UNITED STATES DEPARTMENT OF TRANSPORTATION

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

MASS-SIZE-SAFETY SYMPOSIUM

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Deposition Services, Inc.
12321 Middlebrook Road, Suite 210
Germantown, MD 20874
Tel: (301) 881-3344 Fax: (301) 881-3338
info@DepositionServices.com   www.DepositionServices.com

A P P E A R A N C E S

Dan Smith - Moderator
National Highway Traffic Safety Administration

Rebecca Yoon - Internet Questions
National Highway Traffic Safety Administration

A P P E A R A N C E S (Continued)

A P P E A R A N C E S (Continued)

P R O C E E D I N G S

MR. SMITH: Welcome everyone to beautiful, sunny Washington, D.C. Actually, we've had a better winter this year than last. I'm Dan Smith. I'm the Senior Associate Administrator for Vehicle Safety at NHTSA. We're going to try to get started on time, or close to it, and remain on time. I really appreciate everyone coming here, our friends and colleagues from around the country, to make presentations on this complicated subject but I think getting everything out here, getting everybody's thoughts conveyed all in one symposium I think is a really important, an important step. Welcome our friends from EPA who are here I think and from, thank you, and perhaps from CARB, I'm not quite sure whether they've made it here, and from various parts of the industry, perhaps environmental groups. Welcome all of you.

We have a really full agenda and this room eventually I think is going to be filled in capacity in terms of the number of people who have signed on to come. We ask everyone to be courteous, make room for others if it does get crowded by not piling things on the seats.

A few housekeeping items. You've all got visitor's badges I think. You need to keep those on and be accompanied by an escort, and we have escorts outside, I think, to accompany you through the building. We have, you know, visitor's passes of course that you've all got. You need to wear those throughout the day. We're not supposed to have food in here except covered drinks and so that's, that's basically the rule of the room here. There is a small coffee shop outside if you need it during a break. Of course, we've got a cafeteria here at lunchtime.

Please take your, your BlackBerrys, cell phones and other devices in hand and shut them off so we don't have ringing phones throughout the presentation. We've got bathrooms and water fountains outside the conference center and to the left. We'll have a break for lunch about 12:15. We'll have a break before that as well. Again, the escorts are going to be out there to show you where the cafeteria is or lead you to the, the exit. There are some restaurants, not a lot close by and is a rainy day so the cafeteria might be the better choice. Those escorts will be available to get you back in the building, get you back here at 1:00 p.m. and we'll resume at 1:15.

You've got the agenda I'm sure. You can see that it's very full. Our speakers each have a limited time so we ask that you hold your questions, both those of you who are here and those of you who might be watching the webstream or webcast, you hold your questions and comments until all the panel presentations have been completed and then we're going to have 45 minutes or more of questions and answers. I'll try to lead that discussion. I think it will probably lead itself because there will be lots of, lots of give and take, but one of my jobs here is to, is to make sure that we try to stay on time because it is a very crowded schedule for the day.

I'll show my age here. I remember a show called the Gong Show. I'm not sure if any of you are old enough to remember the Gong Show but I couldn't bring a gong today, but for those of you who don't remember or are too young to know, it was an entertainment show in which when the audience got a little bit dyspeptic about the presentation, someone would go up and hit a giant gong and the presenter, the performer would have to then sit down.

Now, we don't have a gong and I'm going to be sitting over here watching the time and if I do happen to get out of the chair and come this way when you're presenting, imagine that I've got that mallet and I'm going toward the gong. And if I actually get up here and you're still talking, then consider yourself gonged because we really do need to get through the presentations so that all of our great presenters have the opportunity to make their points and then have a good conversation.

When we get to questions and answers, it's going to be also a situation where we may have the limit of time. Some folks have a way, and I'm probably one of them, of doing a windup to a question that itself takes four minutes which may qualify you for politics but it won't work here today. We're going to need to have brisk questions put and then, and then full discussion.

If you've got, either those of you here or those of you observing the webcast, anything that you want to submit, we've got an open docket. The docket is NHTSA 2010-0152. You can find that at http://www.regulations.gov and we'd be happy to help you use that if you've got any questions about how to use that for submission of anything you want to submit. The docket will remain open for about 30 days after this symposium, and we're going to expand the Mass-Size-Safety webpage that we have to include today's presentations and a transcript of today's workshop, information on how to find the docket and other related information. So those are the ground rules. We're going to try, as I say, to stick to the time.

And let me first of all introduce our first speaker. Most of you, I think, or many of you do know Ron Medford. You know that he had a very long and illustrious career at the Consumer Public Safety Commission before joining us here at NHTSA as the Senior Associate Administrator for Vehicle Safety where he served for about seven years. He then was the Acting Deputy Administrator during a year in which we had no actual appointed administrator, so Ron ran the agency during that time and then became our deputy administrator.

Ron is a passionate advocate for all things related to safety and a passionate advocate for the best kind of fuel economy and of course, with our partners Greenhouse Gas Rules, that we can possibly create, and so this is a person who actually has a, is really steeped in all of these issues. Let me, therefore, ask Ron Medford to come up and provide our first, our first presentation. Thank you, Ron.

MR. MEDFORD: Thanks, Dan. Good morning everybody. Thanks for coming today. I think this is an important issue and this workshop is probably long overdue, so we hope that we do fill the room up. First of all, I want to welcome to you to the first workshop on the effects of light-duty vehicle mass and size on fleet safety. We hope this will be the first of potentially several workshops that NHTSA will sponsor to help us dig deeper in to this important issue.

Well, why are we here today? NHTSA and EPA have begun the monumental task of developing fuel economy and greenhouse gas standards for light-duty vehicles for the model years 2017 and beyond. We know that this is a long way out but we’re confident that providing lead time and certainty will create a National Program and will help manufacturers make decisions that will allow them to meet strong standards and improve our Nation's energy security and reduce greenhouse gas emissions.

As you all know, we've already set standard for model years 2012 through 2016. The industry stood with us when we announced these standards and confirmed their willingness to rise to the challenge we set at that time. Make no mistake. We already know that the 2012 and 2016 standards are challenging. All manufacturers will need to apply more and new technologies to meet them.

As we look forward to 2017 and beyond, we have to consider what technologies will be available in those model years for manufacturers to even meet more stringent requirements. One of the technology options that manufacturers can and are likely to choose is to make vehicles lighter. A lighter car or truck will consume less fuel. We'll be considering mass reduction, along with other technologies, in evaluating what levels of standards will be feasible for model '17 and beyond in part, many OEMs have already announced that they intend to invest in mass reduction and in new smaller vehicle designs as a way of meeting future standards.

The other important point of note about the rule-making for 2017 and beyond is that the administration has recently agreed to harmonize the timing of our proposal with the California ARB process for establishing GHG standards for that state in light-duty vehicles. As a result, NHTSA and EPA are working on a little faster plan than we originally announced, that is September 1 versus September 30th, but we're optimistic by working together with CARB, we can reach an agreement on issues like the effect of mass and size on safety and be in a better position to ultimately develop effective, safe and feasible National Program and provide manufacturers with the certainty they need to plan the next generation of fuel efficient vehicles.

What questions are we trying to help answer through this and future workshops? If manufacturers are going to reduce vehicle mass or build smaller vehicles in order to meet future CAFE and GHG standards, we want to know ahead of time whether there will be safety implications as a result and if so, what those implications might be. NHTSA has long been required by case law to consider the safety effects of CAFE standards and the EPA has the discretion to consider safety effects of GHG standards under the Clean Air Act.

Part of estimating potential safety effects is understanding the relationship between mass and vehicle design. The extent of mass reduction that manufacturers may be considering to meet more stringent fuel economy and greenhouse gas standards may raise different safety concerns than the industry had previously faced. For example, manufacturers may need to make a lighter vehicle stiffer to protect against intrusion but making a vehicle stiffer affects both the forces on the vehicle occupants in a crash as well as the forces that the stiffer vehicle exerts on the partner vehicle.

We are also concerned that lighter vehicles have a higher change in velocity, or Delta V, and thus, higher injury and fatality risks during collisions with heavier vehicles, sort of a compatibility issue. This will be especially important as heavier legacy vehicles will persist in our fleet during the transition into lighter and smaller vehicles.

We don't think these are straightforward questions. We have to try to estimate ahead of time how mass reduction might affect the safety of lighter vehicles and how these lighter vehicles might affect the safety of drivers and passengers in the entire on-road fleet as we're determining how much mass reduction we should consider in setting CAFE and GHG standards. We want to make sure that we're encouraging manufacturers to pursue a path toward compliance that is both cost-effective and safe.

So how have the agencies started to try to answer these questions? NHTSA, along with EPA, DOE and CARB, have undertaken a number of studies to evaluate appropriate levels and techniques of mass reduction that manufacturers could consider for model years 2017 and beyond.

We're approaching these questions from two angles. First, we are using a statistical approach to study the effect of vehicle mass reduction on the safety historically. And second, we are using an engineering approach to evaluate the affordable and feasible amount of mass reduction achievable while maintaining vehicle safety and other major functionalities such as NVH and performance. At the same time, we are also studying the new challenges these lighter vehicles might bring to vehicle safety and the studying of potential countermeasures available to effectively manage those challenges.

For this workshop, our goal is to explain the agencies' ongoing studies and to solicit different ideas about how the agencies should consider the questions. We hope to come back to these questions in a few months after we've had a chance to complete some of these studies so that we can discuss them in more detail than we're able to do today. Hopefully, we can develop a plan to incorporate the different ideas raised from this workshop.

How are the agencies using statistical analysis to evaluate fleet-wide safety effects of mass reduction? Researchers have been using statistical analysis of historical crash data to evaluate trends in vehicle safety due to mass reduction for over 10 years. Dr. Chuck Kahane from NHTSA, Dr. Mike Van Auken of Dynamic Research, Inc., and Mr. Tom Wenzel of Lawrence Berkeley Labs, among others, have published a number of analyses of vehicle mass, size and safety.

As we know, these analyses have come up with different results, some associated a significant fatality increase with mass reductions while others associated a fatality decrease with mass reduction. We suspect that part of the reason for these different results stems from the fact that the analyses are often based on different databases and different statistical methodologies.

In order to try to resolve these concerns to support the upcoming CAFE and GHG rule-making for 2017 and beyond, the agencies have kicked off the following studies.

First, NHTSA has contracted with UMTRI to provide an independent review of recent and updated statistical analyses of relationship between vehicle mass, size and fatality rate. Over 20 papers and studies have been reviewed including studies done by Kahane, Wenzel and DRI, among others. We've charged the reviewer with reviewing the validity of the studies in terms of the data the studies are based on, the methodologies used and the potential utility of those studies in predicting the possible effect on fatalities and injuries of mass reduction for future vehicles.

Second, NHTSA and DOE, with help from EPA, are working closely to create a common updated database for statistical analysis. This database consists of fatality data of model years 2000 through 2007 vehicles in calendar years 2002 through 2008. We intend to share this database with the public once its created and confirmed to be robust. We hope to significantly reduce, and perhaps eliminate, any discrepancy in results due to differences in input data by using a common database.

Using this updated database, Dr. Kahane will update his 2010 fatality study that examined crash data for model years 1991 through 1999 vehicles in calendar year 1995 through 2000, and Dr. Wenzel will also extend his 2010 causality study. Dr. Wenzel will also seek to replicate Dr. Kahane’s updated study using the same database and the same methodology.

And third, NHTSA initiated an independent peer review of Dr. Kahane’s 2010 study. NHTSA has created Docket No., I think Dan mentioned this, 2010-0152 for this peer review and two peer reviewers’ reports are available to be read there.

So how are the agencies using engineering studies and crash simulation to evaluate how much mass can be feasibly reduced from a vehicle and how making a vehicle lighter might affect the vehicle's safety for its occupants?

Vehicle manufacturers, government agencies, supplier groups, universities and other interest groups have been sponsoring studies trying to determine how much mass can be reduced from a light-duty vehicle. These studies vary in many respects. Some focus only on the body-in-white enclosures, some focus only on using certain materials, such as high-strength steel or aluminum, some consider costs broadly and some are more limited.

Determining the feasible amounts of mass reduction is a complicated undertaking. A study's results can vary depending on how many factors are being included: The baseline vehicles employed, the mass reduction techniques considered, the cost constraints, the extent to which vehicle functionality is maintained and the applicable time frame of the study. A solid answer to this question will include all of these factors which means that the agencies have to consider a number of available studies to ensure that all of these factors are evaluated since very few studies account for all these factors at the same time.

In order to try to come up with a solid answer that is applicable to high-volume production vehicles and based on the most up-to-date technologies, the agencies have kicked off the following studies.

First, NHTSA has begun a project with Electricore, with EDAG and George Washington University as subcontractors, to study the maximum feasible mass reduction for a mid-size car. The project will consider the use of multiple materials and consider mass reduction in all vehicle subsystems. The redesigned vehicle will need to maintain a plus or minus 10 percent cost parity to the baseline vehicle and either maintain or improve vehicle functionality.

As part of this project, the contractor will build a CAE model and demonstrate the vehicle's structural performance in NHTSA's NCAP and roof crush test and also, in IIHS' offset and side impact test programs. This study is on a very aggressive time line and we plan to have it completed in time to support the final rule for the CAFE and GHG's rule-making for 2017 and beyond.

Second, because meeting NCAP and IIHS tests is only part of the story with regard to how a vehicle will perform in vehicle-to-vehicle crashes, NHTSA will use the model developed by EDAG to perform a variety of vehicle-to-vehicle crash simulations to study the effect of vehicle mass reduction and investigate the consumer countermeasures for significantly lighter designs. The study will evaluate how the proposed design will perform in a variety of simulated crash configurations. This study will also include an evaluation of potential countermeasures to reduce any safety concerns associated with light-weight vehicles.

And third, the agencies are working on the next phase of the Lotus light-weight vehicle study for CARB that came out last year. As you are probably aware, the first phase of the Lotus study has produced two designs for light-weighted vehicles, a high development scenario that reduced the mass of its 2009 Toyota Venza by 38 percent and a low development scenario that reduced mass by 23 percent.

In the second phase of the study, Lotus is validating the high development design by creating a CAE model and performing crash simulations. NHTSA is actively involved in the second phase of the study with Lotus and EPA by performing crash simulations and validating the model. Lotus and the agencies are having biweekly meetings to evaluate the safety performance of this model. NHTSA also hopes to incorporate the Lotus vehicle model into the simulation study to account for a broader range of vehicle designs.

Additionally, EPA has also contracted with FEV and EDAG to take the Lotus low development design and do an engineering evaluation and cost study. The final model will also be given to NHTSA to do fleet evaluation and crash simulation.

So that's a lot of information, and you'll hear a lot more detail about all of these studies over the next several hours through the course of the day but in a nutshell, NHTSA and the other government agencies have a number of studies underway in all major areas of vehicle mass reduction and safety analysis and we're excited to get input from stakeholders and the rest of the public.

We may not have a lot of time for questions and answers from the audience today, given how much material we have to get through, but we're making a transcript of the proceedings and we encourage you to submit your comments to the docket. So listen. I hope you have a productive day. It should be interesting, and I hope everybody respects everyone's different views and that you have lively and productive conversations. Thank you very much.

MR. SMITH: Thank you very much, Ron. We appreciate the opening remarks. I'm not sure I was quite clear about how the questions will work, but we will have the first the three presenters, we'll have a break. Then we'll have the next three presenters and then after they have presented, then we're going to go to the focused discussion so if you can hold your questions until then. Those who are watching online, there's a place above the video display as you're looking at your screen, there is an icon you can click to ask questions and then you can type in your questions and our folks here will be fielding those and providing them to me so we can put those to the panel.

The very first presenter we have, and some of you folks I have not met and if I mangle your names, I apologize in advance, but this person I certainly, certainly know. He's one of our own. Dr. Charles Kahane, better known as Chuck Kahane, from NHTSA is going to discuss for us the relationships between fatality risk, mass and footprint. So, Chuck, it's all yours.

MR. KAHANE: Good morning. The National Highway Traffic Safety Administration published a report on relationships between fatality risk, mass and footprint about a year ago and we're right now in the process of updating that study with more recent data. The objective of all these studies has been to estimate the effect on societal fatality risk of mass reduction without changing footprint. By societal fatality rate, I mean not only what happens to the occupants of my own vehicle but what happens to the occupants of other vehicles in the crash and any pedestrians. Footprint is the measure of size which is the track width times the wheelbase.

The reason this is the objective is that the CAFE standards are footprint-based standards whereby mass reduction is a viable method to improve fuel economy, but a footprint reduction would be self-defeating because it would really require the vehicle to meet the more stringent standard. And that in turn, the reason they're footprint-based standards is the belief that maintaining footprint is beneficial to safety.

Let’s talk for a few minutes about what is mass and what are the likely impacts of mass on safety. Now, when people talk about removing mass without changing footprint, many times this conversation sounds very abstract like mass is something you can take in or out of a car without changing anything else. It’s almost as if you were adding or removing sandbags from the trunk of a vehicle. But in actual practice to date, and the day that we’re looking at, whenever they change mass, it’s usually changed for a reason, most typically to add luxury features or more powerful engines, but there’s even cases where mass has been added in a way that benefits safety, namely to add protective structures or additional safety equipment. Now, in the future, we’re going to see more of mass changing deliberately being reduced by substituting lighter and stronger materials for existing materials. Now it goes maybe a little closer back to that abstract idea.

The classic way in which mass effects safety is conservation of momentum, or the Delta V ratio, in a collision between two light vehicles. Basically, the lighter vehicle has higher Delta Vs, it’s higher risk, than a heavier vehicle with lower Delta V at lower risk. If we remove mass from my vehicle, it’s going to make me relatively lighter. It's going to harm me and it will help you but this is not a zero sum game. This is the important point is that it depends on the relative mass of the two vehicles.

If my vehicle is the lighter vehicle, which has a high fatality risk, then taking mass out of my vehicle will give me more absolute harm than it will help you. And if mine's the heavier vehicle, mass reduction will help you more than it harms me. Now, at least in theory, if you proportionately reduce mass from both vehicles, at least on momentum consideration, it should make null that effect because the Delta V ratio would stay the same.

In addition to momentum considerations, mass has some relationships with handling and stability but these can cut both ways. If mass is added in a way that raises the center of gravity, it would make the vehicle less stable and increase the risk of roll-overs, running off the road but this could be, for example, in the case of powerful engines. But sometimes mass can be added in a way that lowers the center of gravity. For example, sometimes four-wheel drive, and that could actually enhance stability.

Similarly, a heavier vehicle, all else being the same, will respond more slowly to steering and braking and in general, that's bad if someone wants to make a wise maneuver that would prevent a crash but it could also be beneficial if someone would be making an inappropriate maneuver that would lead to a crash. It would be good to slow them down.

There are a few situations where mass has unequivocal benefits. You may be able to knock down a medium-sized tree or pole that would have otherwise brought your vehicle to a complete stop and in collisions with medium-sized trucks, heavy trucks but not that heavy where there's very low fatality risk in the other vehicle or an unoccupied parked car, deformable or moveable object where there's no fatality risk to the other party, increasing your mass will reduce your risk while not really doing harm to anybody else.

While we're on the subject, let's talk about footprint. In general, footprint is beneficial across the board, both in crash avoidance and crashworthiness. Having a wider track should improve your stability and having more vehicle around you at least gives an opportunity for more crush space where you can absorb the energy and protect the occupant. And then there's one additional factor which is important. It's a historical trend that's been around as long as we've been studying vehicle crash rates, and this is that heavier and probably larger vehicles tend to be better-driven. And one evidence for this is that if you look at two-vehicle collisions, the heavier vehicle is less often culpable, at fault, for this getting into the collision.

Now, this is a trend. This is a fact. But the question here is is mass a cause and effect or merely a byproduct. If there's something about a big, heavy vehicle that makes people drive more carefully, then that's a real issue because as vehicles get lighter, they would lose that. But if it's merely some intangible thing that causes good drivers to pick these big vehicles, then that would not really be important because if you made all the vehicles lighter, everybody would still pick the vehicles they wanted but it would be just be sliding down the scale.

The agency's report was published as part of the final regulatory impact analysis for 2012-2016 CAFE about a year ago, and it is a statistical analysis of fatality rates in model years 1991 to '99 cars and light trucks and vans, what we call LTVs, in calendar years '95 through 2000. That was the latest database we had available at the time analyzing fatality rates by a curb weight and footprint and they are the societal fatality rates per billion vehicle miles of travel. Now, we get this vehicle miles of travel based on registration years from Polk data and the very rudimentary VMT statistics from our National Automotive Sampling System.

We used induced-exposure crashes from eight state crash files and induced-exposure crashes, these are non-culpable involvements in two-vehicle crashes. Basically, I'm just driving, minding my own business and somebody comes and hits me so my chance of that happening that to me depends on how often I'm there, how often I'm on the road, and it's a surrogate for exposure.

With these induced-exposure crashes, we can take that VMT and those registration years and apportion them by driver age and gender, urban versus rural and other factors. It is logistic regressions on six types of crashes. Rollovers, collisions with fixed objects, pedestrian, bike and motorcycle, heavy trucks, collisions with cars and collisions with LTVs.

The independent variables are curb weight which we have as a two-piece linear variable so that we're able to get a separate estimate of the effect of mass reduction in the lighter vehicles and in the heavier vehicles of a certain type. Footprint is a separate variable. Driver age and gender, environmental variables such as rural and urban, safety equipment such as frontal air bags, ABS and all-wheel drive or four-wheel drive, the vehicle age and the calendar year.

These were the principle results of that study and basically, in the lightest cars, mass reduction, while holding footprint constant, is associated with significant fatality increase. In the heavier LTVs, it's associated with a significant fatality reduction because above all, it protects people in the cars that get hit by these LTVs. And then the 200 mediate groups, the effect is not statistically significant but leaning ever so slightly in the direction of more fatalities.

Now, let's talk about these effects in terms of what I talked earlier about, likely effects of mass on safety. The idea that mass reduction is harmful in the lighter cars and beneficial in the heavier LTVs, especially in collisions of two light vehicles, is exactly what we talked about in momentum considerations. If you take mass out of the lighter vehicle, you do more harm than good. If you take mass out of the heavier vehicle, you do more good than harm.

Footprint was beneficial in all crashes but especially in the, in the single-vehicle crashes involving rollover or impacts with fixed objects whereas mass reduction was actually even beneficial or at the very worse, not significant in the rollover and fixed object crashes. And this is consistent with the idea that for the most part, that extra mass is pretty high up and remove it, and the vehicles that have less of it tend to have lower center of gravity. However, we do have some caveats about the results because of collinearity between the mass and footprint variables.

And that last issue I talked about, the historical trend of higher fatality rates in the lighter cars because heavier cars are, bigger cars are driven better, this may have something to do with that slight tendency that three of the four vehicle groups, although only one significant, had an increase in fatality risk as the vehicles got lighter.

So the conclusion from that study a year ago is that any reasonable combination of mass reductions, any foreseeable combination of mass reductions were, at least in absolute terms, possibly in relative terms, if you take more mass out of the heavier vehicles and you leave the lightest cars alone or take only a little mass out of them is going to be pretty much safety neutral. You will not see a significant increase in fatalities and with the scenarios that we're talking about, you're very likely to see a decrease.

The 2010 report was peer reviewed by Charles Farmer of the Insurance Institute for Highway Safety and Paul Green of the University of Michigan, and both of those reviews are already in the docket and both of those organizations will be speaking to you shortly. And also, by Anders Lie of the Swedish Transport Administration. And we're going to use their suggestions, their recommendations in the study that we're doing right now with more recent vehicles, namely, model years 2000 to 2007 in calendar years

2002 to 2008 which is about eight or nine years ahead of the database that we had for the previous study.

Let's talk for a few minutes about what have been the developments in vehicles during the past decade and how they may affect how we want to do our followup study. I think the most notable development has been the huge increase in crossover utility vehicles which although technically classified as light trucks, have many features of cars, both in the way that they're built and in the way that people drive them, and they have much lower rollover risk than past SUVs. Another development is that all the vehicles got bigger and heavier by several hundred pounds at least in each class of vehicles and especially in pickup trucks.

At the same time, during the past decade, there's been an almost unprecedented improvement in safety as evidenced by the lowest fatalities we've had in many decades. And there's both specific and the general I want to emphasize. Specifics. We have frontal air bags now in all new vehicles, electronic stability control will not only reduce fatalities greatly but will change the whole accident scene with rollovers and fixed object impacts being much less of the total. Increased belt use and curtains and side air bags are providing additional protections.

And now in the more general, during this past decade, we saw a lot of the poor safety performers getting phased out. There are many reasons for this but I think one thing I'd like to cite is the Insurance Institute's offset testing has set a high bar for the manufacturers to try to design their vehicles.

So these are the issues raised for the followup analysis. What do we do with the crossover utility vehicles? Do we make them a separate vehicle category, combine them with cars or just leave them with the light trucks? We want to study tools to address the issue of collinearity of curb weight and footprints. If our analyses can consider not only the mass of a case vehicle but the mass of the other light vehicle in two-vehicle crashes, we might get more accurate results and also, results that are better suited for saying what will happen in the future when both the new vehicle fleet and the on-road fleet keep getting lighter in mass.

We would like more detailed VMT data such as odometer readings by make and model and will need new control variables to address new safety techniques such as electronic stability control, curtain air bags and the Insurance Institute test results. And this electronic stability control, in addition, will majorly change the baseline fatalities by eliminating many of the rollovers and fixed object crashes.

I'd like to close on somewhat of a sour note, namely the limitations of historical, statistical analyses of crash data. These are cross-sectional analyses. In other words, what we're comparing here is the fatality rates of two different vehicles, this one light, this one heavy, rather than looking at a specific vehicle where mass was removed specifically and then looking before and after as to what it did.

No statistical analysis can control for all driver factors. Now, we can control for driver age and gender but we can't control for some intangible thing that, for example, makes better drivers pick bigger and heavier vehicles.

And of course, historical analyses lags behind the latest vehicle developments which in the context of what we're talking about here is that we're studying vehicles that were still getting heavier year by year when in the future, they will be getting lighter and furthermore, the intentional mass reduction by substituting lighter and stronger materials was not yet all that wide-spread in 2007 let alone 1999. Vehicles mostly became lighter or heavier for other reasons, namely to add or to remove features that consumers either wanted or no longer wanted.

However, offsetting these negatives is one big positive. These are real people driving real vehicles involved in real crashes and you can't ignore them. Thank you very much.

MR. SMITH: Thank you, Chuck, very much. I was remiss in introducing Chuck in not pointing out what an institution he is here at NHTSA. He is the man with the data. He made the ultimate sacrifice today. He did not wear gym shoes to work. He's wearing regular dress shoes. But thank you very much, Chuck, for that excellent presentation.

Our next presenter, from Lawrence Berkeley National Laboratory, is Mr. Thomas Wenzel who will speak on analyzing casualty risk using State data on police-reported crashes, so thank you very much and sorry we haven't met before but nice to meet you now. You've got your clicker here and minutes.

MR. WENZEL: Thank you. I just want to point out that I've made a concession today. I normally wear, I'm from California. I normally wear shorts to work so this is quite a change for me.

I want to commend Chuck. That was a very good presentation not only of what his analyses have shown in the past but sort of the benefits and limitations of this kind of analysis and it touches on some of the points I wanted to raise as well so I think it's a good introduction to my talk. Is there a way of turning that into a presentation?

It's a PDF.

Great. So this slide is just a background, you know. This is what we all recognize. Reducing mass is a quick and an inexpensive way to reduce CO2 emissions but previous analyses have indicated that lowering mass in vehicles does increase risk so that's something we need to be very concerned about. NHTSA studies in particular have estimated what affect the mass reduction has on risk. As Chuck pointed out, they typically look at fatality risks per vehicle registration year or per mile, mile driven in vehicles. They use the logistic regression analysis which allows you to control for a crash, vehicle and driver characteristics.

The coefficients, they have two. As he said there's a two-stage procedure where they estimate the effect of changes in vehicle mass on risk for both lighter and heavier versions of the same vehicle type. And as he said, he looks independently at six different types of crash and with the two major vehicle types, cars and trucks, and this is all the historical analyses that he's done in the past. He mentioned ways of enhancing analysis by perhaps treating crossover utility vehicles as a separate vehicle class.

He also pointed out that regression analyses, by their nature, are historical in their perspective, you know, the 2003 analysis looked at model year '91 to '99 vehicles so, you know, those are 10 to 15-year-old vehicles at the time of the analysis. What he and we are proposing to do for this current analysis will be looking at model years 2000 and 2007.

So that's a limitation with this kind of analysis. It's looking at the recent historical relationship between vehicle mass and safety and you can't really use that to predict what the relationship will be in the future. Particularly when new technologies will be introduced that don't exist in the fleet today or don't exist in large numbers in the fleet today.

So what's our role in this upcoming analysis? I have many years experience looking at fatality risk by vehicle registration year and particularly looking at that risk by vehicle make and model and when Chuck mentioned societal risk, what we were very interested in is separating what Hans Joksch called the risk to driver or risk in, which is the risk to the driver of a particular vehicle, separating that from the risk by a vehicle, the risk to drivers of other vehicles. And Chuck combines those two to measure societal risk, which is the right thing we should be doing, but it's also instructive to see, to break that out into the risk to yourself and the risk to drivers of other vehicles.

Last year, we were contracted with, by DOE to do a similar analysis to Chuck's analysis with guidance from EPA and there's really two pieces of that. The first task of our contract is to replicate the analysis Chuck is doing, use the same data, same methodologies and just sort of consult with him about possibly adding potential variables, trying different techniques just to make sure that we have a robust analysis, an analysis that gives us results that are robust to different changes and parameters. So it's sort of a shadow analysis using the same data and methodologies.

The second task is to conduct a separate analysis using a different set of data and that's what I want to talk a little bit about today. In this analysis, we're going to be looking at casualty risk, not just fatality risk, and casualties include fatalities as well as incapacitating or serious injuries and the casualty analysis will be conducted only using state crash data. That is police-reported crashes from states. And I'll get into the reasons for that a little bit later but the intent is to take a somewhat different approach to looking at the relationship between vehicle size and weight and risk and see if the results are similar to what results Chuck gets when he focuses on fatality risk.

So this sort of describes the two analyses, the first part Chuck went over in pretty much detail. The numerator is total U.S. fatalities from the FARS data system. The denominator of the metric of risk is induced exposure, which is vehicles that are not at fault in a crash, and those data come from the state crash data and in the new analysis, that will be, probably be 13 states as opposed to the 8 states that were available in the 2003 analysis. The beauty of the crash data is it provides a host of information on the conditions of the crash and the driver of the crash, so we can control for driver characteristics and crash characteristics.

In Chuck's analysis, he then takes those induced exposure crashes from the state level and scales them up to the national level using registration data from the Polk Company, national and state level registration data, and then if he wants to do the analysis based on vehicle miles of travel as opposed to registered vehicles, he uses some data. In the past, he used data from the NASS system. I think that Polk is, NHTSA is able to get data from CarFax which will now get them more detailed VMT data from, by make and model from a lot more vehicles so a little more robust data. And the bottom line though is what he's looking at is national fatalities per vehicle, per vehicle or if he chooses to, he can do that per vehicle mile.

What we're proposing to do is we're going to take all the data from one data set. We're not going to be involved, we're not going to have to use Polk data to scale up to the national level. We're going to use all data from 13 states. And we're going to look at, in the numerator, we're going to have fatalities in addition to the casualties, which are fatalities plus the serious injuries, so we'll have two different measures of risk. And the denominator, instead of trying to scale it to vehicle miles, we're going to do it per crash in the crash database.

If we want to, we can do the same approach that Chuck does where he scales the crash data up to registration, national registration levels, to get risk per vehicle as opposed to risk per crash, but our primary goal is going to be looking at casualty risk per crash rather than casualty risk per vehicle or mile. That's how we're going to distinguish the results from the Kahane results.

So what are the similarities in the two approaches? Well, we're both going to use the same techniques to estimate the effect of vehicle size and weight on risk and we're going to use the same vehicle variables to account for driver characteristics and crash characteristics as well as vehicle characteristics.

Chuck has been working hard to assemble a database of vehicle characteristics which not only include curb weights and footprint but a variety of other measures, air bags, presence of air bags, ABS system, four-wheel drive systems, ESC, a whole host of vehicle characteristics which we'll be using the same set of data so we make sure that any differences in our analyses will not be due to the data that we're using. And as I say, I'm going to be looking at casualty risk for crash, but we can convert that to casualty risk per mile so that we will be able to compare the two types of risk using the same metric.

Now, there's differences between the two approaches. One of the benefits of what we're going to be doing is that we're using the data, as I said earlier, all from the same data set, so there's no issue of possible bias that we'll be introducing in the data by having to scale it up to the national level. And if, we may find that using 13 states or possibly even 16 states gives us enough fatalities in those states to also make an estimate on fatality risk in addition to the estimate on casualty risk so that would be directly comparable to the fatality risks that Chuck will be analyzing in his study.

One of the benefits of looking at risk per crash is if risk per crash is sort of a measure of the crashworthiness of the vehicle and as Chuck mentioned, the risk per vehicle is measuring not only the crashworthiness of the vehicle but also, how well vehicles are designed or driven to avoid crashes in the first place, the crash avoidance perspective. And so looking at, we have the capability, hopefully, to look at both pieces of that in this analysis depending on how many fatalities and casualties we get in the state data.

Now, there are drawbacks to this approach. One is that we're limited to the 13 states that provide the vehicle identification number information we need and whether those states are, whether risk, the relationship between weight and size and risk is similar across the states may introduce some amount of bias in the analysis and whether those 13 states are representative of the country as a whole. We need to get a handle on that.

And as I said earlier, if we want to look at fatality risk using the state crash data, hopefully, there will be enough, well, hopefully, hopefully, there will be enough fatalities in the 13 states that we'll have robust analyses and be able to get an estimate on fatality risk in addition to the casualty risk.

So up to this point, we have been working assembling the vehicle parameter database and I've been working on getting the state crash data in-house and cleaning it up and getting that in order so I don't have any results to present yet. But what I am going to quickly go over is an analysis I did last year where I compared these two different measures of risk in a very detailed way to get an understanding for what differences we might see in the risk by vehicle type using these two different measures.

So I used data from model years 2000 and 2004 using crash data from 2000 and 2005 from five states, and I got Polk registration data for those five states to look at risk so I could use the crash data to look at risk per crash and I can convert that to risk per vehicle as well. And I'm going to quickly go through all of these issues that I looked at.

First, I compared the fatality risk per vehicle from these five states with the casualty risk per vehicle to see what differences we see there. And this plat shows the risk by vehicle type ranging, these are the cars over here, vans, SUVs, crossovers and pickup trucks. And on the left-hand side, I have fatality risk per vehicle and on the right-hand side is casualty risk per vehicle. And as you can see, for most vehicle types, they're very similar. They're -- I normalized the two scales to mid-size cars so these two points overlap. But for most vehicle types, the risks are quite similar with the exception of sports cars, which have a lower casualty risk than fatality risk, and pickup trucks also have a lower casualty risk than fatality risk.

Secondly, I looked at casualty risk using two different measures of exposure, the first being risk per vehicle and the second being risk per crash. And here, risk per vehicle is the same as on the previous slide, in blue.

Risk per crash is in red. And down here is the number of crashes per vehicle, and that's the crash rate.

And so if the vehicles that have relatively high crash rates, subcompact and compact cars have lower risks per crash than they have risks per vehicle. So vehicles with higher crash rate have lower risks per crash. It's simple math. You increase the denominator and you reduce the rate. So these two vehicle types have higher crash rate and lower risk per crash. These vehicle types relative to their risk per vehicle. These vehicle types that have lower crash rates have higher risks per crash than they have per vehicle. But you can see the trends are pretty similar across all vehicle types with the exception of some particular cases.

Next, I looked at in a little more detail what effect accounting for the miles driven has on risk, and I obtained odometer readings from state inspection maintenance programs from four of the five states that have those programs as well as other (indiscernible) programs in other states.

And here I'm showing, these are not absolute miles driven. I've re-scaled. Some states have more entire VMT than others. I re-scaled them all, indexed them to the average for that, the average vehicle in that state. But for all states, the range in miles driven is quite similar across vehicle types with sports cars standing out as being driven many fewer miles than the average car, about 20 to 30 percent fewer miles than the average car. And minivans, and full-size vans in particular, being driven about 20 percent more miles than the average vehicle. And for most states, it’s quite similar. There’s something going on here with pickup trucks in Missouri. That could be due to a relatively few number of vehicles in the database there but the trends are pretty consistent across the states.

So I then took the risk per vehicle and multiplied that by a factor accounting for the mileage that each vehicle type has driven to arrive at risk per mileage, per mile, mile driven, and we see here the effect of making that adjustment has very little effect on the relationship of risk across vehicle types. The biggest effect is on sports cars which tend to be driven 20 to 30 percent fewer miles than the average car because when you go from risk per, when you don’t account for that mileage, they have a relatively low risk. When you account for the mileage, it makes the risk higher. So that’s the only, that’s one case where mileage is really important.

Next, I want to look at this issue of national risk as opposed to risk in selected states and as I said, only 16 states have the VIN in NHTSA’s data system so we can’t look at the whole country. What I did was I took, the

GES is a national sample of police-reported crashes that NHTSA collects, so I divided the sampling units in the sample into those states that I had crash data versus those states that I didn't have crash data for and I made that comparison of casualty risk per crash in the GES data dividing the data into those states that we have crash data for and those we don't.

So the five states were the five that I've analyzed so far. The other 12 are the ones we're going to include in the study later this year. But what you see is that the casualty risk per crash in the states that we have crash data for tends to be higher than for the states that we don't have crash data for, at least in the data, national sample we have from the GES. So this suggests that in terms of risk, we might be overstating the risk of the nation when we focus on these states for which we have crash data.

On the other hand, here I'm comparing the state casualty risk for the five states that I generated using the crash data from those states, I'm comparing that with the GES national casualty risk per crash and here, they line up very well. They're on different scales but if you normalize them, they're quite comparable. With the exception of pickup trucks, the data, the national data tend to be lower than the data I generated from the five state crash data.

Now, this is an important issue when you're looking at the crash data from the states. The only crashes that are reported to the police are included in the database and different states have different reporting requirements so for some states, Florida, for instance, they under-report. They only, only about 60 percent of the crashes in the database are non-injury crashes. They tend not to be reported whereas in the other states, it can range up to 90 percent of the crashes in the database are non-injury crashes. So we really need to account for the crashes that aren't in the database and the next slide shows you an example of that.

Here, this is casualty risk per vehicle using the crash data from the states and in absolute terms, the risks are very similar. The one exception is Pennsylvania. They have a different definition of a serious injury so I put them on their own scale over here but for the others, their absolute risk, casualty risk per crash is, per vehicle, sorry, is quite similar. When we look at casualty risk per crash, however, the risks can vary dramatically, and that's purely driven by the fact that states like Florida are under-reporting non-injury crashes so that makes their denominator in that risk measurement artificially low and the risk measurement artificially high. So what we have to do is normalize to the risk of a particular vehicle type, mid-size cars, and once we do that, they all fall in line with some minor exceptions.

So the point of this is that in a regression model, it's easy to account for this effect. You put a dummy variable in for each state and that normalizes everything to the risk, average risk of that state but that's a piece that you have to include analysis or else you get biased results.

Finally, a couple slides on driver characteristics. In Chuck's study of fatality risks per vehicle or per mile, he was very careful to control for high-risk drivers, particularly young males. However, in the casualty risk per crash, in a sense, it's already accounting for some of the driver characteristics. Because we're only looking at risks once a crash occurs, we're already accounting for how often vehicles are involved in crashes and the next slide shows this.

These are casualty risk per crash in the five states again by driver type and I just divided it this way, elderly in green, young males and females and all others. And for each vehicle type, the elderly have a higher, given a crash, they have a higher casualty risk and it has to do with their frailty or what's the term now, Mike, their injury --

MR. VAN AUKEN: Tolerance.

MR. WENZEL: Tolerance. That's the right term.

But and in some cases, it seems that young female drivers may have a high risk, casualty risk once a crash occurs as well.

But for the most part, the driver characteristics are really a function of crash avoidance or the likelihood of being involved in a crash in the first place and once you start looking at risk per crash, once a crash occurs, the driver characteristic is not as important. And that's a detail we can account for that or not, whether we include it in the regression model or not. It's just an interesting point we keep in mind when we do the analysis.

And then the next important variable is the location of the crash and here, I've plotted casualty risks by vehicle type by population density in which the crash occurred with the most rural counties on this side and most urban counties on this side and as you can see, in the rural counties for all vehicle types, casualty risk is much higher in the rural counties as it is in the urban counties and so you still want to count for that in your regression model for the location of the crash.

Some conclusion. You know, there's really no one best measure of risk. What we're going to do is look at additional measures of risk and see if that gives us directionally the same results as what Chuck gets from his U.S., his national fatality risk analysis. But to the extent possible, we're going to be using the same data and the same method and the same control variables to make sure that those, any differences in results are not attributable to those differences in the data we use or the methodologies.

And then these points just summarize the analysis of casualty versus fatality risk. For the most part, they're quite similar. Although for some vehicle types, casualty risks are substantially lower than fatality risks, those for sports cars and pickups. The vehicle types with high crash rates have higher casualty risk per vehicle than per crash and that's just because they have a higher denominator. Vehicles with low crash rates have lower casualty risk per vehicle than per crash.

Accounting for miles driven has only a small effect on risk per vehicle with the exception of sports cars, so you definitely need to account for that there. When we looked at the national crash data from GES, it suggests that the 17 VIN states that we have police-reported crash data on may not be reflective of the whole country. They might overstate risk, so we have to be aware of that.

And finally, for the control variables in my analysis, which is looking at casualty risk per crash, it's not so important to focus on driver age and gender with the exception of the elderly. We definitely need to include that as a variable. But we still need to include the location of the crash in our regression analysis as a control variable. Thank you.

MR. SMITH: Thank you very much, Tom. Another great presentation. I think I failed to tell folks that there will be an exam on these charts before you leave the room so hopefully, you're taking good notes and paying attention and memorized every chart there, but thank you very much.

Our next presenter, and before I get that, our crack staff over here, Jim Tamm and Rebecca Yoon, who of course are central players in our fuel economy program, have asked that the presenters who are on the panel come talk to them at the break for a moment. They've got some logistics that they need to talk to you about for a moment before we have our panels here to field questions. So before the break, we have one more, one more presenter, and I will say that I haven't gotten anywhere near the gong at this point so people are really doing a great job staying within their time and presenting some very interesting kinds of things.

Our next presenter is Mike Van Auken from DRI. Did I pronounce that correctly? Okay, Mike. Mike is going to present on an updated analysis of the effects of passenger vehicle size and weight on safety. So, Mike, come on up. It's all yours. Your presentation should be loaded up and there's the clicker if you need it.

MR. VAN AUKEN: Thank you. Hello. My name is Mike Van Auken and I'm presenting on behalf of myself and my colleague John Zellner at Dynamic Research, and so the topics I'll be talking about today are the first of all, an overview, a brief overview of the past DRI studies.

One is, first is a cross-sectional analyses that are like the ones that Chuck Kahane and Tom Wenzel have been talking about this morning and then also, some fleet multi-body computer simulations. We've also done those in the past. And then primarily, the focus I'll be talking about is a new Phase 1 study that we're accomplishing for the ICCT and Honda and some other, and that will be primarily an update of the DRI, purpose of that is to update DRI previous studies based on the Kahane, or to update them to the Kahane 2003 type level of methods and data and investigate why our previous studies were different from the Kahane results. And that's the focus of that study.

And then we also have planned a Phase 2 study which will be to update the DRI analysis based on NHTSA's shared databases which they've been talking about this morning. They're updated to, for example, the 2007 model year I believe and the 2008 calendar year. And a potential Phase 3 study which will review and investigate forthcoming Kahane methods and results, investigate any possible differences between the new results, between ours and Kahane's in the future and investigate again other analytical approaches that may be appropriate and to basically identify any clear drivers of safety, are there any, weight and size, et cetera.

So first, I'll just quickly, briefly review the terminology we use in these studies and the symbols. So we've been using the symbol "A" for accidents, the number of accidents in a crash, and "F" is the symbol we use for the number of fatalities. So we take and usually come up with a ratio, the fatalities per accident for example. And VRY and VMT are numbers of vehicle registration years and vehicle miles traveled. And then we have induced-exposure which is the number of induced-exposure cases. There's two. Basically, this is the non-size and weight-related crashes for the purpose of determining the vehicle factors including driver and environmental factors. And in our studies, currently and in the past, there's two types. There's the style of vehicle, which was determined based on the Kahane 1997 methods, and then the non-culpable vehicle, which is the newer Kahane 2003 method.

So just a quick overview of our past studies. There's four. We basically have done four reports in the past. The first report in 2002 was basically a reproduction of, we basically used the Kahane 1997 core method which was basically using aggregated data for 50 states using basically a linear regression method. Kahane also mentioned that he used another exploratory type technique and he described it as basically a logistic regression technique of disaggregated data. We explored that in further detail in our 2003 study. It did, though, use an aggregated analysis for induced-exposures per vehicle registration year based on seven data, seven states.

After that, Kahane came out with the 2003 study of his own and we basically updated our analysis based on some of the methods that he used. Basically, the weighted logistic regression technique sort of inspired again by Dr. Kahane's work to try to bring our results more closely into agreement with the Kahane's results. Just note we use a lot of terms here. One is aggregated data are grouped, data that are grouped by make and model typically. And disaggregated data is individual raw case data. And then our studies were basically based on the 1995 to 1999 calendar year data.

So this is just a summary here of some of the results that we obtained and compared to the NHTSA results. This is basically four groups of studies here and results. This axis here shows the, basically, the change in fatalities. There's four, I'll say four different studies here. Each one shows some results. The first, let me pick on this one here. This bar right here is basically the change in fatalities. This blue shaded bar here. The colors are different than on some of the notes. This is the change in fatalities that were estimated due to a 100-pound curb weight reduction, and it's going in the negative direction so that would indicate that fatalities are being reduced when curb weight is reduced.

This is the change due to a one-inch wheelbase reduction and then this is the change in fatalities due to, I believe, about a third of an inch track width reduction. And then this big bluer box is basically the summation of the three components. So if you add up and then assume that basically, if you reduce the curb weight, wheelbase and track all in the same proportions to a 100-pound weight reduction, then basically you'll get roughly about, in this case, about an 800-pound net increase in fatalities.

So basically, as you see, at this point, we though that basically, we were in close agreement with the 2003 NHTSA study which didn't report this level of detail, but so that's where we thought we were at. But more recently, we found out that there were some differences when NHTSA came out with the 2009 results, that actually, the results for curb weight and track, which are these bars, are different than these bars here, and so the purpose of our Phase 1 analysis at the moment is trying to understand where these differences are coming from so.

I also wanted to mention that there's these past theorized studies. There's the fleet multi-body computer simulation work that we've also done which is to investigate the effects of reduced-weight SUVs, holding the size constant, or increasing the length of an SUV, holding the weight constant, using lightweight material substitution. And we're looking at the effect on crashworthiness and compatibility, the F/A ratio. We're not looking at all, crash avoidance in these simulations.

We used, we sampled 500 cases from NASS and actually, one of them wasn't very useful and so we used, we simulated 499 crashes and based on that, the results from those 500, we calculated basically, in the simulated crashes, some were involving one-vehicle crashes and two-vehicle crashes, the total number of equivalent life units of injuries and fatalities for the baseline vehicle and then with a reduced-weight vehicle that dropped and also with a decreased length vehicle, the number of equivalent life units dropped.

So basically, the conclusions based on these simulations were very similar to the DRI statistical results, that an SUV weight-reduction of 20 percent had an overall benefit and an SUV crush zone length increase of 20 percent had a larger overall benefit. The details are described in this report right here.

So now I'll talk about the Phase 1 study. Just to review the method, or the objectives, the methods and then preliminary results because this is still, it's not quite finished yet. The first is the objectives are we're to compare the DRI and Kahane results to first, to reproduce and confirm Kahane's past results and primarily looking at the databases and methodologies and then to be able to provide comment on an understanding of key differences.

So the technical approach for the databases was to update our DRI databases to more closely match the Kahane 2003 databases to the extent we could. This primarily involved adding the 2000 calendar year database as far as state, et cetera, adding in Pennsylvania data. We found out that that was needed basically for, in order to get our matches to agree more closely, and that totally, by adding the calendar years and the Pennsylvania data increased our state-year sort of figure from 34 to 44 as the size of our database. Every state-year combination was counted as one, so we brought that up to 44 which is closer to what Dr. Kahane had used. And then updating the vehicle curb weight data based on Kahane and then also, we're updating to the newer model year vehicles, a couple more model years. That's currently in progress and those results are not available yet.

So the methods to more closely match Kahane's. We developed new analysis software to attempt to more closely replicate the 2003 methods which is primarily, first of all, a single stage weighted logistic regression method. We previously had used a non-simultaneous, a two-step regression for basically these two ratios of fatalities per induced-exposure and then the induced-exposure per vehicle registration year, and these had different mismatched control variables in each stage. This has been eliminated. We also have the ability to look at either the U.S. level, U.S. or state level induced-exposure weightings and fatalities. So we can either, as I think Tom had mentioned before, scaling the data up to the U.S. level.

We've also gone through and updated some of the control variable definitions. They changed slightly between the different studies. And we've also changed to the newer induced-exposure definition from a stopped vehicle, which was used in the DRI and the 1997 Kahane study, over to the non-culpable vehicle which adds roughly about three times as many cases but also, we added the new fatal crash type definition which primarily are the addition of three or four-vehicle crash types. And then we've also, in the future, we're planning all these results, we're looking at the variance inflation factor is also being calculated as suggested by Kahane and other researchers.

So possible sources for differences between the DRI and Kahane results. We consider there are differences in the databases, which we are addressing by the updated databases to the extent possible, differences in the data reduction details, we're using the data for eight states, plus there's the FARS database and each one is slightly different or has many differences and each one needs to be reduced to a common data set.

Differences in analysis methods. NHTSA has mentioned that they believe that the analysis method is the issue and not the database. Kahane used a one-step single-stage method for fatalities per vehicle registration year or to vehicle mile traveled. As I said, we developed that new software package to really address that. Previously, DRI had used the non-simultaneous regressions for fatalities per induced-exposure is one regression and induced-exposure per vehicle registration year is the second regression. Each of those two regressions had different sets of control variables.

So and this is actually a list showing the different variables in the two different regressions. The variable names are listed here and whether they were included or not. The red bars show the places where they're different, and we think this is probably an area that may have contributed to some of our differences.

So basically now, this is a comparison of some of the DRI results and the Kahane results. If you see the, generally, the trends are fairly, pretty close but we're looking at basically trying to understand where the differences are occurring. So we have a quantifiable difference and we came up with this figure-of-merit that we're using to assess how and track how well we're agreeing with Kahane's results or within our results.

So basically, we look at the difference in the regression coefficients, we normalize it by a standard deviation, a compass interval or a standard deviation. Keep in mind that that standard deviation does not include all sources of variation but just the ones that come out of the regression software so it doesn't include other sources of uncertainty. And then we come up with basically a table here looking at basically a drill down of the differences by size and weight variables and the crash type. We come up with a delta squared index.

And then basically, we come up with a root mean square figure here which is -- an average of value over two is probably not very good. It's a value that indicates that there's significant differences between the results. The reason of differences are the size and weight results or the control variable results and ideally, we want to make that as small as possible.

So the comparison. Well, first of all, we did a comparison of the DRI simultaneous three-stage regression method, the technique that we used in 2003, and the more traditional one-stage logistic regression where basically, we saw for this regression by itself or we saw for this simultaneously. And you see the difference in the results are actually very small and it indicates that basically, the simultaneous three-way two-stage technique, which is described in this report, is not significantly different from the more traditional one-stage method and that's again, a figure-of-merit being used.

If we now go and compare the two-step approach where we're looking at the fatality per induced-exposure regression and the induced-exposure and compare that to the one-step type regression, actually, that should be fatality per VRY, we find that basically, a lot of the differences are in the control variables. That's where the source of the, I think, the error is. So these indicate the differences. So these results indicate that the non-simultaneous approach, where you saw for the different regressions separately and then add them together, may be one source of difference between the DRI and NHTSA results and this is attributed in part to the difference in the control variables and the different regression steps, the slide a couple slides back with the different red zones for the different control variables.

Now, if we look at the differences between the DRI, our one-stage type method and trying to reproduce what Kahane had done, we of course made many, many changes to our regression I'll describe on the next slide, and we were able to reduce our figure-of-merit down roughly to about this level here.

That reduction was accomplished by changing the induced-exposure cases from the stopped vehicle to the non-culpable vehicle definition. We changed fatal crash types by adding the two, basically the three and four vehicles involved in a crash. Initially, we did not have the 2000 Florida induced-exposure because we had some difficulties with that data but we bit the bullet and added it in and that helped to reduce our results as well as adding Pennsylvania data. In general, one thing we found was the more case, the more states we added, the more state-years, we brought, the results came more and more into convergence with Kahane's results.

And then of course, there was the change in the curb weight data. We changed it from our values to the ones that were reported in the appendices in the Kahane's 2003 report. And other numerous minor changes. If you go through, reading the report, you find all the details. We tried to implement those as much as we could.

Jh

So the possible sources for the remaining differences between the DRI and Kahane results include first of all, we've not implemented the model year changeover yet. We're missing a couple model years that he is using. And there's some other differences here that we just don't have the information yet to resolve.

And they are differences in the other vehicle parameter data. For example, we don't know exactly the ABS installation rates, for example, that were used or the track data that Kahane used, that NHTSA used. There's a difference in the control variables, particularly the Florida rural variable was one of them. We had a lot of differences. If we compare our calculation for the rural, from the Florida data versus what the FARS was giving, the correlation was not very good so there's some challenges with that, that database variable.

Pennsylvania, we also had some challenges with that database as well. Our particular data files, we weren't able to actually determine the non-culpable vehicles because there was no connectivity between which vehicle was the non, which was culpable and which one wasn't so we used the augmented criteria which was primarily a stopped vehicle or other factors. But we, again, we basically got a third as many cases in Pennsylvania and so we're not quite, that's probably a factor that's contributing to some of our remaining differences.

There's probably also some other differences in the way we're identifying the large trucks based on the rural manufacturer identifier and that type of thing. So these are details. And of course the police car, the non-police car Caprice and Crown Victoria registration, so not quite clear what those numbers are.

So basically, going ahead and now looking at basically U.S. fatality results, what does this do for us? Well, basically, here's where we were. Some changes again in the different results evolution. This first one here is the DRI original result with the mismatched control variables. These were all for four-door passenger cars excluding the police cars, and this is roughly the one that was in our 2005 report. If we go and we go to the matched control variables, it changes the result. The curb weight now becomes almost a zero effect and these, these move up over here.

If we then add in all these other changes, amended these other changes, you know, the U.S. level weightings and et cetera, we get to this type result here. And if we make the two vital changes, we add the non-culpable vehicle induced-exposure and the new fatal crash types, you know, the three and four-vehicle, we get this result which is in much closer agreement with NHTSA's 2010 result here.

So there is some -- so basically, the trends kind of converge on the 2010 results if we use the non-culpable vehicle and the three and four-vehicle crash types. We've observed how the results seem to be very sensitive to the control variables that are used and basically, the mismatching and the induced-exposure and fatal crash type definitions.

In addition, here, this is the results now looking at curb weight and footprint, and this is the result with, the DRI result with the stopped vehicle induced-exposure and the older two-vehicle, one and two-vehicle crash type definitions. And here's with the non-culpable vehicle induced-exposure so again, we're converging. We're not quite there yet but it's closer to what Kahane has got in 2010. So basically, these results are converging, curb weight and footprint results are sensitive to the induced-exposure and fatal crash type definitions. Maybe this has something to do with the weight versus the culpability, whether culpable vehicles are, as you had mentioned, Chuck, whether the heavier vehicles are more culpable, tend to be less culpable or not.

This is now a similar set of results for light trucks and vans. A little more stable result here but the thing is here that there's still a little bit of sensitivity to the curb weight, to the induced-exposure, that definition but again, we're getting close agreement here with Kahane's results if we make these changes here. But the key thing is that we're using those two different definitions of induced-exposure.

So we've also now looked at the variance inflation factor and that's a measure of multi-collinearity. Large values tend to indicate more collinearity and of course, these authors mention, criteria. There's also a counterpoint here which is that O'Brien has mentioned that, you know, yes, you can't just discount a regression because it has a large variance inflation factor. You have to look at other things, and it may not be reasonable or reasonable to merge variables together or to ignore variables. They should be basically theoretically motivated.

So these are some of the variance inflation factor results for basically our past DRI regression results. Actually, these variance inflation factors are computed for all the variables, not just the curb weight, wheelbase and track but, and they're related to all the variables. So but basically, our result was fairly high for curb weight. Wheelbase and track were less high in our regressions. So I would indicate well, first of all, curb weight has the largest variance inflation factor. Maybe that's the one that should be possibly removed as redundant, as redundant with the other variables and dropped from the analysis. I'm not serious about that but, you know, I would suggest that that might be the one to remove as a factor.

So basically, some of our conclusions were that our non-simultaneous method had a lot of, with the mismatched control variables, had a large effect on our results. The induced-exposure definition with stopped versus non-culpable vehicle, that seems to have a large effect on the results. The high rate of induced-exposure case weighting, this was another factor where basically, if we have too few states, we start to get very high weightings, that became, that's a medium effect. The definition of three or four vehicles, I think that probably has a medium effect. These are a little bit subjective here and some are small, very small effects. The three-way two-stage, if done correctly, is a very small effect. There's a couple others we don't really know exactly at the moment what that effect is.

Recommendations from this Phase 1 are that we need better access and disclosure to compare the studies; a common accessible and downloaded databases, I think we're moving in that direction; common definitions for key factors; better disclosure of data reduction methods, the details sometimes are important; and the results. I think it's probably good to report all the regression coefficient results including the control variables. I looked at, you know, a lot in Kahane's 2003 study and they were very helpful. Estimated confidence intervals is useful also, as well as the variance inflation factor for all the regression coefficients. Also, in conclusion here, if small changes in methodologies can change the results, then perhaps the effect of weight is too small in comparison to other factors such as other safety technologies.

For Phase 2 study which is planned, the objectives will be to further update the analysis based on the most recent calendar year and model year vehicles to the 2008 or it's actually 2007 model year and 2008 calendar year data. This will be -- we discussed with NHTSA and others the need to define and make the NHTSA data publicly available, and we haven't discussed yet any details, need for detailed methods and algorithms but that would be very helpful too.

A possible Phase 3 has been discussed and that one, the objectives would be to review and investigate forthcoming Kahane methods and results and basically, to investigate other analytical approaches that may also be appropriate, some alternative ways of looking at things. Predictive fits, parsimonious models and PRESS type statistics are things we can consider. Sensitivity analyses. The model should be relatively insensitive to changes in the non-culpable versus the parked car or stopped car induced-exposure definitions.

The vehicle model years, you know, the changes over time. The vehicle types, two doors or four doors. Our recent analysis has been focused just on the four-door. Vehicles with high proportions of high-strength steel or lighter weight versus conventional designs. And other world regions has been suggested, and et cetera. So and that's still in the planning stage.

Overall observations. Robust factors, for example, curb weight, should be relatively insensitive to the exact data and methods used. However, following more exactly the changes made between the Kahane and DRI methods to the Kahane 2003 methods has been a large, has a large effect on the relative outcomes and also explains much of the difference between the Kahane 2003 and the DRI results.

To facilitate identifying robust factors requires use of a common database including data, induced-exposure, police report data. That's something we use. Tom is using something similar to that I think. And then the vehicle parameters is something we also need to focus on getting a kind of vehicle database. And awareness of the exact data reduction algorithms used. That's my presentation. Any questions or are we --

MR. SMITH: Thank you, Mike. We'll do the questions later. In a unified session, we'll have all the panel members up here. I'd say that the bar was just raised on that exam. If my life depends on explaining those regressions, I'm afraid it's time to call the family and the priest but the, I do appreciate everything that people are presenting because it really obviously is a very complicated technical issue to try to figure out how we weigh these various factors.

We are now at break time and why don't we, let's see, plan to be back here by 10:25 Eastern time. And if we want to synchronize our watches here, that should give us a little bit more than 15 minutes and I will, I'll try to get started promptly on that. Remember, those of you who are panel members, if you could stop by the table over here and talk to our folks about certain logistical issues they have. You folks who are watching by webstream, you're also free to get up and move about the cabin. Thanks very much.

(Whereupon, at 10:08 a.m., a brief recess was taken.)

MR. SMITH: If you could tell those out in the hallway that the time has come. It is that time on my watch. I'll give folks a couple minutes to circulate back in, those on the webcast to sit back down and start watching again I guess. I can tell from the numbers that there are a few folks who are still outside. Kristen, I don't know if you need to summon anybody that's out there in the hallway or something, so we should probably get going so we stay on schedule.

I appreciate the first presenters for staying on schedule very much and as interesting as those previous presentations were, for somebody at my intellect, I’m hoping for some big pictures in the next slide shows so that I can grasp what’s really going on here.

But our next presenter, Dr. Adrian Lund, and apparently, I’ve bestowed Ph.D.s on a couple of previous presenters who actually didn’t have Ph.D.s but now they do, but Dr. Lund, in fact, does. And Adrian, of course, heads the Insurance Institute for Highway Safety which provides just enormous benefits to the traveling public, to the industry, works cooperatively with this department and agency on many issues. Adrian is going to talk with us about the relative safety of large and small passenger vehicles. So, Adrian, you’re on and here’s all the equipment you’ll need, so thank you.

MR. LUND: Thank you. Well, I do have bigger pictures but I sat up here so I wouldn’t waste any of my time getting up here because I have lots of slides. So this is going to go very fast and we’ll just click to the first. I’m going to basically try to cover three questions. I think they’re what we’re about here. We’re trying to understand the history, that is what has been the relationship between mass, size and safety in the fleet.

Also, the other question which was articulated earlier, can weight be taken out of vehicles without safety consequences if size is held constant. And finally, just a little, you know, free association as to what I think the future might hold.

First, historical trends. Everybody's seen this graph. We've been reducing fatality rates for years and years. We've got a real success story in terms of the fatality rate today per vehicle miles of travel. And you can see that since about 1980, it's been a pretty steady, almost linear kind of decline so we've been very successful there. One could ask what might be contributing to that. I would argue that, as Chuck said earlier, one of the things that's contributing is that the fleet has actually gotten heavier, especially during that period.

This shows the cumulative percentage of passenger vehicles by model year and curb weight and we have 1983 in blue, '88, '98 and 2008. Our data wouldn't allow us to go to the full 1978, okay, that decade end. But what you can see is that the 50th percentile vehicle now is much heavier, probably about 800 pounds heavier than it was in 1983. This is one of the things that's contributing to the reduction in fatality risk. Vehicles are in fact heavier than they were in 1983.

They're also bigger than they were but not by quite such a dramatic change. We've seen vehicles gradually increase in their size. I don't have the specifics here but I can tell you that this big jump between '88 and '98, a large piece of that is what happened with pickups. Pickups became much more common, especially the very large pickups, okay? So that's why there's a big jump between, or the primary reason for the big jump between '88 and '98. But the point is one of the reasons the roads are much safer is because vehicles have gotten safer because they're bigger and they're heavier than they were.

It's not the only reason though. Vehicles have gotten safer and what I'm going to go through here is if we look at 1985 through '88 models back in '86 through '89, sort of two decades ago, here's the relationship that we had. In green is the fatality rate, the driver deaths per million vehicle registrations per year. In green are cars and minivans. We classify minivans with cars because we think they're used like station wagons and we have station wagons with cars as well. You have SUVs in blue and you have pickups in red. And you can see that as the weight goes up for each of these classes, death risk for the occupants or for the drivers decreases.

Now, the key here is this is essentially the decade back ending in '89. Now, what about '96 through '99? You probably saw, as we go between here, these lines shift downward. There’s a huge change in the overall safety. It’s happened for every vehicle group, okay? We still have the relationship though of weight and fatality risk. That is as weight increases, fatality risk decreases for each vehicle group.

And when we go another decade, we get another big change, another big drop in the death risk per vehicle on the road. Still have the vehicle weight effect. It’s still there. We’ve reduced everything but it’s still there. Another thing has happened which you probably saw there. In the last decade, the relative position of SUVs and cars has reversed. That is now, SUVs relatively, in each weight class, have a lower or at least equal fatality rate to cars. This is the first time we’ve seen that. We used to always get asked what about the safety of SUVs and cars. We said well, for every, whatever weight you’re in, it’s better to buy the car because it’s safer. Obviously, we can no longer say that, okay?

This is plotting this by weight. We’re looking, again, this is FARS data fatalities per million vehicles registered and we’re looking at 2005 and eight models during 2006 and 9 here. Now, if you look at vehicle size, you see a similar relationship, okay? This is, I’m just going to do 2009 because I don’t have time for too many slides. You see the same relationship for 2009 in that the smaller vehicles have higher fatality rates than larger, so we're seeing both of those factors related.

One thing that is different is that when we look at SUVs versus cars by size, we see that SUVs, in every size class, have a lower fatality risk. Now, keep in mind there is a physical explanation for that. In every one of those size classes, the average mass of the SUV is considerably higher than the car, so we think that's sort of an initial indicator of the fact that mass is still in here. These are separate effects as I'll argue.

Just to really drive this home, let's look at, by curb weight, I'm going to go back to curb weight as the way to present these data. By curb weight, let's look at cars over these, these two decades. Beginning here are cars, the latest, this is the fatality rates that we see for drivers. Ten years earlier, that's the fatality rate. And ten years earlier, that's the fatality rate. This just drives home, again, the continuous improvement we've had in the protection of occupants in vehicles.

I also want to call your attention to a basic fact that we need to keep in mind. If you take a look at cars around 2500 pounds in 2009, that's the green line, go up to 2500, you see what the predicted death risk is. That's lower than the predicted death risk for the largest cars two decades earlier. So the improvement is really dramatic.

Small cars today are like large cars in terms of occupant risk of two decades ago. That's not all the cars. It's also some changes that we had out on the highway. We're reducing risk for everybody, but that relative change is real. Small cars today are doing a better job than large cars.

Again, this just shows you, you get the same relationship with shadow when you put it in.

From the history then, just from looking at the relationships in the past, it's really two simple conclusions. Passenger vehicles of all types and sizes are providing their occupants with greater protection today than just a decade ago and much greater protection than two decades ago. However, occupants of the smallest and/or lightest vehicles still have death rates about twice those of the largest and heaviest vehicles in their class. That relationship holds, and I think that has implications for how we think about this problem.

I want to come back. We heard a lot of analyses trying to look at the separate contributions of mass and size in the presentations before me, some very good math going on there all trying to really get at the question how much mass can you take out before you affect safety. Now, to really talk about this question, I want to drop back from treating this as just a statistical analysis that occurs in a vacuum of not knowing anything. We do know something going into this exercise.

What is the source of injury in automobile crashes? William Haddon, back in 1968, said something that remains true. "In the highway safety area, the problem is almost exclusively one of mechanical energy reaching people at rates that involve sources in excess of their injury thresholds." Full stop. There are other problems. There is, you know, crash fires and there are things like that but this is the main part. Mechanical energy. And what does that really translate though to and what are those forces that he's talking about as they reach the occupants?

Let's take a simple model of frontal crashes. Forces, what that means is that forces act on the occupant to bring his or her pre-crash velocity to its post-crash velocity. Post-crash velocity isn't always zero but you're slowing down suddenly some amount. So you're, the forces act on the occupant, and it's important. We're not talking about the forces in the vehicle, we're talking about the forces on the occupant. The longer the distance, this is just physics, the longer the distance over which the occupant's velocity change occurs, the lower the average force experienced by the occupant. Period. This is easy. So if we increase distance, we lower the force that occurred to bring that occupant to that lower speed.

Now, the occupant's stopping distance is a combination of well, first of all, the space between the occupants and stiff parts of the compartment in front of them. That's fairly standard, I think, across cars. Even small cars and large cars.

But more important to our discussion is it's also the effective crush distance of the car in front of the occupant compartment and generally speaking, occupants of longer vehicles are going to have more effective crush distance. Period. Now, if they put on the extra length in the trunk, that won't be relevant in this but that doesn't usually happen. So typically, more crush distance, we have, occurs with longer vehicles.

The separate effect is the distance which the car's momentum carries forward in that crash or is reversed, okay? That distance the occupant's inside that car. So if the car carries forward, he gets to move further forward. If the car gets hit in reverse, he's going backwards, okay? So and that can happen, as Chuck said earlier, even when, you know, when you hit trees or single-vehicle crashes with objects that deform or even break away. So generally speaking occupants of heavier vehicles typically will benefit from greater effective momentum in all kinds of crashes.

So car size and weight are separate physical factors. They're always going to be there in any crash that occurs. It's physics. Now, the question that I think the previous presenters have been wrestling with is how well can their effects be quantified in vehicle crash experience? There are several problems which have been talked about and I'll try to illustrate them too in some following slides, but let me start by just saying the first big issue is that in the real world, vehicle size and weight go together, okay, and that's a collinearity problem.

The other problem is, and the previous speakers talked about this, Tom and Chuck, car size and weight can influence crash likelihood, including the likelihood of different types of crashes. So we know, for example, that larger heavier vehicles get into fewer rollovers but given that they're in a rollover, the outcomes are usually worse. Why? Because it's harder to get them in a rollover. Their rollovers are more severe. Smaller vehicles are involved in more crashes often, not fewer as some have hypothesized. It actually varies. I'm going to show you that in a minute, too.

And then the final point that I want to make is that many other vehicle characteristics that can affect crash likelihood and severity are confounded with size and weight. Basically, heavier cars for a given size often have larger engines, four-wheel drive or are convertibles. Those things don't augur for improved safety, okay? They augur the opposite. So we've got some counterveiling forces going on.

What's the collinearity that I'm talking about? This is 2008 cars and minivans. Notice that the R square between the shadow of the vehicle, we don't have average axle length so we use shadow instead of footprint, and the shadow of the vehicle and its mass is 0.70. Seventy percent of the variation in car weight is known when you know the car shadow. That's straight forward. So that's a collinearity problem as Chuck has talked about.

What about this issue that we often hear that small cars, because they're so nimble, they obviously get into fewer crashes, they're less crash-prone? We have access to insurance data and the collision claims per insured vehicle year. We don't have a lot of depth in that data but we do know where the vehicle is garaged, we can know the traffic, the density of that area, we know whether it's urban or rural, we know what state it's in, we know whether it's driven principally by male or female, we know the ages of the principal driver. There's a lot of variables that we can standardize for. What I'm going to show you are the crash rates or the collision claims rates that we see for these different vehicles as a result, after all of this adjustment is done.

We look at four-door cars. Now, remember these aren't fatality rates. These are crash rates, understand. These are collision claim rates. And what we see is as the, we go from mini-size cars to the very large cars, we have a step down in crash rates. Now, if we bring luxury cars in there, it's a little less clear. It's more like flat, but we certainly see kind of a downward trend. If we look at station wagons, the lowest crash rates are in the largest ones. If we look at minivans, larger minivans have lower crash rates.

Now, two-door cars, it starts getting a little different, doesn't it, Chuck. Chuck knows this I know because he's looked at these things too. We see something a little different. Now, one of the issues going on with very small two-door cars is they're not driven as much. They can become toy cars and things like that. I'm not sure that explains all this. This is, that micro-category there is the, it's Smart Fortwo, right, Chuck, essentially? There's nothing else there. So there may be something else about that vehicle as well but, you know, we can't say for sure.

Sports cars, it actually goes the other way. What happens if sports cars get bigger? They get bigger engines and they go faster, okay? So we think we know what's going on there but it does show that in this case, size, we don't see a reduction in crash risk. And with SUVs, it's kind of flat except for the very large ones where it clearly goes up. More crashes. For luxury SUVs, same thing. It goes up. And I don't pretend to know the answer to why that is. And for pickups, kind of the same pattern as SUVs except that the very large aren't quite as high. That may be a real turn because very large pickups probably have a different use pattern. There are a lot of construction type vehicles, 350s, 450s, things like that. Okay.

So this is just to give you an idea of how crash risk itself varies. It varies by type but you certainly can't claim that crash risk goes down because you're driving a more nimble vehicle, okay? If anything, it looks like it probably goes up as you make the cars smaller.

Now, the final confound that I wanted to talk about is all these different confounding variables, and I just wanted to give you an example. If we wanted to take a look at a very popular car, the Toyota Camry four-door, and we asked, I think it's about 94 square feet in shadow and it's somewhere around 3200 pounds in mass, curb weight. If we sort of control or constrain shadow to the general area of 94 and we say we look at vehicles with 93 to 95 square feet of shadow, that's very tiny changes by the way if you think about that, and we look at the range in weight, the Toyota Camry four-door that I was talking about is up there fourth from the top, okay, what do you see as you go down?

What is contributing to higher mass if you're trying to estimate the effective mass in a statistical program?

What's contributing to a higher mass in many cases are hybrids, four-wheel drive, and some of these do have bigger engines. So you see that the problem I point to here is it's not easy to separate these factors. These are vehicles with different utilities and how you parse those out in any analysis is difficult.

My conclusions about trying to get different mass and size effects are as follows. They must have, they always do have separate inverse relationships with occupant injury risk in crashes. This is dictated by the physics. Quantifying those separate effects, however, is complicated by the things we've just gone over. And I will submit that failure to find separate effects indicates a failure to adequately account for the confounds in the database, not that physical laws have suddenly been repealed. It doesn't happen.

Okay. So the future. How am I doing here, Dan?

MR. SMITH: A couple minutes.

MR. LUND: A couple minutes. Okay. I want to go through some conclusions that might not be obvious from what I said. What do I think is going to happen? This isn't related so much to the data, just a little bit as you'll see, but I predict that vehicles are going to get lighter and smaller regardless of NHTSA’s size index system. But as fuel prices increase and increase dramatically, there will be a substantial portion of the population that is going to opt for the lightest vehicle they can get. That means it’s going to be small and light within class because they are going to need to save money, okay? So I actually think one of the benefits of the size index CAFE is to keep larger, safer cars affordable, on a gas price basis, longer for all income brackets. I mean, if you don’t do that, then we have rich people buying big cars and poor people buying little cars.

The sky, this might be a surprise, the sky will not fall as the fleet downsizes. I think it’s going to happen but the sky isn’t going to fall in on us. The fact is we probably will not see an increase in absolute injury risk because smaller cars will continue to become safer. We’re all working hard. People in this room are working hard to make that a true statement.

It doesn’t change the fact though that some people are going to die in the future in motor vehicle crashes that they would have survived without the downsizing. That’s just a given, okay, because that fleet of smaller cars, on average, is not going to provide the same kind of protection that it would have if those cars hadn’t been downsized. We will still have the ability. Any technology that makes a small car safer, it's even easier to have it make a large car safer. You've got more to work with.

Now, those of us I think whose mission is highway safety, what we've got to do is adapt to the reality. Gas is going to get expensive. People are going to make choices and we have to adapt to those consumer choices. We're trying to do that, make motor vehicles, as people use them, safer. And, you know, I think we're going to all be okay if we let the data on what works and we don't resort to wishful thinking. But we just keep our focus on what works, what the data tell us and let that guide our strategies, like I said, I think we'll be okay.

Now, I want to close just with some videos because I want to drive home what I mean by the difference in protection. Many of you may remember that we did a Smart Fortwo offset test. Very well performing vehicle, okay? Good rating in our offset test. If Mercedes would just bring up the seat design, it would be a top safety pick but that's their choice. That's for rear protection. Very good in the front on its own but if it hits a mid-size car from the same automaker, it's a different story. These are the kinds of differences we're talking about.

Now, this is, as I said, this is a, I think, a very well-designed vehicle. This occupant compartment structure holds up well. In fact, a lot of the damage to the occupant compartment won't even be so visible here because you can see that the door frame is actually holding up pretty well. Inside, it doesn't look quite so good and the dummy numbers are not quite so good so that's what we're talking about with these vehicles interacting with each other.

And then our bigger worry is that we will relax our standards all together. We already have states licensing mini-trucks which don't meet safety standards for use on the road. This is a Ford Ranger, a small pickup, not even our best performing small pickup in an offset test, but this is the mini-truck. If it's operated on roads with just small, other small pickups, this is a problem.

So we need to -- what we're going to do at the Institute is we'll continue to make people aware of these choices. We would like to convince them that maybe rather than shopping down to a small lightweight car, maybe you choose a couple trips a week that you don't take. That, in many cases, will save the same amount of fuel, maybe more. Not only that but the rest of us have fewer people competing with us on the roads for position. So that's my story, Dan. Big pictures?

MR. SMITH: Yes. I appreciate that. Thank you. Thank you, Adrian. Yes. Those were not only big pictures but moving pictures and the only charts that you had were ones that I actually understood. Moving along, I wasn't going to gong right before the moving pictures but we need to, we need to continue to move along and I'm not sure I'm pronouncing the name. Is it Jeya Pad --

MS. PADMANABAN: Jeya.

MR. SMITH: Jeya Padmanaban. I'm sorry. Sorry. Welcome. And you are from JP Research.

MS. PADMANABAN: Yes.

MR. SMITH: Thank you. Pleased to meet you.

MS. PADMANABAN: Good morning. First of all, I would like to thank NHTSA for inviting me to be one of the speakers here for this symposium among all the giants in this field. Secondly, you can tell I'm all for green but if you have to look at the data and make sense of the statistical fuel performance data as a statistician, you can't stand alone, just like Dr. Lund said, Dr. Kahane said, you can't just take the data and interpret it without looking at the engineering, physical and just real-world common sense point of view, and that's what I'm going to talk about because one of the things that I am particularly interested in is just to let you know, even though statistics is kind of a dirty word, statistical analysis is not something everybody likes, I want to tell you there is a way to go through the clutter and make sense out of things if we keep at it in the way that I would like to present the study.

About 60 percent of the fatalities in automotive accidents are MVA, multiple vehicle accidents. Half of them are frontals so frontals are important. Mass and size effects are closely related to what we call vehicle compatibility. And for 25 years, NHTSA and IIHS and all the organizations that we just talked about, they all talked about and done comprehensive research using field data, testing, modeling on what the compatibility issues are and how they affect traffic safety.

And, for example, there are three components. One is mass compatibility. Light vehicles. If you look at light trucks, pickup trucks, SUVs, minivans, they are, on the average, 900 pounds heavier than passenger cars. Then you have stiffness compatibility. We have heard from IIHS and NHTSA for a long time how the frontal structures are stiffer for light trucks compared to passenger cars. Then you have a geometric compatibility which is the height, bumper height mismatch which IIHS has talked about and NHTSA has talked about. So you have to address these three compatibility issues when you talk about what is important.

Well, JP Research conducted a six phase, ten year study to address the effects of vehicle of mass on odds of driver fatality in frontal and side impact crashes and more importantly, we wanted to identify the vehicle size parameters and try to separate them from mass but like Dr. Lund said, it’s very important to know whether we can even do that, but we wanted to find out are there size parameters out there that can influence the driver odds of fatality, you know, without mass getting in the way. And we also, at the end of Phase 5 and 6, we looked at the societal, and I should put the societal effect under quotes, societal effect, kind of like what Dr. Kahane talked about, with vehicle reduction and then we compared it to other studies.

This study, the six phase study was sponsored by U.S. Car Committee which is, I think is comprised of three domestic automotive manufacturers, and we basically had at a high level -- I have 20 minutes to talk about a six phase study with all kinds of data so I know I speak fast but still, 20 minutes is not enough. So what I’m going to do is at a high level, tell you how it went.

In Phase 1 and 2, we took a look at a whole bunch of parameters, driver of vehicle, environmental factors, picked a few and then in Phase 3 and 4, we looked at the stiffness parameters, bumper height parameters to address the just address the geometry and stiffness compatibility. And Phase 5 and 6, we looked at the societal effects. That’s kind of how it went.

The uniqueness of this study is we looked at over 40 vehicle parameters including mass ratio, stiffness, bumper height, average height of force that came from NHTSA, wheelbase, distance from axle to windshield, distance in overall length and width and anything you can think of. These parameters were put together by a bunch of engineers from JP Research and our industry who is basically, on a daily basis, designing vehicles.

Over 1500 vehicle groupings were looked at, primarily domestic because this was sponsored by U.S. Car and they had the data for some of the vehicle parameters but basically, we got some Japanese and some European vehicles in there, ‘81 to 2003 model years but the last phase I finished around 2006 I think. So we had all the way to 2003 model years, so it’s important to address that the new 2004 to 2007 model years is not included in the studies.

Car-to-car we looked at, light truck-to-car, front, side, left, right, separated all that out, looked at every one of those crash configurations. Logistic models, and again, this is the only time I’m going to use the statistical thing, logistic models predicting odds of fatality. What do I mean by that? It’s basically like you’re betting in Las Vegas. I’m going to tell you the chances of someone getting killed with the presence of a factor like mass, heavy vehicle, versus absence of a factor, wheelbase or weight-to-weight.

So I hope you can read some of the, I don’t know if you can read this, but these are some of the vehicle dimension metrics that we looked at. So if you look at, some of them are, if you look at -- some of the parameters are simple, wheelbase, overall length. And then we look at length versus, length times width which is kind of the, you know, the size. And then we look at the length times width times height which is the volumetric measure for size. Those are simple ones.

And then our engineers kind of went gaga over some things and we started looking at a whole lot of like longitude and the distance from front bumper to windshield, windshield to, front axle to windshield, front overhang which is basically the crash distance in front of the axle in front of the vehicle. It's part of the crash distance. And then we tried to do some of the things that EPA talked about, interior volume, because we were trying to get at a size parameter. Our industry was very much interested in finding a size parameter independently affecting odds of fatality other than mass.

And then there was some kind of, you know, really interesting longitudinal distance from bumper to windshield times vertical distance from bottom of rocker panel to bottom of the glass times the overall width. I mean, we just looked at everything. And this is just to show you the comprehensive list of dimension metrics that we looked at.

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Additional metrics then came along with NCAP test. We got some data from NCAP test, AHOF, bumper height, some stiffness parameters from NHTSA, some headroom parameters and all kinds of other things, the overall height just again, talk about the height compatibility.

The data sources where, we tried to get it from everywhere. We took almost a year to put together this vehicle parameter database for 1500 vehicle groupings and when I say vehicle groupings, I'm talking on a platform. A Chevy Camero from '91 to '95 model year is one platform, so we not only have to make sure it's the same platform and we have to take the sister vehicles and we have to look at 4x4, 4x2, extended cab, super cab, all those things, and then we have to make sure that we got the right dimensions. So it took us a lot of time.

We started off with AAMA and Kelly Blue Book, EPA, NCAP tests but then we went into websites, Gas Truck Index, industry sources. A lot of stiffness data came from industry sources. We also looked at, in terms of accident data, FARS data and states data. We had seven states at that time for various reasons. I won't go into that, but we have obligations on all my studies. If anybody wants copies of it, I can provide them after my talk.

We also looked at frontal stiffness data from NHTSA. There were two things that we got from NHTSA, NCAP tests and KW400, which is another work measure for stiffness that NHTSA has. And then we had three types of, and I'm not going to go into this because I know that a bunch of engineers are going to talk about all this this afternoon, later on this afternoon, three types of stiffness data, Ke1, Ke2 and Ke3. And then we looked at NASS data and we did an additional study at the end to just kind of compare mass versus Delta V to address some of the things that Dr. Lund was talking about. Sorry. If I don't have time, I won't get into the mass data. I'll just touch upon it.

The stiffness definition, again, it is one of those things that it's a published document which basically calculates the average force for a displacement from 25 to 250 millimeter or 25 to 400 millimeter, and those are two things. And then Ke3 was basically a mass times velocity divided by crush. Again, these are all things that we are desperately trying to get at to see whether anything is going to be better predictor than mass.

Now, a talk about a mass versus size will not be complete if I don't recognize the valuable contribution of Dr. Evans so I just put it in there. The first phase, the first thing we did was we repeated Dr. Evans' study on mass versus size for the same data set, same years, and we got pretty much the same results. And where, you know, where he had talked about mass ratio versus odds of fatality for --

the red curve is the left side, which is basically side impact, and the blue one is the frontal impact. So he basically said the mass ratio and fatality rate, you know, they are pretty much correlated and that the mass ratio predicts fatality risk pretty adequately.

Now, he also had, for car-to-car only, I mean his study was all car-to-car because he did this in the early '80s, he had something for wheelbase which was kind of flat for car-to-car and I can kind of, you know, predict that even without looking at some sophisticated model. But the point is in the middle of '85, '86 and maybe '90s, we started bringing in like, you know, light vehicles so everything changed.

So how do I conclude? I'm going to come up with a very high level conclusion but you have to take it and, from me that we spent four or five years of doing regression statistical analysis, regression analysis, modeling, logistic regression, sensitivity analysis, simulation. I mean, you've got to take it from me because we tried, when we put all these vehicles in, vehicle parameters in, we tried to figure out whether there was a lot of correlation, and there is a lot of correlation between weight and wheelbase, and length and weight, and a few other things, and we tried to separate them out by doing models with one not the other, getting both of them and see which one stands.

There's a whole lot of rigorous statistical analyses that went under, you know, for as part of this six phase study and the bottom line is for car-to-car, if you look at front-to-front, frontal accident, frontal crash, the coefficient for log mass ratio, or the exponent of mass ratio, range from 3.87 to 5.4. That's how powerful it is. It is very close to what Evans has got, which is 3.7, and a few others who are ranging between 3 and 5. And for car-to-truck, it was between 6, 5.8 to 6.

The idea is here to say that why is this so important. Now, it is important because I'm going to talk about now the same thing you saw for front-to-left and front-to-right but I'm going to talk about the other variables, the stiffness and other size parameters that came in at secondary order effect. There were some that showed up to be significant predictors of odds of fatality but they were nowhere near the mass ratio in terms of predicting the power of mass ratio, in terms of predicting odds of fatality. So this one was, mass ratio was the big brother over and over and over again. And so, you know, this is something that I say all the time. It's the most important vehicle factor, most important vehicle factor predicting odds of fatality.

Now, we also, in the same model, had a lot of driver factors, we had a lot of environmental factors, we looked at air bag presence, we looked at ABS, we looked at a few other things. They kind of show up but again, they're all very much a second order effect. Now, we didn't have safety canopy. We didn't have it rollovers. These are all frontal crashes, side impacts. Not rollovers. That's a totally different ball game.

We also found that these models, we had to deal with for car-to-car, car-to-truck and car-to-minivan and truck-to-minivan separately because the whole front overhang feature of minivan is very different from car-to-car and car-to-truck crashes so we've got to separate those out. So I'm presenting only these but minivans kind of follow the same thing, pattern.

So again, in a nutshell, for Phase 1 and 2, we looked at FARS and states, crash configurations front, left and right, and the significant vehicle parameter at that time, because this was before we needed to do stiffness, was mass ratio and front axle to windshield distance. Think about it. It's the distance between front axle and windshield. Now, we have talked about the room to have the crash protection and I think Dr. Lund talked about it and there's a lot of engineers who have talked about it. When we brought this up first, the engineers were saying what the heck is that. We don't know what it is. But this never went away. It's one of those uninvited guests at your, you know, Thanksgiving dinner. It just, we didn't understand it but it never went away.

Part of the reason is the engine is somewhere there. We could not get data on the distance between engine and front. It wasn't, you know, enough for all the 1500 vehicle grouping so we couldn't use that but somehow, maybe the engine, maybe there's something that is coming into play through that variable. This is another thing we have to be careful about statistical analysis. You come up with a variable then you say okay, engineers, figure it out. If you don't, maybe it's coming up as a surrogate for something else.

Phase 3, again, FARS and states, front and left, we did only front and left, mass ratio and then, they call it FAW, front axle to windshield distance, stiffness for struck vehicle was very important. Again, mass ratio, first order effect, stiffness, second order effect.

Phase 4, same thing, FARS, frontal, mass ratio, FAW. Then here, we did one thing which was very interesting. We had a bumper height. We tried bumper height ratio, bumper height distance. In all showing up, they're not that good but when we combine that with stiffness and again, this is the whole interaction we're talking about, and that showed up to be a very good model.

So stiffness and bumper ratio combined was doing something.

And Phase 5 and 6, again, we did FARS and states and frontal, mass ratio and FAW showed up. In all of them, the most important thing you have to remember for driver factors is age showed up all the time. Belt use, of course, was very important. And we did some of them for belted drivers only so the belt use is taken care of.

Truck-to-car crashes again, quickly, Phase 1 and 2, FARS and states, front left and right, mass ratio, height ratio before we got into the stiffness and bumper height, height ratio was showing up, and again, the FAW. The distance was, distance for the striking truck between front axle and windshield, that was very important. It was probably going all the way in as part of an intrusion phenomenon.

Phase 3, again, we did front and left, mass ratio, stiffness, FAW, bumper height difference, overall height. Again, they were all kind of showing up, mass ratio being the most important one. Phase 4, frontal, mass ratio, stiffness, bumper height ratio. Again, they keep coming but we have the same two over and over again. Phase 5 and 6 again, mass ratio, FAW, stiffness and bumper height ratio.

So the bottom line is all of these are doing something. I'm not saying stiffness is not important, bumper height ratio is not important but maybe the combination of that with mass ratio is what you want to go at when we are reducing weight.

So the final thing is just summarizing some of this before I go into a couple of other points. Mass ratio, stiffness and FAW, they're very significant predictors. Ke3, which is one of the stiffness predictors, that turned out to be a little better predictor than Ke2 which was kind of like the KW400 NHTSA has. For light truck-to-car, it's kind of the same thing, you know, mass ratio, stiffness, FAW and bumper height ratio, significant and again, Ke3 was the best significant predictor.

Now, when we put in stiffness, we've got to cut the data set in half because not every vehicle had stiffness data. That's why I'm saying that basically, bumper height ratio, stiffness, they all kind of kept on coming in but mass ratio and the distance between axle and windshield are always dominating.

Now, which is better, weight or wheelbase? There's one thing that I always want to talk about. You can't separate, I know Dr. Lund said, the easy answer is you can't separate weight and wheelbase. The correlation is, and he was talking about 0.7, we saw 0.9 with all the data sets that we had, 0.8, 0.9. So what do you do with that? So we tried several models where we just do weight, we just do wheelbase, we just do one at a time and try to see how they, you know, the model fits. Weight was always the better, better model fit compared to wheelbase.

We also looked at a few things that I'm going to touch upon very quickly like Dr. Ross and I think DRI was talking about. Inflated variance factors and we looked at signs and magnitudes and we looked at, you know, what if I do only all vehicles with same weight and then I change the wheelbase, you know, doing, changing just the wheelbase and keeping the weight the same. I mean, doing all kinds of sensitivity analyses with simulations of 200,000 crashes trying to figure out what is going to be the more important predictor. Again, over and over again, weight, mass was always dominating. Our size parameter was the front axle to windshield, you know, weak interaction with the weight but it was better than wheelbase.

The physical interpretation is very important for people who are going to do these models in the next few years. Please, when you get a parameter, even if it makes sense, make sure that it doesn't have correlation with something else that is coming in. And I'll give an example we had. The first phase when we did the model, EPA interior volume was showing up and we didn't understand that, why that was showing up even better than something else. And then we found out that the age and interior volume, they're highly correlated.

Older models, especially the early '80 models, the I call the delta '88, you know, the older models which kind of my dad used to drive, those were very popular among the 65-plus, you know, older drivers. So the whole older age interior volume, that was a very interesting phenomena so when we had to come up with an age equation, which was not just linear, driver age, when we had to come up with an exponential function to accommodate some of that differences, some of the differences in terms of one variable at the end also aggressively, we basically found that the interior volume dropped and then age just stood there. So these are some of the things that, idiosyncrasies that you have to be careful about when developing a statistical model.

And stiffness, again, a second order effect. It explains one percent of the variation whereas mass explains 20 percent of variation in fatality odds, so mass is like, you know, 20X more important. And stiffness parameter still, you know, Ke3 is a good predictor. Bumper height ratio, it is more significant for truck-to-car frontals, as you know, and it is significant when you use the difference as a separate variable. It comes up sometimes and ratio comes up sometimes, so somehow the bumper height mismatch is a problem that we have to address which I think is a nice study done by IIHS on that that we should look into.

And then, of course, the axle to windshield distance, you know, I don't know how many more variables we can get out of that but this is one that we had data for all the vehicle groupings and that showed up to be very significant.

I'm going into societal effect very quickly. I know I have two minutes. Bottom line, we repeated Dr. Kahane's work. We repeated Dr. Auken's study. Exact same state data, same methodology. We basically agreed with, bottom line is we agreed with Dr. Kahane's results. And for truck-to-car, you know, for 4.3 he had for 2003 study, we have 3.4 and for car-to-car, he didn't have combined rates so he couldn't do it. And so the last thing is the same thing with truck-to-car, we were pretty close. Kahane's study was like a -1.4 and JPR is -2.1. This is a societal effect when you just cross the board reduce mass by 100 pounds and just kind of see what's going on.

Conclusions. Mass ratio. Mass ratio. Mass ratio. And FAW, frontal stiffness, bumper height ratio are the second order effect predictors. Societal effect of reducing 100 pounds across the board truck-to-car crashes, reducing passenger cars will result in maybe 3.4 percent increase in fatality, reducing light trucks will decrease 2 percent in fatalities. Thank you very much.

MR. SMITH: Thank you very much. A lot of

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information there, a lot of good information and it's good that you're able to speak so quickly because you were able to put so much information there in that amount of time. I'm sorry if I appear to be rushing but we do need to move to our next presenter who is Paul Green from the University of Michigan Transportation Research Institute. So, Paul.

MR. GREEN: Okay. So a basic overview for this talk is we have a little bit of background on the mass-size-safety problem, look a little bit at data sources, some current approaches using statistical models, the issue of multi-collinearity, some suggestions that we might have for those problems and induced-exposure, which seems to be coming up in a lot of these talks and seems to be a method that you, that seems to be used for lots of these modeling approaches, and then a little bit about the future.

Okay. So the background. I think everyone's pretty well aware of the background in this issue. So NHTSA selected footprint attribute on which to base CAFE standards and these standards are likely to result in weight reductions in new cars and new trucks and of course, government would like to estimate the effect of these new standards on safety. Many studies you've seen today have been conducted and some of them tend to conflict with each other so, many of these studies demonstrate the association between fatality risk and these three factors, curb weight, track width and wheelbase and once again, the studies, many of them disagree with each other.

Some studies report a decrease in fatalities with vehicle weight reduction. Others report an increase. Other studies suggest stiffness, frontal height, vehicle design are better related to fatality rates than weight. Various studies are generally based on different underlying assumptions. The assumptions include different choices about variables, databases, statistical models and investigators, of course, all tend to have different backgrounds, philosophies and ideas. So in statistics, the first thing we do is we make an assumption and that assumption is either good or bad, it’s either right or wrong and maybe not even right or wrong, but some are just better than others.

Some notes for consideration are that analyses have been based on historical data and innovations in materials that provide strength at lighter weights and advances in occupant protection systems may change these relationships in the future. Of course, we’ve seen many of these things. Electronic stability control, a perfect example in terms of active safety technologies. Almost all papers coming out on electronic stability control have shown positive effects in terms of safety. So it’s important that methods for estimating future vehicle safety take into account advances in these technologies.

The usual suspects in the data sources, what's available. I've seen a lot of studies that use the FARS data. Of course, FARS has been around awhile. It's a census file of all the fatalities that occur on our roads so being a census file, I think a lot of people like working with that because they don't have to deal with survey data such as CDS. Of course state data, often used for induced-exposure involvements and that's what we've seen in many of the studies presented today.

So the FARS data, mostly where they get the fatalities from, and the state data is where they get the induced-exposure, the non-culpable vehicles and so there's kind of this comparison between the fatalities and the non-fatalities. And of course, other sources of data include variables about curb weight, track width and wheelbase.

So actually, many of these databases that have been constructed, very impressive. My guess is creating these databases actually is more impressive than some of the analyses. So my guess is it takes quite a bit of time to compile all this information, put it together. As a statistician, sometimes people just give me data and then I feel great because then I just have to do the analysis. I didn't have to do any of the data collection but sometimes, I understand that actually collecting the data was probably the hardest thing of the whole study in designing the, designing the study from the beginning.

So these are the usual variables under consideration. You know the driver level variables, the vehicle level variables, roadway, environment, crash type, crash severity, so we'll just go through that quickly.

You know, crash data hierarchical and for those of you who have worked with these kinds of databases, you know that this is the way the data are usually presented. Usually a separate crash file, there's a vehicle file, an occupant file and then you have to merge all those data files together on certain key values like, you know, the crash outcome and the vehicle number.

So fatalities are at the person level so that makes this sort of a difficult problem because it's at the bottom level and that's what we're interested in. If we're interested in societal benefits, we're interested in all fatalities and fatalities occur at the lowest level so you have occupants in vehicles and vehicles in crashes and these data tend to be very correlated with one another. Two occupants in the same vehicle, their outcomes are going to be correlated with each other as are the two vehicles in the same crash. Their outcomes are going to be correlated with each other too. So it makes the problem a little difficult.

And I think many of the researchers today have mitigated a lot of that, a lot of those difficulties by working actually at the vehicle level. My guess is most of their databases are recorded at the vehicle level, not, they're not working at the person level.

Can regression models be used to relate vehicle mass and size to -- I would say yes. I would say yes. The answer I think is yes. I think, you know, these are observational studies. We've heard that these studies are cross-sectional studies. These are snapshots in time. So, you know, I think that they can find general trends. There's so much uncertainty. We can't possibly account for it all but what we can do is find those general trends, we can find them. They're subject to a lot of uncertainty, a lot of variation but I think they're real. Using appropriate model and the correct data, good assumptions, you can find those associations.

So I don't know if you know. There's a statistician, his name is George Box, and he said that all models are wrong and some are useful, and I put in the middle part, and some are better than others, and I think that's pretty right. You know, they are all wrong but some are useful and the reason is I think because we always start out with the first thing we do is make an assumption, you know, we have to design the study, we have to design, what's our data, what model are we going to use, do the variables enter in a linear way, in a nonlinear way, how close are we to describing the truth, and that's what we really seek. So most of us I think would likely say we know a good one when we find one but we know that they're all wrong. So applied statistics is an art form.

This is a plot, you know, I like simplicity so is this simple? Yes. It's simple but it's great because it really shows, it's very compelling. This is a compelling plot because on the vertical axis, you have the log fatal rate and on the horizontal axis, you have the curb weight. And I took this from Charles' 2003 study and he puts the date in for this. I could actually reproduce this.

Now, this is for all crash types and some of the other, this is for everything so for some of the particular crash types, it's even more compelling. But what's really compelling, I think, about this simple plot, and I make plots like these too, is that the data are aggregated here so each data point is thousands of crashes. It's not just a couple. I mean, each data point represents thousands of fatalities and so there's not much variability in there. It's pretty, those are stable rates I think as long as you believe the denominator's right because remember, we don't have vehicle miles traveled.

We have, these are kind of, you know, the vehicle miles -- the denominator of the rates here are kind of derived but I think this is a very compelling plot and I don't think, in my experience, once I show plots like these and then I start adjusting for other variables like age and gender and night and rural, urban and all the other things that you put in a model, this basic association generally will not change. It may be adjusted a little bit but it won't change to a great degree. I think that's a great thing to show because of its simplicity and probably because it's showing things in the right direction.

Okay. Now, I don't want to bore you with this kind of stuff but traditional exposure-based risk models are some of these. Poisson linear models. Generally too simple so most people don't use those. Negative binomial models. Why? Because they allow for more variation in the data like we usually see in real data. Weighted least squares. Some of the studies use the weighted least squares when they looked at aggregated data models and that's fine. And then random effects models and then just (indiscernible) models and all kinds of models.

So these models generally require aggregated data but what most people, as you've seen today, most people did logistic regression and they used disaggregate logistic regression to study fatality risk. So this really is not one of the standard exposure-based risk models but I think it's okay. When you have a rare outcome like fatality rates, these models are generally adequate to be comparable to one of the exposure-based risk models that I showed on the previous slide. So it is good. It will find the general trends and I think it's okay to use this kind of thing.

And like I said, it appears that the data were not analyzed at the person level. I think they were analyzed at the vehicle level. This model assumes all observations are independent so remember, when you have several fatalities in the same vehicle, I'm not sure that assumption is fair to, I'm not sure that's been satisfied. And like I said, I think it can be used as an alternative to one of the more traditional exposure-based risk models. So you see today, a lot of people were presenting this kind of a model. I do tend to think that it is possible to overstate significance in these models because it's based on a likelihood-based approach and as long as your sample sizes are big, these models will tend to find significant results even when the effects are small so it does have that. It is a simple model. It will find general trends, but it does have some limitations also I think.

Multi-collinearity. This clearly is an issue. These three variables, curb weight, track width and wheelbase, tend to be highly correlated. Now, I'm an independent reviewer so I don't have access to the data. I can say that I have not looked at these data and have not analyzed them. I've only reviewed the papers and the works that have been done. But it appears that many of the researchers are reporting high correlations between these variables.

When you put these things, I think everybody knows this, that when you put these things, all these variables together into a regression model -- they can all show one association when you put them in by themselves. When you stop putting them in together, they can, one of them can change sides and the other one can go the other way and it can lead to a little bit of unstable estimation.

So there are some techniques to get around. Centering variables kind of tends to help you. If you center them around the mean, it kind of helps a little but I think our recommendation would not be to include -- now, like I said, I haven't done, I haven't looked at the data so this is just a recommendation based on what I've seen. So that, you know, that may be right, it may not be but from what I've read, my recommendation would be to not include all those highly correlated in the same model unless there's some indication that that would be a reasonable thing to do. It may be. I don't know but I leave that for discussion I think.

Here's a suggestion. I mean, if you want to start putting, if you want to analyze curb weight and footprint together, I think a reasonable thing to do might be to match on footprint. If you're interested in the effects of curb weight as it varies and holding footprint constant, let's say, so hold footprint fixed and allow curb weight to vary, you might want to construct a database like this. You might want to create a stratum variable where you match a fatality to a non-fatality so the fatality would come from FARS and the non-fatalities were coming from the state data.

So stratum 1-1, that would be your fatal and your non-fatal. You're comparing those two and the curb weights may be different but you match on footprint. So you're going to the state data and you find a vehicle that was in an induced-exposure crash and you match the footprint so see, 40-41 up here. Is this it? Yeah. So you might want to -- they can be close. In stratum 1-1, you might match footprint here and for stratum 2, you have a fatality and a non-fatality. This vehicle registration years would be like a weight factor and so you would just declare this as a weight. The fatals would get a 1 and the induced-exposures get their vehicle registration years. And then see how curb weight would be allowed to vary.

You could design this experiment however you want. Curb weight would be allowed to vary within each stratum but the footprint should be hold fixed, should be held fixed.

You could also match on -- if you think driver age and driver gender, those are confounders, you can match on those too. So see, within each stratum, match on -- so this is male, male, female, female, male, male. And so age would also be matched. We can differ it by one or two. That's fine. But so those are still matched. And then you could also --

Now, the matched variables you don't put in the regression model because they're matched, they're fixed, they're controlled for. See so you don't have to put those in there. So in a matched, in a matched analysis, you don't include those matched variables in your regression model. You only include these other ones like night and rural, urban. These change within the stratum. And standard software packages handle this, for example, the logistic model procedure. You just declare the stratum as a stratum, that's it, and it will handle this fine. And you don't include these variables even in the log.

So this is just an idea. It's just an idea. You match on footprint, possibly other ones that you think are important and those things are controlled for you. Don't fit them and now you watch what happens to the curb. Now you analyze curb because you're focusing in on curb weight. That's what you're interested in.

Why match? Well, lots of reasons. Matching is a tool specifically designed to control for confounders. Well, that's what footprint is. Footprint is a confounder and if you just want to match on footprint, that's fine. If you also want to put age and gender, that would be fine. You can match on those, too. Then you wouldn't have to fit -- now they're controlled for. It results in more efficient estimation.

Now, lots of simulation studies have been done. When does matching, when is matching good and when is matching bad? Matching's good when you have confounding so footprint is a strong confounding so that's a perfect case to use it. Footprint is associated with both fatality risk and curb weight so if it's strongly associated with the response variable, which is fatality risk, and your other variable that you're interested, curb weight, that's when matching is going to result in more efficient estimation.

Simulations show that when you match on something that's not a confounder, your estimation is not anymore efficient than it would be if you just did a standard analysis. So in this kind of a thing, you can focus on the effects of curb weight while holding the footprint constant. So it might require a little bit of creativity but I think that would be a possible thing.

Another thing that would be useful, in reading many of these papers, I saw that there's a contradiction

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sometimes between well, should we include two-door versus, you know, should we include two-door cars in there, should we get rid of the sporty cars or should we get rid of the muscle cars because they have different kinds of track width and wheelbase. I think if you look at, if you fit models and you look at the residuals, you'll, those things will not fit the model properly and big residuals will alert you to those kinds of things.

So if you just examine the residuals, you'll know whether to do that and I think if you find big residuals for the sporty, you just take, I think that's a legitimate reason to take them out of the analysis. Large residuals could alert the analyst to poorly fitting observations. They would also, if you detect these outliers, it may also lead you to something that you may have had no idea about before. You may find out that there's some certain kind of vehicles that are not fitting the model well or there's some certain kind of crash types when things are going a little strange. So I think this is a very simple remedial thing to do and it could lead to understanding the problem a little better. When can you exclude these and when should you not? I think that would be a reasonable thing.

Just a note. I don't really have a good answer to this. You know, we don't have, we don't have vehicles miles traveled. You might hear people say oh, it's exposure,

exposure. We don't have it. We don't have any exposure. We just don't have it. So what do we -- well, so induced-exposure I think, I've done it, I've used it. It's an alternative but, you know, I've seen, when I've used it, I've seen sensitivity to it sometimes because sometimes you --

Induced-exposure crashes are very different than the crashes that you're examining, you know, they have different speed distributions and all different kinds. They have lots of, lots of things that -- the distributions are very different among the fatalities in induced-exposure crashes and I know you try to adjust for lots of things by including them in the model but still, in my own work in using it, I've seen some things that, and I've seen some strange things happen before.

So I just point this, here's, I just point this out for, this is a topic for discussion because I really don't have any solution because we really don't have any. You just hear people talk about this all the time. We just don't have vehicle miles traveled. So there are some concerns about the effects of that on the final results.

And finally, the future. I don't know, how do you, I have to -- you know, when people say how are we going to predict the future, you have to smile a little bit because I don't know. But, you know, using historical, using historical data that show us a certain trend over many years, it's very hard to try to predict the future from something like that. It's a very difficult task. Not easy.

Some trends have already been discovered with some active safety, ESC a good example. And I think the only thing I can say right now, of course as these effects become evident in newer data, it will be detected but I know we don't want to wait until that happens but it will, it will show up when it becomes available. I'm open to simulation. I think that's a great idea. Simulation can be a valuable tool in certain control settings.

I think the discussion today is really excellent because we have statistics and we have engineering in the afternoon. I think both of them have valuable contributions to this, solving this problem and I think both of them should be used to do this. The simulation could be, that's out of my area but I think engineering people would be good at that. And I think that's it so thank you. Thank you very much.

MR. SMITH: If the panel members would take their seats. Paul, you barely hit your seat but back up to the stage if you would. If we could get the panel members up here for our discussion, I'd appreciate it. We'll have questions coming in through the webcast and you'll all be able to ask questions as well. I'll probably get it started with a question here in a moment.

Let me say that in my balloting for panel member of the morning, when Paul showed that simple graph that I really, really, really liked, I picked up my ballot and was ready to go and then we got into Poisson models and collinearity. I put my ballot down at that point from the, in terms of the simplicity vote. But, no. It was a wonderful presentation. I hope you understand that I'm just kidding here, Paul. It was a great presentation.

I think the first question I have, and then we'll open it to the floor and the folks in the webcast, it concerns this whole question of using historical data to predict the future and safety effects on the future fleet. If you can just, if you would, folks, speak of that for a minute without speaking over each other and talk about what the value is of using historical data because we know the fleet's going to change and yet, we're using historical data that's, you know, the data we have. But if you could talk to us about the usefulness of using the historical data to help predict what we're going to be dealing with in terms of the fleet in future years. Anyone who would like to start? Adrian. And do we have mics? Okay.

MR. LUND: Now I can kick it off, right? Is that working. Yes. I think there's some concern about using the historical or hysterical data and it's based on the fact that we haven't seen the kinds of changes in vehicles that we're hoping to see in the future perhaps, that is new materials being used are the source of, say, weight reduction.

So there is a problem in using the current data, if you will, because the weight variation that we have right now is typically not based on the use of different materials but as Dr. Kahane said earlier, it's based on different functionality for the vehicle. So it adds four-wheel drive or it puts in a bigger engine, hybrids are heavier than their standard engine counterparts. So that does raise an element of concern about whether we're getting to the pure effect of size that we're concerned about.

On the other hand, when you look at the decades of data that we showed in my analysis, what we see is there have been vehicle changes in the types of vehicles and so forth over those periods. What keeps coming out though is that there is a size effect and there is a mass effect. They're there even despite quite large changes in vehicle designs and I think that's what needs to instruct us, that again, as I said in my presentation, we're not going to repeal the laws of physics by introducing new materials. We will be able to reduce mass and maintain size in a better way perhaps but again, it will still be that the larger cars and the heavier cars will have a benefit.

MR. SMITH: Someone else want to speak to that for a minute?

MS. PADMANABAN: Very quickly. We did try, for the model years that we looked at, '81 to 2003, we did try with '80 to '90, and then '90 to '95 and '95 to 2000 just to see whether we could get any changes and again, as Dr. Lund said, the mass showed up, size showed up. It was a little different but they still kept showing up. So I think, you know, we have to look at it but I agree with Paul that we may not be able to come up with a prediction like a crystal ball prediction but we should look at it to say that this doesn't go away and how powerful these coefficients are. I think we should, from that point of view, historical perspective of data and fuel data is very useful.

MR. SMITH: Okay.

MR. WENZEL: I'm not going to have a good answer but I just want to point out that we do have an example where we changed technology in the recent past, you know, the introduction of crossover SUVs which you alluded to. You know, and here was a vehicle that if we had used the 2003 NHTSA analysis, it's a vehicle that's 15 percent lighter so it should have a higher fatality risk. Well, crossovers not only have lower fatality risk for their own drivers, they have a lower fatality risk for others, a lower societal fatality risk.

So that's, you know, that's clear example where if we rely too much on a single coefficient from these regression models based on recent historical data, you know, we cannot predict what's going to happen in the future, particularly when we introduce these new technologies. So we just have to be very careful about how much weight we put on these weight coefficients that we derive from these models.

MR. SMITH: Tom, that's a very good point I think and I was noticing in the JP Research presentation that it occurred to me perhaps the dichotomy we have between mass and size and for size, we're only talking usually about footprint or shadow, I'm wondering if that dichotomy is a bit too simplistic, if there aren't other measurements and factors that would really contribute to our understanding.

MR. WENZEL: Well, yes, I agree and so I was really intrigued by the kind of data you were getting at. I mean, people talk about size and footprint, you know, we're not necessarily interested in that. We want something much more refined in detail than that, you know, and I know the work NHTSA's done on, you know, bumper height and average height of force and all these variables, you know. We're still trying to find that single bullet, that one variable that explains it, and it's not going to be one measure that's going to explain every, the risk in every kind of crash. It's specific to the specific kind of crash. So it is a very complicated area and it's hard and we just have to be very aware that we can't, you know, pin everything on a single variable.

MR. SMITH: Thank you. I'd like to take a question from the, from the audience and then we'll take one from the webcast, and I would ask the microphone be passed down to the other end of the panel so that they can field, the folks on the left side of the panel can field the next question. Yes, sir.

MR. TONACHEL: My name is Luke Tonachel. I'm with the Natural Resources Defense Council and first of all, thank you all for your presentations. I did want to note that, you know, for EPA and NHTSA's work in addressing a lot of concerns that NRDC and other public interest groups raised in the NPRM, we really appreciate the work that's being done by the agencies. I wanted to just make a quick comment on both the historical and future aspects that we're having a discussion about.

One pretty simple question is, you know, since we have these studies out there that dealt with older model years, and we're talking about the fact that advancements have been made, what's the time line in terms of having a public database that people can have access to and how do we make sure that, you know, those others like DRI or other organizations that are looking at that updated model year information can be working with the agencies to make sure that they have a clear interpretation of it?

And I guess, you know, I think leading from Dr. Wenzel's comment, you know, the Ford Explorer seems to be an example of a vehicle where, you know, not only has there been better fuel economy with lower mass but also, improved safety, so what's the methodology in terms of looking at improvements in technology and incorporating that into future analysis?

MR. SMITH: Thank you. We've got a two-parter there. You want to start with -- oh, we got a mic. I'm sorry. You want to start with the first question about availability of data, Chuck?

MR. KAHANE: Yes. The database that Tom Wenzel and I are working on and EPA is, Cheely (phonetic sp.) from EPA is also working with us. We hope to make that available to the public. If we can get that first out to our partner agencies for very careful quality control, you know, during the next month, if we can get, we have a number of issues with, we've never really done this before, making, putting data out on the, data that is not NHTSA-generated out on a public site so we have certain issues there with permissions. If we get around those, we'd like, as soon as possible, to get that out to our partner agencies for a very careful review and if they don't find something catastrophically wrong with the data. They oh, my gosh, you took all the cars and made them trucks or whatever. We're hoping, perhaps, to get that database out to the public in April.

MR. SMITH: Okay. Could someone summarize the second part of the question and let's see if we can answer that one? Tom, do you want to repeat what you remember?

MR. WENZEL: Yes. I think the question was looking at particular examples of changes in a particular vehicle's technology and what effect that has on its safety. And so I guess that's a before and after analysis, right, where a particular model has a lot of material substitution in a redesign and see what the effect is.

That is a very important and great way to see the particular effects of a particular change because you, even if you couldn't account for driver, changes in driver variables, the driver should stay the same, pretty same just with a redesign of a vehicle. The difficulty is that because there are, thankfully, relatively few fatalities on the road, you need to get several years of data before you can get the statistical significance to do that kind of analysis, but I do think that looking at the trends in a particular make and model vehicle and their fatality rate over time is very instructive.

For instance, Ford Focus, in their redesign, the Ford Focus, replacement of the Ford Escort, made a huge improvement in safety record and similarly with some of the Hyundai models. So you definitely can see the value of improved engineering as well as specific technologies in improving vehicle safety and presumably, we'll see that as certain models are the early adopters of large amounts of material substitution and light-weighting.

MR. SMITH: Anyone else care to address that or not? Okay. Did you, Paul? Okay.

MR. GREEN: Well, I would say that in many of the -- when people were showing that electronic stability control had a great effect on reducing injuries and fatalities, that's exactly what they did. You know, in the database, you can actually find, you know the makes and models that have ESC as standard equipment so you can find those vehicles and then you can compare them to the same models that don't have, that don't have it and then you can compare their fatality outcomes. So that was, I think, one successful way that was used to look at ESC.

MR. SMITH: Right. I think the challenge now is that some of the, you know, like material substitution and so forth, I'm not sure that we've got a great database that's going to easily pluck those, to the extent that they're in the fleet at all, that are easily going to focus

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on those variables and I think that's one of the challenges.

Do we have a, Rebecca or Jim, a question from the webcast?

MS. YOON: This is from David Green (phonetic sp.) at Oakridge National Laboratory. He asks particularly to Chuck and Mike but to all the panelists. He says recognizing that measuring exposure is a complex issue, the new exposure measure seems to require a strong assumption and introduce potential hidden biases. For example, determining culpability in a crash is, in general, not absolutely definitive. Culpability is often likely to be a matter of degree and shared. Doesn't this make the new exposure system less clearly a measure of simple presence on the highway system? Wouldn't it be better to always also include simple measures such as registered vehicles for comparison?

MR. SMITH: Directed to?

MS. YOON: Mostly Chuck and Mike, but everybody.

MR. KAHANE: Answer yes to both questions. With induced-exposure data, when in doubt, leave it out. There are many, you have to look at each state file and there's many cases where it's marginal, it's not so clear which vehicle they consider culpable. Leave them out. You've got plenty of cases in the state data. You've got millions of cases so don't pull in the cases you have doubts about.

As far as the simple measure such as registrations and VMT, yes. The databases we're talking about, both Mike and I are working with, weight the induced-exposure cases by VMT, registration years or other factors. We're hoping to concentrate more on VMT on this go-around because without that, you have biases introduced by different types of vehicles having different types of crash reporting rates.

MR. VAN AUKEN: I would agree with those comments, answers. I would also add though that the previous definition of induced-exposure with just the stopped vehicles eliminates the question about vehicles that are in motion when the vehicle is, whether there's, there could be some confounding effects going on there with the culpability, induced-exposure criteria. For example, the weight correlation that Dr. Kahane had mentioned earlier today. Also, the fact that if the vehicles are not stopped, that there may be some confounding effects with the ability, the driver of the vehicle's ability avoid the collision in the first place.

So I would suggest that we look at both the stopped vehicle and the non-culpable vehicle as two alternative induced-exposure criterias and to tend to bracket the results and give another estimate of the uncertainty in the analysis.

MR. SMITH: I'd like you to note that due to physical constraints, we're working with one microphone for the panel here so.

MR. WENZEL: That's okay. We're used to sharing. Yes. I guess the point that Mike's making is a stopped vehicle is always not at fault, but I guess there are cases where a stopped vehicle could be a cause of a crash.

I just want to point out that one way of getting around the whole induced-exposure is to not attempt to model risk as a function of vehicle registration but to measure risk as a function of total reported crashes in which case, you don't need, you use all of the crashes in a police-reported crash database which is one of the measures I'm proposing to use, and so you don't need to determine which of these are induced exposure crashes. You use all of them.

The difficulty with that is the under-reporting of the non -- I mean, all of the crashes you really care about, the injury and fatality crashes are included. It's the property damage only crashes that aren't necessarily fully reported. But as I've shown, if you normalize to the non-reporting rate in each state, you get really consistent results across states, so that may be a way of removing that potential bias in these other analyses.

MR. SMITH: Anyone else in the group here with us have a question? Yes, sir.

MR. NUSHOLTZ: Fist I have a question with regard, first I --

MR. SMITH: If you could introduce yourself.

MR. NUSHOLTZ: Oh, I'm sorry. Guy Nusholtz, Chrysler. First, I have a question with an answer or a comment with respect to the last question, and then I'll go onto my question. One of the problems with using per crash is you can get some real artificial results. I've done a recent analysis, primarily using mass but other databases, where I can demonstrate that over time, fatality rates have been going up. Now, that's exactly opposite of what you do when you do it per mile and it's hard to believe that since 1990, that the fatality rates have been going up and so there's something wrong, potentially wrong with doing it per crash and so a lot more statistical work needs to be done before we can actually use that parameter.

I have a general question that's partially ethical and partially technical. If you use other technologies to compensate for the effect of increasing the mass, is that appropriate is the first part of the question. The second one is how would you sort through that that's really what's happening in the statistical database.

An example is if I get everybody to wear their seatbelt, then I'm going to have quite a reduction in fatality rates and it will probably overcompensate for a small increase, a small decrease in mass. Or you can go to other things, have people, have everybody drive a little slower and you can get them to drive slow enough so all of the mass that you reduce will be compensated for. Now, if I -- the problem there is that I would have had a greater reduction if I didn't reduce the mass.

So first question is is that appropriate and two, how would you sort through that data technically.

MR. SMITH: Adrian is holding the microphone so I think he's first up.

MR. LUND: I'm not sure how I got stuck with that. I think that was one of the points that I made, that obviously, we're here discussing this because the Government has a role in setting CAFE standards which could affect the kinds of vehicles we have choices of buying but ultimately, consumers are going to choose and they're going to be the final arbiters and I think we can all project that there's going to be a premium on small, fuel-efficient vehicles.

Now, I think you were asking can you offset and the answer is yes. For us safety advocates, the problem's going to be figure out how you protect people in a somewhat more dangerous fleet, one that doesn't have a inherent protection of the size. That will be what we're about, is looking for those other things. Do we need to slow people down? Do we, can we increase belt use so it's 100 percent? Is there a way to lock the vehicle up so that it can't go unless you're belted? We tried that once before. I didn't work out well politically.

But we'll also be looking, obviously, what could be a game-changer are the crash avoidance technologies that are coming on line. If we can avoid the crash, then it becomes a little less important how big you are because most of the physics we're talking about assumes that a crash has occurred. So I think we will be looking for ways to compensate for that.

And you were asking is that ethical? I don't know whether it's ethical or not. It is reality, so that's what we will do.

MS. PADMANABAN: My answer is can you do anything in the statistical model about behavior? No. But it's not just the mass relation, it's the mass ratio so it's just a variation between the striking and struck vehicle. So if you start reducing everything so, I mean, again, 10 years from now, we've got to look at it and see what it did. So it's not that everything is going to be -- right now in the U.S., the mass ratio for vehicles, motor vehicles is, that range is from 1 to 3, you know, you have a striking vehicle versus a struck vehicle. There's a 3x difference. Whereas in Europe, it's between 0.8 to 1.1. There is not a whole lot of variation between the striking and struck vehicle mass.

So, you know, stiffness plays a more important role in Europe compared to the U.S. because of the mass relation so that's something that I would be careful about to do but behavior in data, there's nothing we can do to separate those out. You're still going to see sports car drivers, less belted, you know, you're going to see stuff like that.

MR. SMITH: Another question from the audience or another comment from the panel? No. Okay.

MR. GERMAN: John German from ICCT. Question specifically for Dr. Lund but anyone else should feel free to jump in. You showed some really nice data on the fatalities versus mass and how it's not changing over time, you know, completely agree, but I think what we're really interested here is in the overall fatalities in society. So if you have two vehicles different in size and weight and you put lightweight materials in them or reduce the weight of both of them by 15 percent, mass ratio isn't going to change, relative fatalities isn't going to change, but the real question is if you do that mass reduction, what happens to overall fatalities? Do they go up or do they go down?

MR. LUND: Our data, which I don't have included in this presentation but we have looked at, in addition to the driver death rates which is what I focused on, we've looked at deaths in other vehicles and obviously, you get the opposite relationship. As mass goes up, and I didn't dwell on this because I think it's inherent in what Dr. Kahane is talking about, as mass goes up, you are causing more damage to road users.

I can provide you with the data separately and anybody who wants it, we'll be trying to finalize this. But looking at total fatalities by say vehicle mass, when we look at cars, we find that up to the largest cars, we're mainly seeing a benefit of cars being larger and/or heavier since those things are going together. When we look at SUVs and pickups, we see something different and that's consistent with what Dr. Kahane is estimating here, and that is the, as the mass increases, the improvement and driver death rates is more than offset by the damage to other road users.

So we are seeing something when we look at the total fatalities that is consistent with what Dr. Kahane has reported. We don't see that upturn for cars and even though they start getting into the same, you do have some cars that are in the same weight categories as some of these vehicles but for pickups and SUVs, we definitely see that increases in mass, the protectiveness of that is offset by increases in damage to other road users at high levels.

MR. KAHANE: We want to -- I believe all of us here were talking to that -- look at the societal fatality rate including the other road users as a function of mass and if at all possible, make the model so that it's also sensitive not only to the mass of the case vehicle but to some extent, to the distribution of mass and vehicle types that's on the road so that as over, this is if, you know, this is a wish list, as time goes by and the other vehicles on the road get lighter, you're going to have less of a problem of these big, heavy LTVs hitting you because there's fewer of them. But the model should be sensitive to that as well if possible.

MR. SMITH: Okay. I have one more and it's a two-parter I guess. And the first is to Adrian. We're putting him on the spot here. I thought that in your data, there was a slide or maybe it was a comment indicating that the safety of small cars is increasing faster than that of large vehicles. Did I get that right?

MR. LUND: Not quite. I know why you heard that but what we're seeing is improvements in safety in all vehicle classes and probably as a percentage, it's not terribly different because large cars maybe haven't had an absolute level of fatality reduction that's equivalent to say the smaller cars but on a percentage basis, since they started at a lower fatality rate, it's a pretty significant thing.

What we actually have is that every vehicle class is much safer than it was before, but we started with the largest cars having about half the fatality rate of the smallest two decades ago and currently, we have still about a two to one relationship in terms of the fatality rate. So the relationship between small and large has remained the same is what I'm trying to get at.

MR. SMITH: Okay. But if the rate of improvement, even given what you just said, of small cars has been greater than that of large cars, even though the differential remains about the same, what accounts for the greater improvement of safety in the small cars since, you know, they're generally subject to the same safety improvements as the larger vehicles? Is there something on the small cars that is driving their safety faster than that of larger vehicles?

MR. LUND: Well, on a percentage basis, it isn't. So if you're introducing a technology that say has the benefit of reducing your fatality risk, say the side impact by 30 percent, and you put that in a large car and in a small car. Small cars are already having many more deaths in those kinds of crashes because they're at higher risk. Thirty percent has a bigger effect on them than it does in terms of numbers, which is what you're asking about, than it does on the large cars. So it's just a mathematical thing and I think what we need to focus on is that we still end up, though, with a mass or size differential in terms of the amount of protection the car offers you.

MR. WENZEL: I'll take the heat off of Adrian. I think what would be nice to see, and Adrian's chart is not accounting for all the other variables, but his scale was so compressed that you couldn't really see if the slope changed when you went to different generation of vehicles. But that's the question. Does that, is that slope becoming flatter over time and if it is, that means weight is becoming less important of a variable. And those are the kinds of things that the regression models that we are all working on will be able to show after you account for everything, drivers and crash location, for everything we hope we can account for, you know, is that slope of that line on weight changing over time and are we making an improvement.

MR. SMITH: Okay. Thank you. We've got another five minutes or so before we break. Anymore questions from our group?

MR. KRUPITZER: Thank you. Ron Krupitzer from the American Iron and Steel Institute. We've had the benefit of working on mass reduction and vehicle safety in engineering projects for the last 10 years or so and I was particularly struck by Dr. Lund's generational improvement in vehicles in fact but still maintaining the laws of physics which I thought that was very appropriate. Thank you.

What we found, quite frankly, is that vehicles over the last 10 years have really changed dramatically in their composition. I really love the images of the 1958 Bel Air colliding with the 2008 Malibu, for example, just showing the difference in the mechanics of deformation.

When it comes to vehicle structure, I think that still plays a big role even though there are air bags and there are other engineering features that obviously contribute to the injury severity data that you're dealing with. Our biggest problem, I think, is we're our own worst enemy over the last 10 years, we've added side impact tests, volunteer tests that all the car companies do now for IIHS and we have the roof crush test requirements and so forth. All of these add new materials requirements so in fact, car companies have dramatically changed if you look at a pie chart, the types of steels or the types of materials, amount of aluminum, for example, over the last 10 years.

So my theory is that if we continue to make vehicle regulations regarding safety, improving, continuously improving, we'll automatically have to be changing the materials and the design requirements. We're going from body and frame SUVs to uni-body SUVs. Almost every car maker is doing it. It's more mass efficient and actually, stiffer and better for handling.

So my challenge to the analysts here, the statisticians especially, is how do you separate all these concurrent, you know, factors that are, you know, leading to predicting ultimate societal safety when they're so significant in and of themselves, and I guarantee you that materials changing will continue over the next 10 or 20 years. Vehicles may not get all that much lighter I'd say but I guarantee you they will be more fuel-efficient and they'll be safer in the end and that's because those are our ultimate goals, but what do you think about how it is possible with analytical methods to separate all these very important factors as engineers work on making vehicles better for the future?

MR. SMITH: Thank you. I knew there was a question coming there.

MR. KRUPITZER: I'm sorry.

MR. KAHANE: I think that there has been, there have been changes in the vehicle fleet from the 1990s to the current one which, of course, you're talking several years into the future. We could not look at that statistically yet. And we have to adapt the analysis to that. I think the biggest issue is to take vehicles that are technically LTVs but really have more car-like features and not throw them into the same hopper with, with the traditional truck base LTVs.

MR. VAN AUKEN: I would add also that you would want to add control variables for the newer technologies as they get added, for example, the ESC and maybe drop other control variables that are no longer needed such as the frontal air bags so that then you move forward with, you know, differentiate in the differences in the generation of the vehicles and their technologies.

MR. WENZEL: And just to make a pitch, if you have any data on the content of makes and models, you know, alternative materials, that would be very helpful to us because it's --

MR. KRUPITZER: We do publish that every couple of years.

MR. WENZEL: Okay. Great. I'd be interested in seeing that.

MR. SMITH: Okay. We have another question from the webcast, Rebecca?

MS. YOON: This is from David Friedman of Union of Concerned Scientists regarding the use of statistics. He says in stepping back and thinking through the various presentations, there seems to be some division in philosophy on the approach to understanding the relationship between mass and size. This is an oversimplification, but one philosophy seems to see the value and difficulty of doing statistical analysis while continuing to dig deeper into the data to understand the more complex relationships. The other, again oversimplified, appears to be that we know the relationship and if the statistical analysis does not support what we know, we have to change our statistical analysis.

Given the complexity of the actual physics in a crash and given the complexity of current automobile design, I worry about the latter approach. I would be interested to know what the different panelists think about the different philosophies and whether this should be about testing our hypothesis versus confirming them.

MR. SMITH: Good question. Are we testing hypothesis or confirming them? Someone who hasn't spoken too much may want to jump in there.

MR. GREEN: I like to keep things simple so, you know, I like to keep my models simple in focusing on specific data. So, you know, I don't want my data to be too variable and then fit a model to those data. I want to try to get rid of all that variability so I'd rather have a simple model that focuses in on, you know, I'd like to pinpoint one specific issue that I think I can tackle and focus in on that data issue and solve it and then, I'd rather solve a bunch of simple, many simple problems than try to solve the whole problem all at once because I think that's just too difficult. There's just too much going on.

So like I said, I like to keep the, I like models to be simple and straightforward and focus in on certain problems because if you try to tackle too big of a problem, there's just too much uncertainty and variability there and that's when all the problems start I think.

MR. SMITH: Okay. Thanks, Paul. I think the question is really are we doing some of our research to confirm hypothesis or is it more wide open? Anyone else want to speak to that? Apparently, folks down here do.

MR. LUND: It took longer than I thought to get that question actually. The issue that I was trying to raise there isn't that we shouldn't be doing statistical analysis but it is, as Paul said earlier and also Jeya said it, if we, if you get a statistical model that doesn't match physical reality as we know it, then you need to look at why the model is doing that. It's one thing to get a finding that as mass is reduced, you actually get safer vehicles. It's then up to you to figure out well, how did that happen since we know that given the crash and given that it's a straightforward frontal crash, that there is a protective effective mass and we're not getting it in a statistical model, what's wrong with it.

So you need to, it tells you you need to pursue your statistical model further and to account for where the expected mass effect went. It doesn't mean you were wrong necessarily but you should be suspicious. You can't stop with a result that is inconsistent with 300 years.

MS. PADMANABAN: And I also would like to add that I thought all of us pretty much agreed on the primary conclusion that you can't go against the physics, laws of physics. I mean, mass is important. But we're talking about all the size effects and when the mass is reduced, is something else going to happen, is there behavior. I mean, we talked about a lot of other things and that's why I think this symposium and some of the projects they are talking about are very important because they are all looking at the same data set, same methodology and I heard that a couple of the inconsistent conclusions, they are now, when they use the same data, they are basically agreeing.

So I didn't see a whole lot of disagreement among everybody, at least what I heard this morning, but I do agree with Dr. Lund. I mean, you have to question. We cannot have a preconceived notion about what we're going to prove other than, of course, laws of physics. We know what it is. But if we find something that doesn't make sense from a particular interpretation point of view, we need to spend some time on working with engineers and try to figure out, and working with the data to figure out what's going on. So statistics is not, you know, I wouldn't call it 100 percent pure science.

MR. SMITH: I think Paul called it an art form so, at least what we're doing here. Chuck?

MR. KAHANE: I'd like to both thank my own agency for sponsoring this symposium but especially our partner agencies, especially the ones that aren't up here, EPA, getting all of us together talking, sharing data, sharing models, and I think this is helping everybody get a more open mind on the question.

MR. SMITH: Thank you very much. I think -- well, we have one more here. One more comment I think and then we're going to probably wrap up for lunch here.

MR. VAN AUKEN: Yes. I just had, I want to, couple comments on the discussion about physics here because the physics, you have to be careful what you're talking about here. Are you talking about the self-protection, are you talking about the subject vehicle occupants, are you talking about the collision partner fatalities and are you talking about the physics related to the crash or are you talking about the physics related to the pre-crash because they're different physics and they are different persons involved and so when you talk about mass --

MS. PADMANABAN: Yes. That's --

MR. VAN AUKEN: This is why we have these, we initially added the additional variables about wheelbase and track because there's things in the physics, the equations of motion that suggest that those are different effects and so therefore, that's why we looked at them. We were directed to that based on our understanding about what the physics was. And also, the fact that we were also looking at both, we were looking at the societal view so therefore, things like mass ratio, I'm not sure what the effect of mass ratio would have if the, if you're looking at the total fatalities in the crash because I would understand where things like maybe wheelbase or the front to, front axle to a windshield might be beneficial for both occupants, they're both pushing partners but.

So you've got to be careful about what the charts are that you're looking at, whether they're labeled as self-protection or occupant driver fatalities or whether they're looking at all fatalities. I think that's just something we need to be clear about.

MS. PADMANABAN: I just want to explain. The mass ratio parts were based on struck driver fatality and then when we went to the next societal effect, we did the rate per induced-exposure and accident and did both striking and struck. So we did it both ways but you're right. We have to look at -- you're looking at struck driver first and then striking driver fatality and then later on, you're going to look at pedestrians and everybody else. Yes. Yes.

MR. SMITH: Okay. One more down here and then I think we do need to wrap up for lunch.

MR. WENZEL: I just want to say to answer David's question directly, I mean, I think the fact that the agencies are making a big effort to make the data set publicly available is going to address this concern of whether the analyst is introducing their own bias in their analysis, and anybody will be able to recreate or change the analysis based on their own assumptions. I don't know if that's necessarily, I mean, that could open a can of worms but at least everyone knows that we're working with the same data and we can see what assumptions everyone's making to get to the results they end up with.

MR. SMITH: Very well said. Let me say that I have cast my ballot for panelist of the morning and they all win. I want to give them a round of applause for doing a very great job and having a very great interesting discussion. I think, you know, what I've heard, we can go on and on and on but we do have the afternoon when we shift to engineering. I think we'll get a little bit of a different twist and spin on things but some of the same issues will keep coming up.

Now, before we all scatter, Kristen, can you identify yourself and who else is working with you to -- okay. Thank you. We have these two folks who are going to help people find their way to and from the cafeteria, to and from the exit and back in. I've got about 12:19. Is that about what you all have? We really do want to try to be back here by 1:15 so focus on that and we'll ring the bell about that time. Thanks everybody.

(Whereupon, at 12:19 p.m., a luncheon recess was taken.)

MR. SMITH: Folks we have a special guest this afternoon who is neither a statistical expert nor an engineer, suffers from the same disability I do as being a recovering lawyer but in fact, he is a very, very special guest. For those of you who do not know David Strickland, our administrator, David has a long history in the transportation business. After graduating from law school and then working for awhile in the legal profession, wound up as the Senior Counsel to the Senate Commerce Committee for many years where he shepherded lots of legislation through the system, including some that he's now implementing to his chagrin, but had in that, his time on the Hill, got to know I think everybody in the City and beyond who deals with transportation.

But his leadership over this last year plus now, he recently had his year's anniversary with us since being appointed by the President, confirmed by the Senate, in that year, he has shown outstanding leadership in extremely difficult circumstances of various kinds. And those of us who have spent most of our careers or all of our careers in the Executive Branch are only too glad to point out sometimes the challenges posed by the Legislative Branch but David is demonstrating that at either of those branches, he does a fantastic job. So I'd like to introduce our administrator, David Strickland.

MR. STRICKLAND: Thank you, Dan. Thank you so much. Good afternoon, everybody. It's great to see you. There's a lot of folks in this room I was actually thinking about. I wanted to make sure that I actually came down and had a few moments with you because I know that several of you, in my former life, was trying to talk to me about these very issues about, you know, the laws of physics cannot be suspended when you're thinking about fuel economy changes, and a number of you were actually very direct and very helpful in the Senate when the House was working on the Energy Independence and Security Act of 2007.

I remember the, all of the years going up to that how the size, mass and safety debate was viewed by the environmental side of the portfolio as a way to subvert moving forward on fuel economy, and the one great breakthrough in the negotiations that we had in 2006 and 2007 was the recognition that you can design for safety, you can think about how materials how are used but you have to be mindful that the laws of physics cannot be suspended but we can find a way forward in sort of accomplishing both goals. Moving forward the efficiency of the fleet, well, I guess the fleet already gets more efficient over the years, actually transferring those efficiencies to fuel savings and at the same time, making sure that the fleet is performing in a way that actually protects every driver.

And I remember, I think it was a Honda study -- yeah. Nice seeing you again, John. How are you? The Honda study that was provided at that time which talked about geometry and materials and how we could sort of make these integrations and hopefully, and I believe that the CAFE provision and ICCT sort of struck that right balance with the attribute system and taking these things into consideration for those baseline standards and I think the hard work that went into 2012 through 2016.

Now that we're working on 2017 to 2025, this is exactly the kind of thing that I always wanted NHTSA to do when I was a staffer and now as administrator, having open forums, having free exchange, gathering information and not shying away from being able to talk about size and safety and fuel economy. Nothing is helped by hiding behind political rhetoric about this issue. The only thing we all want to do is to make sure that the fleet is less dependent on foreign oil and we keep getting the reductions in fatalities and injuries that we've seen over the past handful of years.

You know, when we're talking about 34,000 fatalities in 2009 and we're looking on track to hopefully still going on that downward path, you know, there's behavior that's involved that we're working so hard on but it's also the improved crashworthiness and in some instances now, crash avoidance technologies which are going to help us get these numbers down even further.

So in my humble opinion, I know that it's the engineers and the scientists which makes this go but these issues of fuel economy and safety do not have to be mutually exclusive. And I think the hard work from all the manufacturers, you know, and, you know, all of our partners in the regulatory space have shown that with good open collaboration, decisions made on sound data, sound science and strong engineering, that we all can sort of accomplish these goals together so.

This symposium really does mean a lot to all the team at NHTSA. I'd like to thank Dan and obviously, our entire team on fuel economy, you know, Jim and Rebecca over here and a whole bunch of other folks that work very hard collaboratively with EPA and with California as we go to these next standards. It really is a lot of work and having this type of exchange helps give us the information we need to make a solid decision based on all the right factors which is good data and good science.

Thank you so much again for giving me a couple of minutes. I just wanted to say hello and see so many in the room that have dealt with me over the years and I hope you guys don't think I'm screwing you all up too much in my new role. But I really do appreciate you guys taking the time and sharing up your expertise and your thoughts and have a great rest of afternoon. Take care.

MR. SMITH: Thank you, Mr. Administrator. We appreciate your joining us. You know, one thing that David didn't do on the Hill was pass legislation that would allow Executive Branch employees to be paid for speeches but if he had, the man would be a multi-zillionaire by now because he's in great demand for his speaking ability because, not only his presentation but what he knows, so we really appreciate you coming down. Thank you.

MR. STRICKLAND: You just got a plus upon your review.

MR. SMITH: Well, thank you. I was badly in need of it. I know that.

MR. STRICKLAND: Take care.

MR. SMITH: Thank you. Our next presenter -- first of all, some folks, we've had some circulation in and out of the room and we may not have everybody understanding the ground rules so just to repeat, we're going to have our presenters in two halves now. We've got three presenters and a break, then three more, then we go to the discussion phase. We're going to try to keep the questions limited. I thought, you know, the morning worked well. We're a little bit behind time but we'll pick it up from there.

And let's see. One person I haven't introduced is my colleague, John Maddox, who is, who was here. Oh, there you are. You're hiding.

MR. MADDOX: Hi. Busy texting.

MR. SMITH: Oh, he's busy texting but he's not driving which is good. John is of course our Associate Administrator for Vehicle Safety Research and although he doesn't have a speaking part, he has a thinking part today in helping us figure out all the things we need to figure out on some of these issues. And one of John's very talented people is our next presenter from our Office of Research. Steve Summers from NHTSA is going to give his presentation on finite element modeling in fleet safety studies. Steve. Oh, I'm sorry. I'm looking back there. Thank you.

MR. SUMMERS: Okay. So I'm going to talk a little bit about the finite element models for the fleet studies. This morning we talked a lot about the historical studies and what they can and can't do as far as predicting how these future vehicles are going to behave. We are going to try to augment some of the historical studies by looking at finite element vehicle models for light-weighted vehicles.

As part of the final rule, NHTSA, we included some text for NHTSA and EPA. We're going to work together to research interaction of mass, size and safety and future rulemakings and we're also going to reach out to DOE and CARB and perhaps other stakeholders to evaluate mass, size and safety. This is part of the work that's sort of encompassed by that.

What we're looking to do is, as our objectives here is we want to evaluate new, and by new I mean light-weighted or future vehicles for the 2017 to 2025 time frame, we want to evaluate them through crash simulations or crash models to evaluate the safety of future light-weighted vehicles. We want to understand how they would exist and interact with the existing fleet today. There is expected to be a long transition even if we do set very high fuel economy goals, a long transition, 20 to 25 years, to get all of the light-weighted vehicles into the fleet. We want to see how they interact with existing vehicles.

We're going to examine mostly vehicle-to-vehicle and vehicle-to-structure crashes. For all of the light-weighting projects we have looking at the design of future light-weighted vehicles, they're all going to have a basic standard of meeting the safety requirements, 208 frontal barrier, side impact, rear impact, roof crush. So the main condition is the non-standard crash conditions or vehicle-to-vehicle crashes, vehicle-to-infrastructure crashes, trying to understand their behavior.

We want to develop some safety estimates clearly to help the final rule get some idea what the consequences are but more importantly, we want to understand what are the changes in the safety behavior and how do we take our ongoing research projects and try to optimize safety for future fleets. We are going to use the opportunities of running some fleet simulations for anticipating what vehicle-to-vehicle crash configurations will look like for light-weighted vehicles and see what opportunities are there to improve safety to enhance countermeasures to try to reduce any implications there are for future light-weighted vehicles.

NHTSA's recently started two projects regarding light-weighting. One is a full vehicle design for a light-weighted vehicle. This is going to be conducted by Electricore. Their task is to design a model year 2020 light-weighted vehicle within 10 percent baseline cost. The baseline vehicle is going to be a 2011 Honda Accord and they are going to try to do as much light-weighting as they can but they must maintain a 10 percent light-weighting cost.

The redesigned vehicle is intended to meet all major safety standards, you know, front crash, side crash, rear crash, roof crush, as well as having the same functionality handling, NVH durability as the existing vehicle. They are then going to develop a detailed cost evaluation to help with the fuel economy evaluations.

In addition, we have tasked George Washington University to develop a simulation methodology to evaluate the lightweight vehicle's crashworthiness with existing vehicles. For many years, NHTSA and the Federal Highways have funded George Washington University the National Crash Analysis Center with doing tear-down analysis and developing FEA models for existing lightweight vehicles. We've used those vehicles to help evaluate curtain future test methods, Federal Highways has used them to evaluate roadside hardware. We would now like them to take these existing vehicle models, see if we can use them to evaluate the vehicle-to-vehicle crashworthiness for the existing and the new, our future lightweighted vehicles.

In addition to evaluating the safety consequences, we then want to go look at where does the safety change and what can we do about it, at least start a dialogue on what kind of safety countermeasures will we be able to do for future lightweighted vehicles.

Once we have a fleet methodology, what we'd like to do is integrate in the methodology the new lightweighted vehicles. GW is going to work on developing the methodology and then we're going to reach out to Electricore, who we've hired to develop a lightweighted vehicle model, we're also going to work with Lotus Engineering, which is doing a lightweight vehicle model for the California Air Resources Board, and FEV is doing a lightweighted model for the EPA.

The Electricore design will be for a five-passenger sedan, Lotus is doing the Toyota Venza high development option, and FEV is going to be Toyota Venza low development option. So we're going to have three future lightweighted vehicles designed with very different lightweighting targets and we're going to try to see how they interact and what the safety issues are for the different types of vehicles.

Let me give you some specifics on the Electricore project. It's called, it's entitled "The Feasible Amount of Mass Reduction for Light Duty Vehicles for Model Years 2017 to 2025". Electricore is the prime. They're being supported by EDAG and George Washington University. The objectives for the project is to provide the design for a 2020 lightweight vehicle. It's going to develop crash models as well as NVH models to demonstrate the crashworthiness and that it meets all the basic standards.

The light duty vehicle is intended to be a commercially feasible for high-volume production, about

20,000, 200,000 units per year. The main constraint we give them is they have to maintain retail price parity with their baseline vehicle and they must maintain or improve the vehicle characteristics. The Electricore team will produce a detailed cost estimate including the manufactureability, manufacture tooling costs for the direct and indirect costs.

The team is Electricore is the prime contractor. They are a nonprofit consortium, they build consortiums to help government research. The main designer on this is going to be EDAG. They're an independent engineering design development firm that has worked for the automotive industry, and they are going to be supported by the George Washington University National Crash Analysis Center who has a long history of doing crash simulation models for NHTSA.

The general approach for Electricore will be to establish the baseline characteristics, and this is what's ongoing now. They're establishing characteristics in baseline vehicles, the mass, the other handling concepts of it. They're going to then develop a lightweighting vehicle strategy. Their lightweighting strategy, do some weight optimization, do crashworthiness, handling, durability, loop back and again do the, more optimization until they can come up with a final design for the vehicle and then perform a cost analysis in the end.

They're currently doing the detailed analysis.

The 2011 Honda Accord, this is the LX 5-speed automatic. They've done vehicle scanning and tear-down as shown on the left determining various mass allocations where the mass is in the parts, trying to determine materials. This is all building into developing their lightweighting vehicle strategy.

They're going to look at their weight reduction options, some of the trade-off analysis for the vehicle systems, structures, closures, powertrains, design assembly. So once they get, look at the materials they want, they're going to be, what their material options are, how they're going to manufacture it, and then they're going to do some optimization and go back and continue until they produce their vehicle design.

They have an iterative design process, including the topology analysis, trying to put the mass in the right places, constrained to meet all of the crash standards and keep going through the cycle until they get the maximum lightweight and they can within the cost targets. After the final design, final design is complete, they're going to finish their cost analysis and come up with a final report. This project should complete in about a year time frame.

The whole point of doing the vehicle design is to give us a detailed cost but it will also be able to plug into the fleet study. We have George Washington National

Crash Analysis Center developing the methodology to evaluate the fleet crash safety. They have a number of existing finite element models. We're going to work on the four, work with the four most recent models, try to run them into each other for a variety of frontal-frontal, frontal-side, oblique, offset, rear impact crashes to evaluate the overall fleet safety.

For these fleet safetys, we're really going to go after the structural safety. We're not going to go after the handling or the rollover, the stability issues, so this is only a fraction of some of the safety issues that were being addressed by the statisticians this morning. This is only going after the part of it, really for structural, vehicle-vehicle.

In order, because we're developing the fleet study methodology at the same time that Electricore is doing the vehicle design, we're going to have them take a rather simplistic approach to lightweighting so they can prove out the fleet methodology. They're going to try to take their baseline five-passenger sedan, in this case, it's an older Taurus model, have them do a lightweighting design of it, mostly material swapping, lightweight, down-gauging. We want to make sure we have a baseline and a lightweighted vehicle so they can run the fleet simulation as is. Then with a lightweighted version, they can show where the safety difference is within the GW project and get this rolling while EDAG is still doing, EDAG/Electricore team is still doing the vehicle design.

When they compare the baseline and the lightweighting, we expect to see differences in the safety outcomes and we would like them to look at this and see what opportunities we have for minimizing any safety consequences due to lightweighting, you know, what can we do for crashworthiness countermeasures, and then try to implement them in the lightweighted Taurus design, run the fleet analysis for a third time and help us start the conversation on what kind of opportunities do we have for alleviating some of the change in safety issues due to vehicle lightweighting.

So we're going to start off with doing FEM simulations, finite element model simulations, vehicle-to-vehicle, vehicle-to-structure simulations. That will produce an occupant compartment crash pulse. We're going to use that to draw just a generic MADYMO occupant. Most of the finite element models that we have developed at GW and also for the lightweighting vehicle models, they're not full occupant compartments. They've got the full structure in there for the crash structure in the front and side. They don't have the full seating, the (indiscernible) the dash.

So we will use a MADYMO simulation to, driven by the occupant compartment pulse to give us some of the injury criterias from which we can get the probability of injury. We combine that for the various crash modes so we can get an idea of what the fleet safety is all about.

The vehicle models which we're hoping to use would be our baseline vehicle, which is the Ford Taurus from up through about 2007. We have a small passenger car, Toyota Yaris. This model is just finishing up development for frontal. It should be out in about a month. We have the Ford Explorer model which is already publicly available and the Chevrolet Silverado. So we've got a small car, a mid-size passenger car, an SUV and a truck, large truck, and we hope to get a, to use those around a finite element simulation matrix.

We have an estimate of about 300 simulations. Now, really, that's about 100 for each matrix. We're going to do three runs. Once with the baseline fleet to get an idea what the baseline safety is. Again, do the same fleet only now with the lightweighted Taurus, and then run it a third time with the lightweighting vehicle with the countermeasures in there. Again, so we can compare our baseline, lightweighted and then what opportunities there were for countermeasures.

We're going to run a number of single-vehicle crashes looking at vehicle-to-structure crashes, so we're going to run it into a full barrier offset, into pole center, pole offset. We're going to run a number of vehicle-to-vehicle simulations between the Explorer, Silverado, the Yaris and the baseline Taurus with the vehicle under study.

The one limitation we have in this is all of these, these FEA models and the newly developed FEA models are largely developed to meet the 35 mile an hour NCAP standard so the only real validation we have is up to a 35 mile change in Delta V. So we're probably going to limit our fleet studies to a 35 mile Delta V for the struck vehicle since that's all that's really been validated as far as the structure of these FEA models.

We're going to run them at a number of different speeds up to 35 miles an hour, try to combine the probability of the injury with their real-world occurrence so we can get some idea of the fleet safety. Where possible, we'll try to include some front-to-side with the vehicle not only as striking but also struck, a couple of different speeds, and we've also, we'll look at the front-to-rear again just to make sure there's no problems on there. The idea is that we'll get about 100 finite element simulations per fleet matrix, be able to combine those and get an overall estimation of the occupant injury risk.

These 300 simulation models are really just to get us the whole background or proof of purchase, the proof of concept with fleet simulation models. Where we really want to go next is to actually take the future lightweighted vehicles and run another 300 simulations. So we'll be looking at how the EDAG model performs in these same crash configurations. We will also look at the Lotus high development option vehicle.

California Air Resource Board has funded Lotus Engineering to do further development on the high development option Toyota Venza design, which is the 40 percent lightweighted design. This will include CAD and crash models. Lotus has been working with us over the last few months as they've developed their FEA model. They've been very nice to work with us, allow us to run with the existing GW models making sure that we are getting reasonable and realistic results. We're running it in frontal, offset, oblique, making sure we're getting crash pulses, reasonable intrusions, reasonable energy distributions so that everything looks like it will work.

We've been using Lotus as sort of a proof of concept as will this fleet simulation actually work and it all looks very, very encouraging. We hope when the model is done to include it in a fleet simulation matrix to help us get some predictions of lightweighting vehicle safety.

EPA has also recently funded FEV to continue study of the low development option, or the 20 percent lightweighted Toyota Venza design. Similar to the Lotus and the EDAG, it's going to include CAD and crash models, and we hope to exercise this again in the fleet simulation model so we can evaluate not just, we can evaluate the fleet safety of this vehicle. And we also have now a comparison between a five-passenger sedan that was lightweighted for 10 percent cost, we will have the Toyota Venza at 40 percent lightweight and Toyota Venza for 20 percent lightweighting. We have three different approaches to lightweighting and we can compare and contrast what are the safety implications on those versus the baseline safety fleet.

There's a great advantage in looking at vehicle models that were developed with very different goals in mind and that way, we can get a good comparison of the kinds of things that may occur. We see trends. We know that they're looking better. We tend to utilize these to help inform the CAFE rulemaking. Most of this won't be done until, to support the NPRM, it will be done to support the final rule.

And not just, we're hoping to get some results out of this, not just to support the CAFE rule but we'd also like to see this project help, give us some direction for future safety research, you know. If truly we're going to move towards lightweighted vehicles in the future, we really need to start thinking about it now. It's 2011. These vehicles that we're talking about coming on the market 2017 to 2025. We've got plenty of time to start doing some work, getting some discussion about what are the safety issues. We'd like to put some numbers behind it and this is how we're going to go forth on it. We'd certainly like any feedback from others. Thank you.

MR. SMITH: Thank you very much, Steve. I think you get the gold star for actually coming in under time. I appreciate that. Well done. And Steve, in his presentation, made reference to Lotus, one of the projects they're working on. Our next presenter from Lotus Engineering is Gregg Peterson who will speak to us on the design and impact performance of a low mass body-in-white structure. Gregg, here's your clicker. Nice to meet you.

MR. PETERSON: Thanks. I'd like to thank the NHTSA organization for the opportunity to present today. As Steve Summers mentioned in his review, we have been working with the NHTSA organization, sharing our models with them, and it has been a very beneficial process for the Lotus organization. I've got a lot of information to cover. What I want to start out with is basically the background.

This Phase 2 process that I'm talking about is for the 2020 time frame. We actually developed two models, as Steve had also referred to, at 20 percent mass reduction and in a 40 percent mass reduction. These are opportunity studies that Lotus did funded by the Energy Foundation in 2009. A paper was published by ICCT last year. What we're doing today is ARB had challenged us to verify that this 40 percent mass reduced vehicle would actually work and perform in Federal crash tests, so that's what we're working on today.

So our target is a 40 percent mass reduction vehicle. We've got a low mass multi-material body so we use steel, aluminum, composite materials as well as magnesium in the makeup of the vehicle. I talked about the NHTSA relationship. EPA and DOE are also involved. DOE is contributing from a materials overview. And then the Phase 2 study results are going to be published later this year. We're expecting mid-summer.

All right. The mass reduction approaches. The key here is really the integration of the components and in looking at section inertias. Section inertias are a function of the height and the material cubed, and that's really what we went after as opposed to a linear wall thickness type increase which gets you some benefit in terms of structure but doesn't get you all the way. With low mass, non-ferrous type materials, you need good section inertias to get the properties that are required for the impact events that I'll be showing you a little bit later.

In terms of materials, we looked at a variety of materials, including high-strength steel, aluminum, magnesium, plastics and composites. We also looked at carbon fiber and titanium but those materials were ruled out because of cost constraints.

In terms of how we put this together, manufacturing assembly really drove the design of this, of this vehicle. It’s just absolutely essential to be able to assemble this and manufacture the components. So we looked at reducing the tool parts count. We did that through the integration of the parts themselves. We looked at how we reduce the forming energy requirements, we looked at eliminating fixtures and then looked at part joining requirements. We use a very low-cost process compared to resistence spot welding. It’s also very green compared to resistence spot welding. We structurally adhesively bond this vehicle together. And then the last thing is that we looked at how we minimize scrap materials. So it’s really a green approach to how you do this vehicle. Cost is not only in materials but also, in how you utilize those materials and how you put them together.

In terms of the exterior styling and engineering parameters, some of the keys that we really looked at here was protection for a low-speed impact and we used some old technology that GM had on a Corvette that saved 100 pounds in the front, very simple type stuff where you extrude a bolt through a sheer plate to manage the crash energy. Very lightweight, and it works.

IIHS has shown as much as $68,000 worth of damage in very low-speed six mile an hour type impacts and low mass vehicles typically have a reputation for being fragile so we wanted to make sure that this vehicle didn't come across as a fragile vehicle. As part of that, we pushed the headlamps back a little bit and inward so that in low-speed crashes, the headlamp assemblage would not be damaged. Those things are typically 4 to $500 on new vehicles.

Another thing that we did was we increased the wheelbase and the track. The wheelbase we increased to give us a straighter shot into the sill area. That's one of the major structural areas of the vehicle. And by pushing the wheelbase forward, it gave us a straighter shot into it. If you can imagine, you have a right angle. That creates a torque. What we wanted to do was have a, basically load the vehicle as much in compression as we could. So it's very simple, very basic but it allowed us to get a straighter shot and what that meant was we could manage the impact energy with lighter-weight, lower section materials.

The last thing I wanted to talk about here was a tumblehome for roof crush. Again, roof crush, we want it to meet the IIHS four times rule, not the three times Federal regulation. And tumblehome is basically the angle the sides of vehicles make relative to the roof. We pushed it out slightly to give us a straighter shot. Again, we wanted to load it so that we didn't have a torque acting on that, and I'll show you some of the roof crush results a little bit later in the presentation. Interior remained the same, that was our basic criteria, as did the overall length of the vehicle.

So the basic body-in-white looks like this. There's a total of six modules and I'll break those out. This is all magnesium. It's used on an exotic car called the Ford Flex in production today. This dash assembly is used on the Viper, it has been since 2006. This is all magnesium with aluminum extruded rails. The floor is composite with aluminum rockers on the outer. The roof assembly is all aluminum with aluminum crossbows, and then the body sides are made up of general plastic magnesium and aluminum.

So this is the vehicle that we started with. It basically contained 37 percent aluminum, 30 percent magnesium, 7 percent steel and 21 percent composite materials and had a mass of 161 kilograms lighter than the baseline Toyota Venza which was selected by the customer.

So the next step was to apply topography analysis to this and basically, what you do is you take the inner and outer skins and then you apply loads to create a skeleton much like the human body skeleton supports the body. This is the key to the vehicle and you need to make this as light as possible. In other words, you need to make it as efficient as possible.

So we looked at three different types of materials, magnesium, aluminum and steel, and you can see that the red regions here, these are strain energy densities and as you get into the red area, it's saying that that's a very hot area, it's a very key load path. And you can see the difference between magnesium, aluminum and steel, how it gets cooler and cooler in terms of the strain energy density. So this told us where to focus. So this gave us basically our load path.

Then the next thing we did was a shape optimization. Again, the section height analysis, determining where we could put the parts, how high we could make the sections and then developed the width of those individual areas. And then the last thing we did was to apply material selection and thickness optimization based on our impact and structure requirements.

So bottom line, this is a new vehicle, the Phase 2 that will be the basis for everything else that I show you today. The vehicle is at 234 kilograms or a little bit above our target mass reduction rate of 40 percent but we are continuing to refine the model. We're now at about 75 percent aluminum, 12 percent mag, 8 percent steel and 5 percent composite, so there's been some pretty significant changes in terms of where we went.

We tried to make magnesium work in a front crush structure and we had some issues with the material performance so we've gone to a much higher grade of aluminum. We've also added a significant amount of steel. The B-Pillars are now all steel and that's for side crash. They're managing the energy very well.

These are the impact tests that we're running. Front impacts, side, rear, roof crush and then some quasi-static seatbelt pull and child restraint systems. In terms of the frontal impact modeling, we also ran some non-MVS type tests just to verify the performance of this vehicle. So we've run 50 mile an hour flat barrier, and the energy at 50 miles an hour is roughly double the energy at 35 miles an hour for a given mass vehicle. And this was really done to check the model integrity. We've run car-to-cars with the NCAC models that Steve referred to so we've done it with the Taurus and done it with the Explorer at a variety of different speeds.

In terms of the initial model impacts, this is the very first couple of tests that we ran. What you see here in gray is the Toyota Venza spike. That's the actual vehicle as tested by NHTSA in their performance runs. What you see here are some of the modeling that we've done to reduce the spikes. Our key was to stay at least 10 percent below the Venza peak.

The software that we're using is an OEM-type software. It's state-of-the art and it's good enough that some companies don't even run prototype crash testing anymore. They go right to their production tool vehicles because of the fidelity of the software. So this is where we started and now I'm going to walk into some of the more recent testing.

You see Version 23. That means that this is the 23rd model that we've run, and the 23rd model isn't the number of iterations we had. There's been literally hundreds of iterations that we've done to get to this point but again, you can see what the vehicle looks like here in terms of a crash. One of the key areas that you need to worry about is intrusion. That was talked about earlier. And you can see in terms of the front of the dash, this is a 35 mile an hour frontal impact, you can see that the maximum intrusion is 21 millimeters in the center. The rest of the areas are all less than a half inch intrusion so this vehicle is performing very well in frontal crash. The energy management, again, is well below the Venza peak of near 50g.

This is a little animation showing you the flat frontal. The key to note here is if you look at the A-Pillar, you'll see that this entire area is staying very cool, very quiet in terms of this impact and I showed you the deflection. This is a very good example of how you manage front crash energy. So this vehicle is performing at a point where the average accelerations in the first three milliseconds are in the 22 to 23g range and then for the subsequent events, up to about 33 average Gs. These are very good numbers in terms of comparison to the Venza.

The key areas to note here are in this area, these are basically the front crush cans starting to go. Then we get into the rails where we start crushing those and then these peaks are relative to the engine being pushed into the frontal dash area. So there's a lot of engine development that went into this. Our first test had higher spikes and that was due to the engine mounts not releasing.

Okay. In terms of sensitivity analysis, we looked at what we can do in the first 30 milliseconds to help get the pulse down and we made a change of a quarter of a mill between this point, what you see in black and the green. And essentially, we dropped it out of acceleration levels from 21 down to 14 for this peak and then at this area, we dropped it from 31 down to 22, so it showed that this is a very tunable structure that we have. This is an aluminum rail system that we're using to manage this energy.

Next, this is the, basically stills showing the after crash view and again, you can see that the A-Pillar looks very solid. The wheel tire is not getting into the wheelhouse area. You're not seeing any acceleration spikes there.

In terms of the rear, the key area to look at here is the fuel tank and the battery pack. This is a hybrid and it's a parallel hybrid so we have a small battery pack in this area. You can see the fuel tank and the battery pack are both staying out of any contact area.

In terms of the side impact, you see basically how the vehicle is performing there. The key here is intrusion levels. We're looking at intrusion levels of around 150 in millimeter. The distance from, essentially the B-Pillar to the seat is in the 300 millimeter range so that was kind of an unofficial target so we're staying well below any contact with the seat in the crabbed barrier test.

In the pole test, this is a fifth percent female which means you move basically into a forward section of the door where the B-Pillar isn't really interacting with the, with the pole. And our impact level there went up a little bit to 120 mill but still, a very good number in terms of managing the side impact intrusion levels.

The next test was the pole with the 50 percent male which means we moved the pole back a little bit, a little closer to the B-Pillar. And the results of this, in terms of intrusion, are around 190 millimeters. Again, well within our target of 300 millimeters for overall intrusion level.

Roof crush. Essentially applying the IIHS load and the overall level of the roof crush. What we're showing here is basically three times, which is the Federal standard, and then four times, which is the IIHS standard, and then this is where this low mass vehicle is performing. This upper line is four times the Venza mass, which is the full vehicle mass of the Venza, and we're 40 percent below that so roof crush, we're staying well above the target that we set for meeting the four time IIHS standard.

So in conclusion, a significantly mass produced vehicle does have the potential to meet the Federal crash results for roof crush, side impact and rear impact as well as the frontal impacts. We're continuing to work on this model but at this point, we're very encouraged by the results and how well the vehicle is performing. We're currently working on final details in terms of assembly. Assembly's been a key part of this. As I mentioned, we're refining the design to also minimize the cost, so both of those are ongoing as part of this.

The final report will include cost as well as manufacturer ability and also, the complete assembly process as to how you put this vehicle together. So it’s, it’s a very real study in terms of can this vehicle, can be made. There are many low mass vehicles that when you look at them, you suspect that there was no auto manufacturing thought that went into it. In this case, manufacturing has really driven this design.

In terms of recommendations, a couple of things. One is to actually build this body-in-white and run it for nondestructive tests which should include modules where you basically vibrate it and look at the frequencies of the vehicle as well as bending and torsional stiffness. And then the second obvious conclusion and recommendation is that build a complete vehicle, mass it out and run destructive tests on it such as having NHTSA run frontal barrier with this 40 percent mass reduced vehicle. So that concludes my speech. Thank you.

MR. SMITH: Thank you very much. That’s very interesting, Gregg. I really do appreciate it and I liked all those pictures, so very helpful. No, it was very good.

We next have joint presenters from Honda or -- okay. So do we need an extra microphone or are you going to work -- okay. All right. So Koichi Kamiji is it, from Honda is going to present on Honda’s thinking about size, weight and safety. Here’s your clicker. Thanks very much.

MR. KAMIJI: Thank you. Good afternoon. My name is Koichi Kamiji from Honda in Japan. I'm in charge of safety technology at Honda. I will show Honda's thinking about size, weight and safety and the topics is there, like four topics. Fatality rates and weight reduction and downsizing and compatibility issues and unnecessary testing increases weight. Next, please.

So this graph show the trend of passenger vehicle occupant fatality rate in recent years. Fatality rate of each particular vehicle goes down in recent years. Next, please.

I will show the reason of the colliding trend. This graph shows the relationship between the fatality rate and the NCAP score. Those data are summarized from the Toyota and Honda sedan. As a result of the comparison, fatality rate of the highest score cars is half less than (indiscernible). So NCAP's rating will contribute to safety performance in the real world also. Next, please.

In addition to the former assessment, agencies will promote new variation protocol. NHTSA has already started new NCAP from 2010 with a more severe method and also, the IIHS has a new plan to introduce a narrow offset, a variation for their top 50 pick. So this narrow offset requirement will be impact to the body weight. Next, please.

This slide show the Honda Accord body-in-white

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weight history. The weight of the body-in-white increasing model by model to comply to the new safety requirement in spite of a weight reduction report with a structure consideration like using high-strength steel. Currently, new additional requirement will be up riding in a few years. Next, please.

In example, body-in-white weight changing. Model change of vehicle. The weight of former model, this is Accord body-in-white, is about 339 kilogram. Then for new model, (indiscernible). Additional requirement like those were increasing body-in-white weight. But high-strength steel application and structural optimization will cause a reduction of weight. However, at this time, total weight of body weight is increased. Next, please.

However, the reduction of greenhouse gas is high priority so vehicle weight should be down by the weight in the future. In current (indiscernible) by using optimization, body structure and the joint method of the body and user's rate of high-strength steel, total weight should be down. Next, please.

This slide show the body-in-white technological direction. For the conventional steel body, Honda has reduced the, reduced the body-in-white mass by application of expandable high-strength steel and we reduced it by improving (indiscernible) structure in the near time. By applying (indiscernible) will be reduced much more.

Honda already has experiment, experiment of aluminum body structure technologies and know how mass production for NSX and the fascination Insight. In the case of NSX, at that time, effectiveness went down. It's about 40 percent compared with normal steel bodies. However, the production of those motor was limited, about maybe 50 units per day only in maximum. That's caused by type of production, especially for the welding. Although (indiscernible) body has still advantage for the weight reduction, the benefit, however, will be small by using high-strength steel.

In addition to those technologies, one choice to reduce weight is (indiscernible) which was a report mentioned before. However, the (indiscernible) technology has still concern like production cycle time and the hybrid production recycling and the large investment, et cetera. We cannot operate this technology for the mass production motors soon now. Next, please.

I'll talk about downsizing issues. Basically, downsizing can reduce the fuel consumption. These conditions. Customer role is to consider smaller car and fuel economic values. And the OEM role, make attractive smaller vehicle like advanced safety and fun to drive and functional and more fuel efficient. Next, please.

As an example, this slide shows the sample turn to replace the vehicle size in Honda line of vehicles. If consumer changed their vehicle from the Pilot to CRV, the reduction of greenhouse gas will be 23 percent. Next, please.

However, the downsizing has concern with vehicle compatibility at the same time. This graph show the distribution of a crash type in a fatal accident. Forty-two percent crash of them are single-vehicle crash and those kind of, this single-vehicle crash is contributed by weight rating because of energy of, kinetic energy goes down. And then SUV two-car crash, very similar for the passenger car now. Based on the data, fatality rate of SUV-to-car crash more than three times than car-to-car crash for example. So vehicle compatibility, like SUV-to-car crash, represents key opportunity to reduce fatalities. Next, please.

This slide show the fatality trend for the compatibility. That trend of passenger car will be improving by (indiscernible) and the IIHS promotion, size promotion in a few years. Next, please.

In the viewpoint from the fatality rate, I should buy insurance companies. The fatality rate of a small car is not better than all categories. However, some small car can be, achieve a better score than average. That means small car, some safety technology can be safe. Next, please.

In talking about small car safety, vehicle compatibility is key issues. We had a study with real-world accident data and the crash test. Key issues are there. Overriding, underriding, like a bad car misalignment, and horizontal misalignment, and stiffness mismatching. Fork effect will be caused by horizontal misalignment and stiffness mismatching. Next, please.

Underride and override issue may be resolved MOU (indiscernible) requirement current now. Next, please. However, this requirement defines requirement, defines a requirement only for the horizontal dimensions on the (indiscernible). Next, please. In addition to the override and underride issues, there are other important parameters. Next, please.

One of our solutions is this body structure. This upper graph show the compression of a total (indiscernible) between the former body and the improved body structure. Amount of total (indiscernible) almost similar but two mainframes produce those load in the former body structure. On the other hand, some additional frame operate on the mainframes and improve the body design to produce a similar total rod. A stiffness of the mainframe can be reduced by the additional frame structure. Those additional frames can be prevent from the misalignment and reduce the load apart each one frame structure to achieve the roller discussion under this or too much concentration of rod. Next, please.

This slide shows the compression of load distribution. Those data are (indiscernible) two mainframe indicate, remarkably, higher load in (indiscernible). On the other hand, distribution of load is even in improved bodies. As a result, the aggressiveness characteristics can be reduced by prevention of load concentration with those improved body design. Next, please.

IIHS did a very (indiscernible) for the safety performance of a small car and a large car crash. Next, please.

Several type of crash have been done. Among them, Honda had achieved not a bad result with the Honda Accord. Some poor variation result of Honda in the red portion. However, the upper total result not so bad. These results came from the self-protection performance of Fit as well as partner protection performance of Accord. And according to insurance data, Fit is average, almost average among all vehicles. Next, please.

This slide show the comparison of the insurance gross data of a small size car. It is good achievement among them. More than (indiscernible) less than average. Next, please.

So Honda has achieved a good performance in vehicle compatibility. However, concern for the stiffness matching should be discussed for the small car safety. Next, please.

In general speaking, weight reduction of vehicle will be good effect for the safety, in comprehensive vehicle safety by reduction of kinetic energy of vehicles. However, the compatibility concern have still be in existence. In the vehicle-to-vehicle crash, kinetic energy will rise in the heavier vehicle as it rises in the smaller and the lighter vehicle. However, rate of crash energy absorption is opposite than in general load of a small vehicle becomes (indiscernible) by stiffness mismatching, matching. So stiffness matching of a structure of a vehicle can be, achieve a good compatibility performance in vehicle-to-vehicle crash. Please watch this picture. There is much mismatching of stiffness and this cause (indiscernible) for the small car and (indiscernible). And if our stiffness can be adjusted like this, so our own energy can be absorbed with one's service to achieve the partner protection. Next, please.

To evaluate those kind of performance, many parties continue to discuss now. However, the result of discussion have not, have not reached to the conclusion in this 10 years. Before the spread of a small curve in market, countermeasure should be upright for the compatibility. Honda recommend currently (indiscernible) and the combined result progress (indiscernible). So combination, those combination to evaluate certain, the stiffness matching and the compartment stiffness. Next, please.

And the next issues are regarding unnecessary regulation. Our hypothesis is seatbelt use is growing and effective. Seatbelt reminder is effective, and the seatbelt law also, and enforcement also effective. Unbelted occupant testing requires additional vehicle length in the frontal area so it cause an increase in weight. Real, real crashworthiness is not changed. Can we save maybe, approximately, 20 kilogram on small cars? Next, please.

This slide show the trend of seatbelt uses year by year. Use rate, seatbelt use rate increased to 80 percent in last year. However, there is some difference by low enforcement conditions. So there is some potential to increase from 85 to 88 percent through wider acceptance of seatbelt law enforcement. Next, please.

So on the other hand, this slide show the IIHS study result regarding the seatbelt reminder system. Based on the study data for application for seatbelt reminder, seatbelt use rate increasing more than five percent. Honda has already operated a seatbelt reminder system for the current production model. Next, please.

So for this slide show the unbelted occupant major portion of fatality rates. So this graph show the belted occupant and unbelted occupant fatality, a number. Almost same number as for the, by driver and front passenger, rear passenger. So currently, seatbelt use, belt use is about 85 percent. Therefore, the remainder 15 percent unbelted driver make up 50, 50 percent of fatality, and risk of fatality in case of belts, unbelted and belted. So maybe in case of driver so 80 time, times risks and fatalities. So if all passenger and driver wearing seatbelt, so total deaths in accident would be, goes down to half, so.

And this chart show the unbelted condition and result seatbelt in United States and Japan. So as you know, in Japan, there is no requirement for the unbelted requirement. So however, the unbelted requirement the United States have, however, there is no significant difference in ratio risk of fatalities. Next, please.

And this chart show the comparison of a crash test result between the U.S. and Japan Fit. Both Fits can achieve the highest score in NCAP tests in both region, and the actual measure of head and chest are almost same. However, the crash pulse different because of unbelted performance requirement. To conform to the unbelted requirement, (indiscernible) pulse will be smaller like this red line. So to conform to the unbelted requirement, (indiscernible) pulse will be smaller like this red line. So this, that cause a rest quick rise up response on the chest G to produce a (indiscernible) effect.

United States Fit is about 88 pounds heavier, partially due to the longer front overhang compared to the Japan Fit. Safety performance is nearly equal. 100 millimeter of a 148 millimeter increase in length is due to unbelted occupant test. Next, please.

So this is conclusions. Forty-two percent fatality are single-vehicle crash. They will all benefit from lightweighting due to the decreased, decreased energy.

The application of intelligent design can improve safety even when controlling for the weight and size.

Improved compatibility beyond current MOU has potential to further improve safety even as customers downsizing and OEM down-weight.

Unbelted occupant testing seem to be ineffective in reducing fatalities while adding length and weight to small cars. Rethinking this issue could save, some weight down can be down. Next. Thank you very much.

MR. SMITH: Thank you very, very much. I appreciate it. Everybody's making a great effort to stay on time. I know there's a lot going by on these slides and I know that the presenters all have a lot more to say than we've left them time for but we tried to make all of this doable in one day and I appreciate everybody's cooperation.

Our next presenter from the International Council on Clean Transportation is Dr. John German. I'll say that I read a presentation that he had done I guess sometime last year and found it very helpful, very informative and, you know, provocative in many ways in terms of some of the issues that we've been talking about today so I look forward to his presentation on lightweight materials and safety. Dr. German.

MR. GERMAN: Sorry. I probably should have told you before I got up here that I'm not a doctor either but. Okay. So this is just -- no. I did that wrong. So it's left-right. Okay. Great.

I want to take a little different look at this and I want to try to put the whole size and weight issue into context here. Leonard Evans was once quoted as saying "crashworthiness factors are overwhelmed in importance by driver factors. Crashworthiness factors are relevant only when crashes occur." So that's the main point.

The next point you have is the impact of the vehicle design and compatibility issues and it's only when all these other factors are equal that you can see an impact from size or weight. They're actually fairly small factors.

And if you look at crashworthiness features, you have occupant deceleration, this was discussed this morning as well, which is a function of the vehicle weight and the space to absorb the crash energy and then how well you protect the occupant inside the vehicle. That's strength rigidity of the vehicle but it's also the restraint system's ability as well.

MR. SMITH: We're getting some feedback on the microphone.

MR. GERMAN: Yeah, it's probably my timer.

MR. SMITH: Don't worry. I'll be your timer.

MR. GERMAN: Okay. I'll turn that off. So and if you look at crash compatibility factors, you have the geometry, actually, Jeya, this morning talked about this in more detail and better than I have here but basically, you're just saying is that you want the vehicles to hit each other appropriately and not override, you want to have appropriate stiffness of the vehicles, if one is stiffer than the other, it tends to intrude into the other vehicle, and of course, the relative weight was also discussed this morning where the heavier vehicle will also intrude more.

And if you're looking at how all this works out -- this is an old slide, 2002 from Tom Wenzel and Mark Ross. But there really isn't a lot of uniformity between these different types of vehicles. The X axis is the fatality risk to drivers. On the Y axis is the fatality risk to drivers of the other vehicle. And see you have general groupings here and you kind of tell some differences in the groupings but within these, you know, for cars, you have three to four to one ratio on here. You have some small cars, fatality risk to drivers are lower than some large sport utilities, and it's just all over the map. So these are really, a lot of it's driver's factors where it's been used but a lot of it is also design, and I want to suggest that design dominates.

This test was mentioned this morning. This was the IIHS 50th anniversary test where they went out and found a 1959 Bel Air still in pretty good condition and crashed it against a 2009 Malibu. The Malibu was 177 pounds lighter, 17 inches shorter and you can see the passenger compartment here survived pretty much intact. Not so with the Bel Air. In fact, you really can't see it too well here but this A-Pillar is actually wrapping backwards through here. It's, the whole side of this vehicle just collapsed on the driver.

So okay. That's an extreme example. Everybody knows you've had a lot of design improvements over the last 50 years. Here's another example which is out of Kahane's 2003 report, and this is looking at '96 to '99 sport utilities and is simply a comparison of those four model years. Looking at small sport utilities and mid-size sport utilities, mid-size sport utilities were 850 pounds heavier and fatalities in my vehicle, 50 percent higher fatalities in the vehicle that was larger and 850 pounds heavier. This is design.

And one possible thing, question to ask, okay, how much of it is driver but actually, Kahane found that the small sport utilities have a higher incident of imprudent driver behavior than the mid-size did and in fact, you can also see this in the fatalities in other vehicles where even though the small sport utilities were 850 pounds lighter, they inflicted almost as many fatalities on other vehicles as the mid-size did. So small vehicles, lighter vehicles driven more aggressively have a lot more, a lot fewer fatalities, and the biggest part is rollovers.

The rollover fatalities in the larger, heavier vehicles are almost three times as high as on a smaller vehicle. I suggest it kind of challenges the conventional wisdom that larger heavier vehicles are better in rollovers. This data suggests that. It's not even close. The other interesting thing is that even on fixed-object collisions, the small sport utility have lower fatality rates on fixed objects which suggests that perhaps, their lighter weight made it easier to manage the crash forces.

Okay. Another design example is Ford just released these results a few days ago on the 2011 Ford Fiesta. It's the first subcompact vehicle that's generated top crash ratings in the U.S., China and Europe. IIHS gave it it's top safety pick. You can see it's very little deformity of the passenger compartment. More than 55 percent of this body structure is made from ultra-high-strength steel and they're also using lightweight boron steel, which is one of the highest grades, extensively, to help protect the occupant safety zones.

Here's an older slide from Honda back in the days, I kind of stole it. Mr. Kamiji showed much better slides on this than I did. The ACE structure basically is looking, trying to move from concentration of crash forces to dispersion of crash forces. These are already intrusions that were measured by IIHS on this and you can see significant reductions in the intrusions going into the driver. But the real point of putting this up here is that once again, to show that this vehicle is 50 percent high-strength steel and in fact, 38 percent is a fairly high grade of high-strength steel.

Okay. And a quick slide on the side impact construction as well. Most of this is also high-strength steel.

2000 insight was made out of aluminum and Honda did something I thought was really, really interesting, is that on the side frames pointing forward, they put in these hexagonal structures, and one of the neat things about aluminum is that these hexagonal structures were crushed very uniformly. In other words, the crash absorption does not change much as it compresses. Steel can't do this, and it's a very desirable feature for managing crash forces.

So if you're looking at implications of size and weight, the whole business of the impacts of size and weight are very, very small. You know, they're dominated by the design of the vehicles, they're dominated by driver factors and if you're looking at future vehicles, it's likely to be more true as we move into improved safety designs and lightweight materials. And the other point I want to leave you with is that high-strength steel is being used as much for its safety benefits as it is for its weight reduction. You know, there's no trade-off here. High-strength steels are improving both simultaneously.

So if we look at what are the impacts of vehicle size and weight on safety, and there's a lot of different interactions between the vehicle and fuel economy. The first one is if you increase the efficiency of the drive train, of course, it really has no impact on safety. You can decrease the weight, which affects the crash forces in objects on other vehicles, and you can decrease the size, which affects the interior space, survival space and so on.

And a lot of analyses kind of stop here but there's a lot more that's going on. You have deceleration of the other vehicle. It's just not the occupants that are affected. Your survival and the crush space in your own vehicle is partially affected by how much the other vehicle is absorbing the total crash forces and that's what, again, what Honda was talking about when talking about the relative stiffness of the vehicles and how you can optimize that. You also have geometry issues where taller vehicles tend to be safer for occupants of that vehicle but they also tend to do more damage to other vehicles and to pedestrians and bicyclists, and then you have all the pre-crash effects.

Lighter vehicles do handle better, do brake better. Is that a large effect, is it statistically significant? It's very hard to figure it out but at least theoretically, they're in that direction. You have to consider avoidance of bicyclists and pedestrians as well and the geometry impacts on the pre-crash as well. Not all these things are extremely difficult to try to quantify and to separate out the effects, especially if you're trying to tease out the effects of changes in size and weight.

So I do tend to look at some of these things from a more theoretical point of view and if you reduce the vehicle weight of both vehicles, you're now in a situation where you have lower crash forces that have to be managed in a crash for both vehicles and so if you're maintaining the size of the vehicles, if you're maintaining the design of the vehicles, lower weight really means lower crash forces.

I've shown high-strength steel, aluminum tend to have better characteristics for crashes and often improve safety. And then there's this pre-crash thing which is argued about a lot and nobody really knows. They can't analyze it. But reducing vehicle weight, theoretically at least, should help with the handling and braking of the vehicle.

So there's other researchers that have looked at all these kind of things. Dr. Evans, in 1982, said the likelihood that a crash has an occupant or driver fatality is related to the mass of the car. And in 2004, he put out a paper "How to Make a Car Lighter and Safer", so our thinking about this has definitely progressed over time. A couple other studies that have looked at these effects.

I do want to make one point about the latest safety study from NHTSA they put out in 2010 and it's on the point that NHTSA didn't believe their own regressions. So here we have the actual regression scenarios for the two different categories of cars and light trucks but if you look at their expert opinions, they have upper estimates and lower estimates and if you just go down to the bottom line putting all four classes together and what they have, the regression model said that by reducing weight by 100 pounds and leaving the footprint the same, you actually reduce fatalities by, you have 301 reduction of fatalities in 2016 and that's not what they actually put in their official estimates.

And the single biggest factor in this, which I've highlighted in the red here, so this is for light trucks less than 3870 pounds. This one's for light trucks greater than 3870 pounds. Here's the actual regression results and so for a 100-pound reduction, maintaining footprint, 61 reduction in fatalities for first event rollovers and 108 for the heavier ones. So that's over half of the fatality reductions was actually a reduction in rollovers. And Kahane, applying basic engineering principles that heavier vehicles are better for rollovers, said this has to be wrong and zeroed out the coefficient and wiped out those reductions.

And so we had a discussion this morning about, you know, if your regressions violate your basic principles in physics, then you really need to take a close look at the regressions but I also argue that the reverse needs to happen. We need to be very careful about what we think engineering principles are. There is no inherent reason why lighter vehicles should be more subject to rollover. It's where the weight comes out of the vehicle. And in fact, we saw with the small sport utilities that the mid-size sport utilities were, had three times the rollover fatalities. So I suggest that this may be a long-held understanding that heavier vehicles are better in rollover but I don't think it's actually valid in any kind of genuine engineering sense.

So assessing the safety of lightweight materials going into the future in which they will generally separate the size and the weight of the vehicle. Bill Walsh spent many years at NHTSA and retired, has actually made a suggestion that we try to take a look at the vehicles that have high portions of high-strength steel and lighter weight just in their design. I'm not sure there's enough of them in the fleet that we can actually get a statistically valid, results from these analyses but we are going to give it a shot and have DRI take a look at this sort of thing and see if it's something that could be done.

I didn't realize when I put this slide together that Lotus would be up here making a presentation so I will primarily skip this slide except to point out that it's supposed to be completed, including reports, by June.

The FEV assessment has, was mentioned by Mr. Summers earlier. This is something that EPA and ICCT are funding jointly to try to assess the crashworthiness of the Toyota Venza with the low development case. It's basically trying to maximize use of high-strength steel on this. The whole scope and how it's going about it is very similar to NHTSA's own project as far as developing the FEAs and CAD and all that sort of stuff and doing the crash testings.

It’s designed to meet all the major safety, in fact, not only meet the requirements but actually have like five star ratings and so on. And as a part of this, FEV will be doing very detailed cost assessments of this as well and giving a lot of updating on those. That’s not going to be done for about another year.

So just some summary. We have a lot of lightweight materials coming and the safety of them is really going to be impacted by the design. If you have a good design, they’re going to be safe. If you have a bad design, they’re not going to be safe and that’s what we really need to be focusing on here. Certainly, these materials are going to decouple mass from size and there are real possibilities to both improve fuel economy and safety simultaneously.

And the last thing I want to leave you with is that, and we had a whole discussion this morning and it showed that, you know, just the aspects of induced-exposure effects and a host of other factors can change the results. This modeling is very, very difficult. I doesn’t appear to be very robust and it’s going to be even less robust when you put it into the future on a whole different type of materials and a whole different type of design.

And so, and my conclusion in all this is that neither size nor weight has a whole lot of impact on the overall safety of the overall fleet when you consider all the different type of crashes involved and we should simply be focusing on trying to make the new designs as safe as possible. Thank you.

MR. SMITH: Thank you, John, not Dr. German. We're all doctors now I think after these presentations. We have time for a break here and I've got about 2:40. Let's start no later than 3:00. If we have a quorum back here a couple minutes before that, we'll get started but please be back in the room like five of, couple minutes before and we'll resume right at 3:00. Thanks very much.

(Whereupon, at 2:40 p.m., a brief recess was taken.)

MR. SMITH: Okay. From now on, I'm not introducing anybody as doctor. I guess I keep screwing that up. So if you are a doctor, then you can tell us that when you come to the podium. We'll give folks a minute here because I'm getting started a little bit, a little bit early.

I think Jim Tamm may address this is in the wrap-up when he does it but he will probably mention, someone asked are we going to have follow-ons and, you know, we really don't know. I mean, we're open to that but I think probably more time will pass and more studies will emerge and there will be more to discuss but, you know, we're open to it if there's interest.

And one thing though is Gregg Peterson, oh, okay, Gregg has to catch a plane fairly shortly. He would be on the panel that wouldn't start until really about the time almost his plane leaves so what I thought is I'd make a deviation from the panel process for a moment to see if there are any questions. We'll take maybe five minutes if there are any questions for Gregg Peterson of Lotus on his presentation. Gregg, you can come up and -- are there any questions? We do have one from John so Gregg, come on up and let me get you a mic here.

MR. MADDOX: Hello? It's on, Dan. You mentioned, you showed some preliminary results of your modeling differences where you were showing your --

THE COURT REPORTER: State your name, please.

MR. MADDOX: John Maddox from NHTSA. You showed some preliminary results of your, modeling results showing performance of your lightweighted vehicle structure compared to FMVSS requirements. Earlier, you had mentioned that you were going to do something similar. Are you doing some analysis of car-to-car scenarios? Do you have any results of the car-to-car scenarios, how well the lightweighted structure fared compared to the baseline?

MR. PETERSON: What I can say is that -- is this mic working? Can everybody hear me? Okay. Is that the low mass vehicle fared very well in car-to-car collisions that we did with the NCAC models. So that was obviously, there aren't any Federal requirements there but we looked at intrusion and the vehicle did very well.

MR. MADDOX: Are you willing to share those results with us, not here today but at a later time?

MR. PETERSON: We can include those in the report. I think that's a very good point that we should, I think that's a very good point, that we can put those results in the final report so people can see that. It wasn't a part of the contract but the NHTSA people felt that was important to do and so that's why Lotus has been doing it, so that's some of the positive feedback that I got from NHTSA in terms of things that we should be looking at that aren't necessarily FMVSS related.

MR. NUSHOLTZ: Guy Nusholtz, Chrysler. How did you -- first of all I guess, which code are you using to model it in and then, how did you model the composites?

MR. PETERSON: Okay.

MR. NUSHOLTZ: Did you have to modify the code to model?

MR. PETERSON: Well, what we did, we're using LSDYNA as our modeling software and what we did right at the beginning of this project was put together a supplier base for these materials and then we have run basically material samples where we put the materials together with aluminum, we treated them with a galvanic resistant coating, we ran bonded materials with adhesive as well as friction spot joining and then ran tensile pole tests and peel tests on these materials, including composites, and then transferred that information into the model.

MR. NUSHOLTZ: Right now, DYNA can't handle composites. You have to modify the code. So my question was how did you modify the code to handle the composite? It's not just modifying the material model because the material properties tend to be sample size dependent, so you have to, you have to modify the code so it could handle all the inter-connections to get the right material properties.

MR. PETERSON: Right. What I can say, I'm not the expert in terms of the modeling, but we did use real-world data and then transferred that into the model so that it gave us realistic responses. So I can share that with you in more technical detail when I get the answer from my people.

MR. NUSHOLTZ: You still have to change the code. You can't just do that. You have to also modify DYNA. Okay. Thank you.

MR. SMITH: Anyone else? Okay. Thanks, Gregg.

MR. PETERSON: You're welcome.

MR. SMITH: Our next presenter from the Alliance of Automobile Manufacturers is Scott Schmidt.

MR. SCHMIDT: Thank you.

MR. SMITH: Thank you.

MR. SCHMIDT: Okay. Hi. Welcome. I'll figure out the controls. All right. First off, I'd like to kind of touch on, I know we were asked to sort of talk about how OEMs sort of do some of the safety analysis, integrate some of these materials and the cost and stuff, and I'm going to try to share what I can on that. However, you have to realize that's like incredibly competitive and it's incredibly kind of confidential.

With that said, I think our members are very, very willing as participants, especially with regard to this national one group standard of trying to have more one-on-one dialogue with the various agencies and the various researchers because there's a lot of information I think they're anxious to provide to help make sure that some of these models and some of the stuff that the manufacturing processes are in fact robust and consider all the various constraints.

So these are kind of our top tier issues. Number one, number one, we are fully in support of the national, you know, single national standard and we are also looking to try to look for a flexible/adaptable rulemaking process. And I'm pretty sure, am very optimistic on that. I know that EPA has, in the past, done things I think with the heavy duty knocks. There have been some interim reviews where they've looked at some of their assumptions that they had to do because forecasting's hard.

So they had to forecast out, they've had to make projections and they've done that. They looked at it and what was interesting when I saw it was that one of the leading technologies that they thought wasn't panning out but instead, another technology was coming up and therefore, they were able to maintain the same stretch standard, so to speak, even though what was the ultimate technology wasn't the same. I think that kind of approach is going to be very important here.

There's -- 2025 is a long way out and we're going to have to make a lot of assumptions, we're going to have some stretch goals. We're, as an auto industry, we're going to be out of our comfort zone and so we need to make sure that we all have a flexible path to be able to try to look at those assumptions and talk about which of the key ones are going to be game-changers and are they materializing as we go down this process together.

The other key thing I wanted to touch on is, you know, basically, we're on a flight path. And I'll show a graph, and the graph has been shown before, that, you know, it's a great flight path. I mean, we started high and we're just zooming down towards zero. I'm not, I know there's some countries that have zero as the vision. That's a notable vision and goal and whether we get there or not, I don't know but it's certainly a good goal and we're certainly working there. And I think the big thing there is, you know, we don't want to, you know, a lot of technologies, a lot of safety improvements work for bigger cars and smaller cars together and we shouldn't be compensating. We should be adding and managing this process.

We also are very happy that NHTSA seems to be playing a very big leadership role in trying to ensure that this process with the EPA, CARB, et cetera, and the industry and the safety community in general is being done and looking and accounting for the safety aspects. We're very pleased to see Strickland's words and Medford's words making that commitment. There's a lot of studies which I just heard about and we're very pleased that these studies are going to get conducted.

We're a little disappointed that a lot of them won't be done in time for the NPRM. I realize there's realities out of a lot of people's control and, you know, and I'm sure this is going to be a case where as studies get done, they're going to be put out there and the NPRM is going to be just like the opening shot, so to speak, of how things go, and we're going to be a partner in all that. But to the extent that these studies can be done sooner than later and yet, get into the public domain so we can have the review process and the dialogue, that's going to be very important.

And again, you know, this is where we're going to be here to try to help, and that is that the studies reflect real-world constraints and commercial uncertainties. I mean, there's a lot of good work I've seen on trying to be thinking out of the box, how to build a better mousetrap, and that's something that's good and that's something to good to get fresh minds in but you have to bring in the realities. And there's a lot of realities in terms of noise, vibration, harshness, how the vehicle actually has to function, customer acceptability. And then there's the whole thing of whose going to pay for this completely different manufacturing process and then the uncertainties of going to a new manufacturing process. Like I said, we're moving out of our comfort zone here.

Okay. Well, I have to say looking at this, the degree and timing of the improvements being studied is pretty unprecedented. It's a bit exciting and also, a bit scary. I mean, five percent improvement through 2012, I mean, 2016 and some of the numbers being bantered about are 3 to 6 percent through 2017 and 2025. We know that continuous improvement is something we all do and something we are supportive but it’s not constant or not even linear. Your first couple percent are usually just taking the fat out of the budget so to speak. The last couple percent is really a stretch.

So, you know, again, in order to have this kind of success, we do need to have all the partners to the table, single coordinated program, realistic and commercially achievable standards and again, working through that kind of review of well, are we making progress, are these standards we, once the rulemaking is done, are these standards still making sense based on some of the new learning rule we get after the rulemaking is done.

Again, this is the chart I think that everybody in this room should be incredibly proud of. This was not done by any single person. This is, as they say it takes a community to raise a child, it takes a community to save a life. This is everybody working together through the years from 1950. It’s very dramatic. And this is VMT. This is not just registered. So this includes the times where we’ve had recessions and the near-term recessions and reduced vehicle travel. This is real safety and where the rubber hits the road and we, as vehicle manufacturers, are a committed partner in this and we are working to keep this downward trend.

In fact, you know, as we talk about some of this stuff, you know, we have done work with IIHS in looking at some of the geometric incapabilities but one of the things, when we talked, when we started this compatibility work, we didn't notice it, yeah, well, not notice, we knew all along, that there will be and always are going to be mass incompatibilities. The fleet is going to have big trucks, little trucks, commercial trucks all the way down to the new emerging micro-vehicles and so, you know, the mass incompatibilities are going to be there.

And the other thing you need to really need to keep in mind is that, you know, when we do these studies, just simply maintaining the frontal crash protection that the standards require or even the, the consumer information standards require isn't quite adequate. There are a lot of do care stuff, there's a lot of additional crash modes that manufacturers have to pay attention to. And again, on some of these more intimate discussions between NHTSA and our members, these are the kind of things that our members will be happy to sort of share and help you guys understand what the real criterion should be when you look at the safety of these vehicles.

Again, significant mass reduction requires complete vehicle redesign. I think one of the key aspects we have is as we're contemplating the future of bringing vehicles down, we don't want to go so fast and so furious that we outrun the fleet moving in the right direction. In fact, you know, it was brought out that the fleet, over the years, has been steadily increasing in mass and tapering off and now started its downward slope, so that means we've basically got a wave.

Now, as the population age, the older vehicles, which actually happen to be the lighter vehicles, are dropping off so you could picture the actual average for the next few years increasing. So you've always got to be looking at what you're asking the new generations of vehicles to be relative to what they're going to be experiencing on the road and that's something that we think is very important for the agency to consider and to look at that specifically actually, you know, and I'll talk a little bit about finding a sweet spot so to speak.

So the bottom line here is that really, we have to manage this process acknowledging that there is going to be some mass and size effects and how can we minimize those without sacrificing some of the gains we're going to be putting into the vehicles anyway. We're going to be putting gains, we're going to be making cars safer but let's not take all that safety and sacrifice it just to make fuel economy.

I think there's a lot of levers that you can pull for improving fuel economy. Mass reduction is just one of them. They all need to be fine tuned and turned and pulled in a very appropriate and very systematic way and I think if it's properly managed, and I'm fairly confident it will be, that we can get to where we need to be and still maintain the kind of safety we want and safety improvements that we're all working to make.

And again, this is -- I don't want to beat a horse to death. I mean, these are kind of the things that if you do, as you look out in the future, especially the long distance future, and we appreciate having those long-term goals. We talk about certainty. We agree that we like to have a target where we're going to go. However, we do need, feel that you need to have some fine tuning, some trimming that's built into the process to be able to see are those, are you making progress toward those goals. And as we go along, we need to be looking at the improvements of designing and technology.

The big thing is consumer affordability and acceptance. There's always the economic viability. Bringing new plants, having to make major changes. There's a lot of externalities that are out of our control and maybe even out of the government agencies' control. The other thing is, you know, as we said, safety is not going, is moving forward and most safety devices add some mass. Maybe not a lot but it all adds up, so you're going to have to look at the future of safety improvements and see what they're adding as well.

And then part of this analysis also is looking at the timing and effectiveness in advanced crash avoidance technology. I mean, one of the things that some folks have indicated is they believe that down-weighting helps with, you know, single-vehicle crashes. Well, if ESC is taking a lot of those out of the picture, well, I'm not sure how that works. I'm not the statistician so luckily, I can pose the questions but I don't have to actually do the work. The other thing is, you know, we're going to be looking at future crashworthiness things and those are things that need to be looked at as well.

One of the things, when you talk about incorporating technology, it's, there are many cycles that vehicle manufacturers really have to manage. There's kind of like the introduction of individual models and platforms. There's an integration of innovation, and this is like not just putting a new innovation on a single model but how do you take some radical innovation and bring it into the models that it's appropriate for. And then there's, depending on the kind of change, whether it's a big manufacturing change, you also have to deal with plant refresh and replacement.

So with respect to kind of talking about the model platform change, this is typically a four to six year cycle and one of the things is typically, manufacturers, when they do this, they load a lot of changes up at once. And of course you know, as many people have mentioned, when you're trying to look at the statistics, you know, you've got a vehicle that went from one weight to another weight, it also went slightly different size, it also has side air bags with curtains and this, it also has an optimized frontal geometry, there's a lot that goes in at the same time. Now, I realize there's some very, very smart statisticians that have worked very cleverly to try to isolate this and I encourage that to continue, but it just makes it a real challenge and again, I'm glad I don't have to do those actual analyses.

And one of the things about these product cycles is they typically have a cosmetic mid-year refresh which is pretty much planned from the very beginning. It's not ad hoc. And really, that's, from that mid-year on is really where you bring in some of the profitability of that model because when you bring a new model in, you're paying for everything up front, all the plant and all that stuff, so you're literally starting in the hole and as you sell and get profits from each vehicle's sales, you're now bringing it back up. So again, when you try to think about integrating things as a manufacturer, you do have to keep that kind of stuff in mind.

The other thing is powertrains can even be longer lead time. Engine plants are notorious for being a fairly long lead time. You have casting facilities, you have engine blocks. So sometimes it's like an eight-year cycle and plus, you have to integrate engines in multiple platforms. You know, you might have the same engine that goes in this car, this car, this car. You may have variations but the same engine block may be the one that goes in there. So again, you, just by taking, you've got a plant that's set up to do a number of units and suddenly, you're dropping it out of this car, then suddenly, this plant's being underutilized, so there's a huge juggling process that has to go on.

And again, one of the key things, and I'll bring it up in the next slide, is you don't take these and do them all at once. You know, you have a portfolio of maybe, you know, seven or five or whatever major platforms. You don't just say okay, this year we're going to change them all at once. You stagger them so that you can control it better. So again, it's not, in some ways, you know, we get a wrap that says, well, the auto industry doesn't want to incorporate technology fast enough. Well, even when we move as fast as we can, there's still isn't time to try to phase these in.

Plus, and let me get to the next slide, innovation. Now, this is a very simplistic slide. You notice I have put no numbers on it because really, when you talk about innovation, it's very specific to what the innovation is. Some innovation can be fairly, I wouldn't say minor but easy to implement and some of them can be very, very difficult. However, they all pretty much have the same steps.

Innovation just doesn't jump in your lap. It usually comes from the lab. It has an initial concept. You do lab component test. You do your analysis, your computer simulations, et cetera. Then you kind of work into a low volume prototype to see, you know, maybe you can do some initial customer acceptance of these features in these things, you know, and then at some point, you usually try to find a way to bring it in, especially if it's a risky. If it's a very risky technology, you need to be very careful on how you introduce it and therefore, you usually do low volume pilots.

And so that's maybe why you see a lot of manufacturers have some of these high tech but low volume models that they maintain and you're thinking how are they making money on this. Well, these are technology incubators, you know, the Vipers and the vehicles where you see some of the magnesium going in and some of that stuff. They're low volume. You have a lot more control and if something goes wrong, you have a lot less exposure. And so it's very important to have kind of this technology incubator phase.

And notice, I have just labeled issue resolution loops, you know, I'm an engineer. I believe in Murphy's Law. Things screw up and so you're constantly looking at something. You do your best analysis, you put it out there and you find out sometimes the customers hate it, it doesn't work or you have problems. And then you kind of have to go back and say well, it wasn't the, because we didn't execute it correctly, was it they just didn't want the technology or can we fix it.

So assuming that you can get it out of the lab into a low volume prototype and then you can bring it into sort of a low volume pilot and then you bring it into maybe your first higher volume pilot, again, you're getting experience. You're getting knowledge and getting learning. And then from there, if it all works, then you start bringing it out into wider distribution.

Now, some technologies are applicable for the entire fleet, you know, but some of them are not. You know, they may be expensive and so only certain models have the kind of customer base that will support it so, you know, exactly how this technology goes out can be quite different. And again, like I said, this graph has to be overlayed with, you know, how you're going to change over your plants and especially when you have a plant that may be going from something like a stamping plant to a casting plant and body plant.

You know, we talked a lot about advanced materials and one of the things you'll find is our manufacturers work very hard in trying to understand and apply advanced materials so we're not coming up here saying oh, we don't like advanced materials, we can't do it, we can't do it, we can't do it. There is some risk. We need to work on those risks. But there also is some of the economic issues with trying to make a fast transition or is this really going to pan out.

I mean, again, some of the manufacturing lead time issues are let's say we're going from the typical stamping plants, spot welding to something that's magnesium casting, extrusion and bonding. Not to necessarily say that some of those processes are not doable per se but that creates a huge, you've got the stamping plant that's now no longer stamping, so you've got to retire that and you have the costs involved with that retirement. You have to try to bring in a new plant. You have to kind of come in and figure out what the capital is going to be for that. You're going to try to manage the risk to make sure that, you know, this really is where you want to go and you're not going to have some unforeseen issues.

I mean, you know, we all know when we talk about unforeseen issues and stuff, you know, a lot of these processes, and especially magnesium, it's very electrochemically active. It's a great material for many things but it also corrodes. You also have different welding processes, different bonding processes and different finishing processes. Sometimes you can't put the same material through the same paint plant so you obviously have to make different handling within the plant. And all this takes time and coordination.

The other thing is that some things like electronics seem to get cheaper as you go up in volume. Things that are mined out of the ground typically get more expensive when you increase the demand, sort of like oil, and they also get more expensive if they're not here in the United States and there's somebody who has a tax on it. So, you know, you need to be careful if you have new materials that you're going to suddenly be transitioning to that are going to be like mined. I'm not sure. I think magnesium is done out of magnesium ore. Don't ask me the exact name of magnesium ore. I'm not sure where it comes from. I'm sure it's coming from the ground somewhere but I'm not sure what the cost uncertainty is if suddenly we all did a mass transition over to magnesium. It's a number that needs to be figured out. It's just something that we need to consider.

The other thing is we've talked a lot about the ability for vehicles to meet crash standards. Well, noise vibration, harshness and some of these other customer acceptance things are also big. I've been in vehicles that have very good crash performance, very good reliability and they feel tinny. And, you know, as an engineer, I know it's a perfectly great vehicle but every time I close the door, it just doesn't give me that nice satisfying feeling that says I want to buy this car. Manufacturers, whatever we build, we have to sell so there are a lot of requirements that go into a sellable car that may not be quite accounted for in all of the analyses we've seen today.

You know, one of the other things is repairability. Magnesium. I'm not sure that the current body shops are really capable of handling magnesium repairs, especially bonding. I think they think with a hammer and a mig welder and if they can't hammer it and weld it, what are they doing to do. So not only do you have to bring in a new vehicle technology, but you need to educate and transition the repair force, our repair facilities. And that's just magnesium. When you talk composites, which some of them are out there, but they are very specific.

And the other issue is on damage identification. For example, bicycle frames. Great composite technology. The problem is some of the manufacturers are getting sued because you fall, you pick up the bike. The bike, if it was an aluminum bike, it would be bent. The composite bike looks great, don't see anything. You get on it, it collapses. It has damage that's not seen. So that's another issue that just needs to be addressed in this whole debate.

And of course, there's the Murphy's Law which is the bottom, potential unforeseen consequences. If I could tell you what those consequences are, I'd put them on the slide. However, I will say that we did do an analysis on high-strength steels for roof crush and one of the things that came out of it is after we did all this great work, a lot of the Jaws of Life wouldn't cut it. Thankfully, there are people out there who are very quick at getting new versions of Jaws of Life and I'm sure they loved the extra sales but a lot of the fire departments had to buy, replace their equipment because they couldn't cut the A-Pillars and some of the other pillars with their Jaws of Life. These are things you just don't see and again, when you do these periodic reviews, the unforeseen consequences can sometimes creep in and you can get a clue that well, maybe we need to rethink something real quick.

Not to belabor it too much but, I mean, one of the things, you know, Lotus talked a little bit and we've only seen the Lotus Phase 1 study, so there's some stuff I saw earlier that was a little different. One of the key elements of the Lotus study that kind of concerns us is, you know, really, it's only one body style and one of the things they say, they say well, it's a uni-body, it probably covers a large percentage of the fleet. However, the number one selling vehicle in the United States is a Ford F150. I don't think it matches that vehicle.

Now, maybe in the future, I mean, I know there's some uni-body pickups. I don't think they run snow plows, I don't think they do a lot of things that the F150 can do, especially in its F350 variation. So that's one of the key areas that we think that this needs to look at because it's, you know, if you're going to be looking at down-weighting LTVs, that's where you need to go.

I've been given kind of the hook coming up so I will be very, very quick. As you can see, these are all some of the stuff which I think I've already pretty much cover. I tend to kind of cover and cover over and over and maybe it gets a little annoying.

One of the key areas is, when we talk about uncertainty, is cost uncertainty and that is the fact that a lot of these things are projecting. Now, I took the graph out of the TAR and you'll see it there. Basically, all I did was I took the NAS study, put those numbers on. There was a super light car study that was done awhile ago, put those numbers on. As you can see, the numbers are, A, as you get, not constant, not even necessarily linear. They probably are at parabolic going up. There's a lot of uncertainty in cost per pound that's out there and so that's an area that needs better study and probably monitoring as we go.

Okay. This is my last slide so I will do my big conclusion. And these are things I think, based on what I heard from Medford, I'm pleased to hear. We think NHTSA, being the premiere safety organization here, really needs to take the leadership role, and I'm hearing that they are, to look at the real-world study trends of these newer vehicles as they're coming out. So I'm glad to hear that Kahane's updating his model. I realize the data is old. It's always old because it's always, you know, a few years behind. But as we march into the new CAFE and fuel economy regs, we need to be continuously monitoring, not letting these studies get too old. We need some early look, first look at this stuff.

The other thing is really, we think you guys need to maybe consider its own study as what is the rate of downsizing, the maximum you could do, not necessarily what's feasible but what could you do before you start developing some safety consequences. In other words, this might help you find this weak spot. And again, I'm very pleased to hear that it sounds like most of the studies that were sort of discussed in the 2012-2016 rulemaking NHTSA plans to do. Like I said, we're a little disappointed that they didn't, doesn't look like they're going to come in before the NPRM but we understand some of the timing and as soon as we can get that information, we'd be very happy to hear it. Thanks.

MR. SMITH: Thank you, Scott, very much. Interesting presentation and, you know, makes us all think about some of the practicalities as well, and what we needed in this discussion was more uncertainty so that's, and that's the challenge that you find in government and business of course, whatever it might be, in terms of trying to make decisions in a fast-paced world with so much uncertainty. Our next presenter is, I won't say doctor, is Guy Nusholtz of Chrysler on mass change, complexity and fleet impact response.

MR. NUSHOLTZ: When I was first contacted, I was originally requested to speak on system identification errors and how Godel's Incompleteness Theorem applies to accident crashes so I called up NHTSA and I said is this really what you want me to talk about because the papers

Jh

they had cited covered a lot of that stuff and they said no, it's mass, mass versus size so I sent them the correct papers that they should reference.

I really don't know what size is. I see a lot of people are using wheelbase and Jeya was using FAW front to windshield, so I threw size out. But I'm going to talk about the complexity of this and how it's so difficult to fully understand the phenomena. I'm going to go very fast. If you don't already understand this, you're not going to pick it up from my presentation and if you noticed, a lot of the presentations that have been given, they're also fairly complex.

I'm going to cover a history of some of this stuff which most of it you've already seen, so I'm going to go real quick over that, then I'm going to elaborate on the complexity of mass reduction just a little bit and then I'm going to describe the fleet model we used to try and estimate some of the effects of reducing mass and finally, I'll conclude.

Evans, you've heard about him. He's a historic figure and has done an awful lot of good statistical work. Kahane was here, and I think he's still here, and has done a number of very good studies. The one that we've used the most is the 2003. We're going to the 2010. We don't fully understand it so I'm not going to reference it. And then the person who's done the most elaborate mass, size and statistical studies is Jeya Padmanaban, and you heard that earlier this morning.

This is out of Evans' book and he shows, he does a regression or basically just a plot and he plots it on a log, log scale and he shows that the mass ratio raise to 3.58 is a very good estimator of risk in the cars. Some people have gotten as low as 2.5. We've gotten as high as 6 in some parameters. It's not really fixed at 3.8 but it's still an exponential.

This is sort of the justification he just follows. Conservation of momentum. Two vehicles in a collision. One will have a turnaround velocity of 29 miles an hour, the other about 21 miles an hour, and that's just due to their mass conservation momentum. And then if you go to the accident data and you look at the effect of velocity, you find that that, those two velocity turnarounds give you about a 2.7 times risk for the lighter vehicle. So that's Evans' work and it's consistent with what Kahane did in 2003 and also what Padmanaban did.

This is stuff out of Jeya's study. She didn't show it but I'm going to show it, and it's sort of the relative factors. You can see that in terms of vehicle parameters, mass is the most significant and then basically what you're calling size but in this case it's FAW, is about a third. Stiffness shows up at the very end. It's relatively small. It's larger in some of the crash types. This is car-to-car.

In car-to-truck, mass is more important but that's primarily because trucks have a greater differential in mass than cars and once again, vehicle size or the parameter that relates to size is much smaller.

So now I'm going to talk about a fleet model. This is very close to doing accident investigation but I do two things that are not in an accident investigation. One is I force the data to follow the laws of conservation momentum and conservation of energy. In a lot of fleet models, in a lot of statistics, you can violate that without any problem and it will all be statistically significant. We ran a model where we were able to show that the color of the other car that struck you was important in your survival. We also did one where an air bag in the other car was important for your survival. And some of them we can track down to the misreporting of seatbelt use in this and that was the cause and once we corrected that, we were able to eliminate some of these things.

So statistical models are very tricky, very difficult to do. Right now, since we don't really have an ability to look at the complete space, they're always an incomplete model and you really don't know what your system errors are and what your confidence of the model is. Doesn't mean you shouldn't be doing them, and a lot of people are very careful to try and understand what their models mean but you really can't define a statistical confidence on them because of the system errors.

Original model we did in 2003. We based our impact response or force deflection on NCAP, we approximated or idealized it with a two-step model and then we used average acceleration to link fatality rates to the response of the model.

Our current model, we've introduced a whole number of new factors. We've got intrusion, belt use, air bags, driver behaviors, a wide spectrum of abilities that we can look at and I'm not going to go through all of them in this case. We've included non-NCAP responses. We collected a number of car-to-car crashes, a lot of them done by NHTSA. The original fleet model, which was talked about earlier by Steve that was done at George Washington University and other places, NHTSA put a bunch of these models on the web. We've taken them and used them and normally, I don't really have a whole lot of respect for NCAP but there's a real lot of good data in there that you can use to understand how the cars respond. So we took all this, the finite element models, the car-to-car crash, we parameterized it and used it in the fleet model.

This is just an idea of how we parameterize it. I'm not going to go through all of the details but the green line, if you can see it, for the first one it represents mass distribution from a number of the cars that we use and we fit it with a normal distribution that's basically a truncated normal distribution. We don't get down to masses of zero mass and we don't go above where our largest car is so we truncate it at the end of our data.

And in the other one, we're looking at the crush length and in the current model, we're taking that from low-speed crashes all the way up to high-speed crashes. We also use the IIHS crashes and we're also using crashes that come from car-to-car and from the finite element estimations to fine tune it to get it close to what we expect to see in the field.

This is just a fit. It's a gamma function fitting on the accident data. We used that as our parameterized variable. And this is an average intrusion. We're assuming that even though the intrusion of the instrument panel and other parts of the car is actually a surface, that we can approximate it with a single number.

And this slide represents the meaning of life and the cosmic totality of all of it, and how do you get the slides back on? There we go. No problem. This is a calibration of the model. It's not really a validation.

When a model gets this complex, you never can really truly validate the model but what we did is we created boundaries, limits of what the model should see. And it's not just a two-dimensional type of limit because it's not just the highest and the lowest. We're working it on a 20-dimensional space and so you have to have a hypersurface or a manifold that spans this. So I'm just going to give a couple examples of the limits.

So the first one, we're looking at intrusion rate which is not an input to the model but it's an output and you can see one of the upper and lower bounds are red and blue. And in the next one, we're looking at average intrusion and then, and we're comparing these to impact velocity. The bottom one is two other boundaries in our 20-dimensional space and the same thing with the last slide.

This is estimating injury risk, and I'm using just two of the boundary areas. The green line is the actual data, the solid red and the dotted red and the blue and the dotted blue are the boundaries.

Here's some of the assumptions that we're going to be using in the model. Seventy percent belted. If you change the belted rates, it's going to change the results. No behavior changes in this particular model. Originally, I was going to present them but it takes way too much time to show how behavioral affects it and so my management said get that out of there. It's going to be primarily front impacts, car-to-car, car-to-truck. We've also done it for side and rear. You get approximately the same results. The magnitudes are somewhat different.

Risk is monotonically increasing with velocity. In other words, a crash at 100 miles an hour will always be more severe for all other conditions held constant than a crash at five miles an hour. Risk is a function of velocity change and the average rate of velocity change, so there's a derivative in there.

Fleet turns over at a constant rate. It's approximately 13.5 million cars per year. We're going to do it in 20 years. The national and state accident databases are an accurate representation of the real world. This is very important. They're not really but it's the best we can do. Scaling laws apply during the down-massing and stiffening and adding crush space so that the normal scaling laws actually apply. Now, they really don't but it's a reasonable approximation.

This is the first slice through the response surface. I'm going to look at mass offset and I'm going to look at crush offset. So when I reduce the mass of the vehicle, I'm keeping everything else constant, I can make the sizes of various components like the engine, the radiator, the battery, other things smaller and that smaller gives me an increase in crush space and that crush space then gives me ability to add more energy without increasing the intrusion. And what you can see in this case is mass dominates over increasing crush space.

Now, I've overemphasized crush space because I'm assuming that we have an infinite number of engines and we can downsize it for every single decrease in mass. We can't really do it so it's a very conservative estimate, or not conservative but it exaggerates the effect of crush and even then, we don't get as much change as we do with mass, and this is consistent with Padmanaban's study.

And this is one which shows the effect of belted or unbelted. This is one of the behavioral changes that I said I wasn't going to talk about. And if this surface was flat, then you could really apply everything depending on what the belt usage rate is but it's not flat and therefore, belt usage rate will have an effect on the downsizing.

This is the first approximation or simplified approximation. I've taken my space and I reduced it to one dimension, and I'm going to move 20 pounds out of the vehicle and make no other changes.

MS. PADMANABAN: Two hundred.

MR. NUSHOLTZ: Two hundred pounds out of the vehicle and make no other changes. What happens is the fatality risk goes up on an average of about 10 percent.

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This is consistent with both Padmanaban's study and Kahane's study and, at least Kahane's 2003 study, and when we ran it with 100 pounds, we got approximately what he did for 100 pounds type of loss so it's consistent with the other studies. It doesn't make it right. All three of them could be wrong, but it just means they're consistent.

The next thing we did is we said well, what can we do to try and reduce the effect of the downsizing. So we're adding the crush space, that's one thing. Second thing we do is we change the force deflection characteristic of the vehicle responses so we're kind of optimizing this force deflection. Now, there may not be, it may not be possible to optimize it because you physically may not be able to do a design or you may not be able to find the material substitutions that you need but given that you can, then we did that. I mean, I can do it mathematically. I may not be able to do it physically. And we scaled the vehicle fleet.

So we're now pulling more mass, much more mass out of the heavier vehicles than we are out of the lighter vehicles, and we followed the basic scaling laws to do that. So we're going to take the trucks, and you may only pull 50 pounds out of a lighter vehicle but you may pull 300 or 400 pounds out of the truck. Now, one of the things that happens is this is mass constant. I'm pulling the same amount of mass out. I don't get the same fuel economy that way because I pulled so much mass out of heavier trucks and not out of the lighter vehicles. And so the green line, even though I've reduced very significantly, by a factor of four, the fatality rates, I'm not getting the same fuel economy benefit that I would with a blue line.

Conclusions. The conclusions are based on the assumptions that I made. There's some other assumptions that are in there which I didn't talk about. I'm assuming the laws of conservation of energy and conservation of momentum and so I didn't bother to mention that. One of the things that can happen in a lot of statistical analyses is that you don't have to worry about those laws. You can come up with statistical analyses that are statistically significant and yet violate those laws, and I've done that myself.

First one is a constant 200-pound mass removal, no other changes, then we have an increase in the fatality rates. It goes up about 10 percent. Then we followed the following rules. We used the three-half power law scaling mass reduction, the heavier vehicles have a greater amount of mass reduced than the lighter ones. We scaled the reductions and we scaled impact response. We're holding intrusion constant. We're trying to hold -- you can't really do that but to the best that we can, we're trying to hold intrusion constant, whatever that means because you have different intrusions every time you do a crash.

These crashes, we run about, an estimation of about six million crashes a year and we're going to run 20 years so we're running 120 million crashes. This is many more crashes than you do with a finite element model and the advantage to this, if we did it in finite element models, we'd still be waiting for the outputs from the computers to come out because that's typically -- for car-to-car crash for us, it takes about 20 to 30 hours of computer time and if you did six million crashes a year over 20 years, you're going to wait a long time.

Average stiffness reduction proportional to the mass. This is to hold the intrusion constant. And we're modifying the force deflection to try and optimize it so we can get within the range of the test data, the best possible response. Crush increases obtained from the downsizing and a result of the mass reduction. We still get an increase in fatalities. Although it's reduced by a factor of four or five, we still can't get it to be constant or go away to zero. This is probably, given the data that generates this model, this is the best that can be done theoretically in giving the downsizing or making changes, and a lot of these changes you may not be able to accomplish. And with that, I'm done.

MR. SMITH: Thank you, Guy. I know how fast people are racing through these things because each one of these presentations could, you know, with questions and answers, could go on for three hours and it just kind of indicates how much interest there is and how much there is to be said. We're running a bit behind. That's my fault, not the presenters. We took time for the administrator. I'm very glad he came to visit, and we took a little extra time there because one of our representatives had to leave.

So now we're down to our last presentation before our discussion, and this is from Frank Field of MIT who is going to talk to us about innovative automobile materials technologies, feasibility as an emergent systems property.

MR. FIELD: Thank you. So good afternoon. Here we are at the end almost. Thank you all for hanging in there until the very, until this point. I am here as, I'm a little different, I guess, than most of our other speakers here in that safety is not really what I do. I am part of a research group at MIT that has, for the last 30 years, been studying essentially problems in material selection, substitution and the ways in which that is undertaken in complex product development strategies. This is, unsurprisingly, one of those domains has been, of course, automotive lightweighting, a question that really was part of and really the start of this laboratory in some ways and has continued to be a part of its work.

But what has been a reality of this is that then, as now, there have been many possible ways to think about reducing the weight of a car. There are many challenges to try and think about overcoming them, but the limitations on what we do in this have at least as much to do with what we think of what's feasible as opposed to what we can technically accomplish.

The distinctions between those two are subtle and complicated to try to track, and it's why I have this rather elaborate title of this notion of emergent property, the idea that when one thinks about this, one has to think not just about the part, just about the component but in fact, about the broader system within which we are actually trying to operate.

So to start, we will back up a little bit and talk about what we really think we're talking about when we speak of the concept of feasibility. So here's a fairly simplified notion of the ways we think about it. There is one axis. I'm not sure -- oh, this is it. Maybe not. Those of you in the front row can see that.

There's on one hand, we have this idea that as performance increases, there's a cost and that in generally speaking, in order to get that increase in performance, in a general sense, I have to pay more. As I ask for more performance, just in the sense that we can argue the technical limits, we'll say at some point, there's a level of performance that I cannot accomplish or that I can pay as much as I want to and I can't get any further than that. Generally speaking, that is technologically constrained and it gives us this idea of this upper slope that it's harder the further we push.

This boundary, which is in some ways defined technically of course, is really a frontier. It describes the limits on what we might be able to do and in fact, when you look to actually observe places where one might operate, one will operate at interior points, on this green area largely because, of course, there's more than one kind of performance. It's not as if you're trying to do one thing. Any real product has multiple things to do and there will be competition among those objectives that will lead you to drift off of that boundary. But nevertheless, there is an effort to try to stay in the vicinity of that boundary and to try to figure out what it is to move up and down that edge.

Finding it, however, is difficult. Obviously, there are, for simple products, it's possible to actually analytically think about it as a product designer and of course, we have students that we train in the ways of thinking about how we chase that problem. But when it becomes a complex product for which it has, the performance requires us to think across many domains and many dimensions, it's relatively difficult to actually define what this boundary might look like and instead, we have to make reliance upon what we see, what people are actually able to make and how those things actually are received.

So you get something like this. You'll have observations that lie interior to this space and in general, there are some things we have to think about about this, tend to be first in the regimes where there is a lot of commonality of behavior. You'll see a tight cluster of cases. People all, this is what we seem to know how to do and we can operate well within the vicinity of that. However, as we try to push our performance, things get sparse. We do see applications as Scott described in his earlier talk. We'll try some things and we'll see how they work out. They're likely to be done in sort of a suboptimal way because I'm testing it out, I want to see what I can try to do, but we'll get something of a shape like this.

What this means is that there is this notion of uncertainty to Dan's concern. This idea that around these perimeters, we'll tend to find that there are uncertainties that might actually be achieved and that that uncertainty tends to be narrow in the vicinity of the things we know how to do and/or are doing reasonably well but as we move into the higher regime of performance, that uncertainty band expands. It expands partly because we don't have many observations, and it also expands because those who inform us about what the opportunities of these new technologies might be are unsurprisingly, they're optimists. They want to give us their best-case description of what might happen, and the realities are that for whatever reason, some things are going to, I'm either not going to do as well in a performance sense or it's going to cost me more than I actually might have analytically suggested.

So there is one other important dimension here to consider as well which is that as we are, in the domains where we are thinking about performance that are things that we are already doing or doing well, that performance is driven also by our reliance upon other parts of the system and when we have good understanding of what that performance will be of the system because of experience, knowledge, the ways in which we have handled the use of the products in the past, we have, can make reasonable assumptions about what it is to make small changes.

As we move away from our comfort zone, we are not only challenging what we can do ourselves, technically, but we are also challenging all the subsidiary systems upon which we rely in order to make the things that we are making. The manufacturing plant, the manufacturing operators themselves, the sources of the resources that we use to make these things. They are all geared and organized, unsurprisingly, towards the mainstream. That's what they're trying to do.

And as we rely on those systems, as we rely on those suppliers who are set up to be organized for the mainstream and we want to do something on the high-performance end, we are necessarily not only asking ourselves to operate outside of our comfort zone but also then those suppliers. And so we will, again, have a hard time doing as well as we might otherwise suggest that we might be able to do.

So what does this mean when we start talking about trying to push our goals, push the performance? I'd suggest that first, there is an unavoidable uncertainty that we have to confront, that as we make greater challenges upon ourselves to do better, to improve performance, we are necessarily moving into a domain where we are uncertain and hence, the number of tests, the kind of analyses that we are talking about here today. What can we do to try to narrow and limit that kind of uncertainty?

But there are also some other things about this, that kind of uncertainty that we have to manage in a different way. We cannot simply try to focus on the notion of predictive work because the fact is, as we move into these places where we ask more of ourselves, we are also making assumptions about others upon whom we have very little control or very little ability to manage what they will do. In a sense, we have to think about the broader system within which we are trying to operate. And this suggests that in addition to any sort of purely analytical work on trying to predict what will happen, it is also important to begin to think about contingencies. How is it that this result is dependent upon things that I expect will happen?

So again, I'm going to make a car out of magnesium. Are we sure there's going to be enough magnesium and if there's not going to be, if the suppliers are not going to get there in time, what are we going to do about it? And more importantly, for those who are making business decisions, what do I do as a decision-maker when I have to confront the fact that if I'm about to make a career decision on deciding what to do, do I have a fallback in the case that the contingency doesn't work?

Over the last 25 or so years of looking at what happens for material selection and substitution in the automobile, these kinds of considerations have always been uppermost in the ways in which these decisions have been made. While there is plenty of effort done to try to understand what can be done to try to look at the opportunities that are available, there is always having to come back to making the business case for that change and that because of these kinds of uncertainties, the kinds of choices that are frequently made are not the ones that the engineers, who would like to push you out to the feasibility frontier, wouldn’t necessarily themselves make.

So that’s sort of the end of the academic abstract story. Let’s now talk a little bit in particular about what’s going on in automobiles and lightweight materials today. So you’ve heard today, here’s the list. I don’t think I have to recap this but these are, when we talk about lightweighting for vehicles, this is the material space within which people are operating today and for which, and for pretty much all of these, we can find that there are applications of these materials now. They’ve been demonstrated in some sort of use, wether they are commercial, I mean, commercial requires a sort of characterization of commercial as in mass production or commercial as in formula one cars has, of course, it’s own set of questions but nevertheless, we can say that there are, these are all out there in some form or another, more or less commercialized.

When -- it’s always the gamble of using colors when I don’t know what sort of projection space I’m going to get. When we actually look at research that we’ve been doing over these past years, looking at the ways in which

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materials are substituted into automobiles and the kinds of consequences we see, in this case for vehicle structure, we see something very similar to this idealized curve that we can map along this notion that as I attempt to reduce the weight, I am able to do so at the expense of using some, either materials that are either exotic in form or exotic in process compared to the ways in which we make automobiles today.

Of course, as I said, it's always possible, remember what I said about the curve. It's always possible to find ways to get less weight reduction in an expensive way. It's, on the other hand, very hard to move off to this lower right-hand corner because we don't have the technology yet to get there. We can and I'm sure will but where we are right now, that's not going to happen.

Why so many different technologies? Why so many different places? Because these choices are tactical and strategic for firms, that it's not purely, that it's about chasing the best technology, putting it in the best place. But what kind of vehicle am I making? What kind of system am I trying to build it within? What are the -- how do these things interact among each other? What are the processes that I might use in order to make them or how might any of these sort of be expected to evolve? All of these are part of these grand contingencies that lead to the ways in which these decisions get made.

What this means though is that when it comes to looking at changes in materials and automobiles, they're really sort of, the fast changes in materials happen really for sort of three main reasons. Either because some technology, we have a magic technology that turns up and at which point, it is, in fact, economically advantageous. Everyone has to get there. It's simply what's required to operate.

The other cases are either an overconstrained design space, which is academic speak for introduction of constraints from external sources that require that performance has to be achieved regardless of what's available so, in regulatory constraints say, or and then finally, this notion of disruptive market circumstance. Either the circumstances we might find ourselves in soon on what happens with oil over the course of what happens in the Islamic world over these last several weeks or alternatively, any sort of significant supply disruptions. These tend to happen, of course, for not so much the whole vehicle but specific cases. So the Chinese decide to stop selling us rare earth, we're going to make some changes fast but we're not -- but that also means, as you move along that list is that they also -- these tend to be more expensive. As I move down that list, they cost us more to do each of those.

More generally, in the face of these uncertainties and the technical and strategic consequences of making these choices, we tend to find that decisions are less about optimization and more about satisficing. How do I do as well as I can given what I already have? Again, coming back to this notion of contingency, the ways in which my choices are determined by things in the system larger than what I am trying to operate. We simply have to make a lot of assumptions to get things done and automaking requires that some of these decisions are going to get made less about what is optimal and more about what it is I can do with what I have.

What this means is we look then at the kinds of obstacles or hurdles that we have to think about when looking at lightweighting in material substitution. There are a number of categories here to think about, some of them we've heard about today, the general notions of what the technologies are. In particular though, that's as much about the ideas of design and analysis but also, these questions of what does it take to actually do this kind of processing, what kind of manufacturing infrastructure do I have in place to do it, how do I do it.

One of the things we teach in material science is the idea that a material is not just the chemical compound but also the process by which it is used and turned into its form. I have to think of those things together and so the kinds of processes that I have available for turning raw materials into cars are at least as important as the question of what happens when I drop it into my FEM code and see how well it performs when I do an analysis.

There are also -- this leads us then into the set of institutional questions. Partly, that's analytical methods, again, within these firms but it's also what kind of physical plant do I have to work with, what kind of turnover do I expect to have in order to do that, what kind of worker experience do I have. It's not just a question of talking about what kind of repair happens in a repair plant. As anybody who has watched doors being set on a trim line knows that there are a variety of hammer-looking sorts of processes that take place from time to time there too as well each of which leads to its own set of constraints.

But then finally, there is this larger system within which the production operation takes place. Where are these parts coming from? Are the OEMs making them themselves? Are there suppliers that are actually able to make them for them? Are there, where's the raw material coming from? Is it at quality, is it at grade, is it reliable, is it accessible? Who's putting these things together and where does this expertise come from? Just in

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the same ways we talk about qualification in aerospace, there is a qualification for OEMs in automobiles, the Tier-1s, the Tier-2s, these are all the jargon of the ways in which we qualify these people. Where are they going to come from?

So this sort of leads us to something of the rationale that lies behind some of the compounds of that graph that I showed you, this idea that there are not merely sort of technical capabilities, what do we get in terms of performance, but there's also this question of how well do we know how to do it, what are the things that stand in my way and what are the time tables for that.

So when I look at magnesium, we heard something about this today. Forming is an interesting problem for magnesium. It's hexagonal close packed so it's not exactly like forming steel. You're either going to be doing a lot of interesting casting which suggests I'm going to think, find a lot of diecasters who don't currently exist in order to do that for me or I'm going to have to find somebody who's going to be willing to sell me some magnesium sheet before I even think about whether I can form it with the variety of specialized processes to do anything because right now, there's nobody who can even sell it to anyone for testing purposes. Similarly when we look at something --

So there's then also what kind of institutional change has to happen? Who, what part of the physical plant of the OEM or the supply chain has to revolve and what, within that supply chain, are we contingent upon in order to actually be able to successfully achieve these kinds of substitutions? This broader perspective beyond the question of what we have in terms of material technology, but the where is the important part of what becomes this question of feasibility. What -- is there a system in place that allows us to actually make this kind of production.

So coming back to this chart, on one hand, this looks like an argument that says that we're in deep trouble, they're, it's going to cost us a lot to do this. The issue of course is that, as we heard earlier from I think Steve, there is this question of the fact that we can design. There's a lot of things about design that allow us to take advantage of some of these things. There are also the recognition that it's not a question of what it costs to make but what it's worth.

So there is this question of once you factor in the fact that the vehicle perhaps gives me a slightly better fuel efficiency and that I therefore, if there's a fuel savings, I can take off of the back end of that, then in some ways, suddenly I have, there's this sort of balancing act that allows me to suggest some of these things might make sense. And so notice all high-strength steels ends up sort of looking like something where there's a payoff in the sense of what it's worth in terms of fuel efficiency to have it.

There's also, again, compounding into further sorts of design capabilities once one recognizes that making some parts of the car lighter means I can make other parts of the car lighter as well. The secondary weight savings also continues to improve this and so I can think by putting a clever design, clever processing performance in place, I can take advantage of these materials but it requires being imaginative about this as well as reliance upon some sort of notion that I have a larger supply system that is going to allow me to do this in a cost-effective way.

So as I said, there are wider considerations that will change this. There's technological improvements, better efficient processing, but the big question here is going to be how does one move an industry taking advantage of lightweight materials. Lightweighting, in general, for an automobile is as much a tactical and financially strategic question as it is a product development and safety question as you're talking about here.

There's -- in order to make those changes, firms are not, I think, heard. There's a turnover in physical plant, there's a turnover in design. This all takes money. This all takes cost that has to be paid by someone and if the consumer is not going to pay for it, we're going to have to find other ways to make sure that it's being cost-effective or we have to find otherwise ways in which to make sure that the value proposition for the consumer is such that it's worth taking, having it take place.

One of these areas, for example, is the ways in which we are looking at the opportunities of advanced powertrains. The advanced powertrains have, are changing the ways in which we might think about where the benefits come from from lightweighting so that while it might not be ICCTs when we get into a question where when lightweighting also means I can reduce the weight of a large and heavy battery into a car, I suddenly have real opportunities here to argue that the economic justification for making those changes is defensible and changes sort of the shape of that curve, but it requires us to think again at this broader systemic perspective.

So to summarize, there's no question that mastering advanced lightweighting materials technology is a real technological opportunity for this industry. Getting better at it potentially offers any number being, in particular, being first mover in some of these means that there will be opportunities here for the technology not only to be employed here but also to be disseminated and made use of in a, more broadly across the planet.

However, it requires learning more about these technologies, it requires coordination and in particular, thinking hard about what it’s going to take in order to make sure that when we think about framing the question of lightweighting, that we can make an argument to show where the cost benefits come from and the ways in which these cost benefits can be structured within the way the firms work. As I said, there is something about advanced powertrains here that definitely is a real incentivizer for the way in which this might take place.

But more generally, are we certainly, can we make these fuel targets, and the answer is of course we can make them. We know how to build cars like this but what we don’t know, necessarily, how to do is how to do them in such a way that they are affordable. Thinking about the ways in which we get to affordability is going to require us to think much more carefully about not merely what we want the OEMs to do but also to recognize that they, themselves, are reliant upon a larger infrastructure of resource, supply, service suppliers, all of whom have to be brought along.

Right now, there’s no stake for them, necessarily, to be committed to thinking about lightweighting as a strategy because incrementalism is what they have seen and lack of coordination is what they have seen and frankly, an argument on the ways in which we have thought about innovation in this space and the way in which competitive market places do this incrementalism is what we sort of are pushing everyone toward.

The problem will be if we want to make these kinds of broad jumps, the kind of coordinated effort that we see in this kind of rulemaking, but also in other domains, are going to have to be carefully orchestrated to make sure that we think not only about what the OEMs have to do and what the car has to be but what the supply infrastructure and production infrastructure that they will have on hand to do that and to make sure that we have ways of thinking about how to make sure that is in place when it starts coming time to build cars in that way. With that, thank you.

MR. SMITH: If our panel could take their seats on the stage, I'd appreciate it. We'll move into the discussion portion. That was a great, great presentation. It was a great way to kind of get to the point we are now in terms of conclusions because it put right out there a lot of the issues that we really have to, have to grapple with. I'll give you a microphone.

My first question is for Guy Nusholtz, and that is a lot of us got very anxious when your blank slide with the meaning of life came up and I'm wondering what was on it actually.

MR. NUSHOLTZ: I had a slide, the original slide was all of the equations and images on the creation of the universe, how life was formed and its meaning.

MR. SMITH: We were anxious. We wanted to see it.

MR. NUSHOLTZ: And it just didn't come through and I was trying to cover everything in the entire universe in one slide but I was unsuccessful.

MR. SCHMIDT: It was proprietary, right?

MR. SMITH: It will be on the web page.

MR. SCHMIDT: It's Chrysler only.

MR. SMITH: Jim Tamm says it will be on the web page. I do have an actual question and that is for our representative from Honda and the discussion about seatbelts. Certainly, NHTSA firmly believes that seatbelts are about the most important protection device in the vehicle. We are adamant about increasing seatbelt usage rates and frankly, most of the, a lot of the mayhem on the, on the roads could be vastly reduced through 100 percent seatbelt usage. Not drinking and driving and not being distracted would go a long way toward reducing a 33,808 fatalities that happened in 2009 with those things.

But my question really is this, and this is my own lack of technical understanding I think, are you suggesting that as much as we want seatbelt usage, are you suggesting that belted occupants in a low mass vehicle are as safe if belted as belted occupants in a high mass vehicle?

MR. KAMIJI: (Indiscernible).

MR. SMITH: Are you saying that belting is really kind of the answer because if you just look at mass, that a belted occupant in a low mass vehicle is as safe as a belted occupant in a high mass vehicle?

MR. NUSHOLTZ: Let me respond after he responds.

MR. SMITH: Okay.

MR. KAMIJI: So basically, current ability to condition for the 208 so (indiscernible) should be rule for the (indiscernible) occupant so that's because for belted occupant, seatbelt (indiscernible) it's harder to rise up in (indiscernible) timing so by using a high crash pulse, (indiscernible) more better than initial low crash pulse. So therefore, for belted occupant, by using a (indiscernible) high crash can be better (indiscernible) system performance. So therefore, (indiscernible) can be, can be achieved without the unbelted requirement.

MR. SMITH: I understand the long-term argument about crash pulse and the argument about whether we should be protecting unbelted occupants in the way that we do, but I kind of understood your argument to be so focused on seatbelt usage that it was kind of saying that, you know, that kind of overcomes the mass differences.

MR. KAMIJI: So basically, by using higher seatbelt than now, so achieve the (indiscernible), I hope that 100 percent (indiscernible) eliminate some regulation, current regulation and that we make optimize, will optimize the system for a good performance for the restrained occupant.

MR. SMITH: Okay. Guy, you wanted to add something?

MR. NUSHOLTZ: Yeah. Let me rephrase what he's saying and maybe even put some words in his mouth. I've done a series of studies and they've been presented to NHTSA which on the bottom line says the unbelted test is absolutely useless, doesn't protect the unbelted and doesn't improve the safety in the field. All it does is drives a constraints on the belted and I've done that, published it in a number of places and I've shown it to NHTSA. So functionally, the reason you get rid of the unbelted test is one, it doesn't do any good and two, it may even be negative and so there's -- it's not a question of not protecting the unbelted because you do. You've got the air bag in there, the belt's available for him. You're doing the best you can. You don't need an unbelted test to force designs to the vehicle which really don't have any value.

MR. SMITH: Okay. Questions in the audience? Questions? Yes sir. Here you go.

THE COURT REPORTER: Please identify yourself.

MR. COPPOLA: Bill Coppola, EDAG. Why was there ever an unbelted requirement brought about?

MR. SMITH: Well, I didn't mean to digress in this entire discussion which is not exactly where we're going but unbelted people are people too, you know, and so that's about all I can say is that the, as much as we encourage 100 percent belt use, we know that some folks are not and we know that they're likelihood of dying in a crash is therefore, much higher and as a result, the standards, the FMVSS are designed to take that into account so as to reduce overall fatalities.

I don't want to digress further on that but I was actually trying to get to the connection to the whole mass, size argument that, and discussion that we're having here. Other questions?

MR. MADDOX: For Scott. On one of your slides, you made a suggestion that we should always be looking --

MR. SMITH: A little closer, John.

MR. MADDOX: I'm sorry. One of your slides had suggested we should be looking at future crashworthiness.

MR. SMITH: It was and I don't know if it was -- yeah. It's a faulty microphone. It's erratic.

MR. MADDOX: One of your slides, there we go, had a reference to potential future crashworthiness efforts that we should be looking at considering for the long-term. Do you have any specifics there? Any recommendations?

MR. SCHMIDT: No, not really. I mean, one of the things I did bring out is that a lot of these improvements in safety do have some mass impact. It doesn't necessarily have to be big. Sometimes it's a sensor or something like that that's fairly minor. It was just kind of for completeness to say as you march and look into the future and you're monitoring where things are, you should be kind of looking at holistically well, what's the safety picture going and are there any game-changers.

You know, we had side air bags came on and that was kind of a game-changer for side impact. And I remember when I first started at the Insurance Institute, we thought that there was not going to be a sensor that would allow that to happen so we were kind of like well, this is a great idea if we could get the sensors to work. Well, suddenly, somebody got that little sensor to work and we got a game-changer.

So, you know, again, it's kind of as you look out into the future and you're trying to plot where we're going and you're trying to track the performance, it's probably a good idea to look at all the whole safety picture, and that includes both the crash avoidance and the crashworthiness and as you add these features on, remember how much weight's coming in. There may be a great crashworthiness feature that comes on that's also heavy. I don't know. I, like I said, I'm not the down in the trenches guy so there's a lot of stuff that I kind of look at the big picture and say well, we should pay attention to this. I'm not sure of the specifics but we should pay attention to it.

MR. SMITH: Yes.

MS. PADMANABAN: Jeya Padmanaban from JP Research. I have a question for Mr. German. I think you had a comment about fatality risk is lower for heavier vehicles in rollovers. Did I get that right?

MR. GERMAN: I was referring back to the specific slide comparing small sport utilities to mid-size sport utilities and the fatality, the rollover fatality risk in the small sport utility was a third of what it was for the mid-size. But also, even from a basic physics point of view, taking weight out of the vehicle, it's really where you take the weight out that's going to affect rollovers. You can actually make it better or worse depending on where that weight is taken out, from low in the vehicle or high in the vehicle effects, how it affects the center of gravity.

MS. PADMANABAN: But isn't it true given a vehicle rolls over, it takes more energy for heavier vehicle to roll over than lighter?

MR. GERMAN: Not at all.

MS. PADMANABAN: And the fatality risk is higher?

MR. GERMAN: No. It's totally a function of the

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center of gravity compared to the track width and the wheelbase.

MS. PADMANABAN: For risk of fatality in rollover?

MR. GERMAN: No. I mean whether it's going to roll over or not.

MS. PADMANABAN: Yeah, okay. So you're talking about just a rollover occurrence given a crash, not fatality risk given a rollover.

MR. GERMAN: Correct.

MS. PADMANABAN: Okay. Because we have found basically, and I know Dr. Kahane has found, that heavier vehicles have higher risk of fatality once it rolls over because it takes more energy.

MR. GERMAN: Right. Right.

MS. PADMANABAN: Okay.

MR. SMITH: We have a question from the internet that Rebecca will read.

MS. YOON: This is from Ralph Hitchcock, and I just lost it. Sorry. Ralph Hitchcock, who's email said Honda, and his question is how can a long-term durability of advanced material applications in motor vehicles be predicted given the 20-plus year lifetime of vehicles and real-world factors such as deteriorating roads, customer abuse, corrosion, material fatigue, lack of maintenance, et cetera?

MR. SMITH: Who would like to start?

MR. GERMAN: I mean, it's certainly a good question and you can do a lot of this with computer simulation models but of course, you have to validate it at some stage and so if you generally don't have any end use validation data, then there's always a major risk. Now, in the case of aluminum, we have had some aluminum cars out there and some of them have been around for quite awhile so there's at least some validation for aluminum but, you know, for some of the parts, it could be a problem.

MR. NUSHOLTZ: Normally, you're able to predict things after the fact and that works pretty well but not always. We've had, for example, we've had trouble for a long time trying to really find what the true effectiveness of air bags is even though they've been on the field for a long time.

I'm not sure that you can do it with computer models because you actually have to get into the microstructure in the current models, look at it in a macro summary. So if you understand all the microstructures and the molecular end reactions and the manufacturing processes, then you might be able to do it with computer models but you're basically going to end up predicting it from an inverse model. In other words, going backwards in time.

I mean, there are some techniques that are used such as rapid aging where you subject it to temperature and you subject it to fatigue testing. Those are never exact predictions of what actually happens in the real world.

MR. FIELD: And I think, just to amplify upon that, I think one of the other features of that is that in the end, what that really ends up, what that really ends up meaning is that you basically have to build these things and then see what happens to them because there are, you know, the idea that you're going to have -- you're going to find, some galvanic couples you're going to find easily, others you're not going to know until you get a water leak or you're going to start to see some sort of road ding and suddenly, you're going to get something that's going to happen to you very fast.

I think the design process is, there's a lot of incredible tools out there but to be able to predict failure and particularly, field failure, of that complicated a system is just something that's, it's nice to dream about but it's really what accelerated road tests and torture tests are all really, that's why the industry uses them.

MR. SMITH: Anyone questions? Jim?

MR. SIMMONS: This is Jim Simmons from NHTSA. Considering Dr. Kahane shows that your worse off taking weight out of small cars than you are out of heavy cars, should there be some consideration of linking, taking weight out of small cars with crash avoidance technology, forward collision warning, crash imminent braking, other things that you could do for a small car and maybe not take weight out of them until some other technology could be used to avoid crashes for them?

MR. KAMIJI: (Indiscernible) system currently, but some system available. However, those kind of system cannot prevent all crash now. There is no (indiscernible) prevent all crash. So during those kinds of timing, we have to make, improve the crash safety after, crash safety should be. We have to improve the crash safety (indiscernible).

MR. NUSHOLTZ: I'll try to translate. If you go to active safety and you stop all the crashes, everything becomes irrelevant. That's sort of the final direction that you're going. I think in part, and you can correct me, you're talking about let's take more mass out of the heavier vehicles than out of the lighter vehicles because then you bring the standard, the distribution of masses down and that will reduce the fatality rates. I did that in my presentation. I think I applied everything you can physically do to get that lower green curve.

When you start going to things like active safety, or you could actually reduce the fatality rates just by going to 100 percent belt usage but that's sort of tricking the system and saying I'm going to compensate for the negative effects of mass reduction by adding new safety features but if I add those new safety features without doing the mass reduction, I'll get even more safety benefit. And so you really haven't done anything by adding, adding things like active safety and things like that. So you're trying to compensate for the mass of other things but if you didn't have the mass reduction, you'd get even more benefit out of them.

MR. SMITH: John?

MR. GOODMAN: John Goodman. You mentioned that you are sponsoring the study, I think, FEV. Does that, will that study consider the mass ratio effects of vehicle-to-vehicle scenarios and if not, why not?

MR. GERMAN: No. What I was really kind of pointing to this in my slide is that, you know, if you look at it from a societal point of view and consider all types of crashes, the impacts of both size and weight really aren't very large and so what you really want to do in the future is when you bring in these lightweight materials, you want to make sure that those lightweight materials are going to have good safety designs and you're not taking a step backwards.

And so that's the focus of this study is to say that okay, we're going to, in the case of the one with EPA and FEV, we're maximizing high-strength steel and then we want to go back and say we want to makes sure that this new design is going to be as safe or safer than the old design and so it's targeted more at making sure the new materials are well-engineered say.

MR. SUMMERS: John, subsequent to the FEV design study, we will get a hold of the model and do just the vehicle-to-vehicle analysis, the vehicle structure.

MR. SMITH: Yes. Go ahead.

MR. BREWER: John Brewer, DOT. I have a question for Dr. Field. Frank, I just want to confirm that late in the presentation, you were talking about when some of these things become viable. You're talking about life cycle costs and not, you know, production costs, right, when you say that some of these things have a, "negative", a potential negative impact on costs?

MR. FIELD: It was more -- right. I mean, it's sort of, it's cost from the perspective of the use as opposed to, I mean, so the cost of the perspective of the driver so whatever if the cost has passed through as well as in what he saves in order might not having to purchase as much fuel or buy as many replacement batteries, depending on what it is they have to do. It's over those uses. It's over, but it has to definitely bring the use question into it.

MR. SMITH: Anyone else? Yes.

MR. SNYDER: Thank you very much. Dave Snyder, American Insurance Association. I want to thank everyone for a great presentation and NHTSA for sponsoring this very important seminar. My question is assuming that the public, for reasons of gas prices going up, hits the automotive industry with the demand for dramatically more fuel-efficient vehicles in a fairly short time frame and we don't want to, in any way, degrade safety and we want to maintain that excellent path that we collectively have achieved, how will we get there?

MR. GERMAN: My own personal opinion, I started at Chrysler in 1976 so I've been watching the industry a long time, is customers, yeah, I mean, they could very well demand much higher level efficiency. I'd be very surprised if there's any kind of sustained demand for smaller vehicles. They're going to want vehicles that deliver the features, as many as they want, and still give them the efficiency they want, and that's the direction the industry is heading right now with powertrain improvements and also -- there's been a lot of announcements from vehicle manufacturers about their plans of taking weight out of vehicles. Both Ford and GM have said they're going to take over 1,000 pounds out of their full-size pickup trucks.

And so they understand, you know, that there's a real risk there, that customers are going to demand these higher efficiency vehicles but they also understand that the customers, most customers, are not willing to go to small vehicles to get it.

MR. FIELD: Otherwise, I mean, what you're likely to -- I mean, if you're talking true crisis circumstances, I mean, automakers have a handful, there's always a handful of things that they have built into the cars for, the ways in which they build the cars to take some amount of weight out as well as to arguably change the ways in which they elect to content up either the drivetrain or the transmissions to try to make some small changes in that that will potentially satisfy the market, but there's not going to be, it takes -- to tool for a new lightweight car is, you know, five, seven years and quite, you know, many, many zeros after the significant digit number in order to make that happen.

So what you're going to, more likely to see if you have really that sort of level of crisis is you're going to see people drive less. I mean, there were other, their responses will not be about I'm going to go out and buy a new fuel-efficient car. I'm going to find other ways to get around that doesn't require me to use gasoline to make it happen.

MR. SCHMIDT: And I think the manufacturers already have a fairly wide portfolio of vehicles they offer and there are some vehicles out there like the Smart 42, et cetera. Not every manufacturer builds something that small but there's the full range of vehicles and a lot of manufacturers have a full portfolio. Yeah, we try to offer what our customers want and for each class, we do a lot of work tying to make sure that it delivers as much of the consumer acceptance and safety that we can deliver in it.

MR. SMITH: With all the complexity that we've talked about today and all the uncertainty, it's rather, a challenge to come up with any thoughts to try to simplify it but I'm wondering, I guess, from the manufacturer's perspective, I think if I've heard any consensus, it's that reduction of mass in the largest mass vehicles is likely either to have negative effect or even a positive effect. I mean, I don't know that there's strong disagreement on that and I'm wondering, you know, how in sync the manufacturer's strategies are in terms of looking at mass reduction, obviously, as primarily a strategy dealing with those larger vehicles.

On the other hand, I'm intrigued by the relationship between mass and hybrids and electrics where the battery is of course adding weight which we discussed and whether, you know, the addition of mass to those vehicles is actually likely to have a greater effect on fuel efficiency and greenhouse gases than the possibility of reduction of mass.

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I'm wondering, you know, is there any possible convergence at some point where mass reduction is the strategy kind of aimed at the higher mass vehicles, having less effect on safety and the, all the other advantages or basically, the electrification is more aimed at the smaller vehicles which actually happens to increase their mass. There's a question there somewhere.

MR. SCHMIDT: Well, I mean, I can't speak too specifically because I guess all of our members have their own strategies and again, I said that this is very competitive. Some of the heavier high mass vehicles have certain real challenges. I mean, a lot of them have commercial sisters or brothers. One of the things about commercial vehicles that's a little odd, different, is that we notice we're talking curb weight. We're never talking about the actual weight of which a vehicle crashes. If you're a commercial vehicle, you pay for that vehicle to haul and you're losing money when you're not hauling. So the commercial sisters are a completely different animal than --

MR. SMITH: Different story.

MR. SCHMIDT: Different story. And as you take weight out of that vehicle, keep everything the same, guess what? Your payload goes up. So you now can offer a higher payload for the same exact vehicle, so the commercial guy can now haul more lumber when he's driving on the road. So the actual crash weight, if that vehicle gets in a crash, may not change much. It also provides, since they have these sister relationships, a lot of the similar plants, similar tooling is put together so it provides some additional constraints on the kind of down-weighting you can do.

I mean, there are some pickups out there that don't have commercial counterparts and I think you'll see a lot more down-weighting on some of those products because they don't have to carry snow plows, they don't have to have extreme towing, they don't have the dually versions and they don't have the plumber's truck bed stuck on the back.

So, you know, we all agree that from the model, that may be a goal and I think all our members are taking a very hard look, sharpening their pencil wherever they can but there are some practical constraints in how they can actually provide these kind of, these kind of vehicles that also have the sisters and the twins that have some of the commercial aspects too. So it's a challenge and like I said, we're trying our best to try to meet these challenges.

MR. NUSHOLTZ: Just sort of a caveat to re-explain something that I said. If you pull weight out of the heavier vehicles, you not only have the problem that Scott mentioned, but you don't get as much reduction in fuel usage and CO2 generation as you do if you reduce it out of all of the fleet. And so it depends on what metric. You know, we were talking about the metric with whether you do it per billion miles driven or per crash. If your metric is per ton of CO2 use, then you end up with a different system than the metric I used which was just pulling equivalent weight out of the vehicles.

So we have to be careful when we make that, that assumption because it depends on where we're trying to go. If we're just trying to get weight out of the vehicles, well, it's a little easier to take them out of most of the heavier vehicles because there's more weight there to take out but you may not get what you're after so we have to pay attention to that.

MR. SMITH: Thank you. Anyone else? Well, then unless the panel members have anything more they want to add, I think we're at the point where Jim Tamm is going to help us wrap all this up and actually reveal the meaning of life. So Jim?

MR. TAMM: Thank you. Hopefully, we don't get a whole bunch of feedback here. That should take care of that. On behalf of NHTSA, I would like to thank everybody who has participated in today's workshop. In particular, we'd like to thank the participants, the panel participants for their preparation, for their presentations and the very good discussions that we've had today. I'd also like to thank the audience and those who are on the web for their questions and comments and frankly, I think we felt that this has been a very, very productive workshop so thank you again to everybody.

As we mentioned earlier, NHTSA opened a public docket for comments and the number is, I'll say it once again but if you don't want to write it down, if you go to the NHTSA website, the information is there. It's NHTSA-2010-0152. We intend to review very carefully all of the comments that are submitted to the docket and all of the comments we heard here today.

We strongly encourage comments to be submitted in the next 30 days to maximize the time we have to consider those comments for the work that we're doing in our rulemaking, our plans related to mass and safety as well as what we're doing for our rulemaking. But although we're encouraging comments within 30 days, we do intend to keep the docket open so if there are comments submitted after that, those are also welcomed. The presentations and transcript, this has been mentioned, but everything from today's workshop we'll have posted on our website and will also be posted in the docket.

The comments from Ron Medford this morning basically discussed some of the important questions related to vehicle mass, size and safety that NHTSA must address in our CAFE rulemaking. He also discussed some of the complexities in current research and analysis plans. The research and analysis has been established through the coordinated efforts, as has been brought out in today's discussion, of NHTSA and our partner agencies, DOE, EPA and California Resources Boards.

The plans have been influenced by input and comments we received from experts, stakeholders, the public and previous rulemakings and in connection with the 2017 to 2025 Greenhouse Gas and Fuel Economy Notice of Intent and Supplemental Notice of Intent.

Highway safety is a core mission of NHTSA and we believe it is important to carefully assess the projected effects of our CAFE and the greenhouse gas emissions rulemaking on safety. We believe the assessment of safety should be data driven, should be comprehensive and should be based on the most thorough research and analysis that we can do.

As what's been highlighted in today's workshop, assessing the effects of vehicle mass reduction and size on societal safety is a complex issue, and today's presentations and the questions and comments and the panel discussions have highlighted a lot of those complexities. The presentations have covered a number of approaches and considerations for safety effects in research and analysis. We've heard some different views as well on how some of the work should be conducted going forward.

And while we believe the current research plans that we've highlighted that the agencies have come up with we think will provide a strong basis for estimating the effects of vehicle mass and size on safety, we also believe that our plans will be strengthened by fully considering all the information that we heard today.

As a recap, I'm just going to run real quickly, again, what we're doing but again, we do have a two-pronged approach. First, statistical analysis of historical crash data to project the effects of vehicle mass reduction size on safety.

Chuck Kahane's 2010 NHTSA study was completed and the peer review is now completed in the docket.

Dr. Green, this morning, I think doctor, right, from UMTRI is doing peer review of over 20 studies that use historical data to project the effects of mass reduction and other vehicle attributes on safety.

As presented by Dr. Kahane earlier, NHTSA and DOE, with assistance from EPA, are developing an updated crash database for use in future statistical studies, and we estimate that that database will be available for public release in April 2011.

Also as presented by Dr. Kahane, NHTSA has initiated a new study of the effects of vehicle mass reduction and size on safety using fatality data. The methods that will be used for that study will be informed by the peer review of the 2010 work as well as the UMTRI study and findings.

As presented by Mr. Wenzel, a study of the effects of vehicle mass reduction and size will be conducted using casualty data, and an additional study will be conducted duplicating the 2011 work that Dr. Kahane will be doing using fatality data.

And then Steve Summers of NHTSA presented current research and analysis plans to assess the effects of future vehicle designs on safety. NHTSA initiated a project with Electricore, with EDAG and George Washington University as subcontractors to study the maximum feasible mass reduction for a mid-size car. Target was to maintain cost within 10 percent of the baseline and to either maintain or improve vehicle functionality, NVH and other factors that were discussed today. As part of the project, the contractor will build a CAE model and demonstrate the vehicle's performance to NHTSA's NCAP and roof crush tests as well as IIHS offset and side impact tests.

NHTSA will also use the model developed by EDAG to perform a variety of vehicle-to-vehicle crash simulations to study the effect of vehicle mass reduction on safety and to investigate safety countermeasures for significantly lighter vehicles going forward.

In addition, the agencies are working on the next phase of the Lotus lightweighting study for CARB that came out last year. As mentioned earlier, Phase 1 Lotus study produced two vehicle designs. There's a high development and low development.

In the second phase of the study, Lotus is validating the high development design by creating a CAE model and performing crash simulations. NHTSA is actively involved in that phase of the study through the performing of crash simulations and helping to validate the model. NHTSA hopes to incorporate the Lotus high development vehicle model into our fleet safety simulation study to assess a broader range of vehicle designs in that of vehicle-to-vehicle collision effects.

NHTSA has also contracted with FEV to further validate -- I'm sorry. EPA has contracted with FEV to further validate the Lotus low development design and to estimate cost. EDAG has been sub-contracted and will create a CAE model and perform crash simulation and NHTSA expects to help in the validation of that model. NHTSA also hopes to incorporate the Lotus low development CAE model again into the fleet simulation studies for vehicle-to-vehicle analysis.

Other panelists presented their previous works, planned work and professional views. NHTSA intends to further review all of the presentations and discussion from the workshop as well as comments received in the docket. We'll carefully consider all of those inputs and discuss them with DOE and EPA and CARB and we'll modify work plans and analyses as appropriate.

In addition, for our rulemaking, we will review and carefully consider all available studies and comments.

As Ron mentioned in his opening remarks, we expect to schedule a followup workshop. We haven't selected a date yet and we expect it probably would be scheduled at a time when we have data from some of these ongoing, this ongoing work.

With that, I guess we'll just open up if there's any last questions or comments related to the plan going forward. Okay. Again, we just want to thank our panelists and those participating in the workshop. We will have people at the back of the conference room to escort people home. And just I can't let you leave without me saying please drive safely, use your seatbelts, don't drink and drive and don't drive distracted. Thank you.

MR. SMITH: Thank you, Jim. I didn't introduce Jim properly. Jim, if there's one person who played just a really simple role in getting out the 2012 through 2016 rule on fuel economy here at NHTSA along with our colleagues at EPA, he and Rebecca Yoon, Steve Wood and others were absolutely central to that effort so I thank you very much.

And I was remiss in not thanking the second panel as I jumped off the stage. We don't actually have presenter evaluation sheets so what I'd like to do is hear first of all, your round of applause for the morning panel on statistics. Now, those of you who preferred the afternoon panel on engineering. I think it's a tie.

I really do appreciate not having to use the gong and the fact that we're closing on time, and thank you very much for joining us today.

(Whereupon, at 4:57 p.m., the hearing was concluded.)

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√ Digitally signed by Josephine Hayes

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UNITED STATES DEPARTMENT OF TRANSPORTATION

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

MASS-SIZE-SAFETY SYMPOSIUM

February 25, 2011

By:

Josephine Hayes, Transcriber