TASK ORDER 0001 UNDER
CONTRACT DTNH22-13-D-00298
PEER REVIEW REPORT

PEER REVIEW OF "REVIEW AND ANALYSIS OF POTENTIAL SAFETY IMPACTS AND REGULATORY BARRIERS TO FUEL EFFICIENCY TECHNOLOGIES AND ALTERNATIVE FUELS IN MEDIUM- AND HEAVY-DUTY VEHICLES"

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Submitted to:
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CONTENTS

1.0 INTRODUCTION **1**

2.0 BACKGROUND **1**

3.0 PEER REVIEW PROCESS **1**

3.1 Reviewer Search and Selection 1

3.2 Conducting the Review 2

4.0 REVIEWER COMMENTS ORGANIZED BY CHARGE QUESTION **3**

4.1 Please state your overall assessment of the organization, readability, and clarity of this report, including any changes needed. 3

4.2 Does the document adequately review, present, and summarize the available data? If not, what can be improved? 9

4.3 Are methods and analyses described in this report adequately developed, well-integrated, and appropriate to the aims of the project? 11

4.4 Are the findings and conclusions adequately supported by the data? 14

4.5 Please recommend any additional key published data for vehicle technology and safety that may be relevant to this review and analysis. 15

4.6 Are the statistical methods used in the analysis appropriate? 16

4.7 What are the weakest and strongest parts of this report? Please suggest how the weakest parts of the report can be strengthened. 20

4.8 Please provide any other comments you may have on the report. 21

4.9 Based upon your review, please indicate whether you find the report: (1) acceptable as is, (2) acceptable with minor revisions, (3) acceptable with major revisions, or (4) not acceptable. Please justify your recommendation. If you find the report acceptable with minor or major revisions, be sure to describe the revisions needed. 34

APPENDIX A REVIEWER CURRICULUM VITAE/RESUMES **A-1**

APPENDIX B CHARGE TO REVIEWERS **B-1**

APPENDIX C INDIVIDUAL REVIEWER COMMENTS **C-1**

Dr. Daniel Blower C-3

Mr. Dana M. Lowell C-17

Dr. Donald W. Lyons C-41

1.0 INTRODUCTION

This report documents the results of an independent peer review of the draft publication *Review and Analysis of Potential Safety Impacts and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels in Medium- and Heavy-Duty Vehicles,* developed by the U.S. Department of Transportation's (DOT's) Volpe Center. Eastern Research Group, Inc. (ERG, a contractor to DOT's National Highway Traffic Safety Administration) organized this review and developed this report. The report provides background about the review (Section 2), describes the review process (Section 3), and presents reviewer comments organized by charge question (Section 4). Appendices A, B, and C provide reviewer curriculum vitae and resumes, the charge to reviewers, and the individual comments submitted by each of the three reviewers.

2.0 BACKGROUND

In April 2012, the National Highway Traffic Safety Administration (NHTSA) entered into an Interagency Agreement with the DOT's Volpe Center to review how technologies to improve fuel efficiency in medium- and heavy-duty (MD/HD) fleets may impact vehicle safety and current regulations, both positively and negatively. This broad assessment covers vocational, combination tractors, buses, and class 2b/3 vehicles and involved review and prioritization of the potential safety implications within the relevant contexts of MD/HD vehicle operation, performance, maintenance, and collision scenarios, and cites cases and statistics when available. In addition, for MD/HD vehicle categories with high numbers of occupants, such as transit and school buses, the review includes an analysis of occupant safety and capacity. During June through November 2014, ERG, a contractor to NHTSA, organized and managed a review of the resulting report, *Review and Analysis of Potential Safety Impacts and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels in Medium- and Heavy-Duty Vehicles*.

3.0 PEER REVIEW PROCESS

3.1 Reviewer Search and Selection

For this review, ERG searched for, screened, and selected three reviewers who had no conflict of interest (COI) in performing the review and who collectively met the following technical selection criteria provided by NHTSA:

- Expertise in MD/HD vehicle safety and fuel efficiency technologies.
- Familiarity with MD/HD literature, crash safety statistics, and/or applicable fuel efficiency/GHG or safety regulations.
- Specific expertise, where possible, with:
  - NHTSA and Federal Motor Carrier Safety Administration (FMCSA) crash databases.
  - Conventional and alternative fuel vehicles (compressed and liquefied natural gas, propane, biodiesel, and powertrain electrification).
  - Vehicle safety engineering experience (e.g., vehicle and alternative fuel tank/battery crashworthiness).
  - Regulatory and industry standards.
  - Public transit fleets.
  - Commercial fleet operation.

ERG developed an initial list of potential candidates who appeared, based on publicly available information, to meet the above criteria. After receiving NHTSA confirmation that the candidates were suitably qualified and had no obvious COI, ERG contacted these candidates to ascertain their interest and availability to perform the review. Interested candidates provided their curriculum vitae (CV) or resume, completed and signed a detailed COI form, and signed a non-disclosure agreement (NDA). After carefully reviewing this additional information, ERG selected three candidates who collectively best met the selection criteria and had no conflict in performing the review. ERG provided their CVs /resumes, signed NDAs, and certification of lack of COI to NHTSA. After receiving NHTSA verification that the proposed reviewers were appropriately qualified, ERG contracted with them. The reviewer team, in alphabetical order by last name, comprised:

Dr. Daniel Blower, Associate Research Scientist, University of Michigan Transportation Research Institute (UMTRI), Center for the Management of Information for Safe and Sustainable Transportation. Dr. Blower has extensive experience with all the primary national crash data files and many state crash data files. Medium and heavy trucks have been a primary research emphasis, but he has also directed projects on traffic safety issues related to light vehicles.

Ph.D., History, University of Michigan, 1984
B.A., History, University of Michigan, 1972

Mr. Dana M. Lowell, Senior Vice President & Technical Director*,* M.J. Bradley & Associates LLC. Mr. Lowell has 25 years professional experience in the transportation and government sectors. He has worked in MJB&A's advanced vehicle technology group since 2004, providing strategic analysis, project management, and technical support to mobile source emissions reduction programs. His mobile source project work includes evaluation and implementation of advanced diesel emissions controls, alternative fuels, and advanced hybrid and fuel cell electric drives, as well as development and implementation of diesel emissions testing programs for a range of on-road and non-road heavy-duty vehicle types.

MBA, co-major in Management and Operations Management, New York University, 1995
BS, Mechanical Engineering, Princeton University, 1985

Dr. Donald W. Lyons, Emeritus Professor, Department of Mechanical and Aerospace Engineering, and Director Emeritus of the National Research Center for Alternative Fuels, Engines, and Emissions (CAFEE), West Virginia University (WVU). As a Professor of Mechanical and Aerospace Engineering at WVU, Dr. Lyons' responsibilities included teaching courses in the areas of mechanical design, engineering mechanics and thermal systems, developing research projects in the area of fuels, engines and emissions, and the area of mechanics of materials, and providing service to the State and region. While serving as Director of the National Center for Alternative Fuels and the Engines and Emissions (CAFEE) at WVU, he started the research program and developed the first major funding for the program in 1989. He was responsible for supervision of the faculty, staff, and research programs in the area of alternative fuels, emissions, and engines.

Ph.D., Mechanical Engineering, Georgia Institute of Technology, 1966
B.ME., Georgia Institute of Technology

Reviewer curriculum vitae/resumes are provided in Appendix A.

3.2 Conducting the Review

ERG provided reviewers with the review document and the charge to reviewers (Appendix B). To kickoff the review, ERG organized a 1-hour briefing call. During this call, which was facilitated by ERG, NHTSA provided background about the purpose and development of the review document, and reviewers had the opportunity to ask questions of clarification regarding the charge and review process.

After this call, reviewers worked individually (i.e., without further contact with other reviewers or NHTSA) to prepare written comments in response to the charge questions. Throughout the review, there were no additional questions for NHTSA from reviewers.

Reviewers completed their reviews and submitted their written comments to ERG, and ERG provided them to NHTSA. Both ERG and NHTSA checked the comments to ensure that reviewers had clearly responded to all charge questions. ERG then prepared this peer review report. Section 4 of this report presents reviewer comments organized by charge question, and Appendix C provides the comments by reviewer. In both cases, comments are presented exactly as submitted, without editing, summarizing, or correction of typographical errors (if any).

4.0 REVIEWER COMMENTS ORGANIZED BY CHARGE QUESTION

This section presents reviewer comments organized by charge question. Comments are copied directly from written comments as submitted by each reviewer and presented in Appendix C.

4.1 Please state your overall assessment of the organization, readability, and clarity of this report, including any changes needed.

Blower

Overall, I found the organization, readability, and clarity of the report to be very acceptable. The report is well-written, the explanations are generally clear, and the language is readily understandable. I have specific comments below for certain clarifications and corrections. I won't repeat those here. Taken altogether, I found the report to be very accessible.

Lowell

The over-all organization of the report is clear and understandable. However, in many places the text of specific sections is confusing and would benefit from additional editing for clarity. Often the report appears to be compiling statements or thoughts from disparate sources, and thus with slightly different emphasis or even slightly contradictory information, with insufficient introduction or summary language to draw the reader's attention to the specific point(s) being addressed. The report includes a lot of good data but there is no enough "connective tissue" to allow the reader to easily assess the data. Some sections are also repetitive, with essentially the same information repeated multiple times in succession; rather than strengthening the conclusions this unnecessary repetition is confusing.

Some specific areas of the report which require attention to improve clarity and readability are:

Section/Pg Num	Current Text	Comments
Sec 1.2 / pg 5 -6	Discussion of M/HDV crash, injury, and fatality rates	This entire section is confusing because there is a lot of data presented without adequately setting the stage for the reader as to how to interpret the data. It is stated that there is a long term trend of improved safety, but the recent data presented in detail belies that assessment (data in tables 1-2, 1-3, and 1-4 indicate that large truck crashes, deaths, and injuries all increased from 2009 – 2011). This entire discussion should be more concise and consistent. For example,

		something like: "NHTSA and FMCSA crash statistics show a long-term trend of improved safety, with total annual injuries and fatalities from trucks and buses involved in crashes falling by __% and __% respectively between 1999 – 2009. Due to an increase in total VMT over that time frame the rate of injuries and fatalities was reduced even further – with fatalities per 100 million VMT falling from __ in 1999 to __ in 2009. However, there has been an increase in fatalities from large truck crashes in recent years. Total fatalities from large truck crashes were 3,380 in 2009, rising to 3,686 in 2010 (+9%), and 3,757 (+2%) in 2011. Nonetheless, large trucks continue to have a better safety record than the light-duty fleet. In 2009 the fatality rate for large trucks and buses was 0.123 per 100 million VMT, compared to 1.14 for the entire fleet, including cars and light trucks. Similarly, the crash injury rate in 2009 for large trucks and buses was 3.15 per 100 million VMT, compared to 75.1 for the entire fleet." I would also suggest adding another table, with the same format as Table 1-4, but showing crash, injury, and fatality rates (per 100 million VMT) rather than annual totals. In addition to lines for "large trucks" and "buses" this table should include data for "light duty vehicles" or "entire fleet" for comparison.
Sec 1.2 / pg 10	Bulleted list of "recent DOE data"	This is labeled as "Recent DOE data on MD/HDVs by type, <u>fuel</u>, and fuel efficiency", however, in the following bullets there is no information about fuel type of the vehicles. It also might be more effective to include this data in a table rather than text.
Sec 2.2.1.3 / pg 19	Discussion of safety considerations of CNG fueled MD/HDVs	At the top of page 19 there is a statement about the number of CNG and LNG fuel stations in the U.S. In the middle of a discussion of CNG/LNG fuel properties and safety concerns this seems out of place. This type of information would be a better fit for section 2.2.1.1, Penetration/ Adoption. On the top of page 25 (section 2.2.1.4) there is a good (brief) summary of the "Hazards relating to LNG" – a similar summary of the "hazards relating to CNG" should be added to section 2.2.1.3, including: "fire, thermal explosion if release is into enclosed space, mechanical rupture of pressure vessel, and asphyxiation (by displacing oxygen). Gas release can be from fuel system leak or from activation of a PRD.

		Ignition can result from contact with hot surfaces, open flames, and sparks, including static electricity". On page 26 there is a discussion of codes (NFPA 57) applicable to design and manufacture of LNG vehicles. A similar discussion of codes applicable to the design of CNG vehicles should be included in Section 2.2.1.3. The most relevant code in the U.S. is NFPA 52, *Vehicular Gas Systems Code*, National Fire Protection Association, 2010. There is also a recommended practice from the Society of Automotive Engineers, SAE J2406, *Recommended Practices for CNG Powered Medium and Heavy-Duty Trucks* (March 2002). I should also note that the most recent addition of NFPA 52 (2010) incorporates updated content from NFPA 57 relative to LNG vehicles in Chapter 11. For a complete discussion of codes, standards, and best practices relative to both CNG and LNG vehicles see: FMCSA-RRT-13-044, *Natural Gas Systems: Suggested Changes to Truck and Motorcoach Regulations and Inspection Procedures,* Federal Motor Carrier Safety Administration, March 2013.
Sec 2.4.1 / pg 47	First paragraph of the section	This section launches into a discussion of a specific "fleet telematics" system (Telogis) without first providing an overview of what "driver and vehicle monitoring" or "telematics" means in the context of this report. As with other technologies this section should start with a general definition and description of the technology, including: the types of vehicle and driver information that is typically gathered, the on-board and off-board equipment required, and the typical uses of the information. Discussion of stated benefits from the Telogis system (or other systems) should be included in section 2.4.1.2 (benefits).
Sec 2.4.1.1 and 2.4.1.2 / pg 47 – 48	GreenRoad	This section mentions penetration numbers and benefits from a single manufacturer (GreenRoad) without providing over-all context for the industry; i.e., how many different manufactures are there (my understanding is that there may be hundreds), what is the range of capability for different systems, what types of commercial vehicles are most likely to have telematics systems, and what is the penetration rate for the commercial vehicle industry as a whole (again, it

		is my anecdotal understanding that a very high percentage of the 1 million+ long-haul tractors on the road are equipped with some type of telematics or driver/vehicle monitoring system). There must be some industry statistics available.
Sec 2.5.1.3 / pg 51 - 52	"The **crash rate** for trucks without speed limiters was 5 crashes per 100 trucks/yr, compared to a much lower 1.4 per 100/trucks per year **crash rate** for trucks equipped with speed limiters. The study showed the **overall crash rates** for trucks without speed limiters was higher…."	This section is very confusing because it is not clear to the reader what the difference is between "crash rate" and "over-all crash rate". Are the first set of numbers referring to the rate of fatal crashes and the second set referring to the rate of all crashes (both fatal and non-fatal)? It is not clear. Throughout the report the authors should adopt consistent but different terms for the rate of crashes that result in a fatality (fatal crash rate) and the rate of all crashes including those that are not fatal (crash rate or overall crash rate).
Sec 4.1 / pg 91 Sec 4.2 / pg 93	"The FMCSA Motor Carrier management Information Systems (MCMIS) includes state-reported records of all crashes **involving MD/HDVs operated by interstate or intrastate Hazmat carriers, and tow-away, injury or fatality**"	The full meaning of this sentence is unclear due to awkward construction. As written it sounds like the records are only from Hazmat carriers, not all carriers. Also it initially reads like the "tow-away, injury or fatality" is another category of carrier. I believe that this construction would be clearer: "The FMCSA Motor Carrier management Information Systems (MCMIS) includes state-reported records of all crashes involving MD/HDVs operated by interstate carriers, or by intrastate Hazmat carriers, which resulted in a tow-away, injury or fatality."
Sec 4.1 / pg 92	"The NHTSA Fatality Analysis Reporting System (FARS) includes a **much more extensive dataset than MCMIS**, including conditions at the time of the crash, and events preceding and following the crash".	This sentence is confusing because the phrase "much more extensive" could be read as meaning "more individual crash records". Also, the entire description of FARS does not really address the exact overlap of FARS and MCMIS. I believe that something like this would be more instructive to the reader: "While MCMIS contains records for all crashes in which there was an injury, fatality, or a vehicle needed to be towed away, the NHTSA Fatality Analysis Reporting System (FARS) only contains records of crashes in which there was a fatality. As such, FARS contains many fewer records than MCMIS, but each FARS record has more data about the crash than is contained in MCMIS, including conditions at the time of the crash, and events

		preceding and following the crash. In theory, every crash included in FARS is also included in MCMIS, but many of the crashes included in MCMIS are not included in FARS. For the crashes that are included in both databases, FARS includes more information about the conditions leading to the crash, but MCMIS contains more information about the carrier that was operating the vehicle involved in the crash".
Section 4.2 – 4.3 / pg 91 - 99	Entire section	The use of the abbreviation "CF" for Conventional Fleet and "CC" for clean carrier is very confusing because "CF" could easily stand for "clean fleet". The entire discussion would be much easier to follow if you did away with the abbreviations and consistently referred to "Clean Fleets" and "Conventional Fleets" or to "Clean Carriers" and "Conventional Carriers".
Sec 4.2 / pg 94	Table 4-1	Neither in the table header nor in the text is the definition of "crash rate" given (annual crashes per 1,000 fleet vehicles) – it is not defined until two pages later in Table 4-2.
Sec 4.2 / pg 95	Table 4-2	This table should be separated into two tables, one for FY2010 and one for FY2011, as was done in section 4.3 (Tables 4-3 and 4-4). The data would be easier to interpret that way.
Sec 4.2 / pg 95	Use of DRIVER BASIC Scores	The text indicates that a carrier's DRIVER FITNESS BASIC score is indicative of a carrier's safety risk relative to other carriers. However there is no description of how this score is calculated, so it is impossible to evaluate the utility of using this score for ranking Clean Carriers and Conventional Fleets in this analysis. If the BASIC score is primarily determined based on the carrier's crash statistics, then it should by definition be highly correlated with the crash rates calculated for each fleet in this analysis – so including it here would seem to have little utility (i.e., a carrier with a high BASIC score would automatically have a high crash rate). If it is calculated based on some other information it would be very helpful to the reader to understand what that information is. At the end of the day it is very hard to interpret the results shown in table 4-2 comparing the crash rates of Clean Carriers and Conventional Fleets with the highest

		and lowest driver BASIC scores – the text does not really explain why this metric was used or how to interpret the results.
Sec 4.3 / pg 97	Entire section	The consistent use of the term “crash rate” in this section is confusing because the results are different than the “crash rates” discussed in Section 4.2. In this section, and whenever discussing the results of FARS analysis, the term “fatal crash rate” should be used to distinguish the FARS results from the results of the MCMIS analysis.
Sec 5.1 / pg 103	“Some risk levels related to vehicle operation can be transferred (via insurance coverage), or if considered negligible **and routinely accepted as the cost of doing business”**	This sentence does not make sense. Did the author’s mean: “Some risk levels related to vehicle operation can be transferred (via insurance coverage), or if considered negligible <u>are</u> routinely accepted as the cost of doing business.”?
Sec 5.2.3 / pg 111	“… some SMEs raised potential safety concerns regarding the fire safety and flammability of used as automotive light weighting materials.”	This sentence is incomplete – concerns about “what” used as light weighting materials?
Sec 5.2.6 / pg 116	“There is no reason to expect that larger scale adoption of aero devices on Class 8 tractors will lead to a higher probability of occurrence for highway fairing detachment incidents and resulting crashes”	This sentence is not true. While there is no evidence or theoretical reason why larger scale deployment will increase the probability that any single aero device will detach and cause an accident, there is absolutely reason to believe that larger scale deployment will increase the overall “probability of occurrence of (one or more) fairing detachment incidents and resulting crashes” because there will be many more individual devices on the road which could fail. Probability of occurrence = Probability of single device failure x number of devices.
Sec 6.4 / pg 125	“There **are no** major regulatory barriers…the potential energy savings and efficiency benefits **outweigh this barrier**.”	These thoughts are contradictory. If there is no barrier then what is outweighed by the benefits?

Lyons

This is an excellent report and will make a major contribution to the field. The analysis of the issues is comprehensive and complete. The report is well organized and readable. The report is acceptable for publication in its present form.

However, the report would benefit from the addition of a "Summary of Conclusions" section. Also the "Executive Summary" section of the report would be more valuable if a brief summary of the conclusions were included. The current "Executive Summary" focuses too much on the methods used for conducting the analysis and the challenges of the analysis and not enough on the results and conclusions.

4.2 Does the document adequately review, present, and summarize the available data? If not, what can be improved?

Blower

The discussion and tables, pages 6-9, on the current status of truck safety has the potential to be misleading because the base year, 2009, was the bottom of the recent recession. Figure 1 shows counts of fatal injuries to truck occupants, other vehicle occupants, and nonmotorists in crashes involving trucks for the last 10 years of data currently available. The chart is based on data from Table 11 in *Traffic Safety Facts, 2012* (NHTSA 2014). The 2009 was a bottom after a severe decline from 2007 and 2008. A longer period of time tells a more complete story of a recent recovery to the long-term trend.

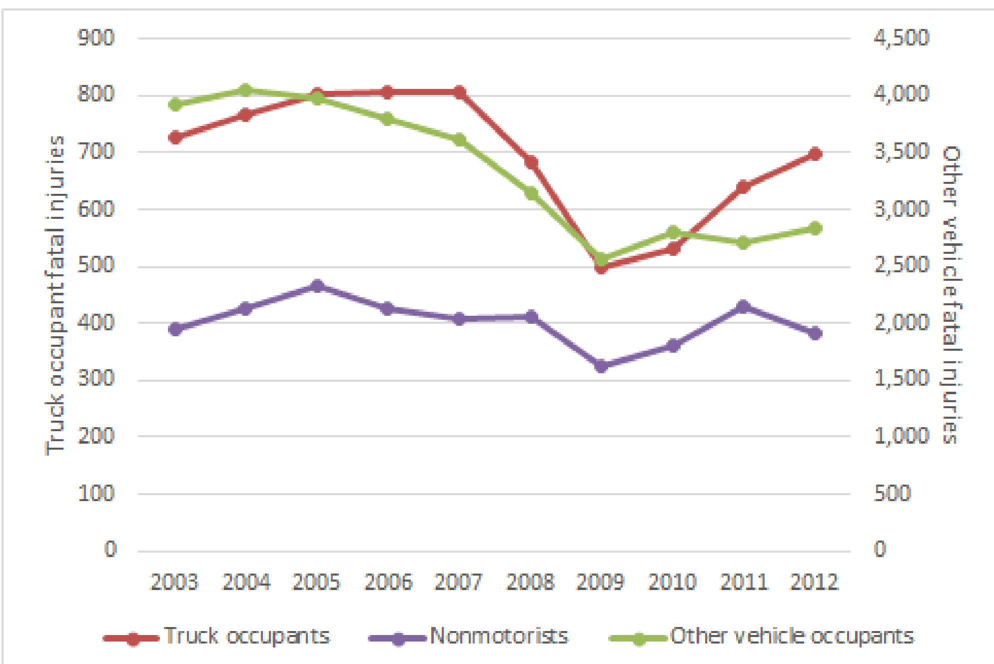


Figure 1

The coverage of the MCMIS crash file is consistently misstated throughout the document. For example, (page 93) the first paragraph after 4.2 section heading is imprecise. Reporting requirements to the MCMIS crash file are:

- Fatality in the crash, or at least one person transported for immediate medical attention (not just an injury), or at least one vehicle towed due to disabling damage.
- Truck with a GVWR over 10,000 lbs, or bus with seating for 9, including the driver.

In the MCMIS crash file, there is no qualification as to whether the carriers were in intra- or interstate. All trucks and buses meeting the relevant definition of a truck or bus, involved in a crash meeting the severity threshold, are included.

The MCMIS census or carrier file is composed of all carriers and shippers who have registered. Interstate carriers and intrastate hazmat carriers are *required* to register, but other carriers *may* register. An increasing number of States requires all their carriers (including intrastate non-hazmat) to register.

Table 1-3 is based on LTCCS data and is mislabeled. LTCCS crashes were sampled from fatal, A-, and B-injury crashes, not all crashes. One goal of the sample was to cover "serious" crashes.

Section 2.4.1.3: I'm not entirely sure what the relevance of the LTCCS data are here. For the record, the statements quoted on "causal" factors are based on the critical event variable. Unfortunately, that variable is consistently misinterpreted. Critical event was (supposed to be) coded for the error or failure or action most proximate to the crash. It is basically the last failure prior to the crash. As such, it is not the "cause" of the crash. For example, a truck may have a blowout, but the blowout could be due to underinflation, poor maintenance, loss of tread, or damage from road debris. Stress on the tire could have been compounded by speeding or overloading the cargo body. Thus, depending on the context and preceding experience, there could be a number of substantially different "causes." The set of data collected as part of the LTCCS was intended to allow researchers to sort out the different mechanisms. In my view, it is important to use critical event in the context of all the other data collected to determine contributing factors in truck crashes. The best that can be determined from LTCCS (or any crash data set) is to identify factors that *increase the probability* of a crash, not that *cause* a crash. Please see (Blower and Campbell 2002) for more discussion of the concept of cause as well as analytical methods for LTCCS data.

Also the "87% driver error" so often cited refers to all drivers in a crash, not just truck drivers. The text does not make that clear. As written, it is correct, but could be misinterpreted by a less-than-careful reader.

Page 97: I do not believe it is accurate to characterize FARS as providing information on causality and accountability. Some variables and some code levels imply or are consistent with "causality," but the FARS file does not attempt within FARS to assign accountability for a crash or to assign a cause or causes. Driver errors are listed, driver conditions are coded, but the file doesn't even capture right of way.

Lowell

All of the individual sections provide a significant amount of information from many different sources, but in some sections the text is choppy and not well-integrated. It reads like a collection of quotes with little attempt to integrate them into a cohesive narrative. Examples include sections: 1.2, 2.2.1.3, 2.4.1, 2.5.1.3, 4.1, 4.2, and 4.3. See the response to question 1 for specific examples.

In addition, there are a number of incorrect or misleading statements in the report – see the response to Question 8 for specific examples.

Lyons

This report summarizes findings of a comprehensive safety analysis conducted to determine the possible safety impact that may occur upon implementation of a wide range of technologies and practices that offer the potential to improve Fuel Efficiency (FE) in Medium- and Heavy-Duty (MD/HD) vehicle fleets. The list of FE technologies and practices which were considered as offering potential improvements in FE is extensive and complete. The analysis of each of the individual FE technology and practice is comprehensive and scientifically sound. The authors did an outstanding job in seeking out the range of different information sources that might provide useful information concerning the subject matter.

The report also summarizes a review of existing Federal and State regulations that might be regulatory barriers to implementation of each of the FE technologies and practices. The review of potential regulatory barriers appears to be complete. The summary of the review is well organized and clear.

4.3 Are methods and analyses described in this report adequately developed, well-integrated, and appropriate to the aims of the project?

Blower

Overall, I think the approach of using multiple methods to assess safety impacts is a good one. The fundamental problem is a lack of systematic and statistically-meaningful on-road safety data. Thus the approach of surveying existing literature; an indirect crash analysis in available crash data; and the hazard analysis, provides as much information as possible in the existing circumstances. I have reservations on the crash analysis, which are discussed below. But in principal, the broad-ranging assembly of information undertaken in the report is a good one.

There are places in the report where the methods are not described with enough detail. Here are some examples.

Table 4-1. Where does the count of power units taken from? The Census file? Is it only matched carriers (i.e., carriers with crashes in 2010 or 2011)? Or does it include all carriers? If so, you should (and probably do) know that the Census file is not purged and contains records for carriers that are probably out of business. FMCSA defines a set called “carriers with recent activity,” which are carriers that are probably still in business. That set might be used for the PU count. Or you might use just carriers with crashes, matched to the Census file on DOT number.

The discussion of the analysis of FARS data, including the match to MCMIS data, was incomplete. (Section 4.3) I’m not sure how FARS records were matched to MCMIS records. The method of matching should be described. FARS includes DOT number, which could be used in combination with other fields to link with MCMIS, but there are no hard link fields available, so there is always a level of error or uncertainty.

The word “complementing” was used in this context, but a better one might be “supplementing.” That is the usual term in crash data analysis when crash records are supplemented by matching records with data from other files.

Lowell

I do not believe that the methodology used to identify differences in crash rates between trucks with and without fuel efficiency and alternative fuel technologies (section 4) was as robust as it could have been given available data. As described further below, this analysis could be improved by modifying the methodology in the following four ways:

1) Use EPA records of SmartWay™ participants to potentially identify additional “Clean Carriers”.
2) For identified “Clean Carriers” with more than one division or affiliate (as identified by DOT number) utilize carrier-provided or third-party information on technology deployment by affiliate or

geographic region to identify which of the divisions or affiliates are most likely to be “clean” and only include those divisions or affiliates in the analysis as “clean carriers”.

3) Normalize the data on crash rates for “conventional fleet” carriers by fleet size. (trucks/fleet) to better match the range of fleet sizes of the comparative “Clean Carriers”
4) Use the vehicle VIN number to identify some of the alternative fuel and/or fuel efficiency technologies included in specific vehicles involved in crashes.

SMARTWAY Fleets:

For this analysis potential “Clean Carriers” with assumed higher adoption rate for alternative fuels and fuel efficiency technologies were identified based solely on membership in the DOE National Clean Fleets Partnership. This list included 17 separate companies with a total of 100 divisions or affiliates, as denoted by unique DOT number.

Since 2004 EPA has operated the SmartWay program, a voluntary public-private partnership designed primarily to reduce fuel use and GHG emissions from the U.S. freight sector. Over 3,000 shippers, truck fleets, and rail companies are members of SmartWay (EPA-420-F-14-003). SmartWay members agree to annual goals to reduce GHG emissions from their operations, and they provide detailed annual reports to EPA as to progress, including information about the techniques/technologies used to meet their goals. In order to maintain confidentiality of competitive information, not all data submitted by SmartWay companies is made public, but it is available to EPA staff.

Based on published SmartWay reports, or discussions with EPA staff in charge of SmartWay, it is very likely that the authors of this report could identify additional truck fleets with higher than average adoption rates for alternative fuel and fuel efficiency technologies, to include as additional “Clean Carriers”, thus potentially significantly increasing the total size of this comparative data set.

Better Screening of Clean Carrier Divisions and Affiliates

Many fleets that are early adopters of technology concentrate their alternative fuel or advanced technology vehicles in only a handful of locations rather than spreading them evenly across their nation-wide operations. The report authors identified 100 different divisions or affiliates of the 17 companies in the DOE National Clean Fleets Partnership, and treated each of these entities as a separate “Clean Carrier”. For example, the report indicates that ten different FedEx divisions were included. However, it is very likely that the alternative fuel and advanced technology trucks currently operated by FedEx are concentrated in only one or two of these 10 divisions. For example, the vast majority of natural gas and electric trucks currently in the fleet are concentrated in California, and to a lesser extent in Texas and New York. Based on published reports, news articles, company websites, or discussion with company fleet managers it is likely that this subset of 100 potential clean carriers could be reduced to a smaller number of carriers with a much greater likelihood of actually having a higher than normal adoption rate of alternative fuel and fuel efficiency technologies.

Normalize Crash Rate Data by Fleet Size

As shown in Table 4-2, the ten “Clean Carriers” with the lowest crash rates in 2010 and 2011 had 119,714 and 206,686 power units in their fleets respectively. This is an average of almost 12,000 power units per fleet for 2010 Clean Carriers and almost 21,000 power units per fleet for 2011 Clean Carriers. By comparison the average fleet size for the 10 “Conventional Fleets” with the lowest crash rates was 1,800 in 2010 and 2,200 in 2011 – so the Clean Carriers were much larger fleets (10x) than the Conventional Fleets to which they were compared. For carriers with the highest crash rates the results are similar. The text indicates that there were

40,000 Conventional Fleets included in the analysis – presumably a large number of these fleets were very small.

In general, one would expect that larger fleets would have better and more sophisticated maintenance and driver training programs, so a comparison of fleets of such different size ranges may introduce a significant uncontrolled variable into the analysis – i.e., in general, larger fleets would be expected to have lower crash rates regardless of any positive or negative effects from vehicle technology choice. The authors should test this theory using the entire crash data set arranged by fleet size rather than presumed Clean or Conventional carrier status. If there is a significant positive correlation of crash rate and fleet size then the sub-set of Conventional Fleets compared to the Clean Carriers for this analysis should only include fleets with a similar range of fleet size as the clean carriers (i.e., very small conventional fleets should be removed from the analysis).

A similar analysis to evaluate correlation between fleet size and crash rate, and if necessary normalization by fleet size, should be conducted for the Bus Fleet data discussed in section 4.4.

<u>Identify Vehicle Technology by VIN Number</u>

The text description of the MCMIS database indicates that for each crash it includes the Vehicle Identification Number (VIN) of the vehicle involved. While not comprehensive as to vehicle fuel type, technology, and other characteristics, VIN numbers do encode a lot of information that could potentially be used to identify specific crashes involving vehicles that are operated on natural gas and/or include some fuel efficiency technologies. This data could be used to inform a more instructive comparative analysis of crash rates.

Some of the information that is encoded in each VIN includes: vehicle model year; vehicle make and model; engine make and model; and body configuration.

At a minimum the following relevant vehicle attributes can be identified using the vehicle VIN number:

- Natural gas vehicles: identified based on engine make and model
- Hybrid vehicles: some (but not all) manufacturers may also encode information that would allow one to identify some vehicles as hybrid-electric.
- Automatic speed limiters: Based on engine make, model, and model year (though it could not be determined whether an available speed limiter was in use at the time of the crash).
- Cab-mounted Aerodynamic features (gap fillers, roof fairing, bumper): based on vehicle make, model, and model year

While VINs follow a standardized format specified by NHTSA, manufacturers are given leeway to encode some attributes based on non-standardized values for certain positions in the over-all VIN. As such, VIN decoding can take some effort. However, there are third-party software and services available that could be used to decode VINs from specific vehicles in the crash database. For example, R.L. Polk & Company maintains a TipNet™ database of all trucks registered in the US, based on data provided by state motor vehicle departments. In their database Polk has decoded all vehicle VINs to provide a significant amount of detailed information about each truck.

In addition, the report notes that relative crash rates between carriers could be affected by factors other than fuel economy technologies, including “newer vehicles”. Since the VIN encodes vehicle model year, this data could be used to evaluate the model year distribution of crashes attributed to each carrier in the analysis, and if necessary to normalize crash rates by model year ranges in order to account for this factor.

Lyons

The methods used to conduct this study were well developed, adequately described, sound and appropriate. The authors reviewed vehicle crash databases, reviewed the technical and trade literature, analyzed cohort safety performance experience of subsets of the industry, and used subject matter experts, all in combination, to develop the conclusions. The authors did a great job of integrating the information from this wide range of information sources. Their approach is scientifically sound and appropriate for analyzing issues in a developing field where there is a shortage of data and the data available comes from many different sources and in different formats.

4.4 Are the findings and conclusions adequately supported by the data?

Blower

Certain problems with the crash data analysis are discussed in response to question 6. In response to this question, I've listed some questions and comments about specific findings and conclusions.

In re: safety hazards of hydraulic hybrid vehicles (pages 45-46). A general problem is that anecdotal data are all that are available. But the goal should be some quantitative statement of the probability of an accident or other harmful event. The 15 month experience of Miami-Dade County with no reported problems is a useful data point. But it is only anecdotal. And one wonders what the experience will be when the vehicles are used as part of routine operations rather than as a pilot.

Page 75: safety considerations of truck lightweighting. The main discussion here seems to have to do with durability, not safety. I would expect two effects relative to safety: 1) reduction in truck mass will reduce crash forces to other vehicles, though this effect will surely be negligible, because the lightweighting will have only a small effect on the mass differential. Moreover, crash partners are undergoing their own lightweight. 2) use of composites, aluminum, and fiberglass may result in less protection to truck drivers in crashes because of lower crush strength. I know of no recent studies or work on this with significant results, however. But those are the issues.

Page 82: 2nd paragraph. How is it known that the buses' quieter operating noise levels are not a safety hazard? Is it because the measured noise is still within detectible range for vulnerable road users? Or is this a matter of opinion?

Page 85: The statement that an SME said he couldn't think of a single road safety incident involving LCVs in the western U.S. needs to be qualified. I'm not sure what this means. There are plenty of LCV crashes in the western U.S. Possibly this means a safety incident that was related to the characteristics of an LCV that distinguish it from a tractor-semitrailer or STAA double, but that is highly doubtful. Triples, which almost all use A-dollies, are prone to a high degree of rearward amplification, which is related to rollover. These may be hard to identify in crash data, but as written, the meaning is not clear and could easily be misconstrued. Incidentally, carriers are likely to assign their best drivers to triples, Rocky Mountain doubles, and turnpike doubles. In addition, these configurations primarily operate on the best & safest roads, i.e., Interstate highways, so their crash rates, unadjusted to account for road type, are typically pretty good.

Page 116: In the discussion of crash hazards from detached aerodynamic fairings, I don't see how a collision with a 200 pound object at highway speeds could be described as unlikely to cause severe primary damage. If the impact is same-direction, the relative speed might be low. But in opposite-direction impacts, the relative speed of object and vehicle could easily exceed 100 miles an hour. Truck wheels occasionally break loose, resulting in collisions between other motor vehicles and the truck wheel. A truck tire and wheel can weigh

150-200 lbs. I have seen more than a few that resulted in fatalities. I think you may find some evidence in this study: (Bareket, Blower et al., 2000).

Lowell

In general, the findings and conclusions of this report are supported by the data cited.

However, these findings and conclusions are hard to find because they are distributed throughout the various sections of the report and are not concisely summarized anywhere. The Executive Summary should include a brief description of the general findings and conclusions from each section of the report - Literature Review, SME Inputs, MCMIS & FARS Analysis, Scenario Hazard Analysis, and Regulatory Analysis – and from the project as a whole. The current executive summary only discusses the process and data sources used to develop the report, and the structure of the report, and it does not summarize the findings in any way.

Lyons

The findings and conclusions are adequately supported by the comprehensive analysis that was done of all of the various information sources which might provide information supporting the conclusions. Because the authors took into consideration all of the available information sources, their conclusions appear to be well supported by all the data and experience that is available at this time for this developing field.

4.5 Please recommend any additional key published data for vehicle technology and safety that may be relevant to this review and analysis.

Blower

(Carson 2011) provides a recent (2011) review of the size and weight literature, including a judicious summary of the best recent research on the subject. The FHWA size and weight study referred to on page 60 is nearing completion. A literature review from that has been available on FHWA's website for about a year. Also, there have been a few U.S. pilot studies of safety and productivity of allowing truck combinations at over 80,000 lbs. GCW. The Idaho study is pretty good, and includes some experience on whether bigger trucks will actually reduce the number of trucks on the road. See also the report from Abdel-Rahim: (Abdel-Rahim, Berrio-Gonzales et al., 2006; Department of Transportation Idaho 2007; Department of Transportation Idaho 2013).

A few other sources that might be helpful are cited throughout this review.

Lowell

See specific recommendations in response to question 1 and question 8.

Lyons

I have no recommendations for additional data to be considered. I believe that the authors did an outstanding job of collecting and reviewing all available data and information on vehicle technology and safety.

4.6 Are the statistical methods used in the analysis appropriate?

Blower

The use of the MCMIS and FARS crash files to attempt to shed some light on the relative safety of Clean Carrier (CC) and Conventional Fleet (CF) trucks is a good one. I haven't seen much productive use of the MCMIS crash file, other than to support CSA, so this effort is somewhat pioneering. And I applaud the creativity of the authors in their attempt to get around the inadequacy of existing crash and exposure data.

However, as executed, I think the effort suffers from a number of problems that together prevent well-founded conclusions on the relative safety of CC and CF fleets.

The problems of the analysis include:

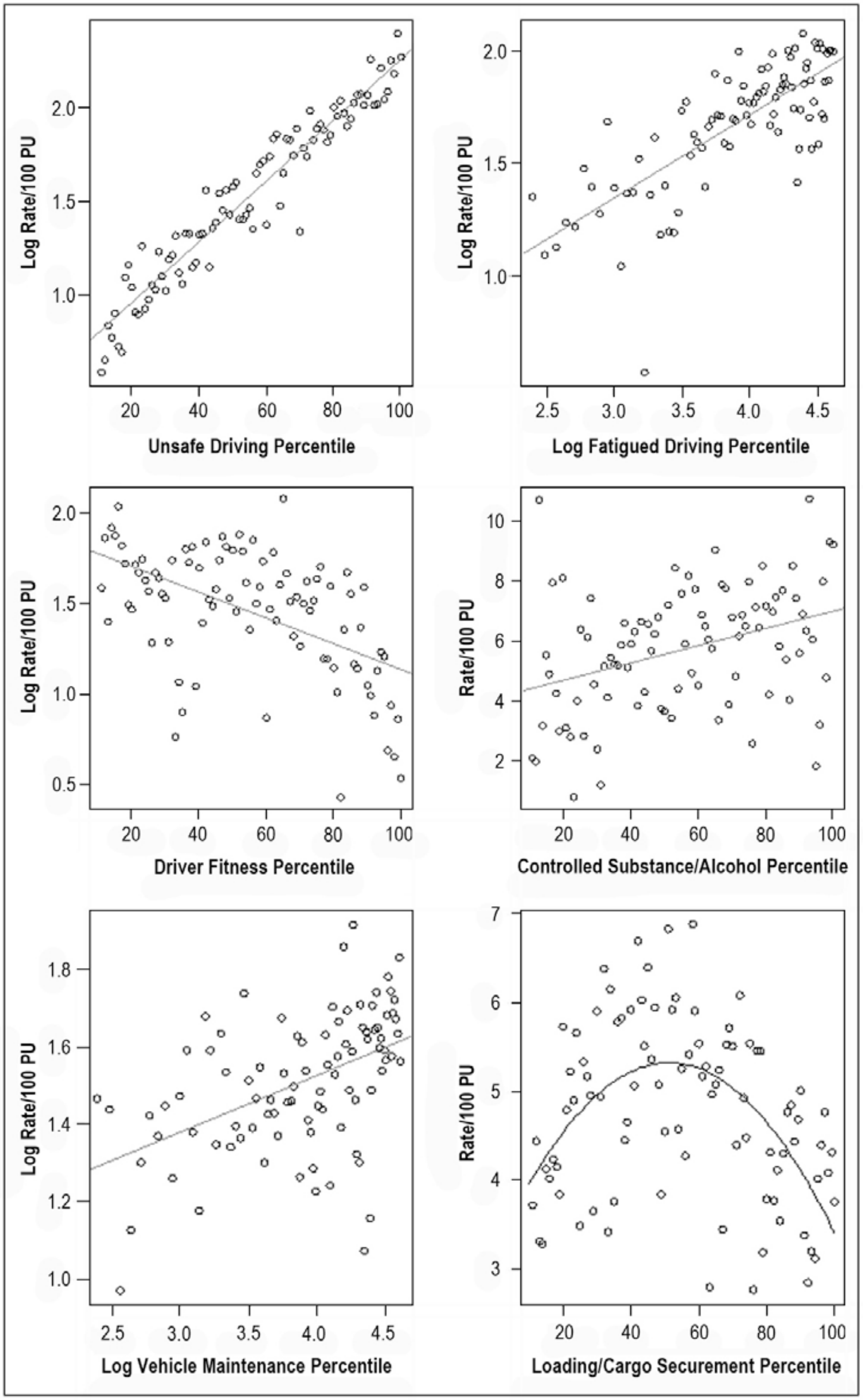
- the lack of control for confounding factors;
- the selection of populations to compare (top 10);
- the use of the Driver BASIC; and
- the use of truck registrations to normalized crash counts.

Why the restriction to the top 10 in the CC and CF populations? The justification for doing this is not clear. It looks like there are only 17 usable CC carriers. Why not use all the CC carriers? It seems a mistake to throw away data from a population that is already very small.

But 40,000 CF carriers are used for the comparison group. By choosing the top or bottom 10 from among the very large population of CF carriers, it is guaranteed that you will pick up outliers. There is always very great variability in crash rates. The requirement for at least 10 MCMIS-reportable crashes doesn't guarantee that you get the "true" underlying safety of the carrier. It'd be interesting to look at the histogram of crash rates for the CF population and look at the groups used for the comparison. In table 4-2, the 2010 crash rate for the lowest 10 CF is 5.5, for the highest 80.2, a factor of 14.6. The same spread for CC carriers is 8.25 to 21.38, a factor of 2.6. Within the CF population, the comparison top 10 or bottom 10 are outliers. The CC population may itself be outliers in comparison with the CF population, but clearly more homogenous.

The way the analysis is structured highly likely to produce an apples-to-oranges comparison.

The use of the Driver BASIC is also highly problematic. What the Driver BASIC measures should be described. I think this is the driver fitness BASIC which covers training, experience and medical qualifications. This is largely a paperwork BASIC, and not really meaningful in the context of FE technologies, where, from the discussion of several of the technologies, the critical factors are maintenance and operations. Moreover, there is substantial evidence that the Driver BASIC is only weakly related to crash rates and safety. See (Green and Blower 2011), on the safety measurement system. Here is Figure 4 from page 41 of that report:



Note that amount of scatter and negative correlation between driver fitness percentile and log crash rate. A better measure would be the unsafe driving BASIC and the vehicle maintenance BASIC. Both show good correlation with crash rates, and therefore are good measures of safety. The source I've cited here is somewhat old and from the CSA pilot. I've seen updated versions though that are very similar. You might contact David Madden of Volpe for updated versions.

Another problem is the use of power units to normalize crashes. Different power unit types average radically different vehicle miles traveled (VMT). According to the FHWA *Highway Statistics 2012* (http://www.fhwa.dot.gov/policyinformation/statistics/2012/), buses averaged 19,299 miles annually, single unit trucks 12,815, and combination trucks 66,161. VMT is strongly related to crash counts.

Looking at the list of CC fleets, they are a mixture of big over-the-road carriers, which operate a lot of tractor-semitrailers and doubles, carriers that probably run a lot of single-unit trucks, and urban transit operations. But of the CF fleet, I would wager that most are combination trucks, so heavily tractor-semitrailers, which means much higher average travel. Given their higher travel, they probably have more crashes per registration. The CF carriers probably collectively have significantly different operations from the CC carriers. This potential mismatch skews the comparison.

Finally, the method as shown is unable to account for confounding factors, such as the possibility that fleets that adopt CC technologies may also be more likely to have other safety programs. This is a fatal problem and prevents drawing conclusions on the relative safety of FE technologies.

There are two general confounders. One is the use of truck registrations to normalize crash counts, because of the interaction by power unit type (tractor or SUT) and VMT. Tractors tend to have high VMT and SUTs significantly lower. Thus even if they had the same crash rates per mile, a firm with predominately SUTs would have lower rates per registration than one with predominantly tractors. The second set of confounding factors has to do with carrier operations. Carriers vary widely in their operations. Some carriers equip their vehicles with collision avoidance technologies, pay well, weed out unsafe drivers, have numerous safety training programs, and keep tight control over the operations of the drivers. Others don't have the capital or business model to buy collision avoidance technologies, don't have a safety director, etc. If CC carriers tend to also be among the latter, and CF the former, then you can't disentangle the safety of FE technologies from the other factors.

The question going forward really is whether (and which) FE technologies will be safe when widely deployed. So you need some controls for carrier operations.

I offer some ideas for overcoming the problems cited here in the answer to number 7 below.

As the report stands, as far as I can tell, there was no effective control for confounders, which really severely limits any conclusions about the relative safety of the FE technologies. The caveats listed in section 4.2.1 are well taken and appropriate. However, I can't agree that the data clearly show that CC fleets maintain high standards of safety. The data are consistent with that conclusion. However, the lack of controls for confounders; the mismatch of CF and CC fleets; the use of outliers among the CF fleets for comparison; the potentially large differences in average VMT between CF and CC fleets; and the use of a BASIC that has little correlation with safety all work to undermine confidence in the conclusion. I would put this down as not proven.

I would make the same comments on the FARS analysis as on the previous MCMIS crash analysis.

- Controls are needed for potential confounding factors. Excluding buses does offer some control for differences in operations. Another approach, though, would be to compare bus operators to bus operators (as is done in section 4.4), and to do the same for the other segments of the CC fleets.
- The top ten among CF fleets are outliers, by definition. I believe that a better approach would be to sample among CF fleets to get a statistically-sound representative set for the comparison group.
- I don't see the justification for choosing top ten among the CC fleet. There are very few to begin with. What's the point of excluding poorer performers among them.

- The driver fitness BASIC is weakly related to safety outcomes at best, and may be negatively correlated to safety outcomes. Unsafe driving and vehicle maintenance would be better. They are more directly related to safety outcomes, reflect on driver behavior and vehicle condition, both of which are issues for at least some FE technologies.

The fundamental problem is that the CC carriers are likely to be more focused on optimizing operations, and thus more likely to use various crash avoidance technologies, driver training, and monitoring to control operations. Thus, the challenge is to tease out the inherent safety of the FE technologies and to separate them from these other effects. The present analysis doesn't and can't tell us if FE technologies are safe or if they tend to be adopted by safe carriers.

Analysis of bus carriers.

- APTA is an association of public transit operators. These operations are typically local, primarily in urban areas, on regular routes, drivers on regular schedules, primarily operating on surface streets and local roads.
- The comparison group appears to be all others—probably including public transit, but also charter, tour, scheduled intercity, school bus, shuttle bus, and private bus operators, such as companies that use buses to transport employees, buses operated incidental to other businesses (like casino shuttles), and other organizations that regularly use buses, including churches.
- A better comparison would be non-signatory public transit operators. I think that comparison would be pretty good, since operational factors would arguably be similar. There remains the question of whether CC bus operators are not, from that very fact, more safety conscious than non CC bus operators.

I would agree that the analysis cannot validate the safety of FE technologies, but can reflect whether carriers that employ FE technologies safely. But the analysis may just show that the best carriers can operate FE technologies safely. But the case may be different when the technologies are deployed more widely. The question for future, widespread deployment of FE technologies is, can average carriers operate the technologies safely?

The discussion (page 101) of whether widespread deployment of FE technologies would pay off in safety benefits and reduce the overall crash rate raises the question of just how FE technologies as such could reduce the number of crashes? What is the mechanism by which this would occur? How does using CNG or LPG help avoid crashes? Speed limiters, telematics, and driver training are the only FE things that seem clearly to have the potential to increase safety. This speculation actually leads me to think that the lower crash rates observed (leaving aside questions of the validity of comparison groups and the metrics of comparison) may actually indicate that safer carriers are adopting FE technologies, not that FE technologies make the carriers safer.

Lowell

I do not have the expertise to evaluate this question.

Lyons

The authors did not make extensive use of statistical methods, but when used they were appropriate. The methods of analysis that the authors used are scientifically sound.

4.7 What are the weakest and strongest parts of this report? Please suggest how the weakest parts of the report can be strengthened.

Blower

The strongest parts of the report is the description and discussion of the various technologies. I found that comprehensive and informative. The description of the safety considerations for each technology appears to be quite comprehensive. In addition, it appears that a very large body of anecdotal evidence reflecting on safety has been assembled.

The weakest is the analysis of crash data. The grounds for that view are discussed above. Here I will suggest some ideas that might help overcome the weaknesses identified above.

<u>To address the problem of confounding:</u>

- Attempt to match the comparison CF fleets as well as possible in terms of operations to the CC fleets. Use data from the MCMIS Census file to classify CC fleets in terms of operating authority, area of operations; types of drivers employed; types of trucks (tractors or straight trucks) operated; types of cargo carried; types of trailers (largely tankers or others).
- Then use this information to define arguably homogenous groups of CC carriers. Public transit bus operators is one obvious group. Others might include large over-the-road for-hire carriers that haul general freight and use mostly tractors; local private operations that use SUTs; and so on.
- The characteristics of these groups could then be used to identify populations of CF carriers in the MCMIS Census file. You will have sets of CC carriers clustered into homogenous groups, and sets of CF carriers classified into groups with the same or similar characteristics.
- At this point, you could do one of two things:
    - Compare crash rates as is, between comparable CC and CF fleets. They are arguably from similar populations in terms of operations. Assuming they are matched on the predominant fleet power unit type (tractor or SUT), the problem of using truck registrations rather than VMT is reduced.
    - Do a survey of CC and CF fleets to collect data on their operations. What safety programs do they use? What crash avoidance technologies are on the trucks? Do they have a safety director? Etc. Obviously you couldn't do this survey on thousands of CF fleets, but I think you need to do some sampling from among the CF fleets regardless. If you sampled 60 or 100 CF fleets for your comparisons, a phone survey would be very doable.

At this point you will have done about all that's feasible to address confounds. You will be closer to apples-to-apples than in the report.

<u>To address the problem of using outliers in the CF fleet:</u>

One strategy could be to randomly sample 60 or 100 carriers from the CF population and compare them to the 18. The purpose would be to reduce spurious statistical associations because of the very large population of CF carriers and small number of CC carriers. Comparison groups are typically three times larger than case. You could draw a stratified random sample from the MCMIS Census file. Then compare mean crash rates and BASIC scores of the CC and CF groups. The problem of using the top 10 from a population of 40,000 is a little like investing in mutual funds with the highest return for the previous year. They change from year to year because they are outliers.

Match the CF fleet to the CC fleet on the data you have on CC fleets in the Census file. One could match the comparison CF fleet to the CC fleet by operating authority, fleet size, number of drivers, number of straight trucks, number of tractors, commodities carried, etc. Then draw samples from the groups and use those samples in the comparison.

To address the problem of using a weak BASIC:

Use the unsafe driving and vehicle maintenance BASICs. Both are clearly related to carrier safety. They are based on more data than most of the other BASICs. And they reflect characteristics that are germane to the problems of operating FE technologies safely and responsibly.

To address the problem of using truck registrations to normalize crash counts:

Use VMT, or at least explore the use of VMT. Carriers are on a program of updating their information every two years, including trucks and miles. You would have to check for missing data and for plausibility (mean and range of average miles per truck), but VMT is a much better measure of exposure for crashes than registrations. You can partially address this if you form your comparison groups by predominant power unit type (tractor, SUT, or bus). But you would nail it using VMT, if that's possible.

Lowell

The weakest part of the report is Section 4. See the response to Question 3 for how this can be strengthened. In addition, a number of other sections of the report are confusing and should be further edited for clarity; see the response to Question 1 for specific suggestions.

Lyons

The strongest aspect of this report is the fact that the analysis is so comprehensive and considers the full range of possible information sources which might contribute to the analysis and conclusions. Also, the descriptions of the analysis, which were done on each issue, are clearly presented. Another strength of this report is the excellent job of source documentation done for all the information sources reviewed by the authors.

The report could be made easier to use by others interested in this field by the addition of a "Summery of Conclusions" section.

4.8 Please provide any other comments you may have on the report.

Blower

Page 1, third paragraph, acronym should be CSA, though actually it should be the MCMIS crash database. That database is used by CSA to compute the Crash Indicator BASIC, but it is not the CSA crash file.

Page 6, second full paragraph: The fatality rate for trucks and buses in 2009 must be off by a factor of about 10. The rate for trucks, per 100 million miles was 1.11. The injury rate for trucks was in 2009 was 19. The injury rate for passenger cars was 100. I think the numbers in this paragraph have gotten garbled somehow. Please see (NHTSA 2014), table 3, page 20 or so.

In the bullet points, the rates should be identified as per 100 million VMT.

Page 13, last paragraph, it should be Natural Gas, not National Gas.

Page 43, second sentence in the last paragraph has too many or not enough words. I think the problem is in the region of "… bus fire problems…".

Page 58: The technical term for the "sway" identified as a safety-related performance characteristic of LCVs is "rearward amplification," which might be preferable here. The term refers to the fact that lateral forces are increased in multi-trailer trucks with each succeeding trailer, so that the last trailer in a combination can experience much higher lateral acceleration in maneuvers than preceding ones. The word "sway" seems to be to be less descriptive. To me, it calls to mind movement in the vertical plane.

This link goes to an excellent source on the relation of physical performance characteristics and safety: http://www.fhwa.dot.gov/reports/tswstudy/vehiclsaf.htm. I would say this is a canonical source.

I would be cautious about the references to CRASH, CABT, and OOIDA (page 58). They are advocacy organizations, with little scientific credibility. I know that the paragraph merely identifies them as organizations that have taken positions and made claims. Some of the claims may have scientific foundation. But the organizations themselves are advocacy and I would be very cautious about any implication that they are authorities. There are plenty of other credible sources that can be used to make any valid point that any of them may make.

Page 59: The statement that one combination vehicle causes wear equivalent to 2,000 to 3,000 cars is too categorical. It may, depending on the number of axles, load distribution, and so on, as the next sentence indicates. You might consider saying it *may* cause wear equivalent…

Page 59, the citation for "Safety performance of longer combination vehicles relative to other articulated trucks" (footnote 272) has some errors. The authors should be Jonathan D. Regehr, Jeannette Montufar, Garreth Rempel. Regehr is the first author.

Page 81: should be "with regard," not "for regard…" 2nd to last paragraph.

Page 97, first paragraph of 4.3, the MCMIS crash file is not limited to interstate or intrastate hazmat carriers. Crash file includes all qualifying vehicles in a qualifying crash. The MCMIS Carrier file includes only carriers who register. Interstate and intra-state hazmat are required to register, but others do as well.

Page 103: Is the reference to the 2007 FMCSA report correct? The footnote seems to be to the 2006 report. I tried following the link and it is no longer valid. Citations by author, title, date can be supplemented by hyperlinks, but not replaced. Also, is the reference to Figure 5-2 in the last paragraph of page 103 to Figure 5-2 in the footnoted report? The discussion in the text doesn't seem to be appropriate to Figure 5-2 on page 104.

I found an FMCSA page that has the statistics on brake and tire problems. (The link in the references section of the report is now broken.) A minor point: Associated factors were coded if present. Coding a factor did not indicate that the factor was "causative." Trucks and drivers could have more than one factor coded. A truck could have both brake and tire problems; similarly the driver could be coded as too fast for conditions and the truck could have had brake problems. The percentages are not additive.

Page 107: CBG should be CNG in the second bullet point.

Page 111, first full paragraph: Sentence beginning "Various carbon-fiber reinforced polymers…" seems to be missing a verb in the second clause. Or maybe there is an extra comma after steel.

Page 112: the acronym PCIV is not included in the list of acronyms on pages xi-xiii.

Comment on section 5.2.3: Fire is the most harmful event for trucks in about 0.2% of crashes (based on FARS plus GES for 2010-2012). But fire occurs in around 7% of fatal truck crashes (I don't have a figure for all truck crashes handy.) The flammability of certain light-weighting materials could possibly be a significant issue if it turns more of the 7% of fires into the most harmful event to the truck in a crash.

Page 123: The sentence beginning “Below in Section 6.2-6.9, the potential…” seems to be missing a verb.

Page 128: Sentence in last paragraph: “However, this was most significant for vehicles ABS.” Possibly the word “without” is missing between vehicles and ABS. I’m not a tire expert, but I’m surprised that ABS adequately mitigates the lower traction. The wheel may not lock in hard braking, but the lack of traction remains.

Comment on the possibility that light-weighting may drive truck manufacturers to go to disc brakes: (Pages 129-130) That would be a very good thing, resulting in improved braking, lower rates of out of adjustment brakes, less brake fade, better stopping power.

Lowell

The following comments relate to inaccuracies or omissions in the existing report.

Section/Pg Num	Current Text	Comments
Sec 2.2.1.1/ pg 12	Paragraph 2: “**Large vehicles are necessary** to accommodate the cryogenic fuel tanks used to store LNG” ….”LNG is **better suited to local applications** such as urban transit buses…”	These statements are inaccurate. As pointed out in the text, an LNG tank is approximately 2x larger than a diesel tank holding the same energy content, while a CNG fuel system is approximately 6x larger. Vehicle size itself therefore has nothing to do with adoption of LNG versus CNG (in fact, a “larger vehicle” could potentially more easily accommodate an even larger CNG fuel system than an LNG system). It is also not true that LNG is best suited to local applications. LNG systems are typically more expensive than CNG systems, as is the fuel itself. Therefore in practical terms one will utilize LNG only if one cannot get enough CNG fuel onto a vehicle (due to space constraints) to give the necessary daily range. CNG vehicles can typically go 300 miles before needing to be refueled, so ONLY vehicles than need to have more than 300 miles daily range will be LNG. Most fleet vehicles used in local, return-to-base service (including most transit buses, refuse haulers, and urban P&D trucks) go less than 300 miles per day and can therefore be CNG. Virtually the only trucks that are now being considered for LNG are regional haul and long-haul trucks.
Sec 2.2.1.1/ pg 13	“Even though natural gas has long been used to power vehicles, **only about 0.1 percent is currently used** for transportation fuel.”	It is not clear what the 0.1% refers to: is it “0.1% of current US natural gas production is used for transportation fuel”, or is it “0.1% of current fuel used for transportation is natural gas”?

Sec 2.2.1.1/ pg 13	"Compressed natural gas (CNG) consumption has increased steadily…"	"Compressed natural gas (CNG) consumption for transportation has increased steadily…"
Sec 2.2.1.1/ pg 13	"… by personal or fleet **dual-fueled** vehicles…"	Duel-fueled vehicles are not defined
Sec 2.2.1.1/ pg 13	"… which amounts to less **than one tenth** of the 15 million Natural gas Vehicles globally."	"Which amounts to less than one percent of the 15 million…." Also, it should be noted that the vast majority of NGVs currently on the road globally are light-duty vehicles, not MD/HDVs
Sec 2.2.1.2 / pg 17	"One gallon of LNG contains about 60% of the energy in a gallon of diesel fuel, while CNG contains only about 30%"	"…while CNG at 3,600 pounds per square inch (psi) pressure contains only about 30%". The volumetric energy density of CNG depends of the pressure to which it is compressed.
Sec 2.2.1.2 / pg 17	"Several recent studies, such as those conducted by CARB, concluded that **natural gas fuels** can **reduce greenhouse gas emissions by 20-30%** compared to diesel and gasoline"	The data shown in Figure 2-3 on page 18 indicates that GHG emissions from CNG are 21% lower than GHG emissions from diesel and that GHG emissions from LNG are only 3% lower. In addition, Argonne National Laboratory's GREET 2013 model indicates that, using US national default assumptions, wells-to-wheels GHG emission from various fuels are as follows: Gasoline – 18,067 g/mmBTU Diesel – 20,033 g/mmBTU CNG - 17,013 g/mmBTU LNG – 18,201 g/mmBTU As such, the GREET model - which is consistent with EPA's national GHG inventory and is generally used by most government agencies - indicates that CNG has 6% lower GHGs than gasoline and 15% lower GHGs than diesel, while LNG has 0.7% higher GHGs than gasoline and 9% lower GHGs than diesel. A more accurate statement regarding the GHG benefits of natural gas fuels for MD/HDV vehicles would therefore be: "Assessments of the greenhouse gas benefits of natural gas fuels vary, but they generally show that on an energy basis (grams per million BTU or grams per megajoule) CNG has 15-20% lower GHGs than diesel fuel, while LNG has 3 – 9% lower GHGs. The

		lower benefits from LNG are due to a higher energy requirement for liquefaction of LNG compared to compression of CNG. However, natural gas engines typically have lower efficiency than diesel engines, so some of the GHG benefit of natural gas fuels is reduced in practice – i.e., gram per mile GHG reductions from the use of natural gas fuels instead of diesel will be lower due to greater fuel use per mile.”
Sec 2.2.1.3 / pg 18	“Natural gas has a **limited range of flammability** – it will not burn in concentrations below about 5 percent or above 15 percent when mixed with air. **Gasoline and diesel burn at much lower concentrations** and ignite at lower temperatures”.	These statements are misleading with respect to the fire and explosion hazard of natural gas relative to gasoline and diesel fuel. The flammability range of diesel fuel is 0.6 -7.5 percent in air while the flammability range of gasoline is 1.2 – 7.1 percent. While the lower flammable limit of both gasoline and diesel fuel are “lower” than for natural gas, both of these fuels also have a “limited range of flammability” – in fact the flammable range of both these fuels is narrower than for NG. However, neither of these points are particularly relevant to this discussion – all three fuels have a flammability range that in practical terms would result in the possibility of a leak from a vehicle fuel system creating a fire and explosion hazard, and with respect to real world fire and explosion hazards all three fuels are very similar. Of greater importance to the discussion of relative hazards is the fact the natural gas is very buoyant - this is mentioned, but the ramifications of this fact on leak behavior are not really explored. Unlike diesel and gasoline leaks, which puddle on the ground and can create an on-going hazard over a wide area, leaking natural gas tends to rise and dissipate to non-hazardous levels quickly, with only a short, vertical column directly above the leak in which the gas mixture is flammable. Unlike gasoline and diesel leaks, natural gas leaks therefore pose little fire or explosion risk if the gas is leaking into open air. However, if the leak is into an enclosed space (either a building or an enclosed space on the vehicle) the resulting fire and explosion hazard can be significant, depending on the size of the leak.
2.2.1.3 / pg 19	“Onboard CNG storage tank pressures….but all must have **pressure relief valves**”.	CNG cylinders are protected by a Pressure Relief Device (PRD) not a pressure relief valves (PRV). A PRD is designed to activate only once (generally based on high temperature) and to dump the entire contents of the cylinder when activated. PRDs cannot be reset and

		must be replaced after activation. Pressure relief valves are designed to open when the pressure in the cylinder rises above a set threshold, thus releasing only part of the cylinder's contents to reduce pressure, and then to close once the pressure has fallen below a lower set threshold. LNG and LPG cylinders are protected by PRVs.
Sec 2.2.1.3 / pg 22	"The NHTSA regulations that apply to CNG vehicles are FMVSS 301, FMVSS 303, and FMVSS 304"	This statement is misleading in the context of this document. Of these regulations only FMVSS 301 applies to MD/HDVs, the other two are only applicable to light-duty vehicles (< 10,000 lb GVW).
Sec 2.2.1.3 / pg 23	"… do not have crashworthiness regulatory requirements for HD trucks ….. most OEMs crash test new natural gas trucks as a proactive safety measure"	Based on recent experience in surveying truck OEMs with respect to both natural gas and electric vehicle safety for FMCSA, I believe that this statement is NOT TRUE. Truck OEMS do not routinely crash-test vehicle models prior to commercial sale, whether they are equipped with diesel or natural gas fuel systems and engines. The commercial vehicle industry is simply too diverse and complex (in terms of vehicle size and configuration, as well as manufacturing process), and sales volumes are too low, to make routine crash testing economically viable.
Sec 2.2.1.5 / pg 27	"There are currently no generally accepted codes and building standards for CNG garages, so facility safety is handled at the local level by fire marshals"	NFPA 52, *Vehicular Gas Systems Code*, National Fire Protection Association (2010) contains standards for CNG and LNG fueling facilities installed inside residential and nonresidential buildings. This document does not provide definitive standards for facilities that house CNG/LNG vehicles but which do not include a fueling facility. In any event, facility fire safety issues would always be handled by local fire marshals, who would be free to adopt/adapt/or interpret any national consensus standard that was developed.
Sec 2.2.1.5 / pg 27	"Essentially the same safety procedural requirements applicable to CNG fleets are relevant to LNG maintenance facilities"	There is one significant difference in requirements for LNG vehicle maintenance/storage facilities compared to CNG vehicle facilities. Since LNG vehicles are expected to normally vent natural gas from LNG tank PRVs, all maintenance and storage locations should be equipped with a device to connect to PRV outlet(s) and vent escaping gas at building roof level; if not, LNG vehicles should be de-fueled before entering the

		facility. This is not necessary for CNG vehicles which are not expected to vent gas from their PRDs except in the event of vehicle fire or equipment (PRD) failure.
Sec 2.2.2.3 / pg 31	"Operational Safety Concerns include: • High-level biodiesel blends can also gel in cold temperatures"	Even low-level biodiesel blends (B20) can gel at temperatures below 20 degrees Fahrenheit if the manufacturing process leaves too much glycerin in the fuel. This concern is minimized if fuel meets ASTM D7467.
Sec 2.2.3 / pg 32	LPG description	When describing LPG this section does not address LPG's physical properties that are relevant to fire/explosion hazard in the event of a leak. In particular there should be a discussion of the density of LPG vapors, and resultant effect on leak profile: i.e., LPG gas is heavier than air. LPG vapors therefore tend to fall to the ground/floor level and can collect to a flammable level in low spots. Unlike NG, which naturally dissipates as it rises, the dissipation of LPG vapors is primarily based on air movement – it will dissipate to non-hazardous concentration faster in windy conditions than in still conditions
Sec 2.2.3 / pg 33	"To operate a vehicle on propane as either a dedicated fuel or bi-fuel (i.e., **switching between diesel and propane**) vehicle, **only a few modifications must be made to the engine".**	Propane must be used in a spark-ignited engine. Since diesel engines do not have a spark plug this statement is incorrect – to convert a diesel engine to operate on propane or as a bi-fuel propane-diesel engine, significant modifications to the engine are required. The following statement is correct: "To operate a vehicle on propane as either a dedicated fuel or bi-fuel (i.e., switching between gasoline and propane) vehicle, only a few modifications must be made to a gasoline engine. Propane cannot be used in a diesel engine without major modifications since a spark or diesel-pilot ignition system would be required".
Sec 2.3 / pg 37	Parallel Hybrid	This list of in-service parallel hybrid MD/HDVs does not include approximately 3,000 transit buses with Allison Hybrid systems. The 2013 American Public Transportation Association Transit Bus database lists a total of 5,569 hybrid-electric buses in service in the US and another 1,137 in Canada. Of these approximately half have BAE hybrid systems (noted in text) and half have Allison systems (not noted in text).

Sec 2.3 / pg 37	"At least 20 fleets are using **Smith** or other electric MD box trucks…"	While Smith Electric Vehicles is a leader in the field, there are at least 4 other manufacturers offering MD/HDV battery electric trucks for commercial sale in the US, including: • Electric Vehicles International • AMP Electric Vehicles • Boulder Electric Vehicles, and • Motiv Power Systems See information on vehicle availability from the New York Truck - Voucher Incentive Program (https://truck-vip.ny.gov/applications.php)
Sec 2.3 / pg 38	Discussion of MD/HDV electric vehicle range	Of the MD/HDV electric vehicles available through the New York Truck - Voucher Incentive Program, two manufacturers offer trucks with only a single option for battery pack size, and the manufacturer advertised range for these vehicles is 90 miles per charge. Three manufacturers offer their trucks with options for different sized battery packs, which result in advertised range between 40 – 100, 80 – 100, and 80 – 120 miles per charge, respectively. The vehicle with 120 miles per charge is the Motiv Power Systems E450 electric chassis with 120 kWh battery pack.
Sec 2.3.1 / pg 40	"Greater adoption (of HEVs) may occur during the years 2014-2018 of the first NHTSA/EPA fuel efficiency and greenhouse gas regulations for MD/HDVs". "Major trucks manufacturers are now competing in the hybrid MD/HDV market niche…."	The 2014 -2018 NHTSA/EPA fuel efficiency standards provide little incentive for truck OEMS to offer more hybrid models; the stringency levels were specifically set such that hybridization would not be required to meet them, and the benefits of hybridization cannot be captured in the vehicle level certification process. While manufacturers can gain credits under averaging/banking/and trading rules for the sale of hybrids it is not clear how these credits would be calculated. All of the truck OEMs noted as competing in the "hybrid market niche" have recently been selling only hybrid vehicles equipped with Eaton hybrid transmissions. However, in September 2014 Eaton announced that they would no longer sell hybrid transmission in the North American onroad market. (http://evmeme.com/2014/09/eaton-discontinues-diesel-electric-hybrids/ As such, it is unlikely that there will be many sales of hybrid trucks in the next three years.

Sec 2.3.2 / pg 40	"**The break-even period** of hybrid-electric transit buses **is under 8 years i**n North America based on fuel consumption only"	According to data reported by the American Public Transportation Association the incremental purchase cost of a hybrid bus compared to a diesel bus is at least $150,000 (See Iowa State University TECH BRIEF http://www.intrans.iastate.edu/publications/documents/t2summaries/hybrid_transit_bus_tech_brief1.pdf). Based on data reported to the National Transit Database (NTD 20111) US transit buses average approximately 30,000 miles per year and diesel buses average approximately 3.5 MPG. This means that diesel buses use on average about 8,600 gallons of fuel per year. At $4.00 per gallon each bus uses $34,400 worth of fuel per year. Most transit agencies will achieve no more than 30% reduction in fuel use with a hybrid bus compared to a diesel, so they will save ~$10,000/year/bus in fuel costs. For most agencies the break-even period will be 15 years, not 8 years. To achieve an 8-year break-even based on fuel savings alone a hybrid bus would need to have greater than 50% lower fuel use than a diesel, or the bus would need to have much greater than average annual mileage (>50,000 mi/yr).
Sec 2.3.3 / pg 44	"…appropriate safety standards are being developed to complement **FMVSS 305** power level…"	This statement is mis-leading in the context of this report. FMVSS 305 only applies to vehicles with GVW less than 10,000 pounds. It does not apply to the MD/HDVs that are the subject of this report. FMVSS 305 is applied in the context of crash testing specified in FMVSS 208, FMVSS 214, and FMVSS 301. MD/HDVs are not subject to these crash tests per current NHTSA regulations.
Sec 2.3.3 / pg 44	"The SAE Truck and Bus Committee is developing a **draft** standard J2910 Recommended practice…"	The final version of SAE J2910, Recommended Practice for the Design and Test of Hybrid Electric and Electric Trucks and Buses for Electrical Safety was issued by SAE in April 2014, so it is no longer in draft. SAE also has numerous other recommended practices related to design criteria and test methods for specific high voltage components and systems used in electric-drive vehicles, including: SAE J1654, SAE J1673, SAE J1742, SAE J1797, SAE J2344, SAE J2464, SAE J2758, SAE J2929, SAE J 2936, and SAE J2990. Relevant standards that have been developed by the International Standards Organization include: ISO 6469-1, -2, -3 and ISO 16750.

Sec 2.4.1.3 / pg 48-49	Safety considerations of telematics systems	One additional potential safety concern related to telematics systems is the potential for additional driver distraction from systems that provide real-time feedback to drivers. For example, MJB&A managed an in-use test program which evaluated the benefits on school buses of a telematics system that monitors engine RPM and provides audible feedback to the driver to back off the accelerator so that the automatic transmission will shift at the optimal time. The testing confirmed manufacturer claims of increased fuel efficiency, but some drivers indicated that the system alerts were distracting and could be a safety concern. See http://www.mjbradley.com/node/243
Sec 2.5.2.1	"Anti-idling systems offer good opportunity for petroleum reduction in heavy-duty vehicles, **particularly those operating in stop-start city traffic**…"	This statement is not true. While vehicles operating in stop-start traffic typically spend 30-50% of engine-on time at idle, virtually all of this idling is done in traffic, and most idle reduction technologies (other than drivetrain hybridization) will not reduce this idle time at all. Idle reduction technologies are designed to automatically shut off the main engine and/or provide an alternate means to power vehicle auxiliary loads primarily when the vehicle is stopped and the transmission is in park. These systems typically are not operational when the vehicle transmission is in drive, as when a vehicle is stationary in traffic. The single biggest potential area for per-truck and total fuel reduction from implementing anti-idling technologies is reduction of over-night idling from sleeper-cab equipped long-haul tractors.
Sec 2.6.3 / pg 58	"Large trucks are involved in a disproportional percentage of fatal collisions owing to their large mass and momentum. However, statistics on LCVs are difficult to obtain because of the low number of vehicles…"	These statements appear to be contradictory. If statistics on LCVs are unavailable, what is the justification for the first statement? If the first statement is intended to apply not to LCVs specifically but to "large trucks" (i.e., Class 7-8) generally compared to smaller vehicles, the data included in Section 1.2 on crash statistics seems to contradict it as well. This data indicates that the fatality rate per 100 million miles was 0.123 for large trucks, but 1.14 for the "entire fleet". This would seem to indicate that smaller vehicles are in fact involved in a "disproportionate percentage of fatal collisions" since they have a much higher fatal crash rate.

Sec 2.6.3 / pg 59	"Heavier truck traffic **deteriorates pavement structures at an accelerated rate,** and serious roadway defects can subsequently lead to crashes."	I believe that this statement as written is somewhat misleading. Roadway deterioration is almost entirety related to axle weight and has virtually nothing to do with gross vehicle weight, so heavier trucks will not accelerate pavement deterioration per se. A more accurate statement might be: "Heavier axle weights deteriorate pavement structures at an accelerated rate, so heavier trucks could lead to a greater number of roadway defects that might contribute to crashes, unless current axle weight limits are maintained. This would require that heavier trucks have additional axles compared to current trucks in order to carry the extra weight".
Sec 2.9.1	"Mobile Energy Solutions LLC introduced a light-weighted transit bus in 2007 with an all-composite body…"	In 2003 North American Bus Industries began manufacturing a 45-foot transit bus with a light-weight all-composite body which was called the Compo Bus. They manufactured approximately 400 of them between 2004 and 2008. The largest fleet (~300) is at Los Angeles County Metropolitan Transit Authority (LACMTA) in Los Angeles, CA. These buses have natural gas engines and CNG fuel systems. Some of them have now been in service for more than 10 years and are still on the road. See http://media.metro.net/board/Items/2009/09_september/20090902OtherSectorSFVItem6.pdf
Sec 3.1 / pg 77	List of companies contacted for SME interviews	The Los Angeles County Metropolitan Transit Authority has the single largest fleet of natural gas HDVs (transit buses) in the country, as well as the longest experience with natural gas HDVs (since the 1980's). MTA New York City Transit has the single largest fleet of hybrid-electric HDVs (transit buses) in the country, as well as the longest experience with hybrid HDVs (since 1994). Why were neither of these agencies contacted for the SME interviews?
Sec 5.1 / pg 103	"In addition the data in **Figure 5-2** reproduced from the 2007 FMCSA LTCCC report to Congress showed that the vehicle related relative contributions to truck crashed are smaller than driver-related crash causes"	Figure 5-2 does not include data on the causes of truck crashes – it is a generic Hazard Level Matrix. There is no table of data on the cause of truck crashes included in the report.

Sec 5.1 / pg 104	"Figure 5-2 shows that most risk categories can be prevented or managed **cost-effectively** through engineered controls, or with design or operational changes…."	Figure 5-2 is a generic Hazard Level Matrix that shows what types of hazards (by frequency and severity) MUST BE addressed or controlled based on design changes or controls – as a good engineering practice- as compared to those types of hazards that can be ignored because they are so infrequent and/or the severity is so low. This figure provides NO INFORMATION about how easy or cost-effectively any particular hazard on any particular vehicle can be addressed through design.
Sec 5.1 / pg 104	Figure 5-2	The horizontal axis on this figure should be labeled "Frequency of Occurrence" across the top of the figure; the vertical axis should be labeled "Consequence Severity" along the left edge of the figure.
Sec 5.2.1.1 / pg 107	Second bullet at top: "… This incident demonstrated the additional fact that new CNG tanks sold in the US as compliant with FMVSS 304 are engineered to fail safe by **postponing explosion** in the rage event of failure"	This is a very disturbing incident which does NOT demonstrate that FMVSS 304 is adequate to protect against CNG vehicle hazards. According to industry best practices (NFPA 52) every CNG cylinder is supposed to be equipped with a PRD which will open and safely vent gas in the event of a vehicle fire, thus totally avoiding cylinder rupture rather than just "postponing it". If this CNG bus did in fact "explode" it means that either: 1) the PRD was not present, or 2) the PRD was present but did not work as intended (it failed). This points to a need to have both manufacturing standards, and in-use standards for vehicle maintenance and condition, to ensure that necessary safety systems (i.e., PRD) are in place and are operable.
Sec 5.2.1.2 / pg 107	"Robert Zalosh, a Firexplo expert…"	What is a "Firexplo expert"?
Sec 5.2.1.3 / pg 108	"Compliance with all **applicable** NHTSA FMVSSs is also required, including **FMVSS 301** (Fuel System Integrity), **FMVSS 303** (CNG System Integrity), and FMVSS 304 (CNG Fuel Container Integrity)	This statement is misleading with respect to this report. Of the cited FMVSSs, the only one that is applicable to the MD/HDVs discussed in this report is FMVSS 304. FMVSS 301 and FMVSS 303 apply only to vehicles less than 10,000 lb GVW, and to school buses regardless of weight.
Sec 5.2.7 / pg 121	"The 2011 Orion VII safety recall…**led to** Daimler's discontinuing the manufacture and	I think it unlikely that one could prove that the recall led directly to Daimler pulling out of the US transit bus market. At best it was likely a contributing factor among many others.

	marketing of Orion VII buses…”	
Sec 5.2.71. / pg 122	“…electrocution and fire hazards can be reduced through **compliance with FMVSS 305** and adherence to NHTSA interim safety guidelines”	This statement is misleading with respect to this report. FMVSS 305 is only applicable to light-duty vehicles less than 10,000 lb GVW, and it deals with electrolyte leakage and loss of electrical solation during specific crash test scenarios mandated in FMVSS 301. MD/HDVs are not routinely subjected to such crash tests. This section should reference voluntary industry standards and best practices such as those in SAE J2910, SAE J1654, SAE J1673, SAE J1742, SAE J1797, SAE J2344, SAE J2464, SAE J2758, SAE J2929, SAE J 2936, SAE J2990, ISO 6469-1, -2, -3 and ISO 16750.
Sec 6.5.1 / pg 125	“Adoption of idle reduction technologies by MD/HDVs is driven by compliance requirements with EPA clean air regulations”	EPA regulations applicable to MD/HDVs apply primarily to new engines, not to the vehicle as a whole. These regulations do not mandate idle reduction devices, and since the certification testing is done on the FTP engine test cycle the inclusion of an idle reduction device would have no effect on the certification results. Prior adoption of idle reduction devices has primarily been based on state and local laws that restrict vehicle idling.
Sec 6.7.3 / pg 128	“However, this was most significant for vehicles ABS”.	“However, this was most significant for vehicles **without** ABS”.
Sec 6.10 / pg 130	“Most of the potential barriers relate in some way to truck size and weight regulations. This may have implications for hybrid-electric and hybrid-hydraulic technologies, idle reduction technologies, and LCVs.”	“Most of the potential barriers relate in some way to truck size and weight regulations. This may have implications for hybrid-electric and hybrid-hydraulic technologies, **battery-electric vehicles**, idle reduction technologies, and LCVs.”

Lyons

This report provides an excellent bibliography of the literature sources and other information sources which will be helpful to others working in this field.

4.9 Based upon your review, please indicate whether you find the report: (1) acceptable as is, (2) acceptable with minor revisions, (3) acceptable with major revisions, or (4) not acceptable. Please justify your recommendation. If you find the report acceptable with minor or major revisions, be sure to describe the revisions needed.

Blower

Acceptable with major revisions.

In my view, the crash data analysis needs to be substantially revised. I recognize the difficulty of using available data, but the problems with the analysis are fatal to any persuasive conclusions. I have suggested some techniques that could address the issues identified.

I've also pointed out a number of minor changes that should be made to correct a few errors of substance and form.

Other than the crash data analysis and handling of some of the data files, I find the report to be an impressive survey of existing literature and knowledge of the safety FE technologies. I don't see any major gaps. I do believe that the crash analysis problems must be addressed though. And I think they can be, which would strengthen the report.

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Lowell

I find this report acceptable with major revisions. The issues that must be addressed include:

- Editing to improve clarity
- Correction of factual inaccuracies and misleading statements
- Strengthening of crash data analysis in Section 4

The required revisions to make the report acceptable are noted below in response to the charge questions.

Lyons

I find the report acceptable as is. I believe that the report could be made even more useful by the addition of a "Summary of Conclusions" section and by including a brief summary of the conclusions in the "Executive Summary" section.

APPENDIX A

REVIEWER CURRICULUM VITAE/RESUMES

The University of Michigan Transportation Research Institute
Center for the Management of Information for Safe and Sustainable Transportation

NAME:	Daniel Blower
TITLE:	Associate Research Scientist
EDUCATION:	B.A., History, University of Michigan, 1972 Ph.D., History, University of Michigan, 1984 Inter-University Consortium for Political and Social Research, Summer Program in Quantitative Methods, 1989.
RESEARCH INTERESTS:	The application of statistical methods to traffic safety, including analysis of factors affecting crash risk for large trucks; the concept and study of "causation" in truck crashes; development of data collection protocols and methods to identify risk factors in heavy truck crashes; truck driver injury; development of event trees to analyze crash outcomes; methodologies for crash and exposure data collection.
EMPLOYMENT:	2006-present: Associate Research Scientist 1992-2006: Assistant Research Scientist 1990-1992: Senior Research Associate, Transportation Research Institute, The University of Michigan. 1987-1990: Research Associate, Transportation Research Institute, The University of Michigan. 1984-1987: Research Assistant, Transportation Research Institute, The University of Michigan.
SOCIETIES & ORGANI-ZATIONS:	Society of Automotive Engineers, 1991-present Association for the Advancement of Automotive Medicine, 1991-present International Traffic Medicine Association, 2000-present

PUBLICATIONS:

Peer-Reviewed Papers

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Winkler, C. B.; Bogard, S. E.; Ervin, R. D.; Horsman, A.; Blower, D.; Mink, C.; Karamihas, S. *Evaluation of Innovative Converter Dollies*. *Volume III*. 1993. Technical summary. Final report. Michigan University, Ann Arbor, Transportation Research Institute. 30 p. Sponsor: Federal Highway Administration, Washington, D. C. Report No. UMTRI-93-47-3/ FHWA/MC-94/019 (3 volumes) UMTRI-85476

Sullivan, K.P.; Blower, D.F.; Pettis, L. *Trucks Involved in Fatal Accidents, 1989*. Michigan University, Ann Arbor: Transportation Research Institute, February, 1992. 123p. Sponsored by the Motor Vehicle Manufacturers Association. UMTRI-92-10.

Massie, D.L., Campbell, K.L., Blower, D.F., and A.C. Wolfe. *Large Truck Travel Estimates from the National Truck Trip Information Survey*. Report No. UMTRI-91-39. Ann Arbor: Transportation Research Institute, The University of Michigan. 1991. 70p.

Blower, D.F. *Trucks Involved in Fatal Accidents, 1980-88, by Power Unit Type* Michigan University, Ann Arbor: Transportation Research Institute, September, 1991. 140 p. Sponsored by the Motor Vehicle Manufacturers Association. UMTRI-91-36.

Sullivan, K.P.; Blower, D.F. *Trucks Involved in Fatal Accidents, 1988* Michigan University, Ann Arbor: Transportation Research Institute, June, 1991. 123p. Sponsored by the Motor Vehicle Manufacturers Association. UMTRI-91-21.

Streff, F.M.; Ervin, R.D.; Blower, D.F. *In-Vehicle Safety Advisory and Warning Systems (IVSAWS).* Final Report. Michigan University, Ann Arbor, Transportation Research Institute. 69p. Sponsored by Hughes Aircraft Company, Fullerton, Calif. UMTRI-91-33.

Campbell, K.L., Wolfe, A.C., Blower, D.R., Waller, P.F., Massie, D.L. and Ridella, S.A. *Accident Data Analysis in Support of Collision Avoidance Technologies*. Report No. UMTRI-90-31. Ann Arbor: Transportation Research Institute, The University of Michigan. Sponsored by General Motors Corporation and Hughes. 1990. 94p.

Blower, D.F.; Pettis, L.; Sullivan, K.P. *Trucks Involved in Fatal Accidents, 1987.* Michigan University, Ann Arbor: Transportation Research Institute, October, 1990. 122p. Sponsored by the Motor Vehicle Manufacturers Association. UMTRI-90-43.

Lyles, R.W., Blower, D.F., Campbell, K.L., and Stamatiadis, P. Report *The Michigan Heavy Truck Study*. No. UMTRI-90-1-1. Ann Arbor: Transportation Research Institute, The University of Michigan. 1990. Sponsored by the Michigan Office of Highway Safety Planning. 168p.

R.W. Lyles, Blower, D.F., Campbell, K.L., and P. Stamatiadis. *The Michigan Heavy Truck Study: Executive Summary*. Report No. UMTRI-90-1-2. Ann Arbor: Transportation Research Institute, The University of Michigan. 1990. Sponsored by the Michigan Office of Highway Safety Planning. 20p.

Blower, D.F.; Pettis, L.; Sullivan, K.P. *Trucks Involved in Fatal Accidents, 1980-1986.* Michigan University, Ann Arbor: Transportation Research Institute, May, 1990. 130p. Sponsored by the Motor Vehicle Manufacturers Association. UMTRI-90-23.

Fancher, P, Mathew, A, Campbell, K.L., Blower, D.F. and Winkler, C. *Turner Truck Handling and Stability Properties Affecting Safety*. Report No. UMTRI-89-11. Ann Arbor: Transportation Research Institute, The University of Michigan, 1989.

Blower, D.F., Campbell, K.L. *National Estimates of the Number of Trucks, Travel, and Accident Experience of Tractor Semitrailers Used to Transport Hazardous Materials*. Report No. UMTRI-89-

1. Ann Arbor: Transportation Research Institute, The University of Michigan, 1989. 21p. Sponsored by the Rohm and Haas Company.

Campbell, K.L. and Blower, D.F. *Michigan Truck Trip Information Survey*. Report No. UMTRI-88-48. Ann Arbor: Transportation Research Institute, The University of Michigan, 1988. 63p. Sponsored by the Michigan Office of Highway Safety Planning.

Blower, D.R. and Campbell, K.L. *Analysis of Heavy-Duty Truck Use in Urban Areas.* Report No. UMTRI-88-31. Ann Arbor: Transportation Research Institute, The University of Michigan. 1988. 76p. Sponsored by the Motor Vehicle Manufacturers Association.

Blower, D.F., Pettis, L. *National Truck Trip Information Survey* Michigan University, Ann Arbor: Transportation Research Institute, March 1988. 88p. Sponsored by the Motor Vehicle Manufacturers Association. UMTRI-88-11.

Blower, D.F. *The Safety of Farm Truck Operations.* Michigan University, Ann Arbor: Transportation Research Institute, June 1988. 11p. Sponsored by Federal Highway Administration. UMTRI-88-45.

Campbell, K.L., Blower, D.F., Gattis, R.G. and Wolfe, A.C. *Analysis of Accident Rates of Heavy Duty Vehicles.* Report No. UMTRI-88-17. Ann Arbor: Transportation Research Institute, The University of Michigan, 1988. 123p. Sponsored by the National Highway Traffic Safety Administration.

AWARDS:

2011 Patricia F. Waller Award, Best Paper in Road Safety, Transportation Research Board Annual Meeting: “Tractor Trailer Rollover Prevention: The Effectiveness of Electronic Stability Control Systems.” Woodrooffe, John; Blower, Daniel; Green, Paul.

2011 Best Paper Award, TRB Truck and Bus Safety Committee. Woodrooffe, John; Blower, Daniel; Green, Paul.

PRESENTATIONS:

Invited

“Overview of the Evaluation of CSA 2010 Operational Model Test.” Presented to Motor Carrier Safety Advisory Committee, FMCSA. Arlington, Va. December 5, 2012.

“Bus Fires in Motor Vehicle Crashes: Review of Available Crash Data.” BusCon Conference and Expo, Chicago, September 2011.

“Heavy Truck Safety Lecture” Presented to International Truck and Engine Corporation, Chicago, March, 2012.

“Truck Mechanical Condition and Crash Involvement.” Commercial Vehicle Safety Alliance Workshop. April 19, 2010. San Antonio, Texas.

"Truck Mechanical Condition and Crash Risk." 34th International Forum on Traffic Records & Highway Safety Systems. July 31, 2008. Orlando, Florida.

"Three Stories from the LTCCS: Using the LTCCS for Safety Research." Federal Motor Carrier Safety Advisory Committee, June 4, 2008.

"CMV Crashes and Countermeasures for Michigan." with Lidia Kostyniuk. Michigan Traffic Safety Summit, March 2008.

"Strategies to Reduce CMV Crashes in Michigan." with Lidia Kostyniuk. Michigan State Police Leadership Conference. February 2008. Lansing, Michigan.

"Enhancing Crash Data: An Experiment in Capturing Critical Crash Characteristics from Police Reports." 33rd International Forum on Traffic Records & Highway Safety Systems. July 23, 2007. St. Louis, MO.

"Strategies to Reduce CMV-involved Crashes in Michigan." Michigan Truck Safety Commission, July 11, 2007. Lansing, MI.

"CMV Studies: A Current Project to Improve CMV Safety." Michigan Traffic Safety Summit, March 13, 2007. East Lansing, Michigan.

"The Large Truck Crash Causation Study," Federal Motor Carrier Safety Administration Research and Technology Stakeholder Forums, November 17, 2004, and Arlington VA; November 29, 2004. Phoenix AZ.

"Use of Aggregate Data in Modeling Factors Associated with Truck Driver Injury and Illness and Linkage of Truck and Claims Data," Occupational Health Speaker Series at School of Public Health, University of Michigan, April 9, 2004.

"Current Developments in Heavy Truck Safety Research," American Historical Truck Society, Michigan Chapter. Washtenaw County, March 19, 2003.

"Using the LTCCS Database for Hypothesis Testing," Transportation Research Board, Crash Causation Review Committee, Washington DC. August 20, 2002.

"The Michigan Fatal Accident Complaint Team (FACT) Program," Commercial Vehicle Safety Alliance, Albuquerque, NM, May, 1999.

"Truck Accident Type and Driver Related Factors," Michigan Traffic Safety Summit, Grand Rapids, MI, May, 1997.

"Data Sources and Primary Factors Affecting Truck Driver Fatal Injury in Traffic Accidents," Navistar Accident Data Seminar, Fort Wayne, IN, February 1996.

Conference presentations

"Real-world Safety Effect of Roll Stability Control." SAE Commercial Vehicle Engineering Congress, Chicago, IL, October 2013.

"Safety Benefits of Stability Control Systems for Single-Unit Trucks." TRB, Washington DC, 2012.

"Safety Benefits of Stability Control Systems for Motorcoach Buses." TRB, Washington DC, 2012.

"Motor Carrier Type and Driver History in Fatal Bus Crashes." TRB, Washington DC., 2010.

"Vehicle Condition and Truck Crash Involvement: Evidence from the LTCCS." TRB, Washington DC., 2010.

"Truck Driver Vision in Serious Crashes: Results from the Large Truck Crash Causation Study." Human Factors Affiliates Meeting, December, 2007.

"Truck Mirrors, Field of View, and Serious Truck Crashes." Human Factors Affiliates Meeting, December, 2006.

"Truck Driver Vision and Pedestrian/Nonmotorist Crashes in Low Speed Maneuvers." Commercial Vehicle Engineering Congress and Exhibition, Chicago, Illinois, November 1, 2006.

"Determining the Severity of Transit-Bus Crashes to Develop Safe Alternatives to Transport Wheelchair-Seated Travelers." International Truck and Bus Safety and Security Symposium, Alexandria VA, November 2005

"Determination of Events Leading to Sport Utility Vehicle Rollover." Transportation Research Board Annual Meeting, Washington DC, January 2005.

"Truck and Bus Safety: Problem Assessment and Data," Transportation Research Board Annual Meeting, Committee on Truck and Bus Safety, January, 2004.

"Evaluation of FARS and BIFA to Support a Bus Crash Causation Study" Bus Crash Causation Study Review Committee, Alexandria, VA, June 16, 2003.

"Vehicle Condition and Heavy Truck Accident Involvement." International Truck and Bus Safety and Policy Symposium. Knoxville, TN. April, 2002.

"Underride in Fatal Rear-end Truck Crashes." SAE International Truck and Bus Meeting, Portland, OR, December 2000.

"Truck Driver Injury and Collision Characteristics." SAE International Truck and Bus Meeting, Detroit, MI, November 1999.

"OMC's Crash Investigation Program/MSP's Fatal Accident Complaint Team." SAE Government and Industry Meeting, Washington DC, April, 1999.

"Heavy Truck Accident Data: Where We Are, Where We Are Going." SAE International Truck and Bus Meeting and Exposition, Cleveland, OH, November 1997.

"Restraint Effectiveness in Reducing Head/Face Injury-Contacts with Interior Rail-like Surfaces," SAE Government and Industry Meeting, Washington, DC, April 1995.

"Application of Log-linear Models to Accident Rates," 73rd Annual Transportation Research Board Meeting, Washington, DC, January 1994.

"A Proposed SAFETYNET Factbook," Accident Data Committee, Commercial Vehicle Safety Alliance, Bar Harbor, Maine, May 1991.

PROFESSIONAL SERVICE

Member, Michigan Truck Safety Commission, 2011- present.

Chairman, Strategic Planning Subcommittee, Michigan Truck Safety Commission, 2011-present.

Member, Executive Committee, Michigan Center for Advancing Safe Transportation throughout the Lifespan, University of Michigan Transportation Research Institute. 2007-present.

Member, Ad hoc committee for Peer Review of Violation Severity Assessment Study (VSAS) for FMCSA. 2007-2008.

Transportation Research Board, Committee of Truck and Bus Safety (ANB70), 2001-present.

Member, D16.1 Consensus Body, National Safety Council, 2005-2007.

Member, Technical Advisory Group for American Transportation Research Institute on Truck Driver Hours of Service study, 2004-2005.

Steering Committee for the Truck and Bus Safety and Security Symposium, November 2005, sponsored by the National Safety Council.

Technical Advisory Committee on National Motor Vehicle Crash Causation Study, for the National Highway Traffic Safety Administration. 2004.

Member and session organizer, Total Vehicle Committee of Society of Automotive Engineers, 2002-present.

Member, Large Truck Crash Causation Study committee, Federal Motor Carrier Safety Administration, 1999-2003.

Member, Advisory Committee for an Integrated Traffic Safety Problem Identification Database Project, California Department of Motor Vehicles, 1998-1999.

Truck and Bus Safety Research Subcommittee, Committee of Transportation Safety Management (A3B01), Transportation Research Board, 1998- present.

Member, ANB70 Truck and Bus Data Subcommittee, TRB, Washington, DC, January 2012.

Member, ANB70 Motorcoach Safety Subcommittee, TRB, Washington, DC, January 2012.

Member, HMCRP HM-07 Oversight Committee, TRB. Met in Washington, DC, July, 2011.

Paper reviewer for Transportation Research Board Accident Data Committee. 1995-present.

Paper reviewer for *Accident Analysis and Prevention*. 1999-present.

Paper reviewer for *Traffic Injury Prevention.* 2004-present.

National Safety Council Committee on a National Agenda for Traffic Records, 1995-1996.

Member, University of Michigan Transportation Research Institute Computing Committee, 1995-1997.

Steering Committee for the Office of Motor Carriers Data Analysis Group, 1994.

Proposal reviewer, USDOT University Transportation Center for Federal Region 10. 1994.

M.J. Bradley & Associates LLC

Dana M. Lowell

Senior Vice President & Technical Director

Dana has worked in MJB&A's advanced vehicle technology group since 2004, providing strategic analysis, project management, and technical support to mobile source emissions reduction programs. His mobile source project work includes evaluation and implementation of advanced diesel emissions controls, alternative fuels, and advanced hybrid and fuel cell electric drives, as well as development and implementation of diesel emissions testing programs for a range of onroad and nonroad heavy-duty vehicle types. Dana brings to clients a wealth of practical knowledge and experience, the real-world perspective of a major fleet operator, and a proven track record in technology implementation.

Dana has 25 years professional experience in the transportation and government sectors. Prior to joining MJB&A, Dana spent seven years as the Assistant Chief Maintenance Officer for Research & Development at MTA New York City Transit's Department of Buses. In his role with NYC Transit, Dana was responsible for both evaluation and implementation of clean fuel technology programs, including technology and vehicle testing, emissions testing and fleet emissions modeling, component/vehicle specification, maintenance program analysis, applications engineering support, financial analysis, budget development and planning, procurement support, and project management. Under his leadership, NYC Transit developed and executed an aggressive program to implement new technologies fleet-wide, resulting in the creation of NYC Transit's Clean Fuel Bus Program to reduce exhaust emissions from the fleet of 4,500 fixed-route transit buses.

Areas of Expertise

- Advanced vehicle emissions reduction technologies
- Vehicle technology development and deployment
- Transit maintenance management
- Vehicle emissions testing
- Diesel inspection and maintenance programs
- Transit vehicle specification and procurement support
- Life cycle cost modeling and financial analysis
- Project management

A recognized electric drive and clean fuel expert within transit, Dana has made numerous presentations at industry conferences and workshops sponsored by APTA, TRB, SAE, US EPA, the Canadian Urban Transit Association, the Electric Power Research Institute, the National Parks Service and the World Bank. He has also served on advisory committees for the Harvard Center for Risk Analysis and the US EPA's Environmental Technology Verification Program.

Representative MJB&A Projects

- NYPA Fleet Analysis – Options to Reduce GHG Emissions
- EDF/Ceres, Effect of EPA Phase 2 Fuel Efficiency Regulations on Freight Rates
- Comparison of Fuel Economy & Emissions from Modern Diesel, CNG, and Hybrid Buses

- Federal Motor Carrier Safety Administration, Recommended Updates to Safety Regulations to Accommodate Electric Drive Vehicles
- Federal Motor Carrier Safety Administration, Training Program for Commercial Vehicle
- Inspectors in Detecting Fuel Leaks from CNG, LNG, and LPG Vehicles
- Port Authority of Allegheny County Bus Fleet Emissions Analysis
- BAE Systems, Hybrid Bus Fuel Economy Testing
- New York City Business Integrity Commission, Analysis of “Age-out” Policy Options to Reduce
- Emissions form Commercial Refuse Trucks in New York City
- Environmental Defense Fund, Policy Options to Reduce Fugitive Emissions from Natural Gas Production Facilities
- ICCT, Policies to Address Electric Vehicle-Grid Integration
- ICCT, Evaluation of Methane Leakage from LNG Marine Fuel Bunkering
- Clean Air Task Force, Diesel Emissions Reduction Policy Toolkits
- Clean Air Task Force, Diesel Black Carbon Climate Comparisons
- New York Power Authority, Hybrid School Bus Demonstration Program
- Federal Motor Carrier Safety Administration, Recommended Updates to Safety Regulations to Accommodate Natural Gas Vehicles
- Regulatory Support to Heavy-duty Diesel Engine Manufacturers for Transition from EPA Tier 2 to EPA Tier 3/4 Regulations
- BAE Systems, Technical Marketing Support and Analysis for Sales of Hybrid-Electric Transit Buses
- Federal Motor Carrier Safety Administration, Guidelines for The Use of Hydrogen Fuel in Commercial Vehicles
- ICCT, Analysis of Trailer Technologies Available to Increase Freight Vehicle Efficiency
- American Clean Skies Foundation, Natural Gas for Marine Vessels, U.S. Market Opportunities
- American Bus Association, Comparison of Coach Bus Service to Amtrak and to the Essential Air Service Program
- ICCT, Policy Options to Address Urban Off-Cycle NOx Emissions from Euro IV/V Trucks
- Chelsea Collaborative, TRU Electrification at New England Produce Center
- Volpe Transportation Center, Fuel Cell Bus Life Cycle Cost Model
- Volpe Transportation Center, Fuel Cell Bus Maintenance Manual & Training Program
- New York Power Authority, Green Fleet Options Analysis
- Clean Air Task Force, Technical Support for Diesel Emission Reduction Policy Development
- Great Lakes Towing, Emissions Testing of SCR-equipped Marine Power Barge
- Conservation Law Foundation, Review of Massachusetts Policies to Reduce GHG from the Transportation Sector
- ICCT, Support for Heavy-Duty Vehicle Fuel Economy/GHG Regulation
- American Lung Association, Technical Support for Energy Policy Development
- CSX, Gen-set Locomotive Emissions Testing
- Keyspan Energy Delivery, Current and Proposed Transportation Technology Review
- Environment Canada, Oil Sands Sector Emission Reduction Feasibility Study
- Translink/GVTA, Bus Technology Demonstration Program, Phase 1, 2, 3 & 4
- Massachusetts Bay Transportation Authority (MBTA), In-service CNG Bus Test Program
- MBTA, Development of an Enhanced Bus Emissions Monitoring and Control Program
- American Bus Association, Transit Modes & GHG Offset Analysis

- Nicholas Institute, BEST BUS Life Cycle Cost and Emissions Model
- PANYNJ, Brooklyn Cruise Terminal Shore Power Feasibility Study
- Massachusetts Department of Environmental Protection, Diesel Engine Retrofits in the Construction Industry: A How to Guide
- STAPPA/ALAPCO, Guidance for the Control of Fine Particulate Matter Emissions from Industry Sectors
- ESP, U.S./Mexican Border Remote Sensing Emissions Testing Project
- Environmental Defense, New York City Idling Emissions Calculator
- NRDC, MTA New York City Transit Bus Fleet Emissions Analysis
- NESCAUM, Region 1 and Region 2 Marine Engine Repower Project
- Northeast Utility Truck Retrofit Program

Prior Work Experience

July 1996 – May 2004	MTA New York City Transit, Department of Buses *Assistant Chief Maintenance Officer, Research & Development*
March 1993 – June 1996	MTA New York City Transit, Dept. of Capital Programs *Manager of Capital Investment Analysis*
Feb 1990 - Feb 1993	City of New York, Office of Management and Budget *Supervising Project Manager, Value Engineering*
Sept 1985 – Sept 1989	United States Army, 299th Engineer Battalion *Battalion Adjutant; Combat Engineer Platoon Leader*

Education

Leonard N. Stern School of Business, New York University, New York, NY

> *Masters of Business Administration; co-major in Management and Operations Management, 1995*
> *Mayor's Graduate Scholarship; Dean's Award for Academic Excellence*

Princeton University, Princeton, NJ

> *Bachelor of Science in Mechanical Engineering, 1985*
> *Summa Cum Laude; Phi Beta Kappa; Tau Beta Pi*
> *Four-year R.O.T.C. scholarship; Distinguished Military Graduate*

Professional Activities

- NESCAUM/MassDEP training on short-lived climate forcers, 2010
- Massachusetts Department of Environmental Protection and MASS Highway diesel retrofit training, 2008
- Chair of Hybrid Bus Working Group, Electric Bus Subcommittee; American Public Transit Association, September 1999 – May 2003

- Member, Technical Advisory Panel for Project C-10 - Transit Bus Technology Related Research; Transit Cooperative Research Program
- Member, Technical Council; Transit Standards Consortium, November 2000 – December 2002
- Member, Technical Screening Committee, FY 2000 Research Program; Transportation Research Board
- Organizer and Session Chair, SAE TOPTEC: Hybrid Electric Vehicles in the Bus & Truck Markets; SAE International, New York, NY, May 2000
- Panelist, Alternative Fuels CUTRcast web-panel session; Center for Urban Transportation Research, July 2000; www.nctr.usf.edu/netcast/altfuels.htm
- Member, Technical Review Panel; U.S. Environmental Protection Agency Environmental Technology Verification Program, November 2000
- Member, Advisory Panel on Alternative Propulsion Technologies; Harvard Center for Risk Analysis, October 1999
- Trainer on alternative fuel technologies; National Park Service Training Session on Alternative Transportation Systems, Philadelphia, PA, November 1999
- Member, Peer Review Panel, South Boston Piers Area Transit Way, Massachusetts Bay Transportation Authority, Boston, MA
- Member, Clean Propulsion & Support Technology Committee, American Public
- Transportation Association

Conference Presentations

- International Association of Ports and Harbors Conference, IAPH 2013
- ICCT International Workshop on Reducing Air Emissions from Shipping, Shanghai, China, 2012
- IUAPPA, World Clean Air Congress, 2010
- Transportation Research Board Annual Meeting, 2006
- World Resources Institute/USAID Workshop on Coupling GHG Reductions with Transport & Local Emissions Management, 2005
- World Bank Training Session on Diesel Pollution, 2004
- World Bank Clean Air Initiative – Diesel Days, Washington DC, January 2003
- Philadelphia Diesel Difference Conference, Philadelphia, PA, May 2003
- Diesel Engine Emissions Reduction (DEER) Conference, US Department of Energy, Newport, RI, August 2003
- EPA-NESCAUM Diesel Retrofit Workshop, New York, NY, October 2003
- SAE Truck and Bus Meeting, November, 2003
- Better Air Quality for Asia Workshop (BAQ 2003), World Bank, Manila, Philippines, December 2003 – video presentation
- Transportation Research Board, 2002 Annual meeting, January 2002
- APTA 2002 Bus & ParaTransit Conference, American Public Transit Association, May 2002
- EESI/NESEA Congressional Briefing on Cleaner Transportation Technologies, Washington, DC, May 2002
- APTA 2001 Bus & ParaTransit Conference, American Public Transit Association, May 2001
- CUTA Annual Conference, Canadian Urban Transportation Association, June 2001
- World Bank Clean Air Initiative Workshop for Lima and Callao, Lima, Peru, July 2001

- World Bus and Clean Fuel Expo 2001, August 2001
- North East Sustainable Energy Association (NESEA), Energizing Schools 2001 Conference, October 2001
- SAE Truck and Bus Meeting, November, 2001
- Transportation Research Board, 2000 Annual meeting, January 2000
- APTA 2000 Bus & ParaTransit Conference, American Public Transit Association, May 2000
- Electric Bus Users Group Workshop, Electric Power Research Institute, March 2000
- Diesel Emissions Control Retrofit Workshop, Corning Inc., March 2000
- Board of Directors Alternative Fuels Workshop, Washington Metropolitan Area Transit Authority, July 2000
- SAE Hybrid Electric Vehicles TOPTEC, May 1999
- Bus Technology & Management Conference, American Public Transit Association, May 1998
- NAEVI 98, North American EV & Infrastructure Conference and Exposition, December 1998

Publications

- Lowell, D., Seamonds, D., “Coming Soon To a Fleet Near You: EPA/NHTSA Fuel Efficiency and GHG Standards For Medium- and Heavy-Duty Trucks”, Environmental Energy Insights, May 2014
- Lowell, D., “Short-term Climate Impact of Diesel Emission Reduction Projects”, Clean Air Task Force, December 2013 “Comparison of Modern CNG, Diesel and Diesel Hybrid-Electric Transit Buses: Efficiency & Environmental Performance”, November 2013
- Lowell, D., “Port Authority of Allegheny County Bus Fleet Emissions 2005 – 2019”, Pittsburgh Foundation, October 2013
- Lowell, D., Seamonds, D., “New York City Commercial Refuse Truck Age-out Analysis”, Environmental Defense Fund and New York City Business Integrity Commission, September 2013
- Wang, H., Lutsey, N., Lowell, D., “Consideration of the Lifecycle Greenhouse Gas Benefit from Liquefied Natural Gas as an Alternative Marine Fuel”, submitted to International Maritime Organization, Sub-committee on Bulk Liquids and Gas by Institute of Marine Engineering, Science and Technology (IMarEST), October 2013
- Lowell, D., “NYPA Hybrid Electric School Bus Evaluation Project, Phase 2 FINAL REPORT”, New York Power Authority, September 2013
- Whitman, A., Lowell, D., Balon, T., “Electric Vehicle Grid Integration in the U.S., Europe, and China: Challenges and Choices for Electricity and Transportation Policy”, International Council on Clean Transportation and Regulatory Assistance Project, July 2013
- Lowell, D. and Seamonds, D., “Supporting Passenger Mobility and Choice by Breaking Modal Stovepipes: Comparing Amtrak and Motor Coach Service”, July 2013, American Bus Association Foundation
- Sharpe, B., Clark, N. and Lowell, D., “Trailer Technologies for increased heavy-duty vehicle efficiency: technical, market, and policy considerations”, White Paper, International Council on Clean Transportation, June 2013
- Lowell, D., FMCSA-RRT-13-044, “Natural Gas Systems: Suggested Changes to Truck and Motor Coach Regulations and Inspection Procedures”, Federal Motor Carrier Safety Administration, March 2013

- Lowell, D., Balon, T., Van Atten, C., Curry, T., Hoffman-Andrews, L., "Natural Gas for Marine Vessels: U.S. Market Opportunities", American Clean Skies Foundation, 2012
- Sharpe, B., Lowell, D., "Certification Procedures for Advanced Technology Heavy-Duty Vehicles: Evaluating Test Methods and Opportunities for Global Alignment", SAE International, SAE 201201-1986, 2012
- Lowell, D., "Clean diesel versus CNG buses: Cost, air quality, & climate impacts", Clean Air Task Force http://www.catf.us/resources/publications/files/20120227Diesel_vs_CNg_FINAL_MJBA.pdf, 2012
- Lowell, D. and Kamaketé, F., "Urban off-cycle NOX emissions from Euro IV/V trucks and buses: Problems and solutions for Europe and developing countries", White Paper No. 18, International Council on Clean Transportation, march 2012, http://www.theicct.org/urbancycle-nox-emissions-euro-ivv-trucks-and-buses
- Moynihan, P., Balon, B., Lowell, D., "NESCAUM Region 2 Marine Ferry and Tug Repower Project FINAL REPORT", NESCAUM, 2011
- Bongiovanni, R., "Chelsea Collaborative New England Produce Center TRU Electrification FINAL REPORT", Chelsea Collaborative, 2011
- Lowell, D., Seamonds, D., "Alternative Fueled Fleet Vehicle Analysis", Electric Power Research institute, EPRI 1023045, 2011
- Lowell, D., Curry, T., Hoffman-Andrews, L., Reynolds, L., "Comparison of Essential Air Service Program to Alternative Coach Bus Service: Keeping Rural Communities Connected", American Bus Association Foundation, September 2011
- Lowell, D., Balon, T., Danos, T., "Bus Technology & Alternative Fuels Demonstration Project Phase 4 Final Report", Greater Vancouver Transportation Authority, 2011
- Balon, T., Clark, N., Moynihan, P., Lowell, D., "Development of a Combined Oxidation System and Seawater Scrubber to Reduce Diesel NOx Emissions from Marine Engines Final Report", Houston Advanced Research Center, New Technology Research & Development Program N-40, 2011
- Balon, T., Moynihan, P., Lowell, D., Danos, T., Seamonds, D., "CSX Genset Switcher#1317 Locomotive Emission Testing FINAL REPORT", NESCAUM, 2010
- Park, D, Curry, T, Lowell, D., Balon, T.H., Piper, S, "Implications of Introducing Hydrogen Enriched Natural Gas in Gas Turbines", Atlantic Hydrogen, Inc, January 2010
- Lowell, D., Balon, T., Seamonds, D., Leigh, R., Silverman, I., "The Bottom of the Barrel: How the Dirtiest Heating Oil Pollutes Our Air and Harms Our Health", Environment Defense Fund, 2009
- Posada, F., Lowell, D. (editor), "CNG Bus Emissions Roadmap: from Euro III to Euro VI", international Council on Clean Transportation, 2009
- Lowell, D., "Lower Manhattan Construction, Construction Equipment Retrofit Case Study", Clean Air Task Force, 2009
- Lowell, D., Seamonds, D.G., "Evaluation of Vehicle Emissions Reduction Options for the Oil Sands Fleet", Environment Canada, March 2008
- Lowell, D., Balon, T.H., "Setting the Stage for Regulation of Heavy-Duty Vehicle Fuel Economy & GHG Emissions: Issues and Opportunities," International Council on Clean Transportation, March 2008
- Lowell, D., Balon, T. H., Danos, T. J., Moynihan, P.J., "Diesel Engine Retrofits in the Construction Industry: A How To Guide", Massachusetts Department of Environmental Protection, January 2008.
- Lowell, D., Balon, T., "Brooklyn Cruise Terminal Shore Power Feasibility Analysis", Port Authority of New York and New Jersey, 2008
- Johnson, P., Graham, J., Amar, P., Cooper, C., Skelton, E., Lowell, D., Van Atten, C., Berwick, A., "Assessment of Carbonaceous $PM_{2.5}$ for New York and the Region", New York State Energy Research & Development Authority, NYSERDA Report 08-01, 2008

- Lowell, D., "Guidelines for Use of Hydrogen Fuel in Commercial Vehicles: Final Report", US Department of Transportation, November 2007.
- "Comparison of Energy Use & CO2 Emissions from Different Transportation Modes", American Bus Association, May 2007.
- Lowell, D., Chernicoff, W., Lian, F., "Fuel Cell Bus Life Cycle Cost Model: Base Case & Future Scenario Analysis", U.S. Department of Transportation, DOT-T-07-01, June 2007
- Balon, T.H., Lowell, D., Moynihan, P.J., Wilensky, L.S., Piper, S.G., Danos, T.J., Hamel, C.J., "Staten Island Ferry Alice Austen Vessel SCR Demonstration Project Final Report," Port Authority of New York and New Jersey, August 2006.
- Berwick, A., Bradley, M., Van Atten C., Lowell, D., Curry, T., Durbin, D., "Controlling Fine Particulate Matter under the Clean Air Act: A Menu of Options", STAPPA/ALAPCO, 2006
- Lowell, D., "Life Cycle Cost & Emissions Model Alternative Bus Technologies; Final Report", Nicholas Institute for Environmental Policy Solutions, 2006
- Lowell, D., Balon, T., Grumet, S., Vescio, N., Full, G., Fraser, J., McClintock, P., "Cross Border InUse Emissions Study for Heavy Duty Vehicles, Nogales, AZ FINAL REPORT", Arizona Department of Environmental Quality and US Environmental Protection Agency, 2006
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PROFESSIONAL RESUME

DONALD W. LYONS

PRESENT POSITION

EMERITUS PROFESSOR and former DEPARTMENT CHAIRMAN, Department of Mechanical and Aerospace Engineering, and DIRECTOR EMERITUS of the National Research Center for Alternative Fuels, Engines, and Emissions (CAFEE), West Virginia University, Morgantown, West Virginia.

EDUCATION

Ph.D. (Mechanical Engineering), Georgia Institute of Technology, 1966
B.ME. (with honors), Georgia Institute of Technology, 1

GENERAL PROFESSIONAL EXPERIENCE

INDUSTRIAL EXPERIENCE - Served as corporate Vice President directing all the technical operations of Texcon Inc., a $3,000,000 per year high technology business. Served as the Technical Director for MVL Inc., a Norwegian owned technology assistance association. Served as an engineering consultant to a number of industrial companies and government agencies. Worked as a design engineer for Boeing Company, Northrop Nortronics Inc, and Fairbanks Morris and Co.

GOVERNMENT EXPERIENCE - Served as Director of the Office of Science and Technology Assessment of the Occupational Safety and Health Administration, in President Carter's Administration. Serve as a consultant to several government agencies including CPSC, OSHA, NIOSH, EPA, DOE, and DOD. Have served as a member of numerous state and federal government advisory boards.

TEACHING EXPERIENCE - Taught a wide range of graduate and undergraduate courses in mechanical and aerospace engineering, textile engineering and industrial management at West Virginia University, Georgia Tech, University of Florida and Clemson University. Served ad Director and senior faculty member of the Bachelor of Science program in Occupational Safety and Health Management. Organized over 40 short courses attended by over 2,000 representatives from government and industry. Major advisor for 25 masters and Ph.D. graduates.

UNIVERSITY ADMINISTRATIVE EXPERIENCE - Served for 17 years as Chairman of a large academic department with 40 tenure track and research faculty, 30 staff, 200 undergraduate students, and 130 graduate students. Responsible for administering BS, MS, and Ph.D. programs in mechanical engineering and aerospace engineering, and for $7 million per year research program and for service programs for the state and region.

RESEARCH CONTRACT EXPERIENCE - Identified funding sources, wrote successful proposals and served as Principal Investigator for tens of millions of dollars of contract and grant support. Provided leadership to establish and obtain funding for several large University Research Centers at West Virginia University, Georgia Tech and Clemson University. Recently established and served as Director of West Virginia University's National Research Center for Alternative Fuels, Engines and Emissions (CAFEE) which has obtained over $75 million in funding from government and industrial sources during the past fifteen years. Author or co-author of 90 refereed Journal publications and 170 conference proceedings publications.

REGISTRATIONS

Registered Professional Engineer
Registered Land Surveyor (retired)
Certified Safety Professional

PROFESSIONAL ACTIVITIES

Have served in active in leadership positions of 12 professional societies. Current or former member of 10 governmental councils and industrial advisory boards.

PUBLICATIONS AND PRESENTATIONS

Published over 90 refereed Journal and 170 Conference Proceedings technical papers on scientific research results in areas of mechanical and aeronautical engineering, occupational safety and health, and textile physics and chemistry. Participated as a speaker at hundreds of meetings and conferences. Testified at congressional and government agency hearings.

EMPLOYMENT HISTORY

1985-Present. Research and Emeritus Professor, Department of Mechanical and Aerospace Engineering, and Director (Emeritus), National Research Center for Alternative Fuels, Engines and Emissions, (CAFEE), West Virginia University, Morgantown, West Virginia. (Served as Department Chairman from 1985-2001).

Professor of Mechanical and Aerospace Engineering with responsibilities for teaching students, conducting research and providing service to the State and region. Teach courses in the areas of mechanical design, engineering mechanics and thermal systems, write proposals and develop research projects in the area of fuels, engines and emissions and the area of mechanics of materials. Serve as Principle Investigator for over $2.0 million per year in research project funding. Supervise undergraduate and graduate student research. Publish 3 to 4 journal and 8 to 10 conference proceedings papers per year. Provide assistance to regional companies and government agencies to promote economic and job development.

Director (Emeritus) of the National Center for Alternative Fuels and the Engines and Emissions (CAFEE) at West Virginia University. Started the research program and developed the first major funding for the program in 1989. Responsible for supervision of the faculty, staff, and the research programs. which are in the area of alternative fuels, emissions, and engines. The Center has been successful in obtaining funding of $75 million over the past fifteen years and over $3 million this year from government agencies and industrial companies.

Chairman (1985-2001) of a large academic department of engineering at West Virginia with 25 tenure track and 15 research faculty, 30 staff, 130 graduate student majors and over 200 undergraduate student majors. Administered undergraduate and graduate teaching and research programs in the fields of aerodynamics, fluid and thermal sciences, solid mechanics and materials, biomedical, machine design and automated manufacturing. Managed a teaching budget of over $1,800,000 and a contract research budget of over $7,000,000 per year. Responsible for personnel supervision and evaluation, recruiting and staff development, program administration and new program development. Lead the Department through a period when the graduate program's size quadrupled and contract research funding increased ten fold.

1983-1985. Manager, Industrial Applications Research in the Georgia Tech Research Institute, and Faculty Member (Professor) of Mechanical Engineering at Georgia Tech, Atlanta, Georgia.

Management position in one of the largest engineering research institutes in the United States with over $65 million per year in contract research. Responsible for providing administrative and technical leadership for the development of millions of dollars of contract research in the program areas of manufacturing technology and automation. In addition to general management duties, also developed funding and personally served as Project Director for five individual projects with funding of over $300,000. Also played a leadership role in the team effort to organize and obtain funding for the Computer Integrated Manufacturing Systems Programs and the Materials Handling Research Center each which was supported at approximately $1,000,000 per year by a consortium of industrial companies. Also a member of the faculty of the School of Mechanical Engineering and advised graduate students and taught courses in the area of computer integrated manufacturing systems.

1981-1983. Technical Director, MVL Inc. (Federation of Norwegian Engineering Industries), Atlanta, Georgia.

Directed the United States office of MVL, the Norwegian Industrial Manufacturers Association. Served in the capacity as the Industrial Attaché to the USA for Norway but without the Attaché title. Conducted technology assessments and identified new technology for individual companies. Developed and maintained contact with manufacturing companies throughout the United States regarding new developments in technology. Developed license agreements between companies in the United States and Norway. Conducted assessments of trends in technology and wrote technical papers and presented seminars on new developments in CAD/CAM, robotics, and new materials for manufacturing.

1980-1981. Vice President for Engineering and Field Operations, Texcon, Inc., Greenville, South Carolina.

Chief Technical Officer for the company. Responsible for the engineering design, fabrication and field installation of industrial dust filtration and air conditioning systems. Provided technical leadership and personnel supervision for the engineering department (8-10 engineers and draftsmen) and fabrication and installation department (30-40 mechanics). Managed the operations through a period which accomplished 100 percent growth in size to a sales volume of $3,000,000 per year.

1966-1980. Professor of Textile Science and Mechanical Engineering, Clemson University, Clemson, South Carolina.

Responsible for initiating, developing, and administering programs for research and teaching. Obtained outside funding and personally served as program director for 16 contract research and training projects with a total funding of over $1,000,000. Wrote proposals to obtain funding for numerous college wide programs for other faculty. Developed and taught a wide range of courses in instrumentation, automatic controls, thermal sciences, textile manufacturing, fiber physics, and safety. Major advisor for 20 students who completed masters or doctors degrees. Founded and served as Director of the Bachelor of Science Degree Program in Occupational Safety and Health Management.

1978-1979. Special Assistant for Technical Support and Director of the Office of Science and Technology Assessment, Occupational Safety and Health Administration, Washington, D.C.

Took leave from Clemson University and got appointed by President Carter's Administration as a Special Assistant to the Assistant Secretary of Labor for Occupational Safety and Health. Managed the Office of Science and Technology Assessment of OSHA. Regularly represented the agency in meetings with representatives from industry, labor, and congress. Served as Chairman of the Interagency Industrial Noise Control Study Group.

1965-1966. Assistant Professor, Department of Mechanical Engineering, University of Florida, Gainesville, Florida.

Responsible for developing teaching and research activities of the department in the technical areas of automatic controls and instrumentation. Conducted NASA-Cape Kennedy sponsored research to analyze the effects of the potential failure of the Saturn V Launch Vehicle during lift-off.

1964-Present. Engineering Consultant (part-time)

Serve as an engineering consultant on a part-time basis. Companies and organizations with which I have had significant consulting contractual arrangements include: Halliburton, Deering Milliken, Celanese, Bigelow Sanford, United Merchants and

Manufacturers, Phillips Fibers, Singer Company, J.E. Sirrine, Allied Chemical, Kendall, Owens Corning, Cone Mills, Duke Power, U.S. Department of Labor, U.S. Environmental Protection Agency, U.S. Public Health Service.

Served as an engineering consultant and gave deposition or courtroom testimony in over 75 legal cases dealing with a wide range of civil, criminal and patent law topics.

1963-1965. Member Technical Staff, Northrop Northronics Company, Huntsville, Alabama.

Held a permanent part-time position with responsibilities for engineering design and analysis of the automatic control systems for the Saturn V Launch Vehicle.

1957-1963. Assistant Engineer, Fairbanks Morris and Company, Beloit, Wisconsin

Full time employment for approximately 18 months over three years with responsibilities to assist in the design, manufacture and evaluation of large diesel engines and locomotives.

APPENDIX B

CHARGE TO REVIEWERS

CHARGE TO PEER REVIEWERS

Task Order 001, NHTSA Contract DTNH22-13-D-00298

Peer Review of *"Review and Analysis of Potential Safety Impacts and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels in Medium- and Heavy-Duty Vehicles"*

BACKGROUND

In April 2012, the National Highway Traffic Safety Administration (NHTSA) entered into an interagency agreement with the Department of Transportation's (DOT's) Volpe Center to review how technologies to improve Fuel Efficiency (FE) in Medium- and Heavy-Duty (MD/HD) fleets may impact vehicle safety and current regulations, both positively and negatively. This broad assessment covers vocational, combination tractors, buses, and class 2b/3 vehicles. At involved review and prioritization of the potential safety implications within the relevant contexts of MD/HD vehicle operation, performance, maintenance, and collision scenarios, and cites cases and statistics when available. In addition, for MD/HD vehicle categories with high numbers of occupants, such as transit and school buses, the review includes an analysis of occupant safety and capacity. The resulting report, *Review and Analysis of Potential Safety Impacts and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels in Medium- and Heavy-Duty Vehicles*, has undergone internal agency review and is now ready for independent external peer review to assess its scientific adequacy.

REPORT OVERVIEW

This report summarizes the findings of an NRC-recommended safety analysis, as described above, of MD/HDVs that adopted FE technologies and/or alternative fuels. The safety analysis (completed in 2013) was based on a comprehensive review of technical literature and web-based resources, including inputs from subject matter experts (SMEs). Also presented are the results of: (1) an independent analysis of 2010 and 2011 crash safety databases; (2) a hazard analysis of the potential safety issues associated with alternative fuels (natural gas CNG and LNG, propane, biodiesel and power train electrification); and (3) the FE technologies recently adopted by the MD/HDV fleets. Specific FE technologies analyzed for potential safety impacts include: Intelligent Transportation Systems (ITS) and telematics, speed limiters, idle reduction devices, tire technologies (single-wide tires, tire pressure monitoring systems-TPMS and Automated Tire Inflation Systems-ATIS), aerodynamic components, vehicle light-weighting materials, and Long Combination Vehicles (LCVs). Recent crash data (for 2010 and 2011, consistent with the 2011 baseline for Phase I MD/HDV Fuel Efficiency and Greenhouse Gas (GHG) rule indicated that MD/HDV "green" fleets have similar or better crash safety records than conventional counterparts. Regulatory barriers to rapid adoption of FE technologies and alternative fuels were also identified.

- **Chapter 1** presents an overview of the study rationale, background, and key objective, which is to identify the technical and operational/behavioral safety benefits and disbenefits of MD/HDVs equipped with FE technologies and emerging alternative fuels. Recent MD/HDV national fleet crash safety statistical averages are also provided for context.

- **Chapter 2** summarizes the sparse safety findings on FE technologies and alternative fuels based on a comprehensive review of available technical and trade literature and of Internet sources.

- **Chapter 3** provides complementary inputs on potential safety issues associated with FE technologies and fuels obtained from Subject Matter Experts (SMEs) who either have experience with operating "green" truck and bus fleets, are Federal program managers, or are industry developers of FE systems for MD/HDVs. The FE technologies described in both Chapters 2 and 3 are organized by clusters of functionally related technologies (e.g., tire systems, ITS, and aerodynamic systems).

- **Chapter 4** describes a novel approach to this preliminary safety analysis of FE technologies, and presents the comparative findings from queries of both NHTSA/FARS and FMCSA/CAS crash databases for the 2010 and 2011. In spite of the modest MD/HDV fleet penetration of FE technologies, a sufficiently large group of "green" truck and bus fleets were identified and compared with the national cohort to derive statistically meaningful relative safety performance measures by crash rates and driver fitness. This crash safety analysis notes that there is no specific information in existing crash databases indicating the explicit association of vehicle crashes with particular FE technologies implemented by commercial and public transit vehicles. However, the findings from this comparative analysis strongly indicate that both truck and bus "clean fleets" that adopted FE technologies displayed superior safety performance records in the two years analyzed (2010 and 2011), relative to conventional fleet counterparts.

- **Chapter 5** uses a deterministic scenario analysis of potential safety concerns identified from the literature, or raised by SMEs. The reason is that only scant or no hard data are available on highway crashes that can be directly or causally attributed to adoption of FE technologies and/or alternative fuels. Similarly, given the limited fleets experience with operating MD/HDVs equipped with these technologies in 2010 and 2011, it was not possible to perform a quantitative risk assessment, or even a semi-quantitative preliminary hazard analysis (PHA). Thus, for each hazard scenario discussed, the source-recommended prevention or mitigation practices—including compliance with applicable NHTSA regulations and voluntary standards—is identified.

- **Chapter 6** reviews and discusses the existing Federal and state regulatory framework for safely operating MD/HDVs equipped with FE technologies or powered by alternative fuels. The review identifies any regulatory barriers to large-scale deployment in the national fleet that could delay achievement of desired fuel consumption and environmental benefits.

- **Appendices.** Additional information is provided in several Appendices:
  - The list of DOE Green Fleets and APTA Sustainable Bus Fleets available in 2012 for the initial (2010-11) safety analysis.
  - More than 550 references and web resources were reviewed for this safety analysis and are listed in the topical Bibliographies provided as Appendices:
    - Operations/Human Factors
    - Regulatory
    - Green Vehicle Deployment Bibliography
    - Safety
    - Advanced Fuels
    - Fuel Efficiency Technology

CHARGE QUESTIONS

In your written comments, please respond to the following questions.

1) Please state your overall assessment of the organization, readability, and clarity of this report, including any changes needed.
2) Does the document adequately review, present, and summarize the available data? If not, what can be improved?
3) Are methods and analyses described in this report adequately developed, well-integrated, and appropriate to the aims of the project?
4) Are the findings and conclusions adequately supported by the data?
5) Please recommend any additional key published data for vehicle technology and safety that may be relevant to this review and analysis.
6) Are the statistical methods used in the analysis appropriate?
7) What are the weakest and strongest parts of this report? Please suggest how the weakest parts of the report can be strengthened.
8) Please provide any other comments you may have on the report.
9) Based upon your review, please indicate whether you find the report: (1) acceptable as is, (2) acceptable with minor revisions, (3) acceptable with major revisions, or (4) not acceptable. Please justify your recommendation. If you find the report acceptable with minor or major revisions, be sure to describe the revisions needed.

APPENDIX C

INDIVIDUAL REVIEWER COMMENTS

COMMENTS SUBMITTED BY

Daniel Blower, Ph.D.
Associate Research Scientist
University of Michigan Transportation Research Institute (UMTRI)
Center for the Management of Information for Safe and Sustainable Transportation
Ann Arbor, Michigan

Evaluation of

Review and Analysis of Potential Safety Impacts and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels in Medium- and Heavy-Duty Vehicles

Evaluated by
Daniel Blower
Associate Research Scientist
University of Michigan Transportation Research Institute

The opinions and views expressed here are my own and do not reflect any opinions or views of UMTRI.

1) Please state your overall assessment of the organization, readability, and clarity of this report, including any changes needed.

Overall, I found the organization, readability, and clarity of the report to be very acceptable. The report is well-written, the explanations are generally clear, and the language is readily understandable. I have specific comments below for certain clarifications and corrections. I won't repeat those here. Taken altogether, I found the report to be very accessible.

2) Does the document adequately review, present, and summarize the available data? If not, what can be improved?

The discussion and tables, pages 6-9, on the current status of truck safety has the potential to be misleading because the base year, 2009, was the bottom of the recent recession. Figure 1 shows counts of fatal injuries to truck occupants, other vehicle occupants, and nonmotorists in crashes involving trucks for the last 10 years of data currently available. The chart is based on data from Table 11 in *Traffic Safety Facts, 2012* (NHTSA 2014). The 2009 was a bottom after a severe decline from 2007 and 2008. A longer period of time tells a more complete story of a recent recovery to the long term trend.

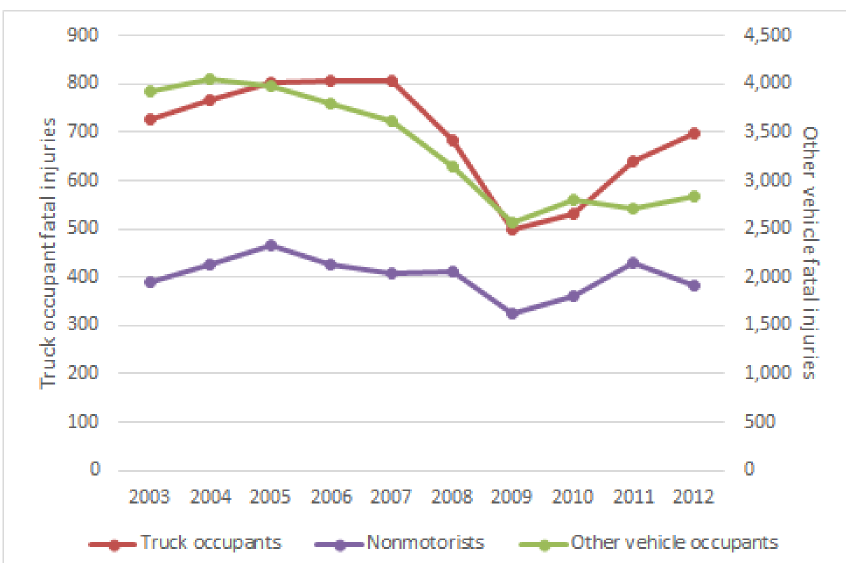


Figure 1

The coverage of the MCMIS crash file is consistently misstated throughout the document. For example, (page 93) the first paragraph after 4.2 section heading is imprecise. Reporting requirements to the MCMIS crash file are:

- Fatality in the crash, or at least one person transported for immediate medical attention (not just an injury), or at least one vehicle towed due to disabling damage.
- Truck with a GVWR over 10,000 lbs, or bus with seating for 9, including the driver.

In the MCMIS crash file, there is no qualification as to whether the carriers were in intra- or interstate. All trucks and buses meeting the relevant definition of a truck or bus, involved in a crash meeting the severity threshold, are included.

The MCMIS census or carrier file is composed of all carriers and shippers who have registered. Interstate carriers and intrastate hazmat carriers are *required* to register, but other carriers *may* register. An increasing number of States requires all their carriers (including intrastate non-hazmat) to register.

Table 1-3 is based on LTCCS data and is mislabeled. LTCCS crashes were sampled from fatal, A-, and B-injury crashes, not all crashes. One goal of the sample was to cover “serious” crashes.

Section 2.4.1.3: I’m not entirely sure what the relevance of the LTCCS data are here. For the record, the statements quoted on “causal” factors are based on the critical event variable. Unfortunately, that variable is consistently misinterpreted. Critical event was (supposed to be) coded for the error or failure or action most proximate to the crash. It is basically the last failure prior to the crash. As such, it is not the “cause” of the crash. For example, a truck may have a blowout, but the blowout could be due to underinflation, poor maintenance, loss of tread, or damage from road debris. Stress on the tire could have been compounded by speeding or overloading the cargo body. Thus, depending on the context and preceding experience, there could be a number of substantially different “causes.” The set of data collected as part of the LTCCS was intended to allow researchers to sort out the different mechanisms. In my view, it is important to use critical event in the context of all the other data collected to determine contributing factors in truck crashes. The best that can be determined from LTCCS (or any crash data set) is to identify factors that *increase the probability* of a crash, not that *cause* a crash. Please see (Blower and Campbell 2002) for more discussion of the concept of cause as well as analytical methods for LTCCS data.

Also the “87% driver error” so often cited refers to all drivers in a crash, not just truck drivers. The text does not make that clear. As written, it is correct, but could be misinterpreted by a less-than-careful reader.

Page 97: I do not believe it is accurate to characterize FARS as providing information on causality and accountability. Some variables and some code levels imply or are consistent with “causality,” but the FARS file does not attempt within FARS to assign accountability for a crash or to assign a cause or causes. Driver errors are listed, driver conditions are coded, but the file doesn’t even capture right of way.

3) Are methods and analyses described in this report adequately developed, well-integrated, and appropriate to the aims of the project?

Overall, I think the approach of using multiple methods to assess safety impacts is a good one. The fundamental problem is a lack of systematic and statistically-meaningful on-road safety data. Thus the approach of surveying existing literature; an indirect crash analysis in available crash data; and the hazard analysis, provides as much information as possible in the existing circumstances. I have reservations on the crash analysis, which are discussed below. But in principal, the broad-ranging assembly of information undertaken in the report is a good one.

There are places in the report where the methods are not described with enough detail. Here are some examples.

Table 4-1. Where does the count of power units taken from? The Census file? Is it only matched carriers (i.e., carriers with crashes in 2010 or 2011)? Or does it include all carriers? If so, you should (and probably do) know that the Census file is not purged and contains records for carriers that are probably out of business. FMCSA defines a set called “carriers with recent activity,” which are carriers that are probably still in business. That set might be used for the PU count. Or you might use just carriers with crashes, matched to the Census file on DOT number.

The discussion of the analysis of FARS data, including the match to MCMIS data, was incomplete. (Section 4.3) I’m not sure how FARS records were matched to MCMIS records. The method of matching should be described. FARS includes DOT number, which could be used in combination with other fields to link with MCMIS, but there are no hard link fields available, so there is always a level of error or uncertainty.

The word “complementing” was used in this context, but a better one might be “supplementing.” That is the usual term in crash data analysis when crash records are supplemented by matching records with data from other files.

4) Are the findings and conclusions adequately supported by the data?

Certain problems with the crash data analysis are discussed in response to question 6. In response to this question, I’ve listed some questions and comments about specific findings and conclusions.

In re: safety hazards of hydraulic hybrid vehicles (pages 45-46). A general problem is that anecdotal data are all that are available. But the goal should be some quantitative statement of the probability of an accident or other harmful event. The 15 month experience of Miami-Dade County with no reported problems is a useful data point. But it is only anecdotal. And one wonders what the experience will be when the vehicles are used as part of routine operations rather than as a pilot.

Page 75: safety considerations of truck lightweighting. The main discussion here seems to have to do with durability, not safety. I would expect two effects relative to safety: 1) reduction in truck mass will reduce crash forces to other vehicles, though this effect will surely be negligible, because the lightweighting will have only a small effect on the mass differential. Moreover, crash partners are undergoing their own lightweight.. 2) use of composites, aluminum, and fiberglass may result in less protection to truck drivers in crashes because of lower crush strength. I know of no recent studies or work on this with significant results, however. But those are the issues.

Page 82: 2nd paragraph. How is it known that the buses' quieter operating noise levels are not a safety hazard? Is it because the measured noise is still within detectible range for vulnerable road users? Or is this a matter of opinion?

Page 85: The statement that an SME said he couldn't think of a single road safety incident involving LCVs in the western U.S. needs to be qualified. I'm not sure what this means. There are plenty of LCV crashes in the western U.S. Possibly this means a safety incident that was related to the characteristics of an LCV that distinguish it from a tractor-semitrailer or STAA double, but that is highly doubtful. Triples, which almost all use A-dollies, are prone to a high degree of rearward amplification, which is related to rollover. These may be hard to identify in crash data, but as written, the meaning is not clear and could easily be misconstrued. Incidentally, carriers are likely to assign their best drivers to triples, Rocky Mountain doubles, and turnpike doubles. In addition, these configurations primarily operate on the best & safest roads, i.e., Interstate highways, so their crash rates, unadjusted to account for road type, are typically pretty good.

Page 116: In the discussion of crash hazards from detached aerodynamic fairings, I don't see how a collision with a 200 pound object at highway speeds could be described as unlikely to cause severe primary damage. If the impact is same-direction, the relative speed might be low. But in opposite-direction impacts, the relative speed of object and vehicle could easily exceed 100 miles an hour. Truck wheels occasionally break loose, resulting in collisions between other motor vehicles and the truck wheel. A truck tire and wheel can weigh 150-200 lbs. I have seen more than a few that resulted in fatalities. I think you may find some evidence in this study: (Bareket, Blower et al. 2000).

5) Please recommend any additional key published data for vehicle technology and safety that may be relevant to this review and analysis.

(Carson 2011) provides a recent (2011) review of the size and weight literature, including a judicious summary of the best recent research on the subject. The FHWA size and weight study referred to on page 60 is nearing completion. A literature review from that has been available on FHWA's website for about a year. Also, there have been a few U.S. pilot studies of safety and productivity of allowing truck combinations at over 80,000 lbs. GCW. The Idaho study is pretty good, and includes some experience on whether bigger trucks will actually reduce the number of trucks on the road. See also the report from Abdel-Rahim: (Abdel-Rahim, Berrio-Gonzales et al. 2006; Department of Transportation Idaho 2007; Department of Transportation Idaho 2013).

A few other sources that might be helpful are cited throughout this review.

6) Are the statistical methods used in the analysis appropriate?

The use of the MCMIS and FARS crash files to attempt to shed some light on the relative safety of Clean Carrier (CC) and Conventional Fleet (CF) trucks is a good one. I haven't seen much productive use of the MCMIS crash file, other than to support CSA, so this effort is somewhat pioneering. And I applaud the creativity of the authors in their attempt to get around the inadequacy of existing crash and exposure data.

However, as executed, I think the effort suffers from a number of problems that together prevent well-founded conclusions on the relative safety of CC and CF fleets.

The problems of the analysis include:

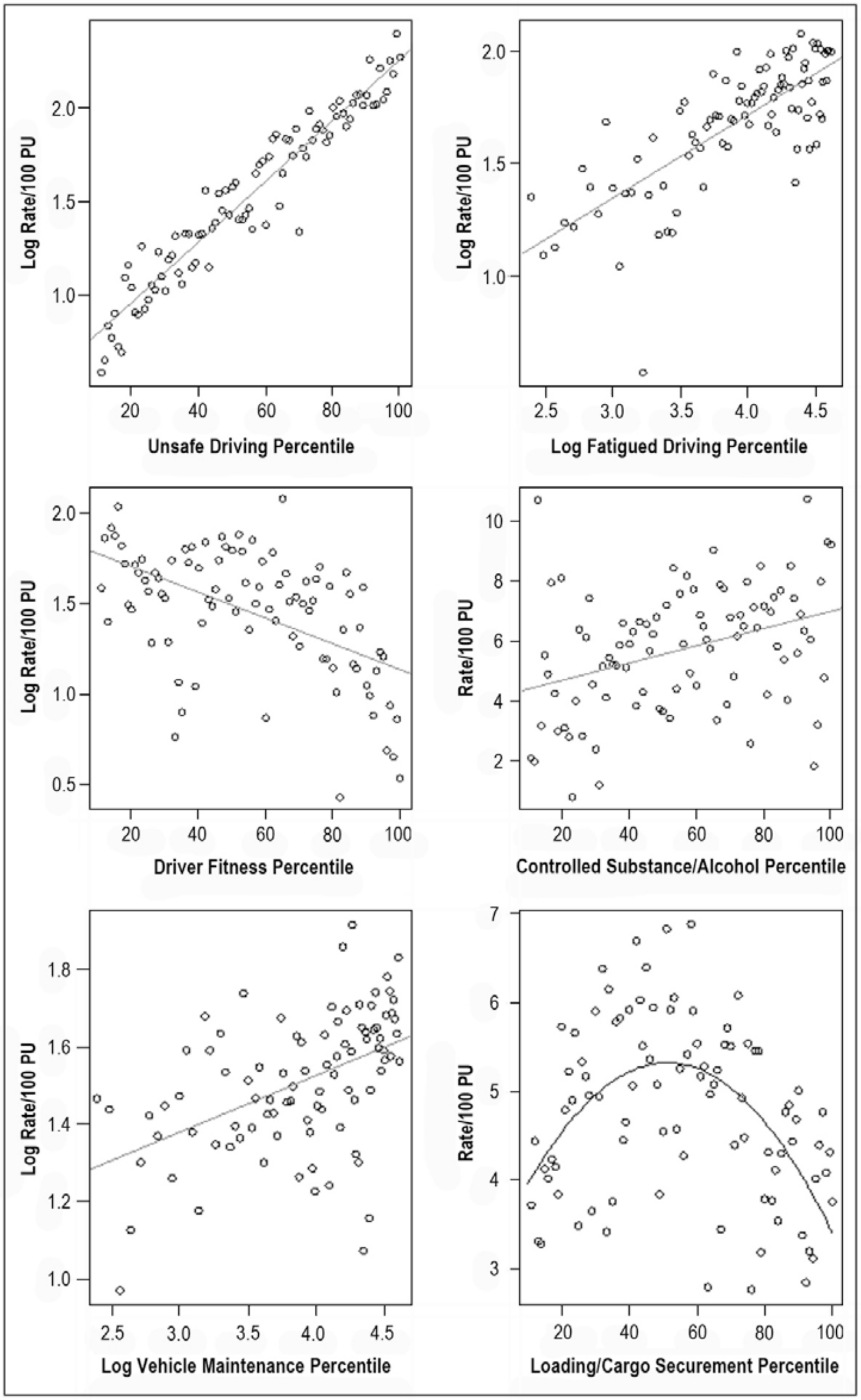
- the lack of control for confounding factors;
- the selection of populations to compare (top 10);
- the use of the Driver BASIC; and
- the use of truck registrations to normalized crash counts.

Why the restriction to the top 10 in the CC and CF populations? The justification for doing this is not clear. It looks like there are only 17 usable CC carriers. Why not use all the CC carriers? It seems a mistake to throw away data from a population that is already very small.

But 40,000 CF carriers are used for the comparison group. By choosing the top or bottom 10 from among the very large population of CF carriers, it is guaranteed that you will pick up outliers. There is always very great variability in crash rates. The requirement for at least 10 MCMIS-reportable crashes doesn't guarantee that you get the "true" underlying safety of the carrier. It'd be interesting to look at the histogram of crash rates for the CF population and look at the groups used for the comparison. In table 4-2, the 2010 crash rate for the lowest 10 CF is 5.5, for the highest 80.2, a factor of 14.6. The same spread for CC carriers is 8.25 to 21.38, a factor of 2.6. Within the CF population, the comparison top 10 or bottom 10 are outliers. The CC population may itself be outliers in comparison with the CF population, but clearly more homogenous.

The way the analysis is structured highly likely to produce an apples-to-oranges comparison.

The use of the Driver BASIC is also highly problematic. What the Driver BASIC measures should be described. I think this is the driver fitness BASIC which covers training, experience and medical qualifications. This is largely a paperwork BASIC, and not really meaningful in the context of FE technologies, where, from the discussion of several of the technologies, the critical factors are maintenance and operations. Moreover, there is substantial evidence that the Driver BASIC is only weakly related to crash rates and safety. See (Green and Blower 2011), on the safety measurement system. Here is figure 4 from page 41 of that report:



Note that amount of scatter and negative correlation between driver fitness percentile and log crash rate. A better measure would be the unsafe driving BASIC and the vehicle maintenance BASIC. Both show good correlation with crash rates, and therefore are good measures of safety. The source I've cited here is somewhat old and from the CSA pilot. I've seen updated versions though that are very similar. You might contact David Madden of Volpe for updated versions.

Another problem is the use of power units to normalize crashes. Different power unit types average radically different vehicle miles traveled (VMT). According to the FHWA *Highway Statistics 2012* (http://www.fhwa.dot.gov/policyinformation/statistics/2012/), buses averaged 19,299 miles annually, single unit trucks 12,815, and combination trucks 66,161. VMT is strongly related to crash counts.

Looking at the list of CC fleets, they are a mixture of big over-the-road carriers, which operate a lot of tractor-semitrailers and doubles, carriers that probably run a lot of single-unit trucks, and urban transit operations. But of the CF fleet, I would wager that most are combination trucks, so heavily tractor-semitrailers, which means much higher average travel. Given their higher travel, they probably have more crashes per registration. The CF carriers probably collectively have significantly different operations from the CC carriers. This potential mismatch skews the comparison.

Finally, the method as shown is unable to account for confounding factors, such as the possibility that fleets that adopt CC technologies may also be more likely to have other safety programs. This is a fatal problem and prevents drawing conclusions on the relative safety of FE technologies.

There are two general confounders. One is the use of truck registrations to normalize crash counts, because of the interaction by power unit type (tractor or SUT) and VMT. Tractors tend to have high VMT and SUTs significantly lower. Thus even if they had the same crash rates per mile, a firm with predominately SUTs would have lower rates per registration than one with predominantly tractors. The second set of confounding factors has to do with carrier operations. Carriers vary widely in their operations. Some carriers equip their vehicles with collision avoidance technologies, pay well, weed out unsafe drivers, have numerous safety training programs, and keep tight control over the operations of the drivers. Others don't have the capital or business model to buy collision avoidance technologies, don't have a safety director, etc. If CC carriers tend to also be among the latter, and CF the former, then you can't disentangle the safety of FE technologies from the other factors.

The question going forward really is whether (and which) FE technologies will be safe when widely deployed. So you need some controls for carrier operations.

I offer some ideas for overcoming the problems cited here in the answer to number 7 below.

As the report stands, as far as I can tell, there was no effective control for confounders, which really severely limits any conclusions about the relative safety of the FE technologies. The caveats listed in section 4.2.1 are well taken and appropriate. However, I can't agree that the data clearly show that CC fleets maintain high standards of safety. The data are consistent with that conclusion. However, the lack of controls for confounders; the mismatch of CF and CC fleets; the use of outliers among the CF fleets for comparison; the potentially large differences in average VMT between CF and CC fleets; and the use of a BASIC that has little correlation with safety all work to undermine confidence in the conclusion. I would put this down as not proven.

I would make the same comments on the FARS analysis as on the previous MCMIS crash analysis.

- Controls are needed for potential confounding factors. Excluding buses does offer some control for differences in operations. Another approach, though, would be to compare bus operators to bus operators (as is done in section 4.4), and to do the same for the other segments of the CC fleets.
- The top ten among CF fleets are outliers, by definition. I believe that a better approach would be to sample among CF fleets to get a statistically-sound representative set for the comparison group.
- I don't see the justification for choosing top ten among the CC fleet. There are very few to begin with. What's the point of excluding poorer performers among them.
- The driver fitness BASIC is weakly related to safety outcomes at best, and may be negatively correlated to safety outcomes. Unsafe driving and vehicle maintenance would be better. They are more directly related to safety outcomes, reflect on driver behavior and vehicle condition, both of which are issues for at least some FE technologies.

The fundamental problem is that the CC carriers are likely to be more focused on optimizing operations, and thus more likely to use various crash avoidance technologies, driver training, and monitoring to control operations. Thus, the challenge is to tease out the inherent safety of the FE technologies and to separate them from these other effects. The present analysis doesn't and can't tell us if FE technologies are safe or if they tend to be adopted by safe carriers.

Analysis of bus carriers.

- APTA is an association of public transit operators. These operations are typically local, primarily in urban areas, on regular routes, drivers on regular schedules, primarily operating on surface streets and local roads.
- The comparison group appears to be all others—probably including public transit, but also charter, tour, scheduled intercity, school bus, shuttle bus, and private bus operators, such as companies that use buses to transport employees, buses operated incidental to other businesses (like casino shuttles), and other organizations that regularly use buses, including churches.
- A better comparison would be non-signatory public transit operators. I think that comparison would be pretty good, since operational factors would arguably be similar. There remains the question of whether CC bus operators are not, from that very fact, more safety conscious than non CC bus operators.

I would agree that the analysis cannot validate the safety of FE technologies, but can reflect whether carriers that employ FE technologies safely. But the analysis may just show that the best carriers can operate FE technologies safely. But the case may be different when the technologies are deployed more widely. The question for future, widespread deployment of FE technologies is, can average carriers operate the technologies safely?

The discussion (page 101) of whether widespread deployment of FE technologies would pay off in safety benefits and reduce the overall crash rate raises the question of just how FE technologies as such could reduce the number of crashes? What is the mechanism by which this would occur? How does using CNG or LPG help avoid crashes? Speed limiters, telematics, and driver training are the only FE things that seem clearly to have the potential to increase safety. This speculation actually leads me to think that the lower crash rates observed (leaving aside questions of the validity of comparison groups and the metrics of comparison) may actually indicate that safer carriers are adopting FE technologies, not that FE technologies make the carriers safer.

7) What are the weakest and strongest parts of this report? Please suggest how the weakest parts of the report can be strengthened.

The strongest parts of the report is the description and discussion of the various technologies. I found that comprehensive and informative. The description of the safety considerations for each technology appears to be quite comprehensive. In addition, it appears that a very large body of anecdotal evidence reflecting on safety has been assembled.

The weakest is the analysis of crash data. The grounds for that view are discussed above. Here I will suggest some ideas that might help overcome the weaknesses identified above.

To address the problem of confounding:

- Attempt to match the comparison CF fleets as well as possible in terms of operations to the CC fleets. Use data from the MCMIS Census file to classify CC fleets in terms of operating authority, area of operations; types of drivers employed; types of trucks (tractors or straight trucks) operated; types of cargo carried; types of trailers (largely tankers or others).
- Then use this information to define arguably homogenous groups of CC carriers. Public transit bus operators is one obvious group. Others might include large over-the-road for-hire carriers that haul general freight and use mostly tractors; local private operations that use SUTs; and so on.
- The characteristics of these groups could then be used to identify populations of CF carriers in the MCMIS Census file. You will have sets of CC carriers clustered into homogenous groups, and sets of CF carriers classified into groups with the same or similar characteristics.
- At this point, you could do one of two things:
    - Compare crash rates as is, between comparable CC and CF fleets. They are arguably from similar populations in terms of operations. Assuming they are matched on the predominant fleet power unit type (tractor or SUT), the problem of using truck registrations rather than VMT is reduced.
    - Do a survey of CC and CF fleets to collect data on their operations. What safety programs do they use? What crash avoidance technologies are on the trucks? Do they have a safety director? Etc. Obviously you couldn't do this survey on thousands of CF fleets, but I think you need to do some sampling from among the CF fleets regardless. If you sampled 60 or 100 CF fleets for your comparisons, a phone survey would be very doable.

At this point you will have done about all that's feasible to address confounds. You will be closer to apples-to-apples than in the report.

To address the problem of using outliers in the CF fleet:

One strategy could be to randomly sample 60 or 100 carriers from the CF population and compare them to the 18. The purpose would be to reduce spurious statistical associations because of the very large population of CF carriers and small number of CC carriers. Comparison groups are typically three times larger than case. You could draw a stratified random sample from the MCMIS Census file. Then compare mean crash rates and BASIC scores of the CC and CF groups. The problem of using the top 10 from a population of 40,000 is a little like investing in mutual funds with the highest return for the previous year. They change from year to year because they are outliers.

Match the CF fleet to the CC fleet on the data you have on CC fleets in the Census file. One could match the comparison CF fleet to the CC fleet by operating authority, fleet size, number of drivers, number of straight trucks, number of tractors, commodities carried, etc. Then draw samples from the groups and use those samples in the comparison.

To address the problem of using a weak BASIC:

Use the unsafe driving and vehicle maintenance BASICs. Both are clearly related to carrier safety. They are based on more data than most of the other BASICs. And they reflect characteristics that are germane to the problems of operating FE technologies safely and responsibly.

To address the problem of using truck registrations to normalize crash counts:

Use VMT, or at least explore the use of VMT. Carriers are on a program of updating their information every two years, including trucks and miles. You would have to check for missing data and for plausibility (mean and range of average miles per truck), but VMT is a much better measure of exposure for crashes than registrations. You can partially address this if you form your comparison groups by predominant power unit type (tractor, SUT, or bus). But you would nail it using VMT, if that's possible.

8) Please provide any other comments you may have on the report.

Page 1, third paragraph, acronym should be CSA, though actually it should be the MCMIS crash database. That database is used by CSA to compute the Crash Indicator BASIC, but it is not the CSA crash file.

Page 6, second full paragraph: The fatality rate for trucks and buses in 2009 must be off by a factor of about 10. The rate for trucks, per 100 million miles was 1.11. The injury rate for trucks was in 2009 was 19. The injury rate for passenger cars was 100. I think the numbers in this paragraph have gotten garbled somehow. Please see (NHTSA 2014), table 3, page 20 or so.

In the bullet points, the rates should be identified as per 100 million VMT.

Page 13, last paragraph, it should be Natural Gas, not National Gas.

Page 43, second sentence in the last paragraph has too many or not enough words. I think the problem is in the region of "… bus fire problems…".

Page 58: The technical term for the "sway" identified as a safety-related performance characteristic of LCVs is "rearward amplification," which might be preferable here. The term refers to the fact that lateral forces are increased in multi-trailer trucks with each succeeding trailer, so that the last trailer in a combination can experience much higher lateral acceleration in maneuvers than preceding ones. The word "sway" seems to be to be less descriptive. To me, it calls to mind movement in the vertical plane.

This link goes to an excellent source on the relation of physical performance characteristics and safety: http://www.fhwa.dot.gov/reports/tswstudy/vehiclsaf.htm. I would say this is a canonical source.

I would be cautious about the references to CRASH, CABT, and OOIDA (page 58). They are advocacy organizations, with little scientific credibility. I know that the paragraph merely identifies them as organizations that have taken positions and made claims. Some of the claims may have scientific foundation. But the organizations themselves are advocacy and I would be very cautious about any implication that they are authorities. There are plenty of other credible sources that can be used to make any valid point that any of them may make.

Page 59: The statement that one combination vehicle causes wear equivalent to 2,000 to 3,000 cars is too categorical. It may, depending on the number of axles, load distribution, and so on, as the next sentence indicates. You might consider saying it *may* cause wear equivalent…

Page 59, the citation for "Safety performance of longer combination vehicles relative to other articulated trucks" (footnote 272) has some errors. The authors should be Jonathan D. Regehr, Jeannette Montufar, Garreth Rempel. Regehr is the first author.

Page 81: should be "with regard," not "for regard…" 2nd to last paragraph.

Page 97, first paragraph of 4.3, the MCMIS crash file is not limited to interstate or intrastate hazmat carriers. Crash file includes all qualifying vehicles in a qualifying crash. The MCMIS Carrier file includes only carriers who register. Interstate and intra-state hazmat are required to register, but others do as well.

Page 103: Is the reference to the 2007 FMCSA report correct? The footnote seems to be to the 2006 report. I tried following the link and it is no longer valid. Citations by author, title, date can be supplemented by hyperlinks, but not replaced. Also, is the reference to Figure 5-2 in the last paragraph of page 103 to Figure 5-2 in the footnoted report? The discussion in the text doesn't seem to be appropriate to Figure 5-2 on page 104.

I found an FMCSA page that has the statistics on brake and tire problems. (The link in the references section of the report is now broken.) A minor point: Associated factors were coded if present. Coding a factor did not indicate that the factor was "causative." Trucks and drivers could have more than one factor coded. A truck could have both brake and tire problems; similarly the driver could be coded as too fast for conditions and the truck could have had brake problems. The percentages are not additive.

Page 107: CBG should be CNG in the second bullet point.

Page 111, first full paragraph: Sentence beginning "Various carbon-fiber reinforced polymers…" seems to be missing a verb in the second clause. Or maybe there is an extra comma after steel.

Page 112: the acronym PCIV is not included in the list of acronyms on pages xi-xiii.

Comment on section 5.2.3: Fire is the most harmful event for trucks in about 0.2% of crashes (based on FARS plus GES for 2010-2012). But fire occurs in around 7% of fatal truck crashes (I don't have a figure for all truck crashes handy.) The flammability of certain light-weighting materials could possibly be a significant issue if it turns more of the 7% of fires into the most harmful event to the truck in a crash.

Page 123: The sentence beginning "Below in Section 6.2-6.9, the potential…" seems to be missing a verb.

Page 128: Sentence in last paragraph: "However, this was most significant for vehicles ABS." Possibly the word "without" is missing between vehicles and ABS. I'm not a tire expert, but I'm surprised that ABS adequately mitigates the lower traction. The wheel may not lock in hard braking, but the lack of traction remains.

Comment on the possibility that light-weighting may drive truck manufacturers to go to disc brakes: (Pages 129-130) That would be a very good thing, resulting in improved braking, lower rates of out of adjustment brakes, less brake fade, better stopping power.

9) Based upon your review, please indicate whether you find the report: (1) acceptable as is, (2) acceptable with minor revisions, (3) acceptable with major revisions, or (4) not acceptable. Please justify your recommendation. If you find the report acceptable with minor or major revisions, be sure to describe the revisions needed.

Acceptable with major revisions.

In my view, the crash data analysis needs to be substantially revised. I recognize the difficulty of using available data, but the problems with the analysis are fatal to any persuasive conclusions. I have suggested some techniques that could address the issues identified.

I've also pointed out a number of minor changes that should be made to correct a few errors of substance and form.

Other than the crash data analysis and handling of some of the data files, I find the report to be an impressive survey of existing literature and knowledge of the safety FE technologies. I don't see any major gaps. I do believe that the crash analysis problems must be addressed though. And I think they can be, which would strengthen the report.

References

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Carson, J. (2011). Directory of Significant Truck Size and Weight Research. Washington, DC.

Department of Transportation Idaho (2007). Three-year Report to the 59th Idaho Legislature on the 129,000 Pound Pilot Project, 2007 revised.

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COMMENTS SUBMITTED BY

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OVERALL ASSESSMENT:

I find this report acceptable with major revisions. The issues that must be addressed include:

- Editing to improve clarity
- Correction of factual inaccuracies and misleading statements
- Strengthening of crash data analysis in Section 4

The required revisions to make the report acceptable are noted below in response to the charge questions.

1. **Please state your overall assessment of the organization, readability, and clarity of this report, including any changes needed.**

The over-all organization of the report is clear and understandable. However, in many places the text of specific sections is confusing and would benefit from additional editing for clarity. Often the report appears to be compiling statements or thoughts from disparate sources, and thus with slightly different emphasis or even slightly contradictory information, with insufficient introduction or summary language to draw the reader's attention to the specific point(s) being addressed. The report includes a lot of good data but there is no enough "connective tissue" to allow the reader to easily assess the data. Some sections are also repetitive, with essentially the same information repeated multiple times in succession; rather than strengthening the conclusions this unnecessary repetition is confusing.

Some specific areas of the report which require attention to improve clarity and readability are:

Section/Pg Num	Current text	Comments
Sec 1.2 / pg 5 -6	Discussion of M/HDV crash, injury, and fatality rates	This entire section is confusing because there is a lot of data presented without adequately setting the stage for the reader as to how to interpret the data. It is stated that there is a long term trend of improved safety, but the recent data presented in detail belies that assessment (data in tables 1-2, 1-3, and 1-4 indicate that large truck crashes, deaths, and injuries all increased from 2009 – 2011). This entire discussion should be more concise and consistent. For example, something like: "NHTSA and FMCSA crash statistics show a long-term trend of improved safety, with total annual injuries and fatalities from trucks and buses involved in crashes falling by __% and __% respectively between 1999 – 2009. Due to an increase in total VMT over that time frame the rate of injuries and fatalities was reduced even further – with fatalities per 100 million VMT falling from __ in 1999 to __ in 2009. However, there has been an increase in

		fatalities from large truck crashes in recent years. Total fatalities from large truck crashes were 3,380 in 2009, rising to 3,686 in 2010 (+9%), and 3,757 (+2%) in 2011. Nonetheless, large trucks continue to have a better safety record than the light-duty fleet. In 2009 the fatality rate for large trucks and buses was 0.123 per 100 million VMT, compared to 1.14 for the entire fleet, including cars and light trucks. Similarly, the crash injury rate in 2009 for large trucks and buses was 3.15 per 100 million VMT, compared to 75.1 for the entire fleet." I would also suggest adding another table, with the same format as Table 1-4, but showing crash, injury, and fatality rates (per 100 million VMT) rather than annual totals. In addition to lines for "large trucks" and "buses" this table should include data for "light duty vehicles" or "entire fleet" for comparison.
Sec 1.2 / pg 10	Bulleted list of "recent DOE data"	This is labeled as "Recent DOE data on MD/HDVs by type, <u>fuel</u>, and fuel efficiency", however, in the following bullets there is no information about fuel type of the vehicles. It also might be more effective to include this data in a table rather than text.
Sec 2.2.1.3 / page 19	Discussion of safety considerations of CNG fueled MD/HDVs	At the top of page 19 there is a statement about the number of CNG and LNG fuel stations in the U.S. In the middle of a discussion of CNG/LNG fuel properties and safety concerns this seems out of place. This type of information would be a better fit for section 2.2.1.1, Penetration/ Adoption. On the top of page 25 (section 2.2.1.4) there is a good (brief) summary of the "Hazards relating to LNG" – a similar summary of the "hazards relating to CNG" should be added to section 2.2.1.3, including: "fire, thermal explosion if release is into enclosed space, mechanical rupture of pressure vessel, and asphyxiation (by displacing oxygen). Gas release can be from fuel system leak or from activation of a PRD. Ignition can result from contact with hot surfaces, open flames, and sparks, including

		static electricity”. On page 26 there is a discussion of codes (NFPA 57) applicable to design and manufacture of LNG vehicles. A similar discussion of codes applicable to the design of CNG vehicles should be included in Section 2.2.1.3. The most relevant code in the U.S. is NFPA 52, *Vehicular Gas Systems Code*, National Fire Protection Association, 2010. There is also a recommended practice from the Society of Automotive Engineers, SAE J2406, *Recommended Practices for CNG Powered Medium and Heavy-Duty Trucks* (March 2002). I should also note that the most recent addition of NFPA 52 (2010) incorporates updated content from NFPA 57 relative to LNG vehicles in Chapter 11. For a complete discussion of codes, standards, and best practices relative to both CNG and LNG vehicles see: FMCSA-RRT-13-044, *Natural Gas Systems: Suggested Changes to Truck and Motorcoach Regulations and Inspection Procedures,* Federal Motor Carrier Safety Administration, March 2013
Sec 2.4.1 / pg 47	First paragraph of the section	This section launches into a discussion of a specific “fleet telematics” system (Telogis) without first providing an overview of what “driver and vehicle monitoring” or “telematics” means in the context of this report. As with other technologies this section should start with a general definition and description of the technology, including: the types of vehicle and driver information that is typically gathered, the on-board and off-board equipment required, and the typical uses of the information. Discussion of stated benefits from the Telogis system (or other systems) should be included in section 2.4.1.2 (benefits).
Sec 2.4.1.1 and 2.4.1.2 / pg 47 – 48	GreenRoad	This section mentions penetration numbers and benefits from a single manufacturer (GreenRoad) without providing over-all context for the industry; i.e., how many different

		manufactures are there (my understanding is that there may be hundreds), what is the range of capability for different systems, what types of commercial vehicles are most likely to have telematics systems, and what is the penetration rate for the commercial vehicle industry as a whole (again, it is my anecdotal understanding that a very high percentage of the 1 million+ long-haul tractors on the road are equipped with some type of telematics or driver/vehicle monitoring system). There must be some industry statistics available.
Sec 2.5.1.3 / pg 51 - 52	"The crash rate for trucks without speed limiters was 5 crashes per 100 trucks/yr, compared to a much lower 1.4 per 100/trucks per year crash rate for trucks equipped with speed limiters. The study showed the overall crash rates for trucks without speed limiters was higher…."	This section is very confusing because it is not clear to the reader what the difference is between "crash rate" and "over-all crash rate". Are the first set of numbers referring to the rate of fatal crashes and the second set referring to the rate of all crashes (both fatal and non-fatal)? It is not clear. Throughout the report the authors should adopt consistent but different terms for the rate of crashes that result in a fatality (fatal crash rate) and the rate of all crashes including those that are not fatal (crash rate or overall crash rate).
Sec 4.1 / pg 91 Sec 4.2 / pg 93	"The FMCSA Motor Carrier management Information Systems (MCMIS) includes state-reported records of all crashes involving MD/HDVs operated by interstate or intrastate Hazmat carriers, and tow-away, injury or fatality"	The full meaning of this sentence is unclear due to awkward construction. As written it sounds like the records are only from Hazmat carriers, not all carriers. Also it initially reads like the "tow-away, injury or fatality" is another category of carrier. I believe that this construction would be clearer: "The FMCSA Motor Carrier management Information Systems (MCMIS) includes state-reported records of all crashes involving MD/HDVs operated by interstate carriers, or by intrastate Hazmat carriers, which resulted in a tow-away, injury or fatality."
Sec 4.1 / pg 92	"The NHTSA Fatality Analysis Reporting System (FARS) includes a much more extensive dataset than MCMIS, including conditions at the time	This sentence is confusing because the phrase "much more extensive" could be read as meaning "more individual crash records". Also, the entire description of FARS does not really address the exact overlap of FARS and MCMIS.

	of the crash , and events preceding and following the crash".	I believe that something like this would be more instructive to the reader: "While MCMIS contains records for all crashes in which there was an injury, fatality, or a vehicle needed to be towed away, the NHTSA Fatality Analysis Reporting System (FARS) only contains records of crashes in which there was a fatality. As such, FARS contains many fewer records than MCMIS, but each FARS record has more data about the crash than is contained in MCMIS, including conditions at the time of the crash, and events preceding and following the crash. In theory, every crash included in FARS is also included in MCMIS, but many of the crashes included in MCMIS are not included in FARS. For the crashes that are included in both databases, FARS includes more information about the conditions leading to the crash, but MCMIS contains more information about the carrier that was operating the vehicle involved in the crash".
Section 4.2 – 4.3 / pg 91 - 99	Entire section	The use of the abbreviation "CF" for Conventional Fleet and "CC" for clean carrier is very confusing because "CF" could easily stand for "clean fleet". The entire discussion would be much easier to follow if you did away with the abbreviations and consistently referred to "Clean Fleets" and "Conventional Fleets" or to "Clean Carriers" and "Conventional Carriers"
Sec 4.2 / pg 94	Table 4-1	Neither in the table header nor in the text is the definition of "crash rate" given (annual crashes per 1,000 fleet vehicles) – it is not defined until two pages later in Table 4-2
Sec 4.2 / pg 95	Table 4-2	This table should be separated into two tables, one for FY2010 and one for FY2011, as was done in section 4.3 (Tables 4-3 and 4-4). The data would be easier to interpret that way.
Sec 4.2 / pg 95	Use of DRIVER BASIC Scores	The text indicates that a carrier's DRIVER FITNESS BASIC score is indicative of a carrier's safety risk relative to other carriers. However there is no description of how this score is calculated, so it is impossible to evaluate the

		utility of using this score for ranking Clean Carriers and Conventional Fleets in this analysis. If the BASIC score is primarily determined based on the carrier's crash statistics, then it should by definition be highly correlated with the crash rates calculated for each fleet in this analysis – so including it here would seem to have little utility (i.e., a carrier with a high BASIC score would automatically have a high crash rate). If it is calculated based on some other information it would be very helpful to the reader to understand what that information is. At the end of the day it is very hard to interpret the results shown in table 4-2 comparing the crash rates of Clean Carriers and Conventional Fleets with the highest and lowest driver BASIC scores – the text does not really explain why this metric was used or how to interpret the results.
Sec 4.3 / pg 97	Entire section	The consistent use of the term "crash rate" in this section is confusing because the results are different than the "crash rates" discussed in Section 4.2. In this section, and whenever discussing the results of FARS analysis, the term "fatal crash rate" should be used to distinguish the FARS results from the results of the MCMIS analysis.
Sec 5.1 / pag 103	"Some risk levels related to vehicle operation can be transferred (via insurance coverage), or if considered negligible and routinely accepted as the cost of doing business"	This sentence does not make sense. Did the author's mean: "Some risk levels related to vehicle operation can be transferred (via insurance coverage), or if considered negligible <u>are</u> routinely accepted as the cost of doing business."?
Sec 5.2.3 / pg 111	"… some SMEs raised potential safety concerns regarding the fire safety and flammability of used as automotive light weighting materials."	This sentence is incomplete – concerns about "what" used as light weighting materials?

Sec 5.2.6 / pg 116	"There is no reason to expect that larger scale adoption of aero devices on Class 8 tractors will lead to a higher probability of occurrence for highway fairing detachment incidents and resulting crashes"	This sentence is not true. While there is no evidence or theoretical reason why larger scale deployment will increase the probability that any single aero device will detach and cause an accident, there is absolutely reason to believe that larger scale deployment will increase the overall "probability of occurrence of (one or more) fairing detachment incidents and resulting crashes" because there will be many more individual devices on the road which could fail. Probability of occurrence = Probability of single device failure x number of devices.
Sec 6.4 / pg 125	"There are no major regulatory barriers…the potential energy savings and efficiency benefits outweigh this barrier."	These thoughts are contradictory. If there is no barrier then what is outweighed by the benefits?

2) Does the document adequately review, present, and summarize the available data? If not, what can be improved?

All of the individual sections provide a significant amount of information from many different sources, but in some sections the text is choppy and not well-integrated. It reads like a collection of quotes with little attempt to integrate them into a cohesive narrative. Examples include sections: 1.2, 2.2.1.3, 2.4.1, 2.5.1.3, 4.1, 4.2, and 4.3. See the response to question 1 for specific examples.

In addition, there are a number of incorrect or misleading statements in the report – see the response to Question 8 for specific examples.

3) Are methods and analyses described in this report adequately developed, well-integrated, and appropriate to the aims of the project?

I do not believe that the methodology used to identify differences in crash rates between trucks with and without fuel efficiency and alternative fuel technologies (section 4) was as robust as it could have been given available data. As described further below, this analysis could be improved by modifying the methodology in the following four ways:

1) Use EPA records of SmartWay™ participants to potentially identify additional "Clean Carriers",

2) For identified "Clean Carriers" with more than one division or affiliate (as identified by DOT number) utilize carrier-provided or third-party information on technology deployment by affiliate or geographic region to identify which of the divisions or affiliates are most likely to be "clean" and only include those divisions or affiliates in the analysis as "clean carriers".

3) Normalize the data on crash rates for "conventional fleet" carriers by fleet size (trucks/fleet) to better match the range of fleet sizes of the comparative "Clean Carriers"

4) Use the vehicle VIN number to identify some of the alternative fuel and/or fuel efficiency technologies included in specific vehicles involved in crashes.

SMARTWAY Fleets:

For this analysis potential "Clean Carriers" with assumed higher adoption rate for alternative fuels and fuel efficiency technologies were identified based solely on membership in the DOE National Clean Fleets Partnership. This list included 17 separate companies with a total of 100 divisions or affiliates, as denoted by unique DOT number.

Since 2004 EPA has operated the SmartWay program, a voluntary public-private partnership designed primarily to reduce fuel use and GHG emissions from the U.S. freight sector. Over 3,000 shippers, truck fleets, and rail companies are members of SmartWay (EPA-420-F-14-003). SmartWay members agree to annual goals to reduce GHG emissions from their operations, and they provide detailed annual reports to EPA as to progress, including information about the techniques/technologies used to meet their goals. In order to maintain confidentiality of competitive information, not all data submitted by SmartWay companies is made public, but it is available to EPA staff.

Based on published SmartWay reports, or discussions with EPA staff in charge of SmartWay, it is very likely that the authors of this report could identify additional truck fleets with higher than average adoption rates for alternative fuel and fuel efficiency technologies, to include as additional "Clean Carriers", thus potentially significantly increasing the total size of this comparative data set.

Better Screening of Clean Carrier Divisions and Affiliates

Many fleets that are early adopters of technology concentrate their alternative fuel or advanced technology vehicles in only a handful of locations rather than spreading them evenly across their nation-wide operations. The report authors identified 100 different divisions or affiliates of the 17 companies in the DOE National Clean Fleets Partnership, and treated each of these entities as a separate "Clean Carrier". For example, the report indicates that ten different FedEx divisions were included. However, it is very likely that the alternative fuel and advanced technology trucks currently operated by FedEx are concentrated in only one or two of these 10 divisions. For example, the vast majority of natural gas and electric trucks currently in the fleet are concentrated in California, and to a lesser extent in Texas and New York. Based on published reports, news articles, company websites, or discussion with company fleet managers it is likely that this subset of 100 potential clean carriers could be reduced to a smaller number of carriers with a much greater likelihood of actually having a higher than normal adoption rate of alternative fuel and fuel efficiency technologies.

Normalize Crash Rate Data by Fleet Size

As shown in Table 4-2, the ten "Clean Carriers" with the lowest crash rates in 2010 and 2011 had 119,714 and 206,686 power units in their fleets respectively. This is an average of almost 12,000 power units per fleet for 2010 Clean Carriers and almost 21,000 power units per fleet for 2011 Clean Carriers. By comparison the average fleet size for the 10 “Conventional Fleets” with the lowest crash rates was 1,800 in 2010 and 2,200 in 2011 – so the Clean Carriers were much larger fleets (10x) than the Conventional Fleets to which they were compared. For carriers with the highest crash rates the results are similar. The text indicates that there were 40,000 Conventional Fleets included in the analysis – presumably a large number of these fleets were very small.

In general, one would expect that larger fleets would have better and more sophisticated maintenance and driver training programs, so a comparison of fleets of such different size ranges may introduce a significant uncontrolled variable into the analysis – i.e., in general, larger fleets would be expected to have lower crash rates regardless of any positive or negative effects from vehicle technology choice. The authors should test this theory using the entire crash data set arranged by fleet size rather than presumed Clean or Conventional carrier status. If there is a significant positive correlation of crash rate and fleet size then the sub-set of Conventional Fleets compared to the Clean Carriers for this analysis should only include fleets with a similar range of fleet size as the clean carriers (i.e., very small conventional fleets should be removed from the analysis).

A similar analysis to evaluate correlation between fleet size and crash rate, and if necessary normalization by fleet size, should be conducted for the Bus Fleet data discussed in section 4.4.

<u>Identify Vehicle Technology by VIN Number</u>

The text description of the MCMIS database indicates that for each crash it includes the Vehicle Identification Number (VIN) of the vehicle involved. While not comprehensive as to vehicle fuel type, technology, and other characteristics, VIN numbers do encode a lot of information that could potentially be used to identify specific crashes involving vehicles that are operated on natural gas and/or include some fuel efficiency technologies. This data could be used to inform a more instructive comparative analysis of crash rates.

Some of the information that is encoded in each VIN includes: vehicle model year; vehicle make and model; engine make and model; and body configuration.

At a minimum the following relevant vehicle attributes can be identified using the vehicle VIN number:

- Natural gas vehicles: identified based on engine make and model
- Hybrid vehicles: some (but not all) manufacturers may also encode information that would allow one to identify some vehicles as hybrid-electric.
- Automatic speed limiters: Based on engine make, model, and model year (though it could not be determined whether an available speed limiter was in use at the time of the crash).
- Cab-mounted Aerodynamic features (gap fillers, roof fairing, bumper): based on vehicle make, model, and model year

While VINs follow a standardized format specified by NHTSA, manufacturers are given leeway to encode some attributes based on non-standardized values for certain positions in the over-all VIN. As such, VIN decoding can take some effort. However, there are third-party software and services available that could be used to decode VINs from specific vehicles in the crash database. For example, R.L. Polk & Company maintains a TipNet™ database of all trucks registered in the US, based on data provided by state motor vehicle departments. In their database Polk has decoded all vehicle VINs to provide a significant amount of detailed information about each truck.

In addition, the report notes that relative crash rates between carriers could be affected by factors other than fuel economy technologies, including “newer vehicles”. Since the VIN encodes vehicle model year, this data could be used to evaluate the model year distribution of crashes attributed to each carrier in the analysis, and if necessary to normalize crash rates by model year ranges in order to account for this factor.

4) Are the findings and conclusions adequately supported by the data?

In general, the findings and conclusions of this report are supported by the data cited.

However, these findings and conclusions are hard to find because they are distributed throughout the various sections of the report and are not concisely summarized anywhere. The Executive Summary should include a brief description of the general findings and conclusions from each section of the report - Literature Review, SME Inputs, MCMIS & FARS Analysis, Scenario Hazard Analysis, and Regulatory Analysis – and from the project as a whole. The current executive summary only discusses the process and data sources used to develop the report, and the structure of the report, and it does not summarize the findings in any way.

5) Please recommend any additional key published data for vehicle technology and safety that may be relevant to this review and analysis.

See specific recommendations in response to question 1 and question 8.

6) Are the statistical methods used in the analysis appropriate?

I do not have the expertise to evaluate this question.

7) What are the weakest and strongest parts of this report? Please suggest how the weakest parts of the report can be strengthened.

The weakest part of the report is Section 4. See the response to Question 3 for how this can be strengthened. In addition, a number of other sections of the report are confusing and should be further edited for clarity; see the response to Question 1 for specific suggestions.

8) Please provide any other comments you may have on the report.

The following comments relate to inaccuracies or omissions in the existing report.

Section/Pg Num	Current Text	Comments
Sec 2.2.1.1/ pg 12	Paragraph 2: “**Large vehicles are necessary** to accommodate the cryogenic fuel tanks used to store LNG” ….”LNG is **better suited to local**	These statements are inaccurate. As pointed out in the text, an LNG tank is approximately 2x larger than a diesel tank holding the same energy content, while a CNG fuel system is approximately 6x larger. Vehicle size itself therefore has nothing to do with adoption of LNG versus CNG (in fact, a “larger vehicle” could potentially more

	applications such as urban transit buses…”	easily accommodate an even larger CNG fuel system than an LNG system). It is also not true that LNG is best suited to local applications. LNG systems are typically more expensive than CNG systems, as is the fuel itself. Therefore in practical terms one will utilize LNG only if one cannot get enough CNG fuel onto a vehicle (due to space constraints) to give the necessary daily range. CNG vehicles can typically go 300 miles before needing to be refueled, so ONLY vehicles than need to have more than 300 miles daily range will be LNG. Most fleet vehicles used in local, return-to-base service (including most transit buses, refuse haulers, and urban P&D trucks) go less than 300 miles per day and can therefore be CNG. Virtually the only trucks that are now being considered for LNG are regional haul and long-haul trucks.
Sec 2.2.1.1/ pg 13	“Even though natural gas has long been used to power vehicles, **only about 0.1 percent is currently used** for transportation fuel.”	It is not clear what the 0.1% refers to: is it “0.1% of current US natural gas production is used for transportation fuel”, or is it “0.1% of current fuel used for transportation is natural gas”?
Sec 2.2.1.1/ pg 13	“Compressed natural gas (CNG) consumption has increased steadily…”	“Compressed natural gas (CNG) consumption <u>for transportation</u> has increased steadily…”
Sec 2.2.1.1/ pg 13	“… by personal or fleet **dual-fueled** vehicles…”	Duel-fueled vehicles are not defined
Sec 2.2.1.1/ pg 13	“… which amounts to less **than one tenth** of the 15 million Natural gas Vehicles globally.”	“Which amounts to less than <u>one percent</u> of the 15 million….” Also, it should be noted that the vast majority of NGVs currently on the road globally are light-duty vehicles, not MD/HDVs
Sec 2.2.1.2 / pg 17	“One gallon of LNG contains about 60% of the energy in a gallon of diesel fuel, while CNG contains only about 30%”	“…while CNG <u>at 3,600 pounds per square inch (psi) pressure</u> contains only about 30%”. The volumetric energy density of CNG depends of the pressure to which it is compressed.
Sec 2.2.1.2 / pg 17	“Several recent studies, such as those conducted by CARB, concluded that **natural gas fuels** can	The data shown in Figure 2-3 on page 18 indicates that GHG emissions from CNG are 21% lower than GHG emissions from diesel and that GHG emissions from LNG are only 3% lower. In addition, Argonne National

	reduce greenhouse gas emissions by 20-30% compared to diesel and gasoline”	Laboratory’s GREET 2013 model indicates that, using US national default assumptions, wells-to-wheels GHG emission from various fuels are as follows: Gasoline – 18,067 g/mmBTU Diesel – 20,033 g/mmBTU CNG - 17,013 g/mmBTU LNG – 18,201 g/mmBTU As such, the GREET model - which is consistent with EPA’s national GHG inventory and is generally used by most government agencies - indicates that CNG has 6% lower GHGs than gasoline and 15% lower GHGs than diesel, while LNG has 0.7% higher GHGs than gasoline and 9% lower GHGs than diesel. A more accurate statement regarding the GHG benefits of natural gas fuels for MD/HDV vehicles would therefore be: “Assessments of the greenhouse gas benefits of natural gas fuels vary, but they generally show that on an energy basis (grams per million BTU or grams per megajoule) CNG has 15-20% lower GHGs than diesel fuel, while LNG has 3 – 9% lower GHGs. The lower benefits from LNG are due to a higher energy requirement for liquefaction of LNG compared to compression of CNG. However, natural gas engines typically have lower efficiency than diesel engines, so some of the GHG benefit of natural gas fuels is reduced in practice – i.e., gram per mile GHG reductions from the use of natural gas fuels instead of diesel will be lower due to greater fuel use per mile.”
Sec 2.2.1.3 /pg 18	“Natural gas has a **limited range of flammability** – it will not burn in concentrations below about 5 percent or above 15 percent when mixed with air. **Gasoline and diesel burn at much lower concentrations** and ignite at lower temperatures”.	These statements are misleading with respect to the fire and explosion hazard of natural gas relative to gasoline and diesel fuel. The flammability range of diesel fuel is 0.6 -7.5 percent in air while the flammability range of gasoline is 1.2 – 7.1 percent. While the lower flammable limit of both gasoline and diesel fuel are “lower” than for natural gas, both of these fuels also have a “limited range of flammability” – in fact the flammable range of both these fuels is narrower than for NG. However, neither of these points are particularly relevant to this discussion – all three fuels have a flammability range that in practical terms would result in the possibility of a leak from a vehicle fuel system creating a fire and explosion hazard, and with respect to real world fire and explosion hazards all three fuels are very similar.

		Of greater importance to the discussion of relative hazards is the fact the natural gas is very buoyant - this is mentioned, but the ramifications of this fact on leak behavior are not really explored. Unlike diesel and gasoline leaks, which puddle on the ground and can create an on-going hazard over a wide area, leaking natural gas tends to rise and dissipate to non-hazardous levels quickly, with only a short, vertical column directly above the leak in which the gas mixture is flammable. Unlike gasoline and diesel leaks, natural gas leaks therefore pose little fire or explosion risk if the gas is leaking into open air. However, if the leak is into an enclosed space (either a building or an enclosed space on the vehicle) the resulting fire and explosion hazard can be significant, depending on the size of the leak.
2.2.1.3 / pg 19	"Onboard CNG storage tank pressures….but all must have **pressure relief valves**".	CNG cylinders are protected by a Pressure Relief Device (PRD) not a pressure relief valves (PRV). A PRD is designed to activate only once (generally based on high temperature) and to dump the entire contents of the cylinder when activated. PRDs cannot be reset and must be replaced after activation. Pressure relief valves are designed to open when the pressure in the cylinder rises above a set threshold, thus releasing only part of the cylinder's contents to reduce pressure, and then to close once the pressure has fallen below a lower set threshold. LNG and LPG cylinders are protected by PRVs.
Sec 2.2.1.3 / pg 22	"The NHTSA regulations that apply to CNG vehicles are FMVSS 301, FMVSS 303, and FMVSS 304"	This statement is misleading in the context of this document. Of these regulations only FMVSS 301 applies to MD/HDVs, the other two are only applicable to light-duty vehicles (< 10,000 lb GVW).
Sec 2.2.1.3 / pg 23	"… do not have crashworthiness regulatory requirements for HD trucks **….. most OEMs crash test new natural gas trucks as a proactive safety measure**"	Based on recent experience in surveying truck OEMs with respect to both natural gas and electric vehicle safety for FMCSA, I believe that this statement is NOT TRUE. Truck OEMS do not routinely crash-test vehicle models prior to commercial sale, whether they are equipped with diesel or natural gas fuel systems and engines. The commercial vehicle industry is simply too diverse and complex (in terms of vehicle size and configuration, as well as manufacturing process), and sales volumes are too low, to make routine crash testing economically viable.
Sec 2.2.1.5 / pg 27	"There are currently no generally accepted codes	NFPA 52, *Vehicular Gas Systems Code*, National Fire Protection Association (2010) contains standards for CNG

	and building standards for CNG garages, so facility safety is handled at the local level by fire marshals”	and LNG fueling facilities installed inside residential and nonresidential buildings. This document does not provide definitive standards for facilities that house CNG/LNG vehicles but which do not include a fueling facility. In any event, facility fire safety issues would always be handled by local fire marshals, who would be free to adopt/adapt/or interpret any national consensus standard that was developed.
Sec 2.2.1.5 / pg 27	“Essentially the same safety procedural requirements applicable to CNG fleets are relevant to LNG maintenance facilities”	There is one significant difference in requirements for LNG vehicle maintenance/storage facilities compared to CNG vehicle facilities. Since LNG vehicles are expected to normally vent natural gas from LNG tank PRVs, all maintenance and storage locations should be equipped with a device to connect to PRV outlet(s) and vent escaping gas at building roof level; if not, LNG vehicles should be de-fueled before entering the facility. This is not necessary for CNG vehicles which are not expected to vent gas from their PRDs except in the event of vehicle fire or equipment (PRD) failure.
Sec 2.2.2.3 / pg 31	“Operational Safety Concerns include: High-level biodiesel blends can also gel in cold temperatures”	Even low-level biodiesel blends (B20) can gel at temperatures below 20 degrees Fahrenheit if the manufacturing process leaves too much glycerin in the fuel. This concern is minimized if fuel meets ASTM D7467
Sec 2.2.3 / pg 32	LPG description	When describing LPG this section does not address LPG’s physical properties that are relevant to fire/explosion hazard in the event of a leak. In particular there should be a discussion of the density of LPG vapors, and resultant effect on leak profile: i.e., LPG gas is heavier than air. LPG vapors therefore tend to fall to the ground/floor level and can collect to a flammable level in low spots. Unlike NG, which naturally dissipates as it rises, the dissipation of LPG vapors is primarily based on air movement – it will dissipate to non-hazardous concentration faster in windy conditions than in still conditions
Sec 2.2.3 / pg 33	“To operate a vehicle on propane as either a dedicated fuel or bi-fuel (i.e., **switching between diesel and propane**) vehicle, **only a few modifications must be**	Propane must be used in a spark-ignited engine. Since diesel engines do not have a spark plug this statement is incorrect – to convert a diesel engine to operate on propane or as a bi-fuel propane-diesel engine, significant modifications to the engine are required. The following statement is correct: “To operate a vehicle on propane as either a dedicated fuel or bi-fuel (i.e., switching between

	made to the engine".	gasoline and propane) vehicle, only a few modifications must be made to a gasoline engine. Propane cannot be used in a diesel engine without major modifications since a spark or diesel-pilot ignition system would be required".
Sec 2.3 / pg 37	Parallel Hybrid	This list of in-service parallel hybrid MD/HDVs does not include approximately 3,000 transit buses with Allison Hybrid systems. The 2013 American Public Transportation Association Transit Bus database lists a total of 5,569 hybrid-electric buses in service in the US and another 1,137 in Canada. Of these approximately half have BAE hybrid systems (noted in text) and half have Allison systems (not noted in text).
Sec 2.3 / pg 37	"At least 20 fleets are using **Smith** or other electric MD box trucks…"	While Smith Electric Vehicles is a leader in the field, there are at least 4 other manufacturers offering MD/HDV battery electric trucks for commercial sale in the US, including: • Electric Vehicles International • AMP Electric Vehicles • Boulder Electric Vehicles, and • Motiv Power Systems See information on vehicle availability from the New York Truck - Voucher Incentive Program (https://truck-vip.ny.gov/applications.php)
Sec 2.3 / pg 38	Discussion of MD/HDV electric vehicle range	Of the MD/HDV electric vehicles available through the New York Truck - Voucher Incentive Program, two manufacturers offer trucks with only a single option for battery pack size, and the manufacturer advertised range for these vehicles is 90 miles per charge. Three manufacturers offer their trucks with options for different sized battery packs, which result in advertised range between 40 – 100, 80 – 100, and 80 – 120 miles per charge, respectively. The vehicle with 120 miles per charge is the Motiv Power Systems E450 electric chassis with 120 kWh battery pack.
Sec 2.3.1 / pg 40	"Greater adoption (of HEVs) may occur during the years 2014-2018 of the first NHTSA/EPA fuel efficiency and greenhouse gas regulations for MD/HDVs".	The 2014 -2018 NHTSA/EPA fuel efficiency standards provide little incentive for truck OEMS to offer more hybrid models; the stringency levels were specifically set such that hybridization would not be required to meet them, and the benefits of hybridization cannot be captured in the vehicle level certification process. While manufacturers can gain credits under averaging/banking/and trading rules for the sale of

	"Major trucks manufacturers are now competing in the hybrid MD/HDV market niche…."	hybrids it is not clear how these credits would be calculated. All of the truck OEMs noted as competing in the "hybrid market niche" have recently been selling only hybrid vehicles equipped with Eaton hybrid transmissions. However, in September 2014 Eaton announced that they would no longer sell hybrid transmission in the North American onroad market. (http://evmeme.com/2014/09/eaton-discontinues-diesel-electric-hybrids/) As such, it is unlikely that there will be many sales of hybrid trucks in the next three years.
Sec 2.3.2 / pg 40	"**The break-even period** of hybrid-electric transit buses **is under 8 years i**n North America based on fuel consumption only"	According to data reported by the American Public Transportation Association the incremental purchase cost of a hybrid bus compared to a diesel bus is at least $150,000 (See Iowa State University TECH BRIEF http://www.intrans.iastate.edu/publications/_documents/t2summaries/hybrid_transit_bus_tech_brief1.pdf). Based on data reported to the National Transit Database (NTD 20111) US transit buses average approximately 30,000 miles per year and diesel buses average approximately 3.5 MPG. This means that diesel buses use on average about 8,600 gallons of fuel per year. At $4.00 per gallon each bus uses $34,400 worth of fuel per year. Most transit agencies will achieve no more than 30% reduction in fuel use with a hybrid bus compared to a diesel, so they will save ~$10,000/year/bus in fuel costs. For most agencies the break-even period will be 15 years, not 8 years. To achieve an 8-year break-even based on fuel savings alone a hybrid bus would need to have greater than 50% lower fuel use than a diesel, or the bus would need to have much greater than average annual mileage (>50,000 mi/yr).
Sec 2.3.3 / pg 44	"…appropriate safety standards are being developed to complement **FMVSS 305** power level…"	This statement is mis-leading in the context of this report. FMVSS 305 only applies to vehicles with GVW less than 10,000 pounds. It does not apply to the MD/HDVs that are the subject of this report. FMVSS 305 is applied in the context of crash testing specified in FMVSS 208, FMVSS 214, and FMVSS 301. MD/HDVs are not subject to these crash tests per current NHTSA regulations.

Sec 2.3.3 / pg 44	"The SAE Truck and Bus Committee is developing a **draft** standard J2910 Recommended practice…"	The final version of SAE J2910, *Recommended Practice for the Design and Test of Hybrid Electric and Electric Trucks and Buses for Electrical Safety* was issued by SAE in April 2014, so it is no longer in draft. SAE also has numerous other recommended practices related to design criteria and test methods for specific high voltage components and systems used in electric-drive vehicles, including: SAE J1654, SAE J1673, SAE J1742, SAE J1797, SAE J2344, SAE J2464, SAE J2758, SAE J2929, SAE J 2936, and SAE J2990. Relevant standards that have been developed by the International Standards Organization include: ISO 6469-1, -2, -3 and ISO 16750.
Sec 2.4.1.3 / pg 48-49	Safety considerations of telematics systems	One additional potential safety concern related to telematics systems is the potential for additional driver distraction from systems that provide real-time feedback to drivers. For example, MJB&A managed an in-use test program which evaluated the benefits on school buses of a telematics system that monitors engine RPM and provides audible feedback to the driver to back off the accelerator so that the automatic transmission will shift at the optimal time. The testing confirmed manufacturer claims of increased fuel efficiency, but some drivers indicated that the system alerts were distracting and could be a safety concern. See http://www.mjbradley.com/node/243
Sec 2.5.2.1	"Anti-idling systems offer good opportunity for petroleum reduction in heavy-duty vehicles, **particularly those operating in stop-start city traffic**…"	This statement is not true. While vehicles operating in stop-start traffic typically spend 30-50% of engine-on time at idle, virtually all of this idling is done in traffic, and most idle reduction technologies (other than drivetrain hybridization) will not reduce this idle time at all. Idle reduction technologies are designed to automatically shut off the main engine and/or provide an alternate means to power vehicle auxiliary loads primarily when the vehicle is stopped and the transmission is in park. These systems typically are not operational when the vehicle transmission is in drive, as when a vehicle is stationary in traffic. The single biggest potential area for per-truck and total fuel reduction from implementing anti-idling technologies is reduction of over-night idling from sleeper-cab equipped long-haul tractors.
Sec 2.6.3 / pg 58	"Large trucks are involved in a disproportional	These statements appear to be contradictory. If statistics on LCVs are unavailable, what is the justification for the

	percentage of fatal collisions owing to their large mass and momentum. However, statistics on LCVs are difficult to obtain because of the low number of vehicles…”	first statement? If the first statement is intended to apply not to LCVs specifically but to “large trucks” (i.e., Class 7-8) generally compared to smaller vehicles, the data included in Section 1.2 on crash statistics seems to contradict it as well. This data indicates that the fatality rate per 100 million miles was 0.123 for large trucks, but 1.14 for the “entire fleet”. This would seem to indicate that smaller vehicles are in fact involved in a “disproportionate percentage of fatal collisions” since they have a much higher fatal crash rate.
Sec 2.6.3 / pg 59	“Heavier truck traffic **deteriorates pavement structures at an accelerated rate,** and serious roadway defects can subsequently lead to crashes.”	I believe that this statement as written is somewhat misleading. Roadway deterioration is almost entirety related to axle weight and has virtually nothing to do with gross vehicle weight, so heavier trucks will not accelerate pavement deterioration per se. A more accurate statement might be: “Heavier axle weights deteriorate pavement structures at an accelerated rate, so heavier trucks could lead to a greater number of roadway defects that might contribute to crashes, unless current axle weight limits are maintained. This would require that heavier trucks have additional axles compared to current trucks in order to carry the extra weight”.
Sec 2.9.1	“Mobile Energy Solutions LLC introduced a light-weighted transit bus in 2007 with an all-composite body…”	In 2003 North American Bus Industries began manufacturing a 45-foot transit bus with a light-weight all-composite body which was called the Compo Bus. They manufactured approximately 400 of them between 2004 and 2008. The largest fleet (~300) is at Los Angeles County Metropolitan Transit Authority (LACMTA) in Los Angeles, CA. These buses have natural gas engines and CNG fuel systems. Some of them have now been in service for more than 10 years and are still on the road. See http://media.metro.net/board/Items/ 2009/09_september/20090902OtherSectorSFVItem6.pdf
Sec 3.1 / pg 77	List of companies contacted for SME interviews	The Los Angeles County Metropolitan Transit Authority has the single largest fleet of natural gas HDVs (transit buses) in the country, as well as the longest experience with natural gas HDVs (since the 1980’s). MTA New York City Transit has the single largest fleet of hybrid-electric HDVs (transit buses) in the country, as well as the longest experience with hybrid HDVs (since 1994). Why were neither of these agencies contacted for the SME interviews?

Sec 5.1 / pg 103	"In addition the data in **Figure 5-2** reproduced from the 2007 FMCSA LTCCC report to Congress showed that the vehicle related relative contributions to truck crashed are smaller than driver-related crash causes"	Figure 5-2 does not include data on the causes of truck crashes – it is a generic Hazard Level Matrix. There is no table of data on the cause of truck crashes included in the report.
Sec 5.1 / pg 104	"Figure 5-2 shows that most risk categories can be prevented or managed **cost-effectively** through engineered controls, or with design or operational changes…."	Figure 5-2 is a generic Hazard Level Matrix that shows what types of hazards (by frequency and severity) MUST BE addressed or controlled based on design changes or controls – as a good engineering practice- as compared to those types of hazards that can be ignored because they are so infrequent and/or the severity is so low. This figure provides NO INFORMATION about how easy or cost-effectively any particular hazard on any particular vehicle can be addressed through design.
Sec 5.1 /pg 104	Figure 5-2	The horizontal axis on this figure should be labeled "Frequency of Occurrence" across the top of the figure; the vertical axis should be labeled "Consequence Severity" along the left edge of the figure.
Sec 5.2.1.1 / pg 107	Second bullet at top: "… This incident demonstrated the additional fact that new CNG tanks sold in the US as compliant with FMVSS 304 are engineered to fail safe by **postponing explosion** in the rage event of failure"	This is a very disturbing incident which does NOT demonstrate that FMVSS 304 is adequate to protect against CNG vehicle hazards. According to industry best practices (NFPA 52) every CNG cylinder is supposed to be equipped with a PRD which will open and safely vent gas in the event of a vehicle fire, thus totally avoiding cylinder rupture rather than just "postponing it". If this CNG bus did in fact "explode" it means that either: 1) the PRD was not present, or 2) the PRD was present but did not work as intended (it failed). This points to a need to have both manufacturing standards, and in-use standards for vehicle maintenance and condition, to ensure that necessary safety systems (i.e., PRD) are in place and are operable.
Sec 5.2.1.2 ' pg 107	"Robert Zalosh, a Firexplo expert…"	What is a "Firexplo expert"?
Sec 5.2.1.3 / pg 108	"Compliance with all **applicable** NHTSA FMVSSs is also required, including **FMVSS 301** (Fuel System	This statement is misleading with respect to this report. Of the cited FMVSSs, the only one that is applicable to the MD/HDVs discussed in this report is FMVSS 304. FMVSS 301 and FMVSS 303 apply only to vehicles less than

	Integrity), **FMVSS 303** (CNG System Integrity), and FMVSS 304 (CNG Fuel Container Integrity)	10,000 lb GVW, and to school buses regardless of weight.
Sec 5.2.7 / pg 121	"The 2011 Orion VII safety recall…**led to** Daimler's discontinuing the manufacture and marketing of Orion VII buses…"	I think it unlikely that one could prove that the recall led directly to Daimler pulling out of the US transit bus market. At best it was likely a contributing factor among many others.
Sec 5.2.71. / pg 122	"…electrocution and fire hazards can be reduced through **compliance with FMVSS 305** and adherence to NHTSA interim safety guidelines"	This statement is misleading with respect to this report. FMVSS 305 is only applicable to light-duty vehicles less than 10,000 lb GVW, and it deals with electrolyte leakage and loss of electrical solation during specific crash test scenarios mandated in FMVSS 301. MD/HDVs are not routinely subjected to such crash tests. This section should reference voluntary industry standards and best practices such as those in SAE J2910, SAE J1654, SAE J1673, SAE J1742, SAE J1797, SAE J2344, SAE J2464, SAE J2758, SAE J2929, SAE J 2936, SAE J2990, ISO 6469-1, -2, -3 and ISO 16750
Sec 6.5.1 / pg 125	"Adoption of idle reduction technologies by MD/HDVs is driven by compliance requirements with EPA clean air regulations"	EPA regulations applicable to MD/HDVs apply primarily to new engines, not to the vehicle as a whole. These regulations do not mandate idle reduction devices, and since the certification testing is done on the FTP engine test cycle the inclusion of an idle reduction device would have no effect on the certification results. Prior adoption of idle reduction devices has primarily been based on state and local laws that restrict vehicle idling.
Sec 6.7.3 / pg 128	"However, this was most significant for vehicles ABS".	"However, this was most significant for vehicles **without** ABS".
Sec 6.10 / pg 130	"Most of the potential barriers relate in some way to truck size and weight regulations. This may have implications for hybrid-electric and hybrid-hydraulic technologies, idle reduction technologies, and LCVs."	"Most of the potential barriers relate in some way to truck size and weight regulations. This may have implications for hybrid-electric and hybrid-hydraulic technologies, **battery-electric vehicles**, idle reduction technologies, and LCVs."

COMMENTS SUBMITTED BY

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Peer Reviewer's Comments on "Review and Analysis of Potential Safety Impacts and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels in Medium- and Heavy- Duty Vehicles.

1) Please state your overall assessment of the organization, readability, and clarity of this report, including any changes needed.

This is an excellent report and will make a major contribution to the field. The analysis of the issues is comprehensive and complete. The report is well organized and readable. The report is acceptable for publication in its present form.

However, the report would benefit from the addition of a "Summary of Conclusions" section. Also the "Executive Summary" section of the report would be more valuable if a brief summary of the conclusions were included. The current "Executive Summary" focuses too much on the methods used for conducting the analysis and the challenges of the analysis and not enough on the results and conclusions.

2) Does the document adequately review, present, and summarize the available data? If not, what can be improved?

This report summarizes findings of a comprehensive safety analysis conducted to determine the possible safety impact that may occur upon implementation of a wide range of technologies and practices that offer the potential to improve Fuel Efficiency (FE) in Medium- and Heavy-Duty (MD/HD) vehicle fleets. The list of FE technologies and practices which were considered as offering potential improvements in FE is extensive and complete. The analysis of each of the individual FE technology and practice is comprehensive and scientifically sound. The authors did an outstanding job in seeking out the range of different information sources that might provide useful information concerning the subject matter.

The report also summarizes a review of existing Federal and State regulations that might be regulatory barriers to implementation of each of the FE technologies and practices. The review of potential regulatory barriers appears to be complete. The summary of the review is well organized and clear.

3) Are the methods and analysis described in this report adequately developed, well integrated, and appropriate to the aims of the project?

The methods used to conduct this study were well developed, adequately described, sound and appropriate. The authors reviewed vehicle crash databases, reviewed the technical and trade literature, analyzed cohort safety performance experience of subsets of the industry, and used subject matter experts, all in combination, to develop the conclusions. The authors did a great job of integrating the information from this wide range of information sources. Their approach is scientifically sound and appropriate for analyzing issues in a developing field where there is a shortage of data and the data available comes from many different sources and in different formats.

4) Are the findings and conclusions adequately supported by the data?

The findings and conclusions are adequately supported by the comprehensive analysis that was done of all of the various information sources which might provide information supporting the conclusions. Because the authors took into consideration all of the available information sources, their conclusions appear to be well supported by all the data and experience that is available at this time for this developing field.

5) Please recommend any additional key published data for vehicle technology and safety that may be relevant to this review and analysis.

I have no recommendations for additional data to be considered. I believe that the authors did an outstanding job of collecting and reviewing all available data and information on vehicle technology and safety.

6) Are the statistical methods used in the analysis appropriate?

The authors did not make extensive use of statistical methods, but when used they were appropriate. The methods of analysis that the authors used are scientifically sound.

7) What are the weakest and strongest parts of this report? Please suggest how the weakest parts of the report can be strengthened.

The strongest aspect of this report is the fact that the analysis is so comprehensive and considers the full range of possible information sources which might contribute to the analysis and conclusions. Also, the descriptions of the analysis, which were done on each issue, are clearly presented. Another strength of this report is the excellent job of source documentation done for all the information sources reviewed by the authors.

The report could be made easier to use by others interested in this field by the addition of a "Summery of Conclusions" section.

8) Please provide any other comments you may have on the report.

This report provides an excellent bibliography of the literature sources and other information sources which will be helpful to others working in this field.

9) Based upon your review, please indicate whether you find the report: (1) acceptable as is, (2) acceptable with minor revisions, (3) acceptable with major revisions, or (4) not acceptable. Please justify your recommendation. If you find the report acceptable with minor or major revisions, be sure to describe the revisions needed.

I find the report acceptable as is. I believe that the report could be made even more useful by the addition of a "Summary of Conclusions" section and by including a brief summary of the conclusions in the "Executive Summary" section.