October 26, 2021

The Honorable Steven Cliff **Docket ID No. NHTSA-2021-0053**
Acting Administrator
National Highway Traffic Safety Administration
Docket Management Facility, M-30
U.S. Department of Transportation
West Building, Ground Floor, Rm. W12-140
1200 New Jersey Avenue SE, Washington, DC 20590

Re: Corporate Average Fuel Economy Standards for Model Years 2024-2026 Passenger Cars and Light Trucks, A Proposed Rule by the National Highway Traffic Safety Administration [Docket No. NHTSA-2021-0053]

Dear Administrator Cliff,

The American Chemistry Council (ACC), acting on behalf of its Plastics Division, is pleased to provide the following comments to NHTSA (the Agency) regarding the "*Corporate Average Fuel Economy Standards for Model Years 2024-2026 Passenger Cars and Light Trucks, A Proposed Rule by the National Highway Traffic Safety Administration"* (NPRM).

I. BACKGROUND

The ACC is a national trade association representing U.S. companies that manufacture chemistry and plastics. ACC's Plastics Division represents the leading producers of plastics resins in the United States, as well as foremost companies throughout the entire plastics value chain. American chemistry is an innovative $486 billion enterprise that plays a critical role in delivering a more sustainable future through resource and fuel efficiency, material innovation, and continued advancements in our products and operations. Last year alone, America's chemistry industry spent approximately $10 billion in research and development to support innovation in a variety of fields, including energy, food, health and water.

The business of chemistry creates more than 529,000 U.S. manufacturing and high-tech jobs, and 4.1 million related jobs that support families and communities. This includes the manufacturing of lightweight plastics and polymer composites used by the transportation industry in automotive applications. Every day, plastics and polymer composites help deliver cleaner air and water, safer living conditions, efficient and affordable energy sources, lifesaving medical treatments and innovative lightweight vehicle solutions that enhance passenger safety.

Polymer composites are a combination of tough plastic resins that are reinforced with glass, carbon fibers and other materials. These materials often weigh far less than traditional automobile materials yet maintain high levels of strength and resistance to corrosion.

Lightweight plastic and polymer composites provide an economical way to sustainably lightweight vehicles while preserving important safety features and consumer preferences through improved design flexibility. Additional properties of plastic and composites, including strength to weight ratio and excellent energy absorption, make these materials especially well-suited for the design and manufacture of light-duty vehicles.

ACC member companies are committed to providing sustainable solutions to the automotive industry. Advancing reycling and circularity solutions industry-wide will require widespread commitment from material producers, manufacturers, brands and retailers, recyclers and waste haulers, as well as citizens, communities, nonprofits, and policymakers. For example, the U.S. automotive recycling infrastructure is currently spread out throughout the country with markets and partnerships between recyclers, dismantlers and shredders forming primarily within municipal and regional geographies. While this model of operation has worked in the past, this fragmented approach makes the comprehensive incorporation of new processes and technologies that can accommodate advanced multi-material parts challenging. This includes the automotive industry, where the transition toward a more circular economy for industrial goods will require an expansive nationwide automotive value chain to rethink the ways that vehicles and their materials are designed, constructed, used, and handled at end of life.

In that regard, ACC identifies our *Transitioning toward a More Circular Economy for Automotive Plastics and Polymer Composites*[1] Roadmap for consideration as a valuable resource in the Agency's planning. As circularity grows in importance, the plastics and polymer composites industry is committed to working together and with all material suppliers, part suppliers, and automakers to help the automotive industry transition toward a circular economy – including designing materials, products, and systems for disassembly, recovery, reuse, recycling and upcycling. ACC recently signed a five-year Memorandum of Understanding (MOU) with Oak Ridge National Lab (ORNL), to advance end-of-life and circularity solutions for durable automotive plastics. The partnership will bring together automotive OEMs, shredders, recyclers, researchers, and government to solve problems that will help the automotive industry, and other durable goods, advance end-of-life and circular economy solutions. The project will pursue a pilot-scale multi-material separation line that reclaims durable plastic through efficient sorting, separation, traditional and advanced recycling to make new high-performance plastics for reuse. Additionally, partners will seek to advance designing components for circularity from the start and evaluate whether the solutions developed can be applied to other industries beyond the automotive industry[2].

II. COMMENTS TO THE EXECUTIVE SUMMARY: THE ROLE OF PLASTIC AND COMPOSITES IN LIGHT-DUTY VEHICLES (Section I of the NPRM; Pages 49603-49611)

[1] American Chemistry Council, "Transitioning toward a More Circular Economy for Automotive Plastics and Polymer Composites", (October 2020), *available at*: https://www.automotiveplastics.com/wp-content/uploads/Transitioning-to-a-Circular-Economy_10-1-20_singlepage.pdf

[2] American Chemistry Council, "ACC and Oak Ridge National Lab Partner to Advance Durable Plastics' End-Of-Life & Circularity Solutions", (September 15, 2021), available at: https://www.americanchemistry.com/chemistry-in-america/news-trends/press-release/2021/acc-and-oak-ridge-national-lab-partner-to-advance-durable-plastics-end-of-life-circularity-solutions

ACC applauds the Agency for its effort to create a sustainable and safe highway transportation platform in the United States. These comments provide the Agency with feedback and data to support a final rulemaking informed by robust scientific governmental and industry research regarding how lightweight plastic and composite auto parts can be used as a tool to improve fuel economy while maintaining safety.

The lightweighting of vehicles by manufacturers has, and will, continue to spur innovation, growth and competition in the U.S. automotive industry to meet consumer demands for stylish and safe vehicles. ACC supports these efforts and the Agency's recognition of lightweight plastic and polymer composite technologies, as a tool for auto manufacturers to comply with federal corporate average fuel economy (CAFE) requirements and make vehicles more efficient. Among other numerous benefits, automotive plastics and composites play an important role in improved safety, improved design, mass reduction, aerodynamic improvement, electrification and autonomous deployment and optimized component integration.[3] Utilizing plastic and composites within the global automotive industry follows well-documented trends of polymer usage to economically reduce mass and increase efficiency in the civilian and military aerospace industries. Choosing plastic and polymer composites to reduce mass in light-duty vehicles is a decision supported by science that can pay immediate and long-term economic and environmental dividends, including efforts to combat the effects of climate change.[4]

In the NPRM, the Agency proposes to increase the CAFE standards by an average of 8% applicable in model year (MY) 2022 for MYs 2024-2026. ACC supports a national standard that continues to recognize vehicle lightweighting as a responsible and feasible strategy to achieve safety standards as well as improved fuel efficiency, including techniques for improved design, aerodynamic drag improvement, and optimized component integration. This is an area where lightweight plastic polymer composites can play a significant role in economically reducing vehicle mass of new light-duty vehicles.

Lightweight plastic and polymer composite auto parts generally comprise more than 50 percent of a vehicle's material volume, but less than 10 percent of its weight. Sustainable, durable automotive plastic and composites are essential for enabling a lower carbon future, including lightweighting vehicles to offset the heavy equipment for advanced driver assist systems (ADAS), autonomous driving systems (ADS), and advanced propulsion technologies. Durable, yet lightweight polymer materials are well suited in helping protect electric vehicle (EV) batteries and hydrogen fuel cells while maintaining vehicle performance and extending range between charges. Polymer materials are also essential for advancing a multitude of advanced vehicle safety features, both for occupant and pedestrian protection. Beyond plastic and composites, chemistry enables a multitude of vital vehicle innovations, including synthetic rubber for improved air retention over the life of the tires, adhesives and sealants for multi-material joining, lubricants for improved engine performance and batteries for vehicle

---

[3] EPA, NHTSA and CARB, "Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025, Appendix", pp. B-46-B-76 (July 2016), *available at* https://nepis.epa.gov/EPA/html/DLwait.htm?url=/Exe/ZyPDF.cgi/P100OYCH.PDF?Dockey=P100OYCH.PDF.

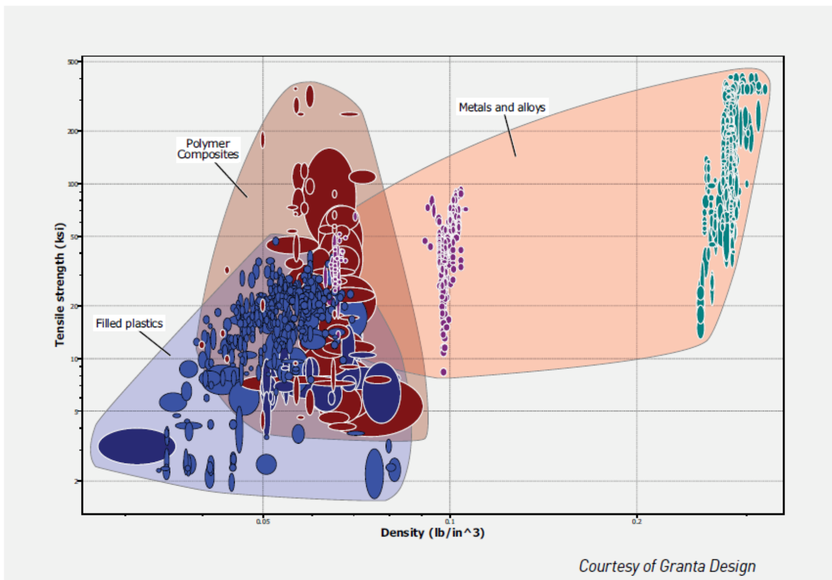
[4] Trucost,"Plastics and Sustainability: A Valuation of Environmental Benefits, Costs and Opportunities for Continuous Improvement" (July 2016), available at https://www.americanchemistry.com/content/download/6921/file/Plastics-and-Sustainability-A-Valuation-of-Environmental-Benefits-Costs-and-Opportunities-for-Continuous-Improvement.pdf

electrification. Virtually every major component of a lightweight vehicle, from the front bumper to the rear tail-lights, is made possible through chemistry.

The chart labeled “Figure 1” below provides data regarding the tensile strength and density of filled plastics, polymer composites, metals, and alloys. As shown in the chart, there are many plastics and polymer composites that are significantly less dense than tested metals and alloys while offering similar tensile strengths. This data illustrates the fundamental physical advantage that many plastics and polymer composites can offer over many metallic automotive materials: higher strength-to-weight ratios enable automakers to lightweight while maintaining performance and innovative designs that consumers demand.[5]

Figure 1

Figure 3. Tensile strength versus density for filled plastics, polymer composites, and metals and metal alloys



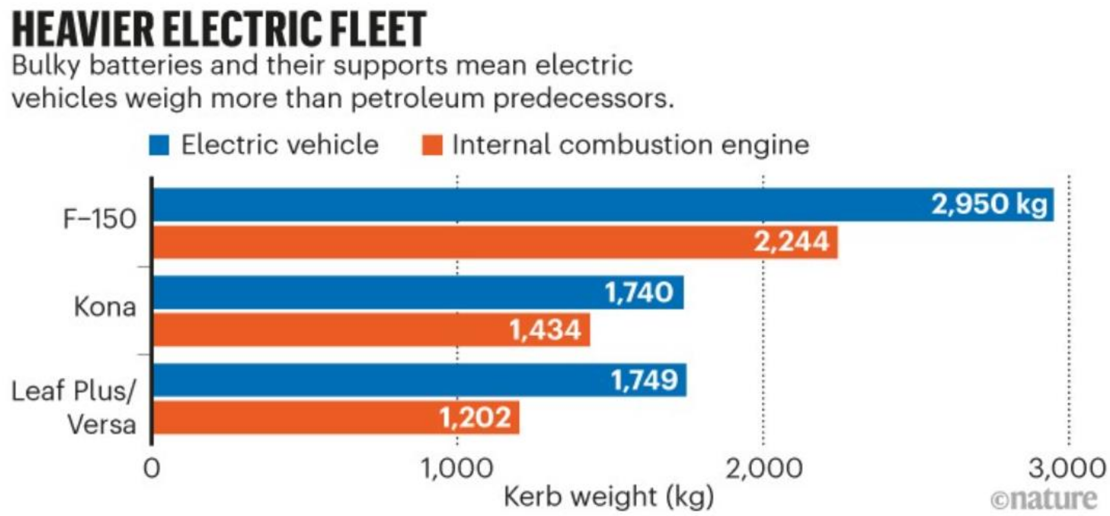
ACC encourages NHTSA to consider in parallel the importance of vehicle lightweighting as vehicles with heavier components, such as EV batteries, ADAS and ADS, are introduced into passenger vehicles to maximize the social benefit of these improvements. A recent article in *Nature* from Dr. Blake Shaffer *et al.* of the University of Calgary highlights the importance of this approach with a rough calculation: “Under the energy systems operating in most countries today, the cost of extra lives lost from a 700-kg increase in the weight of an electrified truck rivals the climate benefits of avoided greenhouse-gas emissions.”[6] As noted by Dr. Shaffer et. al in the October 12, 2021 edition of Nature: “About one-third of a vehicle’s mass is conventional steel, down from 44% in 1995. Vehicle structures can be made stronger and lighter by using advanced forms of steel, more aluminum and magnesium, and polymers reinforced with carbon fibre.” The *Nature* article includes an analysis of three EV models as compared to their internal combustion engine counterparts, which we have included here as “Figure 2.”

---

[5] American Chemistry Council, “Plastics and Polymer Composites for Automotive Markets Technology Roadmap”, pp. 10-12, 36-40 and 58, (March 2014), *available at*: https://www.automotiveplastics.com/wp-content/uploads/Roadmap-Full.pdf

[6] Blake Shaffer, Maximilian Auffhammer, and Constantine Samaras, “Make electric vehicles lighter to maximize climate and safety benefits,” Nature 598, 254-256 (2021), *available at* https://doi.org/10.1038/d41586-021-02760-8

Figure 2



The *Nature* article further states that as the U.S.'s power sources become cleaner, the overall social benefits of vehicle electrification "without addressing the weight issue… will be smaller than they could be in the next decade."[7] Lightweight plastic and polymer composite automotive parts can help address the increased weight of advanced powertrain and safety features by reducing the weight of the vehicle infrastructure and use in battery enclosures. In order to maximize the social benefits of next-generation vehicles, NHTSA must encourage vehicle design that allows for the safe lightweighting of passenger vehicles across the fleet, lest the overall social benefit of vehicle fuel economy improvements to be degraded by increased vehicle weight.

III. COMMENTS TO NHTSA'S ANALYSIS ON MASS REDUCTION TECHNOLOGY LEVEL AND ASSOCIATED GLIDER AND CURB MASS REDUCTION (Section III(D)(4) of the NPRM; Pages 49688-49695)

ACC agrees that multi-material solutions will be needed to reach a low carbon future. However, the NPRM approach makes several assumptions, sweeping statements, and generalized conclusions regarding carbon fiber and carbon fiber composites that the ACC disagrees with and believes need to be corrected in the final rulemaking. As written, the NPRM could be construed as NHTSA discouraging the use of carbon fiber composites as well as an endorsement for utilizing steel and aluminum-based designs to achieve mass reduction. This includes noting an inflated "aspirational" price for carbon fiber of $10-$20 per pound in addition to stating "For example, there are direct labor, R&D overhead, manufacturing overhead, and amortized tooling costs that will likely be higher for carbon fiber production than current automotive steel production, due to fiber handling complexities. In addition, R&D overhead will also increase because of the knowledge base for composite materials in automotive applications is simply not

[7] *Id.*

as deep as it is for steel and aluminum".[8] Further the statement that "Today, only roughly 10% of the global dry fiber supply goes to the automotive industry, which translates to the global supply base only being able to support approximately 70k cars" is equally misleading.[9]

The Agency's comments regarding global supply for automotive carbon fiber is misguided in that it ignores key macroeconomic principles for industry demand, capacity, and supply. As evidenced by the Agency, today's supply and capacity for automotive carbon fiber is successfully meeting current demand as manufacturers are increasingly turning to carbon fiber composite design solutions. Macroeconomic principles suggest as demand continues to increase for carbon fiber in automotive applications, capacity and supply will respond to meet the industry's needs.

According to Oak Ridge National Lab's (ORNL) technoeconomic analysis from its carbon fiber technology facility, the development of low-cost commercial grade carbon fiber of heavy-tow, >50K tow for large scale applications in the automotive and wind energy estimates the baseline commercial grade 50K tow carbon fiber cost falls within the market price range of $18-$22/kg or about $9/lb. This is a significant difference from the $15/lb average noted by the Agency. ORNL notes the latter "price" metric values are impacted by the market supply/demand dynamics and that preliminary cost estimates of low-cost carbon fiber based on heavy textile tow and coal mesophase pitch precursors have the 50%-60% cost reduction opportunity suited for automotive applications[10]. ACC requests that the final rule be updated to include this latest data available from the experts at the Department of Energy's ORNL, and in particular, request close coordination by NHTSA to inform the final rule on carbon fiber with Sujit Das and Merlin Theodore, of the Manufacturing Science Division at Oak Ridge National Laboratory, National Transportation Research Center, 2360 Cherahala Boulevard, Room I-05, Knoxville, TN 37932-6472, Ph. 865-789-0299.

Finally, ACC continues to encourage NHTSA to consider this data in the context of overall social impact including emissions reductions. As noted by Dr. Shaffer *et. al* in the October 12, 2021 edition of *Nature*: "About one-third of a vehicle's mass is conventional steel, down from 44% in 1995. Vehicle structures can be made stronger and lighter by using advanced forms of steel, more aluminum and magnesium, and polymers reinforced with carbon fibre."

IV. COMMENTS TO NHTSA'S ANALYSIS ON MASS REDUCTION IMPACT ON SAFETY (Section III(H) of the NPRM; Pages 49737-49741; Chapter 7 of the TSD)

---

[8] Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks, 86 Fed. Reg. 49690 (proposed September 3, 2021).

[9] *Id*, at 49691.

[10] Personal knowledge of Oak Ridge National Lab Sujit Das, Senior R&D Staff Member, Manufacturing Science Division, Oak Ridge National Laboratory, National Transportation Research Center, 2360 Cherahala Boulevard, Room I-05, Knoxville, TN 37932-6472
Ph. 865-789-0299

In Section H of the NPRM and in its Technical Support Document (TSD), NHTSA notes that statistical analysis of historical crash data indicates reducing mass in heavier vehicles generally improves safety, while reducing mass in lighter vehicles generally reduces safety.[11] While ACC recognizes the value of focusing lightweighting efforts on the heaviest vehicles, ACC encourages NHTSA to recognize in the final rulemaking the importance of improved vehicle design, improved passenger restraint technology, and the energy absorption capabilities of advanced materials, such as lightweight plastics and polymer composites, to improving safety while reducing mass across vehicles of all sizes. For instance, the National Academies of Science/National Academies of Sciences, Engineering, and Medicine (NAS/NASEM) has published reports noting that future changes in technology and fleet composition could lead to different conclusions than those underlying NHTSA's views about the relationship between mass reduction and safety[12,13]. Consequently, the 2021 NASEM report qualifies the general conclusions associated with mass disparity, noting that "new vehicle designs, continued effects associated with footprint-based fuel economy standards, changes in demand across vehicle classes, and increased demand for vehicles with (heavier) electrified powertrains could yield different safety relationships from those identified in relevant studies[11]". ACC agrees with the Agency's assessment that vehicles have become safer through a combination of new regulations and safety improvements, including the expectation that this trend will continue as emerging technologies, such as ADAS and ADS, are incorporated into vehicles. ACC calls the Agency's attention to several studies demonstrating that well designed lightweighted vehicles met or exceeded federal motor vehicle safety standards and, in many cases, may help improve occupant outcomes in crash models.

Readily available design practices have been developed to both lightweight and improve safety for a given vehicle. For example, as early as 2013, manufacturers began using lighter and stronger ultra-high strength steels and carbon fiber reinforced plastic composites; and even earlier were using aluminum and high strength steel for lightweighting, as well as improving the crash performance of the body-in-white.[14,15] Furthermore, restraint systems have continued to improve. More recently, for example, inflatable belts have been made available in production vehicles, providing better occupant protection as the crash loads transferred through the belt are spread out over a larger area of an occupant's thorax. This reduces the mechanical stresses incurred by a person's skeletal structures, in particular, the shoulder, sternum, and rib cage.[16]

---

[11] National Highway Traffic Safety Administration, *Technical Support Document: Proposed Rulemaking for Model Years 2024-2026 Light-Duty Vehicle Corporate Average Fuel Economy Standards,* August 2021, available at https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-08/CAFE-NHTSA-2127-AM34-TSD-Complete-web-tag.pdf

[12] National Research Council. 2015. Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles. Washington, DC: The National Academies Press. https://doi.org/10.17226/21744.

[13] National Academies of Sciences, Medicine, and Engineering and Medicine. 2021. Assessment of Technologies for Improving Light-Duty Fuel Economy 2025-2035. Washington, DC: The National Academies Press. https://doi.org/10.17226/26092

[14] Dr. Dirk Lukaszewicx, Design Drivers for Enhanced Crash Performance of Automotive CFRP Structures, Twenty-Third International Technical Conference on the Enhanced Safety of Vehicles, Seoul, South Korea (May 2013).

[15] SAE, "Pros and Cons of Advanced Lightweighting Materials," *SAE International Tech Briefs*, Vol 42, No. 3, pp. 14-17 (March 2018).

[16] Personal knowledge of ACC consultant and retired Director for Safety Research at NHTSA, Dr. William Thomas Hollowell, from his research at NHTSA and his personal communications with researchers at the OEMs.

As part of their efforts to improve occupant safety, engineers analyze a variety of components associated with a vehicle crash. In particular, engineers break down the crash into two impacts during which the designer has some control: the first being the impact of the vehicle to another vehicle or a stationary object, and the second being the impact of the occupant to surfaces within the interior of the vehicle. Managing the crash time duration during the first impact is critical as this provides the opportunity to further optimize the performance of the occupant restraint systems during the second impact. That is, the longer the crash pulse duration can be increased, the lower the impact speed of the occupant to interior components will be and the better the opportunity to properly deploy the restraint system. This in turn defines the design of the optimal interior components—including required component performance (e.g., padded dashboard and pillars) and strength (e.g., the structural members of the safety cage, such as the pillars), as well as the accompanying proper restraint system characteristics, which provide very effective system performance. Such improved performance derives in part from designs incorporating the use of materials which have high specific energy absorption (i.e., high energy absorption per kilogram of material). For example, carbon fiber reinforced plastic (CFRP) composites can be engineered to provide far more energy absorption per unit mass of material (as depicted in Figure 2 below) providing a designer the potential to reduce vehicle mass while improving a vehicle's safety performance.

In fact, the Agency's own Technical Assessment Report included the following conclusion regarding carbon fiber auto parts:

> Carbon fiber reinforced polymer composites are of particular interest for automotive applications because they can be designed to have mechanical properties that are comparable to steel, but have a significantly lower density. Furthermore, they can have good energy absorbing characteristics in a crash which can improve vehicle safety.[17]

In an ongoing study[18] utilizing finite element modeling, George Mason University (GMU) has been incorporating CFRP composites to provide the equivalent performance provided in a NHTSA research project undertaken to improve the crash performance of a Toyota Corolla subjected to the frontal oblique offset test procedure being developed for the New Car Assessment Program. [19] In NHTSA's project, high strength steels were utilized resulting in a 17 kg increase in the baseline vehicle weight. In the GMU project, the use of CFRP composites provided the equivalent safety performance, while also providing a reduction of 7 kg in the baseline vehicle weight. Both studies resulted in substantially improved crash performance with respect to compartment intrusion while providing essentially equivalent crash pulses.

---

[17] *See supra* note 2, p. B-52.

[18] Research Project: *Advanced Polymer/Composite Material Modeling for Automotive Applications*, George Mason University, completion anticipated Q1 2019, progress reports available thorough Center for Collision Safety and Analysis, George Mason University, *available at* https://www.ccsa.gmu.edu/people/.

[19] Awaiting publication of NHTSA final report, anticipated by year-end, per NHTSA approved draft report has been submitted for formal publication and is currently undergoing necessary edits to satisfy American Disabilities Act requirements, https://www.nhtsa.gov/research-data.

Figure 3

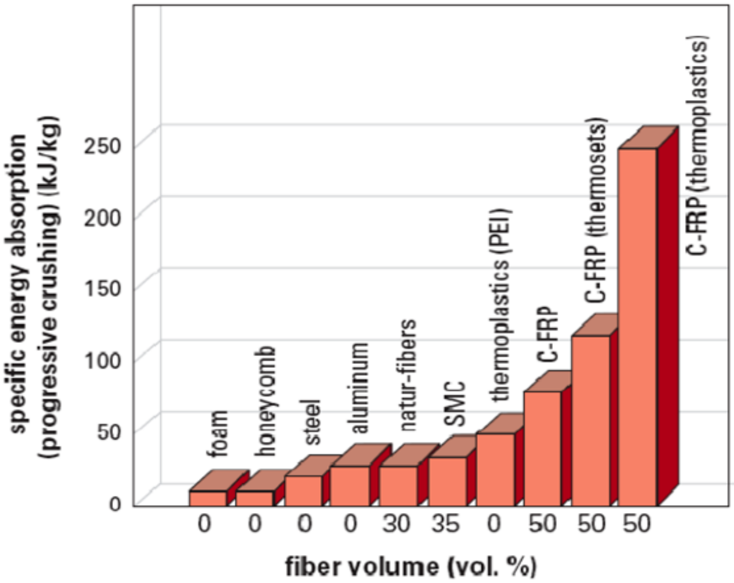


Figure 3. Energy Absorption (Energy/kg of Material) Potential Structural Materials

In another earlier study, researchers at The George Washington University (GWU) also demonstrated that improved vehicle designs could readily provide equivalent crash protection.[20] This project was a collaborative effort with NHTSA, GWU, and participating member companies of the ACC's Plastics Division. The goal of the project was to lightweight a Chevrolet Silverado pickup truck using plastics and composites, including the utilization of finite element modeling, but the results reinforce that lightweight plastics can provide comparable safety benefits to heavier materials. In this project, the vehicle size was maintained while achieving a 19 percent weight reduction through lightweighted component replacements using plastics and CFRP composites as well as downsizing of the powertrain and suspension system, made possible by the reduced weight realized from the component lightweighting. The lightweighted vehicle provided equivalent safety performance as the baseline vehicle.

In another project, NHTSA awarded a contract to the National Center for Manufacturing Science and its partners, the University of Delaware's Center for Composite Materials and BMW, to investigate the use of carbon fiber reinforced thermoplastic materials (CFRP) for vehicle side structures.[21] The project team investigated using CFRP materials for these structures, created requirements, and defined assessment strategies. In particular, a B-pillar was designed to meet structural and crash safety requirements specified by BMW and team members using the CFRP composites to provide improved side crash performance. In this study, scientists designed, manufactured, and tested CFRP intensive vehicle components, and validated the predicative engineering tools. The design of the B-pillar was followed by the manufacturing and testing of a

---

[20] Chung-Kyu Park, Cing-Dao (Steve) Kan, William Thomas Hollowell, and Susan I. Hill, "Investigation of Opportunities for Lightweight Vehicles Using Advanced Plastics and Composites," National Crash Analysis Center, George Washington University, Report No. DOT HS 811 692 (December 2012), *available at* https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB2013103220.xhtml

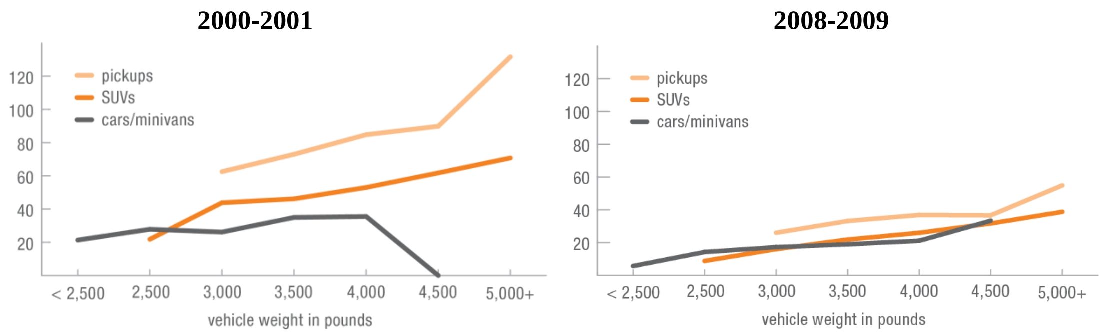
[21] National Center for Manufacturing Sciences, *High-Performance Computing Studies*, Report No. DOT HS 812 404, Washington, DC National Highway Traffic Safety Administration (April 2017), *available at* https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/812404_computingstudiesreport_v2_0.pdf

prototype. This study demonstrated that the designed carbon fiber thermoplastic B-pillar offered 60 percent weight savings over the metallic baseline and satisfied the specified side impact crash requirements. Also, the dynamic impact and crush response of the B-pillar was adequately modeled using computational tools.

A presentation by Joe Nolan at the 2013 NHTSA Workshop on Mass-Size-Safety further supported the importance of good designs[22]. Nolan's research examined crash test data, vehicle technologies, insurance, and NHTSA accident data bases to investigate the relative safety of large and small passenger vehicles. For the future of vehicle design, he noted that: (1) Disparate size and weight vehicles will always exist in the fleet, and (2) Smaller and lighter vehicles can have some disadvantage. However, Nolan stated that advanced structural engineering and technology innovations have improved the fleet compatibility and occupant protection across all vehicle sizes. Nolan ended by summarizing the countermeasures that help equalize occupant safety in a mixed-size fleet. These included crashworthiness improvements, especially for the smallest vehicles; strong front, side, and roof structures; head-protecting side airbags with rollover deployment; better light truck compatibility with cars; lowering light truck structures to car levels; electronic stability control; and continued improvement in belt use rates.

The countermeasures advocated by Joe Nolan have been providing positive results. For example, IIHS published in its September 28, 2011 *Status Report* that changes in sport utility vehicles (SUVs) and pickup trucks have made crashes involving the two vehicle types less dangerous to car occupants than they used to be.[23] The highlights of this study were presented at the aforementioned 2013 NHTSA Workshop. Shown in Figure 3 are graphs depicting the crash partner deaths for one-to-four-year-old vehicles per million registered vehicle years. As seen, fatality rates at a given weight decreased substantially between 2000-2001 and 2008-2009. Also note that the death rates were as not as far apart in 2008-2009 for the various vehicle types as they were in 2000-2001. While weight is a contributing factor in the crash outcomes, these graphs also demonstrate that good design can improve those outcomes. The design changes leading to these improvements resulted from a voluntary agreement established out of meetings between NHTSA and automakers to address the issue of compatibility.

Figure 4



---

[22] Joe Nolan, "The Relative Safety of Large and Small Passenger Vehicles," Insurance Institute for Highway Safety, Presentation to the 2013 NHTSA Workshop on Mass-Size-Safety, Washington, DC, May 2013

[23] IIHS, "Better compatibility has lessened the danger that SUVs and pickups pose to people in cars," IIHS/HLDI Status Report, Vol. 46, No. 8, September 28, 2011

Figure 4. Crash partner deaths, 1-4 yr. old vehicles per million registered vehicle years[24]

Advanced propulsion and new ADAS and ADS safety features will continue to increase the weight of vehicles, if left unaddressed, and will reduce the benefits of environmental benefit of the fuel economy increases. Data shows that "being hit by a vehicle that is 1000 pounds heavier generates a 40–50% increase in fatality risk."[25] Lightweight materials are already improving the safety of the current fleet. As noted by Dr. Shaffer *et al.* in the October 12, 2021 edition of *Nature*: "About one-third of a vehicle's mass is conventional steel, down from 44% in 1995. Vehicle structures can be made stronger and lighter by using advanced forms of steel, more aluminum and magnesium, and polymers reinforced with carbon fibre."

We expect safety countermeasures to further improve with the ADAS and ADS. These are especially significant as such efforts will address the 94 percent of crashes NHTSA estimates are caused by human error by preventing crashes from taking place at all; or, at a minimum, reducing the severity of crashes that do occur. Such developments include lane keeping systems, blind spot information systems, automatic emergency braking systems, drowsy driver alert systems and side sensing systems that detect and provide warning that objects are coming closer to the side of one's vehicle.

V. COMMENTS ON PEDESTRIAN PROTECTION

ACC would like to highlight two reports on pedestrian protection advancements. Both papers reinforce the idea that safety technology will continue to improve in the near future and may help to inform the Agency's methodology for evaluating crashworthiness across road users, including both passengers and pedestrians.

The first, *An Enhanced Methodology for Lightweighting a Vehicle Design Considering Frontal Crashworthiness and Pedestrian Impact Safety Requirements* notes that traditionally, design solutions for crashworthiness and pedestrian safety have been addressed separately by designing front rails and back-up structure of a car for crashworthiness and occupant safety, while optimizing the front bumper for pedestrian impact protection.[26] This report notes that it would be more prudent to pose the task of designing a vehicle for frontal impact and pedestrian impact safety as a single problem of weight reduction (i.e., lightweighting) by considering major vehicle crash safety requirements in the form of US NCAP (United States New Car Assessment Program) and IIHS Insurance Institute for Highway Safety offset impact test standards, and pedestrian impact safety according to the European Enhanced Vehicle-Safety Committee/Working Group 17 (EEVC/WG17) standard. To illustrate this methodology, a finite

---

[24] *Id.*

[25] Michael L. Anderson, Maximilian Auffhammer, "Pounds That Kill: The External Costs of Vehicle Weight," The Review of Economic Studies, Volume 81, Issue 2, April 2014, Pages 535–571, *available at* https://doi.org/10.1093/restud/rdt035.

[26] G.R. Srinivs, et al., "An Enhanced Methodology for Lightweighting a Vehicle Design Considering Frontal Crashworthiness and Pedestrian Impact Safety Requirements," 11th International Symposium on Plasticity and Impact Mechanics, Implast 2016; Procedia Engineering 173, 2017, at 623-630, *available at* https://doi.org/10.1016/j.proeng.2016.12.118.

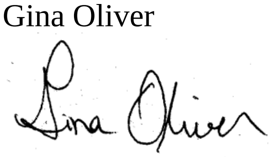
element model of a passenger car sold in the USA is chosen and simulation is carried out in the form of a nonlinear explicit dynamic analysis using a robust commercial solver, LS-DYNA. It is shown though this study that lightweighting of an automotive structure can be done by accounting for pedestrian and major front occupant safety targets simultaneously leading to an optimal mass solution with a 40 percent weight reduction of the components considered (i.e., the front rails, the bumper beam, the bumper fascia, and the bumper foam insert).

An additional research publication, "*Toward Lightweight Smart Automotive Hood Structures for Head Impact Mitigation: Integration of Active Stiffness Control Composites*" noted that recently, novel material concepts for high-performance carbon fiber–reinforced composites with active stiffness control (ASC) were presented in the literature. Although this new class of smart materials has wide application potential, design concepts using active stiffness control are still rare. This is likely because the integration of smart materials into conventional products often requires new design concepts. This communication presents an innovative automotive hood design concept, which integrates active stiffness control composites to achieve improved design performance trade-offs in terms of structural weight reduction and vulnerable road user safety. Currently, there are two main types of concepts or techniques to achieve ASC in carbon fiber functional materials. The first technique is based on resistive heating of the fibers with a thermoplastic coating between the fibers and a thermoset matrix (Bachinger et al., 2014; Tridech et al., 2013). The second technique is based on resistive heating of the fibers in a thermoplastic matrix material in (some of) the laminate layers (Bachinger et al., 2015). The integration of active stiffness control for composites in the hood structure aims to enable active stiffness reduction of the hood or bonnet structure in order to reduce head impact injuries in case of a collision, while satisfying the structural stiffness requirements and lightweight objectives under normal operating conditions. The design concept is investigated using simulation-based evaluation of static, dynamic, and lightweight design criteria. The results are promising, and the presented concept design is a step toward the realization of lightweight smart hood structures for head impact mitigation. Several design features could also be of interest for the integration of active stiffness control composites, in other applications.

VI. CONCLUSION

We thank you for the opportunity to comment on the Agency's Proposed Rule, "*Corporate Average Fuel Economy Standards for Model Years 2024-2026 Passenger Cars and Light Trucks".* We look forward to strengthening our partnership as we continue work on lightweighting vehicles and improving safety and fuel economy with plastics and polymer composite solutions.

Sincerely,
Gina Oliver



Sr. Director, Durable Markets Advocacy Team
American Chemistry Council, Plastics Division
Gina-Marie_Oliver@americanchemistry.com . 248-244-8920