UNITED STATES DEPARTMENT OF TRANSPORTATION

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NATIONAL HIGHWAY TRANSPORTATION SAFETY ADMINISTRATION

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MASS-SIZE-SAFETY SYMPOSIUM

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MONDAY,

MAY 13, 2013

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The Symposium convened in the Robert S. Marx Media Center at DOT Headquarters, located at 1200 New Jersey Avenue, S.E., Washington, D.C., at 9:00 a.m., Christopher Bonanti, Moderator, presiding.

PRESENT:

CHRISTOPHER BONANTI, Moderator
DAVID STRICKLAND, NHTSA Administrator
GREG KOLWICH, FEV
GREGG PETERSON, Lotus Engineering
JACKIE REHKOPF, Plasan (via telephone)
DOUG RICHMAN, The Aluminum Association
STEPHEN RIDELLA, NHTSA

SCOTT SCHMIDT, Alliance of Automobile Manufacturers
HARRY SINGH, EDAG, Inc.
JAMES TAMM, NHTSA
CHUCK THOMAS, Honda
BLAKE ZUIDEMA, Arcelor Mittal

T-A-B-L-E O-F C-O-N-T-E-N-T-S

T-A-B-L-E O-F C-O-N-T-E-N-T-S

P-R-O-C-E-E-D-I-N-G-S

9:05 a.m.

MODERATOR BONANTI: Well, good morning and welcome to NHTSA's Mass-Size-Safety Workshop. My name is Christopher Bonanti. I'm the Associate Administrator for Rulemaking here at NHTSA. We are very -- we have a very full agenda and the room is expected to be packed today.

Please be courteous and make room for others by not placing items on the seats next to you.

I would like to thank you all for coming and we are looking forward to hearing from all our expert panelists about the engineering and realities as well as the statistical evidence of the roles of mass and size in safety.

First, it is my pleasure to introduce my boss, Administrator David Strickland. Mr. Strickland was sworn into office on January 4, 2010. Since then, he has overseen the development of the First National Fuel Efficiency Program and oversees a broad range of vehicle safety and policy making programs, which support NHTSA's mission to reduce crash-related fatalities and injuries.

Prior to his appointment, Mr. Strickland served for eight years on the staff of the U.S. Senate Commerce, Science and Transportation Committee and Senior Council for the Consumer Protection Subcommittee.

He originally hails from Atlanta, Georgia. He received his law degree from Harvard University and his bachelor's degree from Northwestern University. Mr. Strickland?

(Applause)

ADMINISTRATOR STRICKLAND: Thank you, Chris, and good morning, everyone. Welcome to our second Mass and Size Symposium. It has always been a very daunting task for me to get in a room full of people who are intensely bright and I am intensely not very bright, well, on these issues. I'll give myself a pat on the back on other things I may be bright about.

But it really is an important work for us here at NHTSA. We have worked very hard in establishing the National Program along with the EPA and also in partnership with the California Air Resources Board.

And part of the work that we had to think about was how do we get as stringent a standard as possible, but within the realities of the costs and benefit, affordability for the folks that are buying these vehicles and, of course, never compromising safety.

And the work that went into the standards that actually began in 2012 and go out to 2021 are incredibly stiff. Now, recognizing that the industry right now is stepping up to meet the challenges of these standards today. We are now preparing or actually in full throes getting into our work for the mid-term review for setting the final standards for 2022 to 2025.

Now, there is a lot of technology pipelines that are going to be used in order to achieve these standards. And one of these pathways is clearly usage of the reduction of mass and size and weight in a safe way.

Now, while we have been working for a very long time on these fuel economy standards over the past several decades, we really are sort of at a new part in our future in looking at CAF□.

We have the foundation of the Ten-in-Ten Fuel Economy Act, so even beyond our fuel -- our current rulemaking, we have a statutory mandate to establish standards out to 2030.

So clearly, the work in the foundation that we are looking at today and our approaches as we look at the midterm review for 2022-2025 will also be the foundation of that work in the future as well going forward.

So we are using an engineering approach to investigate how much mass reduction can be affordably and feasibly achieved while still maintaining vehicle safety and reasonable levels of major functionality, such as noise, vibration and harshness. These factors can have a significant impact on drivers' awareness of road conditions and on performance.

At the same time, we are studying new challenges that lighter vehicles might bring to vehicle safety and the potential counter-measures to be effectively able to manage these challenges.

Today our goal is to present results from studies completed so far, obtain feedback and solicit ideas about how the agencies should be considering these questions.

NHTSA will continue to examine these issues as we approach the next round of rulemaking. We look forward to receiving as much input as possible on the complicated studies and to help us refine our approach going forward. Today, we will hear from researchers who have done this engineering and statistical analysis.

We have invited OEMs, material suppliers and safety specialists. There will be a lot of information shared and you will be hearing more detail about how these studies are coming together today and tomorrow.

The overview is that NHTSA and the other Government agencies have completed a number of studies in all major areas of vehicle mass reduction and safety analysis and we are excited to receive the input from the stakeholders and the public.

It really is our opportunity to sort of learn, be incredibly transparent and share our work, but more importantly be able to receive the input from all the experts in the room today. It really is how we can sort of make sure that we have the best standard possible to address NHTSA's mission, which is the reduction of the dependence on foreign oil and for reduction of greenhouse gases, but, first and foremost, making sure that safety is always the number one priority.

Thank you so much everyone. Have a fantastic two days worth of information sharing here at the symposium and looking forward for the results in the days, months and weeks ahead. Thank you so much.

(Applause)

ADMINISTRATOR STRICKLAND: Thank you.

MODERATOR BONANTI: Okay. Before we continue with our speakers, a few housekeeping and ground rules for the meeting to be a success.

Now, for those needing to place your luggage or other materials, we have -- we reserved Room No. 5, which is across the way. Also for visitors to the building, all visitors must be escorted at all times. If you need to leave the conference center area, please, notify one of our escorts located by the door of the media center.

Please be aware that no food is allowed in the media center and only drinks with lids are, basically, allowed.

There is a small coffee kiosk in the front that -- in the atrium just outside the doors that you can get some coffee or beverages in that regard.

Also, please silence your cell phones and BlackBerrys. Also, please be aware that this workshop is being broadcast over the web and open to the public. There are microphones in the ceiling and at the same time, please, be aware that even during breaks, you may be heard from others around the country that are logging in through the web, at this time.

Bathrooms are located either outside towards the left hand side, outside the media center to the left or you can go out and to the right and it curves around to the back.

Also, in the event of an emergency, I'll have Lixin from my staff dial 911. Also, if the building alarm system is activated for a fire or an emergency, please, exit quickly and do not collect your personal belongings.

We will break for lunch around 11:50. Escorts are available to walk you to the building exit. You must be escorted at all time while in the building, so we ask that you refrain from going to the DOT cafeteria unless you have lunch with someone from the DOT that will meet you here.

We have provided a map of local eateries in your agenda. To return to the conference center area after leaving the building, escorts will be available at the front door at 12:45 on.

Please return in time to resume the meeting by 1:20. Please, make sure that when -- you have to account for time going through security.

As you can see, today we have a very full agenda. Our speakers each have limited time, so if you could, please, hold your questions and comments for the end of each presentation, it is appreciated. I'll be watching the time closely. I didn't bring my hook, but, you know, I will signal to every presenter when your time is getting close to the end and also when your time is expired.

Question cards have been identified and left on each individual seats. Please submit your questions to the NHTSA volunteers who will periodically walk around the room collecting cards. Do not wait until the end of the presentation, so that we will have the questions in hand as soon as the presentation is finished.

I will be asking the questions to each one of the presenters and also at the end of the day.

If you are listening to the webcast, you may submit questions on-line. At the end of the day, as I was indicating, I will have a 30 minute presentation for a focused discussion with all the panelists.

During that time, we will allow the audience to share questions or comments which will also be requested to be placed on the cards. We realize that there is much to contribute and apologize for the time constraints. We ask you to, please, submit to the docket any questions or comments that we were unable to get to.

It is located at NHTSA-2010-0152. I'll say it again so for those that are writing it down. NHTSA-2010-0152. With that said, we are ready to begin.

Our first speaker is James Tamm, Division Chief for our CAFE Program in my office, who will present the assessment of vehicle mass reduction feasibility, cost and safety effects for CAFE and greenhouse gas rulemakings. Thank you.

MR. TAMM: Okay. Bear with us as we are taking care of our technical difficulty here. We're trying to get the presentation on the screen.

Okay. Thank you, Chris, and hopefully for everybody who will be presenting, we will have this all up and operating when you get up here.

So anyway, I just wanted to first say how pleased we are to have this large turnout. We also have a number of people who are monitoring on the web, so welcome to everybody to today's workshop.

The topic that we are discussing today is, as David Strickland had mentioned, very important to NHTSA and also to EPA and CARB and to DOE. As -- particularly as the agencies move forward to the midterm evaluation and NHTSA's full rulemaking, which will be conducted for model years 2022 to 2025.

I'm going to be today sharing how the agencies assess the feasible amount of mass reduction, the cost for mass reduction and the safety effects for mass reduction.

So I'll first start with -- let's see, I think we are going back one. I think I got it here, Lixin, so thanks.

So as far as the specific topics I'm going to run through, it's going to be very brief. A few comments on the 2017 to 2025 rulemaking that are relevant to mass reduction and safety. I'm going to talk a little bit about the midterm evaluation and the 2022 to 2025 rulemaking. And then focus mostly on, basically, an overview of how the agencies have assessed the feasible amount of mass reduction and cost.

I kind of tied together some of the presentations we will be seeing today. And also how the agencies look at safety for mass reduction, again, trying to tie it together, a perspective on how we have been looking at things in our rulemakings.

So as far as the 2017 and beyond CAFE and Greenhouse Gas Emission Standards, first, the -- in the last two rulemakings, we have conducted joint rulemaking with EPA. And California Air Resources Board has participated with NHTSA in assessing the effectiveness and cost of technologies as well as the infrastructure for distributing alternative fuels.

In the rulemakings, NHTSA is responsible for and has issued fuel economy standards. EPA has issued greenhouse gas emission standards. And the CARB has accepted compliance with the Federal Greenhouse Gas Emissions Program as compliance with the CARB Standards.

And the most recent rulemaking for 2017 and beyond was published in October of 2012. In establishing the standards, the agencies have conducted extensive technical economic and environmental analyses. And a key part of assessing the technologies that can prove fuel efficiency, the effectiveness of technology and cost and also the price -- I'm sorry, the pace at which industry can implement the technologies that are different assessments we have done.

The analysis that the agencies have done, we have put forth analysis that shows pathways that the industry could use to comply with the standards. And we have used those pathways that we have analyzed along with other analyses to establish stringency for standards as well as to assess what the cost and the benefits are for the program.

It is important to note that the standards that are issued are performance-based standards, so we don't mandate any specific technologies be used to comply with those standards. And the manufacturers are really free to choose whatever technologies they feel are most effective for compliance.

Next, I would like to move to the

midterm evaluation and NHTSA's Rulemaking for 2022 to 2025. So there is a provision in the Energy Independence and Security Act of 2007 that limits NHTSA to establishing Fuel Economy Standards for no more than five years at a time.

So based on that, the standards that were established for 2017 and beyond for NHTSA were final for model years 2017 to 2021, but the standards for 2022 to 2025 are not final. We went to the dictionary and found the word augural to describe those standards, which just means they are not -- well, they are not final, but they would suggest what standards would be had we had authority to finalize them at the point in time that we issued the standards.

So NHTSA will be conducting a new rulemaking for model years 2022 to 2025. And that will be based on the best available information at the time of that rulemaking. It is going to be comprehensive rulemaking.

It will be similar to the rulemaking that we just recently finalized, so it's going to be fully comprehensive. It will provide opportunity for public notice and opportunity for comment to that rulemaking.

The EPA Regulations that were issued with the standards in October require EPA in the future to determine whether the 2022 to 2025 standards, Greenhouse Gas Standards are appropriate under the Clean Air Act, based on circumstances at the time of the review.

So in regulation, EPA will make this determination no later than April of 2018. If EPA determines that the standards are appropriate, then they will issue a final decision. If EPA determines that they are not appropriate, then they will initiate a rulemaking to change them.

Also connected is that there is another element in EPA Regulations is that there will be a midterm assessment that will be conducted and that will be conducted by EPA, NHTSA and the California Air Resources Board. There is a requirement to complete a joint draft technical assessment report by October of -- I'm sorry, November of 2017.

And on this slide, we took a whack at trying to put things on a time line for the rulemaking. The one thing that is important here is that the regulatory text basically says no later than dates, so there is a possibility the agencies could conduct one or more of the elements ahead of the time frame.

But this basically shows that in 2012 we did the Final Rule. We are indicating up through about 2016 this key time for the Agency's work and research to inform the midterm evaluation and the rulemaking for NHTSA.

Okay. So in the agency's analysis, we identified and believe there are certainly a wide range of technologies that manufacturers can use to comply with the new standards. And one of those technologies is mass reduction and, of course, the focus of our discussion today.

Why is it important? Well, literature and evaluations support that for each 10 percent reduction in mass, that the fuel efficiency of the vehicle can be improved by 6.5 percent and that's assuming that the engine is downsized to maintain performance.

So based on the effectiveness of mass reduction, we expect and we have also heard from manufacturers, though fairly widely, that mass reduction will be an important technology in complying with standards moving forward.

So therefore, we are sponsoring this workshop. We think this is part of an ongoing effort to, basically, be looking at developments in projecting what can be done with mass reduction, what its feasibility and costs are going forward, as well as to look at its impacts on safety.

Go back one. Sorry. So on this topic, manufacturers, the Government agencies, supplier groups, universities and other interest groups have been sponsoring studies to determine how much mass can be reduced from a light-duty vehicle. And the studies have really varied very widely.

Some have focused on body-in-white, some on closure, some on components, some on materials, such as steel-focus, some on aluminum and some have considered costs very broadly.

In determining how much mass reduction is feasible, we really feel it is a fairly complicated undertaking. And the study results can really vary based on a number of factors, including the baseline vehicle that the study was starting from, the production volume of that vehicle, the mass reduction techniques considered, cost constraints and to the extent to which vehicle functionality is maintained, as well as the time frame for the study, what model years the projections are for.

So in order to assess the feasible amount of mass reduction and cost, the agencies, NHTSA, EPA and CARB, have conducted studies each using holistic vehicle design approaches.

And this slide provides an overview of the studies that the agencies have sponsored. At the top is a study based on the 2009 Toyota Venza that CARB sponsored that was completed in 2010. The study developed two design concepts, what is so-called low-development design which had 20 percent mass reduction and a high-development design that had over 30 percent mass reduction.

And the design concepts from this so-called Phase 1 work were then studied in Phase 2 follow-on studies by EPA and CARB. And the first of those Phase 2 studies was funded by EPA and ICCT. We will be hearing about that later this morning.

It started with the low-development design concept from Phase 1. The primary contractor was FEV, EDAG served as a subcontractor. The study used technologies that were judged to be mature for high-volume production in 2017, that included detailed engineering and cost analysis for the whole vehicle, used material substitution with gauge and grade optimization for the body structure and closures. This particular study did not look at changes in geometry.

Other components used a best-in-class design approach and then those designs being rescaled to the Venza application.

The second study was sponsored by CARB and the ICCT. The work started with a high-development concept from Phase 1. The contractor was Lotus Engineering and the study included additional analysis from the Phase 1 study for the vehicle structure and the closures. It used an aluminum-intensive body design and included a new cost analysis for that body structure and the closures.

The third study was sponsored by NHTSA and the baseline vehicle was a 2011 Honda Accord. The primary contractor was Electricore and subcontractors were EDAG and George Washington University.

The study focused on detailed engineering design and cost analysis for the whole vehicle. The body structure and closures were optimized for geometry, grade and gauge.

That study used technologies that were judged to be mature for high-volume production in 2020 and the design criteria was to maintain the same functional performance as the baseline vehicle.

As far as future work, the EPA has a current study on light-duty truck and that is with FEV as primary contractor and EDAG as subcontractor. Also, we have, NHTSA, posted a synopsis on fedbiz.org for a potential study of a light-duty truck.

So one challenge that the agencies face in rulemaking is determining the feasible amount and cost of mass reduction for each year is that the number of data points that we have to try to determine what is representative for the overall fleet.

Basically, if you look at the studies that we are representing here, there is really three studies, so we have got three point estimates that are covering two vehicle models and we are really trying to extrapolate those findings across the entire fleet to reflect the influence of our regulations.

So as part of that, as mentioned earlier, the assumptions that are used in each of these studies is important and each of the presenters today will be talking about what those assumptions were as well as their attempts to basically project what the cost curve would be for the entire fleet based on the study.

So we think this is an inherently

difficult task and that's why this dialogue is a very important element as we go forward. We are really seeking comments on what, if any, studies was done right? Are there things that could be improved going forward? There will be valuable dialogue.

So each of the studies included simulation modeling to assess the performance to FMVSS, NCAP and IIHS tests. But additionally, NHTSA and EPA consider the effects of mass reduction on societal safety.

And what is societal safety? Basically, it is the safety of the overall fleet that is on the road and pedestrians.

So NHTSA has long-considered the potential safety effects in determining the maximum feasible CAFE Standards. If OEMs are going to be reducing vehicle mass or building smaller vehicles in response to future CAFE Standards, we want to, basically, anticipate whether there will be safety implications and, if so, what are those safety implications?

So for example, if manufacturers make lighter vehicles, stiffer to protect against intrusion in a crash making the vehicle stiffer will affect both the forces on the vehicle's occupants in a crash as well as the forces of that stiffer vehicle would exert on other vehicles in the fleet that it may crash in to. And so these are the interactions that we need to understand.

We are also concerned that lighter vehicles have a higher change in velocity in a crash and that would result in potentially higher injury and fatality risks during crashes with heavier vehicles. So understanding this dynamic is going to be important because heavier legacy vehicles will persist in the fleet during the transition to the lighter and smaller vehicles.

CAFE Standards should be designed to encourage manufacturers to pursue a path toward compliance that is both safe and cost-effective.

NHTSA is assessing the societal safety using two different approaches. The first is what we termed as a backward-looking approach which uses the statistical analysis of historical crash data to assess the effects of vehicle mass reduction and size on safety. That is going to actually be the topic that will be focused on in tomorrow morning's portion of the workshop.

The second approach is what we are terming as a forward-looking approach, which uses engineering design in analysis models. It, basically, is performing crash simulations using these CAE models that I mentioned earlier. And the results of that will be discussed, as far as NHTSA's first phase of that work, later this afternoon.

So I'm just going to talk briefly about each of those, the forward -- first, the rearward-looking and then the forward-looking. So we will start with the statistical analysis of historical data.

So in the statistical analysis of historical crash data approach, we believe that this is useful for several reasons. First, it shows what the real-world trends are in crash incidence and severity. It can show it for smaller versus larger vehicles and it can show it for lighter versus heavier vehicles.

This information is really not available through other methodologies and it provides the Agency with a pool of data to analyze as well as enables us to look at different crash scenarios and exposures. However, there is also drawbacks that we recognize.

First, there is a question because the data is historical, is it -- are we confident that it represents what is going to happen in the future?

And also, because the data are mixed from various crash scenarios and exposures, some times there is not enough data to pinpoint the exact cause.

So researchers have been using a statistical analysis of the historical crash data to evaluate trends for over a decade. NHTSA's doctor Chuck Kahane, Mike Van Auken of Dynamic Research Incorporated, Tom Wenzel of Lawrence Berkeley National Lab among others, have published a number of analyses.

The body of research has yielded in the past conflicting results. Some studies showing significant increase in fatality with mass reductions and others finding a decrease in fatalities. So to -- as far as way of background, in the past, NHTSA sponsored a peer review of over 20 studies to assess methodologies and that was completed in 2011 by Dr. Paul Green from the University of Michigan.

Also in the prior mass reduction workshop that we had, there was -- it was postulated that a part of the reason for the different results stem from the analysis being conducted using different databases and different statistical methodologies.

So since then, NHTSA and DOE with help from EPA created and published a common updated database for the statistical analysis and that consists of fatality data from model year 2000 to 2007 vehicles in calendar years 2002 to 2008. And anyone that's interested in doing research has access to that database. It's on the NHTSA website and can be downloaded.

And we are thinking that having that has helped with the most recent round of analyses in at least helping to reduce one of the sources of variations in the studies. So using that common database, Dr. Kahane has updated his 2010 Fatality Study. Also, Mr. Wenzel has independently replicated Dr. Kahane's work as well as updated his 2010 Casualty Study.

Dynamic Research Incorporated has also been working with the database and others such as Chrysler have downloaded the database and done some analysis.

So we are really hoping for a good robust discussion of that issue. Again, that is going to be tomorrow morning.

So moving back to our rulemaking just to tie this in, what do we do with that analytical data? We use, basically in our analysis, mass reduction levels that achieved a net neutral effect on safety. So therefore, the analyses that the Agency has conducted for the 2017 to 2025 rulemaking showed a path that industry could use that maintains overall fleet safety while complying with the standards.

The chart at the bottom shows the -- the section at the bottom shows the -- well, first -- well, second row from the bottom is the maximum amount of mass reduction that the analysis allowed for these different subsegments of the vehicle fleet. And then the bottom row shows the projected industry average mass reduction by each of these classes to achieve that result.

In these -- go back. I'm sorry. So just for reference, these mass reduction levels are referenced to 2010 fleet. And it is -- one thing that is important to stress is that all vehicles must meet applicable safety standards and we have expectation that manufacturers will continue to build vehicles that perform well to NCAP and IIHS testing.

Okay. So then lastly, I'm going to just have just a few remarks on NHTSA's forward-looking assessment of societal safety effects. And part of this research uses the finite element models that were developed as part of the light-weighting studies that were mentioned earlier and NHTSA is using those models to evaluate how those proposed designs perform in a variety of simulated crash configurations.

The -- really what I'm saying is that, you know, the FMVSS, NCAP and IIHS tests are very important parts of analysis, but they can't capture all the diversity of types of crashes that occur in the real-world.

So NHTSA sponsored this work. It has been -- the contractor was George Washington University. It, basically, is conducting simulations of vehicle-to-vehicle and vehicle-to-object crashes. And again, as mentioned, they are moving beyond the crash conditions that are used for standards and voluntary ratings.

So we are looking at broader array of speeds and conditions. We are also -- we have conducted some compatibility work between light-weighted and non-light-weighted vehicles. And we are intending to use the study in the future to evaluate potential counter measures which could include different airbag deployment timing for lightweight vehicles and potentially adaptive occupant restraint systems.

So the first phase of the study is

nearly complete. We are going to hear about it later today. We expect it to be completed with a peer review in July of this year.

And let's see with that, next steps. I'm not going to comment on next steps. There were some that were filtered into -- were included in what I just remarked here. But some of the speakers will be, basically, covering some of the future work that is intended with studies.

So with that, again, in advance I just want to thank everybody for participating here today. We look forward to some good questions from the audience, some good dialogue among the panelists. So thank you very much.

(Applause)

MODERATOR BONANTI: Okay. I understand that our next speaker needs to flip out their laptop. Is that correct?

MR. TAMM: Yes, that's correct.

MODERATOR BONANTI: Okay. Do you

have the computer?

MR. TAMM: Yes.

MODERATOR BONANTI: Oh, Lixin is getting it. Okay. Great. Okay. While -- the next speaker is actually Gregg Peterson from Lotus Engineering and is going to be discussing the analysis of the impact performance and cost considerations for a low multi-material body structure.

Again, if you have any questions, please, we will have volunteers going through the aisles with any questions that you may have. Please write them down on your -- on the pads or the cards that we provided and we will be collecting them and being able to ask them towards the end of the presentation.

Unfortunately, we are having some technical difficulties here. For those that are on the webcast, please, just bear with us. Okay. This is long.

Replication of Dr. Kahane's analysis is done for the ICCT by DRI. It adds an analysis of the separate effects of mass on crash probability and crash outcome. That analysis shows that while there are some opportunities statistically significant relationships between mass and crash probabilities, there are no statistically significant negative effects of the mass on crash outcomes.

Are there any theories consistent with this result? That's the first question.

Does this change NHTSA's understanding of the mass and safety? That's the second question.

And the word apparently -- oh, okay. So is that the end of it, the end of the question? Okay. Okay.

So the first question we will go--

PARTICIPANT: We have a theory to explain the follow-up mass crash probability -- increases crash probability, but does not bundle the effects of crash outcomes.

MR. TAMM: Okay. Those are

excellent questions. You know, I think actually I'm going to defer those though to one of our experts, Dr. Kahane, because I think he has taken a closer look. I don't know if Steve can. Yes, which he just left, so I don't mean to dodge the question, but I think we will probably get a little more informed answer to get his perspectives on it, which would be tomorrow, yes.

Yes, okay, and I guess related to that, I mean, we will have copies of the transcripts from this meeting, so we will hold that question and make sure it gets asked tomorrow and have discussion on that point. We will make sure that gets covered.

MODERATOR BONANTI: Okay. We are going to be downloading a -- are there other questions, at this point? I understand there is one at least. Okay. And this is for Jim as well? This question is for Jim Tamm as well? Oh, he will answer it tomorrow. He will answer his question tomorrow. Okay.

Actually, if we get this back up in a minute, we are still on time. So hopefully this will work. We are switching out computers. There you go. Okay.

No further ado, Gregg Peterson.

MR. PETERSON: All right. Thanks, Chris. All right. I would like to thank NHTSA for the opportunity to present today. I apologize for the technical difficulties. I'm going to be running without animation here.

James covered pretty much what I wanted to talk about in the first slide here in terms of the background. There is a lot of information here and I'm not going to go through it in any detail.

Suffice it to say, there are a number of studies done on what I'm going to be talking about today.

All right. So to continue what I am going to be talking about today will be the continuation of the Phase 1 high-development, which was targeted for a 40 percent mass reduction. And essentially what happened, we published a White Paper and predicted roughly a 40 percent mass reduction was cost-effective and essentially ARB challenged Lotus to show that a very lightweight body structure could meet federal crash requirements as well as some internal standards for bending and torsional stiffness.

So that's what I'm going to be talking about. As part of the process, we shared our early models with NHTSA. They were crash testing the vehicle independently using their modeling. George Washington University was involved as part of the study.

We also worked very closely with the EPA and Department of Energy. The Department of Energy contributed to the material science as part of this study. And this paper was published in 2012.

This is the Phase 1 mass and cost results. And essentially, we found about a 38 percent mass reduction and the very surprising thing was about only a 3 percent cost hit. And that came about, number one, the body-in-white cost was about plus 35 percent, but every other system we found, essentially, about a 4 percent cost-save.

And the reason for that is you take 30 or 40 percent out of a vehicle and use pretty similar materials in every area but the body-in-white structure, you are going to effectively be able to save some money.

And that's really what we predicted from the Phase 1 study. There was no analysis as part of this that was beyond the scope of the project.

So what are some of the fundamental designs/factors affecting vehicles today? Well, obviously, fuel economy and emissions. So these are key areas that everyone is very concerned about, very good objectives in terms of saving U.S. consumers money as well as saving billions of tons of emissions.

The -- it is important to note that the 54.5 mile per gallon standard translates to somewhere around 40 mile per gallon EPA sticker number. So it's not quite as severe as what it sounds like to the general public.

Factors that affect fuel economy, James hit on that. Every 10 percent reduction gives about 7 percent fuel economy increase. So about 30 percent results in roughly a 20 percent fuel economy savings, that's with equivalent powertrains.

There are also some other effects that happen as a result of this. You get into mass de-compounding effect where you hit a tipping point and it allows you to redesign some of the body systems and some of the chassis systems to help make your vehicle lighter.

There is also a positive effect on dynamic performance. We found that the tire size doesn't shrink as fast as the mass reduction, so that effectively you get more tire contact patch area per pound of vehicle weight, which can help in emergency situations and dynamic transitions.

Okay. There are other factors that affect fuel economy besides mass and I'm just showing some examples here that don't follow the 10 percent mass-reduced vehicle that will get you about 7 percent better fuel economy.

The Toyota Scion that is shown at the end there has about 10 percent less weight, yet it has 37 percent better fuel economy than the baseline Nissan Versa that I show there. A much heavier car, the Chevy Cruze Eco which weighs almost 30 percent more than the baseline gets 22 percent better fuel economy.

So there are, obviously, other factors besides mass that you need to pay attention to when you are designing a vehicle.

In terms of lightweight effect on performance, there is, obviously, fuel economy, but there are also an improved potential for braking, handling, acceleration times remain the same with a properly designed engine system to give you the same weight-to-power ratio as you had with the baseline vehicle.

Also, the center of gravity tends to come down as the central masses stay low, but you are reducing the top hat section weight of the vehicle. And BMW uses carbon fiber roofs in some of its M variants for that very reason to help get the center of gravity lower.

Okay. Engineering parameters. When we looked at the Phase 2 design, which was targeted for 2020 model year with a 2017 technology readiness level, we looked at every class of material, steel, aluminum, titanium, carbon fiber, ductile cast iron, etcetera, before we made final decision.

One of the key factors was being able to utilize proven software. If you got a new material that looks great on paper, but you don't have the ability to model it, OEMs are going to be very reluctant to us that material, as there is high risk involved with that process.

All right. Use of lightweight materials doesn't guarantee a lightweight vehicle. This is an example, Lamborghini has outstanding engineers and yet despite their best efforts, they ended up engineering a carbon fiber body, 2-ton, two-seater sports car.

The Mustang GT 500, which has a steel body is actually lighter by over 200 pounds. And when you look at it from a specific density, meaning the area, the volume of the vehicle divided by the weight, you end up with a vehicle that is actually about 10 percent lighter on a specific density-basis.

So again, you need to pay

attention to the details. Lightweight doesn't mean that it is going to -- lightweight materials don't necessarily translate into a lighter weight vehicle.

All right. Also, what I wanted to point out here basically is that recycled materials we think have an opportunity to help reduce the cost of the lighter weight materials that are going to be used in vehicles. Plastics play a large role in automotive systems today and are showing that they are -- the very dismal record that the U.S. has in terms of reclaiming materials.

The blue shows the use rate and the magenta shows the recycled rate. So we think there is some opportunities for using recycled materials. And we used recycled PET, which is from water bottles, in the floor on the vehicle that I'll be describing.

In terms of the manufacturing process selection, this is also key in terms of looking at every possible process as part of the design. And really, tooling investment is also a key consideration.

So looking at lightweight methodologies and looking at low-cost tooling methodologies contribute to the overall vehicle cost.

The joining process selection, again, we looked at everything that was out there. Resistance, spot welds, clinching and I'll be going into this in more detail. A key part of a multi-material vehicle is the galvanic considerations. You have got a big battery out there and you want to make sure that you don't get anodic and cathodic reactions with the various materials.

So there is a tremendous amount of work that is being done by industry. And we worked with one of the chemical companies, Henkel, to help make sure that we had the proper corrosion and galvanic protection as part of this process. And then we -- the processes were chosen to meet the cycle time requirements.

This vehicle was targeted for 60,000 to 100,000 units per year, body design methodology. This is a real key point. If you are using materials, let's say, that average about four times the cost of the base materials and you have the weight, you still have double the piece cost. So going in on day one, you know that you have to do something to help offset that.

If you use the same processes, the same forming techniques and the same material joining processes that you used on the baseline vehicle, then you aren't going to get any cost offsets. So you need a different design approach to help offset the added costs of the more expensive non-ferrous materials.

The design methodology that we use, essentially, was a total vehicle holistic approach where not every system was necessarily down-massed or used lighter materials. It was a function of the total vehicle system, so that the total contribution would allow the vehicle to become lighter as a whole.

We used a multi-material approach. The one material we think is best, so we used steel, we used aluminum, we used magnesium, we used composites as part of this design process. We designed for low-cost tooling. Extrusions are very inexpensive. We minimized the scrap process and then we maximized the structural attributes through continuous joining techniques. And we also used electronics and electrical systems to replace mechanical hardware.

A couple of examples, using solenoids to control transmission gear selection and parking brake actuation. You don't think a transmission gearshift lever has to handle much force, but yet, when a 300 pound person leans across that, you generate as much torque as a V-6 engine and you have to offset that not only in the transmission selector lever, but also in the structure underneath it that supports it.

All right. We started with the Phase 1 design. We did the interior and exterior. And then we used topology analysis to essentially develop the skeleton of the vehicle. And we did a sensitivity analysis using magnesium, aluminum and steel, each of those pictures that I show here are 100 percent mag, 100 percent aluminum and 100 percent steel.

Load-path determination played a real key role. On Day 1, you start looking at how you minimize torque input. The smoother the surface -- the transition, the better and lighter weight the solution can be from the design standpoint.

Shape optimization also played a key role for section inertia is BHQ divided by the shape factor, which means every little bit that you can add, every tenth of a millimeter you add to the height is an exponential contributor to section inertia increases.

And then we -- basically, material selected after that and then apply thickness optimization. So this is the vehicle that we ended up with. Silver is aluminum. The purple is magnesium. The red is steel. And then the blue is composites. And we used a variety of processes to put this together.

We used rivets. We used friction spot joining and we used mechanical fasteners. It is 100 percent bonded using a structural adhesive. And what that effectively means is with a resistant spot weld body, you can essentially get a gapping during a crush situation, an impact situation where the materials separate on a microlevel.

With the structural adhesive you get 100 percent bonding. And what it allows you to do, we used actually the inverse of what you do when you are racing. You stitch weld the entire body-in-white to improve the stiffness. We used the converse of that where we were able to down-gauge the material thickness as a result of having a 100 percent intimate contact throughout the entire flange length.

All right. Is anybody else doing this? Well, if you look at the 2014 Chevrolet Corvette chassis, which is a work of art, it's just a stunning work by the GM Engineering Team, they use extrusions. They use castings and they use stampings. This is an aluminum-intensive body. It does have composite underbody as well.

So this is a step in the direction. And this isn't the optional chassis. This is the base chassis for 2014. The Z06 has an aluminum chassis. This is now the new base chassis for the Corvette.

So the bottom line is we took about 140 kilograms of weight out of the baseline vehicle. We didn't quite get to 40 percent, but we got very close. And the real key here is that we minimize the parts count.

We took about 35 percent of the parts out from the baseline vehicle and we did that by being able to integrate components using castings and extrusions.

All right. Why structural adhesive bonding? Well, I talked about one of the advantages, the 100 percent flange length. It also helped us reduce the cost of joining it using friction spot joining. Lotus has had a long history of using, successfully using, structural adhesive bonding. And so we had a lot of background in terms of this technology.

Okay. Friction spot joining. Friction spot joining for those who don't know what it is, it's basically a small drill motor with a unique drill bit that comes down and joins two pieces of aluminum. We couldn't get it to work with mag. We worked hard to join mag and aluminum. There is work being done around the world to try to make that happen. We are very encouraged by those results.

But essentially what you do is you

come down and you stand the plastic region of the material, so you don't degrade the parent material properties with this. It also has the advantage of being one-fifth the cost of resistant spot weld, primarily due to the energy.

So another key advantage is to reduce flange width. We see automotive companies today starting to do scalloping where you scallop around the material when you come in with a resistant spot weld and it saves weight on the protection body, but in the meantime you are throwing away some of that steel.

In this case, we are able to go to a 20 millimeter flange width versus say 26 or 28 resistant spot weld and that is material that comes off each side. So there is some material advantages to doing that.

In terms of riveting, there are single sided and double sided rivets. There are a wide variety of family of rivets that work well that are out there in production today.

In terms of putting this together, we used a new assembly plant. It cost $53 million, which is within a million dollars of what the -- the new Corvette body-in-white plant is. This was developed by a European company that we worked with and essentially allows you to build an A, B, C, D or E class vehicle on the same line. So it's a very versatile plant.

In terms of the structure and crash performance, we basically looked around the world for the best performing SUV, CUV-type vehicle that we could find. And the published information that we got -- that we found was on a BMW X5, which has a 27,000 nanometer per degree torsional stiffness. This is a world-class number. It is better than many super cars, exotic two-play sports cars that are out there today.

And what we ended up with was a

number that was in excess of that. Our target was to use and allow for 10 percent error, which still put us around 30,000 nanometers per degree. So it's a very good number. And remember, this is still modeling. It's not actuality, but the fidelity of the software to reality is about 10 percent. So we think that this is certainly a very solid number.

In terms of the crash tests that we ran, there were front, side, rear and roof as well as some quasi-static seatbelt-type pulls.

In terms of crash performance, we had a good background in our latest vehicle, the Evora, which is an all aluminum structure with some steel reinforcements. So that car meets all U.S. requirements. This is a front-impact. You can see how the aluminum extrusion basically accordions there. Side-impact, you can see that's a steel roll hoop that is in there to help manage roll-over as well as side-impact. And the car performs very well.

One thing I didn't point out in the first slide here is that there is less than 10 millimeters of deformation in the footwell area, which is a very solid number for a 35 mile an hour full frontal crash.

And then fuel tank integrity at the rear. There is really no deformation in the tank barrier. So very good indication that a very lightweight body structure is certainly capable of handling U.S. Compliance Regulations.

These are the various tests. These are normally animated. These won't be animated today. This is the pulse from the front crash. And we worked with TRW, a safety system supplier for OEMs. And essentially, they said this was a conventional-looking pulse.

The time to zero is a little bit quicker, the body is a little bit stiffer than the steel body. But essentially, the acceleration levels are conventional. They said no new invention required for airbag systems. And we carried over the 10 bag system from the Venza. We carried over that mass and because these acceleration levels are very similar to the Venza, their actual peak load is about 10 percent less acceleration than the Venza. We think that there is certainly high potential that this vehicle can meet the Federal Regulations.

This is the side barrier. And the intrusion level is quite low, 80 millimeters. As referenced, the seat index point in reference to the same base is 300 millimeters, so it gives you, basically, in this 33.5 mile an hour impact, you have got a cushion of about 220 millimeters before you hit the side, outboard side of the seat.

The roof-crush model. The results of this, we actually used IIHS four times curb as our target. We exceeded that. We are in the six times curb weight range. It's not that this vehicle is super engineered and super strong, it's just that because it's lightweight, it, essentially, will meet these requirements.

We put the Venza curb weight and applied that at the federal level, the three times level and, essentially, passed the test with the Venza. So it says that our roof structure is really about the same strength as the Venza, but because the vehicle is so much lighter, it gives added protection in terms of the roll over.

And then lastly, the rear barrier, which is, essentially, the fuel tank integrity test. In this case, the magenta that you see in the upper right hand corner is the fuel tank and then the blue is a small battery pack. In this test, there was no deformation to either of those.

And we looked at fuel tank strains and we are in the 10 percent fuel tank strain range, which is an acceptable number. So bottom line is that you could say that this body-in-white certainly has the potential to meet the performance of a steel body, not only in bending and torsional stiffness, but also in federal crash requirements.

Noise, vibration and harshness management. This is a key issue that comes up again and again. I just wanted to show some of the current information.

This is from the Chevy Corvette. This is from a GM site that is listed below, but, essentially, unwanted noise is reduced and ride and handling has improved, thanks to the structures greater torsion or rigidity, so they are saying that essentially, this very stiff body is 57 percent stiffer than the steel body it replaced and is contributing to NVH improvement.

This is from a Great Designs in Steel presentation given and that is a terrific event in terms of contributing to industry, showing what everyone is doing in terms of steel. And the steel industry is doing a great job in terms of providing materials that are absolutely at the forefront of technology.

What this slide is saying is essentially that he increased the use of structural adhesive. Structural adhesives are not limited to aluminum bodies or magnesium parts. And they also found a 44 percent reduction in airborne noise and that makes sense because you are sealing essentially the cracks in between the bonding areas.

And then lastly, again from Great Designs in Steel, the Hyundai i40, which is called the Sonata in some areas of the country, they looked at the impact of aerodynamics at NVH and again, if you have got an air dam down below the car, you are going to be generating turbulence, which is noise. So smoothing the air flow has a positive effect on an NVH.

So we are -- really, the bottom

line is you can say that increasing the body stiffness, improving aerodynamics and improving sealing can all contribute to reduced NVH levels and that those fundamental principles are applicable to ferrous as well as non-ferrous body design.

In terms of cost analysis, this is really key. We ended up with over a $700 hit for the body-in-white. And if you had used existing technologies for forming and joining, that cost would have stayed at that level and probably be higher than that, which would be a very high number.

But because we are able to get offsets from the tooling and from the assembly process, we are able to offset a good deal of that, roughly $480.00 went away. So we ended up having a piece cost-hit of about $250 after those offsets.

And then once we amortized the $52 million plant in to that scenario, we ended up with a plus 118 percent cost or 18 percent higher than the baseline. And once we fully amortized the plant, that dropped to 108 percent cost penalty.

And then when you do the same weighting scheme that I showed you from the Phase 1 report, we essentially used the 118 percent cost factor for the body. Then from the chart, the pie chart on the right, the 18 percent projected cost contribution of that body to the total vehicle multiply those, you get a weight of cost factor of 21 percent.

For all non-body items, as I mentioned very early in the presentation, that number was 96 percent. I was more conservative here showing 100 percent, so effectively, the weighted cost factor comes down to about 3 percent, plus 3 percent when you do -- go through all of these numbers. And then once you fully amortize the plant, that drops to above 1.5 percent.

So there are other considerations that we wanted to look at, but one of them that really jumped out at me when I started looking at some C Class vehicles is that the Hyundai Elantra, which is a very similar size to the competitors, I show the Cruze, the Dart and the Focus, it is 400 pounds lighter on average than these vehicles. That is 15 percent lighter.

And when you look at the Elantra, it is an unremarkable vehicle. It has got steel body, steel closures. There is no titanium, no carbon fiber. And yet, it is essentially 15 percent lighter.

So how did they do it? Well, if you look at the cost, you will see that the cost is also reduced. These vehicles all have automatic transmissions, alloy wheels and four-wheel disc brakes. So some cars I had to take money out, some cars I had to add money to get those features in, but the bottom line is it is 10 percent less costly on average versus the other three vehicles.

And if you do a further analysis

and say well, it's really not fair to penalize a car that is using the same materials, why does it come out with a higher cost per pound? So I said well, let's look at averaging the cost from the other three vehicles and then apply that cost per pound to the weight of the Elantra and you find that there is another 4 percent potential.

So you could say Hyundai Elantra today is producing a car that is similar size to its competitors. You know it is physically smaller. It has the same interior volume and a comparable trunk volume. That car is roughly 14 percent, you could say 10 to 14 percent less expensive than its competitors and that may explain why it has some of the best warranties in the business.

So what happens if you take the 30 percent mass reduction and apply it to the Dodge Dart that I showed earlier in this slide? Well, a couple of very interesting things happen. The first is that a 30 percent weight reduction means that you are going to go down to almost take almost 1,000 pounds out of this vehicle.

If you look at the EPA Combined Mile Per Gallon at the bottom, you will see that that never jumps up to 39 miles per gallon, which is starting to get into the range for the 2025 Regulations.

And this is with a vehicle using current technologies. This doesn't have start/stop. This doesn't have increased aero and it doesn't have better tires for lower rolling resistance.

Another very interesting thing happens when you do this analysis is that you see the cost per pound goes up to over a 40 percent advantage. In other words, you can spend another 40 percent per pound because you made the vehicle lighter. So that right off the bat, you get an advantage in this case, of about, at a manufacturer level, $1.65 a pound or about $3.50 per kilogram more money to spend on this lightweight vehicle.

But the only way you can do that is if you do the total vehicle holistically and simultaneously and make that happen. If people -- if subsystems don't get lighter and systems don't get lighter as a whole, then this doesn't happen.

So in summary, there is certainly potential for a lightweight multi-material body to perform as well as a steel body in not only bending and torsional stiffness, but also in craft situations. And again, remember this is modeling. This isn't an actual vehicle yet.

There is also potential for a substantially mass-reduced body to meet federal crash requirements and then it's also, we think and are showing that, possible to manufacture a high-volume lightweight vehicle at an MSRP competitive with much heavier vehicles.

And then lastly, by using a

holistic total vehicle mass reduction approach, there is potential to utilize more expensive materials, lighter weight materials in volume production automobile and truck body structures while maintaining competitive vehicle pricing.

Some next steps. We think there have been a lot of very good paper studies that have been done. We certainly recommend building one of these lightweight vehicles and running it through tests. So to build an entire body-in-white that we show here would be very expensive.

We think there are options in terms of building say the front structure or the roof structure and then testing that and modeling and then providing that information to industry.

So that concludes my remarks. I would be happy to answer any questions. Thank you.

(Applause)

MODERATOR BONANTI: Did we get any questions? Thank you. Anyone else? Okay. First question. You noted improved emphasis-- no, excuse me.

You improved -- you noted improved evasive capability reduced braking distance and lowered center of gravity as effects the light-weighting. Are you saying that everything else equal light-weighting vehicles should be less likely to be involved in a crash?

MR. PETERSON: No, I'm not saying that at all. That is very driver-dependent and some of the studies that the NHTSA Team have done show that the driver is one of the key -- has a key role in the vehicle. I mean, so it just means that there is -- for a given situation, that a lighter weight vehicle in an identical situation with a heavier vehicle that has less tire contact patch area per pound of vehicle that the lighter weight vehicle could be more maneuverable.

MODERATOR BONANTI: Okay. Another question. Your conclusions call for increased use of adhesives. Automotive adhesives are subject to EPA Clean Air Act Max Standards. Was the cost of compliance with these standards taken into account when calculating down-weighting costs?

MR. PETERSON: No, they were not. We are relying on the chemical companies to handle that aspect of the production of the material. I should point out that the number of -- the amount of material that we did use in this was about 1.5 kilograms, so it's a relatively small amount, but certainly that's a very good point to make in terms of well to wheel. That was not part of the study in terms of looking at total emissions as a result of this entire process.

MODERATOR BONANTI: Thank you. Another question. Please explain how a "totally holistic approach" fits with today's practice of sharing platforms across multiple models, for example sharing platforms.

That's the first question. The second question has Lotus performed any analysis of investment required to revamp facilities?

I need to be able to read the questions first.

MR. PETERSON: I'll answer the last question first and the revamped facility that I talked about was $52 million for this new body-in-white plant. And as I showed from earlier data, the Corvette plant, which uses similar types of components that are extrusions, stampings and castings was about $51 million. So that is in the ballpark, so certainly we did that.

And then the first question, what was the question again? I think it related to the architecture?

MODERATOR BONANTI: The first question said -- yes, please, explain how the- - a totally holistic approach fits with today's practice of sharing platforms across multiple models.

MR. PETERSON: Yes. I'll give an example. The Lotus has developed what we call our VVA or Versatile Vehicle Architecture and it is aluminum-intensive. And what we essentially did was design a vehicle that has the ability to be stretched and widened very easily in the plant.

So that is something that as part of this process certainly needs to be taken into account on Day 1 of the design.

MODERATOR BONANTI: Can you comment on reliability of joining assumptions made in CAE models, specifically failure incorporated.

MR. PETERSON: Yes, that's a very good question. I didn't point this out, but what we did, we worked with our suppliers, which included Alcoa for the aluminum. We used Meridian for the magnesium. We used Henkel for the structural adhesive and

Kawasaki for the joining process.

And what we did was we developed lab coupons and tested those to destruction and then input that data into our FEA model. So all of the data that we used was essentially created in the lab testing for failure.

MODERATOR BONANTI: Okay. Thank you. Next question. How much do you trust the result without the testing from the -- I'm sorry.

MR. PETERSON: I think the --

MODERATOR BONANTI: From the vehicle, what is the -- I'm sorry. What is the best to be answered?

MR. PETERSON: Well, we used a software called LS-DYNA for all of our craft testing and it is used around the world by OEMs. It is a well-respected software and the fidelity is typically within about 10 percent. Some companies are claiming even better than that.

And the bottom line is that we know of at least one OEM that no longer builds mules in crash tests and they rely on the software itself as their starting point. So it has, in our opinion, about a 10 percent modeling error.

MODERATOR BONANTI: Okay. Thank you. Are there any other questions? Sure. Yes, one more coming. The clearer the writing, the easier it is to ask the question, so I apologize.

Okay. Here is a question that I would like to have the answer myself as well.

Do you believe in this software used for simulation?

MR. PETERSON: Well, as I just mentioned, not only does Lotus believe in it, but OEMs around the world use it as part of their process development.

MODERATOR BONANTI: Okay. Well, this is a question specifically for you. Will the OEMs be able to use this software to avoid actual crash tests?

MR. PETERSON: That is dependent on how much risk OEM management is willing to take. Certainly for the early development, as I mentioned, companies are already foregoing some of the very early mules and going more into their, basically, prototype development models.

MODERATOR BONANTI: Okay. I think we have time for a few more questions if there are any. Yes? This is an excellent study in the application of a multi-material solution. Aren't OEMs more receptive to this type of approach using a mono-material holistic approach?

PARTICIPANT: Versus a mono.

MODERATOR BONANTI: Versus a mono. Excuse me. Versus a mono-material approach.

MR. PETERSON: Yes. It's a very good question and the answer is yes. We have been working with OEMs from around the world and every company that we are working with is really starting to say that this is the way that they are heading in this direction.

I think the use of steel as I showed you, even though this is a very lightweight vehicle with aluminum, a lot of aluminum, steel played a key role in not only side-impact, but also in roll over protection.

So we simply don't think that there is a good reason to use just single material for any vehicle. We think that the use of multi-materials allows you to make your selection not only in process, but also in joining based on cost, allows you to be much more effective than just picking a single material and sticking with that and forcing that material into all the different stresses and strains that it needs to meet the various regulations and internal targets.

MODERATOR BONANTI: Okay. Thank you. I have two last questions, unless there is any further, that are very similar in nature. However, I'll ask them both at the same time that way you can answer them.

How is aging considered for the adhesive joint? That's the first one. And second, what is the contribution of an adhesive bonding for crash and safety?

MR. PETERSON: Repeat the second question.

MODERATOR BONANTI: What is the contribution of adhesive bonding for crash safety?

MR. PETERSON: Oh, okay. All right. First of all, relative to the aging, that's always a big concern when you have got new materials that haven't had 20 or 30 years of history.

What we do is look at our previous vehicles. We have been producing adhesively bonded aluminum structures since the early '90s. And those vehicles, Lotus vehicles, spend a lot of their time at racetracks and are driven near their dynamic limits very frequently.

And at this point in time, we have not had a single issue relative to delamination of the parent material and the structural adhesive. We do use on these vehicles rivets. We use friction spot joints here and the reason is to prevent a peel condition.

Structural adhesive is very good in terms of joining of materials, but once you get a peel condition, then it starts unzipping. So we have to be very protective of that and that's why we friction spot joints or rivets or mechanical fasteners to kind of prevent this zipping action from happening.

So again, 20 years of experience and we have not had a single issue related to delamination of structural adhesive.

MODERATOR BONANTI: Okay. This card has three questions. What is Lotus Engineering's relationship to Lotus vehicles?

MR. PETERSON: We have the same parent and we work together joined at the hip.

But just to give a brief overview, Lotus has, basically, 70 percent of its engineers doing automotive and transportation industry consultancy, 30 percent of our engineers actually design our cars.

So we are underground. We do a lot of work that nobody knows about, because we don't put the Lotus brand on customer work, obviously.

MODERATOR BONANTI: Okay. The second question I think you already answered, is have you produced any vehicles?

MR. PETERSON: Yes. Lotus has been building vehicles since 1952.

MODERATOR BONANTI: Okay. The third question. I'm doing this for the court reporter. Lotus vehicles do not perform well on a footprint versus fuel economy basis. Why is that taking into consideration what you -- what you have presented this far?

MR. PETERSON: Well, I can say, from personal experience, that I have gotten over 35 miles per gallon on highway in a car that does zero to 60 in under 4 seconds. I think that is a pretty good number.

In terms of the fuel economy numbers that are actually obtained by our owners, I think most of our owners are very pleased with the fuel economy that they do get.

When you are designing a car -- our current car that is sold in Europe is the Exige S, which has almost 400 horsepower. It has the same power-to-weight ratio as a Porsche 911, and it certainly gets comparable fuel economy to that competition, as well as being about half the cost.

MODERATOR BONANTI: Okay. Do we have any further questions? If not, okay, we are going to get ready to go to our next speaker, but in the meantime, I wanted to ask, does everyone need a five minute break? Yes. Five minute break. Okay. Please be back here in the next five minutes. Thank you.

(Whereupon, the above-entitled matter went off the record at 10:29 a.m. and resumed at 10:35 a.m.)

MODERATOR BONANTI: Okay. Our next speaker will be Greg Kolwich from FEV. He is going to be talking about NHTSA's mass-size-safety workshop light-duty vehicle technology cost and mass analysis. So I would like to give him a warm welcome to Greg. Thanks, Greg.

(Applause.)

MR. KOLWICH: Good morning, everyone. My name is Greg Kolwich. I work for FEV. A little bit of background on me first, I guess. I have been in automotive roughly 20 years, both on the production/ design side as well as production implementation, both for chassis and powertrain components.

The group that I work with or in at FEV is called Production Development and we do basically all the manufacturing and costing within FEV. So it's everything from new innovative designs, be it hybrid design technology, new engine design technology, new transmissions, whatever, our group is kind of in charge of the costing side of it. And the, you know, B-to-business case study or design trade-offs or whatever that may be.

So to jump into the presentation. For those that don't know, we basically did a 2010 Venza study ourselves. It was kind of a continuation of the Phase 1 Lotus work. So you will hear the word or the terminology Phase 1, Phase 2.

The original work done by Lotus Engineering had two parts. It had a low development or 20 percent mass reduction target, and a high-development, which was roughly 40 percent. And so our work really took to 20 percent low-development work and kind of continued on with it.

So the things we will talk about today are project objectives, the vehicle attributes and analysis assumptions, a kind of a run through of the methodology, the costing methodology, some of the mass reduction results, cost results, and then conclusions and recommendations.

So as I mentioned, there is kind of three key objectives for the work we did based on the previously completed Lotus work. And the first was that there was no CAE analysis done in the first phase of the Lotus work, so EPA requested that we take the Lotus work and do CAE analysis on it, both from an NVH and crash perspective to kind of validate the changes.

And if for any reason there were issues with that, basically, take that model and add in changes to make it sure, so it does match up relative to stiffness in crash to the baseline model.

And then we also were to take -- in the Lotus study, originally there was not powertrain stuff done, so engine transmission light-weighting. So we expanded that section plus reviewed some of their ideas and kind of -- and basically brainstormed on those ideas to create new ideas.

And then the last part of it was detailed costing. So we are probably all sitting in this room and we probably all would -- if I said, you know, do we think you could achieve 20 percent mass reduction in the vehicle, we would all probably stick our hand up.

If we said, at what cost factor, we would probably write it down on a card and we would probably have about 20 different answers coming from everybody.

So a lot of the work we did for EPA on the powertrain stuff was really digging into that part of the analysis, and I'll get more to it in a minute, but it was really trying to work out a detailed cost methodology that was transparent and flexible that everyone could understand the numbers. And if there were 20 different answers out there, people can go to the sheets and see why their answer was right or wrong or indifferent.

So that's kind of the three objectives we tried to accomplish in this study.

So, again, it was a 2010 Venza, is what we tore apart. Our goal was a 20 percent mass reduction, similar to the first phase. The vehicle weighed roughly 1711 kilograms. Relative to a cost target, our goal was to get a 10 percent maximum increase for mass reduction. That's all in. That's direct manufacturing costs, indirect cost, all those costs are in there. I'll kind of break that out here in a minute as well.

And then our volume assumption was the vehicle roughly sells 60 to 75k per year, and our program assumed that we would produce 200,000 custom components, like the body-in-white components, that weren't cross-platform shared. Anything that was cross-platform shared, like an engine or transmission or so on, it would be 450,000 units a year.

So those were the boundary conditions going into the assumption. Some other cost assumptions were, everything was produced in North America, it was 2011/2012 rates for material, labor, overhead and such. And I'll highlight some of that here as well in a minute.

So the process -- I guess one step here was we had three people participate in this project. It was ourselves, FEV, Monroe & Associates, who does benchmarking and costing, and then EDAG, who focused on the body-in-white section of this analysis.

So three of us participated. For the most part, the five steps were the same, though there was a little bit of differences because the EDAG work was more CAE-based, so there was more automation relative to mass reduction in some of the costing stuff.

But the five primary steps were

taking the baseline vehicle, tearing it down and getting a fingerprint of that vehicle. Then the second phase was kind of doing the detailed idea generation. The third step was our preliminary mass and cost estimates. And then the fourth step was then going through an optimization process, which I'll get to in a minute here. And then lastly we get into the detailed costing and the mass reduction.

So the vehicle was purchased. The first line there. Tore down the vehicle, scanned in the vehicle level. So key measurements were made at the vehicle level, ride heights and such. The whole vehicle was scanned in and then the tear-down started.

So every piece was pulled off the vehicle chunk-by-chunk, doors, seats, exhaust system, fuel tanks and so on. As those parts came off, they were put into a BOM. They were categorized, quantities, weights, photos and such. And then along the same process, as the body was coming apart in bits and pieces, the scanning continued on, both for the body-in-white pieces that were involved in the crash in NVH as well as some of the components that would be involved in the crash later on, like the engine, transmission and fuel tank and such.

The last part of the process was then to basically get all the stuff into a BOM, an organized BOM. So it's 21 different vehicle systems we broke it down into, and then each person within our team took on one of those vehicle systems, one or several of those systems.

The other part of the baseline was to establish a CEA model that was representative of the baseline Venza. So as part of this analysis, EDAG worked on taking the scanned in data, white-light scanned data, basically then correlating it to actual NVH data. So we had an actual Venza that was taken apart and tested for NVH, torsional stiffness, bending stiffness and such. And then the model was tuned to that actual data.

As well, there was NHTSA crash data that was used to then correlate the crash results or compare it to relative to the NHTSA crash results to make sure that the vehicle was crashing like it did in the model.

So the next step was the -- step two was the idea generation. So using the Lotus ideas from their report as the starting point, what we did is our team then started brainstorming each of the different systems, be the it interior, body, you know, fuel system, engines, transmissions, exhaust, all that good stuff.

And to do that, you can imagine, we have thousands of ideas going on in these lists and you have to somewhat start to boil these ideas down into workable ideas. You know, you have got your titanium and carbon fiber on one end of it, and you have got standard aluminum, maybe some higher-end aluminum mag on the other end of it.

How do you start to rank which of those ideas seem to be feasible than others? So we come up with a five grade -- a five kind of factor rating system. It looks at manufacturing feasibility. It looks at functional risk performance degradation. It looks at estimated percent mass reduction, estimated cost impact and estimated tooling impact.

So for those that are familiar with kind of a DFMEA concept, the idea is you are factorizing these parameters and eventually you will factor them out and you get a net value. And that helps us assess if that idea is better than the next idea and if that's an idea we should include in the study.

On the other end of it, EDAG then takes the base model that is now established from a CAD perspective, and they brought in the Lotus mass reduction ideas from the Phase 1 study and did their preliminary analysis.

From that analysis, the NVH wasn't

the same as the baseline, so the team said we would need to, basically, take some of the Lotus ideas, pull those in to the basket that stays with mass reduction, and some of those ideas that weren't panning out we pushed off the table, and that was kind of the starting point for the body-in-white analysis at that point.

So in the next phase, what we are doing now, we are doing the -- we have these-- all these ideas that are ranked out. What we have to do is start the down-selection process. So, again, thousands of ideas need to be boiled down into different component ideas. So what we do is we have a score of 50 in the first step there. And anything that is greater than 50 falls off the table at the get-go.

And now what you are left with is potentially three 49 ideas for the same component and you have to pick, well, which idea again is better.

So in this phase what we are doing is now starting to put mass and cost to each idea. The goal was to get a cost per kilogram. And what we want to do is then take those ideas and bin them in the respective cost group.

We created five cost groups, as you can see on the right hand side there. So anything that was a mass reduction and a cost-save, anything that was zero to a dollar in a mass save, and so on and so on. And the 4.88 is representative of the 10 percent increase in price at a mass reduction.

So anything that was over 4.88 was, essentially, greater than a 10 percent cost-hit from the mass reduction.

So now we have these five bins, all these ideas loaded in for each system, and now what we have to do is start grouping those ideas. So you can imagine, this is an example of kind of the flow of how the vehicle is broken out from a BOM perspective.

So what we are doing is if you are starting on the far right on the conrod, you have a cap, a conrod and two bolts. On any one of those components, you might have two or three ideas to pick from. You could take those ideas, roll them up in different combinations that get you a conrod assembly. You can then take that conrod assembly, and there might be three different versions of a conrod assembly that are mass-reduced, and roll them up into a crank-drive system.

So now you have got a crank, you've got a piston, you've got a conrod assembly and, again, mixing and matching you can have different combinations based on mass reduction and cost impact.

Eventually those get rolled into various engine combinations and eventually you can get a vehicle. You take all these different systems and you can roll them into different vehicle solutions.

The approach we use, we started

off -- when we first started this, all our engineers were all thinking big, thinking carbon fiber, titanium this, titanium that, and we had a couple of team meetings and we quickly realized that we shouldn't necessarily be taking these very expensive ideas, that the OEMs more than like will not implement out of the gate, and was them down with low cheap ideas.

So if I take a plastic trim panel and I MuCell everything, does that allow me to take titanium and bring it in now and I could pay for the titanium, because I've got this cheap MuCell?

Well, we agreed that probably wasn't the right approach and we created two kind of pathways. One pathway was for the conservative engineer. We call it the low cost solution, which was only ideas that save money, ideally, and save weight, or the ones that the OEMs would more than likely jump at.

The ideas that were bringing in

and mixing and matching titanium with MuCell were ideas that would be considered more of an engineer solution. Those are the guys that are stretching the boundaries with carbon fiber, metal matrix composites and so on. We called that the engineered solution.

Then the ground rules for that are kind of shown with this brake example. So we have a brake rotor as our example. You could reduce the rotor thickness. You can change the diameter, again, with the assumption that the whole vehicle is going to get 20 percent lighter. You can do additional venting and cross drilling on the rotors. You can go to a two-piece rotor. You can do scalloping, OD scalloping and so on.

So if you look at all the red boxes on the chart, they have -- they are using ideas that are coming from A, B and C. When all those ideas come together, they create a $1.35 hit per kilogram, which falls into the C category because all the ideas are in that C category, unless that's a low cost solution in our eyes.

If you now stretch it and you pull in a two-piece rotor design, which is a lot more expensive, and you mix that with the other ideas there, you end up with $3.56 a kilogram. That actually puts it in a D category. And, again, because it has ideas on the more expensive side of what the final idea fell in, and on the cheaper side, it becomes an engineered solution.

It was really just some ground rules for our guys to help sort through the bins of different cost reductions -- or, sorry, different mass reductions and cost impact.

The same process then followed through again, if you look at the previous slide where I showed you the conrod, the crank assembly and so on getting built up, we now take this to the next layer.

So the next subsystem is the front

rotor and shield subsystem. And now we are looking at rotors, dust shields, brake calipers, pad kits and so on, and now we have got to do the same process. We have got to kind of go in these bins, pick and choose, mix and match and try to build up an optimized brake subsystem.

And then we go to the next level, same idea. Now we are going to the brake system level. We have got the front rotor drum and shield subsystem, the rear rotor drum and shield system, parking brake, brake actuation. Exact same process, we are just going up to the next step.

Essentially, what we are doing is working our way up in each system to a final solution or final solutions and then eventually to a vehicle solution.

So now we have all these systems evaluated and we put these into a vehicle optimization. So we've got low cost vehicle solutions, we've got engineered vehicle solutions. And these are represented by the points on the curve there.

And our goal was 20 percent mass reduction at the best value. So our starting point was the little blue triangle off to the right there, which was roughly -- I think it was like 19.7 percent at roughly an .83 cent hit per kilogram, was our initial assessment based on what the team did in their initial evaluation.

So we all agreed here is all the ideas they are going to fall into that point. Do we all agree as a team that the risk level is right for 2017/2020? And, if so, let's then start the detailed analysis now and start going through these in a more engineering perspective.

So the next step now, the team is now starting to pull in more and more data and more and more resources. From an engineering perspective, they kind of validate that these ideas are real. The mass reduction assumptions that we are going to take are actually kind of fine-tuned. And then we start working on the detailed cost model as well.

Through this process, we probably lost 2 to 3 percent of our ideas that were originally on the list, but then pulled in, you know, 2 or 3 percent of new ideas. So it is kind of an iterative process.

Our study is really on all the systems, but body-in-white was really more based on published literature. So it includes support from raw material suppliers, many in the room that we have dealt with on these studies in looking at alternative industry technologies, looking at performance vehicle benchmark data, published literature, all these different areas are what our guys use to kind of come up with these ideas. Because it had to be 2017, we really couldn't go out there and stretch the barriers on carbon fiber and some more of the exotic materials, but had to kind of stay with what was kind of in the production pipeline either today at low-volumes or at some level.

And then what our engineers would do is take those ideas, work with the suppliers and then boil those ideas down into the change. So we had a steel fuel tank. We took those ideas, established what the material specs were, you know, what the engineering design differences were. Because we are comparing it from part A to part B, we have got to kind of make those two parts normalized. And then eventually take any secondary mass savings due to the whole vehicle getting 20 percent smaller and we end up with our plastic fuel tank on the bottom, basically.

So a lot of participation from suppliers. This is just a small list of the guys that participated. A lot of organizations: AISI, Aluminum Org, Magnesium Meridian and so on. I could put pages and pages here, but we really tried to leverage the industry experts, because all the guys on our team are maybe an expert in one particular field, but by getting everybody's input, it really helped out a lot in the study.

On the EDAG portion, again, they are taking it to a whole other level, kind of similar to what Lotus did in their -- you know, going shooting for 40 percent mass reduction. So just quickly to summarize the nine steps kind of in the process.

So, body-in-white was torn down, scanned in. We took over 150 material samples that AISI got data for us. So they were sent out, chemically evaluated, tensile tested and all that so we could get the right material cards into the study.

All the parts in Step 2 there were scanned in that were involved in the crash study. And eventually, the model, as you can see in the top right, was tuned to the model before the actual NVH data. And then the crash data from NHTSA compared to the actual crash data in Step 5 there are from the CAE analysis, that created the baseline.

Any change that was now brought in to create a light mass reduction was always compared back to that baseline model. And they always had to have, basically, similar stiffness, similar crash performance to get the thumbs up for mass reduction.

So looking at NVH, crash pulse, dynamic crush, intrusion and so on, those were the parameters we kept comparing back to. Ideally, you would like to do this on every component and the next step eventually comes a full vehicle, but due to, you know, resource limitations, we can only do so much on this.

So the cost side, again, I think, in my eyes, is probably the most controversial topic on this, is what is the real cost for mass reduction? We all again probably agree that you can get 10, 15, 20 percent on most vehicles if you really went to the limits.

So what our team does is we have-- we basically build up custom models for everything we cost. It's not just, hey, the material went from steel to plastic, we are going to change it and take the cost of plastic at $1 a pound, times it by 2, and that's the price of the new part plastic.

But rather what we do is we build up a comprehensive manufacturing model, most of our team is basically all manufacturing engineers, and the model, you know, tracks material costs, labor contributions, it's direct labor, indirect, maintenance repair and other -- all those costs that are associated with labor.

The overhead rates are built up from scratch, so if it is a line to put together an engine, there is a complete layout of that engine line. We bring in a guy that has 30 years plus making engines and he will put that line together. We will cost out the equipment, the utility usage, the floor space and basically build up comprehensive cost models.

And then for each of the mark-up levels, what we do is we have different levels. So if you are a Tier 1 system integrator, like a Bosch or Delphi, you get a certain percentage and we break those open and report. You may disagree with our values that we chose, based on our boundary condition assumptions, but the models are there and they could be easily tweaked and you can change those.

So, for example, a Tier 1 high-system impact guy makes 21 percent mark-up. A low-end guy might make 9, 10, 11 percent. Those are kind of the ranges we would kind of work within. And, again, all our assumptions are based on mass production, you know, mature market, competitive market, because we are really looking out in the future.

And that kind of ties into this next slide in this whole, what I see as this controversy around costing methodologies and what methodology is the best methodology, and how do we know the right prices, this price versus that price?

In our eyes, the devil is in the details, like everything. So if you are getting prices from all over, from different suppliers, OEMs, you are pulling stuff off the Internet, you are reading it into SAE paper, you've got a snippet of information over here and you try to put that all together, you are left with a mess, essentially.

So you are left with this big circle here of all these points of what it could be. Now, if you had spent a lot of time, you could probably continue to boil that down and eventually get to a price that you think is reasonable.

On the base technology, represented by the orange lines, you might say, hey, this technology has been around forever, I know a six-speed transmission goes for $1,200 all day long, I don't even need to look at it any further. So that one you are pretty comfortable with.

But depending on what point you pick here, the answer at the bottom of it could be considerably different. So the goal is what is the right point to pick? You know, I'll give you an example on seats.

You can talk to a Lear or JCI who welds seat frames all day long and said, hey, if you want to convert to mag, it's a huge premium, we don't recommend it. Well, sure, sure they're not going to recommend it, because they got all this capital investment in the facilities.

You can go talk to the guy maybe that wants to get into making mag seat bases, and he is going to undersell it, because he might be an automotive supplier and he might say, yes, I can make those. How much harder can it be, right? Welcome to automotive.

So the bottom line is you've got

these two dramatically different price points and they are all out of whack. And so our methodology is to try to not understand the end result, but all the bits and pieces that go into it and work with those bits and pieces to try to get the right answer.

And by understanding that, people can scrutinize and look at it and say, well, your process time looks too long ,or the price of mag looks too high, or the price of steel looks too low or whatever it may be, all that data is kind of sitting there.

And the goal is in -- much to the credit of EPA, I think -- is put the details in front of everybody and let them scrutinize it. And then we will have these meetings hopefully and walk away and we say we all agree that that pricing is right or, no, that price doesn't seem right, let's go back and look at the numbers again.

So that's kind of the approach we take. No matter what the baseline technology is in the new technology, I'm a new OEM, I'm going to start making stuff from scratch. I can make a heavier vehicle or a lightweight vehicle. I can make a six-speed automatic transmission or a six-speed DCT, dual clutch transmission.

All my assumptions are going to be the same. My material costs are going to be the same. My labor rates are going to be the same. How I make them, obviously, will be different, but all those factors. So same cost, same technology maturity, which affects the mark-ups, same manufacturing volumes, and then you get a real true apples-to-apples comparison on those two technologies.

And then eventually what you can do is you can take to those two points, and we all agree, well, these technologies aren't really mature right now. We are going to slide them out to where we think they are mature, and that is going to be kind of our ground point or our neutral point where our learning factor is one, say. And that may be 2020.

Now when you go and you apply your reverse learning to figure out what the cost is at the low-volume, or you go the other way and you say, well, the technology we tore down and evaluated was pretty young. It is probably going to grow a lot as the years go on. It will probably realistically get a little cheaper.

Now, you are kind of cutting that error. So even though you are going to have potentially error in that learning factor, you have sliced it considerably. So that's kind of the approach that we have taken on many of the powertrain studies as well as the mass reduction study.

So, the results. This kind of graph is kind of a bar chart of all the systems we evaluated and the mass reduction we got for each. So the blue is representative of the Venza starting point. And then the yellowish-green is the new mass-reduced systems.

So you can see engine, transmission, body group A, brakes, suspension, interior body, were the major contributors to mass reduction, basically.

I'll just quickly go through. I'm not sure how many of you have had a chance to look at the report or read through some of these sections. I'm going to just high-level each system, some of the key factors.

So on the body-in-white structure that EDAG did, the focus was on high-strength steel. And so a lot of the design was basically material substitutions, adding back in some new stampings here and there to get support. They used tailor-rolled blanks in some areas, and then on some of the closures, like the hood and fenders and rear hatch, there was aluminum introduction as well.

The steels they chose were relatively, kind of not your stretches, so to speak. They are more applicable to this near time frame. So it wasn't really a stretch at all.

And, anyway, long story short, they came up with roughly 70 kilograms, I think it was a little bit more once you add in some of the other stuff, approximately 70 kilograms on the body-in-white structure enclosures.

On the suspension components, a lot of aluminum change-overs. We do a lot of benchmarking of full vehicles at FEV. And any given day, if you walk through our shop and look at the Audis, the BMWs, that's all you see, pure aluminum control arms, knuckles, everywhere. It is rare you will see a cast knuckle on anything nowadays, to be quite honest.

So the amount of aluminum that was pulled into the Venza was considerable. As well, we looked at the stuff like pull-forming the springs differently. Some tire changes, which were changing the aluminum alloy rims to be a different shape and different size. Some of the original Lotus work that kind of contributed to that.

On the interior side, it was basically taking steel-welded frames and going to Thixomolded frames. The back seats were very archaic, to be quite honest, so those were very low hanging fruit, easy to pick from. A lot of the new stuff that a lot of the OEMs are picking out nowadays are higher density PUs for seat structure, less wiring.

Anyway, there was a huge weight-save in the back and a cost-save that made up for the cost-hit on the front seats, which were converted to magnesium, basically.

As well, there are some other changes in technology. The chevron, which was the mechanism that helps keep the driver's head closer to the seat rest eliminating -- or the head rest, sorry, eliminating the need for a retractable head rest essentially.

So again, some trade-offs on design and materials that washed one another out resulting in a net save. A lot of MuCell-ing was introduced as well, as far as the interior components.

Brake system, same deal. A lot of aluminum was used in the caliper brackets. It went to a two-piece rotor, you know, aluminum hub and an outer cast piece, lots of drilling and scalloping and trying to get out as much mass as possible. And then. again, a 20 percent mass reduction on the vehicle as a whole affords you to do a lot of downsizing on the brakes as well.

Engine system. It was a mag block, a little controversial. You know, there is different takes on magnesium used in the block application. It was used by BMW. They have since discontinued that purely because of wanting to commonize their diesel line between gas and diesel.

Hollow camshafts. They have, you

know, plastic covers, all those kind of good things. Again, the report kind of details all that information. The transmission was magnesium case from aluminum. The use of micro-alloy, higher micro-alloy steel gears that allow you a little bit of a downsizing of the gears.

Aluminum torque converter structure. There is a metal matrix composite that was integrated into that aluminum torque converter. So, again, some different technologies there.

So, at the end of the day, we came up with roughly an 18.3 percent mass reduction. All the ideas that we came up with, obviously, weren't implemented into this. There were things that we kind of threw into the mix at the last minute that would have took it well over 20 percent, like the aluminum doors and run-flat tires and some other ideas, but we kind of stopped at essentially the 18.3 percent mass reduction.

So, the cost, don't fall out of your chairs, but the cost, direct manufacturing cost, what we see the cost to be if you took away the indirect OEM cost, and you take away any learning, into the future, we are seeing that at the end of the day you will save money or you will be -- in my eyes, when you are talking $100, you are pretty much cost-neutral give or take.

So we are saying that in the long haul, saving 20 percent of the vehicle should save you cost. The amount of mass reduction we achieved was 312 kilograms and it works out to basically a .47 cent kilogram save. Again, direct manufacturing cost-save. That was, again, 18.3 percent vehicle mass reduction.

What we did then is take all of our ideas and we kind of ranked them in order of best value to least value to create the blue line you are looking at there. So we had a lot of those ideas.

So a lot of those ideas had

secondary mass savings into them. So what we had to do is pull at the secondary mass savings so we could add ideas together that include secondary mass savings and that's how we kind of created that blue line. And then what we did is had our -- our blue line, I think, went up to roughly -- or the non-compounding line went up to about 14 to 15 percent.

So the blue line then was our kind of trend line going through the green point, which is the point we achieved, which was the 18.3 percent mass reduction at a .47 cent cost-save.

So what we did is we had the blue line that had no compounding on it, and you will see in a minute here the red line is the line that when we peel out the compound, the secondary mass savings, what the impact of that is.

And, unfortunately, it's just a single point that we didn't interpolate between zero back up to 20 percent, but it's what our prediction line is basically on what mass would be if you did it solely on a component-by-component basis and you didn't really look at kind of the holistic vehicle approach.

So you get up to roughly, what is it, $3 a kilogram hit. Again, just direct manufacturing cost at about a 20 percent mass reduction is what we are seeing on the Venza.

The purple X is -- what we did is we threw in aluminum closures at the end and run-flat tires, which took it down or got us to the 20 percent mark and it lowered the savings from the 47 to the .11 cent cost per kilogram.

So, again, this last slide just shows you, to kind of put you in perspective on short-term versus long-term, learning versus non-learning, ICMs versus non-learning -- or ICMs.

So we all acknowledge that, coming

out of the gate, on vehicles that aren't using a lot of aluminum, aren't using a lot of mag right today, you will pay a premium. There is no doubt. And you could argue it's one times, two times or whatever it may be. I don't want to not promote any given material, but there is just going to be that learning curve associated with these new materials.

Europe has gone through it. We will go through it in North America as well. But the bottom line is that over time the purple line representing the net incremental direct manufacturing costs, you over time will approach that line. And again, getting -- when you look at purely from a direct manufacturing perspective, you will approach that line and this mass reduction over long-term should be very cost-effective.

Again, in our eyes it is -- it approaches essentially a neutral or a save.

So our recommendation, obviously, is there is a lot more work to be done here.

It is, in our eyes, picking up 10-fold in the industry. A lot of suppliers want to get involved. They have all these great ideas and there is a lot of great technology out there, so we are, you know, through these continued studies and these kind of meetings, it's a great way of sharing ideas and building on what is being developed to date.

Our studies, you can see at the links there if you haven't caught them already, I'm not sure I'm assuming this presentation material will be sent out, but feel free to go to those links and if you have any questions, feel free to follow-up with myself.

I'm assuming they will send out the contact information after the meeting and give me a call if you have any questions on anything. That's it.

(Applause)

MODERATOR BONANTI: Thank you, Greg.

MR. KOLWICH: Yes.

MODERATOR BONANTI: Real quick. Okay. We have volunteers going around picking up the questions. In the meantime, I just wanted to make everyone aware, those of you that have wi-fi-enabled devices that are trying -- have been trying to potentially access the network, I would like to give you the network itself.

It is not on the agenda, so the select -- you need to select the network dot-- oh, excuse me, d8011t.g. and the user name would be -- these are all lowercase, mss_symposium, S-Y-M-P-O-S-I-U-M. The password, if you are familiar with it, it would be Summertime01. But the s in summertime would be capitalized. Summertime09, excuse me. Okay.

We have time for a few questions. We -- our five minute break turned into more like a 10 or a 12 minute break, so hopefully we will be able to get through these. Thank you.

Okay. Greg, what materials would be suitable for light-weighting the drive shaft?

MR. KOLWICH: The half-shafts, yes, there is the half-shafts. There is not-- this is a front-wheel drive, so there was not a rear or a prop-shaft in the back. So I'm assuming we are talking about half-shafts. And things we have looked at are there is a US Manufacturing, there is a couple of guys that do this. It's kind of a cold-forming, cold extrusion process where you basically take a hunk of bar or a tube and you form it in. You can pull out a lot of weight. I think it is up to 30 percent, I think, is what we are finding, by taking weight out of the shafts by basically putting the section where you need it and taking it away where you don't need it.

There are carbon fiber shafts out there as well. Tejon does, I think, a million carbon fiber shafts in production today as well. So I would recommend both. If you are in the short-term, I see this kind of -- not-- I'm not here to represent suppliers, the guys that we worked with. I would suggest kind of a US Manufacturing-type process where you are streamlining the material usage in the shaft.

MODERATOR BONANTI: Okay. And following up to that, how much reduction could be achieved by replacing the currently used steel with an equally durable lightweight material?

MR. KOLWICH: Well, I know for sure the US Manufacturing process touts, I think, 20 to 30 percent. Closer to 30, I believe. And carbon fiber, when we looked at it, when you start adding the ends back on, it wasn't all that big. When you start putting the cost for carbon fiber and you are trading out putting the metal ends in, it wasn't really that big of a save. I can't remember the number.

MODERATOR BONANTI: Okay. FEV

report shares cost-down 30 -- $3.51 with lightweight for body-in-white enclosure. You are proposing many aluminum applications. Can you make a comment about this?

MR. KOLWICH: I think body weight was actually not a cost-down. It was a cost-hit. We were up three. So yes, just maybe to -- due to the way we add and subtract numbers in our spreadsheets, it is always base minus new. So the three -- what you are looking at on the screen there is the $3.33, that's actually a cost-hit.

The blue is the save and a red is a cost or the negative number is actually a cost-hit in our sheet. So probably the question would be different, I suppose, knowing that.

MODERATOR BONANTI: All right. The next question. As you did mass reduction, did you consider front/back/sides? Would vehicle functions change?

MR. KOLWICH: When you say

front/back/sides function change --

MODERATOR BONANTI: When it comes to weight and balance.

MR. KOLWICH: No, we did not. So it was put into the crash model, but there was no vehicle dynamic modeling done on the Venza.

MODERATOR BONANTI: Okay. I don't know who asked this question, but I'll ask it. Thanks. Interesting presentation.

I completely agree with your comment "The cost of the given action depends on if you are a buyer or a seller." Can you, please, talk about why you would ignore indirect costs, such as BMW and others cannot avoid these costs?

MR. KOLWICH: Yes. So we don't -- the indirect costs eventually get applied, so we don't apply them, so in all our costs, what we do is we develop a direct manufacturing cost number and then the indirect. So in our number, you will have the Tier 1 mark-ups and ED&T.

So the mark-up in our numbers include supplier ED&T, engineering design and testing. It includes profit, SG&A and any in-process type scrap. But what we don't apply is the OEM mark-up and that is done through EPA's indirect cost multiplier.

So we recognize that it is a real number. In all the studies we have done to date, FEV has never applied that portion of it.

MODERATOR BONANTI: Okay. In order to reach the point on the cost curve where costs are neutral, you must pass through a period where costs are high.

MR. KOLWICH: Yes.

MODERATOR BONANTI: Who do we ask to buy the expensive early vehicles at volume? Who will spend money on weight reduction, rather than comfort features?

MR. KOLWICH: Good question. I think it is like everything else. It's the same guy, you know, that buys an iPhone, I suppose, for $500 knowing that there are going to be guys out there buying them and eventually that price is going to come down rapidly.

You know, you look at the vehicles in Europe, the Audis and the BMWs, there is people that buy -- make those vehicles. They are great vehicles. They cost more money, but eventually that will drive the cost down for some of the other vehicles.

I suppose it is no different than what Cadillac does, what Lincoln does where those new technologies go into these luxury cars first. People pay the premium and eventually that gets transferred to the lower models.

MODERATOR BONANTI: Okay. What learning factor is used to estimate cost? Is this 20 percent by five years? Is this industry practice used?

MR. KOLWICH: Yes. We, FEV, doesn't get so much into that. I'll be honest. So there are all types of different learning practices out there. I guess I wouldn't know if 20 percent is the right number to be quite honest without looking into it.

I think what we tried to promote in the -- going forward is that each technology will have a different learning curve depending on where it sits on that curve and it may be not just a position on one curve, but there might be different curves for different technologies. So we haven't dove into that part of this assignment, so I would rather not, I guess, add much to that.

MODERATOR BONANTI: Okay. And the last question, unless there is any other questions out there. What is known about cost-effective mass reduction as a function of vehicle mass and/or size? Different or similar percentage with regard to reduction?

MR. KOLWICH: Repeat that one more time.

MODERATOR BONANTI: What is known about cost-effective mass reduction as a function of vehicle mass or size? Is it -- does it take into consideration different or similar percentage in reduction?

MR. KOLWICH: Yes. So we did a -- we kind of did that assignment for another person. We took mass reduction on the Venza and actually applied it to different vehicle segments. Now, these vehicle segments were in Europe. So what we did is we took the Venza ideas and we looked at them in two ways.

One, are those ideas already implemented in Europe and if so, we can't include them in the A segment, B segment and so on. And then (B) is the technology so much different in Europe that that -- that those ideas don't even exist?

For example, we use mechanical water pumps. They have electric water pumps everywhere already. So the stuff you might have taken on a mechanical water pump, we couldn't apply. But the reality of it is it is probably -- you know, we are taking one snippet of information.

We are taking the Venza, so even within the Venza vehicle segment, you could probably argue that that mass reduction won't be the same for all those vehicles. And then when you drop to different segments, it is going to be different as well.

And then some of the European stuff, I think we were getting roughly around 10 percent. Speaking on say A and B segments, and maybe a little bit higher like 13, 12 or 13 on some of the larger vehicle segments.

MODERATOR BONANTI: Okay. Thank you. Are there any further questions? No. Okay.

MR. KOLWICH: Thank you.

MODERATOR BONANTI: Great. Thank you.

(Applause)

MODERATOR BONANTI: Okay. Our

next speaker is Harry Singh from EDAG Incorporated. He is going to be speaking about the feasibility, amount of mass reduction for lightweight vehicles for models years 2017 to 2025.

Remember at the end of the day, we are going to have an overall moderated panel and so if there are specific questions that you want to ask these individual panelists, speakers, as a collective, it would be very beneficial for -- if you would like to submit those questions now and just indicate that it is for the panel and we can hold them until the afternoon, if you would like. Thank you. Thank you.

MR. SINGH: Thank you, Chris. Good morning, everybody, and thank you NHTSA for the opportunity. This particular project was funded by NHTSA and we had to identify mass savings for year 2017 to 2025. The work has been written up in the report. It is about 500 pages. I recommend all of you print a copy and keep it under your pillow. And it is a great cure for insomnia.

Okay. Okay. I am going to be talking materials and manufacturing processes for high-volume production, about vehicle system weights, light-weighting options and costs, also all the engineering work which we did, the combination of which was very detailed, finite element models and the results from those models.

And since this work has been done, we have been getting a lot of feedback from OEMs. We had a very good meeting with Honda engineers, Honda team and I want to go over some of that feedback and conclusions.

But very quickly, EDAG, we specialize in automotive design and engineering. We offer our services worldwide to the OEMs. With our sister company, sort of FFT, we also provide production solutions and plant construction.

We are worldwide and the team who

did this work, we were based in Detroit in Auburn Hills. And we have about 6,000 employees worldwide.

We are two-partner companies sort of in this program, George Washington University and National Crash Analysis Center and Electrical. And the way the team was set up, electrical basically did all of the communication between NHTSA and us and really kept the engineering team in line, so we were meeting all the deadlines and everything.

And George Washington University provided crashworthiness support and make sure that all the models which were being generated they were actually up to the standards, you know, which are required and as well as directly correlating the results.

But overall, the boundary conditions for this program, our baseline vehicle was Honda Accord, 2011 Honda Accord. And we had to design the vehicle keeping the overall cost in mind, the cost had to stay within 10 percent of the manufacturing MSRP cost. And the vehicle had to meet all of the functional and performance requirement as the current vehicle.

And the engineering team, we had the freedom to, basically, choose any light-weighting technology as long as it met the cost constraint and the high-volume production constraint which for this class of vehicle was set at 200,000 vehicles a year to run over five years at 1,000,000 vehicles in total.

And our deliverable very detailed CAE models which NHTSA used in additional safety studies. But of course, before you can construct a detailed FE model, you really have to do very detailed design first.

The program started with benchmarking exercise. We actually purchased a 2011 Honda Accord, four-door LX model, which was that particular, you know, sort of vehicle. We really took all of the data from that in terms of all the surfaces on the outside as well as the sort of interior.

The vehicle was actually torn down and all the components were weighed and we sort of, you know, created a complete development material of the current vehicle, which was also costed out.

Also the body structure, the stripped down body structure, we actually did some stiffness tests and normal vibration tests. And the numbers which I'm going to be showing on some of these, you know, slides, they all came from the tear-down vehicle.

And when we look at the mid-size sedan, it is really a very popular package in the U.S. market. 20 percent of the vehicles which we buy are mid-size cars. And when you look at the package, it is really the very comprehensive package. It can carry five adults, you know, comfortably with reasonable leg room and stuff for the occupants in the back. It can carry so much luggage and occasional towing.

And if you sort of, you know, look at the payload, we are looking at 470 kilograms, which is almost a quarter of the gross vehicle mass. That is what we are designing the vehicle for as well as the performance it has to meet.

The vehicle have to carry the payload over 500 miles with a single filling in comfort, safety, entertainment, day or night, rain or shine, and then also achieve vehicle maximum speed of the order of 112 miles per hour, naught to 60 times, you know, acceleration.

So it's a really very comprehensive, you know, package. And in my opinion, this really is a very important slide. This is what the customer wants. And we have to actually design for this. And then looking at the other masses, when you look at -- you have to keep, you know, five occupants sort of, you know, comfortable and safe.

We end up adding the sort of --

you know, quite a bit of mass to these systems, airbags, interior trim, instrument panel, all the sort of entertainment, heating and, you know, air conditioning. That's another quarter of the weight, which, you know, the vehicle is not moving yet.

And then for the chassis, which is about 15 percent of the weight, there is your, you know, suspension components and wheels, brake systems and then the powertrain.

In order to achieve the performance we would be looking at engine transmission, driveshafts, exhaust systems and also the fuel system, which is required. That's another 20 percent of the mass.

And then the body structure almost 344 kilograms, 18 percent. And I have those three numbers in red. Those numbers, the mass of those numbers is kind of directly determined by your payload, all the non-structural masses and even the mass of those systems by themselves.

So if the vehicle gets lighter by 1 kilogram, that means some of those systems can also get lighter. Not the payload, not the non-structural masses but at least those three red numbers. And we use the term sort of a mass compounding for every one kilogram you can save, there is a secondary mass-saving advantage of half to .7 of a kilogram on those red systems.

And the approach which we took in our project was to really holistically look at the entire vehicle and try to get the mass out as much as we could out of all of the systems.

And I'm going to talk a little bit more about, you know, some of the options which we considered.

We started with kind of a comprehensive assessment of materials and manufacturing technologies. The materials which are kind of, you know, readily available or which are over the horizon which are going to be available in the near future and also the manufacturing process and we rated each technology either as mature, if it's already in high-volume production or -- and midterm would be if the technology is available on kind of low-volume, up to 50,000 vehicles a year production and long-term which is really kind of, you know, exotic sports car, you know, type, maybe up to about 10,000 a year.

And we looked at steel with the corresponding manufacturing techniques, which include stamping, hydroforming, forging and that sort of thing. Same thing with aluminum. We looked at other materials magnesium, plastics, composites.

And if you look at composites, we -- I mean, just about all the categories, application for body structure, closures or for the powertrain, we kind of -- they're all long-term. And we also looked at the assembly technologies once you made all these parts, they have to be put together, either like spot welding which is very common in the automotive industry than laser welding, big welding, laser braising, adhesive bonding, those technologies were also rated.

And for this particular project, we basically chose only the mature and limited number of midterm technologies, because we are looking at time frame 2017 to 2025 and it's very high-volume, 200,000 a year. If you have to make anything of 200,000 a year, you basically have to make one a minute, two shifts, two eight hour shifts in 24 hours all the year, that's how you get 200,000 a year.

So you really have to keep that in mind when choosing the materials and the technologies that we connect and implement those in high-volume, you know, production environment.

And then the approach which we took, we basically ended up dividing the entire vehicle into a number of systems. And I'm going to talk about, you know, a couple of these systems in detail, you know, like the body structure, because that's a major system.

And for each system, we actually had -- we actually sort of -- what are our possibilities in terms of mass reduction as well as the cost increase? And then we actually, you know, chose the technologies which kind of made sense in terms of dollars per kilogram of mass saving.

If you look at the body structure, we basically looked at four options. We could make the body, you know, structure entirely out of advance size strength steels or it could be we can use advance size strength steel and selectively some of the panels can be other materials like the roof panel possibly could be aluminum or part of the floor panels could be plastic, that's Option 2.

And Option 3 all aluminum, sort of, you know, aluminum-intensive. And Option 4 possibly going to composites, although it is -- you know, it has its limitations but at least we did some numbers. And after looking at the, you know, cost numbers, our recommendation was for the body structure go with advanced high strength steel.

And all this is fully discussed why we chose some of these options, you know, in the report.

And then the next, you know, major item the closures, which is your doors and hoods, deck lid, the parts, you know, which you see on the screen in green. When you look at the assemblies of all those parts, they weigh up to, you know, 144 kilograms. And out of those 144, 92 kilograms is the actual steel frames. So there is, you know, opportunity there.

And we looked at each one of those assemblies and if you look at the door, we looked at three options for the doors. Option 1, use advanced high strength steel where we would get -- I think if we optimize the design in steel, we can achieve about 15 percent mass savings.

Or if you go with the aluminum sort of stampings, and we chose aluminum, you know, aluminum stamping because some of the infrastructure which were -- you know, which is out there for stamping steel, those presses can still be used for stamping aluminum.

And Option 3 was there are some of those in low-volume production. Magnesium casting for the door and we also looked at that option. But here our recommendation was to go with aluminum stamped solution.

And the -- so what you see here, this is sort of all of the body panels, the door panels and every single panel was redesigned. We basically kept the Honda Accord external surface, kept all the interior sort of, you know, clearances, things like, which are required for the occupant's, you know, leg room and so forth.

But every single sort of, you know, panel was redesigned and here we're looking at that kind of material map, what materials we chose for each of, you know, the panels.

And in the body structure, the manufacturing processes which were chosen really most of them are already in high-volume production. Sort of, you know, hot stamping which is, you know, graining ground. It is being used more and more. We used hot stamping, you know, roll-form section. We took advantage of the roll-form section.

So we feel that in terms of what we selected, there is nothing really to invent. I think, yes, it needs engineering improvements to make those designs work, but really no new technology.

And this slide kind of, you know, shows where the mass saving came from. About 73 kilograms from the body structure and then the closures all the way around from the hood, you know, 7.7 kilograms.

The bumper beam is a steel design

in, you know, hot stamping. So all together about 28 percent saving in mass on account of your typical body structures by taking this approach.

And then on the chassis components, one of the areas where we ended up getting significant mass saving which you won't necessarily achieve on every single mid-size sedan, was the front suspension on the 2011 Honda Accord, it was a double wishbone and then we felt that there are a number of mid-size cards with the MacPherson Strut for going from double wishbone to MacPherson Strut. That was almost about 30 kilogram saving and also, you know, significant cost saving as well.

And then that was our recommendation. In fact, Honda's new Accord they have gone from double wishbone to MacPherson strut as well. But that sort of -- results like this, which was kind of the low-hanging fruit, you know, which we were -- that mass-saving necessarily, you won't be able to apply to other mid-size cars if they already have the MacPherson Strut.

But in this case, I think we had a good mixture on the -- on a lot of the brake components. As Greg mentioned earlier on, I think if it is cast iron, we went with either cast or forged aluminum. The only cast iron parts we kept were the brake rotors. We feel that they are really -- that's the best solution, the brake rotors and, you know, with current technology.

And then other systems on the powertrain, we -- sort of our belief was really just downsize the powertrain keeping the same technology. With the lighter vehicle, we didn't -- we -- instead of 177 odd horsepower for the lighter vehicle, we needed 140 horse power.

And that, in fact, there is a Honda engine available which is in the Honda Civic which is, you know, 1.8 liter, so we basically substituted the powertrain and these weights you are seeing are for the 1.8 liter powertrain from the Honda Civic and then, you know, some of the other systems.

On the interior, the mass saving about 30 percent on the trim, on the instrument panel beam and the seats. Again, each of these systems is fully discussed in the report, why we chose what we chose and what other alternatives were in those areas.

And so, you know, overall, we were able to achieve about 22 percent mass saving and we did -- we also did a very detailed cost model of the first baseline vehicle and then the new design which we did, so we can, you know, calculate the delta increase in cost.

So for 22 percent mass saving, the cost increase in MSRP was just over 2 percent. We didn't make use of the full 10 percent, because it just didn't make sense to. I mean, that additional cost can go towards more advanced powertrain, you know, stop/start and other technologies.

And just looking at the overall, you know, material usage, the chosen material if you look at the steel, although the steel content goes down, but it's sort of regular steel are being replaced by more advanced sort of high strength steel and ultra high strength steel.

Just an example, if you look at the current Honda Accord, the 2011 Honda Accord, not the current one, for the body structure, the average tensile strength was of the order of just over 400 megapascals. This is for the engineers there. Where the design which we did, we pushed that average up to over 700.

So taking advantage of the highest strengths which are available from new ultra high strength steel and techniques like hot stamping. And most of the other materials are, you know, cast iron as I mentioned. That, you know, went down and replaced by cast aluminum, which has gone up a little bit.

And then sort of additional aluminum sheet for the closures, you know, which was our recommendation. And at the moment, Alcoa, I believe, they are building or they are investing in two plants to provide additional sheet. They obviously see the demand going up there.

But all the other materials, the material has gone down. And the previous peak was they defined if you are buying less material, your cost will also go down as well. Then that's one of the reasons why when we do our cost calculation, we do put more cost in say aluminum doors and in some of these parts, because some of these other systems are going down, that cost is offset. The increase is offset by the reduction.

And now, we -- all together the vehicle was broken into about, you know, 40 subsystem and each subsystem we had number of options. So we kind of, you know, put sort of options together of increasing mass reduction, so we basically end up with -- I don't expect you to read the numbers, but Options 1, 2, 4 is basically going from all steel solution all the way up to Option 4 using more exotic, you know, composite type of material achieving a mass saving from about 19 percent all the way up to 28 percent.

And looking at the cost curve, if you ignore some of the early points, but those four options all steel solution, additional manufacturing direct cost of $111 increase the solution which we did detailed design work Option 2 to, you know, $319 sort of additional sort of cost.

And then all aluminum solution Option 3, I will calculate the number, additional manufacturing cost of $927. Then for composites really it blows our target of, you know, plus or minus 10 percent.

And we did a very detailed sort of, you know, design and computer optimization. We started with topology optimization, which is basically you take the outside shape of the vehicle, then you take out the volumes where the engine is going to go, where people are going to sit, where you are going to put your luggage and you take that out and what is left behind is where we can put the structure.

And with this topology optimization, you apply the various loads and the, you know, computer basically kind of, you know, gives you an indication where the natural load parts needs to go. And then so the engineers, who do the design work, we basically try to follow some of those sort of -- you know, follow that direction and then make the design more manufacturable.

And now, in this picture, you see the results from the topology in kind of a pink color. And the way we follow that design is it's the, sort of you know in the background, darker gray color.

And so, you know, straight away you start seeing differences. You know, normally, this front rail structure on a lot of the cars is continued underneath the floor, but here from the topology optimization, it is kind of indicating, you know, start feeding the loads into the body side structure.

So we did follow, you know, some of this and made the designs, obviously, more manufacturable. And then the sort of, you know, another method of optimization which we would be applying now, you know, as an engineer when you start designing your vehicle, here is the body structure design.

And I've got to make a decision. What should I make this part of the structure from? And you have choices of all these grades of steel and equally you have the choice of, you know, maybe aluminum grades and other material grades. And then the material is available in various forms and coils or extrusions or rolled-foam sections.

Then we have the manufacturing processes of hot stamping, regular sort of stamping, hydroforming. As an engineer, you have to make a decision which part, which material I choose, which path I follow to make that part so it's the most efficient cost-effective design?

Not an easy choice. Up until now, I think a lot of these decisions had been made based on experience, but experience is not always, I feel, the best guide when you are looking into the future. I think again, we kind of developed the -- we use optimization technology where we are looking at not just the, you know, thickness of the panels or the grade of the panels, what grade of material to use, but also the geometry sort of, you know, shape and then put this into a computer simulation and let the computer come out with what sort of shape would be required for a section through here.

And using this approach, I mean,

going through a computer loop where you do, you know, a number of simulations, you look at the results, compare the results with the target we are trying to achieve and then you say is this my minimum mass solution?

If not, you keep on, you know, going over this sort of loop over and over until you find the minimum mass solution, you know, for the -- and meeting all the targets. And there is a lot of detail when you look at the body structure. You know, this is just the body side. This is the panel you see, there is the opening for the door.

But on the inside, we have to design a lot of panels which have to be welded together or spot welded together. And in this type of simulation, we are actually optimizing these sections. We are optimizing what grade of steel to use and also the shape as well.

And again, using this approach, the solution you end up, you know, getting are a little bit unconventional.

Here we are looking at when you walk into the sort of car and you open the door, you have that, you know, big section. This is the section, you know, through that. The red line is what is on the baseline vehicle. And this kind of, you know, blue line is the shape which was developed through this computer simulation. And we did have a very interesting discussion on this with the Honda engineers, so it was good.

And then I just want to go over, you know, the results. We -- the approach we -- you know, up front we do the optimization, but still you have to make certain decisions up front, you know. Was there -- you know, what strategy you going to use, especially for the front end.

And then the strategy which was used really for the -- this is the front of the vehicle. When you are involved in a crash, all these members come into play and start absorbing energy. And we sort of really, you know, kept these same sort of, you know, strategies as Honda ACE concept. They use the term, you know, sort of ACE concept for the structure.

For the load parts 1, 2 and 3, but load part 4 which is the engine cradle underneath, that's where we did not use the same approach. And here you see the underneath of the vehicle when it is going through, you know, frontal crash.

This, the engine cradle, and that mount sort of, you know, it is designed to, you know, fail at a controlled sort of, you know, load. This is the, you know, strategy which Honda uses and there is some other companies use the same approach.

But we did not. We went away from this approach. We did not allow this mount to fail. With this approach, we feel it is just a little bit more inefficient in terms of mass. And you have to design that engine cradle section really very, very strong, so you reach that failure load.

But if you don't want to rely on that mechanism, we can design the engine cradle to actually absorb energy during impact. That was our reasoning. And so based on the design, we did a very detailed, you know, finite element model, about 1.5, you know, million elements.

One thing I want to point out, the external shape is the 2011 Honda Accord. But we are not claiming this vehicle which we have designed is a Honda Accord. It is a lightweight vehicle with similar size and similar performance, but I think only Honda can design the Honda Accord with the Honda DNA. What makes Honda different is why people buy Honda as opposed to, you know, other vehicles.

And this model, we did simulation for all the load cases, which is used for the NCAP rating plus the IIHS load cases. We did add the rear impact for, you know, fuel tank, you know, integrity and then also the torsional bending/stiffness and normal modes of vibration.

And looking at the results, on top you have the animation of the Honda Accord test and underneath we have the lightweight version of the, you know, structure which we designed. And I think that, you know, overall behavior can see it's, you know, similar.

And looking at the acceleration path, that's what -- the occupancy of the occupant compartment area. If you look at this particular part, it's the acceleration path. The dark line is the Honda Accord test. And the dotted line is the FEA simulation of the lightweight vehicle.

And this drop in peak is that engine mount failing, you know, which I was talking about. When that mount fails, then the rest of the structure takes -- overload has to build up, so you do see that. But we haven't got that because we didn't take advantage of that.

This is the acceleration path on the driver side, that's the acceleration path on the passenger side. And then also the important area is front of the dash where driver's feet are, the passenger's feet are. How much is this area going to come in?

I normally tell people that when a vehicle is involved in an accident, it's like your feet are there and on the other side is, you know, hit with a sledge hammer, that's kind of what's happening, that is what your feet end up seeing. And more intrusion there is at the feet level, more lower leg injury there is going to be.

So measurements are taken in this area relative to the seat. These are the test numbers in millimeters, which is really very tiny. And these are the FEA numbers which, again, you know, are quite small.

And we also looked at the offset barrier. Here the results were not available for the Honda Accord, so we compared it with the Crosstour, which have similar structure sort of in the front end. And looking at the paths here, we have similar paths.

Looking at sort of underneath the vehicle our engine cradle is not failing at the back. This is the footwell area where people's feet are. And when we held the discussions with Honda engineers, you know, they point -- they felt uncomfortable with the amount of intrusion we were getting here.

And you can sort of see it here. These are the various points in this area. The blue line is the FEA for the lightweight, but the actual test is this line here. Although, according to IIHS rating, we are still in the good area, but Honda engineers felt very uncomfortable about this increased, you know, sort of deformation in this area, which I'm going to talk about a little bit later on.

We did side impact. Here you are

looking at the images. The FEA model versus the test. Also, you take measurements. We are comparing the amount of intrusions sort of, you know, in to the area and the impact velocity. I'm kind of, you know, hoping you understand all this and there is going to be a test later on.

And then there is a pole impact which is kind of equivalent of a vehicle going out of control and hitting a lamp post. Here are the test pictures and this is the FEA simulation. You know, the amount of intrusions which are predicted on the FEA are in line with, you know, the test numbers and that was in our brief.

A roof crush test, again, the same thing. Here the dark line is the FEA model and this is, you know, one of the test curves.

So again as I said, we did a very interesting meeting with the Honda team. They did a lot of work. They actually didn't just download the report, they downloaded all the

FEA model which they kind of, you know, ran and their experts looked at it.

They identified areas of, you know, shortfall in performance of that offset barrier, additional intrusion, side impact. We actually simulated material failure. There were areas where the material was a little bit failing and they were concerned about that. And on the rear impact, clearance with the fuel filler line on drivability, sort of, you know, handling response due to ground clearance on a lightweight vehicle torsional stiffness, riding comfort on certain surfaces and also noise.

And then also, you know, we would talk a little bit about sort of, you know, commonality effect with other vehicles, because each vehicle is really a family and you have to take that into account.

I only need another 20 minutes. Okay. I'll quickly go through this.

MODERATOR BONANTI: Okay.

MR. SINGH: All right. So we actually did some additional work where we, you know, modified the body structure in those areas. And this is the -- you know, what I showed you, but the improved. We actually, you know, made changes and reduced the amount of deformation, you know, in this area.

And here I think, you know, Honda engineers will, you know, like this. This is our improved design compared with the test results.

And also the concern which was with, you know, the side impact by some, you know, material failure, we made changes there. Actually increased the thickness of the gauges, reduced the strength of the material with more elongation, so those failures will not account -- would happen. And so again, you know, we have an improvement.

You know, for the rear impact, we feel the concern which was we will be able to, you know, reroute, you know, some of the components. There should be no mass impact. So, you know, sort of torsional/stiffness, there was a discrepancy which we have corrected. This was the test number, the way the test was done. This is the lightweight. This is the lightweight improved. And the other way of testing, these are the FEA numbers.

And so it's really not -- I mean, you know, there is a difference, but I think we have improved the structure and these are the results for -- again, for bending stiffness, for normal modes, you know, for vibration.

We did look at the, you know, sort of engine clearance issue, which was the red line is the Honda Accord geometry in the front. The blue is what we had designed. So we ended up encroaching into the ground clearance, but this we were able to correct or really solve just by turning the flanges the other way on the section.

And if you redesign the engine cradle to take into account that -- that was kind of a mass hit off by the kilogram. And so we felt that in order to meet the performance in these areas, there would be a total mass impact of about 23 kilograms.

But I think we also identified new areas where mass could be saved. One of the areas is use of tailor-rolled blanks which we didn't use, but that technology is really being used now on high-volume production. There is potential for 13 kilogram mass saving there.

We used a minimum thickness in our lightweight design of .6 millimeters. And a number of steel companies are beginning to roll materials at about .55 or even .5 and the .60 are already in production. By 2020, we can possibly go down to .55, that's an additional 4.5 kilogram mass saving.

And also just general packaging, because we are using, you know, a smaller engine in the front, we could save some mass by, you know, better packaging in the front and the rest of the vehicle. But the net effect, even, you know, for improving the performance would take a material hit off, which is shown in red, but the other opportunities, I think there is an additional 20 kilogram.

So we feel that the overall conclusion of our report is still, I think, about 22 percent mass saving, you know, is possible. And I just wanted to show we had also estimated that for a compact vehicle, mass saving would be about 240 kilograms.

And a vehicle which VW have announced, Golf Mark VII, they are achieving a mass saving of 100 kilogram and it's slightly a larger vehicle across three platforms. So we feel that the vehicles which are coming out now, they are already meeting part of that mass saving, but, you know, 100 kilograms out of 245, another two generations, Golf will be able to save another 145 kilograms.

On platform sharing, this is my last one, if you look at the sales of vehicles, these are the Honda vehicles based on their UV platform. Honda Accord with the four-cylinder engine is the highest seller, 200,000 a year for 2010 and these are the siblings which all share the same platform, much lower sales.

And I think they -- maybe a changing strategy may be required. And this is a comment from GM from Mary Barra. "We are maniacal about, you know, mass."

On the new Cadillac ATS, Dave Masch, the chief engineer, I think the comment he made is sort of very interesting. And the biggest break from past practice, "GM engineers built the ATS platform with only one highest volume model in mind. Initially, they didn't incorporate weight here, more durable parts for say V-6 engine or rear drive version."

So I think a change in strategy here for these vehicles make those sort of additions rather than, you know, penalizing the vehicle, but adds the economic decisions with the OEM. And our conclusions, you know, overall, I think we were able to achieve 22 percent mass saving using conventional, sort of most of the, technologies which are available now or will be shortly available.

And most of the techniques -- yes, they will require engineering effort, but I think all new vehicles require engineering effort. I think this can be implemented. Thank you.

(Applause)

MODERATOR BONANTI: Thank you, Harry. Okay. So we have gone over our time, at this point. We do -- I want to offer up a number of questions, if you do have them to Harry, but at the same time, the first three speakers besides Jim Tamm from my staff at

NHTSA discussed both CARB's perspective from studies, EPA's studies as well as Harry just discussed what NHTSA asked him to do and his team.

This afternoon, we will be able to have the OEMs respond to that and others on a mass-safety basis with their expertise. And I just wanted to at least make you all aware that the interaction here is very important to establish what we have learned and what the industry is focused on and what you hope to achieve as well.

So at the same time, after I ask the last question, we are planning on being back here and starting at 1:20. So it is 12:00 now. If you want to hear the questions and the answers in response, feel free to stay, but I'm going to start at 1:20. Thank you.

Okay. What manufacturing process did you assume for the composites? Assuming CFRP prepreg, okay? Did you consider RTM process or polyamide thermoplastic laminate?

MR. SINGH: Boy. That's kind of a technical question, which I will not be able to answer. But when you look at composites, the -- when you look at what BMW are doing with the I-3, that we kind of took some of the cues and ideas from that. They are claiming about 50 percent mass saving and that was the assumption we used in our calculation.

But I think very early on, we kind of ruled composites out because of we are looking at high-volume production, one part, you know, one vehicle coming off the line a minute. And in order to make a high-volume production kind of cost-effective, you really need to have one of these parts coming up, single sets of tools wherever possible.

If you have to look at composite cycle times, the best possible cycle times are down to about maybe seven minutes now per part. So in order to reach that one a minute, you would probably need seven sets of tooling.

So sorry I can't answer that, sort of detailed question, but because we did not really exactly design the body structure in a lot of detail in composites.

MODERATOR BONANTI: All right. Okay. With your mass reduction, were you able to judge how much fuel economy improvement you could get? That's the first question.

The second question, what safety standards did you evaluate for NHTSA? Did you include Honda's internal requirements as part of that?

And they also want to thank you for a good presentation.

MR. SINGH: Oh, thank you. Okay. We used all of the NCAP, you know, testing and the list is in the report and I showed which is mainly all of the occupant safety. We did do sort of additional stiffness of the vehicle, normal modes, which is vibrations of the vehicle, but we did not consider any Honda's internal, you know, kind of tests.

We did do -- you know, other load cases, you know, say for durability, a vehicle hitting a pothole, vehicle going around a corner and what sort of loads are generated in those maneuvers. Those loads were used to make sure the vehicle, you know, the stress levels are going to be low enough.

But there are right now -- when you design a vehicle, there are basically hundreds of load cases, but a lot of those load cases are very, very localized. And then in those areas, we basically used good engineering design lines principles like where the seatbelts are attached. There has to be reinforcement back there. We make sure there is reinforcement in our design.

Besides the bolts which is used, we make sure we use the standard size of bolt. So we did take account all of the mass which would go into it, but the actual test was not done.

And then when you do the actual

test, sometimes you end up actually taking some material out, because you are optimizing for that test. Other times you end up adding a little bit of material in under those sort of, you know, localized load cases. But we feel overall impact of those -- that type of detailed testing it should weigh out the mass saving versus mass you may have to put in certain areas.

MODERATOR BONANTI: The first question, which I don't recall you actually answering was with your mass reduction, were you able to judge how much fuel efficiency improvement you could get?

MR. SINGH: We did detailed models in PSAT, which is a performance simulation program in which you can put your powertrain, you know, type of parameters and you can predict what miles per gallon you would get. And we did -- had a PSAT model which we ran and the results which came out of the PSET model were very close to the guidelines, you know, which we generally use, which is for 10 percent mass saving, you get about 6.5 to 7 percent increase in fuel economy if you resize the engine.

And the PSAT results were very close to that rule, but we did have a detailed PSAT model which we used for NULL to 60, you know, performance prediction as well as miles per gallon and maximum speed and that sort of thing.

MODERATOR BONANTI: Okay. I believe this is the last question, unless there are any others.

Okay. What were the joining optimization performed? How does optimum joining compare to baselining?

MR. SINGH: When it comes to, you know, joining, the strategy which we used was about half the flanges we are using laser welding. The other half we are using spot welding with increased amount of adhesives, which is, I think, we are using a little bit more laser welding, which does give you a mass advantage.

You need smaller flanges and in the report there is an entire chapter comparing laser welding versus spot welding. And a lot of the joint -- as soon as you start using more adhesive in the joint area or laser welding, your joint stiffness also improves.

So in and around key joint areas, we have adhesive bonding and possibly a little bit more laser welding, but that is fully discussed in the report in more detail.

MODERATOR BONANTI: Okay. Thank you, Harry.

(Applause)

MODERATOR BONANTI: Okay. We have escorts outside for those that are going to be leaving the building for lunch. Hopefully, if you have any questions, any of my staff or any of the guides will be able to assist you. And we look forward to getting you back here at 1:20, so please take into consideration -- you can leave -- yes, if you want to leave your stuff here, you can leave your stuff here.

(Whereupon, the Symposium was recessed at 12:09 p.m. to reconvene at 1:22 p.m. this same day.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

1:22 p.m.

MODERATOR BONANTI: Thank you. It looks like the majority of everyone heeded my warning that we were going to start at 1:20, so I'm glad you all are back in attendance.

The next speaker to start the afternoon as we discussed this morning most of what you received when it came to presentations was looking at the three agencies, both CARB, EPA and NHTSA's perspectives on the type of research that each one of the agencies has developed and put forward.

This afternoon, we are fortunate enough to have OEMs as well as technical representatives from other areas that will be able to provide perspectives on what has been discussed this morning, as well as initiatives on their own.

So first and foremost, I would like to have Chuck Thomas from Honda come up and give his presentation. He is going to be discussing the Honda study and report that was commissioned by NHTSA that you just received a lengthy presentation before lunch and I'm looking forward to hearing Chuck's response to that. So thank you, Chuck.

MR. THOMAS: Hello, everyone. I'm Chuck Thomas with Honda R&D and I do really want to thank NHTSA for inviting us here today to discuss the study that was conducted by EDAG.

Harry stole a little bit of my thunder today, so hopefully -- that is good, he covered some of the material, so that way it saves me a little bit of time.

So I want to start out with a few observations about the lightweight vehicle study that was conducted by EDAG. You know, our position is that we think the report really is a pretty good study of light-weighting possibilities and has -- identifies a lot of technologies that we think have a lot of potential to reduce vehicle weight. And I think everybody can agree on that.

You know, many of the technologies and the approaches that they discuss in the study reflect in sort of parallel our own activities, our own research into vehicle light-weighting.

Honda arranged to have this presentation initially with NHTSA and with EDAG to really kind of share some of our observations of the study that was conducted and a few corrections we think are really important, both in the details of the study and in some of the conclusions that it reached.

And really, we think it is important as a manufacturer in the automotive industry to work with NHTSA and kind of collaborate. So they understand what our perspectives are, what our concerns are. And you know, we bring a lot to the table, I think, when it comes to the actual potential of some of these light-weighting ideas.

As a manufacturer, these are the things we cope with and struggle with every day.

So kind of like I think to touch on what Harry said, you know, we looked at the lightweight vehicle study and if you look underneath the chair over there, there is a copy of it printed out that I don't keep under my pillow, but I did read it. And I think it was very well-done.

But there were some areas, I think, that we had concerns with. One of the assumptions of the study is the lightweight vehicle that they created would match the performance of the 2011 Honda Accord. We looked at it and we thought in some areas it doesn't, we believe, meet that level of performance, particularly in the area of crashworthiness, performance and drivability and also related to some ground clearance issues.

So also there were some business conditions that we think weren't really discussed or explored by EDAG in the study and those are related primarily to platform commonality and Harry touched on that a little bit and I'll expand on it.

And then, you know, one of the things that occurs is when you look at these light-weighting studies, because you can take weight out of the vehicle, then you have this sort of multiplier effect where people begin to downsize other components of drivetrain and chassis.

Of course, the problem is when you have to put some of that weight back in to correct for that, that effect reverses itself. So there is some weight that has to be added that we kind of call the mass rebound and I'll try to cover some of that as well.

So if you look at this chart, this is what we call at Honda, a Yamataka, which is just kind of a fancy name for a stair step kind of weight analysis. And this looks at the change that the lightweight vehicle proposed compared to the 2011 baseline Accord.

And you can kind of see the different categories and weight reduction that they proposed. And they, from their study, achieved a 332 kilogram weight reduction, so which is about 22 percent of the vehicle weight.

So when we looked at this, you know, as I had already mentioned, we observed that there are certain areas of performance that we feel the lightweight vehicle didn't achieve parity with the 2011 Accord, particularly crashworthiness, some drivability issues. And to correct for that, you know, some weight is going to have to be added back in.

So when we think about like what is the lightweight vehicle adjusted weight based on the performance, what we started to look at were the finite element models and the other data that was available from EDAG to make some assumptions and some rough calculations on what we think would be a more reasonable level of weight.

So I think maybe you saw this chart in Harry's presentation. This is at our common radar chart that looks at sort of performance mapping. And, of course, the study of the 2011 Accord was attempting to achieve a vehicle that met all the performance criteria of the 2011 except in one area and that is fuel economy.

So the idea was they would be improving the fuel economy of the vehicle while maintaining its performance.

I think when -- you saw this chart in Harry's presentation as well. And this, you know, our chart that sort of shows what we believe to be the performance of the lightweight vehicle. Of course, this is a qualitative chart. This isn't a quantitative radar chart.

But in the area of safety and some handling response, ride, comfort and noise and vibration, we feel that the lightweight vehicle's design would be degraded compared to the 2011 Honda Accord. And I'll touch on these.

First, I want to kind of explain a few things in define a few assumptions that we made in the work that we did with the lightweight vehicle. As Harry had mentioned, I think there is kind of a misconception for a lot of people in this study that the lightweight vehicle is the 2011 Honda Accord with some weight removed from it.

But like Harry pointed out, really the lightweight vehicle is a completely new vehicle. The vehicle platform architecture was redesigned by EDAG. Really the only thing that is sort of the same is the exterior shell.

So two of the assumptions that we worked with when we did this study, one was the sub-frame design. So Harry had mentioned that the sub-frame design for the lightweight vehicle is a fixed sub-frame that is not designed to separate from the body the way the Accord's sub-frame is designed to.

And then the second thing is we didn't change the geometry of the platform. So you can kind of see these components in the lower picture that are identified in red. This was construction that was developed by EDAG for this lightweight vehicle.

We didn't -- it was beyond the scope of what we were going to do to go back and redesign all the components, so the countermeasures that we have applied are primarily looking at either changing the material or the thickness of the components that already exist. And in some areas, adding some additional components to reinforce different components of the structure.

So I want to start with front crash testing, particularly the Insurance

Institute's moderate overlap crash test, which I think probably many of you are familiar with.

And Harry had touched on this that we had discussed this when we had met with them previously. The design of the lightweight vehicle had increased levels of dashboard lower intrusion which we saw. And also what we saw in some of the -- in our initial runs was that the dashboard upper intrusion was increased as well.

So these are areas that are of concern, because even though the Insurance Institute defines these regions as, you know, good acceptable, marginal and poor, what we do know is increased intrusion in these areas increase the risk of injury, particularly to lower extremity injury.

So even though the values in the lightweight vehicle were not excessive, the increase in those values to us would be an indicator that we probably need to do something to prevent that from occurring, because it is increasing the risk of injury.

So when we looked at the model, we came up with four different things that we changed to improve the front crashworthiness of the vehicle. There was a patch that was added to the toe board right area to help reinforce that area to prevent intrusion. The front rail-end or the front side for rail-ends buckle very quickly in the analysis, in the structure. So those areas are reinforced to try to prevent that buckling early in the crash and to drive the front side into a more column-type crush behavior.

The upper wheel house members and the pillar areas were reinforced to try to help rebalance that load going into the cabin to reduce the pillar intrusion.

And then also what we saw in the model, there is a lot of seat pitching in the model that was designed. Now, this model didn't have an occupant in it, but there were masses that were added to try to create some of the inertia loading, so it appears.

So we reinforced areas of the seat, because that seat pitching pushes the occupant closer to the instrument panel and we wouldn't want that to happen. So when we applied all of these countermeasures to the vehicle, it adds up to be around 25 kilograms of mass.

Now, some people could argue maybe we could do this with a little bit less mass. As I mentioned, you know, we made certain assumptions. We weren't going to redesign all the geometry, but I think that it is fair to say that mass would be -- have to be added to improve the front crash performance of the vehicle to match the 2011 Accord. And I don't think 25 kilograms is an unreasonable amount of the mass.

The next thing I want to talk about is side crash performance. So we looked at the size model, because the size has a tendency to be a very demanding side crash model of the structure. There is a lot of energy that goes into the vehicle.

One thing we notice when we looked at the EDAG analysis of the lightweight vehicle, there was a lot of fracture that was occurring in the side impact areas of the vehicle. The cabin structure is, you know, designed primarily to maintain the integrity of the space around the occupant and protect them from intrusion, which is one of the kind of the key mechanisms that cause injury in side impact events.

The cabin in a side impact event is not intended to absorb energy, because there is very little stroke in the cabin structure. So you can imagine unlike the front crash, the side crash -- our intention as a manufacturer is to maintain the integrity of the space around the occupant.

So since EDAG went to new types of materials, particularly these hot stamp materials, which, you know, we are very fond of and we are beginning to use in our vehicles as well, one thing that has a tendency to happen with these materials, they have the tendency to fracture when they fail.

Unlike traditional materials that are milder that have longer levels of elongation, when these materials fail, they fracture and you see catastrophic failure in the structure. So we can't tolerate that type of behavior in the structure, because it destroys the integrity of the protective cage around the occupant. So we have to design the vehicle such that these types of fractures aren't going to occur in these types of crashes.

When we looked into the EDAG model, it was predicting quite a few fractures in the side impact structure. You can see a few of them that are highlighted in these figures. You can see fractures at the base of the B Pillar, some fractures in the roof arch.

These types of fractures would indicate a very high risk of sudden increases in intrusion in real-world crashes. And we wouldn't tolerate these types of fractures in our vehicles.

So we went back and looked at it and much like Harry just explained, what we did was we left it go into materials with higher elongations and with lower yield strengths for these certain areas where you have inner pillar structures, which are placed in tension during side impact events, because tension loading is what has a tendency to cause them to fracture and kind of fail catastrophically. And that adds up to about 10 kilograms.

And then lastly from a crash mode, we looked at rear crash. So I think we are all -- probably most of us are familiar with the 301 crash mode. In the model that was developed by George Washington in a lightweight vehicle study, they didn't have a fuel tank, but the lines and particularly the filler neck were missing out of the simulation.

So what we did was we added those back in. And what we found is if you kind of see the filler neck which is shown there in red, the filler neck is contacted in the simulation by the upper control arm of the rear suspension structures. That is something that we wouldn't tolerate in our design.

While FMVSS 301 has allowances for certain amounts of fuel to leak during a crash, we don't allow any fuel to leak by our own internal requirements. We actually don't allow for the potential of fuel leak. So we try to avoid contact if at all possible with the fuel system and certainly minimize any contact with hard steel components that could damage the fuel system.

While not by design, it's certainly possible the filler neck could have fluid gas in it, because customers overfill it and, of course, the vehicle can turn.

So we made modifications to the rear frame rails of the vehicle as well as the rear sub-frame to increase the strength of those areas to help prevent that contact.

Now, I think Harry mentioned in his presentation that we could redesign the fuel system and we could try to route the filler neck somewhere else. That is certainly a possibility. The problem is the real estate in the rear area of the vehicle is very tight and, you know, already we struggle with how to route that fuel filler neck.

So we think we have probably found a pretty optimal position for it. And it was something that needed to be protected. So this adds up to about 15 kilograms.

So if you go back to our fancy word Yamataka and you look at sort of where we are right now, so if we started at 1148 with 25 kilograms for front collision, 10 kilograms for side collision and 15 kilograms for rear collision, that gets us to 1198 kilograms, which is still a pretty big reduction in mass.

There are a few other areas I wanted to look at and next I'll get into drivability and performance and we can see what kind of weight increases we think might be necessary there.

So when we talk about driving and performance, we are really kind of talking about handling. And probably the most representative characteristics of the vehicle related to this is what we think of as body rigidity.

So this affects how the vehicles turning response is going to be affected and also its stability as it recovers from a steering maneuver. If you look at this chart, you know, we are estimating right now that you are going to see a significant drop in performance of the lightweight vehicle against what we think is the 2011 Accord's performance.

Harry had touched on this, too,

and I'll just go over this quickly, but the target for body rigidity for the lightweight vehicle was derived from the performance of the 2011 Accord that was tested by DEFIANCE.

From looking at the study, we think that DEFIANCE used a boundary condition that was different than what was intended by EDAG, because when we looked at their data we saw that their results seemed very different than ours. And it looks like, from the photograph, they had supported the vehicle in different locations than the shock tower.

When we looked at it, and the numbers I'm sorry, I had to remove for confidentiality reasons, our physical test and our CEA results are much similar. And they are significantly higher than what was measured either by EDAG or what is predicted in the lightweight vehicle.

So really the target for the lightweight vehicle's torsional rigidity, I think, is low compared to what the 2011 Accord already achieves. The good news is though when you looked at the weight we had added for crashworthiness, it increased the overall torsion of the vehicle.

So those changes alone seem to address a lot of the torsional concerns. So we really didn't need to add any additional weight for body rigidity. It was addressed through the crash countermeasures.

Another area that I want to touch on is noise. I think everybody who drives a car wants their car to be quiet and understands, you know, that from a competition factor today, road noise and vehicle quietness is a very important consideration for the customer.

Some of the things that was looked at in the EDAG report to reduce weight, for example, was reducing the thickness of the wheel rim for the steel wheel and going to a stronger material. Our concern with that is thinning that wheel, we think, would increase road noise, transmission into the cabin.

We have looked at these types of things before and we don't think that's a very good idea. So we suggested putting that weight back into the wheels, which is about 4.5 kilograms.

Also EDAG looked at aluminum closures for the vehicle. We have some experience with aluminum. We have developed the old NSX. The inside -- we understand that, you know, there is certainly big weight advantages to aluminum closures. However, the noise transmissibility through aluminum is higher than steel.

So probably some additional soundproofing or insulation material would be required, so we estimated 1.2 kilograms would be added. And then there is some additional noise countermeasures and it all sort of adds up to about 5.8 kilograms.

Another issue that came up was the ground clearance. So I know Harry had mentioned this, but what we looked at when we looked at the sub-frame design that EDAG had come up with with their new sub-frame, one thing they removed was the curved rear beam area of the sub-frame that the Honda Accord has.

One of the reasons for this curved rear beam is the exhaust A pipe runs underneath the engine and that curve creates an escape space for the exhaust pipe to fit up underneath the engine to reduce the likelihood it is going to strike the ground.

With the sub-frame that was developed in the lightweight vehicle, that A pipe is closer to the ground and there is potential impact of that relatively fragile exhaust system component to the ground.

So we would recommend that be raised back up. We tried to look at their sub-frame and make some estimates of what we think would be necessary to change as the rear beam, but to maintain the kind of design concept of their sub-frame. And we thought about somewhere around 8.5 kilograms would be necessary in additional weight.

So now if we look at sort of these drivability and performance weights, if we start with the 1148 and we add in the 50 kilograms of crashworthiness, the 18 kilograms of drivability and performance and then about another 7 kilograms that we found, mainly because we think there were some mistakes in the baseline weight. It didn't add up to be a lot, but a few things that we found, that puts us back up to around 1223.

So then so that weight going from 1148 to 1223, we think is a pretty reasonable amount of weight to adjust what we think are some of the performance parity issues between the 2011 Accord and the lightweight vehicle.

But there are some other areas we need to think about as well and that is some business consideration in what we call kind of this mass rebound effect.

So when we talk about the business condition, one thing we want to talk about is platform commonality. And Harry kind of touched on this. We discussed it earlier.

You know, the Accord is a vehicle that has a lot of sort of children that go in its family. Besides the four-cylinder and six-cylinder version of the Accord, the Honda Crosstour and the Acura TL are actually both in the same platform as the Honda Accord. And both of these vehicles are significantly heavier than the Honda Accord.

So our strategy is, and I think many auto makers are, that we look at how that platform is going to be used throughout a family of vehicles and we have to make certain decision on the design of components to accommodate the different types of mass that these different vehicle configurations are going to bring.

So when you look at the lightweight vehicle, what you really have is a four-cylinder vehicle that has no family. It is a vehicle in and of itself and it really is just one design, but when you think about the Accord, you know, the Accord has multiple engine configurations as well as larger vehicles that are derived from the same platform.

So again, I'm sorry, due to confidentiality reasons, there was some data we had to remove here that we had shared with NHTSA, but, you know, Harry had touched on the idea that maybe some auto makers are rethinking this strategy. And, you know, for some vehicles maybe it makes sense. Like the ATS volumes are significantly lower than the Honda Accord, so maybe for the ATS that General Motors is talking about, it makes more sense.

But one of the things that becomes a problem is if you do that, a lot of these other vehicles that are derived from the common platform have much smaller amortization volumes than the Accord does. So by sharing a part, even though that part may be a little over designed for the L4 Accord across the entire family, our amortization values are much more reasonable.

But if you have to take a vehicle that only has 10 or 15,000 units that are sold and have to design exclusive parts for it, the amortization numbers become very difficult. So there are complicated kind of situations that have to be managed when you think about this sort of business compatibility structure, because as the manufacturer, you know, we do want to create a family of vehicles that we can sell to customers that sort of are designed to meet their needs depending on the type of vehicle that they want to buy.

And then I guess to kind of hit the last point is that based on this commonality and those sort of family of vehicle issues, we think that would add about 40 kilograms back into the vehicle.

So if you go back to our Yamataka, if we add 40 kilograms in for business considerations, we are now back up to about 1263 from the original 1148.

So the last thing we want to talk about is what we call mass rebound effect. So in the EDAG study and in like many of the studies we have seen this morning, as we reduce weight from the vehicle, other systems related to vehicle weight can be changed, because the performance that's necessary based on lighter vehicles is now more than we originally requested, particularly areas like the drivetrains and the braking systems and chassis systems we have discussed can be downsized or have some weight reduced without impacting performance.

The problem is if we go the other way, if we wind up having to put some of this weight back in, we have to kind of back off some of those things. So when we looked at it, originally the 332 kilograms of mass production, about 90 kilograms of that from the EDAG study were related to sort of like being able to reduce weight based on the weight that they had already reduced.

We had our power train group look at it and based on the weight that we added back in, the EDAG proposal of going to 140 horsepower probably wouldn't really meet the performance targets that we have for the vehicle.

We didn't want to end up going all the way back up to 177, which is the Accord, but they estimated that they needed to go up to about 160 horsepower. And we asked them to make some estimates of what that weight would cost. They said that, you know, 30 kilograms they thought was a reasonable target based on some changes they may have to make to the transmission or different types of engine configurations to achieve that.

Some other systems added up to be about 12 kilograms. So totally from this sort of weight rebound effect or mass rebound, we were looking at about 42 kilograms.

So if you add in the 42 kilograms, that brings us all the way back up to around 1305. So if you look at the total weight that was adjusted, you know, we started at 1148 or 1480. The lightweight vehicle went down to 1148. From our investigation of it going back up, we come back to about 1305.

You know, so I think 1305 is still a pretty significant weight reduction, but, you know, kind of they conclude there are a few things we wanted to kind of point out to EDAG and Harry and I have talked about this.

Certainly, we think that the original lightweight vehicle model while it really looks at a lot of good ideas, it sort of over-emphasizes the potential for some of the weight reduction, primarily because it doesn't necessarily match the performance requirements of the 2011 Accord, particularly in the area of crashworthiness, drivability, and NVH.

And then when we add those in in the business kind of conditions, you know, we think an achievement of 175 kilograms for the lightweight vehicle project is probably more reasonable than the 332 kilograms that were reported. You know, of course, this is a difference of opinion and I haven't built this vehicle, so the exact amount of weight that this would actually be if we designed this car, you know, I can't prove it, but identifying some of the things that we were concerned with in the lightweight vehicle, I think would definitely require additional mass to address.

You know another thing, too, which is a really important factor that I haven't heard anyone really talk about today yet is the manufacturer -- what we have to think about is what our customers are going to want in the future.

So most of these studies have

looked at, you know, two generations of vehicles and sort of the time lines. So we are thinking about, you know, 2020 to 2025.

I would ask all of you to think back to the car that you owned in 2002 and think about what that car is like versus the car that you may be on today, assuming it's not the same car. And you know, over two generations, vehicles have changed quite a bit.

And I think it is unreasonable to think that over the next two generations, the vehicles won't change again. You know, the one thing I have learned in the automotive industry over the past 20 years is that the customers are really unreasonable and they want a lot for their dollar.

And as a manufacturer, you know, we are constantly trying to find ways to satisfy that customer, but still provide a vehicle at a price that they are willing to buy.

So, you know, in crashworthiness, I think in the past 10 years and how much things have changed in crashworthiness in the design of the structure and the protection that we offer people today, I don't think that is going to stop. I think that is going to continue in the -- moving forward in the future.

But the Insurance Institute, Small Overlap test, and the Oblique test that is being developed by NHTSA currently are tests that are going to be more demanding of the vehicle for crashworthiness. It is going to make it harder for us, you know, to achieve a level of performance and continuously work to reduce the weight of the vehicle.

So these are things manufacturers I think really are thinking about and are concerned about. And I think this is an issue that sometimes is overlooked by some of these studies.

But I want to end though, I want

to say that, you know, EDAG really had, I think, a good study. It was very thorough. I think that a lot of the technologies and a lot of the approaches that they highlighted are very valuable to kind of bring out and discuss.

As a manufacturer, many of the things that they identified in their study we have begun introducing to our vehicles and some of them are already in our vehicles. The new NDX will go on sale very shortly and it has many of the attributes that were shown in the EDAG study, many of the technologies.

So things like these advance high strength steels and hot stamp steels have become widely used in vehicles today and that's going to continue to grow. The next NDX has a cast magnesium steering hanger beam, which is significantly lighter than previous generations.

And we are looking at, you know, reinforced plastics and even new types of carbon fiber composites that we are going to introduce over the next couple of generations.

So I think everybody in the automotive industry is moving in this direction as quickly as we can, but, you know, we are trying to balance all the challenges that we face. And I think these studies are good. They help, you know, look at these technologies and kind of bring some of them to light.

But I think that, you know, there are a lot of assumptions that get made in the studies, I think, that maybe kind of simplified or kind of overlooked some factors and as a manufacturer we have to deal with.

So that's really all I had to say about that. And I want to thank Harry and his work and I think that was a good study. And I would be happy to try to answer any questions if I can.

(Applause)

MODERATOR BONANTI: Okay. Thanks,

Chuck. Appreciate it. Questions? Does anybody -- well, you have to write them down, please.

PARTICIPANT: Oh.

MODERATOR BONANTI: Do you have the cards?

PARTICIPANT: Yes.

MODERATOR BONANTI: Thank you. The first question with Honda's technical and design expertise, could Honda achieve a similar mass reduction as the FEV and EDAG design without the loss in crashworthiness comfort or handling properties if Honda performed the same exercise?

MR. THOMAS: Well, I think that just like I said in the study, if we had performed the same exercise, I think what we would expect is maybe about 175 kilograms of mass reduction is what we think we could achieve reasonably. So I guess that's what we think.

MODERATOR BONANTI: Okay. Others?

I'm sure there is a few. There is a few. Okay. Okay. Honda's analysis is 12 percent mass reduction at what cost?

MR. THOMAS: I didn't go back through all the cost numbers in this. I'm not really a cost expert, so it was hard for me to try to come up with it. Certainly, some of the cost that was removed from the study, I think, would show back up, because I remember from the EDAG study a significant amount of sort of the cost rebalancing came from the downsizing of the powertrain. That helped offset the cost for the structure.

That would -- some of that would certainly come back, so that would impact their cost. I think, too, you know, we didn't mess around with the aluminum that they added to the vehicle. From an engineering perspective, I think, you know, aluminum closures are completely feasible and completely meet the performance targets that are necessary, but they are expensive.

So I think that, you know, probably the 175 kilograms we have in this vehicle would actually probably be at a higher cost than what EDAG achieved at their weight reduction, because some of the weight -- or some of the cost that they took out of the downsizing would have to go back in.

MODERATOR BONANTI: Okay. The next question. With a turbo direct injection four-cylinder engine, it now puts nearly 150 horsepower per liter. Is Honda considering replacing a normally aspirated V-6 with a similar output 300 horsepower from a 2 point liter four-cylinder to help reduce vehicle mass and build complexity?

MR. THOMAS: I'm not really much of an expert when it comes to powertrains. I'm a steel-bender kind of guy myself.

I know Honda is introducing direct injection engines now and most of the technologies we have looked through the turbocharging and direct injection as well as more advanced transmissions are working themselves into our product cycles right now.

So I guess that's really all I can say.

MODERATOR BONANTI: Okay. Great. We have our first question of the day from the web. So we are listening. Do you think the challenge -- excuse me. Do you think the change Honda made based on your business constraints and performance parity would add additional cost to EDAG's design?

Roughly speaking, how much would be the overall cost increase?

MR. THOMAS: Well, I mean, other than the cost increase due to the mass rebound, it's hard to say. You know, my own experiences in use of certain materials, such as some of the advanced high strength steels and some of the hot press materials, you can really avoid much of the cost impact of those through better design.

So short of going back and

redesigning the geometry in the lightweight vehicle, it is really hard to say how much it would add to the cost of the white-body. But with these advanced steels, I mean, the cost impacts are not that particularly large. Most of the cost impact and the structural changes that EDAG made, I think would really, like I said before, come about because of the aluminum that they introduced into the closure systems.

MODERATOR BONANTI: Okay. A few-- a number of questions, which is good. Another one from the web. Okay. Okay. Let me get to these first. Since you produce a fleet, would you have started with the Accord? Can you comment on the reduction by segment?

MR. THOMAS: Well, I mean, I guess they are talking about sort of the family of vehicles for the Accord platform. We start with the Accord, because, of course, the Accord is the largest volume production out of that particular family.

So in a lot of ways, the Accord is what controls that overall platform development. And then other vehicles that are going to be developed are reflected into it, particularly some of the larger vehicles.

So when we develop a platform, what will happen is that, you know, groups that represent different vehicles will be designed off that platform meet to discuss what their needs are. But because the Accord's volume is so large and it is produced in multiple countries, it really is where we start when it comes to trying to size and select those structures.

I don't know if that answers their question or not, but it's probably the best I can do.

MODERATOR BONANTI: Okay. This is a question from the web, our second one. When mass was added to -- for IIHS frontal offset as well as side impact, were countermeasures added to both driver and passenger sides of the vehicle?

MR. THOMAS: Yes. So for the Accord configuration -- well, of course, the Accord in certain countries are sold with a right hand side configuration as well.

Side impact, of course, it would be necessary to apply these structure changes to both sides of the vehicles, because, of course, the vehicle is symmetric for side impact performance.

But we definitely try to maintain symmetry in the structural performance for crashworthiness. You know, because, of course, we -- in the real-world we really don't know what type of crash you are going to have. So we need to make sure that the structure can deal with impacts from any direction.

MODERATOR BONANTI: Okay. This adds to it as well, this question. After you add additional mass, do you think there might be more mass-up? What is your prediction for

2025 mass-up in vehicle based on consumer need?

MR. THOMAS: Well, I don't really have a good prediction for a 2025 mass-up number. I mean, our intention is to try to reduce the mass of the vehicle. One of the things I think sometimes people don't recognize is that in automobiles, like we talked about with performance improvements over time, whether it is driving performance or whether it is comfort performance, sort of the natural inclination of every vehicle is to add more features and more technology, which has a tendency to push its mass up.

Often people like me who design the structures of the car are the ones that are kind of looked to to try to help offset those additional features. So often times, unfortunately, the numbers -- the curb weight numbers don't necessarily reflect the amount of mass reduction that has occurred in the structure, it's on the engineered components in the vehicle, because things like new entertainment systems and power ventilated seats and, you know, eight-way power seats for the passenger side kind of eat up some of that additional mass reduction.

So when you look at the curb weight over a couple of generations, it may go down just a small amount or it may even go up a few kilograms, but you don't recognize necessarily how much mass overall has been reduced from certain areas of the vehicle.

So I don't know if I have a great answer for 2020 or 2025, but, you know, probably the number that we -- came out of this at around 175 kilograms is probably not an unreasonable target that we would like to try to achieve within two generations of the Accord.

But again, you know, that is just sort of our estimate, at this point.

MODERATOR BONANTI: Okay. How should OEM support future NHTSA, EPA and other studies to make outputs relevant and adaptable for use?

MR. THOMAS: Well, I mean, I think it is important as a manufacturer to certainly be involved with the study. It was a really nice opportunity, you know, we got a chance to meet with EDAG and review their study and discuss it with them. We got a chance to meet with NHTSA.

I think it is important to do that, because I think like I mentioned there is a lot of things that manufacturers know when it comes to vehicle design that maybe aren't quite so obvious. And particularly, when you talk about large volume design. I don't want to take anything away from Lotus or EDAG or other companies who have a lot of design capability, but, you know, there aren't that many companies out there that are, you know, designing and selling millions of automobiles a year.

And there definitely is a

difference in trying to cope with a vehicle that is, you know, going to be produced in multiple factories in multiple continents and, as like Harry said, has to be built in one minute compared to say, you know, some specialty vehicles or some more exotic vehicles.

So I think that, you know, NHTSA by working with the manufacturers and having a really good dialogue with us allows us to help inform them of some of these issues that maybe they are not aware of or maybe things they haven't really thought about the way we have.

MODERATOR BONANTI: Good. There is another question from the web. What are some of the other business constraints that might hinder the adaptation of light-weighting technologies?

MR. THOMAS: Well, you know, one thing that we have run into is that often vehicles that are the same are produced in multiple factories across multiple countries. And that can be a problem because not all materials are available in all countries.

So, for example, if we are going to produce a vehicle in Japan and the United States, it is pretty similar, but I mean, we are producing vehicles in Asia, in China, in other destinations and certain materials and certain types of technologies are difficult to procure in those markets.

So you know, we don't want to have to design multiple different vehicles to be sold in different countries. So because of that type of situation, sometimes constrains how quickly new types of materials and new technologies can be introduced into a vehicle.

You know, first, we have to build up a supplier base in a country that is capable of providing like certain types of material before we can begin using those in the vehicle, even though maybe in a different country that supplier base is already established.

MODERATOR BONANTI: Okay. In Honda's reevaluation, 40 kilograms is added to the platform. What is the breakdown of the 40 kilograms?

MR. THOMAS: I really don't have the breakdown to give you guys. I would have to go back through it and look at it. I don't have it prepared today.

MODERATOR BONANTI: Okay. Are there other questions? No? Okay. Thank you.

MR. THOMAS: All right. Thank you.

(Applause)

MODERATOR BONANTI: Okay. Our next speaker is Scott Schmidt from the Alliance of Automobile Manufacturers. And he will be discussing engineering and market realities. So I'm looking forward to hearing this. Thank you, Scott.

MR. SCHMIDT: All right. Let me find my way back to the beginning of the --

first off, I'm extremely fortunate to have followed the Honda guy, because I'm going to be talking more big picture, platitude type stuff. It was nice to have a very detailed technical description of a lot of things I'll probably be bringing out in my presentation.

One of the things that we are, as participants here, really trying to do is to sort of provide some feedback recommendations to try to assure that the midterm review will be based on the most current, up-to-date information and also especially accommodating some of the safety analyses and mass reduction.

And even when I say midterm review, I know we are -- kind of have this tendency that it is -- there is a review. I think what we would like to suggest is while there may be a review, but the job is not over once you do that review or even leading up to it. It really should be more of a continuous review process.

And just like an aircraft pilot is trying to land a big jet, he doesn't halfway through check his altitude and say oh, I'm good and just cruise on in. He is constantly monitoring all the things going on, so that he can successfully land it.

And I think reaching the fuel economy goals, which are very ambitious, it's just as hard as landing a 747.

So I would like to kind of keep -- raise the idea that we applaud NHTSA's work on all their studies. I think even after the review, they probably will be not done. There probably will be more additional updates. There will be more data. And as you look at some of the costs and some of the things that come in for some of the ultra powertrains, I think those are all very important things to try to include.

I keep hitting the wrong button. The other thing, of course, is as you heard from Honda and other people is that being an

OEM is a huge undertaking that is always balancing and it's balancing very competing business case, technical issues, availability, you can't -- you know, getting the materials.

So I think it is again important to balance the safety considerations, not too far too fast. Not getting ahead of the fleet. Keeping those mass differentials at a manageable rate. And at the same time, trying to balance the realities of procuring some advance materials, understanding the advance materials and utilizing them.

And so, again, you know, we kind of talked here about that. You know, it is every time you try to go to a substantial mass reduction, it's not a matter of just carving out mass out of a certain area. As the Honda presentation and the EDAG, they have all acknowledged that you make a change over here, you have the abilities to make change if we are here and you need to balance everything. So it's an important thing to keep in mind.

The other thing here, and again the Honda people talked about trying -- they have internal standards. Our manufacturers have those, too, because they are competitive. We don't necessarily publish them on the web.

So I understand the EDAGs and the NHTSA people might have a hard time trying to say, yes, this meets OEM specifications when they don't know what those specifications are. But we work very hard just as the Agency does to protect the current safety trend. We are always trying to get it down.

And so one of the things we are very interested in is making sure that we can look at what the mass reduction from a safety standpoint is and try to maintain that current safety trend.

Again, we think we are anxious to see what the fleet safety evaluation study that is due out, I think, in July -- we are very anxious to see that. And we also have some recommendations later on to maybe expand or give more depth to the statistical analysis that Chuck Kahane and others have done.

Again, the periodic reviews and I do this as plural. We should really look at the potential mass associated with future safety requirements and voluntary provided equipment. As the Honda guy brought out, you know, IIHS and well, NCAP -- we got a notice on the street now asking for comments on future NCAP.

So we know that there is going to be a lot of big improvements in terms of NCAP and IIHS. And they are not going to come free in terms of weight. I mean they are going to be either additional structure, additional sensors, additional things on the car. What's that? Oh, sorry.

So like I said, there is no free lunch. Everything costs money.

We also have to look at the potential for the safety impacts of mass reduction. And one of the things here I have at the top of one of the bullets here is the timing and influx of advance crash avoidance. And it's not that we expect crash avoidance to sort of suddenly say okay, it's going to be -- it's going to compensate for, you know, vehicle safety effects from mass reduction.

But one of the things that crash avoidance can do is actually change the relative crash modes. For example, the ESC has done a great job in reducing rollover. So as you look at your safety analysis, you have to also say well, are these crash avoidance technologies changing the relative crash modes? And what is that doing to safety, because the mass effects, safety mass effects, may be different from frontal, side, rear and rollover? So that's something you have to also include. And again, the potential further enhancement for crashworthiness will add mass as well.

Again, some of the more important safety studies. As we talked about periodic reviews, again, I think and I would encourage NHTSA to kind of continue what they have done which is to track the real-world safety benefits. Kahane has often revised and reanalyzed his studies. And as these more mass-reduced vehicles enter the fleet, I think that is going to be ever critical to continue that.

And again, I think the bottom line idea of this is to try to estimate that balance between what is the rate of mass reduction and the potential impact? You know, do you pull the mass reduction lever? If you pull it too fast, too far, I think you could get some significant mass mismatches between the existing fleet and what is coming out in the future. And so I think there is a managed approach to try to bring that down and try to minimize that.

We also just kind of noted that even back as the 2016 -- 2012 to 2016, there were a number of NHTSA studies that talked about -- I think a number of them have been done, but I believe there a couple that haven't -- we haven't seen yet.

So I think a lot of those analyses that were talked about would have benefit even as we go forward further, because this is an issue that never goes away. You are pushing the envelope, these studies will need to be continually done or updated.

One of the recommendations for the Chuck Kahane is that, you know, he did a statistical analysis and he looked at kind of the effect of 100 pound increment. Well, the real-world is not in 100 pound increments and we think that it would be very helpful to try to do some more varied scenario studies that will look at different levels of weight reduction and not necessarily just a 100 pound increment up and down.

Now, with respect to the sort of the non-safety stuff, there are a lot of things that we also think the midterm review or reviews should include and that is sort of the baseline fleet assumptions, because we have noticed that there is a lot of vehicles that already have some of those technologies that are in the baseline of fleet assumption.

They have already been implemented. And again, one of the things that was mentioned was you have to maintain performance objectives. Sometimes it is hard to tell whether you have maintained that, because there are internal standards and I realize that's a problem, but that's one thing that we have to try to do.

There is noise vibration targets and functionality. We also have the whole issue of the lightweight material availability and cost. And I'll cover that a little bit more and also the state of the manufacturing techniques and the assembly processes.

I mean, moving from a steel-centric manufacturing base to something aluminum, carbon fiber or whatever, has its challenges and has a lot of costs and will have lead time involved.

And we also have the whole issues of durability and serviceability. I mean, some of the things like carbon fiber panels, what happens when the vehicle is crashed? How do you repair them? Even aluminum which is fairly well understood, I think there could be some more information brought out to try to help the service industry, the body shop to be able to repair them properly, especially things that are heat treated.

You don't just take a MIG welder and blast in new panel, throw some bondo and call it good. And I think that if we can provide that information to the service industry, hopefully that will help these vehicles get a better reputation out in the real world.

The last thing we want is somebody saying "oh, I don't want an aluminum vehicle. I saw Joe put his in and he couldn't get it fixed." I mean, word of mouth can kill a vehicle very quickly.

Again, we are always looking for the what are the actual midterm fuel economy benefits coming out and are they -- are the predictions panning out? And there is always the field of dreams. You know, build it, they will come. Well, we have built some cars in the past that they didn't come. Those are some classic ones that I'm not going to call out, but you all know those.

So customer acceptance and willingness to pay are key aspects of any kind of a winning or profitable business plan. And so that's something that also needs to be looked into. So you need to be looking at the customer's acceptance of some of these new powertrains. And are they being -- are the customers -- are we getting ahead of the customer too much?

This is kind of a busy chart. It is really kind of -- it touches on a lot of the aspects of mass increase. And really there is kind of -- there is the safety issues of mass increase and you can see some of them here on the chart. And there is also the customer I want, I want more.

And customers are always raising their expectations. And our engineers are working day and night, losing sleep, trying to provide those wonderful, open those Christmas present moments when you get into a car and it's like "oh, wow, this does that. Oh, 16 speakers, oh, you know, 10-way power seats, oh, I can look up. It's almost like a convertible, except I don't get wet or I don't have wind in my ears, because you've got panoramic sun."

So, you know, a lot of these things are now the norm in business in selling cars. You know, once somebody brings this out, everybody is like oh, well, he has got one. "I want that car" and the other manufacturers note that and say, "we are putting it on ours, too."

So there is this ever increasing list of options that we are trying to put in our vehicles. And one of the things that was brought up a little bit about was well, you know, why -- the whole idea of having this one platform and you have these niche vehicles that, unfortunately, because they are niche vehicles, they tend to reduce the kind of flexibility to optimize that design on your core high-volume.

But there is a reason they are niche vehicles because customers have a desire for those. There may not be a lot of customers, but that's your way of satisfying your customers.

And I don't know that we want to go back to the Model T where it is the customer can have everything as long as it's black and a single model. These models have a purpose and they are what differentiate our manufacturers among themselves in this intense competition.

So that is going to be continued, not going to be, it is going to continue to be the norm within our industry. We are just going to have to accommodate that when we deal with our standards and deal with the cost of trying to bring these and optimize our vehicles across those product lines.

The other thing, and unfortunately I had a chart, but it is copyrighted and I haven't got permission to show it yet, but I can explain it, was sort of the relative effect. And this was something that the Honda people brought out, too, and that is when we looked at the baseline vehicle structure since the '80s when the big fuel economy craze came in, the actual baseline basic structure has stayed about the same mass.

What you see is a little bit of increase for emissions. Then a bigger increase for safety. And a big increase for the customer convenience. And we, again, as

I mentioned for the customer convenience, don't see that going down. The customer is greedy. He wants everything and he wants to pay less for it.

And safety is the same way. Safety is now selling. We have got the new IIHS, the new NHTSA and you know, we are putting out crash avoidance technology. And while some people say "well, that's just a software change" all the sensors are not software, so it (A) adds cost, but it also adds a little bit of weight to it.

So those are some of the realities that we are going to have to keep in mind as we go through our midterm reviews.

The other thing is that we are a global manufacturer and, as such, you know, we have to meet vehicles on all these different continents. And one of the things that we have noticed is in the U.S. our fuel economy, global greenhouse gas requirements are based on a footprint basis.

However in Europe, it is normalized to mass, which they are -- kind of don't really match up very well when you are trying to build a car and optimize the car for both markets. So it's a real challenge.

And I'm not saying one is better than the other. I'm not trying to do that, but they are different and it makes for, you know, a real challenge there. That needs to be at least recognized and accommodated as we move forward.

Again, scalability concerns. You know, it is one thing to do something in low-volume. And the low-volume is great because it becomes an incubator for technologies. You see all these whizbang technologies, all this -- it's on the Corvettes. It's on the -- and that's a good thing. That's how it should work.

But scalability -- when you get within a company is one thing, but scalability has an industry and it can -- you know, suddenly everybody decides oh, magnesium is what we are going to do. We need tons of magnesium.

Well, is the supply base ready to scale for that? And so you have to always say "okay, how scalable is this? Can we take these technologies and scale them overnight?" Probably not. We can scale them gradually? Probably. And again, we also have to -- it's one thing to have -- even have the product available. The question is, is the cost able to support the investment? And is it so volatile?

One of the things that this chart shows is sort of the market material price volatility. And you notice the steel and, of course, the big jump is during the recession, a big jump in almost every chart during the recession.

But the idea here being is that you can see steel and it has volatility. We always have to deal with that. We are always

-- but for the material, for the aluminum, it was a lot larger. And so when you are trying to develop a product that you are going to have to be selling quite a bit of you are going to have to meet a power -- a price point and you are trying to predict availability and cost and you have got something that has got a lot of variability in it and volatility, you manage for the worst case and that's what you base your business decisions on.

You don't do an optimistic projection because you will get burned. And so you, basically, and that may be a reason why you might see some of the go-slow take more time on some of these technologies, because the business model says these -- we are not sure about this availability. The cost is an issue and the volatility is an issue.

And those all drive the business models that we all have to run. And the business realities we have to deal with. And again, some of the -- you know, the material challenges, this slide you have all seen a million times.

Again, you know, while the advance high strength steels are very well developed in many areas, just like everything, they are pushing the envelope and with new alloys, new formability techniques. And so as we even push out in the steels, there is a lot we don't know and that's something that needs to be accounted for.

Aluminum. Again, we have the feedstock cost, the manufacturability and some of the improved alloys again are something that we are working on. Magnesium is very similar, except it does have some of the corrosion. It is a little more reactive from a galvanic position standpoint, so you have to do more to protect corrosion and that might limit its applicability in certain areas.

Maybe inside the vehicle interior cocked headlight under the dash, that is probably pretty protected, that's probably not that big of an issue. But in other areas you just can't say "let's just do magnesium since it is so light."

And, of course, carbon fibers have some of the same issues. There is -- fiber cost is the first one. The manufacturing for high-volume, that's the next big deal. We also have some of the predictive modeling issues, recycling and, of course, joining.

So one of the things again within -- with respect to the actual EDAG's FEV, and ICT, we talked about is that again a large number of the suggested solutions are at least partially incorporated in many of the current designs.

Again, some of the proposed mass reductions violate the assumptions that functionality performance or safety should not be degraded. The Honda presentation sort of gave some specifics to that.

And for some proposals, the

performance functionality constraints, we really weren't even sure. We are still trying to get some more information on how they can be really evaluated.

And again, the last point is kind of a key one, because an integrated vehicle solution for a mass reduction is missing a system approach. And this is -- people think of systems as the vehicle systems.

Well, there is a vehicle system. There is a manufacture system. And there is the industry system. And so you might be able to do something on a vehicle system's approach that gives you an answer. When you do it on a manufacture system's approach, you will get a different answer.

Again, you are trying to -- you only have so many engines that -- you can't just scale back your engines to a 1.5-cylinder engine. You are either a one-cylinder, two-cylinder, three-cylinder. You can go back down in displacement, but it's not like you are going to just build a new engine facility.

So you have stair steps, not continuous. So until you can get enough mass reduction that you can go down to the next available engine in your portfolio, assuming that even has the proper characteristics, because sometimes they are high RPM performance engines versus other kind of engines, assuming you can do that, you know, you won't get quite the level of mass reduction that you could on paper, if you are willing to build a dedicated engine for every vehicle design.

And again, the systems approach for the industry kind of keeps up with the is there a supply base? You are going to be making decisions as a manufacturer looking at the total industry and saying okay, is the supply base there to provide these materials? Do they have the volatility that is going to be -- have to be managed for a potential issue?

And so we really have to think in terms of three systems and make sure that we contemplate all of those systems when we make our decisions. And that's it. I'm ready for any questions.

(Applause)

MODERATOR BONANTI: Thank you, Scott.

MR. SCHMIDT: Yes.

MODERATOR BONANTI: Questions, please? Okay. We have a few coming in.

The first question, how much mass has increased in the last 10 years based on different standards and consumer need?

MR. SCHMIDT: I can't show the chart, but I could read off it. Let's see, kilograms to about 1,600 kilograms, so that's 400 kilograms over the span from 1980 to present.

MODERATOR BONANTI: 400 kilograms?

MR. SCHMIDT: According to Steven Zoepf, Masters of Science Thesis MIT 2011.

I've got the citation. I just wasn't able to get copyright to be able to show it.

MODERATOR BONANTI: Okay.

MR. SCHMIDT: This is in -- this chart is in -- also had been shown, I think, in the -- in some of the NES presentations. So if you want the chart, send me an email or a business card and once I get permission, I'm sure we will get permission, it's just the problem is this author had to go through his campus to get permission which takes a while.

So I'm assuming I'll be able to get the chart and maybe we will put in the docket as part of the presentation or I can certainly provide it.

MODERATOR BONANTI: Okay. Thank you. The second question, how do you overcome for material usage in different countries for global models?

MR. SCHMIDT: I think if I had the answer for that, I would make a lot of money. One of the problems we have is, of course, that some of these materials -- some materials are fairly scarce and they are located around the country and not always in the most stable economic region either.

So that probably provides for some volatility. Again, the other part is is that well, what -- you have supply and demand. And it is a chicken and egg. Do you have the factories there? And is the -- if the demand outstrips the factories, your price is going to go up. If the demand drops, then it's somebody -- they over-build factories, the price may go down.

So there is this constant tension between supply and demand, but, you know, I don't have a good answer, because I think our members are grappling with that.

MODERATOR BONANTI: Okay. This is the third question from the same person.

MR. SCHMIDT: Yes.

MODERATOR BONANTI: Despite many of the challenges, how many -- what's the percentage of mass reduction that can be achieved without a big cost impact?

MR. SCHMIDT: That's a very loaded question and a good question. I think we are talking in the time frame. I mean, again, mass reduction is kind of an evolutionary thing. You will notice that people have been putting in more efficient structures as we get better and better at our CAE, our model is more predictive. We are able to put that in.

And so over time, yes, you can provide a level of mass reduction at a reasonable cost rate. The question is when you have to pull that level too fast, too far. And again, you can have safety implications and you have cost implications.

I don't have the number for that slope that said either a zero cost or a low cost line, but I envision there is at least some level of reduction, that's sort of a natural evolution of industry that is probably pretty low cost or no cost.

MODERATOR BONANTI: Okay. Are there any other questions? Yes. Do your members hedge prices of materials?

MR. SCHMIDT: I have no clue. You mean hedge in terms of?

MODERATOR BONANTI: Cost.

MR. SCHMIDT: Cost. I don't know. I know they -- from periods -- well, they do whatever they need to do to try to live in the economic certainty. So I don't have a real answer for that.

MODERATOR BONANTI: Okay. Are there any other questions? Any questions from the web? Okay.

MR. SCHMIDT: Thank you.

MODERATOR BONANTI: More questions? Okay. Thank you, Scott.

MR. SCHMIDT: All right. Thanks.

(Applause)

MODERATOR BONANTI: We have scheduled a break in between and we are definitely ahead of schedule by about 15 minutes. So let's take a 15 minute break at this point. Let's be back at 40 after. Thank you.

(Whereupon, at 2:24 p.m. the proceedings went into recess until 2:43 p.m.)

MODERATOR BONANTI: Okay. I would like to welcome Blake Zuidema from ArcelorMittal. He is going to be talking about the role of body-in-white weight reduction in the attainment of the 2012 to 2025 U.S. EPA, NHTSA fuel economy mandates. So I welcome him.

And, please, if you -- during the discussion, if you have the opportunity to write down some questions, so after the presentation is over I can immediately ask instead of us waiting, because I would really like to, if possible, finish either on time or ahead of time and that will enable us to have a further discussion during the panel session in the afternoon. So thank you. Blake?

MR. ZUIDEMA: Okay. Thanks. What

I would like to do is try to take some of the things that you have heard so far today and put them in a perspective from the steel industry's point. And we all know and I think can stipulate to the really significant challenge we have before us in getting to the 2025 Fuel Economy Regulations.

And as we look at the technologies that will be available for getting us there, it does not really surprise us that weight reduction in a particular body-in-white weight reduction ranks as one of the most important technologies from a magnitude of improvement standpoint.

In fact, if we look at some of the assumptions in the EPA models, it is right up there and, in fact, is surpassed only by things like electrification, battery-electric vehicles, hybrids and the like.

And if you look at body-in-white weight reduction from a cost-per-improvement or improvement-per-dollar standpoint, especially those which come from the steel light-weighting solutions, rank as some of the most cost-effective of all technologies.

So no matter what we do, body-in-white weight reduction has to be a significant part of any fuel economy attainment strategy. So that immediately brings up a number of very important questions for the materials and for steel and are some of the things that we have been trying to answer ourselves.

The most important is how much do you need to get to 54.5 in terms of weight reduction? And can any of these materials really deliver it? And for steel, it is can steel deliver enough body-in-white weight reduction to get the fleet to 54.5?

But that's not the only set of questions. We also have to look at it from a cost standpoint. We also have to look at it from a total lifecycle CO_2 analysis footpoint as well.

So I'm going to try to touch on

each of these as we go through.

When we start to look at weight reduction, you have heard a couple of terms that I really want to stop and just reinforce right now. When we talk about body-in-white weight reduction, there have been two approaches shown here.

The first is a simple 2-G, gauge and grade optimization. That is basically where you go into the body structure and keep the same basic load paths, but then substitute a different material and then redo the gauge to make sure that the material meets all of the requirements. That's what we call the 2-G.

But there is also, as Harry pointed out, a 3-G where we include geometry. And this is where we go back out and start to relook at the load paths to make those more efficient. Why would we do that? Well, in many cases, vehicles evolve over several different design cycles and vehicles can't always have the opportunity to do a clean sheet each time.

As the input requirements change, so do the optimum load paths and after two or three vehicle cycles where we haven't had a chance, there is often a lot of weight that can come from now reoptimizing the load paths.

When the steel industry did the Future Steel Vehicle Program, and in fact just recently we completed the last phase of it, we found that we were able to get from a roughly 2009 baseline, a 29 percent body-in-white weight reduction, and this was achieved through a 3-G optimization.

Now, steel has a number of different grades that are used right now. This represents the grades that were largely shown in the future steel vehicle as well as the three programs you heard about today: The Lotus study, the FEV and the EDAG/Honda Accord study.

And again, these are giving the

kinds of weight reductions you see. But as we move up and to the right on this graph, we are getting more weight reduction, because as we go to the right in higher strength, we can, again, for those parts which are still not stiffness challenged, get additional gauge reduction.

And more importantly, as we go up in formability and particularly as we go up into higher strength, we can now get higher strength into parts that were previously precluded from a formability standpoint. So both of those directions are important for getting more weight.

And this really shows the map of where the steel industry is going right now. It truly is up and to the right and for future reference, the little open circles are grades that we are working on and are going to become available in the next couple of years. The solid ones are the grades that are available right now.

And I just want to talk briefly about an epiphany I had a couple of minutes ago here. When I looked at this chart, it all of a sudden became very clear to me that we have been talking about multi-material solution. And it just occurred to me that steel is already a multi-material solution, because each of the grades that you see here have been through reverse engineering developed specifically for certain parts in the car.

And we, as a steel industry, have gone through many of these loading case requirements and looked at the mechanical properties that require or are required in a part and these grades are the result of that.

For example, you would never use a high strength martensitic product to build a hood outer panel. And for the same reason, you would never use the bake-hardenable steel you use for a hood outer panel to build a B pillar.

The grades of steel we are using for each of those components are specifically engineered for the unique requirements. So steel is already a multi-material solution.

So let's go through a couple of the studies and start with the Venza Phase 1. I looked very closely and as far as I can tell, guys correct me if I'm wrong, this was a 2-G study, gauge and grade. Where, for the low development, the basic structure was retained and new grades were substituted. This achieved a 21 percent vehicle weight reduction. And within the body-in-white itself, about an 18 percent weight reduction, a cost increase for the body, but when looking at the whole vehicle, it was a net decrease.

And when we look at the grades of steel, we are seeing that there was an increase in the amount of the advanced steel grades, but, at this point, it looks like it is probably around a 65 percent or so of the body structure was advanced steel grades and

I didn't do the numbers, but this is probably going to come in around 450 or 500 as the average tensile strength.

So compared to the EDAG study we saw a little bit earlier, again, these applications are on the fairly conservative side in terms of using the advanced grades that are available today. And this chart shows where each of the original Venza grade solutions are.

And again, you can see they are on the lower part of the strength curve of grades that are available right now.

When we look at the Phase 2 study that was done by FEV, we found after going through and now in, what is the word, accommodating all of the various crash requirements and doing the full CAE, their final solution achieved an 18 percent vehicle rate reduction, a little bit lower, and the body-in-white weight reduction was around 13 percent.

One of the things I looked at when you see the grades of steel, they used a little bit higher strength level mix. And this is taking the average tensile strength up a little bit.

So a little bit more aggressive use of the advanced steel grades. And again, in this case, the weight reduction went down because they had to do certain things to meet all of the crashworthy requirements.

Again, looking at the grades that were used, they are all commercially available today. And you can see they are starting to use them out to a little bit higher strength level.

Now, I wanted to look a little bit about the EDAG Honda Accord study. This achieved a 22 percent body-in-white weight reduction in the study itself. And we do have to take into account now the comments from Honda on the practicalities of some of these things, but it was a 22 body-in-white weight reduction, a similar vehicle weight reduction, a small cost penalty for the steel solutions in the body-in-white.

But again, if you look at the grades used by EDAG, they represent a much larger cross-section of the advanced grades available. And you now start to see grades in the above 1,000 MPA UTS and so EDAG here has pushed the envelope a little but further and has gone to an even higher level of average tensile strength.

But again, if you look at the applications of those grades, again, they are grades that are largely commercially available today.

So what I wanted to do is to try to put these things in perspective. And again, realizing that we have 2-G approaches and 3-G approaches, I wanted to show those separately because the 3-G, when geometry comes into play, is providing a little bit larger increment in weight reduction.

So if we look at these, the 2-G approaches are coming in somewhere around 13 up to maybe 18 percent or so. The little, I think it is, purple diamond up there is a 2-G approach, but that was one of the ArcelorMittal S-in Motion solutions where we used both today's as well as emerging grades.

And so we were getting a little bit extra increment in strength from some of the other higher strength, higher formability grades, but again, you can see two batches of data.

So when we try to put those in perspective, we are coming up with three levels of weight reduction attainment. At the lower end of the scale, somewhere around 15 percent plus or minus a couple of percent, we are finding the 2-G solutions where we are just doing grade substitution with today's grades.

A little bit higher than that, somewhere around the 20 percent mark, are the

3-G solutions where now we bring geometry into play or the 2-G solutions if we apply the additional weight we can get with some of the higher strength materials. And then up around the 25 weight percent body-in-white weight reduction we see perhaps some of the more aggressive applications where we are using both the 3-G geometry optimization as well as the emerging steel grades to get the full benefit of that, which can come out of steel.

So this gives us at least now a picture of the level of weight reduction that we can get out of steel.

Now, how much do we need is something that we, as a steel industry, really can't answer. It requires knowledge of the full vehicle integration. This is something that, obviously, the OEMs are working on very, very carefully and it is not something that they discuss outside of their own internal discussions.

And so we had to go to some of the

public domain material to find some models and tools that we could use. Fortunately, there are a number of such models. The EPA has the data visualization tool. They have the ALPHA model, the OMEGA model. Of course, NHTSA has the Volpe model.

And when we looked at each of these, we found the Volpe model to be most suited for our effort to look at the role of weight reduction in the overall scheme of getting to 54.5 miles per gallon.

So we took the Volpe model and now started to put into it some of the weight reductions that we feel we can get from steel and compare those to the weight reductions that we see we are getting from some of the other materials.

And so for the basic weight reduction, we looked at levels ranging from zero up to 50 percent in the body-in-white. And that would reflect the couple of levels of 15 to 25 percent from steel, something around

40 percent, which is around that which we are seeing from some of the aluminum solutions and then, of course, the carbon fiber gives us a little bit more up around 50 percent.

But we also had to look at a number of other key assumptions. I won't go into them in detail. We used a secondary weight compounding of 35 percent and that's lower than the number you saw from Harry, primarily because Harry's included body structure compounding.

In a sense, that is assumed to already be in those preliminary body weight reductions. We can't double count for it. So we are only looking at the secondary from non-body-in-white sources.

We used the weight elasticity of 7 percent, in other words a 7 percent improvement in fuel economy for each 10 percent reduction in vehicle weight and I think that is fairly consistent with the numbers I have heard so far today.

And the other thing I want to point out is we looked at levels of non-body weight reduction because we know the body is not the only place. In fact, many of the studies you saw today looked at weight reductions from non-body-in-white sources.

We went through, trust me Harry, all 500 or so pages of your report and pulled out what we felt are some of the more short-term viable non-body-in-white weight reductions and they added up to about a 7 percent vehicle weight reduction.

But we also know that you can't count on all of that for reasons we have heard today. Maybe consumers want more cup holders. Maybe we are going to have to put sensors in computers for vehicle-to-vehicle connectivity. And most likely, the static safety requirements are going to continue to go up. So we can't account for all of that.

We also -- and I want to say this with all due respect to my EPA and NHTSA colleagues here, we assumed that we may, through some quirk of fate, not get all of the improvements in powertrain technologies that were assumed in some of the initial EPA models.

We don't know the future. They may have been optimistic. There may be other things which prevent us from getting all of that. And if we don't get as much as we think out of the powertrains, that is going to put more pressure on weight reduction. So we had to account for some changes there.

So what we are looking for is a gap. We know that you can get only part way to 54.5 miles per gallon with powertrain technologies. The rest of that is going to have to be made up with weight reduction.

And so what we are looking for are do these weight reductions from the other materials make up that gap or is there something left over?

So we start with the case of all

of the weight coming from the body-in-white. That is the only source of weight reduction. And what we are seeing here are the gaps and the degree to which the 54.5 mile per gallon standard has been met.

Now, a couple of things to point out. First of all, there are two completely unrealistic scenarios here at the lower end of the EPA assumption reductions, because that says no material will close the gap. And in a case like that, the only solution will be to change the regulation.

On the other end of it, with the improvements coming from the EPA, even the steel solutions provided sufficient weight reduction to get the entire fleet to 54.5 miles per gallon without paying fines.

Okay. Now, let's look at the situation where we include the weight reduction from these other sources. This provides additional increment in fuel economy and takes some pressure off of the body-in-white. And again, there is a scenario at the most pessimistic powertrain improvement assumption where no material gets us all the way. This again is considered to be nonrealistic.

But again, with the other levels of powertrain improvement, the steel solutions are providing situations where we are getting the fleet to 54.5 miles per gallon. So there are a number of foreseeable circumstances where steel will provide the necessary weight reduction to get the fleet to 54.5 miles per gallon, but that's not the end of it.

We also know that the other materials will provide an additional increment in weight reduction. And if that additional weight reduction affords the removal of powertrain technologies that had cost more than that material, it could still result in a lower cost vehicle.

But when we go through the calculations, what we find is that in each of the scenarios where steel gets the fleet to 54.5 miles per gallon, it is doing so at a lower cost than if these other lighter-weight materials are being used. So in these cases, steel provides the lower cost solution.

Now, we can't leave without at least mentioning the lifecycle assessment part of all of this. When we talk lifecycle, the first thing that comes up is the as-manufactured footprint. It is fairly well-known that steel is far less carbon-intensive to manufacture than other materials.

In fact, it's about five time less carbon-intensive than aluminum, ten times less than carbon fiber and about 15 times less than magnesium. And what happens is when you build a car out of these materials, the car sitting on the showroom floor before even one mile goes on to it has a larger as-manufactured carbon footprint if you build it out of some of these other materials.

But now here is where the

arguments start. The other materials, in theory, are going to be lighter and therefore provide better fuel economy. And so during the use phase, they are going to be putting out fewer emissions. And over time, depending on the number of miles driven, that benefit is going to offset the initial as-manufactured carbon footprint.

And if you drive the vehicle long enough, it will match or end up with a lower carbon footprint. So there are discussions around how many miles do you drive the vehicle? What is the increment in fuel economy?

There are discussions around recycling credits. Steel inherently is more recyclable because it is magnetic. It is a little bit easier to separate from the mix. We also know that aluminum and other materials are making excellent strides in improving their overall recyclability.

So we can't count on that

advantage forever. But again, there are differences. And we, ArcelorMittal, published a paper last month in SAE that basically showed by the time you account for some of these uncertainties, the relative differences in total carbon footprint are, in many cases, less than the noise introduced by the uncertainty.

So with the uncertainty many times, it is difficult for us to make any statements. So we thought about this a little bit and I would like to try to take some of the uncertainty out of it.

The first is whether or not in 2025 an aluminum or carbon fiber or magnesium vehicle is going to get better fuel economy. And we have looked at this very carefully. If you take a vehicle in steel that is getting its required fuel economy, and you substitute another material, aluminum, it is going to be lighter and that weight reduction is going to give it probably about a 2.5 to 3.5 better mile per gallon fuel economy.

Over 15,000 miles per year that adds up to a $50 per year fuel savings at $4 a gallon gas and $100 a year for $8 a gallon gas.

Now, I don't have exact numbers for the additional cost to the consumer, but I'm pretty sure it is going to cost far more than $100 per vehicle to build these aluminum or magnesium or carbon fiber vehicles.

The point is OEMs have shown many times that consumers will not pay for things where they cannot get a payback in less than a year. And this is a case where yes, these other materials are going to provide better fuel economy, but it's not going to pay the consumer to do it.

What is probably going to happen is the OEMs are going to take away powertrain technologies to bring the cost back in line and vehicles are going to get very close to their 2025 fuel economy target no matter what material we make them out of.

And so realistically, we don't anticipate that there is going to be a big difference in fuel economy in the fleet whether or not they are made out of steel or some of these other materials.

Now, let's look at the other end of it. The recycling phase. There is still uncertainty as to where we are going to be. Right now, there is no major recycling stream for aluminum. That needs to be built up. But again, we recognize that this is going to happen over time.

So when we ran the UCSB and lifecycle analysis models, we assumed the same recycling rates, whether it is steel or aluminum, we wanted to take that uncertainty out. And so when we do that, when we take away the uncertainty, the steel solutions are still providing the lower total lifecycle carbon footprint.

So right now based on this, what

we are finding is that at least according to the Volpe model and the publicly available tools we have at our disposal, the steel solutions are getting us to 54.5 miles per gallon and they are doing that at a lower cost and they are doing that at a lower carbon footprint.

But this is not game over and we are not ready to go to the midterm review. Obviously, there are a lot of other considerations that have to go into this and we, as steel, just as the other materials, are committed to working with the OEM community to try to find the best and most optimum applications of these solutions to get those requirements at the lowest possible cost.

And that brings me to conclusion and I would be happy to answer any questions that come up.

(Applause)

MODERATOR BONANTI: Thank you, Blake. Let's see what we have. You referred to adding weight that would come with sensor components -- computers, sensor computers. If and when cars have sensors to detect other vehicles and other things, isn't it likely that, at that time, the sensor computers will be tiny devices? I'm sorry, I can't read this.

MR. ZUIDEMA: That's okay.

MODERATOR BONANTI: They, basically, --

MR. ZUIDEMA: Yes.

MODERATOR BONANTI: I can't read the last half part of it, but, basically, they are asking: does that impact, do you believe that that is going to impact weight?

MR. ZUIDEMA: Yes, I do, because no matter what, it is going to be a net increase. Between the sensors and the additional computers and other things that go into it, there is going to be a weight gain. We can't ignore the fact that there are other things that are going to add to it and this is just one component.

My point is there is still a lot of opportunity in some of these other non-body-in-white components. And while these weight gains are going to take up some of it, I don't think that is going to take up all of it.

So I think there is a good portion of that additional non-body-in-white weight which is going to find its way to the bottom line of the vehicle.

MODERATOR BONANTI: Next question. How is Arcelor making -- managing steel production for global model vehicles, like Toyota -- like the Toyota Corolla or Honda Accord and others?

MR. ZUIDEMA: Well, we certainly have facilities around the world and of the steel makers, we are probably the most global. We are not everywhere and we recognize we are not everywhere yet. And for those regions where we are not producing certain grades of steel, we have supply arrangements and very good pipelines for exporting from those regions where we do have the capability to make these products.

So I'm not aware of any customer which is going without steel because of local supply problems right now, at least not from ArcelorMittal.

MODERATOR BONANTI: Okay. What are the challenges for high strength materials with lower elongation? Is there an issue with productivity?

MR. ZUIDEMA: No. I'm going to say no, there are not issues. Are productivities lower in the steel mill? Yes, they don't process nearly as fast, but that is taken into account in the overall design and scheduling of the mill.

Are there problems in the manufacturing? No, because those properties have already been accounted for in the selection of the manufacturing processes. And so we are naturally steering these products to things like roll-forming or crash-forming where we don't need the strong formability in more conventional processes.

So this has been a real evolution where the material properties have been looked at from both the design and the manufacturing standpoint to make sure we are using them in the right areas.

And when I said we don't want to use a Martensite to make a hood outer, this is what I'm talking about. We are using Martensite in roll-formed applications where we can account for the lower forming.

MODERATOR BONANTI: Okay. Thank you. What is your projection for high strength and high elongation materials which can be used in normal stamping processes, such as time frame, 5 to 10 years from now or even more?

MR. ZUIDEMA: Within the next 5 years, we are going to have commercialized this third-generation of advanced high strength steels. These are going to provide strengths ranging from 1,000 up to about 1,500 MPa and the target ductilities are ranging from about 30 percent total elongation at the 1,000 MPa level up to about 20 percent at the 1,500 MPa level.

And this is being done entirely to provide for grades which are stampable. And in many cases, they are going to be replacing some of the press-hardening steels. And we are going to be able to get the strength in something which can be stamped by more or less conventional coal stamping processes.

And so I believe those grades are going to be available much sooner than that 5 to 10 years that you are talking about.

MODERATOR BONANTI: Thank you. Has Toyota vetted the Venza Lightweight Project?

MR. ZUIDEMA: I ask you.

MODERATOR BONANTI: No.

MR. ZUIDEMA: Okay.

MODERATOR BONANTI: I don't know why. Okay. Sorry, strike that.

MR. ZUIDEMA: Yes.

MODERATOR BONANTI: Second question. Honda stated the need for milder grades of steel than the high strength steel used in the FEV study due to embrittlement. Can you comment?

MR. ZUIDEMA: Yes. There again are today a number of solutions. One of the-- the first and foremost that struck me was the cracking they were getting in the lower B pillar area. Arcelor Mittal has specifically developed a grade called ductabler, which is used as a laser welded component in a traditional hot stamping process, except the chemistry has been adjusted so that after hot stamping, it provides a level of strength and ductility which is more commensurate with some of the DP 590 grades, and it was done specifically to provide hot stamping components, which provide that level of ductility in areas that are required by the crash.

So there are a number of steel solutions available already today to address some of those challenges.

MODERATOR BONANTI: Okay. The questions keep coming in. The Europeans are regulating emissions at more severe levels than the United States and are now considering even tougher future laws. Are you aware of any interest in Europe in the inclusion of LCA in future regulations, say beyond 2020?

MR. ZUIDEMA: At this point, the Europeans have agreed that it is important to look at total lifecycle. They have decided it is important and will look at it for the rules after 2020, but as of right now, there is no official mandate. They are looking at it. And I think they are seeing lifecycle as something which really needs to be taken into account and slowly the process of working it into the regulations in a means which is fair and equitable to everybody is happening right now.

So they are, I think, already moving in that direction, but from where I see it, there is still a ways to go.

MODERATOR BONANTI: Okay. What is the rate limiting factor for automotive OEMs to implement more advanced high strength steel into the vehicle component content?

MR. ZUIDEMA: It is a problem of both experience and rate of carryover. The more constrained they are, the fewer opportunities they are going to have to do revolutionary new things with advanced grades of steel.

This has been a problem which has been going on for quite some time and we heard philosophy change as one of the requisites. This is one area where we might have to look at those paradigms and rethink how we are building different vehicles off of each other and how we are paring those things to try to find a way to give the designers a little bit more freedom in terms of the application of the grades.

And then the other is experience. And, obviously, nobody is going to use a brand new grade of steel which they have never touched, tasted or smelled. And so getting them into prototype development programs, getting them into at least limited applications is also very important because we need some small successes before we can really start to use it on a wide scale.

MODERATOR BONANTI: Okay. And what are the major cost drivers to producing high strength steels relative to conventional steels?

MR. ZUIDEMA: There aren't significant cost drivers. And the costs go up fairly slowly in terms of the production cost. And in many cases, particularly for cold stampings, our experience is the cost of the steel itself goes up at a slower rate than the weight of the steel goes down. And in many cases, there is a net cost saved to the manufacturer.

MODERATOR BONANTI: Here is a question from the audience, of course. What time frame would you consider for the regulation of material production for greenhouse gases? And does your company support economy-wide cap and trade?

MR. ZUIDEMA: I'm --

MODERATOR BONANTI: I qualified it by saying it came from the audience.

MR. ZUIDEMA: Yes, okay. I'm going to have to decline. And if somebody wants to get with me, I will get them in touch with the appropriate folks in our organization who can comment on the broader aspects of cap and trade.

MODERATOR BONANTI: Okay. For CAFE compliance, NHTSA set constraints on the maximum mass reduction due to the estimates of fatalities and maintaining safety neutrality. In your study, did you relax the constraint to meet 54.5 miles per gallon?

MR. ZUIDEMA: None whatsoever. We are assuming that the safety regulations and safety performance are going to be maintained. Of course, the issue of what happens when mass goes down is going to be addressed tomorrow. And I'm not a safety expert, so I'm not going to comment on that.

But in all of our studies when we do weight reduction, we are always focusing on maintaining parity in terms of the body structure's ability to withstand the crash loads and maintain a safe passenger environment.

MODERATOR BONANTI: Okay. I think this is the last question, unless there is any further questions from anyone. But are the higher lifecycle emissions you estimate for aluminum and other materials unsolvable or inherent in the material or can they be addressed?

MR. ZUIDEMA: To the extent that the free energy formation of aluminum oxide and iron oxide and in certain physical things that I have to profess not even I am an expert are controlling, it is kind of hard to say long-term whether or not there is going to be a closure of that gap.

From what I have seen, it is always going to be more energy-intensive. There are certainly technologies for aluminum which are trying to reduce the CO2 intensity, but I can assure you at the same time, there are programs going on in the steel industry that are focusing on revolutionary new ways to reduce iron ore and iron oxide with much more carbon friendly.

So long-term, I think both materials are going to reduce their manufacturing footprint. And I think ultimately it comes down to the laws of physics as to which one is going to take more carbon.

MODERATOR BONANTI: Okay. Well, thank you. Are there any other questions? No, okay.

(Applause)

MODERATOR BONANTI: Okay. Our next speaker Doug Richman from Kaiser. He is going to be talking about aluminum and the growth and trends associated with it. So thank you.

MR. RICHMAN: Thank you, Chris. Well, the title of this -- by the way, for complete disclosure, although I work for Kaiser Aluminum, I represent Kaiser Aluminum on the Aluminum Association Automotive Transportation Group and I am here representing that group, not Kaiser. Just so we get it all straight here.

And you know, I have been in this industry a while and I've got to tell you, I am -- I have never seen and I don't believe ever in the history of the automobile has this industry ever been as exciting as it is now and will be for the next five years.

We have never been challenged on so many fronts at the same time and we have never had the strong tools and talented people to address those challenges that we have got now. The computers, the science, the advanced materials, this is just a spectacular time for an engineer. And I happen to be an engineer, so it's a great time.

I'm going to talk about how -- the strategy for lighter and safer cars. And Jim actually gave me a great segue this morning when he talked about the statistical analysis looking backward and the paper studies looking forward. And I had never really thought about it that way, but it was a great lead-in, because we look at the statistical studies and that is history.

And history is really important. We need to learn from our own history so we don't make the same mistakes again. And it gives us clues about what we have to address going forward. So I think these studies are great to look at. We have to be careful just how much we try to read into them, because technology marches on every single day in this industry and in most industries.

Every time these engineers come to work, they've got another bright idea and some of them are actually good ideas and they work. So as we look at history, we take the learning that is in it, apply it to the new frontiers we are dealing with and we will get to a new level that we could never have imagined before.

And I was telling Jim at the break, I used to do engine technology. 25 years ago we did forecasting on where engine technology should be for the next generation engines. Horsepower per liter was one of the parameters.

We wondered if 50 horsepower per liter for a naturally aspirated engine was realistic, not question whether we could do it next year. Would it ever be realistic? 75 horsepower per liter today is average in 25 years. And I actually plotted that out, just hear for a minute. I plotted that back to 1902.

Do you know what the horsepower per liter was in 1902? It was 6. 6! We have gone from 6 to over 60 in 100 years. Every year got better. And safety engineering is in the same category as I see it. The engineers are going to get better every year.

Now, I'm going to talk about -- I'm not going to talk any more about history. I'll go forward looking and I wanted to review a couple of the studies which we think are of value. They are independent third-party studies that looked at various aspects of lightweighting and safety.

Some specific to aluminum, some to the general question of lightweighting. And I'm going to talk about first a DRI study.

DRI will be here tomorrow speaking, but a DRI study that was done in -- a few years ago. Talk about some -- because they give us some insight into how to think about safety going forward and because the title of this conference was safety, I thought I would tie it in there.

So now the DRI study was 2008 and the objective was to look at the compatibility question. Now, why compatibility? We have IIHS. We have NHTSA tests. We have European Crash Test Standards. Well, even at that time, the general feeling was that car companies were already pretty darn good at engineering to meet those tests. And the cars are way better from a safety standpoint than they were before engineering focused on these objectives.

Those were achievable, but one question that really bothers a lot of people, engineers and regulators and insurance companies, is the compatibility question, which wasn't clearly addressed in those standardized tests.

So we ran some tests, some studies. I'll show you some data on that or they did, DRI. And really they are dealing with the question of how much energy must be dissipated in a collision? And how do the vehicles decelerate? What is going on inside the vehicles in a compatibility vehicle-to-vehicle type situation, where vehicle weights are different and vehicle sizes are different?

Now, these are paper studies. All of the studies I'm going to be talking about are paper studies. Generally, I think any of us who have actually gone from paper studies to production vehicles -- Honda said from the paper study on that particular vehicle in their set of circumstances, a 50 percent reduction in expectation may be realistic from a mass reduction standpoint.

Depending on the situation, we use 10 to 20 percent. We don't really normally have all the constraints that Honda has to deal with, the International Frontier and the platform separations, multiple platforms.

So somewhere between 10 and 50 percent, but the directionality is what is important, not the absolute values. So the compatibility of cars and trucks, SUVs and the DRI folks simulated 3,500 collisions that were part of the NCAP Pulses Study and NAS descriptors for the collisions.

The metric for collision performance was equivalent life units, ELUs, and so I'm going to show a couple of tables on the ELUs for a series of thousands of simulations that DRI did, particularly looking at SUVs versus lighter SUVs and passenger cars.

Now, this is a very busy chart, but it tries to summarize a very long study in just a couple of charts. I won't kill you with these charts. But what we have got here is the SUV and the driver in the SUV and a driver in the other vehicle and we have a number of crashes.

One important takeaway is when people -- when I talk to people about safety, and safety professionals, there is normally a particular collision that comes to mind and it is usually the vehicle-to-vehicle.

But really when we look at the whole spectrum of typical accidents in the marketplace throughout -- this is North American cross-section of 3,500 sampled accidents, vehicle-to-vehicle is certainly a large part of it, but rollover accidents, hitting objects, hitting passenger cars, we kind of hit about everything that is out there.

The car-to-car is an important one. And we have looked at the car-to-car or vehicle-to-vehicle. PC is passenger car and LTV is light truck and van. And then we have the SUV and the driver, number of cases. This is the baseline data from the initial survey.

Now what DRI did was they created models of these various platforms. So they have a baseline vehicle and fundamentally the baseline societal impact for these collisions in the standard fleet, call it 86 ELUs just as an index.

They then reduced the weight of the SUV and they reduced the weight by 20 percent. It was just an estimate of what might be achievable with lightweighting technologies as it was viewed in 2008. And the overall societal impact of reducing the heavy vehicle weight was a reduction of about 28 percent. This is the percentages over here.

So the lightweight vehicle reduced injuries in the total fleet by 28 percent, although, the driver of the SUV, when it hit a passenger car, was actually at a disadvantage. The driver in the lighter vehicle was at a disadvantage. The rest of society was ahead by 28 percent.

Now, they then took that same vehicle and re-engineered it to make it longer by 4 inches and added 30 pounds to the vehicle for the 4 inches that were added. When they did that, virtually all of the configurations got better. All of the collision experiences got better.

24 percent overall societal impact improvement without any deterioration for any individual configuration of accident. Encouraging. It says that mass reduction can be done, I think I wrote that, I have stepped through this already, and reduce equivalent life units in the fleet.

Mass reduction at 20 percent, 28 percent, reduced the struck vehicle ELUs by 61 percent. If you are in the lighter vehicle being hit by the other vehicle and it is lighter, we are all better off for that. And that's where the gains go.

And there was some increase in ELUs for the driver of the lightweighted vehicle. By increasing the length, this is design. This is the design part. Increasing the crush space and managing the energy in the collision reduced the fleet by 24 percent, it reduced the long vehicle driver by 10 percent and the target vehicle by 33 percent. A win-win for everybody. Okay. That's the DRI study.

Now, a few years ago, 2010, the Institute of Automotive Engineering at Aachen University did a study on a European midsize passenger car to see what could be done on mass reduction with the constraint that, to the best of their modeling capability, would have equivalent -- indexed equivalent performance on safety.

And they looked at -- they wanted to understand the feasibility with steel and with aluminum for the autobody. Now, this was just the body. It wasn't like Harry and the FEV study with a total vehicle. It's just looking at what could be done in reducing the body.

And they did a modeling exercise and they classified each body component as stiffness-dependent or strength-dependent in a collision environment, also for NVH. And as most everybody in this room knows, probably better than I, that body engineering is the balancing act between NVH expectations and collision expectations.

So they did both, looked at stiffness-dependency and strength-dependency of every element or group of elements in the vehicle. I'll show that in a minute. And they looked at high strength steels.

Now, the vehicle they started with was a comprehensive European -- it was actually a spin-off of the Ultralight European Vehicle Study, if you are familiar with that. And it had about a comprehensive use of advanced steels for 2010. I think it was around 45 percent early advanced steels.

They broke the body into 26

subsystems, looked at each subsystem in detail, calibrated the models to actual -- to an actual body structure performance for torsional stiffness, bending, tried to do a decent -- and I think they did a reasonable job of calibrating the models to reality -- to the reality of the body from a stiffness standpoint, modeling, number of collision environments, FMVSS 301, rear crash, NCAP side.

They classified and came up with an index for each body component on which components would gain from use of advanced high strength steels. They would have weight reduction potential with high strength steels, which ones would have weight reduction potential with aluminum.

This is the rank order and all the parts didn't gain with aluminum and all the parts didn't gain with steel.

The key finding was that in their study to the limit of their modeling capability, their conclusion was NVH and safety parameters seem to be achievable with either lightweight strategy, steel or aluminum, both could be met.

Strength was not the limiting factor on a majority of the mass of the vehicle. And the maximum optimizations study for the steel vehicle, they achieved with steel grades up to 1,200 MPa, about an 11 percent reduction in body mass. Now, that's body-in-white and the closures.

The aluminum study on all aluminum or aluminum -- it was actually all aluminum in this study achieved about a 40 percent reduction in mass. And they felt that, again, to the extent of their modeling, these would be technically feasible.

The practical sense is that at least a 10 percent reduction in those numbers would be a more realistic number and perhaps with a lot of real-world constraints, it could be half of that to the Honda example.

Okay. The studies that were done by Lotus and FEV and EDAG, in my opinion, are just outstanding pieces of work. They are not absolute. They are paper studies, but they are really outstanding pieces of work and they give us again a sense of direction for what might be achievable.

It is not proof that anything is achievable, but what might be achievable. And that's what we need to keep in front of us, I think.

So this is the SUV, midsize SUV study. And I wanted to show this chart because it kind of says why do we look at -- why do we want to look at the body or can we look at something else and get our -- get the mass reduction objectives met?

Well, this bar chart the absolute height of each of these bars is the distribution of mass of that original vehicle. And what we find out is the body-in-white plus closures is a little over 30 percent of the total curb weight of the vehicle. Throw in the interior and we get over 50 percent of the -- now, when I say interior, that includes the seating, the cross-car beam for the IP, the full structure as well as the trim. The combination is over 50 percent of the total weight of the vehicle.

If we are going to get significant mass reduction on these vehicles, we can't not do the body. In fact, well, I think Babyface Nelson said "Why rob banks? Because that's where the money is." Why the body? Because that's where the weight is.

You could -- if we wanted a 20 percent mass reduction, we could take the entire engine out of the vehicle and not achieve our objective. So we have to look at the body. We don't have any choice, but it's a great opportunity.

The findings in general and we have heard summarized, I'm really delighted that my predecessors already covered these.

I don't have to explain these studies again, so that's great. I'll just give you my rehash on the findings.

The crossover SUV was about an 18 percent and we call that, I call that, the MMV Solution. Not only is it multiple steel grades, as Blake talked about, but that vehicle had aluminum fenders, deck and hood. So it's a mix. It's a multi-material. And I think this industry has been talking the solution is a multi-material solution. In fact, it's always been a multi-material solution.

18 percent of the vehicle mass was achieved -- reduction was achieved. Advanced steels for the body-in-white achieved about a 14 percent, total body mass about 14 percent, aluminum we'll use for closures, but a big area that the aluminum was deployed and in the body discussions, we kind of overlooked some of the other areas, a lot of applications in the chassis.

And we heard about them from Harry and other discussions, suspensions, control arms, brake calipers, estimated cost, argue about it. I can't stand behind the number. The team that did the work says it is a cost savings. I think Honda sort of says well, maybe in a perfect world, but the reality is it probably costs something.

Our position is mass reduction generally costs something. It doesn't come for free. If it did, Honda and GM would already have done it. Okay.

Now, we took that study and you saw that these models were heavily calibrated, very, very thorough, very detailed analysis, probably as good as anybody outside of an OEM engineering department can do. And we said, okay, we have got now an MMV study and we have an assessment under a certain set of guidelines about what the mass reduction could be for a vehicle that, on paper, has the potential to meet the safety objectives.

We then went to the EDAG, in this case, and said we would like to take that exact model with the same modeling assumptions and the same structure, no change in structure and see what it does as an aluminum-intensive vehicle.

The same set of guidelines, same vehicle, same objective, must meet the safety requirements, everything is the same as the original study. Technique, you have heard about it, but the baseline vehicle was calibrated, as we saw, converted to an aluminum design, the initial concept evaluated for NVH and collision iterative process and coming up with a full aluminum design that met, essentially, all the objectives of the lightweight steel design.

Interestingly, and I will come back to this in a minute why this is interesting, it wound up that because of the sections that were involved, and in cases of aluminum we had some thicker walls and things, the design in almost all NVH criteria except -- in fact in all of them was actually stiffer than the steel-bodied vehicle it replaced in the models.

Generally, that was traced back to wall thicknesses. It is stiffer. That is going to be important in a second.

We ran the collision models or they did for deformations to see about the classic index of safety performance. Of course, the intrusion, the amount of the intrusion and also G-forces. This happens to be a picture of the front end on a -- this is a 35 mile barrier and this is -- the top view is the steel vehicle. The highlighted areas are the intrusion mounts.

And, in fact, the steel vehicle actually had higher intrusions than the aluminum, basically triggered back by the increased stiffness in front of the cab. A little red light went on and said well, if it has got less intrusion and it is stiffer, what is that doing to G-forces?

This is the side view of the same collision. Less deformation, slightly less, but quite a bit less deformation throughout the front of the vehicle compared to the aluminum vehicle.

A red flag went up looking at the acceleration or these are the force curves. We see significant differences. The 001, the blue line, is the original vehicle. The red is the lightweight, the steel or the aluminum-intensive vehicle, it's all aluminum. Now, when I say all aluminum, by the way, we wound up using high strength steel for the door beam and reinforced the A pillar. It is a multi-material solution.

Higher loads, higher forces in the initial -- these are along the length of the front beam. We looked at the -- so the findings. An aluminum-intensive crossover vehicle appears capable of meeting all of the functional objectives and safety objectives.

That study concluded a 28 percent reduction in total vehicle mass.

And what we did here or they did was take all of the weight savings in the rest of the vehicle and applied it to the aluminum-intensive vehicle. So if you went up from 28 percent total vehicle, body mass reduction 39 percent, almost exactly what the Aachen study said. Cost impact, net cost after corrections for the secondary mass reductions $534 premium.

But as I stated in the outset of this discussion, the real story on safety, at least the one we have been looking at, is the compatibility question, vehicle-to-vehicle compatibility.

So we had this and we had a little concern when we saw that we were stiffer and we had less deformation in front of the vehicle, so we ran some offset frontal collisions. This was the base vehicle offset frontal. This is the aluminum-intensive

vehicle.

The red again is the penetration, dash panel intrusion. And again, same story, less intrusion in the aluminum vehicle than in the steel vehicle.

This was the chart that convinced us engineering needs to now step in. This is again the structure was not changed from the parent vehicle. What we have got here is a velocity curve of the original vehicle and the velocity curve of the lightweight vehicle.

The lightweight vehicle's time to zero was 20 percent shorter than the heavier vehicle. We have the G-forces. The standard vehicle, the lightweight vehicle. Substantially higher G-forces. What that told us was for this structure, for this lightweight aluminum-intensive concept to be viable, it must be re-engineered to remanage the energy. It needs to be softened.

And the DRI work said adding 4 inches had a substantial improvement in the safety performance of their predicted safety performance for the vehicle. We stopped at this point, but the offsetting story here is we have done some preliminary look at this and it does seem technically feasible to re-engineer the front end of this vehicle to increase the crush space, soften it up and bring down -- actually lengthen the stopping distance, the time to zero speed and reduce the G-forces inside the cab.

Now, so the conclusion is just taking the weight out without re-engineering when we take substantial chunks of weight out would not be an overall significant strategy.

Now, this distribution of the -- how am I doing on time? I'm over? Okay. I'll fast-forward here.

Key findings. Floor plan intrusion was reduced. Velocity and accelerations, the AIV concept had more severe deceleration and potentially higher occupant loading. The increased structural stiffness is the -- was the result and we need to put in higher energy absorption capacity.

And the final conclusions to this discussion, vehicle design, not mass, is the key to collision performance. That's our opinion. Reduce mass body structures with equal or superior collision performance appear feasible. We by no means have the definitive answer here, but they are not out of the question based on these studies.

Potential mass reductions based on the three studies I talked about, advanced high strength steels from today's baseline technology about 10 to 12 percent reduction in mass.

Now, these are the theoreticals. And if the practical constraints of multi-platform, multi-national production and business strategies and investment capital constrain that, these will go down from 10, 20 to 50 percent of these numbers.

Multi-material optimization, 12 to

16 percent mass reduction, theoretical. Steel, advanced high strength steel, aluminum, magnesium are the candidates. Aluminum-intensive vehicle 24 to 28 percent. This is body mass, not vehicle.

But what is the future? Mass reduction is not a single point problem. It is a multiple problem and it is different for each manufacturer, each vehicle configuration and each market that is being served. What do we think is going to happen? There will be a mix. The mix is likely. There will be advanced high strength steels, particularly in the price critical segments of the market that may require some downsizing. May.

There will be multi-material vehicles and unlike Blake's this is the one with aluminum and steel. This is not the three different steels. The size, where size and cost are, both need to be optimized. There may be some moderate downsizing in there. And there will be aluminum-intensive vehicles serving certain segments of the market where downsizing is just not consistent with the overall objective of the vehicle. Thank you.

(Applause)

MODERATOR BONANTI: Thank you, Doug. Questions? I have several. Okay. Okay. The first question. Aluminum costs fluctuate 100 to 180 percent based on commodity indexes. On the other hand, automotive industry has tight budgets for vehicles. What are your thoughts on this?

MR. RICHMAN: Well, I have not seen 100 or 180 percent, so that's, I mean, kind of a loaded question. But there is -- it's a commodity like all other metals and it does fluctuate. It is managed. It is quite well-managed. It has been -- we have, you know, 22 billion pounds of aluminum going into the marketplace today and it's managed just like any other commodity.

I'm not in the trading side of the

business, so most of the -- I heard the comment about manufacturers must do their planning on the peak price. They have to protect for the peak, but they usually -- my experience is they have been doing it based on averages.

The long run average rather than the short run, because usually when it spikes up, not too long after that, it goes back down the other way and then finds an equilibrium point. Most of the work I have seen for the last over 20 years has more often at kind of a long run average. So I don't know if that's the right answer for what you are asking.

MODERATOR BONANTI: I'm just asking the questions. Okay. Next question. What was the crush zone distance for the crash models that you show in your presentation?

MR. RICHMAN: The baseline?

MODERATOR BONANTI: I believe so.

MR. RICHMAN: I don't know. Not off hand. I mean, there is -- I don't know what the actual crush -- I mean, it's the whole front end. There wasn't a designated space in the original vehicle that I know of that was -- maybe, Harry, do you know?

MR. SINGH: It should be about 650 millimeters --

MODERATOR BONANTI: You are saying 670?

MR. SINGH: 650.

MODERATOR BONANTI: 650 millimeters. And that's the whole front?

MR. SINGH: Yes.

MODERATOR BONANTI: The whole front. All right.

MR. SINGH: The crush distance in front.

MODERATOR BONANTI: Okay. That's the whole front. Yes, okay.

MR. RICHMAN: We added 4 inches with nothing. You know, with nothing on -- no neighbors inside, you know.

MODERATOR BONANTI: Okay. What is

the rate limiting factor for more aluminum to be used in BIW construction? Body-in-white construction, I guess.

MR. RICHMAN: I think it's the practical need and the evolution of platforms as they -- platforms that need to be an aluminum body intensive -- aluminum-intensive body. It's not every platform. It's going to be a multi-material approach for most vehicles.

We are not limited on availability and material. It is mostly the need of the OEMs to have that type of product in their portfolio and the time it takes them to bring it to market.

MODERATOR BONANTI: Okay. Next question. Your results seem to violate the conservation of momentum and energy. How is this explained?

MR. RICHMAN: I like that question. I actually do. If you noticed -- I didn't point it out and maybe I should have, but the -- in that -- when I showed that chart, if you noticed the zero velocity, we are not violating any conservation momentum. The red line, the velocity goes negative. The lighter-weight vehicle gets pushed back. It does.

But what the -- but the first order conservation of momentum fails to recognize what all of those safety engineers all over the world have been working on. How many years ago would you have said no way when somebody said you can drive your car at 35 miles into a wall and walk away? Conservation of momentum says you are dead, but you can do it today.

The safety systems, the ability to absorb energy in the structure are the difference. That vehicle does -- it gets pushed back. The heavier vehicle doesn't. It keeps going forward. The lighter vehicle bounces back a little.

The heavier vehicle gets pushed

back quite a bit. The G-forces went up. It is all accounted for. The energy is totally accounted for. Our objective is to consume the energy in the structure, in the crush zone, not in the cab, but it's there.

MODERATOR BONANTI: Okay. We can get your engineering question. Aluminum is very energy-intensive with a huge influx of cheap reliable natural gas. Do you expect aluminum prices to stabilize or remain low?

MR. RICHMAN: Well, there are two elements to that very important question. Aluminum is 95 percent recycled. I mean, repeat that because there was maybe some other image here. Aluminum in automotive is 95 percent recycled. There is no loss of properties. There is no degradation.

Now, primary aluminum is energy-intensive, but the real energy content and the products that go into an automobile are 95 percent recycled, which has the same energy content as other recycled metals and ferrous metals particularly. So at an energy balance, it's about the same.

Now, do I expect the price of aluminum to change with the price of gas? It's a commodity. I don't know that they are related. This is not -- commodities are not a cost plus business anywhere on earth and not in this particular -- I didn't see gold come down when gas prices went down. It's just a commodity. I am not a speculator. I'm not a commodity broker.

MODERATOR BONANTI: Okay. What is the effect of the aluminum-intensive vehicle weight reduction on the collision parameter in delta v? Yes, partner. Sorry, collision partner in delta v?

MR. RICHMAN: Well, this is the lightweight vehicle, 20 percent mass reduction was quite a bit of mass reduction. This is a full weight vehicle hitting a lightweight vehicle or a lightweight vehicle hitting a head-on collision.

So there is a collision partner issue, but again, these are not -- this aluminum -- the lightweight structure was not fully engineered to absorb the energy. This told us it has to be. The take-away from this is it has to be. And we haven't got that model, but I believe we, as engineers, will figure out how to manage that energy very efficiently.

The folks at Honda will know how to do it. I won't know how to do it. The folks at GM, the folks at Daimler, they will know how to do it eventually. Maybe right now. So we don't know the answer in a truly engineered lightweight vehicle.

What we do know is that aluminum-intensive vehicles that are in the marketplace today, there is three of them and we all heard about them, every one of them has a higher safety rating than the vehicle it replaced. Every single one of them.

Every time somebody has actually

gone to production with aluminum-intensive total vehicle concept, it has had higher safety ratings than the heavier vehicle it replaced.

MODERATOR BONANTI: Okay. Well, thank you, Doug. That's all the time we have for today, outside of this afternoon's panel.

(Applause)

MODERATOR BONANTI: If you could bear with us for a second, we are going to be trying to get Jackie Rehkopf on the telephone. She is going to be giving a presentation via telephone, because she is currently predisposed and in the hospital.

So but she still wants to give her presentation, so bear with us a few minutes. Okay. Jackie?

MS. REHKOPF: Yes, can you hear me?

MODERATOR BONANTI: Yes, we can hear you, Jackie.

MS. REHKOPF: It's working very

well.

MODERATOR BONANTI: Great. Jackie, if you have the opportunity, please, speak a little louder, so everyone can hear you. Thank you.

MS. REHKOPF: Okay. Is that loud enough now?

MODERATOR BONANTI: Yes.

MS. REHKOPF: Okay. First of all, I want to apologize for not being able to be there in person, but I do want to thank, you know, Chris and Lixin, for working out the technical aspects to allow me to present remotely.

So, you know, if I'm not speaking loud enough, somebody just yell out and I'll try to up my volume a little bit and with that I'll just start.

And I would like to sort of spend a bit of time talking about the feasibility and likelihood of carbon fiber composites entering mainstream automotive. I'll give you a little outline introducing Plasan Carbon Composites because I don't expect everybody is familiar with us.

I'll outline some opportunities for carbon fiber reinforced plastic in mainstream automotive and our viewpoint of what requirements there are to have efficient production of carbon fiber composites for the auto industry specifically.

We will also talk about the evolution going from the NHTSA use of carbon fiber composites into mainstream developed through advances in our technology and our business development.

Plasan Carbon Composites is one of several companies owned by Plasan Sasa which is based in Israel. It is a well-renowned military company that does work in armor protection, both for military vehicles and personal protection.

And we are a company that only does carbon fiber composites and with only for the automotive industry, not for the other military or marine industries. We have got the partner companies that are doing that.

We do leverage the research and development capabilities across the companies, so expertise say in the high rate performance of composites in ballistics we can translate some of that knowledge and expertise into automotive crash performance.

Okay. Plasan Carbon Composites has two Michigan facilities. We have a customer development center in Wixom. It is 24,000 square feet with half of it being manufacturing space that allows us to have a scale-up facility for new technologies.

So the equipment we have on-site there is exactly the same as what we had at our manufacturing plants, so it is production representative. Our customers can come on-site and see first runs or prototype parts being developed very hands-on.

We have our new manufacturing

facility in Walker, Michigan, which is almost 200,000 square feet and it was developed with some very nice incentives from the Michigan Economic Development Corporation. The parent company invested over $20 million in capital investments and last year and going into the next year, we will create over 200 new jobs in the community.

This facility is geared strictly to mid- and high-volume production for the automotive industry. It incorporates our new manufacturing methods and the processing breakthroughs that Plasan has developed.

Those breakthroughs are currently, today, supporting 30,000 to 50,000 vehicles per year and the future development that we have got underway are targeted to reach that 100,000 units per year. So we think it is very amenable to what the automotive OEMs are in need of and so we are on target to meet their needs.

Most of us, if you do know us, are

probably familiar with us in more of a niche market. We were the provider of the hood, fender, roof, roof bow covers, rockers and splitters on the specialty models of the Corvette ZR1 and ZR6. And we are also providing the hood/fender assembly, the roof assembly and lift gate assembly of the 2013 FRT Viper.

The carbon fiber components reduced the car weight by 100 pounds from the previous model and 44 percent of the exterior components are in carbon fiber composites.

We see great opportunities for carbon fibers to be used in mid-volume vehicles to help with light-weighting goals that the North American fleet is on target to achieve. We have kind of stayed at the main drivers for the evolution going on in the automotive industry are led both by Government and the consumer.

We have got those CAFE Regulations that we all know about and also the Energy

Independence Initiatives. The consumers are also concerned about the high gasoline prices and environmental concerns.

Carbon fiber addresses only one of the main vehicle aspects that will be to improve fuel economy and better environmental emissions. We are basically focused on the mass reduction. We are not involved in better propulsion systems or aerodynamics, unless it is through styling. But carbon fiber does offer great opportunities for mass reduction.

Okay. It's common knowledge amongst everybody in the audience, you know, the lower density, the high specific strengths to weight ratio that carbon fiber has compared to the other light-weighting technologies.

It offers excellent corrosion resistance as well as good thermal and moisture stability, good NVH characteristics, not always improved, but often times improved, great design flexibility, part consolidation, fairly shortly times because of different capital investment that is required and fairly low capital costs compared to some of the other technologies.

The consumers also benefit, however, for example, the vehicle that has a roof replaced from a metal to a carbon fiber roof will experience usually improved structural rigidity and that will be felt by the consumer in terms of improved vehicle dynamics and handling.

Having a lighter weight on certain components such as the roof or the hood will also lower that center of gravity improving the vehicle dynamics and improving that power to weight ratio.

We are looking at the market segment where we see a need for significant weight reduction, both in the hybrid vehicles and the crossover vehicles. The hybrids, obviously, because of the battery pack and the then the crossover vehicles because of a larger vehicle size, but we do see those as very strong opportunities for us to enter mainstream automotive.

Okay. Just a little history on how carbon fiber composites entered into automotive. It was obviously an offshoot from aerospace using the autoclave process. And the autoclave process does have some very good attributes, one of them being it produces very high quality parts, very good structural integrity.

Limitations, however, are that it has a very slow cure cycle. It is very thermally inefficient, very energy-intensive. It requires a nitrogen atmosphere to do your curing. It is very labor-intensive and only supports low-volume, so it's not at all amenable to the automotive industry for mainstream.

Plasan views a few key requirements to efficiently get carbon fiber composites into mainstream and that is, basically, a target around 50,000 units or greater per year. We look at cost in terms of a system cost and I'll touch on that a little bit more later, but, basically, we have a rule of thumb that, you know, it shouldn't be more than 3 to 4 times the cost of a lightweight metal. And then the other cost factors like capital investment can come into play.

Obviously, the high surface quality, high structural integrity, low void content are very key to entering mainstream automotive. You have got to have that repeatability and reliability in the integrity of your material system.

And you also need to be able to readily fasten the composites to other components on the vehicle. And that's a huge issue for the industry in terms of joining dissimilar materials. Okay.

Just taking a step back at what we view as a good market segment, it's that mid-volume range where you are looking at somewhere between 50,000 to 100,000 units per year. And I just highlighted some of the brands that are out there in that target range. You have got the Chevy Camaro, Ford Taurus, Dodge Journey, the Mazda 6. It is quite a large segment and that's the market that we are after.

We are not trying to hit in the first step that 200,000 vehicles per year class. We think there is lots of opportunities to start cascading carbon fiber components into the 30, 50, 75,000 units per year and there are quite a few nameplates that are in that range, as you can see from this chart.

So for the target such as volume, Plasan developed a new technology. We call it a pressure press technology, which unfortunately is a bit of a misnomer. It is not run under high-pressure. It is only 150 psi and it's not a press. So we apologize for the name, but that's kind of what stuck with us.

What we have done with the technology is reduced the cycle time about 75 percent from the conventional autoclave technology. The pressure press technology is amenable to both Class A, which is Plasan's forte, as well as structural parts.

It has got the capability of being a one-coat-primed quality surface. It can hit production volumes right now of 30,000 per year. It will reach 100,000 per year with multiple tool sets and some other advancements in the entire production cycle, which I'll touch on.

And we are doing further development, obviously, to continue to reduce that cycle time, but right now as it stands in the technology that we are launching this year, we have a faster cycle and an improved circuit quality.

As it stands today, our cycle time is below 20 minutes and it is a balanced cycle, meaning that there is no step within our entire part production cycle that is greater than 20 minutes.

It doesn't look too different from a convention autoclave cycle where you start with a kit cut stage. Plasan is currently working with prepreg carbon fiber, so our parts are, you know, a stack-up of a particular laminate structure.

So we start with a kit cut. We do our layup. Instead of going into an autoclave, we go into our pressure press and then it goes through trim and finishing operations. And we keep all of those steps balanced so that it just is a continuous flow and no step is greater than 20 minutes.

So any time we reduce one of those steps, say we want to improve the technology on the resin chemistry to reduce the cycle time in the press, we would also reduce the time in any of the other stations.

For the mid- to high-volume automotive applications, we have taken the same material system that we used in the autoclave parts. So on the high-end Corvettes and we have taken that material system, process it under a pressure press technology, which is less than 20 minutes per cycle and we have the same end mechanical and physical properties of the material system.

This was a great strategy that Plasan developed in order to get the material system qualified, based on just a simple change in the processing side of it and not also a change in the material system. We will continue to make advances in the overall cycle by improving the material system, the resin chemistry and things like that and that would require a different qualification, but we took the first step at only, you know, changing the process and not the material at the same time.

The economies that we have from our pressure press technology are pretty great, we think. In terms of energy, we are using about half the energy that the autoclave process would use. Our parts are made using a single-sided tool, so we have got consumables for the vacuum side and we have reduced the consumables down to a third of what were used on the autoclave.

In terms of labor, we are running at about two-thirds of the labor costs for the autoclave technology. And when it comes to tool transfer and part teardown, we have got huge savings. Our tool transfer time is about 10 percent of what it was for the autoclave technology and our part teardown is about a quarter of what it was for the conventional autoclave.

So from a business perspective, we have got great economies to go to the OEMs with this technology and say it is very amenable to the mid- to high-volume vehicles.

We link our technology development very closely with business development, so we have got, you know, our near-term technology and business developments. We have got our long-term and our medium-term where we are looking at different things from either the current pressure press cycle or RTM for our structural components, that's an area that Plasan is getting into for both thermal sets and thermoplastics.

In the medium-term looking at cutting down the cycle time of our pressure press down to seven minutes, and that would be through new resin chemistry, also looking at thermoplastic two minute cycles, which is then targeting closer to the 100,000 vehicle per year and also the structural and semi-structural components that are needed for the body-in-white applications.

In the long-term, we have got business and technology paths to be looking at alternative-based carbon fibers, besides the pan-based, so we are looking at the lower cost carbon fibers that there is a lot of activity on with the National Labs and other companies and also looking at different resin chemistry, epoxies, urethanes, thermoplastics, that type of thing.

But we don't do any technology development without its partnered business development in step with it. In order to reach sort of the higher volume, the 100,000 and above vehicle per year, the technology developments that we will have to achieve are advances in the mold tooling to reduce the cycle time.

With our current pressure press process, we use a highly engineered tool. It has got a nickel shell surface to improve the heat transfer right from the tool to the composite and it is also plumbed on the back side to have a heat transfer fluid that is used for both for heating and cooling that tool, so you get very quick heat transfer into the composites.

But in order to get up to the 100,000, we would have to improve some of the materials that are used for the plumbing and for that heat transfer. We are looking at laser placement and we are already currently using that on one of our programs and that helps us to control the localized thickness variation, so you have an optimized layup, but you are also having very repeatable well-documented control of that particular layup.

Water jet trimming will be needed to trim the parts to have a balanced process flow. Our current programs that we have with the Corvette and the Viper don't warrant water jet trimming yet, but the next step up in terms of volume will require some automated trimming.

Likewise, we will need automated tape lay once we get to a slightly higher program volume. The advanced resin development is needed for a faster cure time. And automated etching for the paint preparation, which will greatly speed up that final finishing touch.

And then getting into the

structural side of things with the RTM molding and the preforming, there is a lot of work to do with partner companies on developing quicker preforms and very high-cycle RTM molding operations.

On the business side, we are very focused on just-in-time material supply. We are trying to reduce that time and the distance from the source of our carbon fiber, either preform or prepreg, from that source to our manufacturing locations.

We are also wanting to minimize the supply risk, so we do work with multiple material suppliers and qualify multiple sources, but not too many, because with the advances that are going on with carbon fiber these days, there is a phenomenal movement going on right now. I'm very excited to be part of it, but you can't be latched on to every development that is underway.

So we pick and choose, you know, a few strategic partners and we work with them and qualify those material sources, so that we minimize the risk to our customers.

Plasan is also going to continue leading the qualification advancement that our technology has developed. We have been leading the qualification process already with our customers and we will continue to do that.

Our view is that as the carbon fiber fabricator and provider of these components, we should have the best knowledge about their performance and their reliability and their quality. So we will continue to lead the qualification on those.

And, obviously, to meet our customers' demands, we will be expanding our manufacturing processes into RTM and other things as well as expanding our material portfolios. This is not a one-size-fits-all for any family of materials, you know, whether it is aluminum, advanced high strength steel, magnesium, carbon fiber, and even within any one of those lightweight options, such as carbon fiber, there is not a one-size-fits-all. So we need to have a portfolio to offer our customers, so they can pick the best system for their particular application.

And then another point to touch on a little bit in depth is the design and analysis tools for composites, for carbon fiber specifically. We are working heavily on that independently as well as with some other companies to improve the design analysis capabilities for carbon fiber, so that we can work with our OEMs and have proper design.

Cascading our technology from the niche to the mainstream is what we are doing currently. We have taken some of the technology from the Viper hood assembly. The Viper hood is basically a hood/fender combination, a single piece very large complex clamshell geometry and to our knowledge it's the largest single piece, carbon fiber composite that -- on a vehicle that is sold by a mainstream OEM.

So we had a lot of technology development in order to manufacture a part that size. We also developed a textured surface on the B side of the outer panel, we thought, exposed with inner panels, integrated mounting points and it meets all the structural requirements through some local section thicknesses and layup changes.

On the roof assembly of the Viper, the roof assembly is a key structural component of that vehicle. It does meet roof crush, so there are some very local layup thicknesses and orientations that are, you know, tuned specifically to meet various requirements of that part, structurally and otherwise.

And our CAE tools were very useful in permitting us to develop the kits and work instructions before the tools actually arrived. And using our CAD-driven laser placement system ensures very accurate layups. That is shown on the picture on the right hand side where the laser sort of outlines the piece of the kit that needs to be placed in that particular location and it guides the operator through to making sure that the right piece is put in the right place in the right sequence.

So our strategy is to engage and collaborate with our OEMs very early in the design stage, that way you can have a hope of combining several of the advantages of carbon fiber not just its reduced mass and increased stiffness or strength, but also part consolidation, design flexibility. In some cases, some safety improvements.

We have found the pedestrian impact can really benefit from a carbon fiber composite design. And at times, there is an improvement in NVH. There is always definitely a change in NVH performance, so it needs to be assessed whether it is an improvement or a detriment.

We also look at the cost from a

comprehensive systems model with the OEMs looking at the cost all the way through the development, manufacturing and lifecycle, so they get a very bird's-eye view of the true cost to them as a business.

And what I mean from a systems' viewpoint, we kind of look at everything in terms of, you know, reduced warranty costs that could be potentially realized through the use of a carbon fiber composite, reduced supply chain costs, part consolidation, map and talk consolidation, the reduced capital costs.

Typically the capital investment for carbon fiber composites is much less than the competing lightweight materials, so that can be factored in.

We also like to factor in some of the value adds and -- to put a number, like a monetary value to that depends on the OEM's perspective. But there are particular attributes that carbon fiber can bring in terms of either permitting the OEM to add additional content that they couldn't have unless the part was made out of carbon fiber and reduced the weight by a certain amount or there might be other parts that the consumer might find great delight in having lightweight, such as the sliding door on a van or a lighter-weight lift gate or hood on a vehicle.

There might be a true benefit that the OEM can realize when the customer sees that they really like that particular component being made so light.

MODERATOR BONANTI: Jackie, this is Chris Bonanti. I just wanted to make you aware that your -- actually, you are over time, but I wanted to ask how much further you have? I know it's a situation where you are not here, so I couldn't give you a sign.

MS. REHKOPF: That's all right. I can just speed up. Would you like me to finish in like five minutes, three minutes?

MODERATOR BONANTI: Okay. That would be fine. Thank you.

MS. REHKOPF: Okay. All right. In terms of the tooling costs for carbon fiber composites there is really a sweet spot that is somewhere around that mid-volume range, 50,000 or so, so that's sort of another reason why we are targeting that market segment.

Another thing that we point out with our OEMs is the final finished assembly cost. And over the last four to five years, Plasan has been able to reduce the cost per pound of a bonded finished prepreg assembly by 40 percent. So that's quite a significant change in cost that the industry can benefit from.

I'll go real quick through the composite design and analysis tools, which we, obviously, use all the way through the business from R&D to quoting, prototyping, prepreg and manufacturing.

We use it for the materials'

models database as a sandbox for new design technique, so that we can test new layups and sort of ply design techniques without actually using the material or using tools or operators and we can take a look at our roll width and ply counts, cycle times, production volumes, etcetera, all virtually.

Obviously it is used for creating a virtual analysis of our ply structures, so we have to build fewer physical prototypes. We can get quick design feedback to our customers in terms of design constraints and limitations. Every material system has its own manufacturing constraint.

We can communicate that very effectively with the CAE tools and we can also demonstrate joint construction nominal thicknesses by giving them cross-sections to show what the laminate would actually look like.

It allows us to do quick and reliable kit design much faster than without the software tools and cost estimation is a huge benefit. We can get, you know, a directional cost turned around in about four hours for the OEM to decide whether it is worth pursuing for their particular program that they are interested in.

Improved quality control are achieved with this software, as well as grid exchange with the operators on the shop floor in terms of operations that might be repeatable that we can design right into the kit themselves so that the operators aren't having to do a specific task.

And I'm just going to touch a little bit on some of the challenges for getting carbon fiber composites into mainstream automotive. Obviously, cost is a factor that needs to be addressed. The cycle time, how it's assembled to the rest of the vehicle.

But another big one that I know others have talked about with the lightweighting vehicle studies is predicting the behavior of this material in crash. And Plasan is fortunate to be a principle investigator in a DOE program looking at the capability of current software models to predict the performance of carbon fiber in automotive crash.

And a big part of that project will also be characterizing the behavior, so you have the input for the material model.

We also look at composite processing. The process itself dictates what kind of properties you are going to get in the end part, that is addressed through analytical tools.

And then this summarizes all into our current forte into a base model vehicle, the 2014 Corvette Stingray. Using our new technology, using the same prepreg as we had previously on a higher end Corvette, where we have got the hood and the roof in painted or exposed weave, and it's the first entry into a baseline vehicle, so we see that there is a huge future for carbon fiber composites in mainstream automotive.

And you know, it's just a matter of deciding with your OEM or our customer, you know, what is the best material system to meet their particular needs?

And with that, I'll take any questions if there is time for those.

(Applause)

MODERATOR BONANTI: Thank you, Jackie. We are going to be collecting any questions that we do have here. I know there are a few. Also, I wanted to ask you if you will still be available for the panel discussion in about 30 minutes or so?

MS. REHKOPF: I can be if you think it is beneficial. I'm not sure how well this works with me being not able to see the audience.

MODERATOR BONANTI: Okay. Well, that's totally up to you. I'll understand either way.

Okay. The first question, you said you are all about mass production. Others have claimed that CFRP can greatly improve crashworthiness. Do you disagree or are you focused entirely on non-structural components?

MS. REHKOPF: I do not disagree. I think carbon fibers can improve crash performance, but it is an area that needs particular work. And as my -- the previous speaker mentioned, it is all about the design. You would definitely design a part differently for carbon fiber than any other material system.

So it's about designing it to manage that crash energy appropriately.

MODERATOR BONANTI: Okay. Is it true that carbon fiber components is brittle and shatters into shards flying wide during a crash?

MS. REHKOPF: Well, I guess

anybody who has seen Formula One racing knows what happens in a crash. There are many different architectures of carbon fiber composites the way the fiber and the matrix are combined, so you can control that type of deformation, whether it is going to break off into shards or whether it is going to be retained somehow.

So that's again something that needs to be designed for and the material system needs to be developed to get the performance that you want. Obviously, carbon fiber, yes, it doesn't have much elasticity in itself, but there is ways to use the architecture to get a bit of that flexibility that you need in a crash.

MODERATOR BONANTI: Okay. What is the cost index for carbon fiber? What is the cost index for carbon fiber hoods compared to steel or aluminum, if aluminum or steel are at a 100 index?

MS. REHKOPF: That's a tough one.

Just to generalize, we are definitely more expensive, at this point, and part of that is because we are not at those mid-volume production levels. You know, we are just entering that 30,000 per year phase and we are also currently limited by, basically, having a bolt-on component that is replacing the aluminum or advanced strength steel.

So until we start designing specifically for carbon fiber, the cost index is always going to be higher than an aluminum.

MODERATOR BONANTI: Okay. Is recyclability a potential aspect associated with carbon fiber?

MS. REHKOPF: There is and we are working with a few firms on reclaiming carbon fiber and reusing it both from the end of life use as well as manufacturing scrap. It's not -- I couldn't say it's, you know, as recyclable as aluminum is, at this point, but there is definitely a means to reuse the material.

MODERATOR BONANTI: Okay. And last question unless there are others, but what is the fidelity of the software to actual performance, 10 percent, 15 percent? Which is it?

MS. REHKOPF: That's an excellent question and I think that's why the DOE put out the FOA for us to analyze the capabilities of existing software tools, so USCAR is working on that project as well with Plasan and its partner companies. We are going to determine in the next three to four years what that fidelity is.

MODERATOR BONANTI: Okay. Thank you, Jackie. You can stick around on the telephone if you would like or sign-off, it's up to you. But I wanted to thank you for participating either way.

MS. REHKOPF: Thank you for having me.

MODERATOR BONANTI: Okay.

(Applause)

MODERATOR BONANTI: Okay. Next up we have Stephen Ridella, that's what I was told. Stephen, Stephen. He is going to be talking about the fleet safety evaluation methodology application to lightweight vehicle design here at NHTSA. Thank you.

MR. RIDELLA: Thanks. Wow, you stayed long. Appreciate it. My office is responsible for developing test procedures and methodologies to assess vehicle structure restraint systems to improve crashworthiness and occupant protection. We do this through a variety of methodologies and research projects.

Currently, we have some projects going on: dynamic rollover, as you know, and oblique impact, those are still ongoing among many other projects.

We also do research in our biomechanics groups, both here and in the VRTC in Ohio to assess occupant protection and, you know, human tolerance to impact, developing crash test dummies, evaluating current dummies and maybe even future dummies under the associated injury criteria. So this project really brings together those two kind of divisions into, I think, a really elegant study.

I'm glad Jim mentioned earlier this morning where we are at in the timeline on CAFE. This study really does support, you know, our rulemaking decisions that we are going to make and then the evaluation we have to do for the midterm that he mentioned earlier.

So we are in that kind of early phase, that bubble I think you show between 2013 and 2016. Two years ago, at this symposium, Steve Summers, my Division Chief of Structural Restraints, really outlined some of the programs that you have heard about this morning.

And the program that he had mentioned that I'm going to give you some results today for the first time really came together from -- after that presentation 2011.

And we awarded the project to George Washington University, but it has really been a project between the GU folks, GWU folks or folks at NHTSA, both in rulemaking and the research and also some outside consultants that we will acknowledge later.

So really a great study to bring a lot of expertise together in evaluating how we can bring these vehicles together, but not in a test environment, just in a pure simulation environment, at this point, because it's just we don't have these vehicles to test right now, that many of them. So we're going to be doing most of this evaluation in the virtual space.

The agenda today, I just want to review the goals of the study, the field crash assessment that was done by GW to look at the sort of crash modes that we want to investigate, the simulation approach that they took, injury assessment that was used, how we brought all that together and some of the model results into what we call a societal injury risk, an overall synthesis of all the results that were generated from the study together into something that we can compare the lightweight designs versus the baseline designs and also against the self and partner protection that we did in the study and then some conclusions on where we are going after that.

So I'll try to get through this as soon as we can and get to the panel discussion and actually get you guys out, because it has been a long day, but I think a very productive day.

I think Jim actually put up this slide earlier, but just to review it again, we did use new and existing vehicle crash models to evaluate the safety of future lightweighted vehicles. This involved vehicle-to-vehicle and vehicle-to-structure, fixed-object crashes.

It only focused on belted-occupants for the study. And we looked at regulated and also non-regulated, non-standard crash test conditions with a variety of speeds from 15 up to 40 miles an hour, which we thought represented the real-world crash conditions and risk occurrence that was out there.

Of course, the whole idea was to assess the interaction of lightweighted vehicle designs with existing vehicles in the fleet. This could allow us to look at countermeasures in the future, such as restraint systems, airbag deployment timing and stuff we did a long time ago, but still is relevant today.

And also, looking at adaptive restraint systems, projects that we have ongoing right now at NHTSA that we can put into this program at a later date, once we develop those systems.

First, what they did was an assessment of traffic fatalities. They looked at data, a variety of data in the FARS and NASS CDS. They looked at light vehicle crashes, vehicle-to-vehicle, vehicle-to-object. We didn't want to look at rollover for this study, only light passenger vehicles.

And if you look at the two pieces of the pie here, the -- I wish I had a pointer, the sort of red one, the orange one, this was the two vehicle crashes, no rollover and this was a light vehicle, single vehicle crash into fixed objects, no rollovers also and it's comprised of about 32 percent of the fatal crashes that we wanted to analyze.

Diving a little bit further, there is a lot more statistics that were on the paper, but I'm just going to be giving you some of the highlights.

We only want to look at frontal crashes in the study and that presented about

51 percent of the non-rollover one or two vehicle crashes in the study. So overall then, the study evaluated about 16 percent of the fatals, about 5,500 crashes, fatal crashes, that were out there.

We also looked at speed of the crash. So this -- instead of just looking at delta v, which had a little less representation and mass, we looked at BES for the barrier equivalent speed. We found that when we looked at different cumulative risk of injury versus speed for the passenger cars and the pick-ups, it was pretty equivalent. The SUVs went a little bit farther, but we limited the study only to about 64 KPH, which represented about a 50 percent chance of a NAIS 3+ injury.

I did take a drink of water the last two hours. Okay. In the fleet vehicle models that we used, where existing vehicles that had been developed actually by GW over the last several years, we wanted to make sure we represented the fleet. And the smallest car, like a Yaris, midsize SUV, like an Explorer, larger car like a Taurus and also the largest pickup, like the Silverado.

So we have used a large fleet modeling characterization and then compared the performance of the fleet to the lightweighted models that we had.

Let's talk about those models. We talked about them earlier. You have heard about them. We did sort of a sanity check at the beginning that we call a sanity check, but sort of a methodology check.

We had a baseline Taurus model that GW had evaluated before and we did some variations on that, which I'll explain in a minute. And then earlier today you heard about both the Venza lightweight- and high-option and the Accord lightweighting that was done. These are weights that represent sort of the test weights that we had in the -- with the dummies and everything that we would evaluate in a typical test, we put that into the model and those are what we compared against.

The Taurus model variations had two variations, one for both lightweighting where we had the -- we basically just reduced the density of the steel in the model, kept the same stiffness. We also had one with the same weight, increased stiffness by using more advanced high strength steels.

And these are some of the forces placed and characteristics to show the differences in the models that were run for the Taurus model variation.

For the Venza, you heard about this earlier, both the lightweight low-option and the high-option. And then the Accord model. We had to lease the baseline model, I think, from Altara and then we had the lightweighted model that we used from the study that was completed by EDAG.

So all those were brought together

and really a simulation -- this is the overview of how we actually did the process or how GW did the process. First, we did a finding on the fleet simulation. So a single vehicle, multiple vehicle, I'll get to that in a second.

But the simulation was done in finite element. The crash pulse was then extracted from that as well as things like the intrusions of the occupant compartment and other interior things that we could get out of the simulation.

This was fed into a MADYMO model and from the MADYMO model we did both 50th percentile male dummies and 50th percentile female dummy modeling, extracted the injury criteria, light HIC, chest deflection, femur load outputs, compared those to the risk curves that we had in NCAP and created a sort of risk of injury, NAIS 3+ injury, that was synthesized from all the different model runs that we ran.

These are the model runs then that we did. For both on the top side, we ran five different speeds, fixed-object crashes with full engagement, partial engagement and center pole. We used both midsized male and small female occupants in those crashes.

When we compared the target vehicles, again this is the lightweighted vehicles at different crash speeds to the fleet vehicles that I mentioned earlier. We did both full engagement and offset and we had different dummies and different things, so we had midsize male, midsize female in both the target as well as the partner vehicle.

Now, you can imagine now we are creating all these simulations and getting lots and lots of injury data, so the point was to summate all the different injury risks from both speed partner crash-type and occupant and then weight those according to exposure in the field to come up with something called a combined injury risk.

So these are the simulations that were done about a single vehicle crash. We did about 120 LS simulations, which translates into about 240 MADYMO runs. With the two vehicle crashes, we had 320 simulations and over 1,200 MADYMO runs. So now, we have got all this injury risk data and we've got to put it together and come up with something.

So let's step back a second and go back into the MADYMO runs. The MADYMO models were developed kind of generically. I mean, we had -- the finite element models don't have a lot of interior stuff, that's some of the issues that we had with some of the GW models. It's very specific to the vehicles and the manufacturers.

But we did -- were able to extract a lot of good data from what we had and what we could get in terms of occupant compartment geometries and restraint systems, airbags that we could get and put this all together and did some sanity checks, did some runs to make sure that these did actually look correct and weren't out there getting strange results. A lot of work was done.

And like I said, we brought in the things like toe pan intrusion and other intrusions and then used the acceleration fields to apply to the occupant and to assess the injury assessment for all these different MADYMO runs.

Like I said earlier, we used the NCAP risk functions for the male and small female dummies. We looked basically at head, chest and femur risk injuries. This was done based on some analysis I did in the NASS data that showed the head, chest and lower extremities had the highest incidence of injuries.

We did three different combining measures, head, neck, chest and femur; head, neck and chest; and then head, neck, chest and -- and then something called an intrusion penalty where we looked at the models and we saw some major intrusions that came in. We kind of said okay, well, that could actually increase both head and chest injury, so those were added to the combined injury risk in the third different method that they used.

This kind of summarizes that whole thing I just talked about. For each impact speed and vehicle, we did the single vehicle simulations and the combined injury risk that I mentioned for head, neck, chest and lower extremities; head, neck and chest; and then head, neck and chest with A Pillar intrusion.

Then looked at all the different simulations with the fleet vehicles and all the combined injury risks from that as well. Eventually, these were all summated, if you will. I'm going to get to -- a little bit into it and one single injury risk that could be compared across both the target vehicles as well as the field vehicles.

So let's look at some of the data. It's kind of interesting, actually, I think it's very interesting.

The combined injury risk for the single vehicle crashes looking at full engagement, we looked here just at the Honda Accord. So what you see is some interesting stuff. This was full engagement, offset the center pole, like I said, so self-protection for both the baseline vehicle in the solid line and the lightweight vehicle in the red and then the green is the lightweight vehicle and then 50th percentile is solid, the dashed line is female.

So in general, what you see right away is there is increased risk for the lightweight vehicle at almost all the speeds, crash speeds and that the female has a higher injury risk. That's pretty much, you know, expected. When you give a female the same restraint system as a male dummy, typically, you will see higher injury values. That has been shown many times and also the increased risk of injury based on increased crash speed.

Interestingly enough, looking at the vehicle-to-vehicle models, we looked at this evaluation, both crash mode, partner and speed and we see the same effects. Higher risk for females, higher risk as the speed increases. Now, this is across all the different vehicles that we modeled.

And then we found that in some respects when we had the femur load it was dominating the injury risk. So in some cases, we took it out and this was just the combined injury risk when you take out the femur load. So it comes down, obviously.

So what we did with all those injury risks was sum them. This is kind of doing it very, very fast. In the paper they go through very exhaustive treatment of how they came up with these final injury risks.

Basically, it is to combine the injury risks to get an overall crash risk for that vehicle, for society. So looking at the target vehicle, we've got that target vehicle risk in both the single vehicle and vehicle-to-vehicle, combining them for both single vehicle and vehicle-to-vehicle to get an overall risk for each vehicle and crash mode.

So what you see here is the vehicles that we had, the Taurus baseline, the Taurus lightweight, the Accord baseline, the Accord lightweight, the Venza baseline, the Venza -- both options.

This is looking at single vehicle risk. And you would compare them and say the baseline risk for both the male dummy and female dummy, you can see that the baseline risk is here, there is increases, slight increases for the lightweight options that I mentioned, both in stiffness and in reduced mass. It pretty much holds true for almost all the vehicles when you compare these, you know, individually, if you will.

Looking at, in this case, the two vehicle crashes, we start to see numbers that are a little bit higher. These approach a 1 to 2 percent which is pretty much consistent with the injury risk that Chuck Kahane showed earlier in his crash test that he used. I think he will document again tomorrow.

So we feel that these were, you know, in the right range of risks that are capable and that are possible compared to field risk. So what we are seeing in the simulation is mirroring what we see in the field. And that was a good sign and good for us to see that result.

This was really the punchline slide, if you will, looking at all three kinds of ways. As I said, we combine the injury risks. This was when you combined for all the different crash risk -- injury risk modes for head, chest, neck and femur.

Then looking at just head, neck and chest and then looking at head, neck, chest with the intrusion penalty comparing let's say the Taurus baseline, 1.25101101. We saw increases, slight increases, if you will, but they are on the order of 12 to 20 percent increase in societal risk and the lightweight options are the stiffer options.

Comparing the Accord is the same thing, about 10 percent risk compared to baseline. The Venza about a 5 to 15 percent, depending on what method you chose for the societal risk.

So again, these are in line with what we think that Dr. Kahane has shown. Slight increases, note those are very small risks on the order of 1 to 2 percent.

So a lot of information a short amount of time. The study is undergoing review at the Agency. Eventually peer review and publishing later on this summer. But we think we really did find a methodology that evaluated designs for a range of crash configurations and speeds.

These results are sensitive to the vehicle interior and occupant models as we all know who run these models. Small changes can make a difference, so we have to be sensitive to that and understand what we are doing when we do these models.

And then we will probably have to do some refinement to the models in the future. We did -- with the Taurus model it was both mass and stiffness changes and we found out they do affect occupant injury risk, in that, you know, the lower speeds really are important. They do dominate some of this analysis, because we know that, you know, historically lower speeds and I'll say in the 10 to 20 mile an hour range really are the peaks of where we see the highest numbers of injuries and fatalities.

And also this methodology helps us look at both self- and partner-protection in two vehicle crashes. We intend to look at more column and intrusion in the future to see how that can actually -- instead of just using a penalty factor, see how it does actually play a role in injury.

Look at, as I said earlier, more advanced occupant restraint systems. We can look at other vehicle types. This methodology says hey, you know, we have got -- we can do it for one vehicle, we should be able to do it for a variety of vehicles in both the fleet, the lightweight fleet as well as the current fleet that is going to be out there in the future if these vehicles start to interact with each other.

We would like to improve the correlation between fleet model and real-world. It is there, but it can be even better.

Finally, I just think this study really did show us how we can combine all this information together and come up with an idea and a methodology to assess the lightweight vehicle fleet interactions you are going to have with the fleet in the future.

So with that, like I said, the study will be available some time this summer.

We would appreciate your feedback and comments on it and I'll take any questions now. Thank you.

(Applause)

MODERATOR BONANTI: Thank you, Steve.

MR. RIDELLA: Before I -- I do want to acknowledge everybody that worked on the study at GW. They are all most of them here in the audience. We want to thank you so much for your work on this and our people at NHTSA as well. It has been a very collaborative study.

MODERATOR BONANTI: I totally agree. Okay. So questions? Let's see, Jamie is bringing some.

MR. RIDELLA: If I can't answer them, there are plenty of people here who can.

MODERATOR BONANTI: Okay. The first question, Steve. Can you describe what factors in a crash between two lightweight vehicles is increasing a risk? What happens differently?

MR. RIDELLA: Two lightweight vehicles? Okay.

MODERATOR BONANTI: Yes, but that's not what the question says.

MR. RIDELLA: One more time?

MODERATOR BONANTI: Yes, two lightweighted vehicles increasing the risk.

MR. RIDELLA: Do we have that data, Steve, the lightweight-to-lightweight? We did run those in this simulation. Exactly. So at this point, we are only looking at the two. We didn't run the lightweight-to-lightweight, at this point.

We probably will in the future, but we want to see what would affect more on the current fleet evaluation as these enter the fleet, how they interact with the other vehicles. I think we will get to that eventually.

MODERATOR BONANTI: It's going to take a while for the original fleet to turn over, so it's definitely something we need to look at from when it comes to a safety basis.

MR. RIDELLA: I mean, they will eventually start to interact. Right away? Maybe not.

MODERATOR BONANTI: Okay. Next question. Is 20 percent of 1 percent significant?

MR. RIDELLA: Well, I think you have to look at the numbers. Clearly, you know, we look at small numbers, but we deal with these kinds of numbers. I mean, you know, your risk of injury in any given crash is very low. It's only the 1 to 3 percent range anyway. So these seem to be in line with that.

And differences like that can make -- you know, are showing us something, that there is an effect there, yes.

MODERATOR BONANTI: The follow-up to that is, is it acceptable with regard to safety?

MR. RIDELLA: I think that's your job, isn't it? I'm just a research guy.

MODERATOR BONANTI: You are the one answering the questions. I'm just asking them. Yes, you are correct. Okay. Next question. Kahane's study is 1.5 percent increase in fatality risk for every 100 pound mass reduction. Is your study using the same measure in terms of mass reduction?

MR. RIDELLA: Not really. I mean, it is similar showing that the lighter mass vehicles will have an increase in injury risk, but it's not using quite the same methodology in terms of looking at it from a perspective of, "for every 100 pounds, you have this increase." And we are also looking at injury, not fatalities.

MODERATOR BONANTI: Okay. Is the societal injury risk parameter a new statistic or a parameter created for this study, or is it a standard metric commonly or previously used by NHTSA?

MR. RIDELLA: Those are comments that we are looking for. Clearly, for this study, it was something that we had to make up to synthesize all the different variety of results that we were getting.

So it is fairly new. In fact, it is very new for this, and I think that it came across very well in giving us an idea of how to combine all that data we are getting from the simulations into kind of like one measure, if you will, for that vehicle.

So I think it was an effective way. And we will take feedback on it. I think this will be good to see what kinds of feedback you have and if there is other measures that we should be using in the future.

MODERATOR BONANTI: Okay. I think this is the last question, unless there is any others.

The stiffer but same weight Taurus seemed to have a higher increase in societal risk than any of the lightweight scenarios. Why?

MR. RIDELLA: That would be this one. Yes, it does show interesting -- did we make any assessment on that, guys, besides just saying the increased stiffness, the increase in acceleration? So I would say the pulse would be higher, so it's going to make a difference.

MODERATOR BONANTI: Okay. I have another question coming. We are ahead of schedule, which is a good thing, I guess, since it's late in the evening. We are going to have our panel discussion.

Jackie, are you still with us? She is still on. Okay. Well, after I ask this last question, then we will set up the chairs and we will have our panel discussion. You can start writing up your questions now, if you would like, for the panel.

Okay. Can the re-engineering or 3-G of the front crash load paths enable the mass reduction deficiency to be overcome?

MR. RIDELLA: It sounds like it's something beyond the scope of the study. One more time?

MODERATOR BONANTI: One more time?

MR. RIDELLA: Yes.

MODERATOR BONANTI: Okay. Can the re-engineering or 3-G of the front crash load paths enable the mass reduction deficiency to be overcome?

MR. RIDELLA: Well, I think yes. I mean, we look at this from just the vehicles that were out there. Certainly, that changes the front end and how it affects both, you know, load paths and stiffness is going to make a difference. So, you know, this is just a study to look at the current models that we had, but future models that have that kind of capability and changes that we can make to it to look at load paths and restraint systems, we will certainly see if we can make that difference, that -- it's small, but it's there. Maybe it will get less or go away. So, clearly more to do and we are looking forward to it.

MODERATOR BONANTI: Okay. Great. Thank you very much.

(Applause.)

MODERATOR BONANTI: Okay. You can take a seat. Okay. Can I have all the individuals that will be on the panel, those are the authors and presenters today, come up and sit down, please?

Okay. Since we have everyone up here, and this is a holistic approach, we have individuals from the Agency presentations as well as the OEMs and everyone else. So I suggest that those individuals in the audience that have questions, please write them down as we have done all day, and please provide them to our panel. Thank you.

Well, I guess the questions that I have already written, I'll wait on. Okay. The first question to the panel, and depending on how you would like to answer it, feel free.

Should the projections for affordable mass market vehicle weight reductions fall short, can any of the panelists explain the penalties for noncompliance under the Clean Air Act? Anyone?

I can't, but -- Jim, there is another seat here. You were -- yes, do you want to sit down?

MR. TAMM: Sure. I think maybe the perspective from the regulatory agencies would be that mass reduction is one of a number of technologies that manufacturers could use to comply with standards. So the expectation would be that other technologies would be used.

I did, in the presentation at the beginning of the day, list the amount of mass reduction that we assumed in the analysis, and you might have noticed that for a lot of the vehicle categories, it was zero or fairly low levels.

So that would be a scenario. Honestly, I don't think we evaluated, assuming, you know, no mass reduction, but we did have pretty low levels in our base assumption. I think, on average, overall fleet was probably around 8 percent, so maybe our assumption is at least that type of level would be achievable and that would be consistent with the analysis that we did do.

MODERATOR BONANTI: The one thing I would say is that takes into consideration CAFE-related aspects. The question specifically asked about the Clean Air Act, which I don't know if --

MR. TAMM: Yes, maybe I'll just comment. We have got a couple of EPA representatives. But when we structured the standards for 2017 and beyond, we essentially tried to have coordinated standards, so the expectation is that manufacturers would be able to build a single fleet that would comply with both the greenhouse gas and the CAFE standards.

So our expectation would be that there would be a single technology -- you know, a collection of technologies that would enable compliance with both. So my comments towards CAFE we would expect to also apply to greenhouse gas program.

MODERATOR BONANTI: Okay. For the panel, these are a few questions on cost reduction over time. Should the cost reductions be a function of industry-wide production volumes or individual manufacturers or supplier production volumes? Anyone? We have some OEMs and we have the manufacturers.

MR. KOLWICH: My opinion, I guess, is it is going to be the --

MODERATOR BONANTI: Could you state your --

MR. KOLWICH: Sorry. Greg from FEV. So I think it will be an industry-wide use of aluminum or carbon fiber or high strength steels that will eventually drive the price down. Any one OEM that chooses to use it will pay the premium up front. Over time, I think, as more people jump in, it will only get the cost down lower.

MR. THOMAS: Yes, this is Chuck Thomas with Honda. I would agree with that. I think that all manufacturers -- you know, we are trying to solve really the same problem and we are going to use the same technologies and the same approaches to solve it.

And you know, the economics of the situation are such that for any large mass market vehicle, it's just not practical to try to introduce some of these technologies until enough people are beginning to use it. You know, we can really have very little impact on the cost of the vehicle for mass reduction.

I mean, you know, we have talked a little bit today about what people are willing to pay for mass production -- mass reduction. And, you know, my experience is people really aren't willing to pay for mass reduction.

So, you know, they are not going to give us a premium for the vehicle, for a vehicle like the Honda Accord or the Honda Civic, to be lighter. That's just something that they are not interested in, because they don't perceive that as a feature that really is going to be something desirable.

MODERATOR BONANTI: Okay. I'm going to ask a follow-up question to that specifically. And that is to what extent is prior adoption of technology or materials in Europe accelerate cost reductions in the United States?

MR. THOMAS: Well, I'm not from Europe, but I'll try to answer. I think it helps. You know, we have looked at a lot of technologies that were first introduced into European market and they are slowly beginning to move their way into the United States market.

A lot of the press hardened steels

that we use today were first introduced in Europe. What we see, you know, we touched on during the discussion there are sort of two issues that are necessary for these things to become available.

One is the availability of the material itself and then secondly, is the availability of the supplier base that's actually able to, you know, work with these materials for these parts.

You know, even though it's a global market, it's not really practical to ship a lot of these, both, materials and fabricated parts around the world. If you look at the United States, you know, when we move our factory productions around, typically, our suppliers come with us.

So when we build a factory in say the southern part of the United States, suppliers that we already have say in Canada, they set up facilities in the southern part of the United States to produce the parts locally that we can send directly into our factories.

So as those suppliers and technologies in Europe have become available here in the United States, we have introduced them. And as they move and become available in other countries, I think we will continue to do the same.

MODERATOR BONANTI: Okay. We have a substantial amount of questions specifically focusing on mass reduction and, of course, this is the topic of the workshop, but there is about four or five different types of questions that are all very similar, so I'll try to give a summarized question.

Mass reduction is, of course, important and this individual wants to thank you all for your presentations today. Now, can each of you, please, speak to how mass optimization is constrained in practice? For instance, the majority of models today share platforms powertrains and components because of investment constraints.

Please, speak to how this works on a fleet of vehicles. I would say the OEMs and, of course, the Alliance and the manufacturers would probably be good at answering this question.

MR. SCHMIDT: Well, I'm not sure I'll be good at it, but I'll give it a shot. You know, again, it is a case where you have a platform, but it does have unique sub-vehicles or niche parts of that common platform and they do provide, as I mentioned in my presentation, real constraints.

They also are marketplace opportunities, that's why they exist. We wouldn't make them if there wasn't a marketplace opportunity. So I think they are an important part and it's not so simple to say well, just get rid of those, make the Model T the modern Model T all one-size-fits-all.

You can optimize the hell out of it, pardon my language, but that's just not practical in this customized consumer environment. I want customized products for me. I don't want the same thing that everybody else is driving. And we have come to expect that, so that's the norm and it does provide some limitations on the amount of optimization you can do.

And then when you figure that you have got a -- the manufacturer has got multiple platforms, yes, maybe that does provide some opportunities, because there may be an engine for that platform that when they downsize, that might fit in there.

But you know, Murphy's Law is that usually that engine may not fit exactly what you want and so you end up still being constrained at least at some level in your ability to optimize and pull parts from some of your other sub-platforms, because, again, as vehicle manufacturers we try to communize as many components and make one component fit as many different models as possible, that way you don't have the exact same -- you know, every vehicle doesn't have unique parts to just that vehicle. This model has unique parts to that vehicle.

So we do our best to optimize weight and do what a lot of these manufacture -- a lot of the analyses are saying, but there are some real limitations.

MR. THOMAS: I think that I mentioned before and we kind of touched on it that, you know, from a particular platform, there is a lot of different configurations and different vehicles that are developed and that really is necessary for several reasons. I mean, one is that some of these small volume vehicles, they really couldn't survive the amortization, you know, scrutiny based on the volumes if we had to really design completely unique parts for them.

Also, two, you should keep in mind that, you know, most of these vehicles that are derived from the same platform are built in the same factory. So, you know, the factory itself deals with limitations and we had significantly designed differences between, you know, say like the Acura TL and the Honda Accord, which are built on the same line, even though they are not the same car.

If we had radical different architecture developed for one vehicle than other, it creates a lot of complexity in our manufacturing environment.

The other thing, too -- which particularly with platforms and they create challenges for us is, you know, we have talked a lot about kind of clean sheet design. So, you know, if we could just kind of back-up and we could just start from scratch and design a vehicle, that gets even more complicated, because of the life-cycle of each vehicle that is derived off of this platform isn't synchronized.

So for example, when the current Accord went into production, it's a new platform, but the TL, which is still being produced, is based on the old platform being built on the same line.

So we have to be able to accommodate two different platforms on the same line at the same time, because the TLs product renewal cycle isn't completely synchronized with the Accord. And this happens across a lot of different vehicles.

So you know, I don't want to sound like I'm making excuses, but as a manufacturer, there is a lot of moving pieces involved in the development of a platform and development of all the daughter vehicles that are associated with it and the management of all that sort of machinery makes it difficult sometimes to sort of approach this as this kind of clean sheet idea and we will just kind of tear down everything that we have done and start over every five years or every six years.

So you know, I think somebody used

the description that, you know, mass reduction in vehicles, because of the nature of the industry, I think is more evolutionary than revolutionary, because even when we come up with good ideas, it takes time to kind of work those ideas into the machinery of both platform engineering and vehicle production to kind of introduce itself through our entire product cycle.

MR. RICHMAN: We are talking about technology innovation in general now. And it is a really complex problem in the auto industry, because of all the invested capital, the product cycles, the spare parts, the commonality, the different platforms. It is a hugely complex problem.

History has been that typical evolution -- and it is absolutely technology is an evolution in automotive and it has to be -- typical technology adaptation curves are on the order of 20 years from 10 percent of the fleet to 90 percent of the fleet. It's a 20 year cycle.

I would question anybody that thinks there is a technology that went from 10 to 90 in much less than 20 years. We are not talking revolution here. This is evolution, like all the other advancements in automotive for a lot of very important business and technical and commercial reasons.

MR. KOLWICH: This is Greg from FEV. So I agree. I think, as I mentioned earlier, time kind of heals all wounds. So you look at a lot of the technologies in engines and transmissions, lightweight technologies, and they will make it into one engine platform first. They will slowly work its way across.

So one argument could be these platforms will share that lightweight technology. There are going to be certain technologies that are going to be maybe more custom to a vehicle platform, but a lot of these technologies that we have investigated, be it brake calipers or caliper brackets or knuckles or whatever it may be that are shared across platforms, some of these technologies will be brought across all the platforms.

Now, cost is one factor. You are not going to put maybe an expensive aluminum suspension on an A Class vehicle necessarily. But as costs come down and things evolve and time goes on, maybe that will be the case. In Europe you see it already. You see it, smaller cars do have the use of aluminum throughout.

So I think it is -- and when we generalize it is hard to kind of wrap our hands around, but time does heal that. And eventually if it makes financial sense, it will come down to that.

MR. PETERSON: Gregg Peterson, Lotus. Lotus, although we are a very low-volume car manufacturer, we certainly are looking into economies of scale and one of the ways we are doing that is looking at using some of our nodal castings which are four-corner type connection points, which are highly integrated, and using extrusions that can be cut to various lengths, very cheaply, very inexpensively, to create longer wheel base or shorter wheel base platforms that can be built in the same plant very simply by the same people with similar skills to what is used in body and weight construction for steel bodies.

MR. ZUIDEMA: From a supplier perspective, it does not escape us that the cars we launch in 2021 are still going to be built in 2025 when the full magnitude of the fuel economy requirements kick in. And those cars are really going to be locked into their production by 2018.

So we are looking at almost one vehicle cycle or less in which to really commercialize all of these technologies and one of our biggest points all along is we, as suppliers, want to work with the OEM community to find a way to overcome some of those roadblocks and make sure we get the right solutions and the right applications, because, frankly, we are running out of time.

MODERATOR BONANTI: Okay. Thank you. I'll ask a fairly general question. Given Government studies and industry feedback, how much mass reduction is feasible in model years 2020 and 2025? Anyone?

MR. THOMAS: It's what I get for being the only -- the Honda guy. You know, kind of like we talked about. I think in that time scale, I think our estimate of something on the order of like 2025, something around -- a net of around 175 kilograms is probably what is, you know, reasonable from what we see.

I think we have kind of said something on the order more of around the 10 percent reduction compared to the 20 percent reduction that we have seen in some of the studies.

One thing that is very hard to,

you know, anticipate in the future is like we talked about, what are the future demands of the customer going to be and where the market is going to go?

You know, as customers get more interested in technology, you know, both infotainment technology, collision avoidance technology, as well as, you know, additional driving technology, comfort, noise, isolation, as we make cars, you know, more like your living room, what people are going to want to do in your living room, you know, I mean, people might want to have big screen TVs in their car, so they can watch TV because their car drives itself.

Some of these things are hard to anticipate, but from a point of view of the structures of the car and the components of the car, I think that 10 percent target is reasonable over those time scales.

MODERATOR BONANTI: Okay.

MR. RICHMAN: We see an overall

average around 10 percent being the kind of number we are looking at, about 400 pounds on an average 4,000 pound fleet. That is the kind of numbers we have been working with.

And it actually aligns, I think, pretty well with the assumptions that we see in the CAFE Regulations to 2025. It is going to be a mix. Some cars are going to get more. Some cars are going to get less.

From what we are seeing from OEM reactions to the long-term planning now, I think the 400 pounds is a very, very realistic expectation for 2025.

MR. PETERSON: Gregg Peterson, Lotus. I just want to make a comment. The presentation I gave earlier certainly showed a lot more than that, but, please, keep in mind the fact that we didn't have constraints that the OEMs do. We didn't have any Legacy hardware in there and there were a lot of other considerations that Honda has presented today that really have a big impact on the mass.

So we certainly feel that there are significant mass reduction opportunities, but Legacy hardware and plants, existing plants, etcetera, infrastructure, all play a huge role in defining what an OEM can actually do in that time frame.

MR. ZUIDEMA: Just a third, I guess, comment on the 10 percent. Our own work showed we need somewhere between 7 and 10 percent total vehicle weight reduction to make up the gap between that which powertrain technologies can provide and that which we need to get to 54.5 miles per gallon.

But again, a lot of it depends on how well the powertrain technologies themselves evolve as well as the additional mass required to meet some of the other challenges. My work said it was 10 percent or I'm sorry, 7 percent. The 10 percent, to me, sounds like a reasonable safety factor.

I think we are right in that

ballpark.

MODERATOR BONANTI: Okay. Another comment?

MR. SCHMIDT: Yes. I don't have a whole lot of better data other than the fact that, again, depending on the vehicles, I mean, vehicle for duty cycles, for example, some full-size pickups you often have to have that vehicle not only carry the payload, but you also have to be able to bolt on a snow plow and hit curbs and stuff like that.

So again, the exact number is really probably vehicle-specific, vehicle class-specific. And again, when you have a vehicle which you are trying to sell, the majority of your customers may not need some of these special heavy-duty features, but that vehicle also is sold as a construction or as a commercial vehicle and has to have them.

Again, that may have some limitations and things that they need to consider.

MODERATOR BONANTI: Okay. This question is for anyone that doesn't work at NHTSA. Fuel Economy Regulations in the EU are mass-based and in the U.S. they are size-based, of course. Please comment on how you view mass reduction given these two different regulatory requirements.

MR. ZUIDEMA: This is Blake Zuidema from Arcelor Mittal. We are, obviously, producing steels in both regions, so it is equally important for us to understand the dynamics in Europe.

The fact that they are all mass-based makes the consideration very different, because light-weighting a vehicle actually increases its fuel economy. I mean Europe is all based on tailpipe emissions, but we know there is a fairly predictable link between fuel economy and tailpipe emissions.

And the fact is as the weight goes down in Europe, the requirement for tailpipe emissions also goes down. And depending on the vehicle size and starting point, the dynamic can be very different.

So the two regulations are very different. There is talk in Europe, I have heard, about changing to a footprint-based regulation as we have here. And from our initial work, the footprint base is probably going to put a lot more emphasis on weight reduction.

MR. RICHMAN: Doug Richman with the Aluminum Association. We very much support the footprint-based standards. We think it addresses technology improvement in all segments of the vehicle fleet and it avoids the unintended consequence of having a bias towards unimproved smaller vehicles that may have some, as we have seen, may have some safety issues that don't exist with the larger vehicles.

And much like Blake's experience, our colleagues in Europe actually have -- we have been in collaboration with them for a couple of years -- there is a very strong move to try to change the thinking in Europe to go to a footprint, and even among the regulators, I understand that they recognize that the footprint-based standard drives technology at all levels of the fleet and that's the real objective of these standards.

MR. SCHMIDT: Yes, as I said in my presentation, you know, that's a real conundrum for our manufacturers who try to build a global platform or global vehicle. I don't think we have yet decided which system we want to support, but, at this point, it is an issue and it is an issue that does raise the complexity of trying to design world-wide.

MODERATOR BONANTI: Okay. I think this would go to the Alliance and as well as Honda as well as potentially the two material manufacturers. We will see. We will see who wants to answer it.

To what extent are Asian car manufacturers developing or suggesting development locally of lightweight materials that they would use?

I'm sorry. To what extent are Asian manufacturers developing or supporting the development locally of light-weighting materials that they would use?

MR. THOMAS: This is Chuck Thomas. I guess that may be directed towards me, since I have worked for an Asian manufacturer, I guess.

You know, I mean, really, I mean, I don't really think there is much in the way of difference. I mean, the vehicles that we design and engineer here in the United States as well as the ones we designed in Japan, you know, we are designing them with the same types of technologies intended for the same market.

So as an example, the Accord -- last generation Accord was designed in, you know, our R&D center in Japan. It is produced here in North America. Almost all of its content is produced here in North America. The materials that are used to make the components are primarily sourced here in North America.

Yes, I don't think really so much, at least from the -- as an Asian manufacturer, there is really a difference based on, you know, where the vehicle was designed or, you know, any technologies that were being created in different regions that aren't being pushed here in North America.

Realistically, what we are trying to do is trying to push these technologies globally into all our markets as quickly as we can. So I don't really think there is any difference, as an Asian manufacturer, what we are making available here in the United States.

MR. RICHMAN: The study we have seen on aluminum is that the aluminum use in Europe -- in the developed economies, Europe, North America and the developed segments of

Asia is about the same, about 9 percent of the vehicle curb weights are aluminum in all three segments.

The segment we see may not be at 9 percent in future thinking, at this time, is the developing economy is where the starvation for any level of transportation at the lowest possible price supersedes any other of these issues.

And you know, where you get three-wheeled vehicles and motorcycles with a body on them, you know, that market yet -- that's the part we are talking about. Not yet. They are not there yet. They will be some day, but I segment developed economies versus developing economies in that discussion.

MODERATOR BONANTI: Okay. Anybody further?

MR. ZUIDEMA: Yes. From another global producer, we really see no difference in the importance of weight reduction in any of the, call them, developed or even some of the developing regions, even places like China are now getting very serious about fuel economy, safety and many of the other environmental concerns. And they are just as interested and committed to weight reduction. So it truly is a consistent global approach.

MODERATOR BONANTI: Okay. Thank you. The main focus of this session has been about light-weighting the body structure. What is being done to reduce the weight of non-structural mass, such as accessories, electric devices and so on and so forth?

MR. THOMAS: Well, we talked a lot about the body. I think somebody made the comment, you know, that's where the money is or that's where the weight is, which is one main reason we focus on the body.

But if you look at those charts, I mean, there are a lot of other areas where there is a lot of mass. A lot of the interior components, seats, instrument panels, HVAC systems contribute a lot of weight to the

vehicle.

I'm sure just like every manufacturer, you know, we are looking hard right now at trying to figure out how to reduce the weight of those.

Again, one of the problems you get into is your development cycle and your legacy structures make that difficult sometimes, because what you may have is that seat device which was designed seven or eight years ago may be used on six different vehicles whose, you know, lifecycles aren't coordinated.

So if you are going to take it out of production and replace it with something else, it takes a lot of planning, so you can introduce that all at the same time into these vehicles.

You know, we have looked at things like in the -- the next MDX, which Honda just designed, you know, the IP support structure we switched to a cast magnesium structure which is quite a weight reduction for that

vehicle.

And you know, we have looked in the past at steel and then we would kind of move to aluminum and now we are moving to magnesium.

The same thing with even the carpet and the insulation material we use. I know we are looking lighter weight insulation materials that are just as effective at reducing noise transmission into the vehicle, but don't depend so much on mass to do that.

Even the electrical systems, you know, we are looking at electrical components on where we can reduce the weight of the housing, you know, things like, you know, better electrical infrastructure and better networking allows us to cut down the amount of harnessing in the vehicle, which believe it or not, you know, is a lot of weight is actually in the electrical harness that people don't even think about.

So, you know, I think like most

manufacturers we are trying to find, you know, mass wherever we can, especially in areas where, you know, sometimes we don't think about it, because mass can sort of creep into designs that maybe traditionally aren't as mass-conscious as areas like the chassis and the body.

And I think that all of us, as manufacturers, are looking to try and improve them.

MR. PETERSON: A couple of more comments. One is relative to mass reduction in the interior. Certainly, one of the things that Lotus is looking at is using active noise cancellation. And we are projecting with some of the studies they are doing today as much as 10 to 20 kilograms of mass reduction, where you, basically, eliminate the very heavy mass sticks and use the audio systems of the vehicle to attenuate the sub-200 Hz frequencies.

And although not many cars can do

that today because the audio systems aren't there, in five or six years --

OPERATOR: All participants are now in listen-only mode.

MR. PETERSON: -- our speaker supplier is certainly projecting that many midsize cars are going to have sufficient capacity to do that, so that will almost be a freebie in terms of being able to start reducing the mass of carpeting.

A couple other areas that we like are using USEL process, which basically replaces plastic with air. And you get 30 percent reduction in material density with some increased properties where you go 1:1 with the ratio, so you can reduce apparent material thickness.

A couple other areas that we like in the interior are the ability to use the seat as a structure where you are now integrating the seat structure in the vehicle, the body structure.

If you box the seat, form the lower seat and box it to the sill on the tunnel, you now have created, basically, a box section for side impact. And it's something that was done in the 1980s by Ford and Audi, but it's a time whose time has come again, in terms of being able to help reduce the body weight by using another ancillary system to help contribute to the body structure.

MR. RICHMAN: If you haven't read the FEV or EDAG reports, the EPA and NHTSA documents, you really should because that question is really answered very, very firmly and strongly in those studies.

In fact, when we talked about the body and that's where the big mass is and we talked 14 or 15 or 16 or 18 percent, but when the vehicle got to 18 percent, every single, and if you remember the chart that stair step chart, every single vehicle system was subject to similar mass reductions.

We won't get there without

attention to every single system in the vehicle. And even today, the chassis components, engines, transmission cases, they have already -- they are 100 percent. It's already done. There is nothing left to go after except downsizing.

Suspensions are growing in lightweight materials. Brake calipers and so there is a lot of attention and there is a great menu of ideas in those two reports, those studies. And most of them are in production some place. They are not dreams. Somebody is doing them already. They are production worthy.

So it is going to take a village to get where we need to be and it's the whole vehicle. It's not -- we talked about the body, because that's the safety story today.

I have another presentation on the whole vehicle if you want to come back some time.

MR. KOLWICH: I was going to say

for the FEV report that we did for EPA, out of the 18 percent mass reduction, approximately, 4 percent of the mass reduction was body-in-white and the remainder of the 14 percent was through brakes, suspension and so on.

So thanks for the plug there, Doug, and read the report, it has got a lot of good information.

MR. SCHMIDT: Yes. I mean, I'll just kind of agree to some degree. You know, our manufacturers look at the entire vehicle. And they look at it with, you know, a magnifying glass. So there is no component, no stone that is not turned.

Now, every piece/component can potentially be light-weighted. It is the difference in cost. I mean, you can look at this piece and you can change the material. You can change the design. Sometimes you can make a more elegant design and it's almost a free cost.

You know, you can go from a so-so

design to a superior design. Sometimes to get that part down a little bit, it's going to cost new material and that would be very expensive. So, you know, what you see is the whole vehicle is looked at. Your first round of light-weighting is you are picking the low-hanging fruit.

So you are going to pull the components from all over the vehicle that you can save ounces, pounds at a low cost. Then the next round of light-weighting is going to be at the next higher cost, because, you know, you need to go even further. And therefore, you are going to pull the next level.

So it's almost a series of stratified levels of cost. And again, those weight savings are going to come from the entire vehicle pretty much.

MR. RIDELLA: I think I'm up. Steve Ridella, NHTSA. The concern I have is just across the board we have to look at tradeoffs, so that when we look at things like seat systems and IPs and restraint systems and inflaters, everything that could possibly be made lighter and cheaper, the effect on safety has to be looked at.

So I worry about just across the board with that. It has got to be selected and tradeoffs have to be looked at.

MR. THOMAS: This is Chuck Thomas with Honda. I agree with what Steve is saying. I mean, you know, when we look at, you know, taking weight out of the design, I mean, the whole goal of course is never to affect its performance.

So, you know, one thing that has changed over the years and really changed a lot in recent years is, you know, a lot of the computer modeling technology that we have available to us today allows us to do levels of optimization and a lot of like kind of what if studies that realistically in the past weren't practical in a development process, because we just didn't have the time.

You know, one of the differences I think someone said once between engineering and science is the scientist can study something for 10 years and write a paper that says, you know, he couldn't figure it out and publish it and get famous and the engineer just gets fired.

So, you know, we really need to be able to produce and we really need to be able to solve these problems. And, you know, a lot of things in the past were designed the way they were because, you know, given the time and the constraints that we had, we just really didn't have a better solution, because we have to make it work.

You know, we can't just say well, we didn't have time to solve it. We have to come up with something at the end of the day.

The other thing I was going to mention is to go to my friend Lotus here, active noise cancellations are a great idea to help with weight reduction. Honda has been doing it for several years. You may not hear about it too much, because it's quiet, but --

MODERATOR BONANTI: No pun intended.

MR. THOMAS: -- it's part of the variable cylinder management system that we use in our vehicles, for the cylinder cut system we use active noise control to help cut down on noise.

And again, these are great ideas. They are really nice technologies that are available that, you know, a lot of people don't even know about. They are actually working their way into the fleet today.

MODERATOR BONANTI: Well, there is another question. It's really for Lotus.

Had Lotus included the legacy constraints that Honda and other OEMs have dealt with? Would they agree 10 percent reduction is reasonable?

MR. PETERSON: That's a good question. And I answered it a little bit earlier when I referred to a lot of background. We had a clean sheet of paper and we had no legacy constraints. And that is what we hear from all the OEMs is all the legacy constraints that they have to deal with and the hoops they have to go through.

So I strongly feel that what we published is very accurate and achievable, but it takes a huge step to get there in terms of changing infrastructure of legacy and that's not going to happen over night.

And there is not that much time to get between here and 2025. So I would agree that a 10 percent mass reduction is probably pretty reasonable and still reasonably aggressive for the OEMs to get there.

MODERATOR BONANTI: Thank you. We have about six minutes left. I have several questions and I'll be picking and choosing. Those that are not asked or answered will be placed into the docket for further discussion.

So 54.5 miles per gallon or 40

miles per gallon, what is the actual 2025 target? And what specific scenarios would trigger EPA rulemaking?

MR. TAMM: Well, being a NHTSA guy, I can't answer the second question, but I can answer the first one. And I'll try to make it pretty brief, so, you know, we can get back to maybe some other questions about the materials.

But so if you take 54.5 miles per gallon and that includes improvements in air conditioning technologies under the greenhouse gas program and you essentially pull those back and what I should say is improvements in the refrigerants that help reduce global warming, but they don't really affect efficiency directly.

So if you account for those, it takes you roughly, I had the exact numbers, to just around 49 miles per gallon roughly is what you get.

And then the rest is going from 49

down to 40 is really accounting for the real-world fuel efficiency recognizing that the standards are based on two cycle testing which we, basically, recognize in our rulemaking analysis does not reflect real-world fuel efficiency. And 40 would be more like a label fuel economy number or label equivalent.

So but the reality is if you look at a percentage improvement, it is -- still the challenge is there because where you are starting from would be a lower label-type value to then, you know, like a 27.5 type number, which is regulatory.

MODERATOR BONANTI: Thank you, Jim. Does anybody else want to comment on that? Okay. What is being done to ensure paired vehicles are still safe and meet original safety requirements based on the criteria and the components in the materials that are being used for light-weighting? Any comments? Repaired, repaired. Did I say "paired"?

PARTICIPANT: Yes.

MODERATOR BONANTI: I'm sorry. Repaired. I'll restate it. What is being done to ensure repaired vehicles are still safe and meet original safety requirements?

MR. ZUIDEMA: This is Blake Zuidema, Arcelor Mittal. From a steel industry perspective, we have recognized for many years now that the grades that we are introducing have to be treated differently. You can't take a heat treated steel and take a torch to it on a frame straightener and pull the frame out and have the same properties.

And so we have been working extensively with the repair industries as well as the repair people within the OEMs to help develop specific guidelines for repairing materials. And now there are guidelines on what to repair, what to replace and things like that.

And this is the same process we are going to have to go through for all of these new materials. It has got to be an education for the repair community.

MR. RICHMAN: And the OEMs are stepping up to that with the new materials. We are involved with similar activities at OEM level and in the repair industry on the introduction of the new aluminum products.

So the industry knows how to step up to those. The OEMs and the repair industry are getting ready. They know it's coming and they are preparing.

MR. THOMAS: Yes. It's not exactly my area of expertise, but I know as a manufacturer, you know, we work with the repair companies to try to give them guidelines on what can be repaired and what cannot be repaired, as well as recommendations on techniques to try to make certain repairs to the vehicle.

One thing I think that from a repairability that is really kind of thing I worry about is that, you know, as we get into these new materials, you know, a piece of steel isn't a piece of steel any more. A piece of aluminum is not a piece of aluminum any more.

You know, we have seen some of this as an OEM and having problems with repairability with, you know, third-party parts that are sold to repair our vehicle with. So there are geometric copies of our components that people use to replace or repair the part, but they are not made of the same materials and they are not made to the same standards.

This is even a bigger problem when you think about in the future, you may get a body part that might be, you know, a multi-phase martensitic hot press part, very complicated, very sophisticated piece of metal and the part that you get is a piece of, you know, 270 megapascal, you know, steel that looks like the part, but it may not have the same properties.

So particularly with repairability, I think, you know, using those original equipment parts is even more so of an issue in the future when we look at these really advanced materials in the body.

MODERATOR BONANTI: Anybody else?

MR. SCHMIDT: Yes. That was one of our points was, you know, some of these advanced materials as our members, we have to evaluate what the effect is, not just building the car, but as it is being used and as it is being repaired.

And then, of course, we lose sleep at night because even if we put out guidelines that say this is a nonrepairable part, and I'm not one to pick on carbon fiber, let's say there is a carbon fiber part, it's a very expensive car, this guy crashes it, our recommendation is you replace that whole body shell, because it is -- it doesn't -- well, somebody is going to decide this is an expensive car.

I'm not replacing it and they are going to go out and find some fiberglass and some of their own carbon fiber and do whatever and then paint it up to look nice and down the road it goes.

So, you know, we can't control that, but it is a consideration in some of our material selections and again, how we try to put these guidelines out, so that not only are they out for their repair industry, but we try to minimize the incentive for people to go around the guidelines.

So it's a tough issue and we don't have all the answers.

MODERATOR BONANTI: Okay. Well, thank you. At least this one and we'll see if I can get -- grab another one.

How do the weight reductions in the light-weighted concepts in the NHTSA Fleet Study compare to the typical expected weight reductions?

MR. RIDELLA: I was thinking about

that as I was hearing this discussion that 10 percent is what you guys are talking about, but these are much higher, on the order of 20 or 30 percent. I mean, the Venza was 18 and 31 percent. The Accord was probably what 20 percent. And the Taurus lightweight was 25 percent.

So these were higher reductions that we did in the simulation than what you guys are saying now.

MODERATOR BONANTI: Anybody else care to comment?

MR. RIDELLA: Well, you will have to read it in July.

MODERATOR BONANTI: Okay.

MR. RIDELLA: Yes, something to consider. I mean, we perhaps in the future will look at more like 10 percent, but then we would have to start looking at what you guys are coming up with before we make those kind of changes. So I see a lot of interaction here in the next -- as I said, the next two or three years are going to really be important for us.

MODERATOR BONANTI: Okay. One last question and there is about six or more questions, so I apologize we didn't get to those, but I think this has been a very good discussion and exchange.

To what extent do assumptions about post-2025 regulations drive decisions now about materials and progress and processes? I thought I stumped them.

MR. ZUIDEMA: This is Blake Zuidema from Arcelor Mittal. And I think it is really way too early to start even thinking about post-2025.

We still don't know for sure that we are going to get to 2025. There are still a lot of questions on materials. There are a lot of questions on powertrain technologies. And one of the big purposes of the midterm review is to track the trends of those technologies and try to figure out if we are on a trajectory to get even to the 2025.

And I'm optimistic that by the 2018 time frame when the midterm year review comes out, we will have a much better feeling for is even 2025 going to be realistic. And that's when we can start to think, I think, a little bit more about post-2025. But we have got a lot of challenges even to get to 2025.

MODERATOR BONANTI: Okay. Well, thank you for the answers. And any last minute comments that any of the panelists would want --

MR. RICHMAN: Well, I was going to put in a plug for the 2025 standard, because it did a really important service to our entire industry. It gave clarity to all the planners.

The uncertainty of what the future may hold, at least from a regulatory standpoint, became clearer. And I have seen better alignment across the industry to a standard than I have ever seen in my career.

So it really has -- it has just taking the uncertainty out of the planning cycle. There is still the uncertainty of can it be -- can it happen? But there isn't a whole lot of uncertainty about what are we trying to do by then and that has really helped a lot.

MODERATOR BONANTI: Okay. Well, thank you very much. We have a -- no, you can't leave yet. There is a wrap-up that Jim Tamm is going to be providing and I think what I would say is tomorrow, I think, the agenda starts at 8:30 in the morning. I'm looking forward to seeing everyone here at 8:30 and I'll give five minutes to Jim to do a wrap-up session. Thank you.

(Applause)

MR. TAMM: Okay. I'll see if I can finish this in less than five minutes, that's my goal.

But first on behalf of NHTSA, thank you to all of the participants today, particularly those who presented. We appreciate how much time it takes to prepare. The presentations were all very outstanding today, so we thank you for that.

Also for the discussion and answers to questions, we got a whole stack. We are delighted. I mean, we had to go to the store to get more index cards, but we are delighted to have all the questions we had today.

So also thank you to the audience for participating and bringing up the questions.

So just as an overview, we started the morning and we talked about, from the Agency's perspectives, how we go through and assess mass reduction for fuel efficiency and also for safety.

We also had discussions of the various mass reduction projects that the Agency has sponsored.

And then in the afternoon, we got

into some feedback related to those studies and some of the concerns and limitations from manufacturers and the associations as well as from the various material groups.

So we also had a presentation on the NHTSA assessment of some of the new lightweight designs and the impact in our first phase analysis of what the impacts would be on societal safety.

So with that again, thank you to everybody. As Chris mentioned, tomorrow's program begins at 8:30 in the morning and we are -- the topic tomorrow is going to focus more on the real historical analysis of crash data and what that tells us about societal safety and mass reduction in vehicle size.

So thank you once again for your participation today. We are very pleased with how things went.

(Applause)

(Whereupon, the symposium was concluded at 5:36 p.m.)

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C E R T I F I C A T E

This is to certify that the foregoing transcript

In the matter of: Mass-Size-Safety Symposium

Before: DOT/NHTSA

Date: 05-13-13

Place: Washington, DC

was duly recorded and accurately transcribed under my direction; further, that said transcript is a true and accurate record of the proceedings.

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