each. The project will also assist Freight Without Borders, proving to consumers and policy-makers the feasibility of transforming the trucking industry.

Risks and Opportunities. The push to demonstrate a transformational vehicle comes at an opportune time. There are multiple government funding opportunities for research, development, and demonstration in this area; however, that also means there will be competition. This demonstration project will likely differ from its competition because it centers on creating intellectual property for the public realm. This could also complicate group dynamics and discourage private financing. As a fragmented industry, many stakeholders are not accustomed to working with people whom they could consider the competition, but creating an integrated and transformational truck will require input from technology entrants and design firms, component suppliers, and engine, tractor, and trailer OEMs. RMI will mitigate these risks by leveraging the common vision and relationships developed through the charrette process. Designing a transformational truck with input from multiple stakeholders could create a new status quo for vehicle design within the industry.

Operations. The demonstration project will begin with a technology design charrette. A small group of truck research and development innovators will meet to conceptualize a transformational truck and develop a business plan for the design, building, testing,

and production of a transformational truck. This charrette will build on applicable early research on best-in-class designs.

Figure 9: Operations Plan for First Twelve Weeks of Transformational Truck Demonstration

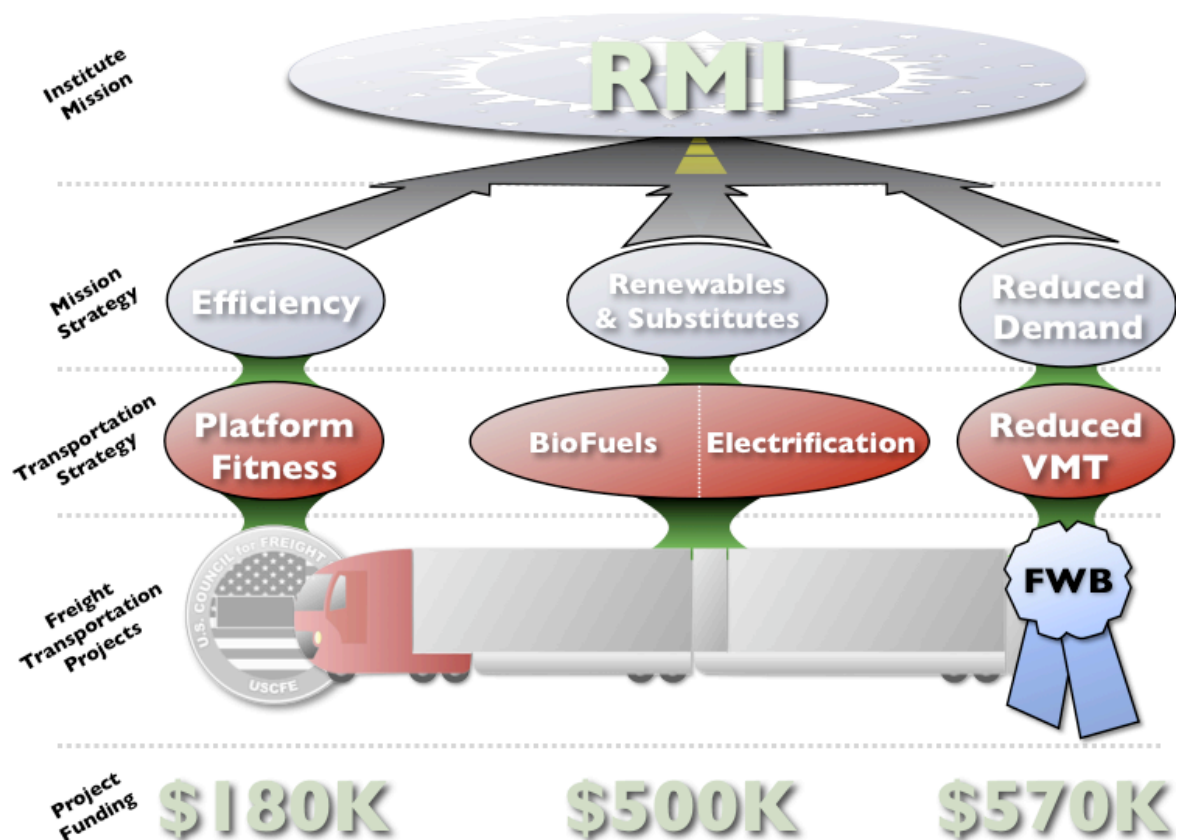


Funding Strategy. The Transformational Truck Demonstration project will simultaneously seek public and private funding. We are seeking initial funds of \$184,000 to organize and run the design charrette. Additional funds, grants, or in-kind donations worth \$3.3 million will be required to complete the design, demonstration, and testing of a transformational truck. RMI and other groups are currently applying for funds to begin this process.

Conclusion

The Transformational Trucking Initiative has gotten off to a good start towards its goal of doubling trucking efficiency. This Initiative will help advance RMI's mission of reducing fossil-fuel use by engaging the trucking industry—a key fossil-fuel user. Using RMI's three approaches to reducing fossil-fuel use—efficiency, substitution, and reduced demand—the Initiative and the three proposed projects will transform the trucking industry and the way freight moves to, from, and throughout the United States.

Figure 10: RMI's Strategic Approach to Transforming the Trucking Industry, as it Relates to RMI Mission and Strategy



As this graphic shows, the **U.S. Council for Freight Efficiency** addresses platform fitness, as does the **Transformational Truck Demonstration**. The Transformational Truck Demonstration will also address substitution via electrified propulsion. Meanwhile, **Freight Without Borders: A National Freight Strategy** addresses vehicle miles traveled (VMT) and whole-system efficiency. These projects address the key barriers that industry identified at the Transformational Trucking Charrette. Together, they will result in the demonstration and adoption of efficiency technologies used in a way that maximizes (and at least doubles) freight efficiency.

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Appendix A: Charrette Participants List

OEMs and Suppliers

Danaher Motion
Eaton
Jacobs Vehicle Systems
Michelin
Silver Eagle Manufacturing
Volvo
Webasto

Innovative Technologies

Achates Power
ATDynamics
HybridsPlus
Freight Wing Inc.
Nilar
Sturman Industries
TARDEC
VanDyne SuperTurbo, Inc.

Logistics and Fleets

Colorado Fleet Management
J.B. Hunt
Wal-mart

Non-Governmental Organizations

Cascade Sierra Solutions (CSS)
Environmental Defense Fund (EDF)
International Council on Clean Transportation (ICCT)
Union of Concerned Scientists (UCS)

Research Organizations

Avalanche Engineering
BMI Corporation
Clemson University (Department of Mechanical Engineering and International Center for Automotive Research)
National Renewable Energy Laboratory (NREL)
University of Michigan Transportation Research Institute (UMTRI)

Other Stakeholders

Bright Automotive
Colorado Department of Transportation (CDOT)
Department of Transportation (DOT)
Energy Systems Network (ESN)
Mileage Matrix
New Belgium Brewery
RolandBerger Strategy Consultants
SmartWay Transport Partnership

To see the individual participant list please visit: www.move.rmi.org/transformationaltrucking.