Mr. Chairman, good morning. My name is John German, Senior Fellow and Program Director for the International Council on Clean Transportation (ICCT), with primary responsibility for technology innovation and U.S. policy development. I have been actively involved with vehicle technology and efficiency for 40 years. In earlier stages of my career, I spent 8 years in Powertrain Engineering at Chrysler working on fuel economy issues, followed by 13 years doing research and writing regulations for EPA’s Office of Mobile Sources and 11 years as Manager of Environmental and Energy Analyses for American Honda Motor Company. To support my credentials, I was the first recipient of the Barry D. McNutt award, presented annually by SAE for Excellence in Automotive Policy Analysis. Thank you for the opportunity to appear before the House Subcommittees on Commerce, Manufacturing, and Trade and Energy and Power to present our views on vehicles and technology and how they relate to the mid-term review of the CAFE and greenhouse gas standards.
SUMMARY

Forecasts always understate technology development and overstate costs. This is because there is a constant stream of innovation and new technology development. Because these technologies are unknown, the single most important factor in the accuracy of cost and benefit projections is the use of the latest, most up to date technology data. Using older data or implicitly assuming the end of innovation has been reached guarantees that the cost of meeting the standard will be overstated. This is especially important because the pace of technology development is actually accelerating, due to advances in computer aided design, computer simulations, and onboard computer controls. To evaluate technology progress, ICCT has collaborated with automotive suppliers on a series of papers on technology developments since the analyses conducted for the 2017-25 standards four to five years ago. Technology developments over the last 5 years have been astonishing. Technologies already in production or for which production plans have been announced, even though they were not anticipated or even considered in the supporting analyses for the 2017-2025 rule, include higher efficiency naturally aspirated engines with Atkinson cycle and very high compression ratios, dynamic cylinder deactivation that can deactivate each cylinder every other stroke, Miller cycle for turbocharged engines, variable compression ratio, electric compressors to assist turbocharged engines (e-boost), less expensive 48v hybrid systems, continuously variable transmission improvements, and major advances in lightweight materials and part optimization. These developments will make it easier and cheaper to meet the standards than was projected in the rulemaking.

The agencies updated technology analyses in the draft TAR include most of these improvements, but not all. Thus, the cost estimates in the TAR, while much improved over the rulemaking, are still overstated.

The new technologies also provide many benefits desired by consumers, in addition to the fuel savings. For example, turbochargers have better low rpm torque for the same high rpm power, transmissions with more speeds improve launch and are quieter on the highway, and weight reduction improves acceleration, ride, handling, braking, and tow capacity. The value customers place on these benefits is usually not accounted for.
TECHNOLOGY

During the course of my 40-year career, initial cost estimates for complying with emissions and efficiency requirements have consistently been overstated. Not some of the time, or even most of the time, but all of the time. While he said it in an entirely different context, Donald Rumsfeld hit the nail on the head:

"there are known knowns; there are things that we know that we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns, the ones we don't know we don't know."

To relate this specifically to projections of vehicle efficiency and cost, studies and reports usually do a good job laying out the things that we know, i.e. the technologies that are already in use. While most reports stop here, the better reports also attempt to lay out the known unknowns, such as technology that is already in development somewhere and estimates of cost reductions due to learning and volume. But unknown unknowns, i.e., technology innovations, are almost never assessed, even though there is a long history of constant technology innovation. There is a good reason for this: they are unknown. What this means is that the single most important factor in the accuracy of cost and benefit projections is the use of the latest, most up to date technology data and developments. Using older data guarantees that the cost of meeting the standard will be overstated, as it does not include more recent technology developments and thus must default to more expensive technology, such as full hybrids. Similarly, assuming that the end
of innovation has been reached and basing projections on what is in production today ignores technology developments in process and overstates the cost of future compliance.

Contrary to the common perception that the internal combustion engine is at the end of its development, the pace of technology innovation is accelerating. This is because there has been a genuine technology revolution: computers. Computer simulations and computer-aided design are enabling vastly improved designs and technologies. On-board computer controls provide unprecedented integration of engine, transmission, and hybrid operation. Instead of slowing down, the pace of technology development just keeps accelerating.

Computer simulations will especially impact lightweight material design. In the past, interactions between the thousands of parts on the vehicles and their impacts on safety, ride, noise, and vibration were impossible to predict. Optimization of materials was a long, slow process of gradually changing a few parts at a time to avoid unanticipated problems. Secondary weight reductions were similarly difficult to achieve. The recent development of sophisticated and accurate vehicle simulations is opening up a new world. The initial use of these models was to improve safety design. The simulations are so effective that 5-star crash ratings became almost universal and NHTSA had to revise their rating criteria for the 2011 model year. The simulations are continuing to rapidly improve, to the point where they are being used to simultaneously optimize the material composition, shape, and thickness of every individual part, including secondary weight reductions.
The technology assessments performed by the agencies to inform the 2017–2025 rule were conducted four to five years ago. In preparation for the mid-term term review of the U.S. 2017–2025 CAFE and GHG light-duty vehicle standards, ICCT has collaborated with automotive suppliers on a series of working papers evaluating technology progress and new developments in engines, transmissions, vehicle body design and lightweighting, and other measures that have occurred since then. The papers combine the ICCT’s extensive analytical capacity and expertise in vehicle technology with the practical knowledge and experience of auto suppliers. Each paper evaluates:

- How the current rate of progress (cost, benefits, market penetration) compares to projections in the rule
- Recent technology developments that were not considered in the rule and how they impact cost and benefits
- Customer-acceptance issues, such as real-world fuel economy, performance, drivability, reliability, and safety

Eaton, Ricardo, Johnson Controls, Honeywell, ITB, BorgWarner, Dana, FEV, Aluminum Association, Detroit Materials, and SABIC have contributed to one or more of the technology papers. Papers on the following technologies are part of this series (three of the papers have been published, with publication of the rest expected by the end of 2016:

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• Hybrid vehicles

• Downsized, boosted gasoline engines

• Naturally aspirated gasoline engines, including cylinder deactivation

• Transmissions

• Lightweighting

• Thermal management

• Diesel engines

Technology developments over the last 5 years have been astonishing. For example, the following technologies are already in production or production plans have been announced, even though were not anticipated or even considered in the supporting analyses for the 2017-2025 rule:

• **High-efficiency naturally aspirated engines** with Atkinson cycle and high compression ratio. The rulemaking assessments found that naturally aspirated engines would not be able to compete with turbocharged, downsized engines and would be almost completely replaced with turbocharged engines by 2025. The only exception was the continued use of Atkinson cycle engines on full hybrids (5% of the

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fleet), where the electric motor could offset the performance tradeoffs with the Atkinson cycle engine. However, Mazda has introduced a very high (13.0:1) compression ratio naturally aspirated engine with exceptional efficiency and is already using this on most of their vehicles.\(^5\) Toyota has found ways to offset the performance losses with its Atkinson cycle engine, using variable valve timing and other techniques, and is expanding the use of Atkinson cycle engines to non-hybrid vehicles.\(^6\) Toyota has announced that this technology will be in production soon.

- **Dynamic cylinder deactivation.** Cylinder deactivation was considered by the Agencies in the rulemaking, but only deactivation of groups of cylinders at a time. A new type of cylinder deactivation is in widespread development that allows each individual cylinder to be shut off every other revolution of the engine.\(^7\) This technique reduces noise and vibration, extending cylinder deactivation to lower engine rpms and allowing 4-cylinder and even 3-cylinder engines to use cylinder deactivation.

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• **Miller cycle** for turbocharged engines. This is basically the higher-efficiency Atkinson cycle concept extended to turbocharged engines. The performance tradeoff can be addressed by increasing the turbocharger boost. Miller cycle adds about 5% efficiency to a turbocharged engine at no cost, although there can be costs involved with increasing the turbocharger boost to compensate for the performance loss. If Miller cycle is combined with e-boost or 48v hybrids, these technologies provide the needed performance boost and the cost of Miller cycle becomes zero. The first Miller cycle application is in production on the new EA211 engine from VW.\(^8\)

• **Variable Compression Ratio (VCR).** Higher compression ratio improves efficiency, but at high engine loads it increases detonation, which is especially a problem for boosted engines. Variable compression ratio (VCR) changes the engine's compression ratio to suit particular speeds and loads. The benefits of VCR overlap with those of Atkinson/Miller cycle, as both enable higher compression ratio. However, VCR does have one significant benefit over Miller cycle: it allows performance to be completely maintained at lower engine speeds. Thus, VCR may be a competitor to Miller cycle concepts in the long run, offering manufacturers more options to improve efficiency while maintaining performance. Nissan is


implementing the first VCR application in a production turbocharged engine in MY2017.9

- **E-boost.** These systems comprise a higher voltage electrical system (48 volt) used to provide power for a small electric compressor motor within a turbocharger. This either directly boosts the engine, or spins up the turbocharger to greatly reduce turbo lag. This increases the ability to downsize and downspeed the engine and also reduces backpressure.10 E-boost allows the use of larger turbines with lower backpressure, for a direct reduction in BSFC in addition to the benefits from engine downspeeding/downsizing. The first E-boost system application is in production on the 2017 Audi QS7.11

- **48-volt hybrid systems.** Unlike expensive full hybrids, 48v hybrid systems are not designed to power the vehicle. The lack of a large electric motor and the correspondingly smaller battery greatly reduce the cost for this level of hybridization. The rulemaking considered 110-volt mild hybrid systems and projected that they would capture 17% of the market by 2025. However, 48v systems provide much of the same benefits at lower cost, as they stay below the 60v lethal threshold, also improving safety.12 There are also excellent cost synergies

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with e-boost, as the same 48v controllers, inverters, and power electronics are used for both systems.

- **Continuously-variable transmissions (CVTs).** The rulemaking analyses found that CVTs would not be able to compete with other transmissions and would be completely replaced by 2025. However, certain long-standing design issues with CVTs have been resolved and the latest generation of CVTs have reduced internal friction, wider ratio spread, and increased torque capacity.\(^\text{13}\) These new CVT designs have efficiency similar to conventional automatics and are cheaper than either conventional automatics or dual-clutch automated manuals. As a result, the CVT market share has exploded, from 9% in 2012 to 18% in 2015.

- **Lightweighting.** Advances in modeling/simulation tools and joining techniques have opened the floodgates to unprecedented levels of material/design optimization. Suppliers are rapidly developing the advanced materials and methods for major lightweighting endeavors, as well as the computational tools for simulating full vehicles all the way down to nanoscopic material behavior. Many recent vehicle redesigns have reduced weight by at least 4%, already meeting or exceeding 2021 projections in the rule (table 1). There are numerous material improvements in development that were not considered in the rule, such as higher strength aluminum,\(^\text{14}\) improved joining techniques for mixed materials, third-

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generation steels with higher strength and enhanced ductility,\textsuperscript{15} a new generation of ultra-high strength steel cast components, and metal/plastic hybrid components.\textsuperscript{16} Combined, weight reduction of about 15\% should be feasible by 2025, at a cost of only about a third of the rulemaking cost projection.

<table>
<thead>
<tr>
<th>Vehicle make</th>
<th>Model year</th>
<th>Weight reduction (kg)*</th>
<th>Weight reduction (%)*</th>
<th>Designed market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford F150</td>
<td>2015</td>
<td>318</td>
<td>14%</td>
<td>US</td>
</tr>
<tr>
<td>Acura MDX</td>
<td>2014</td>
<td>111</td>
<td>5%</td>
<td>US</td>
</tr>
<tr>
<td>GM Cadillac CTS</td>
<td>2014</td>
<td>111</td>
<td>6%</td>
<td>US</td>
</tr>
<tr>
<td>Peugeot 308 SW Blue Hdi</td>
<td>2014</td>
<td>140</td>
<td>9%</td>
<td>EU</td>
</tr>
<tr>
<td>VW Golf TDI</td>
<td>2015</td>
<td>49</td>
<td>4%</td>
<td>EU</td>
</tr>
<tr>
<td>Audi Q7</td>
<td>2014</td>
<td>363</td>
<td>15%</td>
<td>US, EU</td>
</tr>
<tr>
<td>BMW i3 EV</td>
<td>2014</td>
<td>249</td>
<td>17%</td>
<td>US, EU</td>
</tr>
<tr>
<td>Land Rover Range Rover</td>
<td>2014</td>
<td>350</td>
<td>14%</td>
<td>US, EU</td>
</tr>
<tr>
<td>Porsche Cayenne</td>
<td>2012</td>
<td>181</td>
<td>8%</td>
<td>US, EU</td>
</tr>
<tr>
<td>Audi A8</td>
<td>2014</td>
<td>145</td>
<td>7%</td>
<td>US, EU</td>
</tr>
<tr>
<td>Audi A3</td>
<td>2014</td>
<td>80</td>
<td>6%</td>
<td>US, EU</td>
</tr>
<tr>
<td>Nissan Leaf</td>
<td>2012</td>
<td>80</td>
<td>5%</td>
<td>US, EU</td>
</tr>
<tr>
<td>Lamborghini Huracan</td>
<td>2015</td>
<td>78</td>
<td>5%</td>
<td>US, EU</td>
</tr>
<tr>
<td>Audi TT 3rd gen 2.0 TDI</td>
<td>2015</td>
<td>50</td>
<td>4%</td>
<td>US, EU</td>
</tr>
</tbody>
</table>

Production or near-production technology developments that have occurred since 2012 will make it easier and cheaper for manufacturers to comply with the 2022–2025 standards that are under review. And this does not include new technologies in


\textsuperscript{16} Mana D. et.al “Body-in-white Reinforcements for Light-weight Automobiles”, SAE technical paper # 2016-01-0399

development, such as the VariGlide® Planetary Variator, which while unproven could improve transmission efficiency, reduce cost, and extend durability.

**Novation Analytics Phase 1 Technology Assessment**\(^{17}\)

Novaton’s study for the Alliance of Automobile Manufacturers clearly defined what they did and didn’t do, which I appreciate, but Novation did not actually evaluate technology potential. Instead, they simply duplicated the technology packages in the 2017–2025 rulemaking and compared them to current vehicles using these technologies. As a result, the study used both outdated technology assumptions and implicitly assumed there would be no technology innovations after 2014.

Novation’s technology assessments did not incorporate projected improvements in each technology from 2014 to 2025, as EPA and NHTSA did in the rulemaking. Instead, Novation started with the 2014 distribution of engine efficiencies and assumed that the average efficiency of each technology in 2025 would be the same as the 90% percentile efficiency in 2014. The Novation study specifically states, “In the timeframe of the MYs 2012-2016 and MYs 2017-2025 rulemaking, however, it is not likely that the sales-weighted fleet performance will exceed the current boundaries established by the best in class vehicles utilizing many of the technologies listed above. This implicitly assumes that there will be no technology innovations beyond what was already incorporated into some vehicles in 2014.

Given the history of constant technology innovation, this assumption is completely unjustified. It is essentially the same as saying that the iPhone 6 was the best smart phone in the market in 2014, so in 2025 the average smart phone will be the same as the iPhone 6. Applying this methodology to vehicle technology is no better than applying it to smart phones.

As a specific example of an unfounded assumption, Novation's study stated: “the current compression ignition (24-29 bar maximum BMEP diesel) can be used as a representative proxy as it is unlikely even an advanced SI package will exceed the current CI efficiency boundary.” It is accurate that 2025 SI (spark ignited, or gasoline) engines must exceed the efficiency of current CI (compression ignition, or diesel) engines. But any competent analysis of upcoming powertrain technology (which includes transmissions and accessories, not just engines) finds that 2025 gasoline engine powertrains will exceed current diesel powertrain efficiency. Novation’s assumption makes for a good sound bite, but it has no analytical basis. To illustrate the shortcomings of Novation’s approach, Novation's found that the 90th percentile efficiency for naturally aspirated engines, which they used as the average efficiency for 2025 naturally aspirated engine, was 22.8% (with high-spread transmission without stop/start). However, Novation’s own data showed that the 2014 Mazda SkyActiv engine already had an efficiency of 25.1%. This is 10% higher than Novation’s 2025 estimate — and almost as high as the average 2014 diesel engine (26%) — with 11 years of improvements yet to come.
Another flaw is that Novation simply duplicated the technology set that was used in the rulemaking. As this technology set is 5 years old, Novation implicitly froze the level of innovation at the 2012 level. Not only did Novation ignore all future technology innovation, it also ignored all technology innovation that have occurred in the last 5 years.

Overall, there is some interesting information in the study on the efficiency of the 2014 fleet, but the Novation study violates both of the criteria for a good analysis: it uses old data (5-year old technology sets) and it assumes there will be no improvements beyond what was in the better vehicles in the 2014 fleet.

**EPA/NHTSA Draft Technical Assessment Report (TAR)**\(^{18}\)

There is much to commend in the updated EPA and NHTSA analyses, as documented in the TAR. Both agencies have done massive amounts of work to update the technologies and the technology assessments since the 2017–2025 rulemaking. The most significant change was the addition of new highly-efficient, cost-effective naturally aspirated engines (i.e., high-compression Atkinson engines, like Mazda’s SkyActiv) in EPA’s analyses. This resulted in a reduction in the penetrations of turbo downsizing and hybridization for the EPA modeling. Both agencies also implemented a number of other updates, including:

- A more cost effective mild hybrid, based on a 48v system.
- Addition of Miller cycle turbocharged engines, based upon the engine map

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published by VW on their 2016 2.0L EA888 engine. This technology was applied to 4% of the 2025 fleet in EPA’s OMEGA analysis.

- Addition of variable geometry turbocharges (VGT) on 24-bar turbocharging systems.
- Updated mass reduction costs, based on four independent teardown studies. At lower levels of mass reduction, these studies produced lower costs than the rulemaking estimates.
- Increased effectiveness of future 8-speed transmissions, as informed by benchmarking of multiple transmissions, published reports of future planned improvements by ZF, and results from EPA’s new physics-based Alpha model.
- A significant reduction in battery cost estimates for EVs and PHEVs as a result of updated battery and motor sizing estimates, and the application of DOE’s latest version of the BatPaC model.
- Improved on-cycle effectiveness estimates for stop-start, based on more recent implementations of the technology

Due to the improved technology and cost reductions since the rulemaking, the standards will be easier and cheaper to meet than originally anticipated. This is illustrated by EPA’s technology forecasts in the TAR, which include only 4% penetration for Miller cycle and 7% weight reduction by 2025. If necessary, Miller cycle could be extended to all turbocharged engines (37% of the market forecast for 2025) and 15% weight reduction is also feasible by 2025, thus only a relatively small amount of these technologies are needed to meet the 2025 standards.
Another important finding from the TAR, which confirms a similar finding in the rulemaking, is that the MY2022–2025 standards are not dependent on any single technology. There are multiple promising technology pathways that have similar cost-effectiveness, and there are already several examples where different strategies employed by manufacturers have produced competition in innovation, such as automatic transmissions versus CVTs, downsized turbocharger versus Atkinson cycle naturally aspirated, and high-strength steel versus aluminum.

The agencies are also to be commended for their expanded use of rigorous peer-reviewed “tear-down” cost studies. Although expensive to conduct, these studies are more accurate and far more transparent than the older method of surveying manufacturers. Note that the 2015 National Academy of Science report specifically endorsed tear-down studies as the most appropriate way to get at costs.

Still, despite all of their new work and all of the updates, the agencies are still behind what is already happening in the market. For example, the agencies did not explicitly model e-boost, variable compression ratio, or dynamic cylinder deactivation. This is understandable, as it is critical for the agencies to have a robust, defensible analysis. But it also means that the agencies are always going to be somewhat behind in their assessments of potentially promising technologies. This may be particularly a concern for the NHTSA results, as it appears that NHTSA used slightly older data for some of their analyses and did not model the new high compression ratio naturally aspirated engines. On the other hand, EPA and NHTSA show relatively similar results, even though they conducted fairly independent
analyses. This supports the robustness of the technology availability to comply with the 2025 standards.

Although the agencies’ results are conservative, they are far more up to date and accurate than the Novation study.

**CONSUMER IMPACTS**

The argument is often raised that higher vehicle costs due to addition of efficiency technology will cause customers to keep their old vehicles longer, reducing the effectiveness of the standards and costing manufacturers sales. However, this argument is persuasive only if the technology does not deliver benefits desired by consumers. In fact, even at the current relatively low fuel prices, the monthly savings in fuel costs usually more than pays for the increase in the vehicle monthly payment. Most customers will recognize the improved vehicle fuel economy and will not balk at the increased vehicle price. It should be noted that the aggressive standards implemented from 2012 to 2016 coincided with the longest and strongest vehicle sales increase in history.

More importantly, many of the technologies required by the standards have other attributes that are highly desired by consumers. Turbocharged engines are downsized to

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deliver the same amount of power at high engine speeds. However, turbochargers have more power at low engine speeds and, thus, accelerate faster, climb steeper hills without having to downshift the transmission, and provide more towing ability. This effect was dramatically illustrated with a recent high-volume turbocharger application, the Ford 3.5L EcoBoost engine offered on their F150 pickup truck. The 3.5L V6 turbocharged engine was an optional engine on the F150. Ford charged an extra $595 over the standard 5.0L V8 engine. Ford originally expected that 20% of customers would pay the additional $595 for the smaller engine. The reality was that 45% of F150 customers paid $595 for the 3.5L EcoBoost and sales were higher than the standard 5.0L V8 (the F150 offered two other engines that combined for about 15% of sales, with 40% for the 5.0L V8). Certainly the better efficiency of the smaller engine was desirable, but what most customers wanted was the higher low rpm torque and higher towing capacity of the 3.5L EcoBoost.

Many other engine technologies, such as gasoline direct injection, variable valve timing, variable valve lift, and cooled EGR, also provide improved vehicle performance in addition to the efficiency benefits. Thus, there are no consumer acceptance issues for these technologies.

New transmissions with more gear ratios and wider gear-ratio spread have major positives in addition to better fuel economy. Lower gears improve vehicle launch, a lower ratio for the top gear provides quieter operation on the highway, and more gears can better maintain both lower rpm for better fuel economy and higher rpm for faster acceleration. These advantages have contributed to the rapid adoption of more gear ratios in recent years.
Lightweighting has very large benefits, beyond fuel savings, that have substantial value to customers. These includes better acceleration, ride, handling, and braking, as well as higher towing and payload capacity. For the 2025 rule and in the TAR, EPA and NHTSA did not evaluate the value of these benefits to consumer, instead assigning the entire cost of lightweighting to fuel consumption/CO\textsubscript{2} reductions. This is not appropriate and dramatically understates the benefits of lightweighting to consumers and overstates the cost to reduce fuel consumption and CO\textsubscript{2}.

This is supported by a 2015 report published by the National Academy of Sciences (NAS),\textsuperscript{20} which projected that manufacturers will reduce light-truck mass by 20\% in 2025, despite very high cost ($1,617–$2,343 for a 5,550 pound truck). They reached this determination because “implementation of mass reduction techniques can provide several benefits that might be attractive to an OEM”.

As a specific example, the official Ford website for their F150 pickup truck\textsuperscript{21} does not even mention improved fuel economy when discussing the aluminum body benefits on the front webpage:

“THE MATERIAL THAT MADE EVERY OTHER TRUCK HISTORY”

“The use of high-strength, military-grade, aluminum alloy not only makes F-150


\textsuperscript{21} http://www.ford.com/trucks/f150/
lighter and more agile than ever before, it's also one of the reasons it can haul and
tow more than any other half-ton pickup. See the story of this revolutionary advance
in truck manufacturing."

SAFETY

Safety should no longer be an issue, because the standards are now indexed to vehicle
footprint. Older studies reported that reducing vehicle weight increased fatalities, but these
studies inappropriately grouped the effects of vehicle size with weight and reported both
effects as a weight effect. More recent studies by NHTSA and DRI have found that it was the
smaller vehicle size that increased fatalities, not reducing weight. The footprint-based
standards were deliberately designed to create a safer fleet, as they encourage larger but
lighter vehicles and there is no longer any incentive to downsize vehicles. This is exactly
what you want to reduce fatalities. The latest draft NHTSA report on the impacts of size
and weight on fatalities found that if size is held constant, then the impacts of reducing
weight on fatalities are statistically insignificant.

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22 Updated Analysis of the Effects of Passenger Vehicle Size and Weight on Safety: Supplemental
Results on the Sensitivity of the Estimates for 2002 to 2008 Calendar Year Data for 2000 to 2007
Model Year Light Passenger Vehicles to Induced-Exposure Data and Vehicle Size Variables, DRI-TM-
12-09, R. M. Van Auken J. W. Zellner, February 2012

DRI, UPDATED ANALYSIS OF THE EFFECTS OF PASSENGER VEHICLE SIZE AND WEIGHT ON
SAFETY, PHASE II: PRELIMINARY ANALYSIS BASED ON 2002 TO 2008 CALENDAR YEAR DATA FOR
2000 TO 2007 MODEL YEAR LIGHT PASSENGER VEHICLES, Volume I: Technical Report DRI-TR-12-
01, R. M. Van Auken J. W. Zellner, January 2012

23 NHTSA, Relationships between Fatality Risk, Mass, and Footprint in Model Year 2003-2010
Passenger Cars and LTVs, Preliminary Report, DOCKET NO. NHTSA-2016-0068 JUNE 2016
The draft NHTSA report also found that older data may not be representative of future vehicles subject to footprint-based standards:

(viii) "The vehicles manufactured in the 2003-2010 timeframe were not subject to a footprint-based fuel-economy standard. NHTSA and EPA expect that the attribute-based standard will affect the design of vehicles such that manufacturers may reduce mass while maintaining footprint more than has occurred prior to 2022–2025. Therefore, it is likely that the analysis for 2003–2010 vehicles may not be fully representative of those vehicles that interact with the existing fleet in 2022 and beyond."

An important factor that is rarely addressed is that future weight reductions will be accomplished primarily with the use of high strength steel and aluminum and with better vehicle design. High strength steel and aluminum both have better crash properties than standard steel. Reducing weight using these better materials will improve vehicle crash performance and reduce fatalities, even in small cars. For example, Honda has moved aggressively towards using HSS in small cars in part because of the safety benefits.24

**FULL HYBRIDS AND PLUG-IN VEHICLES**

Much has been made of the market drop in full hybrid vehicles, corresponding to the drop

in fuel prices. While full hybrids are sensitive to fuel prices, this is a very expensive technology that is not typical of the technologies available to comply with the standards. Most technologies are much lower cost and will not engender the same consumer resistance. This includes 48v hybrids that are only about 40% of the cost of a full hybrid and are projected by both ICCT and the agencies to capture a much larger share of the market in 2025 than full hybrids.25

The manufacturers have been quoting the Novation study results, which found that 30% full hybrids would be needed to meet the 2025 standards. However, this study is based on 2012 technology sets and also assumes little improvement in technologies from 2014 to 2025. The best way to find that a lot of full hybrids are needed is to use outdated data and assumptions that cause the amount of available conventional technology to run out. In reality, there are many technologies that have become available since 2012, which will allow the standards to be met without the need for full hybrids.

Neither full hybrids nor plug-in vehicles are needed to comply with the 2025 standards. Between the technologies that are already near production that were not included in the agencies’ assessments in the TAR and the low penetration of Miller cycle and weight reduction projected for 2025, conventional technology will be more than enough for manufacturers to comply with the standards.

Plug-in vehicles required by California’s ZEV mandate are built into the EPA Reference Case

25 ICCT Hybrid paper 2015 and Draft Technical Assessment Report
fleet for the TAR. This is a constructive change from the assumptions in the 2017-2025 rule, as it ensures that EPA is not double-counting policy costs incurred by a different regulation (the ZEV mandate). These vehicles also make it easier for manufacturers to comply with the CAFE/CO₂ standards.

**OFF-CYCLE CREDITS**

The vehicle manufacturers have petitioned EPA to streamline the off-cycle credit approval process. Due to the current lack of data on how vehicles are actually operated in the real world, approval of this petition would be counter-productive.

In theory, off-cycle credits are a good idea, as they encourage real-world fuel consumption reduction for technologies that are not fully included on the official test cycles. However, real-world benefits only accrue if double-counting is avoided and the amount of the real-world fuel consumption reduction is accurately measured. The problem is that there has not been any systematic study of driving conditions and consumer driving behavior for at least 25 years. This lack of data makes it difficult, if not impossible, to establish generic credits. It also provides an incentive for manufacturers to generate real-world data on a biased sample of in-use vehicles, in order to obtain artificially large credits.

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The proper solution is for EPA to launch a collaborative data collection program, in cooperation with the manufacturers and the Department of Energy, to collect real world data representative of national driving behavior and conditions. This data set would allow EPA to establish standardized credits that would apply to all manufacturers and would not be subject to gaming. The ICCT would be happy to collaborate in such a data collection program. But any effort to streamline the off-cycle credit approval process must be contingent upon gathering this data.