UNITED STATES DEPARTMENT OF TRANSPORTATION

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NATIONAL HIGHWAY TRANSPORTATION

SAFETY ADMINISTRATION

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MASS-SIZE-SAFETY SYMPOSIUM

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TUESDAY

MAY 14, 2013

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The Symposium convened in the Robert S. Mark Media Center at DOT Headquarters, located at 1200 New Jersey Avenue, SE, Washington, D.C. at 8:30 a.m. Christopher Bonanti, Moderator, presiding.

PRESENT:

CHRISTOPHER BONANTI, Moderator
STEVE BARRY, University of Chicago
CHARLES KAHANE, NHTSA
JOE NOLAN, IIHS
GUY NUSHOLTZ, Chrysler
MIKE VAN AUKEN, DRI
THOMAS WENZEL, LBNI

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P R O C E E D I N G S

(8:36 a.m.)

MODERATOR BONANTI: Good morning, and welcome to the second day of our Mass, Size and Weight Safety Workshop.

I am Chris Bonanti, Associate Administrator for Rulemaking here at NHTSA, and I will be moderating this panel, as well, as I did yesterday.

Yesterday we received information and presentations from perspectives from each one of the agencies involved in the CAFE rulemaking: EPA, CARB and, of course, NHTSA.

We heard from the agency's perspective. We heard from the OEMs and we also heard from the material manufacturers that provide supplies to the OEMs.

Now, today, we are going to be discussing the safety criteria with regard to data. I think this is a very important part of the process, as all of you -- or you probably should know, NHTSA is a data-driven agency.

So, the process by which we go about developing regulations normally stems from data unless we are Congressionally mandated to do something.

That being said, we have a very aggressive agenda this morning. We -- at the end of the morning, we will have a panel, as we did yesterday. As part of the process by which each one of the speakers are -- at the end of each speaker we will -- I will be asking them questions based on the questions that you provide on your note cards.

And that includes individuals from the web. Please submit your questions via the web, and we will be able to ask them in time.

If, however, there are questions that I do not have the opportunity to get to, we will place them in the docket. That docket is NHTSA-2010-0152 for those that did not receive it yesterday.

Before we begin, I wanted to

remind you of a few things. One, visitors must be escorted at all times within the confines of the DOT headquarters building.

Bathrooms are either available to you when you leave the building -- when you leave the room to your right, and you go around the end. That stays in the conference center, or you can go outside, get escorted down to the end and there are restrooms on the left-hand side in the corridor.

Please silence all your cell phones. Also, we ask that you -- if you do not get a question answered today and you have additional questions, please submit them to the docket.

And I wanted to, one, thank everyone for coming. Those individuals that are listening on the web, I do appreciate that, as well. We had over 40 individuals yesterday on the web and today, at this point, we have over 20, almost 25 people.

So, it is good to hear that we

have a lot of interest in this topic and with no further ado, I would like to introduce Dr. Charles Kahane from NHTSA, from our National Center for Statistical Analysis.

He will be discussing the relationships between fatality risk, mass and footprint in model years 2000 to 2007 and then the future of passenger cars and light vehicles. Thank you.

MR. KAHANE: Good morning. February 25, 2011, I will never forget Dan Smith's first words, welcome to beautiful Washington, D.C. Today we have a beautiful spring day, but you will never know it because you were all stuck half an hour underground on your Metro trains.

We have looked at relationships between fatality risk, mass and footprint in vehicles of the last decade and we will undoubtedly be looking at it again in somewhat later vehicles sometime not too far in the future.

The objective of these statistical

analyses is to estimate the effect on societal fatality risk of mass reduction without changing footprint.

Now, societal fatality rates, we have talked about a lot. That means, not only the fatalities in my own vehicle but also those in -- in any other vehicle in the crash and any pedestrians.

Footprint is the measure of a vehicle's size, the track width times the wheel base, and it is important in the CAFE context because these are footprint-based standards. In other words, given a certain footprint, you have to meet a certain CAFE level.

Here are some ways that you can change -- you can reduce mass without changing footprint. You can substitute lighter materials for what is currently in the vehicle, or you can substitute with stronger materials, but because they are stronger, you don't have to use as much of them.

And, you can downsize the engine and the power train, either by making it less powerful or by designing it in a way that uses less mass to get the same performance. And the same can be done with other features of the car, luxury equipment and so on, comfort features.

You could also reduce the size of a vehicle without reducing its footprint by getting rid of some of the overhang outside the wheels.

The mass reduction may have effects on safety, and I would group them into predictable and unpredictable effects. Now, the predictable effects doesn't necessarily mean we know exactly how to quantify them.

The best-known predictable effect of mass reduction is what has to do with conservation of momentum. Basically, when something light hits something heavy, the two vehicles tend to go in the same direction as the heavy vehicle.

The delta v or the crash severity is greater in the light vehicle in inverse proportion to the mass ratio.

Now, what this does for safety in collisions of two light vehicles whereby I mean a car, a pickup truck, an SUV or a small van, this depends a lot on what the vehicles are and what the overall distribution of mass is in the fleet, and I will get back to that in a few minutes.

However, conservation of momentum factors have a -- a negative -- have a harmful effect on safety. Mass reduction has a harmful effect on safety, although it is relatively small, in collisions with a moveable object or with a heavy vehicle.

Either way, if you reduce your mass, you are going to have more risk without compensating for that by giving somebody else less risk.

Another feature of mass reduction that is within the laws of physics is, if you remove mass from the vehicle while leaving everything else exactly the same, you will get improved braking and steering response.

And a crashworthiness area where mass reduction is helpful is in a rollover, if a vehicle falls on its own roof, if you have removed some of the mass from that vehicle, you are going to crush it somewhat less.

Let's talk for a little while about conservation of momentum effects in collisions of two light vehicles. Basically, mass reduction in my vehicle will harm me because I will experience a higher delta v in the same crash, but it will help the people in the other vehicle.

So, you have two offsetting factors, but they do not offset exactly the net result, which is the societal effect depends on the relative mass of the two vehicles.

If I am the lighter vehicle, mass reduction helps -- harms me more than it helps you in the other vehicle. But, if I am the heavier vehicle, mass reduction helps you in the light vehicle more than it harms me.

So, that is what you will see over and over, is that, just based on conservation of momentum grounds and no other considerations, mass reduction will tend to increase societal risk -- mass reduction in light vehicles will -- lightest vehicles tends to increase societal risk and, in the heavier vehicles, tends to reduce it or, at least in relative terms.

Now, if you --

MR. BARRY: In the mass reduction of the -- were you referring in the last one to the mass reduction in the heavy vehicle or in the light vehicle?

MODERATOR BONANTI: Okay. If there is a question specifically on that, because we have a court reporter, we need to have it in the -- through the microphone and/or -- if you have a question and you want to ask it as part of this, because it is -- it is confusing if that is the case, feel free to raise your hand, and write down, and I will ask the question at that point in time.

But --

MR. BARRY: It is a very specific interpretation of what was --

Could you show the -- this one. Yes. The last line. The mass reduction, does that refer to mass reduction of the heavier vehicle or of the lighter vehicle?

MR. KAHANE: In the first diamond it refers to -- these are two -- these are two light vehicles to begin with. One is heavier than the other.

MR. BARRY: Right.

MR. KAHANE: So, if my vehicle is lighter, mass reduction in my vehicle, in the upper first diamond it would be the lighter vehicle --

MR. BARRY: Yes. I understand the first line.

MR. KAHANE: -- would harm me more than it would help you in the heavier vehicle in that crash.

So, we are always talking about mass reduction in my vehicle only.

MR. BARRY: Okay. Fine. Thank you.

MODERATOR BONANTI: Please state your name.

MR. BARRY: Steve Barry, University of Chicago.

MR. KAHANE: Proceeding to the next, if you proportionately reduce mass in both vehicles, you will get, just on conservation of momentum considerations, no net effect, because the delta v's would stay exactly the same.

And then you have some fleetwide effects. Generally speaking, if you increase the fleetwide mass disparities, make vehicles less similar to one another, you would tend to increase societal risk and if you reduce the disparities, if you bring vehicles in the fleet closer together in mass, it would generally tend to reduce the societal risk.

Here are some less predictable mass effects of future mass reduction. The first one is not so predictable because it has to do with the human/vehicle interface.

In the past, we have historically seen heavier and larger vehicles better driven, getting into fewer crashes, less severe crashes than light -- lighter, relatively lighter vehicles.

Now, this historical trend has been diminishing over time and we don't know what is going to happen with it in the future, but it could continue to diminish.

Another issue is material substitution, which they talked about quite a bit last night -- yesterday, using different materials could change the force deflection properties of vehicles and the crash pulses seen by the occupants.

While we are at it, let's talk about some of the harmful effects of reducing footprint and why we don't want that to happen.

It would tend to make vehicles more rollover-prone, reduce their directional stability and result in less crush space, a potential for less crush space around the occupants.

And that is, of course, why these are footprint-based standards. It does -- they do not encourage footprint reduction because it would be self-defeating and it would merely require the vehicle to meet a higher standard.

Our latest report was published last September, and you can download that in PDF format in one click from our website. Similarly, the databases that we created for that report are also available to the public, and you can download those from our website. We have been studying this for about two decades here at NHTSA.

The analysis method in that report was a statistical analysis of fatality rates in the latest cars for which we had data available: model year 2000 to 2007.

And these are societal fatality rates per billion vehicle-miles of travel. We analyze those by curb weight and footprint because the idea is to see what happens if you leave footprint the same and curb weight changes.

The vehicle-miles of travel were apportioned by driver age and gender, rural and urban and other factors, using state crash data, something that we call induced exposure.

The analysis method was logistic regressions for nine types of crashes and five types of vehicles. The independent variables in these regressions were, of course, curb weight which, in many of the regressions, was a two-piece linear variable so that we would get a separate estimate for the effective mass reduction in the lighter-than-average vehicles and the heavier-than-average vehicles.

And footprint. And then what we call control variables, such as driver age and gender, environmental factors and the type of safety equipment that we knew about in the vehicle.

These were the five classes of vehicles that we looked at: lighter and heavier cars, CUVs and minivans and lighter and heavier truck-based LTVs. LTVs being pickup trucks, traditional truck-based SUVs and possibly full-sized vans.

In these five classes, only one was the fatality increase for a hundred-pound mass reduction while holding footprint constant statistically-significant, and that was a significant, but small, increase in the lightest group of cars.

The other four results were not significant, but specifically in the two heavier vehicle groups, there was a small societal benefit for mass reduction because you are helping people in the vehicles that they crash with when -- when they reduce their mass.

The trend that you see there, the pattern is what I talked about when I talked about conservation of momentum considerations, namely mass reduction tends to be relatively more harmful in the lighter vehicles, relatively more beneficial in the heavier vehicles.

Another feature of our latest report was that, in addition to our baseline statistical model, we had 13 sensitivity tests which were plausible alternative models which, in many cases, were suggested by our various reviewers, our peer reviewers, our sister agencies and reviewers from the general public.

And in these 13 alternatives, we changed something in the baseline model. For example, deleting some of the control variables or adding new control variables, such as track width and wheel base, or the driver's income or the vehicle manufacturer as a control variable, and different ways of apportioning the vehicle-miles traveled, using state crash data in different ways, or limiting the analyses to just sober drivers or just drivers with good driving records in the past.

The way we checked out what these sensitivity tests did was to apply all of them, and also the baseline model to a specific scenario, a sort of cocktail of mass reductions, ranging from very little in the lightest cars, to quite a bit more in the heaviest LTVs.

But, when you average that over the whole fleet, it averages to a hundred-pound mass reduction per vehicle.

And when you apply our baseline model, the point estimate is zero. That is to say, for that particular scenario, it is completely safety-neutral as a point estimate.

However, there is statistical uncertainty with that result; confidence bound is moderately wide, ranging from 240 lives saved per year up to an additional 240 fatalities per year.

Now, when you apply to the same scenario these 13 alternative models, you get a range of point estimates from 321 lives saved per year, up to 276 additional fatalities per year.

So, it is kind of interesting that the range of point estimates for the alternative models is not too different from the statistical confidence bounds on the baseline model.

However, I caution to point out to you that each of these point estimates with the alternative models would, itself, have some statistical confidence bounds so that you actually would have a somewhat wider range than -- than what you see here.

We have basically two conclusions from what we've have looked at. The first is, you know, what is the result and, second is, how much uncertainty do we have about it.

Basically, our main finding is that the effect of mass reduction is small. Specifically, if you have mass reduction that is more concentrated on the heavier vehicles, much less on -- if any, on the lighter vehicles, and you keep footprint constant, we don't see any significant increases in overall societal fatalities and, as point estimates, they could even possibly decrease.

These confidence bounds on the main model, and these various sensitivity tests, however, I think, also show the limitations on how far you can get with statistical analysis of past crash data.

I mean, you can't zero in on a single number and say this is it, but you will have this range of, you know, what it is telling you, and you will have to accept that is -- you know, that is about as close as we can get it that way.

Another feature of our last report that we noticed and that others also noticed, is the comparison with previous reports, specifically the one just before it, which was based on vehicles about a decade older, 1991 to '99, rather than 2000 to 2007.

If you put the effect of a hundred-pound mass reduction side by side, you see two things. Firstly, directionally, the results are similar. It is always the same pattern. Mass reduction is relatively more harmful if you take it out of the lighter cars, relatively more beneficial if you take it out of the heaviest light vehicles.

But the other thing that seems to have changed is the -- the magnitudes of these effects have diminished. For example, the effect in lighter cars went down from over two percent to one and a half percent and the societal benefit of mass reduction in the heavier LTVs went down from something fairly large to something fairly small.

We think that there are several explanations for this change, and what I wanted to talk about here is, some of these explanations are sort of unique one-time events pertinent to that 2000 to 2007 period, and some of them are trends that could likely continue into the future.

Something that was kind of unique about 2000 to 2007 is that the lightest vehicles on the road just didn't exist. I mean, the light vehicles, the very light vehicles that existed in the 1980s and 1990s, a lot of those were simply phased out for the time-being, or have been up-sized every four or five years with redesigns until they are now fairly good mid-sized family cars, even though they have the same names.

And this trend, I say, might not continue after 2007. As a matter of fact, it is safe to say, what we are seeing already, it is not continuing because very light, much lighter vehicles are starting to come back for sale and we are also going to see a lot of material substitutions and other techniques to make vehicles lighter.

Something else that was kind of unique was that, in general, older vehicle designs with poor safety performance were phased out.

This -- and particularly, the insurance institutes offset impact test, which came in in the mid-90s and where initially many vehicles had quite poor performance but, by the mid-2000s, you had almost every vehicle was a good performer.

But the important point is that many of these poor performers were light vehicles. I think now the design of light vehicles has come up, in many respects, to parity with the somewhat heavier vehicles.

And the third -- possibly unique, not necessarily -- is that strong efforts were made to improve compatibility of the heavier LTVs with the lighter vehicles on the road, such as the introduction of blocker beams.

Now, there could be further improvements, but there might not be. We don't really know.

On the other hand, something that we have been seeing is a diminishing tendency of these small and light vehicles to be driven poorly. We don't know exactly why that was happening, but I think there has been less of it, and that, conceivably, could continue in that direction.

The lessons for the future is the basic laws of physics stay the same. Conservation of momentum effects, for example, or that mass reduction, leaving everything else the same is going to have -- result in better braking and steering response.

But many other things can change from year to year, and you have to watch those as they change. For example, even though conservation of momentum in theory stays the same, the safety effect is highly dependent on how mass is distributed in the new vehicle fleet and that is, of course, up to who sells what cars and who buys them, and we can't fully predict that into the future.

We may see new safety equipment, and we may see changes in who selects what type of vehicles and where and how they drive them.

For those reasons, we are undoubtedly going to revisit these analyses, probably sometime around 2015, which is, you know, in preparation for the interim CAFE review.

And, at that time, because crash data lags quite a few model years behind what you can analyze right now, we would have crash data available up to model year 2011, which would be four years further than our last study and, in that time, we would begin to see, number one, a fairly large number of newer light-weight or light-weighted vehicles and also a fleet where, at least, the new vehicles are all equipped with electronic stability control. Almost all.

At that time, we will consider revising the model that we used last time, as we always do. We would maybe borrow some of the techniques in the various alternative models that we have already seen and, of course, we will look for new ideas, how to address changes in the crash environment. Thank you.

(Applause.)

MODERATOR BONANTI: Thank you, Dr. Kahane.

Questions? It looks like we have many. That is good. Do me a favor. As I indicated yesterday, please print as legibly as possible.

MR. KAHANE: You shouldn't have invited any of those MDs.

(Laughter.)

MODERATOR BONANTI: Okay. First question. "Recent complementary statistical analyses have suggested that mass reduction has resulted in increased crash involvement.

"What are your views on these findings?" That is the first question.

Second question. "Do you believe it is a data-reporting issue, rather than an R-E-A-C effect on mass reduction?"

MR. KAHANE: A real effect on mass reduction.

MODERATOR BONANTI: Okay.

MR. KAHANE: I lean in the direction that that is a data-reporting issue. I have avoided -- in fact, I have been working for years trying to take out the reported crash part of the numbers out of the analysis, make it as seamless as possible, fatalities, which is something real per vehicle mile of travel, which is something about as real as you can get on the exposure side.

I think we are talking, it is a

signal to noise issue. I think the effect of mass reduction is small. I think just a few percentage of bias in reporting, I think, is somewhat heavier vehicles tend to underreport their crashes, but it doesn't have to be something that you can easily demonstrate because the effect of mass reduction is so small that the effect of just a few percent change in reporting rates of crashes can be a big factor there.

I also think we should take both/and, not an either/or approach to this. I don't like doing statistics per hundred reported crashes, but other people do and, you know, I think we should look at what they are saying and then consider it.

MODERATOR BONANTI: Okay. Thank you.

Next question. "Your research shows that small vehicles are more maneuverable, but crash more. And when they are in a crash, they are safe. Is this correct? Would this imply OEMs build safe small cars and the driver is the main contributor to the fatalities?"

MR. KAHANE: I will take those one at a time. Firstly, small vehicles are not necessarily more maneuverable. We are tending to mix up two issues here.

If you take mass out of a vehicle and leave everything else the same, that vehicle will become more maneuverable. That is the laws of physics.

In general, though, when people take mass out of the vehicle, they also take performance out of it or, rather, if you look at a cross-section of vehicles, it is not that the small vehicles necessarily have much better maneuverability because they also tend to have lower performance in other areas.

Second part of it, manufacturers are building safe, small vehicles. Yes, manufacturers are building safe vehicles across the entire spectrum.

If you look at performance, both in, you know, on crash tests and whatever, there has been a lot of improvement over the years, in absolute terms, safety has improved tremendously over the past 40 years.

This does not, however, obscure the fact that, when the small vehicle hits a large vehicle -- I am sorry. If a light vehicle hits a heavy vehicle, the delta v is higher in the light vehicle.

There was a third part to that.

MODERATOR BONANTI: Would this imply OEMs build safe cars and -"

MR. KAHANE: That it is all the drivers?

MODERATOR BONANTI: "-- or is it the driver?" Yes.

MR. KAHANE: Yes. Separating what has to do with a driver and what has to do with a vehicle is complicated.

MODERATOR BONANTI: Okay. "You stated that the mass effect is small, as shown with the insignificant results in four of the five vehicle sizes, and the low percentage increase.

"If the next study shows all car sizes, five-of-five, are insignificant, would this prove mass effects are insignificant in the updated fleet?"

MR. KAHANE: No, it probably would prove that we did the study too soon before we had enough data.

MODERATOR BONANTI: Okay. That is a short answer. Okay.

"Yesterday we learned that increasing the length of a vehicle improves the safety, even an increase of about four inches. Can this extension be done with lightweight materials, or must it be made with a strong and heavy metal?"

MR. KAHANE: I can't answer that.

MODERATOR BONANTI: Okay.

MR. KAHANE: You will have to bring some of yesterday's speakers back up for that one.

MODERATOR BONANTI: Well, I understand he's not a structural guy. I am just asking the questions that I am asked.

Okay. "Increased crash zone length will decrease the delta v in a collision, thereby decreasing acceleration acting on occupants. Do you agree that increased crush space can partially or wholly offset the need for mass increases to maintain occupant safety?"

MR. KAHANE: In general, I believe people say that. Yes.

MODERATOR BONANTI: Okay. Next question.

"How did you account for continuing improvements in occupant protection fatalities of vehicles used in your database?"

MR. KAHANE: There were two parts of that. One was for a specific -- you know, very dramatic improvement such as frontal airbags, side airbags, electronic stability control, blocker beams.

These were actual independent variables, categorical variables, so this vehicle does have blocker beams, this vehicle does have electronic stability control, or it doesn't, and how does that affect the fatality rate.

And then, for the somewhat less tangible improvements, we also ran some of the statistical analyses with the Insurance Institute's performance levels on the offset frontal test as an independent variable.

So, in other words, given this level of performance on the offset impact test, you have this fatality rate with this level, you have that fatality rate and so on.

MODERATOR BONANTI: Okay. Thank you.

"Dr. Kahane, everyone recognizes that weight reduction is a transitional issue. Have you or can you project into the future where there might be a crossover to the positive side, assuming, for example a 20 percent across-the-board weight reduction?"

MR. KAHANE: I think that models -- you know, there are two issues here. What is the societal risk, and then, you know, who benefits and who is harmed?

I think the models now, our models emphasize societal fatality risk, and that is going to be -- that is not going to change hugely. It will -- it is a second order thing that will change, but that -- that is pretty much will be predicted whether or not you have a mix of new and old vehicles on the road, or you have only the newer vehicles.

Then there is an issue of who benefits and, of course, during the transitional period, the people in the heavier vehicles will benefit from crashing into a fleet that has lighter vehicles, a mix of lighter vehicles than it did in the past.

MODERATOR BONANTI: Okay. Thank you.

"The new CAFE requirements effective with model year 2012, will the updated analysis that you will do in 2015 really catch relationships between mass reduction and fatalities"?

MR. KAHANE: These are cross-sectional analyses, these statistical analyses, at least as we have done in the past.

So, what they are looking at is not the effect of a specific mass reduction, but they are, rather, looking across the spectrum of vehicles from light to heavy vehicles of the same type, how fatality rates vary.

And, yes, there is -- there is not -- you know, there is always a certain amount of, you know, arguing from this to that. There is a caveat that you always have to place with it.

It is conceivable that the next generation of studies will say, "Let's try some other methods of looking at the data statistically."

If you have, for example, very specific targeted mass reductions that you can model easily, that is something to look at but, again, that is getting way ahead of me.

MODERATOR BONANTI: Thanks. Okay.

"You indicated, 'older designs with poor safety performance phased out.' Isn't this a trend which will inevitably continue, assuming engineers and OEMs always try to improve their products?"

MR. KAHANE: It is a trend I hope will continue. Yes. But it has got to happen and, you know, we don't know right now exactly where we will be in eight years.

MODERATOR BONANTI: This is a loaded question.

"How many years does it take to show improved safety rulings/requirements actually lower fatalities?"

MR. KAHANE: In many cases, we

already have strong statistical evidence that future safety standards are effective before they go into effect because we are very fortunate that many of the major safety developments have been voluntarily tested and then implemented in production vehicles before the agency has mandated them.

So, in many of our recent rulemaking, such as curtain airbags as the side-impact pole test, electronic stability control, we already had strong statistical evidence that these were effective.

However, if you -- if something is on the spur of the moment made a safety requirement, a new standard with little advance notice, it usually takes three to five years for crash data to accumulate and for the processing of the data for us to be able to show an effect.

MODERATOR BONANTI: Thank you.

"Given the demographic shift to an aging population, what is the predicted effect on the older population?"

MR. KAHANE: The old population is highly vulnerable in side impacts and you will also have generally higher fatality rates.

However, I think a lot of that demographic shift has already happened and it is only going quite slowly now. We saw, during the past 20, 30 years, I think much more of a shift than we will be seeing in the future.

MODERATOR BONANTI: Thank you.

"For small vehicles, does the data indicate significant differences between manufacturers?"

MR. KAHANE: Generally speaking, after controlling for driver age and gender and rural/urban location, these differences are small.

MODERATOR BONANTI: Okay.

MR. KAHANE: May I say, people are building safe vehicles now. The level of safety is much higher than when I started 40 years ago at NHTSA.

MODERATOR BONANTI: Okay. This is the last question, unless there are any further questions from the audience, so please raise your cards.

"Improved braking and steering with mass reduction" -- that is the topic -- "what if part of the mass reduction is reducing in the brake system with regard to smaller discs or pads or other type of equipment? Would this have an effect?"

MR. KAHANE: Yes. I am glad you brought this up because often you hear -- remember, I kept saying, "All else being equal, if you remove mass, then you will have faster response to braking and steering," but generally speaking, all else doesn't stay equal.

What you often have -- in fact, I have heard this a number of times and it has bothered me. People come and talk about, "If you use this material you will be able to reduce mass in the body.

Ah, but if we can reduce mass a lot more because once you start reducing mass in the body, you don't need all those brakes and all that, you know, steering, so you can reduce that, too, and then you will get a real mass reduction.

Well, you can't have your cake and eat it, too. You can reduce some mass and have improved performance, and you can reduce mass a lot more and have the performance back to where you started. So, yes, that can work both ways.

MODERATOR BONANTI: Here's a question. I have a few other questions.

"Is another possible explanation for the most recent data's diminishing impact on mass reduction on safety the fact that, as vehicle cabin structures and restraint systems have improved, safety is less influenced by the difference in vehicle masses in multivehicle crashes?"

MR. KAHANE: Well, you know, that -- again, that is difficult to answer exactly that way.

I mean, I think the safety improvements played a big role, but if you have two vehicles of unequal mass hitting each other, you are still going to see the same, you know, historically the same ratios of fatality risk in one vehicle to fatality risk in the other vehicle.

MODERATOR BONANTI: Okay. And there are a few other questions.

"It was noted the magnitude of lightweighting effects is smaller with the most recent data. Some explanations were given, but one appears to be absent. Is it possible that the diminishing impact of mass --" --

MR. KAHANE: Mass reduction.

MODERATOR BONANTI: Yes. "Mass reduction" -- thank you. It is hard to read this. Oh, it is the same question. Oh, excuse me. Same question you just answered.

So, any further questions?

(No response.)

MODERATOR BONANTI: No? Okay.

Thank you, Dr. Kahane.

(Applause.)

MODERATOR BONANTI: Okay. Our next presenter is Tom Wenzel from the Lawrence Berkeley National Laboratory.

He will be discussing relationships between mass, footprint and societal risk in recent light-duty vehicles.

I also wanted to ask that the presenters, if they are -- if they need to utilize a pointer for the audience that is actually on the web, listening and also viewing the presentations, if they can use the mouse that is up here instead of a pointer.

That way, everybody that is looking at or viewing this over the web can actually see what you are pointing at. Thank you.

MR. WENZEL: Thanks, Chris. Good morning. I brought my pointer, but I guess I won't be able to use it.

A lot of this -- my talk is going to be resummarizing what Chuck just told you about, the NHTSA analysis, but LBNL did some additional analyses of the same data and have slightly different conclusions from the analysis.

One thing I wanted to point out, and this was raised in one of the questions brought up for Chuck, is that all of these statistical analyses, we are not literally looking at the effect of literally pulling a hundred pounds out of a specific vehicle and what effect that has on safety, and we all have to recognize that.

What we are doing is, we are comparing two different models, one of, say, a Civic and a Hyundai Elantra, one of which happens to have a hundred pounds -- happens to weigh a hundred pounds less than the Honda

Civic.

And so, we are trying to correlate the difference in the risk between those two existing models with their difference in their masses, after accounting for every other difference between those two vehicle models.

And, you know, we try our best to account for everything between those two models, but we can't account for everything. And so, we just have to be aware that we are not looking literally at the effect of removing mass from a particular vehicle.

So, DOE contracted with LBNL, Lawrence Berkeley National Lab, to perform two analyses of the data that Chuck just presented, and we creatively termed these phase one and phase two.

The first phase is to replicate the unit's analysis, using the same databases, and that analysis looks at the societal fatality risk, the national societal fatality risk for vehicle mile traveled, and additionally did a separate analysis which looks at casualty risk and casualty is defined as fatality and serious injury risk per vehicle crash, using data from 13 states that report the vehicle and identification number in their database.

Both analyses used logistic regression analysis, as Chuck mentioned for 27 combinations of vehicle and crash type. Three different types of vehicles, nine different types of crashes for 27 total regression models.

As Chuck mentioned, for the mass variable for cars and light trucks, there are -- the fleet is divided into two segments of the fleet, those that are lighter and heavier than average, for a total of five classes of vehicles, two for cars, two for light trucks and then a third group, crossover utility vehicles and minivans.

In addition, we accounted for another roughly 28 control variables, which account for different vehicle characteristics such as side airbags, electronic stability controls, driver age and gender, and crash characteristics such as whether the crash occurs in a rural or urban area, what the speed limit of the road that the crash occurs on, whether the crash occurs at night, et cetera.

Again, all the risks that we are talking about here are societal, which include fatalities, both to the occupant of the case vehicle, as well as any crash partners or pedestrians that might be killed in the crash.

And I just want to, you know, reemphasize that, you know, these statistical analyses are looking at the historical -- the recent historical relationship between vehicle mass and size and safety, but they can't -- it is not clear how much we can project that historical relationship on the future, particularly when manufacturers are redesigning vehicles using new materials that may break the recent historical relationship between vehicle size, mass and safety.

Okay. I wanted to apologize for the small numbers on all my figures here. I was hoping we would have a larger screen to be able to see these, and now I can't use my pointer, so I have to try to highlight things with the mouse here. Sorry.

Oh. There is a mouse. Okay. Thank you. So this -- this slide is basically re -- I don't want to say "repackaged," and showing the results from Chuck's study in a different light -- not a different light, just a different format.

But the baseline NHTSA analysis found, as Chuck said, that, you know, the effect of mass reduction on safety is only statistically significant for the smallest of the -- or the lightest, lighter-than-average cars, and so this top figure here on the left-hand panel, these are the five vehicle classes, the effect of mass reduction on the five vehicles -- on risk, fatality risk for the five vehicle classes, ranging from about one and a half percent for the lightest cars to slightly reduce risk for heavier light trucks and CUV's and minivans.

Of course, those numbers are not -- are so small they are not statistically significant.

On the right-hand panel, I have also put the effect of footprint reduction holding the mass of the vehicle constant. And here we see that, if you were to reduce footprint by roughly one square foot, you would have an almost two percent increase in fatality risk for cars and similar value for CUV's and minivans.

And, as Chuck noted, only the effect of mass reduction on the lightest cars is statistically significant. The error bars I show here are based on the standard errors on the regression model.

Chuck did a more involved

uncertainty analysis using jackknife method and so, you know, for this -- for the lighter to light trucks, I show it is just barely statistically significant. Well, that more involved jackknife method increased the uncertainty of that estimate. And so, in his analysis, that result was not statistically significant.

The bottom slide shows the effect of all the other control variables in the regression model, and this is for -- just for cars only.

But so, for the first three models -- the first three variables here are the same variables here, the two weight variables and the footprint variable for cars and, if you compare them to all the other variables in the regression model you can see that there is a much smaller effect than everything else in the regression model.

And so, that was a major conclusion from our study is that, you know, size -- weight and size can be important, but they are sort of overwhelmed by all these other factors involved in the crash of a vehicle.

And those other factors, I grouped them into other vehicle factors ranging from the type of side airbag installed to electronic stability controls, ABS systems, the driver age and gender variables here in the middle, and then, the ones that have the biggest effect are the crash characteristics, whether the crash occurred on a high-speed road, in a rural area or at nighttime.

Those factors have a dramatically, you know, an order of magnitude higher effect on fatality risk than the other factors in the regression model.

I just also would like to point out that Chuck sort of -- I don't think Chuck mentioned this in his presentation, all of these -- these analyses in the baseline analysis took into account the full penetration of electronic stability controls in the vehicle fleet by the time frame we are talking about here.

And so, we took the estimated effect of mass reduction from those 27 regression models, and then reweighted them by the expected distribution or the expected number of fatalities if all vehicles in the fleet had electronic stability controls installed.

And the -- -- based on other NHTSA research, they found that ESC will reduce fatalities in rollovers and crashes with objects, so the -- the results are reweighted to show the estimated effect of that in the future.

And, as you see here, the SCE, we see that as having a significant safety benefit, at least certainly in cars in this -- in this example here.

Now, this slide shows some of our interpretation of additional analyses we did based on the Kahane study, and what we looked at was the risk, fatality risk per VMT of individual vehicle makes and models.

And what we found was, when we plot the risk versus mass, there is literally no correlation. There is a trend line on average where increased vehicle mass results in a lower fatality risk.

But the individual models grouped around that trend line, it is a cloud. There is no correlation between all those individual points. The R-squareds are under .2.

What I am showing here is not the raw risk per the written -- not the raw relationship between raw risk and mass, but rather, the residual risk.

So we took their actual risk per VMT and adjusted it by all the factors in the regression model and then subtracted the predicted risk from the actual risk to come up with what we call a residual risk.

And that residual risk, by -- for

each make and model can be interpreted as the additional risk that our model is not accounting for, our regression model doesn't account for.

And so when we applied that residual risk against mass, we see there is, again, no correlation for the -- several vehicle types, and so that suggests that, even if we can account for everything, which we know we can't, the remaining -- even the remaining risk is not correlated with vehicle mass.

So, again, it is just an important point to realize that, you know, on general, the regression models tell us that there is a relationship between mass and risk.

On an individual model basis, that relationship does not exist, that manufacturers are able to mitigate the safety penalty from lower-mass vehicles, and that the people who tend to drive certain vehicles also influences what their actual risk is.

The plot below -- so, we were satisfied with 14 additional models. We did an extra five or so. The plot below, I don't expect you to look at that in the close detail, it just wants to show -- I just want to show the range in the estimates of all those alternatives.

The blue columns are the baseline model results from the NHTSA analysis, and then all of these additional models to show you the range or the alternatives that we all -- that we looked at.

The alternatives are arranged so that they rank from lowest to highest for the lightest cars. So that is just a function of how I plotted this.

But, as Chuck mentioned, you know, the alternative models that we looked at range from almost a three percent increase in fatality rate for mass reduction for the lightest cars to, in some cases, a slight decrease in fatalities from mass reduction.

This slide just lists the 19 alternative regression models that we looked at. I have highlighted in green several and I am going to talk a little more in detail now.

And then, in red down below, I have highlighted some that DRI looked at -- proposed and looked at and it is a -- and we looked at it as well. And I think Mike is going to talk a little bit more about those in his presentation.

So, the alternative models that we analyzed that I am going to show you -- as I mentioned earlier, we didn't see this correlation between the residual risk and mass by vehicle model and so, as I said, that could either be due to differences in vehicle design among vehicles or differences in who tends to purchase and buy -- and drive these vehicles and how they drive these vehicles.

Another point that Chuck didn't mention is that in his -- the baseline regression model, he purposely excluded sporty cars, mostly for the reason that we didn't feel that driver -- or he didn't feel that driver age and gender could fully account for how those vehicles are driven on road, and so he didn't want to bias the model by including certain vehicles that are driven in a more risky fashion than the typical vehicle.

And, as an aside to -- well, sorry. I will do that later.

Okay. So, we looked at two measures of vehicle design. We tried to isolate the effect of vehicle design on risk. We looked at the manufacturer or, actually, something with a little more detail than that.

Brand -- what we call brand. We had a dummy variable for each of the 14 vehicle manufacturers, as well as for some of the larger manufacturers we included a dummy variable for the luxury version, or the luxury brand within that manufacturer.

So, for instance, Infiniti was a

separate variable for Nissan and Acura is a separate variable from Honda, that type of thing.

We also looked at the initial vehicle purchase price as another possible indicator of the quality of the vehicle design.

We made -- we also, for driver behavior, we looked at two different measures. As Chuck had done, we excluded crashes that involved alcohol or drug use with -- under the assumption that those vehicles were driven in a highly-risky manner, as well as vehicles that -- whose drivers exhibited poor driving records or poor driving in the current crash.

And the second measure for driver behavior was we looked at the median household income of the households that tended to own certain makes and models based on data from California.

And then, finally, we looked at -- an alternative measure of risk. Rather than fatalities per vehicle mile travel, we looked at fatalities per crash using the data that Chuck had generated.

And the point of this was try to get at the crashworthiness of different -- what effect vehicle mass has on crashworthiness, the ability of a vehicle to protect its occupants once a crash has occurred.

Okay. So the top slide here, or the top figure shows the effect of vehicle differences under the two alternative regressions.

You know, the light blue column show the baseline model. The red columns show what effect we see when we include the 19 vehicle brands, and then the purple column show what effect we see when we include vehicle price.

And I don't want to go into this in a lot of detail. Just to point out that, depending on what -- how you try to account for this factor, you know, the differences in vehicles, you could get a slightly different -- you get either a more detrimental effect of mass reduction or more beneficial effect of mass reduction.

And so, the baseline model is sensitive to what changes you make in the regression model, and it could go in either direction, depending on -- on the variable you use.

The bottom slide shows the effect of looking for driver differences and the light green shows the effect of excluding the crashes that involve alcohol, drugs or bad driving.

The light violet bars show the effect of including a variable for household income. And, again, depending on which of those variables you use, it can have either beneficial or a larger effect or a smaller effect, estimated effect of mass reduction on risk.

And then, finally, we looked at an alternative measure of risk, the risk per crash, the fatality risk per crash, and this was quite interesting. When we looked at that measure of risk, we found that, in fact, mass reduction is associated with the reduction in risk, fatality risk once a crash has occurred.

And this is something that we wanted to investigate in more detail, so we -- that is what we looked at in phase two of our study.

The phase two study, as I mentioned, comes -- uses -- only uses data from 13 states that report state crashes. It is not combining data from different sources.

It is using the same database for both the numerator and denominator of the analysis. Both the measure of risk and the measure of exposure come from the same source.

And what we are looking at is casualty risk per crash. Using the data also allows us to separate the two elements of

Chuck's fatality risk per VMT into its two elements.

The crash frequency, that is, the number of crashes per mile traveled or VMT, as well as the crashworthiness or the risk once a crash has occurred or the risk per crash.

The drawbacks of this type of analysis is we are limited -- we are not -- we can't do a US analysis. We are only limited to the states that provide the VIN, and there are 13 of those.

And so, if the relationship between mass and risk varies among the states based on the vehicles and drivers they have on their roads, our relationship may not represent the whole US, or our analysis won't.

And, as I -- and there aren't enough fatalities -- this is not a bad thing. There are not enough fatalities in the 13 states to necessarily -- to get robust estimates, so that is why we have to go to the casualty risk, as opposed to fatality risk.

So, the top figure here compares the -- again, the -- it is a baseline model. The US fatality risk per VMT in blue, with the 13-state casualty risk per VMT from our 13-state analysis, and the results are comparable in the same direction.

In some cases, they are higher, or a larger effect than -- than Chuck measured in the US fatality risk analysis but, in general, it looks fairly similar. So that gives us confidence that we are, you know, measuring -- we are roughly getting a national -- something that is representative of a national relationship.

The bottom figure, then, separates out the green bars up here, which are casualty risk for VMT into its two components. The orange is the crash frequencies, so it is the number of crashes per VMT, and the red bars are the risk once a crash has occurred, or the crash worthiness.

And what we see here is that the

orange bars indicate that mass reduction results in an increase in crash frequency, so the lighter vehicles have a higher crash frequency than heavier vehicles, and that -- that might be counter-intuitive in terms of physics of vehicle design but, as Chuck mentioned, that is something that he's observed over many years of looking at the data, and that is -- likely has to do with either data reporting issues or, in my view, it might have to do with who tends to purchase these vehicles and how they drive them.

The more interesting aspect is the estimate of mass reduction on casualty risk once a crash has occurred, the red bars. And here we show that the effect is not significant or, in some cases, it is significant, but it is a -- it is a -- mass reduction actually reduces casualty risk once a crash has occurred, or improves the crashworthiness of a vehicle.

And so, we wanted to -- so that is

a quite interesting and unexpected result. And we looked at that in a little more detail.

Mike from DRI is going to discuss a regression model that they have developed where they -- in the same regression model they model the three -- the two aspects of crash risk per VMT, the crash frequency and the crash worthiness in the same regression model.

LBL developed a similar model to -- so we could benchmark our results against theirs. The results in the top figure here show the DRI model which -- which uses US fatality data from NHTSA and the VMT weights.

I was only able to get crash data from ten states. And, of those crash data, they sampled a representative sample of the vehicles instead of using all of them, but the results were quite similar to what we saw in the previous slide, that crash frequency increases for lighter vehicles and crashworthiness actually improves with mass reduction. These are the red bars.

The bottom slide shows our replication of the DRI results and, extending the data to include all the data that NHTSA had from the 13 states, and not doing any sampling of the crash data.

And we -- again, we see very similar results. In fact, our results are -- tend to be more consistent across the five vehicle types. Up here, we sort of see a glitch, that the trends are not consistent for the heavier cars, but down in our analysis we see quite similar trends across all vehicle types.

So -- so the data, using DRI's method, confirms what we had seen in the LBL phase two analysis, and that is that mass reduction is associated with an increase in crash frequency, which is not entirely unexpected, but a reduction in crash -- or an improvement in crashworthiness, a reduction in crash and risk once a crash has occurred.

And we have a couple of possible explanations for that. One is that, you know, over 20 years of NCAP testing, manufacturers have, you know, have had to respond to public, you know, publishing of the crash test results, and that we feel that manufacturers have learned how to mitigate the detrimental effects of lower-mass vehicles in other aspects of vehicle design.

They can build a lighter vehicle that has good crash characteristics, and is not inherently less safe than a heavier vehicle, and we see that in our analysis of vehicle makes and models.

So, there are a couple of discrepancies we wanted to reconcile in the DRI work with our work that we are going to be working on that.

We want to take a little deeper look at this issue of the crash frequency, how that -- the way we see the lighter vehicles have higher crash frequency, and whether that has to do with aspects of vehicle design or if that is truly an effect of the drivers of those vehicles.

And another aspect we are looking at is how changes in gas prices have changed vehicle miles traveled. That is something that wasn't fully-incorporated in Chuck's regression analyses.

I think that is important because of the reduction in VMT will obviously change the -- your fatality risk numbers, and we need to account for that in the modeling.

So, in conclusion -- you know, the regression analyses can inform regulators what effect standards may have on safety, but it can't really predict that effect.

I mean, we are looking at differences in recent historical vehicles and not able to predict how new vehicle designs will act, will pan out in the real world.

And these points just summarize my earlier points. You know, mass reduction is associated with a small increase in risk, particularly in the lighter-than-average cars.

Other factors overwhelm that effect, and that is important to recognize. There is a wide range in risk by vehicle make and mode, even for models of the same or similar mass, and even after accounting for all the control variables in the regression models.

And that last point is that, you know, we have seen that mass reduction is associated with an increase in crash frequency, but a decrease in risk per crash, and we need to understand better why we are seeing that in the data.

So, with that, I will be happy to take any questions.

(Applause.)

MODERATOR BONANTI: Thank you, Tom.

Questions. Okay. Makes a note indicating that he's not sure if the first statement is true. However, "Phase one did sensitivity, reference exposure" -- example -- "by ZIP code indicators.

"Did you do the sensitivity analyses on your crash frequency findings? For example, to account for risk error or less income/educated drivers?"

MR. WENZEL: The short answer is no, but we can do that. We can do all of these -- in particular the ones that look at driver differences and what effect that has on crash frequency.

And one of the things we are going to be doing -- well, yes. That is -- that is in the -- the works.

MODERATOR BONANTI: Thank you.

"You show a significant increase in occupant risk as a result of reducing footprint by square foot. Was the mass also adjusted to maintain the same specific mass/square foot? Did you look at increasing or decreasing mass while also reducing footprint? If so, what were the results in the trends?"

MR. WENZEL: Right. So, all those plots that I -- figures I showed earlier were with holding -- were the effect of footprint reduction -- or mass reduction, holding footprint constant and the effect of footprint reduction, holding mass constant.

We did do a sensitivity where we allowed footprint to vary with mass. So, this model here, the blue columns, again, show that the baseline NHTSA analysis, the dark violet shows the effect of mass reduction if you allow the vehicle to get smaller, as well as lighter.

And, if you allow that to happen, the effect of mass reduction becomes more detrimental. It is a larger effect and it is a larger increase in fatality risk.

The lighter violet bars show the opposite, where you allow vehicle mass to decrease as footprint decreases. And, again, if you do that, if you allow both variables to decline in -- in concert, the negative effects of that reduction are exacerbated.

MODERATOR BONANTI: Here's a follow-up question to the same individual.

"Any theories on why lightweighting -- lightweight cars have higher accident frequency? Age or driver tickets?"

MR. WENZEL: Well, certainly, that is one -- the factor I think is important is who tends to own these vehicles and how they drive them.

And, you know, that -- sort of the -- the analysis with the sporty cars, which Chuck -- and we excluded from our analysis -- is instructive. You know, those vehicles have the best handling and braking scores. Right? But they have the highest risks.

So, you know, the capability of the vehicle is not realized by who tends to drive them, and that is something we really have to account for, or try to account for as best we can in future analyses.

MODERATOR BONANTI: I am going to try to --

MR. WENZEL: Reinterpret?

MODERATOR BONANTI: Yes. Reinterpret this question, or say it in a different way. "Please clarify how your residential risk is defined."

MR. WENZEL: Residual.

MODERATOR BONANTI: Residual. Okay.

MR. WENZEL: So, the -- the actual -- that is good. I have a picture.

So, the top figure here shows the actual risk. So, observe -- actual fatality risk for VMT plotted against the curb weight of each vehicle, and you see those very -- you know, again, there is an -- on average, there is a trend with -- heavier vehicles have lower risk, but there is a huge cloud of individual makes and models around that trend line and here are the R-squared's of those clouds.

The first step is to estimate what the predicted risk would be if you normalized, for all of those control variables we used in the regression model.

And this plot, down below, shows the predicted risk of each make and model, given that it is driven 90 percent of the time at night, 65 percent of the time on a high-speed road, et cetera, et cetera.

And so, the residual risk is simply the difference between these two. It is the leftover risk after we have predicted what the model says the risk should be for that model.

We -- it is the difference between the actual risk and the predicted risk. That is the residual risk. And, as I showed earlier, even the residual risk that is not explained by the model shows no correlation with vehicle mass.

So, whatever else is driving the differences and risk between vehicle make and model, it is not correlated with mass. It is something else.

MODERATOR BONANTI: Okay. Now that you have explained that --

MR. WENZEL: Oh.

MODERATOR BONANTI: "Why use residual risk to do the analysis? How important is it to the analysis?"

MR. WENZEL: Well, it is simply pointing out that, you know, the regression model -- the regression analysis gives you, you know, the slope of this line and says that that is a relationship that -- that exists on average.

And what we were trying to show is that -- that might exist on average, but individual design plays a huge role and can mitigate the effect of mass reduction on risk.

MODERATOR BONANTI: Okay. Next question. This is the last question that I have, unless there are any others.

I would actually like to find out

from whoever asked this question if it is a one and a five, because it looks like an "S."

PARTICIPANT: It is one and five.

MODERATOR BONANTI: One and five. Thank you. Okay.

"Finding one and five are not consistent. Explain."

MR. WENZEL: In the summary? Well, finding one is risk in terms of fatalities per VMT, per vehicle mile travelled. And, as I showed, when you break that into its two components, crash frequency, or number of crashes per VMT and crashworthiness, which is risk per crash -- so this is -- the green bar is the combined effect, of fatalities per VMT and the orange and red are the two factors that, combined, result in the green result. Right?

And so, the effect of mass reduction increases crash frequency, but tends to have small effect and, in some cases, a reduction in risk once a crash has occurred.

So, the combination of those two effects is the green bar, the effect of mass reduction on risk per VMT.

Does that answer it?

MODERATOR BONANTI: Okay. And we have a question from the web.

"In your duplication of DRI analysis, was exactly the same regression process followed? Specifically, were the crash frequency and crashworthiness effects obtained in one simultaneous regression instead of two separate regressions?

MR. WENZEL: Yes. So we developed the same simultaneous model, regression model. The only different -- and I didn't show that here, I did it, exactly everything -- DRI is exactly the same data, and we came up with slightly different results.

And I think the reason for that is we didn't use -- we probably did not use the same definition of crashes, the type of crash in our analysis, and so that is what I want to reconcile with the DRI work.

But then, the plot I showed on here is, once I had the model in place and I felt I was getting almost exactly repeated results, then I added in the data that DRI was not able to add in.

I added the 13 states as opposed to just the ten, and I didn't sample the crashes. I just used all of the crashes, and that is the result I get down here.

MODERATOR BONANTI: Another question.

"Statistics versus physics. Who wins? Lighter cars -- a lighter car is hit by a heavier car, means a higher delta v, therefore, increased fatality and casualty risk for occupants in lighter vehicles. Yet, all told -- all red shows benefit -- shows a benefit for mass reduction bars."

MR. WENZEL: Right. So, again, I just want to point out that, you know, physics, the laws of physics apply when everything else in the vehicles are equal, right, and we know that that is never the case.

We are talking about different vehicle models, different drivers, and we are trying to account for all of that, but we haven't, and I am not sure we even could.

You know, I don't -- I don't think the data are out there and fully account for every -- for all the differences.

And, as you saw, where a vehicle is driven has a huge effect on the risk. So, you know, if we are not fully-accounting for all of these other attributes that -- that define the vehicle/driver interaction, we are going to see results like this where, you know, lighter vehicles tend to have better crashworthiness characteristics.

It is not because they are lighter, it is because everything else that is different about those vehicles. And we try to account for all those differences, and we just can't account for everything.

MODERATOR BONANTI: Okay. Well, I am looking forward to the panel discussion with both Chuck and yourself and the other presenters. That is going to be very interesting. Thank you.

MR. WENZEL: Okay.

(Applause.)

MODERATOR BONANTI: Next up we have Mike Van Auken from DRI. He's going to be presenting an assessment of the effects of passenger vehicle weight and size on accident and fatality risk based on data for 1991 through 2007 model year vehicles.

Mike.

MR. VAN AUKEN: Thank you. Good morning, everyone. Thank you for the introduction.

I will be presenting today in a discussion about the -- an assessment of the effects of passenger vehicle weight and size and accident fatality risk based on data for

1991 through 2007 model year vehicles.

On behalf of my colleague, John Zellner and the other -- my colleagues at Dynamic Research. And I would also like to thank my -- our sponsors, which were the ICCT and Honda and the Energy Foundation.

Topics today I will be talking about are -- or, first I will list some acronyms we will be using today, and then also, the background, talk about the basic methodology results, some discussion and then summary conclusions of those results.

So, just some -- just some initial acronyms, we are using CY is calendar year. We will talk about light trucks and vans, LTVs, which comprise crossover utility vehicles, SUVs and truck-based LTVs, as well as minivans. And, MY, we use that for "model year," and PC is "passenger cars," and SV is "subject vehicle," which is the focus of the analysis.

So, I will begin with the

background. The understanding of the effects of vehicle weight and size on overall safety is necessary to assess the risk and the benefits of weight reduction and other vehicle design goals such as fuel -- improving fuel economy.

The earlier research in this area assumed that weight and size were not independent, and the effects of size were implicitly attributed to weight.

This analysis typically focused on the self-protection viewpoint, such as just the subject vehicle drivers and also focused on specific crash types, such as front-to-front collisions.

And these results, using this more focused analysis tended to indicate that weight and size reduction was harmful, but more recent research has focused on -- on more comprehensive models that address all crash types and persons involved in the crash.

They represent a societal

viewpoint where we are looking at both the subject vehicle occupants, as well as the collision partners. And also, we have been looking at the independent effects of weight and size on safety.

So, we begin, first of all, with a very basic view of the methodology here. We are looking at fatality and accident risk models. And so we being with an assumed -- basically, a mathematical relationship, a two-stage model -- and this is just an algebraic equation where the logarithm of the fatalities per exposure, which "F" represents the -- is a mass symbol representing the number of fatalities.

And this includes all persons in the crash, the subject vehicle driver, as well as the collision partners, the pedestrians and so on.

The symbol "A" represents the number of accidents that would be police-reported accidents, and "E" is the exposure, which can be various measures of exposure, but the two we are looking at today are the number of registered vehicles which might be something from Polk, we get from Polk data, or the number of vehicle miles traveled, which would be, you know, the Polk, the registrations times their annual miles traveled that they -- each vehicle travels in a year.

And so, we have this basic relationship that the fatalities for exposure, which is a measure of the overall fatality risk can be separated into the fatalities per accident and the -- which is a measure of the crashworthiness and compatibility because we are looking at all persons, and the -- the accidents per exposure, which is a measure of the crash involvement.

From that, we take it to the next level of detail which is, we begin to have a model here, which is you assume that each stage can be modeled by various vehicle, driver and environmental factors, which are represented here by the symbol "X" with some subscript, "I."

So, we have these -- basically these three equations where these beta coefficients are -- are unknown values. We don't know what they are, and they are to be estimated by the analysis and then conclusions drawn by the values for those coefficients.

And we also know that -- we assume that the effects of each stage are related, according to this equation at the bottom. So, basically, the sum of the fatalities per exposure number is equal to this number plus this number.

Then the models, the vehicle weight and size variables were the main variables of interest in this analysis, and these included the subject vehicle curb weight.

Early analysis was used basically in linear curb weight model and then this was later extended to a piecewise, or two-piece linear model. This was introduced by NHTSA to address the observant -- possible nonlinear effects beginning in the 2000 -- or 2003 analysis.

We also looked at subject vehicle size. That was also of interest. And there are two -- two possible approaches of -- maybe many more models, but we looked at wheelbase and track width and we chose those because those are related to -- those parameters are related to the precrash vehicle dynamics, and they are also related to the vehicle length and width, which are assumed to be related to crashworthiness and crash compatibility.

And there is -- also, the footprint is another measure, and that is equal to the product of the wheelbase times the track width, and that is related to the proposed fuel economy and greenhouse gas rules.

There are other control variables

that are used in the analysis, and the ones we used were selected by NHTSA that may also affect safety, and are also available on the accident exposure databases.

So -- and this is a key point. We don't -- we can't control for variables that are not in the databases. So, the variables that were used were other vehicle-related factors, such as the vehicle subtype, whether they are two-door cars or SUVs, the type of equipment, such as ABS or ESC or airbags, and then the vehicle age.

We also -- another were the driver variables were the driver age group and the sex, and these variables represent a whole variety of -- they are assumed to represent the behavior of the -- of the driver, and assume that there is -- that is related to some of the risk-taking effects, as well as their injury tolerance for the driver.

There is also the environment and other factors, and these were the rural and urban road classification, whether the crash occurred on a high- or low-speed limit roadway, and whether the crash occurred at -- or the vehicle was driven in daytime or nighttime.

There is also a control variable for the state group, which was broken into two groups. And again, this is -- this is based on Kahane's method, and this is the higher and lower average fatality rate states, and then the calendar year, which is -- allows for controlling for changes over time.

And so, the data that we used -- and we conducted the study in two phases here. A phase one analysis was focused on the -- looking at the 1995 through 2000 calendar year data for 1991 through 1999 model year vehicles.

And our phase two study was -- used the 2002 through 2008 calendar year data for the 2002 through 2007 model year vehicles.

These studies used fatal accident

data from the US FARS database. In phase two, that was provided in a reduced form by NHTSA. The second -- we also used nonfatal police-recorded accident data, and that was in our phase one study from eight states. And in phase two, we used ten states. These were states that we could obtain data for.

There was also induced-exposure data which were also obtained from eight states in our phase one study and, in phase two, we used data for 13 states, and that was reduced by NHTSA, so we -- it was -- they were able to obtain the additional states and did the reduction on that.

The vehicle types in our phase one study, which was really modeled after the Kahane's 2003 and 2010 analysis involved basically passenger cars and light trucks and vans.

And then the second study was the passenger cars, truck base, LTVs and minivans and crossover utility vehicles as a third breakout group.

And then the crash types were -- we looked at the six crash types defined in the earlier NHTSA analyses, and then the phase two was the nine crash types in the most recent NHTSA analyses.

Now, we used this methodology because it is comprehensive, with a few exceptions. In phase one, these excluded the two-door passenger cars and, in phase two, we excluded midsized vans.

But, in general, we are trying to cover -- the intent is to cover all crash types and all person types and all vehicles, at least in the light passenger vehicles in this analysis.

So, it is comprehensive and that is why we -- and we -- the NHTSA approach was comprehensive, and that is why we used it.

Just to explain a little more about what induced exposure data is, it is a case-by-case data that provides information about the vehicle drivers and the environment, such as the driver age, whether the vehicles are being driven at nighttime or on rural roads or -- or high-speed or low-speed roads, in order to control for these factors in the analysis.

If we were not interested in controlling for driver age or gender or a nighttime use or rural road, then we wouldn't necessarily need induced exposure data, we could just use the Polk-type data directly.

So the cases were extracted from state accident data using one of two different methods. The first was a stopped vehicle -- what we refer to as a "stopped vehicle" case selection criteria, and that was first introduced in Dr. Kahane's 1997 report in which the subject vehicle was legally stopped.

The second method was the nonculpable -- we call the "nonculpable vehicle" induced exposure criteria. And that one was introduced in NHTSA's 2003 and more recent analyses, in which the other vehicle driver was at fault based on coded data, as well as reported in the police report which ended up in the database.

And in this case, the subject vehicle driver was also assumed to be not at fault, based on the same coded data.

So, for example, one driver was given a -- cited -- given a ticket and the other driver wasn't. Well, that was considered a nonculpable vehicle case, in which the person that didn't get the ticket was the -- was assumed to be nonculpable.

And, of course, the main purpose of this analysis is we are trying to assume that the cases are randomly sampled from exposure and that the subject vehicle drivers were blamelessly involved in the crash.

That is the intent of the analysis, or the method. Whether we get there or not is debatable, but the point is that that is the intent, and there are two different approaches to achieve that.

Subject vehicle cases are then weighted such as the aggregated data represents the vehicle miles traveled at the registration data, on a make and model year basis.

So, in terms of registrations and vehicle level exposure, there is very little difference between the two sets of data. And I will show that on the next slide.

This shows a comparison of the -- of VMT weighted average values for the two different databases. This is the database variables that are used -- or many of them that are used in the regression analyses, beginning with things like the curb weight and track width, which are vehicle parameters, and then also there is the driver age and the age group variables. And then there are also other exposure variables.

And this is the mean values for the nonculpable vehicle database and the stopped vehicle database. And you will see that the mean values were found to be almost identically the same and that is sort of by intent.

There was no significant difference in the -- in the average curb weight for -- for, you know, a 2005 Ford Explorer in one database versus another database. They are exactly the same.

The only thing that is different is that the average age of the drivers that are driving that Ford Explorer or whatever that vehicle might be.

And so, we didn't find that there was differences on the vehicle -- I mean, on the person type and the crash environment variables.

And you might expect, for example, with a nonculpable vehicle criteria that some drivers that are better able to avoid a crash, even though that they are not actually involved in it might be underrepresented in this database, and so you will see that there are some differences in the -- in the younger drivers, for example, between the two databases.

And also, another factor that you might expect that is, in the stopped vehicle crashes, there might be an underrepresentation of some conditions on a rural high-speed road where that maybe people typically are not stopped in the middle of an expressway out in the middle of nowhere without -- that would be an unlikely situation.

So, you are going to underrepresent the exposure of those type of environmental conditions. So, the driver and environmental exposure are different.

The next step, though, is now to estimate the model coefficients, and the method used was using a logistical regression so the case-by-case data where we used -- basically the one-stage models were based on fatalities per exposure, were based on fatal cases and either a registration year or vehicle miles traveled-weighted induced exposure cases.

And we also looked at two-stage models in which we looked at basically the fatalities per accident, accident exposure and fatalities per exposure based on data for the individual fatal, nonfatal in exposure -- in exposure cases in various combinations, using a simultaneous method which ultimately allowed us to constrain this equation so that the overall effect was equal to the sum of the two individual effects, or the two stages, which is more for consistency.

So, we also looked at basically the one- and two-stage models that we are -- we looked at basically four different models, looking at two different combinations of the wheelbase and track, which are more directly related to the vehicle parameters, you know, such as the -- which are related to the physics of the crash, and the other was the comp.

So we looked at wheelbase and track or, as an alternative, we looked at the footprint metric, and we also looked at both the combinations of stopped-vehicle and nonculpable-vehicle-induced exposure. So, we looked at both combinations.

And the last one is NHTSA's preferred model that they used. And so, just a summary, some of the phase one results with the older data, the results were sensitive -- we found were sensitive to the data and methods, and particularly the induced exposure was just one of them we found was -- there was some sensitivity to.

And the methods were similar to the -- or the results were similar to the -- Dr. Kahane's 2003 and 2010 reports, provided the data and methods were the same. We tended to converge. We didn't exactly agree, but we didn't exactly have all the -- weren't able to reproduce all of the results because of the differences in our data versus NHTSA's data.

The two-stage results for the phase one were similar to the DRI one stage results, and they are not exactly the same because there are some differences due to the model fitting, which may be due to unmodeled factors that affect the accident risk in reporting, such as state data that is not available for some years, and the different state accident severity reporting thresholds.

However, the one-stage and two-stage results for the weight and size were in close agreement. It was other variables, such as the nighttime and a couple of the other control variables had some stronger differences.

The results were also sensitive to the data and methods, in particular, the accident exposure per results, as would be expected, would be sensitive to the induced exposure method.

For phase two, the one-stage

results for fatalities per vehicle miles travelled were sensitive to the data and methods, as well. Particularly, there was the induced exposure method again, which was the choice of stopped-vehicle or induced exposure, or nonculpable-vehicle-induced exposure data.

The vehicle size and weight terms in the model, whether we used wheelbase and track or footprint, and also the exposure measure, whether we used vehicle miles travelled or vehicle registration years.

I won't be going into the results for the exposure measure, but those are in some of the -- our phase two report. And the main implication of that is, I think it implies that there might be some sensitivity to that effect or the accuracy of the registration -- of the vehicle miles travelled data if they are -- which is a little bit unknown, to us, at least.

We tend to agree that the vehicle miles travelled is a better choice of exposure, but it is also a more challenging data to obtain at the make, model, year level of detail.

And the results were in very close agreement with Dr. Kahane's 2012 results. We used the NHTSA's reduced fatal data to obtain that and exposure data.

And our two-stage model results were similar to the NHTSA and DRI one-stage results and begin not exactly the same. There are small differences, but they -- the differences for the weight and size variables were very small.

There again, the primary difference was some of the control variables, such as real road use and nighttime. Therefore, the -- it was also sensitive -- the two-stage results followed the track -- the one-stage results, they are also sensitive to the data and methods and, therefore, the accident exposure results would, therefore, be sensitive to the induced exposure method, as would be expected.

So now, I will be presenting some various bar graphs here, showing some or the results in graphical format. And I first of all wanted to show you -- first of all, the -- what each one of these -- there is a series of bar charts that will be showing -- this cyan-colored bar represented on the vertical scale that the percent change in fatality is due to a hundred-pound weight reduction.

Also shown, next to that in the yellow bar, is the percent change due to a corresponding wheelbase reduction that would correspond to a 100-pound weight reduction if we were to use -- allow the two to vary at the same -- in their historical proportion.

And similarly, this is the result -- this magenta bar is the result for the track width reduction which would also be allowed to, if it were to occur, in the same percentage or proportion as a 100-pound weight reduction.

And why we do that is -- and that turns out to be, with the older data, a .34-inch track width reduction, was associated with a hundred-pound weight reduction.

The reason we do that is, if we were to, then, combine all these numbers together, we get basically a combined effect of -- of the weight and size reductions as if we were to allow all the -- all the variables to vary in the average trend for that -- for that database.

So, it is somewhat equivalent if we only had a curb weight only variable in the model where curb weight was representing all of the variables for size and weight.

And we will see that this overall blue bar, the top bar, is somewhat invariant to the type of size variables that is used in the model.

Presenting results in terms of the -- they are arranged in rows, where basically the top row is the fatalities-per-accident result, which is a measure of the crashworthiness and crash compatibility.

The second row is the accidents-per-exposure result, which is the measure of crash involvement effects. And the bottom is the fatalities-per-exposure, which is the summation of the two top rows. So, this number -- this result plus this bar equals this bar, for example.

And then, of course, then we also arranged the results in columns here. So basically, this is the -- the first model A is the wheelbase-and-track model with the stopped-vehicle-induced exposure data. And the -- this is a wheelbase-and-track model again with the nonculpable-vehicle data. And the foot -- now do the same thing with the footprint models here.

So now I will begin with a comparison of the results for the lighter passenger cars.

On the left is the older data, or

phase one results for the 1991 through 1999 model year vehicles and this is the results for the 2000 to 2007 model year, the newer vehicles.

And, over here, as a point of reference, this is the results -- our two-stage results that are very similar to the NHTSA's baseline model, one-stage results.

And there are also error bars shown on here, which are the -- in this phase-two analysis are the jackknife-based confidence intervals.

So, one thing you can see is that there are a lot of similarity between the two sets of older data and the newer data. There are some differences as well, but there are many similarities. And I will go over some of them.

One is that -- first of all, is that the -- notice that the nonculpable-vehicle-induced exposure data tends to increase the estimate of the effect of curb weight reduction on fatalities, as shown by this bar here.

This is a change from the stopped to the nonculpable and the trend is similar, actually, across both the newer and the older databases for both looking at a footprint model and a wheelbase-and-track model.

The estimated footprint effect is a combination of the wheelbase and track effects, as you might expect, however, there is some possible spillover of the wheelbase -- or, I mean, some of that when you -- when you force two degrees of -- two variables into a single variable, you also have -- you also have the spilling-over effect into the curb weight.

So that tends to increase, in this case, the effect on wheelbase, the estimated effect, and that is -- you see consistently in these two bar graphs. We didn't see it this strongly in the phase one analysis.

Also, just to point out that the

overall effect of the sum of the weight and size reduction is not very sensitive to the -- to the terms that are used in the weight-and-size model. So, these two bar heights would be the same, and over here the same, as well.

And that is just why we have arranged this, so that we have some tie back to our older analyses, which were based only on -- on curb weight way back.

These are the results for the heavier passenger cars. And another thing you will also notice is that both the heavier and lighter had -- passenger cars, had a relatively small effect on the overall effect of weight and size reduction on the fatality per accident risk is primarily affecting the accidents per exposure, but it is also less in the heavier passenger cars.

And that would explain why the results for the overall effect is smaller in the heavier passenger cars, is there less of a crash involvement effect here, which is really what is driving the passenger car results.

For lighter trucks and vans, LTVs that -- basically reducing the weight tends to benefit or reduce the number of -- of fatalities in the crash once they occur, but it tends to also increase the crash involvement here.

So, but the net effect is this very small net effect here for lighter cars and then, also this is for the results for the heavier light trucks or vans.

So there is some common observations we can make about the phase one and two results which are based on -- on different data, whether there is some -- there is similarity between the data because some of the curb weight databases are the same, but -- but -- but primarily they are different -- they are almost completely independent data sets.

And the estimated combined effect

of weight and size reduction is not very sensitive to the size model, wheelbase and track, versus footprint, and that the estimated effect of curb weight does depend on the size model.

The combined effect of weight and size reduction has a small effect or tends to -- to reduce the fatalities per accident, which is the crashworthiness and crash compatibility, depending on the vehicle type, and tends to increase the accidents per exposure or the crash involvement.

The reasons for this are not known at this time, but may be due to factors that have not been controlled for, such as driver risk-taking. A lot of theories floating around as to what this might be, why this is occurring, but we don't have anything definite for sure to say about that.

The common phase one and two results for passenger cars are that the estimated effect of passenger car weight reduction on fatalities per accident are small, not statistically-significant or they tend to decrease fatalities.

And a wheelbase reduction is small or not -- and not statistically-significant. But track width or footprint -- and footprint includes track width -- on fatalities per accident or accidents per exposure are either small or tend to increase fatalities.

The combined effect of passenger car track width or footprint reduction on fatalities per exposure are to increase fatalities.

Some other additional results for the passenger cars is they are relatively small. Effects due to effective curb weight and wheelbase on passenger car and crash -- passenger car crashworthiness and crash compatibility may be due to an equalizing effect on crash-based safety standards and cab tests, IIHS tests, star ratings and intelligent vehicle design.

The small cars have to meet the same -- or lighter cars have to meet the same standards as the heavier cars, and that may tend to have an equalizing effect on vehicles.

And also, in the side-impact test with an MDB barrier, the smaller -- the lighter cars are actually at a disadvantage to that test because they are being struck by the same mass, so it is a -- it tends to be -- they tend to be an equalizing effect.

And also, that the vehicle manufacturers were able to design the vehicles to meet these standards, so that tends to equalize the performance.

The use of nonculpable-vehicle-induced exposure data does tend to increase the estimated accidents per exposure due to the passenger car weight reduction, and that is compared -- compared to the stopped-vehicle- induced exposure data.

So, one technique just has a slight different -- tends to increase the result compared to the other induced exposure data.

Other common results for the truck-based LTVs are that the estimated effect of LTV -- weight reduction and footprint reduction are that they decrease the fatalities per accident, but increase the accidents per exposure, and then there is no net or small effect overall, so they are equal and opposite opposing effects.

And then you estimate the effect of the track width reduction are to increase the accidents per exposure.

There were other results that were mixed or not -- not a strong conclusion could be made, in general, about the effect of LTV weight reduction. There are various results, depending on the model years and the weight group.

There were some differences between the phase one and two results as well. One is that the estimated effect of the lighter car and lighter LTV weight reduction has -- on the increased crash involvement was smaller in the new vehicles, and this decreased the overall number of fatalities, compared to the older model year vehicles. And so, this is a desirable long-term trend if it continues.

The phase two results also indicated that the estimated effect of weight reduction was, on overall fatalities, was not statistically-significant in all passenger vehicle types, weight groups and size models with a couple of exceptions, which may be due to random chance.

If you were to run an experiment several times, you might expect to see statistically significant result one out of 20 times at the 95 percent confidence level.

So, there are a number of limitations to these results as well, including that the -- as previously noted by Dr. Kahane and Tom Wenzel, that these results are based on past data, which may not be predictable of future trends or future vehicles.

The induced exposure data may not be a representative sample of U.S. exposure although, you know, that is the best exposure data that we have available. So, it is just a -- it is a limitation and we just have to, I think, deal with it. And results may depend on the choice of control variables that are used in the analysis.

So, in summary, the -- we looked at the effects of vehicle weight and size, using two different data sets, the older 1991 through 1999 model year data set, as well as the 2000 to 2007 model year data set.

And we got similar results which suggests that these results are robust, and the overall results tend to confirm the one-stage model results reported by -- by NHTSA, provided we use the same data and methods as close as we can do.

And these are some of the results that we obtained, just looking at the curb weight, only effect, which would be the inputs to the Volpe model.

And they are shown here the -- this table lists the -- on the five different rows for the -- the car, two different car weight groups and the truck-based LTV weight groups and the minivans, and these are the results showing the four different basic models.

And the ones that are statistically-significant are shown in the bold font, and the ones that are not significant are shown in the lighter nonbolded font.

And, of these 20 combinations, there was only two that were statistically, so you might expect that some of these might be -- might have occurred by chance, although there could be some debate about that, but it could be -- these could have occurred by chance, and that these -- also, these estimates are small, considering the range of estimates and confidence intervals in the different models that were considered.

And also, that these -- the crash-based safety standards, NCAP tests, IIHS tests and so on, and the intelligent vehicle design, may tend to decrease the effects of weight and size reduction and crashworthiness and crash compatibility.

In a more detailed discussion and the methods data and results in the following reports in an SAE paper, we had a phase one and a phase two report, and a summary report that are already in -- the original versions were already in the docket as of January last year, and then the updated version in June of last year for the phase two.

And we have updated a peer-reviewed reversions based on the -- the updated NHTSA database that, hopefully, would be submitted to the docket shortly. And there is also an SAE paper which came out last month, and that has, again, a summary of some of the same results that are presented here with some additional tables, more details. And you can go to the SAE website and look up that paper number.

And I want to acknowledge that this research was supported by the International Council for Clean Transportation, American Honda Motor Company and the Energy Foundation. I appreciate their support. And, are there any questions?

MODERATOR BONANTI: Okay. Thank you.

(Applause.)

MODERATOR BONANTI: Okay. Are there questions for Mike? Okay. And they are coming around.

"Which footprint factor track" -- okay. "Which footprint factor has the biggest impact on fatality rate?"

MR. VAN AUKEN: I would say -- in

terms of bringing in the wheelbase or track?

MODERATOR BONANTI: That is correct.

MR. VAN AUKEN: Okay. I would --

MODERATOR BONANTI: How it is phrased.

MR. VAN AUKEN: The track width has the much stronger effect than the wheel base, according to this data and these results. The wheel base, in fact, is relatively small. The track width was relatively large. Much larger.

MODERATOR BONANTI: Okay. Great. Thank you.

"Any footprint factor differences between track, wheel base and -- between the vehicle size and -- for example, compact versus large SUV, any variation?"

MR. VAN AUKEN: Would you repeat that again.

MODERATOR BONANTI: Sorry. "Any footprint factor differences between vehicle size, for example, compact versus large SUV?"

MR. VAN AUKEN: Yes. I think that was -- they weren't quite as strong as our -- I have to go back to look at the figures, but I think it was not as strong on the LTVs as it was on the passenger cars.

MODERATOR BONANTI: Okay.

MR. VAN AUKEN: The track width effect.

MODERATOR BONANTI: "Why was 1991 through 1999 and 2000 through 2007 chosen as breakpoints for this analysis? Could using, as an example, 2005 to 2007 data versus 1991 through 2004 show significantly different results?"

MR. VAN AUKEN: The reason we used the -- those two data sets is that they more or less were in parallel to what NHTSA, that Dr. Kahane had done for his -- our older data set corresponded to NHTSA's 2003 and 2010 study, and then our new data set corresponded the NHTSA's 2011 and 2012 study.

MODERATOR BONANTI: Okay. Thank you.

This is based on attribute or variable. "Would the factor or variable of inclement weather play a role in the occurrence of crashes?" That is the first thing. And then, second, "Will this workshop also be discussed at the SAE or industry/Government meeting?"

MR. VAN AUKEN: The first question that is -- I believe the earlier analysis did include control variable for the -- the road condition, you know, whether it was snow or ice, but that was dropped as -- due to NHTSA's choice in the more recent analysis.

I can't recall the reason why they dropped it, but -- and it -- the conclusions, apparently was it was not a strong effect. And, secondly, the SAE paper was already presented last month, and I am not sure what -- when that would be discussed in any Government and industry meeting.

MODERATOR BONANTI: Okay. Thank you.

Any further questions?

(No response.)

MODERATOR BONANTI: Really? Okay. Anything from the web?

(No response.)

MODERATOR BONANTI: No? Well, Mike, I think you got off easy.

MR. VAN AUKEN: Okay. Thank you everyone.

MODERATOR BONANTI: Thank you.

(Applause.)

MODERATOR BONANTI: Okay. As it currently stands, we are actually now a little bit ahead of schedule, which is good, but we will -- with that being the case, we will add five minutes to the break and be back here at 10:40, please. Thank you. 10:50. Excuse me. 10:50. 10:40 would only be a five-minute break.

(Whereupon, the above-entitled

matter went off the record at 10:35 a.m. and resumed at 10:53 a.m.)

MODERATOR BONANTI: Okay. Our next speaker is Guy Nusholtz and he will be speaking -- he's from Chrysler. He will be speaking on fleet fatality, risk sensitivity to vehicle mass and size, changed in vehicle-to-vehicle crashes.

We have Guy going now. After Guy, we will have Joe Nolan from IIHS. That being said, however, the focus discussion will be afterwards and I am looking forward to that because there is such variation in the presentations.

So, I will introduce Guy.

MR. NUSHOLTZ: As stated, I will be discussing vehicle-to-vehicle crashes and mass/size change and the effect on vehicle-to-vehicle crashes.

In general, I understand what mass is. I know how to weigh a car. I can put it on a scale, but I am never quite sure what "size" is because there are all sorts of different metrics which act as surrogates, and we never have any form of a sizeometer which tells us exactly what the size is.

So, one way that I look at it is mass primarily relates to conservation of momentum and that is the amount of energy that the occupant has to deal with. There is a little bit of the rate of energy in that, but it is mostly the amount.

And size deals with conservation of energy and, in the case of a crash, that is primarily the rate, although there is a little bit associated with the amount of energy.

So, we are going to use a combined empirical and theoretical model, and I presented a lot of the details of the model in 2011, so I am assuming that everybody remembers that and knows all the details.

We take the accident data, parameterize it, then we include the laws of physics -- and it is not all physics. We are not including quantum mechanics. There will be no neutrinos or oscillations, nor are we going to include string theory and galactic expansion. It will just be conservation of momentum and conservation of energy.

From this, we generate a fleet model, and this is different from what Steve presented in terms of a fleet model yesterday where he crashed a bunch of FEA cars. It is completely different.

However, in order to build our model, we used NHTSA's crash models that they developed and made publicly-available, and so it became a critical aspect of this model, although, in this presentation, I am not going to go through any of that detail.

This just gives you an idea of what I mean by parameterizations. This is the mass distribution, and I am going to fit it with a gamma function so I can use that function in my analysis and as part of my equations, rather than using the individual mass distributions.

So, our goal is to figure out the fatality risk, and fatality risk is generally a function of many, many variables, mass, all sorts of vehicle parameters, driver functions, road conditions, lots and lots of stuff.

And the problem is, it is a very difficult task, and it is actually something that you can't really do. We understand that the statistics of colored marbles in a jar and when you draw marbles out, what your probability is of getting a particular marble.

But, when we start to go to try and extracting the information from the accident databases and other factors, we never have all the necessary information.

Invariably we make assumptions. We introduce modeling errors. We have system errors. There are correlations that go on. There is leakage. There are all sorts of problems associated. We are somewhat in the Mark Twain domain where he said, "There's liars, damned liars and statisticians," and having said that, I am now going to show you a bunch of statistics.

There is background. Some of this we have already covered. Evans, Kahane gave his presentation, Van Auken, Padmanaban has probably has done more work than anybody looking at the effect of fatality rates, and I have only cited one of the papers that we have done on this.

This is the fundamental physics behind this, and Chuck sort of went over it and, in many ways, I am going to be repeating what Chuck said in his presentation.

But, there is a relationship of velocity to fatality rate. So, that means that, if you get in a crash at a higher velocity, you have a greater chance of a fatality.

And then, there is conservation of momentum and, if you look at conservation of momentum and fatality rate as a function of velocity, you end up discovering that the mass ratio becomes very important, and there have been a number of people -- Evans was the first one -- who started looking at M1/M2, or the mass of one vehicle versus the other vehicle.

Now, if you go through the equations, you discover that I can take the velocity data, assuming that a higher velocity, a greater amount of energy into the occupant creates greater risk, and that will give me the effect of the mass ratios.

So, it is a fundamental law of physics. And if you believe that mass doesn't matter or even if the mass effect is negative, then you are telling yourself that at the higher velocity of a crash, "I am safer than a lower velocity. I am safer going a hundred miles an hour into a bridge abutment than I am sitting in my driveway listening to the radio."

And then, finally, at the bottom, down here, these two will not give me the societal risk, but I have to somehow come up with an equation, pulling out from here, plus from the accident data what the overall societal risk will be.

And I look at a number of -- this just lists some of the variables that we look at. We have, looking at truck characteristics, belt use, age, some of the other factors that we use for normalizing our data.

In general, the data came from Kahane, and he helped us quite a lot in understanding it and discovering what was there. We had to supplement it with a lot of other data. We took some state data, we used NASS, both CDS and GES.

We are only going to look at vehicle-to-vehicle cases only, and I will separate out front and side types of impact. We looked at rear, but they were such a small contributor that we didn't include them in our model. This is in terms of fatalities.

So, this is the general trend. What I have is the mass on this axis here and the condition fatality risk. And, as the mass gets up, goes higher, your fatality risk goes down, and that is what you would expect from conservation of momentum and the fact that, at higher velocities, you are a greater risk. There is more energy you have to manage.

When we look at belted and unbelted, and we also look at age, we see, yes, your risk is much lower with a belt than unbelted and as you get older you tend to have a fatality risk.

There is also a slight difference between males and females, where females are at a slightly greater risk, but we didn't include it in the model.

This is sort of a way to -- to explain some of the mass data that we are looking at, but to also show some of the problems associated that you can have in terms of modeling error.

So, these two lines represent the exact same data, but it is aggregated differently. This keeps the same number of samples in each bin and this keeps the same mass distribution in each bin.

And, when you do the analysis, you get slightly different numbers. And this is typically what we would call a modeling error.

So, included in our error analysis, we not only have to look at the number of samples that we have and the way we sample it, but you also have to look at the errors introduced by your assumptions.

In many cases, the error is introduced by the assumptions can be an order of magnitude greater than your sampling errors, or they could just distort the data and contaminate it.

One of the things to notice here is that it goes through zero which indicates that it is symmetric, so it doesn't matter which one you pick as the striking and which one you pick as the struck vehicle. For frontal impacts, at least, it is symmetric.

This is the same example looking at side impacts, and you will find it doesn't go through zero. It is asymmetric, so you are at a somewhat greater risk if you are in the car that is getting hit in the side than if you are in the car who's basically doing a front impact, but you still get a fairly straight line in terms of your mass distribution. And the exponent is a little bit higher, so the mass has a little bit more effect in the relative mass between the two.

This is an example of a potential modeling error that you could get into here. This is a standard method and we use it in a lot of our integrations, but you have to be careful.

And what happens is, when you get to above 70, let's say at 85 miles an hour, your risk gets close to two, so that means that if you are in a crash -- this may be a quantum mechanical effect. If you are in a crash, someone who you have been entangled with, quantum mechanically, in Alaska dies because of your crash.

So, it can produce certain errors in the system. I have seen some statistical analysis which have negative fatalities which mean, when you are in a crash, after the crash you have more people in the car than you started with.

I have also seen some statistical analysis in which the effects of seat belts in one car affects the risk in the other car, and that is when you use certain risk ratios, you get leakage.

It is very easy to get leakage, and if you don't account for the modeling errors, you can get a lot of problems.

And one of the ways that we are trying to do it is forcing everything to meet the relative laws of physics, and that helps to reduce it, but it never completely eliminates the problems.

And, oh, to -- you can solve the problem by using a logistic function. You can also use a hyperbolic tangent. For those of you who like hyperbolic tangents, it will do the same thing.

The trick that we used -- this looks a risk ratios, but we chose to use a logistic function. We found, after we did and extensive amount of study, this minimized our modeling errors, but we have to do a numerical trick here where we look at both risks, and we look at the ratio of risk one to risk one plus risk two, and then we do the logistic in this manner.

And this helps us sort through the data and minimizes the amount of errors that we get. And one of the things that came out of it, which was our -- our test, is that the exponent on the velocity risk that we pulled out of CDS was basically the same exponent that we got on the mass ratios, which is derivable strictly from conservation of momenta. And Chuck was talking about that quite a bit earlier.

We did a lot of testing to see what happens when we change the sample rates, what happens when we change our models. This is an example when we use different sets -- different numbers and we randomly went through these to get sort of a feel similar to Kahane's jackknife theory.

We looked at different sample size. We looked at different sets of samples of the same sample size to see how stable our modeling procedure was and, in general, overall, the spectrums -- and I am not going to go through all of them -- they were relatively stable for all the different testing that we did to try and make sure that the model was consistent and had minimum introduced modeling and system errors.

This is a normalized subject vehicle risk, and I am using two -- three different methods of estimating it. And you can see there is a slight difference, depending on what type of estimation of the risk that we choose. And one way that we test this is, we generate a set of data artificially that we know what the risks are, and then we go through a numerical process to try and predict that risk, and then we use the different processes which predicts the risk with the least amount of error.

One of the tricks that we used was to test how stable our modeling was under different velocity distributions. This is a probability of velocity distribution that we typically see in the field.

And, once again, I fit it with a gamma function. For some reason I have got an emotional attachment to gamma functions.

And then we basically moved the velocity up by a factor of two. We have twice the average velocity but, in this distribution, it is different. It is a

Gaussian distribution.

And then we test to see how that affects the different models -- how it affects the models and you can see, you get slightly different errors, depending on what the velocity distribution is, but the model is relatively stable, considering the extreme that we moved the velocity to.

This looks at conservation of energy, functionally, and conservation of mass. This is -- we have done this with both track width, wheel base and footprint to try and determine what the effect is.

So, here's the mass relative risk ratios. We are looking at two things. One is, in this case, for this example, though, you get basically the same thing regardless of what you do. There are slight differences, depending on what you chose.

We look at the wheel base length. We raised it to the two-force power. We also look at, without raising it to the power, you get kind of the same trend. And then -- and that would be conservation of momentum.

Now, if I look at conservation of energy, what I am trying to look at, as I increase the crush, I can absorb the energy at a lower rate, theoretically, and make certain assumptions on the forces that I am generating and the force-time history of the impact.

But, assuming that I can make those assumptions, I basically discover either track width, footprint, whatever, either has a negative effect, slowly rising, clearly not statistically-significant, or it has no effect.

So, I am not seeing, based on the physics, and assuming it is an energy-absorbing and an increase in length increases the available crush, then I should get a greater rate -- a lower rate of energy absorption, so there is less power to the occupant, so I should have less risk, but I don't see that in the data.

And, in part, this is basically why we have this. When you collide, one vehicle is heavier than the other, you have a change in velocity, lower for the heavier vehicle, much higher for the lighter vehicle.

And then, when these two vehicles collide, there is an interaction force. And what is important here is the force-deflection history, so it is the amount of energy that is absorbed.

If there is more crush space, I should get a lower rate of energy absorption, but that depends on the force-time or force-deflection characteristics.

Now, we don't fully know how to characterize this, so one of the parameters that I use is "stiffness." However, I don't know how to parameterize "stiffness" because it is highly nonlinear and "stiffness" is a linear function, so I choose ten different stiffness parameters.

Some of them, I just integrate the

force-deflection history. Some of them -- and some of this comes from NHTSA's models. Some of it I just take and do a least-square's fit on the first part of the curve. Some of it I do a least-square's fit on the full part of the curve. Sometimes I just integrate over only 400 millimeters. Other times I will integrate over the entire time.

So, I have -- I have approximately ten different stiffness parameters that I use in the model to try and estimate this. And what I discover is -- this is one of the stiffness parameters -- is that stiffness tends to have a statistically-significant contributor to the effect, but it is nowhere near the type of parameter that mass has.

This is a little bit of leakage because drunk drivers tend to get into more crashes than other people, and that tended to leak -- that a numerical artifact -- into the data to say that, whether you are drunk or not affects your risk, given a crash.

And we have been able to show that this is just an artifact.

This, right here, is another vehicle parameter that we are looking at. Airbags tend to offer some benefits. And then, vehicle age, which we don't fully have a physical description for, seems to enter into the parameter in this approach to the system. But, mass is clearly the dominant factor.

And when we tried to estimate out of crush this, as a response manifold, what we discover is, once again, over available crush and crushing of the vehicles, that the amount of crush -- the mass dominates significantly the crush effect, very little effect from the crush.

Now, I can change this if I make the vehicles about a meter longer, and I increase -- and I make sure that that meter has -- is mostly empty space so I can absorb the energy, and I also increase the distributions of the crushes of the vehicle, and I am getting, once again, the crush is from NHTSA's fleet model, and from NCAP data to make my estimations.

If I increase it by a significant amount I can get crush to dominate over mass, but I have to make the vehicles at least meter longer, possibly two meters longer, and they have to have a lot of crush space in there to compensate for the effect of momentum and velocity.

I am not going to go through this too much because Chuck already went through what he did. We are just going to pull out those things that we can compare to Kahane's analysis.

And, just sort of as a comment, the way Chuck described it, it is very similar to the way, at least, I am attempting to describe it, it almost sounds like Government/industry collusion, it is so similar, at least from my standpoint. Chuck may feel differently.

Okay. So here's what we are going to do. We are going to use the models taken from -- as a velocity effect, we are going to look at the relative ratios.

Then we are going to try and determine a risk function of all the -- and we are going to have to normalize for all the different parameters, age, belt use, airbags, everything else that we found to be significant and find what we can use in the model without causing contaminations of leakage.

Obviously, I am not going to include drinking and there will be no quantum mechanical effects.

Okay. From that, we look at the velocity distributions. Once again, a gamma function, another gamma function. We are going to integrate over all of this to get the risk, and then we are going to get an estimated risk now.

We are going to look at societal risk. We have been using societal risk for about ten years. We think it is the best estimate, and I notice that Steve presented it as the estimates they were using. It is good way to look at it.

You are looking at the overall -- and also, Chuck, you are looking at the overall effect of what this has. So, when we are done with it, we then have to consider, not only the effect on the vehicle of a given mass, but all the other vehicles that it collides with, and you have to do the integration, and the integrations depend on all the other parameters that you have.

If you change the other parameters, you change the mass distribution, you change the velocity distribution. You change a number of the other factors, the age distributions, you are going to get slightly different effects every time you do this.

So, it is dependent on a moment in

time. Nothing is inherent. It depends on every -- it all depends on everything else.

So this is the curve, and to sort or reexplain what Chuck tried to explain, you will see this slope rises faster than this slope does. So, what happens is, this represents a normalized societal risk.

And for those people who are familiar with normalization procedure, you are probably asking why is this risk 2.2? Why isn't it at 2, which is where it should be, because you have a risk for both cars?

And the reason is, the normalization procedure that we use assumed all the masses are the same. So what happens if we run a hundred million crashes, all the masses are identical, what is the risk that comes in.

And so, because of -- just because of the mass distribution in the system, the risk rises up a little bit as a result of that.

So, if I do the integrations over this, I will discover there is more area under this curve than there is under this. And so, the effect for reducing mass for the heavier vehicles is smaller, and this tells you about how much smaller, then it is, then, the effect of reducing mass for the lighter vehicles.

So now, we want to compare it to Chuck's, so I have to map Chuck's into our domain and I have to map ours into another domain in order to be able to make a direct comparison.

And we are going to use what we call the relative rate to societal risk to determine -- to make the comparison. And this is the comparison in the values.

So, here's what you have got. These are -- these are our mappings of Kahane's work into our model, and you can see that, in general, they are about the same. The red dotted lines are error terms that we are -- or 95 percent confidence.

And these lines are the 95 percent confidence that Chuck had, and you can see they are about the same. Obviously, not exactly the same. And you can look at it one of four ways.

One is, we are both right. We are both wrong. One of us -- Chuck is right, and we are wrong, but we get the same results by accident. Or, we are right and Chuck is wrong and he got the same results by accident. All those -- all four are still possible.

But the only thing you can say is, they are relative -- they give you about the same estimations, although I think, overall, ours is a little bit lower, but not by much.

This is in a -- this is what happens if you do the entire fleet by a hundred pounds. And, since I am given a -- the red card, I will move faster and explain this.

This is the -- this is what happens as I change mass, overall in the fleet, what the risk will end up being. And you can see up where around here, 300 pounds. It is almost linear. It is not quite. It is to the sixth/fifth power is how it rises, but it is pretty close to linear as you remove mass from the vehicle.

Now, this is removing the same amount of mass from all the vehicles. If you remove more mass from the heavier cars -- and we have done a number of similar -- from the heavier vehicles, if you remove more mass from the heavier vehicles, then this curve comes down.

So, we did that phenomena. We used the scaling laws -- and I am assuming everybody knows what that means, plus we use -- said, "Okay, we are going to get this much additional crush by mass reduction, and we are not going to make the vehicles smaller. We get smaller components in the vehicles, so we will get a little additional crush."

If you add all that, then your

risk comes down quite a bit. But then you discover you don't get the same fuel economy benefit so, when you compensate for that, you end up having to pull more mass out, and it is basically about half of this value.

So, instead of being about two and a half, 2.7, you are about 1.6, 1.7 is where your risk is, so it is even lower than what this is as the best estimate of where we might be.

And with that, I will just quickly go through the summary and conclusion -- is we did a fleet fatality risk model. This is the second one I presented. I presented one in 2011, but we have had this model for about ten years.

It is based on conservation of momentum and empirical relationships which is basically inverting the accident data, and the current distribution of vehicle parameters.

Like NHTSA, we are using societal risk. We think that is the best estimate.

And the theoretical model is consistent -- in other words, when we use conservation of momentum and we take the velocity data, it gives us the same risk that we -- we predict what the risk should be out of the accident data for M1 versus M2.

Okay. Kahane is assuming that -- Kahane's results is based on the same -- although it is statistical, the physics is basically the same. It is a function of the velocity distributions and mass distributions that we have in the field and conservation of momentum.

Anytime you have model uncertainty, you should never really -- there is always uncertainty. We check to see that the models stay, but we did our best to try and remove the modeling error, but you can't ever completely eliminate them.

And what we found -- vehicle size, we did have a relationship between things like SUVs and minivans, but we found that stiffness was a greater parameter, or a greater effect in determining why there are differences between the bigger vehicles than the smaller vehicles than actual available crush.

And so, both of them are contributing and it adds a little bit. It is nowhere near the effect that mass is, but it does add a little bit, and you have to take care, you have to consider conservation of energy, which means the force deflection history has to be include in how you are interpreting it.

You can't just look at crush, because that is not going to give you a whole lot. The mass ratio exponent was 3.8, and that is consistent with the velocity which is also about 3.9.

There is an advantage to being belted. Hopefully, everybody knows that. And the other thing is, don't get old.

Okay. And for front-left crashes, they -- you have an offset. You are more at-risk in the side impacts, but the exponent is slightly higher. And, once again, don't get old.

And, in summary and conclusion, the effects of mass on societal risk, it is a function of crash velocity being greater risk, having more energy into the occupant, conservation of momentum, and it gets a lot of the fact from the parameter distribution.

If you change the parameter distribution significantly, you could probably wipe out the effects of mass. If all of the vehicles are the same mass and I lower it a hundred pounds or 200 pounds, I am not going to see anything.

If I increase the crush very significantly, I am going to see an effect of that, and mass will probably disappear and not be statistically-significant.

And, with that, I would just like to thank a number of people. Chuck Kahane, for helping us with the data. Fariba at

Chrysler. Chan Ping at Chrysler, and Jeya Padmanaban, because she provided us all of the data that she has done, and it is extensive.

And with that, I will take any questions.

(Applause.)

MODERATOR BONANTI: Thank you, Guy. Okay. Several questions, I am sure.

"Can you summarize the difference between your approach and NHTSA's simulation study by Steve, NHTSA yesterday afternoon.

MR. NUSHOLTZ: Steve NHTSA?

MODERATOR BONANTI: Oh, Steven Ridella.

MR. NUSHOLTZ: He has got a new name.

MODERATOR BONANTI: I know. That is what it says. Steve "at" NHTSA. But it doesn't say that.

MR. NUSHOLTZ: The answer to that is no, but I am going to attempt. What NHTSA is doing is, they have a model -- they have a model of the vehicle, and they have a number of vehicles, and they take those models and run them into each other and get an acceleration time history, a deflection time history, the response of the vehicle.

Then they take that vehicle, put it into a MADYMO model and use the MADYMO dummy to get a risk result. In other words, they use the assessment values out of the MADYMO model and run it through a number of risk curves to estimate what is the societal risk.

The difference between my model is, I take the accident data and a number of other sets of data, because I have to get mass distribution, sizes and everything. I parameterize them and then I write a set of equations relating to conservation of energy and conservation of momentum.

I use the finite element models to help me understand what the rebound velocities are going to be in cars, how cars will deform, what sort of deflection they have. But all of that is parameterized, and I don't use it directly. I use it very indirectly.

MODERATOR BONANTI: Okay. Thank you. To follow upon that, there is a -- "Also, could you please describe the differences between yours and the Kahane approach. And please focus on methodology differences."

MR. NUSHOLTZ: It is -- it is not quite the same, but it is almost the same. Kahane's is doing it pure statistically. He is looking at the statistics.

Obviously, he understands conservation of momentum and the velocity effect and that risk, and he is using that, I think, to guide him through the statistics, but he is basically just pulling out the -- just straight from the statistics.

Okay. That is -- that is one thing I don't want to do because what we do is, we force our data to meet the laws of physics, conservation -- not all of them, but conservation of momentum and conservation of energy.

And so, when I do a statistical process, and I get something which violates that, then I change the process.

The other thing is, he just takes the data, and everything that I am doing is parameterized, so I can do it in close form, which means I can solve integral equations and get the results that way. I can take derivatives of my data.

And his is not a model, so he can't do that. His is pure statistics, and mine is a mix of statistics, which is parameterized and then turned into a model.

MODERATOR BONANTI: Okay. Thank you.

"Do you have, quote, 'the exposure measure,' end quote, to look at the risk -- the fatality risk in your approach? If 'Yes,' what is it? If 'no,' how is your fatality risk in the model defined?"

MR. NUSHOLTZ: Okay. I am going to have to interpret that. When you say "exposure," I am assuming you are talking about per mile driven and now -- we don't know, so I am going to assume that.

But, I am looking at just what happens per accident, so it is not the overall exposure. It is, given an accident, these are the results. You can get very different results if you look at it by exposure.

I don't like exposure data because of the difficulty of actually getting the miles driven or using it by registration or anything else. That introduced an error that my model won't tolerate, so I can't do it.

MODERATOR BONANTI: Okay. Thank you.

"Other researchers have found track width was a significant factor in vehicle size instead of wheel base. Did your research go to this level of detail?"

MR. NUSHOLTZ: Okay. We looked at three parameters. I only presented wheel base because that was Leonard Evans. But we looked at track width, footprint and wheel base.

And we get basically the -- there are some differences, but you get basically the same results.

MODERATOR BONANTI: Okay. A follow-up question was, "How many vehicles are in your fleet? Is the comparability -- is this comparable to NHTSA's DRI or LBNL's fleet with regard to your model?

MR. NUSHOLTZ: When you -- in the model, once you generate the model, I can run a hundred million vehicles. I can run a thousand million vehicles, you know, a billion vehicles, if I have enough computer time.

So, how many are actually in the model? I think the question is, "How many vehicles did we use to build the model?" I don't exactly know, but I used everything that Kahane gave us, so everything that is in his statistics.

Plus, I had to take data, additional data from NASS and from the state data. So, it is whatever it is, Kahane's "plus."

MODERATOR BONANTI: Okay. "Delta velocity and the conservation of momentum are important, but isn't delta acceleration more important? Delta acceleration can be controlled by vehicle design, such as energy management. How do you account for this?"

MR. NUSHOLTZ: Well, obviously, I wasn't clear. The way we are looking at acceleration -- I talked about forces and if there is not a direct relationship between force and the acceleration of a vehicle.

And the other problem with acceleration of the vehicle, you have to assume that there is no deflection and you just do it as a -- as a rigid mass.

But assuming it is the acceleration of a nondeformable vehicle, we are looking at -- rather than looking at the acceleration, we are looking at the force as an estimate of the force and deflection as an estimate of the rate of energy transferred to the occupant, and that is generally what the acceleration time history issue is for.

It is not the same, but that is the method we are using.

MODERATOR BONANTI: Okay. "Is increased risk of weight reduction a transitional issue? Is there a crossover point at which the overall fleet has a benefit from weight reduction, five or ten years?

MR. NUSHOLTZ: That depends on all sorts of factors that we don't know, because it is going to depend on what is the parameter distribution, what is the mass distribution, what is the stiffness distribution -- if you can use the word "stiffness" -- what is the crush distribution, what are all these different distributions that are going on will be needed to be found -- understood or be able to predict in order to say whether there will be a crossover or not.

It is a very complicated problem and requires understanding what the vehicles will be in the future.

MODERATOR BONANTI: Okay. "Does your study separate mass and size as two control variables? In your model, does the -- does M represent both mass and size, or" -- I am sorry -- "or does your model discuss mass and size separately, not the same -- in the same equation?"

MR. NUSHOLTZ: My model doesn't talk, so it doesn't discuss anything, but the way -- the way that we look at it is mass ends up being related to conservation of momentum and size ends up being related to conservation of energy, and we try and address it through those two physical laws.

So, "size," primarily we are looking at two things. One is the available crush and, two is the force deflection history that comes on it and we address it by that method.

MODERATOR BONANTI: Okay. "Speaking of physics, is it the same if two cars crash? Take, for instance, the first car is 3,000 pounds, the second car is 2500 pounds. However, there is an additional 500 pounds of sand in the trunk. Explain."

MR. NUSHOLTZ: Okay. This is -- this is a complicated problem. You could ask the same question with, "you have got two people in the car."

So, if the sand is allowed to fly freely, the sand has no effect. If the sand is bolted down to the car, then it will have an effect.

Occupants in the car generally bounce around, but they are seat-belted and so, in fact, when they are coupled, that mass has an effect on the vehicle response. When they are uncoupled, it doesn't have an effect. So, it depends on how coupled it is.

MODERATOR BONANTI: Thank you. "Have you considered using recent results on the physics of crumpling to test impacts? Was that included in the -- in treating stiffness?"

MR. NUSHOLTZ: The stiffness -- the answer -- the general answer is no. I could stop there. But the stiffness, I look at the force/time history that comes out of NCAP tests or comes out of the fleet model that we have gotten from NHTSA to try and estimate what is going on, and that is what determines the stiffness.

We don't look at individual mechanisms, whether the beams are deforming, whether they are crumpling, whatever. We are just looking at the contact forces and whatever causes that is the -- are the things we are looking at.

MODERATOR BONANTI: Okay. These -- this is the last card that we have time. We are already over. So, if you have any further questions, we will try to either ask them during the panel discussion or through the docket.

"Any theories as to why older people who are belted have a higher fatality rate than younger people? You would expect more broken bones, but why more fatalities?"

And then the second question is, "Please explain why you stated crash" --

MR. NUSHOLTZ: Let me answer the first question.

MODERATOR BONANTI: Okay.

MR. NUSHOLTZ: And then you can get your interpreter to understand what that is.

When you get older, you are basically weaker, so you have greater rib fractures. And, when you have a rib fracture you can impinge more on the internal organs, the heart, the lungs. So, that is going to increase injuries.

But it is not just your ribs. You

have got problems associated with your neck and your spine and a lot of other areas. You are just not as resistant to impact.

If you hit an older person, it is going to hurt more than if you hit a younger person.

Okay. Has the interpreter told you what you have got there?

MODERATOR BONANTI: Yes. I am glad I have Jim in my shin back here to look at this, too, get another eye.

"Please explain why you stated crash distances of" -- oh, excuse me -- "crush distances of greater than one meter are necessary to offset mass reduction. The presentation yesterday showed 100 millimeters added crush distance had a substantial effect on reducing acceleration levels."

MR. NUSHOLTZ: Okay. There is -- first of all, I think the one yesterday was statistical. Ours is physical. So, in other words, to reduce the amount of energy or the rate of energy going to the occupant -- you can go through the calculations and you will find it is about that much.

So, ours is based on the physics. The other is a statistical estimation and you can believe which one you want.

MODERATOR BONANTI: Well, thank you very much, Guy.

(Applause.)

MODERATOR BONANTI: Okay. Our next speaker -- we are ten minutes over -- is Joe Nolan from IIHS. He is going to be speaking on the relative safety of large and small passenger vehicles.

So, thank you very much.

MR. NOLAN: Thank you. I am going to be doing something a little bit different. I am going to look for more like a thousand-foot view or a 10,000-foot view at the problem of what I call compatibility, size of weight, sort of the same issue, and see sort of where we have been and where we are heading and are we on the right trajectory for protecting people in crashes despite the size of the vehicle or the weight of the vehicle that they are in.

And I won't use any quantum physics. So, just a quick reminder of where we have been. This is fatality rates per mile driven over time. Sixty years of data here.

As an industry that is trying to reduce fatality rates, we should all look at this and be very proud. There are some upticks and some little movements here and there, but we continue to beat the fatality rates down year after year after year.

And, if we look at our fleet, these only go back to 1983. Just to give us an idea that things -- things are changing over time.

To the left-most bar is 1983. This is showing the cumulative distribution of weight in the fleet. And the right-most bar is actually 2008.

So, somewhere in the 1990's, we kind of porked up. We added mass about, on average, 700 pounds. But, in the last -- in 2012, we have actually crept backwards just a little bit. This is, I think, some of the efforts at getting better fuel economy.

Same issue for size. It is not one-to-one. I know there is a lot of debate in this audience about size and weight and how they are coupled together, but same kind of thing.

Vehicles grew. I heard discussion earlier in the group about Honda Accords and, you know, how much they have grown over the years, if you go all the way back to their original introduction in the US.

So, jumping back 20 years ago, these are fatality rates in vehicles, cars, pickups and SUVs, and the trend is pretty constant, has been for a long time.

When we saw it earlier today, the lighter vehicles have higher fatality rates.

The heavier you go, the lower your own fatality rate. So, that is the situation 20 years ago. And I am going to keep the scale constant now and jump forward a decade.

So these lines have all dropped down, quite positive, and also changed slope a little bit, so the big disparity between the lightest and the heaviest has ironed out a little bit.

And let's jump forward to today, or as close to today as we can study. These lines are dropping even further. This is tremendous progress.

If I look at that same chart by size, you see the same trend. The bigger the vehicle, the lower the fatality rate. The smaller the vehicle, the higher the fatality rate.

But, in aggregate, the takeaway is all of these rates are dropping down. And so, if we look at this -- this is just for cars -- just as an illustration over time -- this is

20 years ago, 10 years ago and now.

What that means is now the smallest cars or small cars in the fleet are offering a level of protection only afforded by the largest cars in the fleet 20 years ago.

That is a huge improvement in safety. That doesn't mean there is not still a disparity between small and large or big and/or light and heavy, but we have made huge strides in dropping these.

Same trend is evidence. I am just showing the relationship to size. Same thing, the smallest size vehicles are offering protection only available 20 years ago on the largest of cars.

So, that is basically my summary. You know, across all vehicle categories and across all weight ranges what we are seeing, over time, is a reduction in fatality rates.

What we also see is that the effect of mass, and at least with today's construction style, size, that trend is also evident that heavier vehicles are more protective than lighter, larger are more protective than smaller.

But the good news is, we have neutralized some of the gap. We have equalized. And I have heard that phrase earlier today, actually. So, how did we do that?

So, if you look at countermeasures for occupant protection, improved crashworthiness was raised earlier today by a number of the speakers.

I can illustrate that. I am using IIHS ratings here, but these could be NHTSA ratings. It doesn't matter. So these are frontal crashes, 40 percent, 40-mile-an-hour crashes.

The left bar is from 2003. These are the vehicles that we rated. Red is a poor rating and the darker orange is marginal. Green is good.

So, if you look back in 2003, the

small cars were dominating the poorer ratings that IIHS published. And, if you look at the largest of cars, we didn't have any. So, what this is sort of saying is that there has been a disproportionate improvement in small cars relative to large cars.

That doesn't mean the large cars are unsafe, it just means the small cars had a longer way to go, and this is really evident in this slide. So, this is the same setup, but it is looking at side-impact protection.

And what we saw in 2005, the first time we rated small vehicles for side impact protection, which dominated the poor ratings categories, that small cars were getting torn to pieces in this test.

Jump forward to 2013, every vehicle is good. That is a huge improvement. So, again, there has been a relatively larger improvement for small cars, as large cars, and that is helped balance the size/weight issue quite a bit.

The other area of improvement -- this is improving vehicle compatibility. I think we heard reference to this earlier. There was an effort -- 2003 kicked off for automakers to get together and agree that they would sort of amp-up self-protection in cars via side airbags with head protection.

At the same time that they were going to take their light truck fleet and make their structures either with blocker beam or lowering of structures, interact better with the better with the front structures of cars.

So you have got two elements of this compatibility. One was self-protection and one was a partner protection.

And the way we evaluated this is - or like to look at it, is by looking at partner vehicle death rates and it is very important that you understand the setup of this slide, because there is a number that follow.

And so, if I may deviate from the

norm, if somebody's confused, we should answer that before I proceed, or you will continue to be confused.

So, on the bottom is the weight of the -- what I call the striking vehicle. The striking vehicle is indicated in the legend as a car, an SUV or a pickup truck. And these are death rates in all cars. So, it is unrestricted.

So, these are cars striking cars, SUVs striking cars, and pickups striking cars. So, just to make sure we have all got it, this point right here where the mouse is pointing would be for a 5,000-pound SUV category vehicle striking a car. And so that would be the fatality rate.

And so, what you see is, back a decade ago, a relationship that the higher the striking vehicle or partner vehicle mass, the higher the death rate in the opposing vehicle.

Jump forward a decade, and that rate has dropped significantly. Now, this is all crashes rolled together. You can pull this apart and ask what crash mode is driving this.

So, if we just look at front-to-front crashes, this is the same chart I started with, but now just limited to front-to-front crashes.

You can see the pickups are the pretty bad actor here. We don't know all of the reasons for that but, nevertheless, their fatality rates by partner vehicle fatality rates are extraordinarily high relative to cars and SUVs are also higher than cars.

This is most evident -- so, if you jump forward a decade that all improved. There still is some room for improvement, I think, in the -- in the pickup truck compatibility, if you will.

And this could be -- and I hate to get off on a tangent, but this could be a mass categorization issue. Pickups are very difficult to know what is actually out there in the fleet versus what is the curb weight.

So, same slides now, but moving to side impact. This is 10 years ago. Again, pickup trucks, SUVs have much, much higher partner vehicle fatality rates than cars hitting cars.

With these improvements in cars, for self-protection and possibly some of the improvement to the light truck fleet to better interact with cars, these rates have dropped down significantly, to the point where SUVs striking cars, from a fatality rate standpoint are indiscernible from cars. And pickup trucks are just slightly ahead.

I mean, this is phenomenal progress. Now, hiding in here, because this is all -- everything is intertwined, hiding in here are other countermeasures that are not related to the vehicle.

I am not going into a lot of detail today, but we are, as a safety community, doing things like installing red light cameras.

The primary purpose of a red light camera, from a safety standpoint is to reduce high-speed intersection crashes. That is these crashes. So, some of them are just going away or becoming lessened by our interventions.

The other is roundabouts. Roundabouts on the roads virtually eliminate high-speed intersection crashes unless you are crazy and drive straight through the roundabout.

So, I don't want to say this is all vehicle-related, but there is -- there are other elements of what we are doing as a safety community that contribute to the reduction in the most serious crashes that we are trying to battle.

And so, these are the same slides, but just giving you the chronology. So this is SUVs ten years ago, partner vehicle fatality rates. They drop down. Oh, I am sorry. It was 20 years ago. This is 10 years ago, and that is today, or as close to today as I have.

This is pickup trucks 20 years ago, 10 years ago, and today. And the time line for side impact is -- that is SUVs 20 years ago, 10 years ago, now. Pickups -- it is just a different way to illustrate the same data that were on the previous slides.

So, there has been a lot of discussion about crash involvement and the nimbleness of small cars, and the Institute, Insurance Institute has always countered that with data from the insurance industry that we collect.

And we look at claim frequency by vehicle size. This is a little bit busy, and I apologize, but the main body of data in this chart is two-door cars, four-door cars, SUVs and pickups. The others are much smaller categories of vehicles and are subject to sort of onesie, twosie, type of -- type of things.

But we have seen historically is that the smallest cars within any vehicle category have the highest collision claim frequencies, how often do you file an insurance claim for damaging your vehicle.

That is been consistent for as long as I have been looking at data for the Institute. That is, until this change. So we just wrapped up a report looking at these data, and those trends where the smaller or more frequently involved -- certainly for four-door cars, either -- has basically just disappeared. It is flattened out.

And, even in the other vehicle categories, the downward trend or the higher involvement of the smaller versions of each of the vehicles is not there.

We don't know the answer to this, but it is -- it is something we are trying to chase down.

A couple of hypotheses, smaller wheel base vehicles potentially get more benefit from ESC. That smaller wheel base gives them more steerability, but that may also be more -- potential steerability into trouble.

It could be that small cars just improved in handling, the same way that they did in crashworthiness, kind of disproportionately.

Could be changing demographics. I think I spoke with somebody at the break about this, that maybe, instead of younger people, low socioeconomic folks driving inexpensive small -- smaller cars.

We have got daily commuter people swapping out larger cars for smaller cars. So, we are getting more large car drivers in small cars.

It could be economic factors. And the last bullet on there is, this could be purely just an insurance thing. So, don't take any of this as gospel, because we need to sort it out.

It could be that bad economy leads to people censoring claims, and people in small cars are censoring more claims than people in large.

We will continue to chase this within our company. So, to summarize, and hopefully, I will get us back on time, the Institute thinks it is critical that we continue to push for crashworthiness improvements.

The great thing about crashworthiness improvements is you carry them with you every day. It doesn't rely on exotic technology to activate, and it usually doesn't require much for the driver to do. It is just the -- it is built-in.

We are mostly there, quite frankly, with the fleet of really strong front structures, side structures, roof structures, head-protecting airbags for side impact.

We are getting there in the fleet. We are nearly there will all new products. It is -- it is very encouraging. I think the capability efforts were -- were a good payoff for us, and I think the fact that the industry did this voluntarily is -- should deserve a hat-tip.

Electronic stability control. Huge change in crash modes. I think we are just now starting to see the effect of that, of how it is moving crashes around. I don't have a slide for it but, you know, SUVs rollover tendencies now are very different than they were 10 years ago, and the types of crashes has completely changed for the SUV fleet.

It is not all completely understood, but we have to recognize that the addition of SUV -- ESC is not only eliminating crashes, it is moving the relative importance of each crash mode around.

And then, of course, belt use is hiding in there. We have had continued improvement over decades, so some of this self-protection is based -- you know, based on belted occupants, or more people being belted.

And the last sort of thoughts, piece, we are always going to be dealing with disparate size and weight vehicles in the fleet. The amount of disparity may jiggle around a little bit, but it is the reality.

And, as such, and bowing down to the laws of physics, lighter vehicles are always going to be at a disadvantage when they have a frontal crash with a larger vehicle, no matter how much metal they put in the middle, there is that issue of momentum transfer.

But, we are mitigating that benefit via technology, structural engineering, things like, you know, side airbags that sense rollover crashes.

You know, smart technology, seat belt technologies are helping alleviate some of that big mismatch.

And then, of course, the big thing coming down the pike is crash avoidance technologies. Things like Ford collision warning, we know from our own analyses, are working to reduce crashes.

For some models, up to 15 percent of collision claims and property damage liability claims are disappearing with the presence of vehicles with some amount of autonomous braking.

So, we know that that is going to help and those will continue to just improve. I want to throw a little thought out there, though, to the auto industry guys -- you can bring this home to your marketers -- it seems to us that these forward-looking technologies that we know will be beneficial probably should be targeted on the most vulnerable part of the fleet first.

So, what we see historically is the large luxury segment gets the exotic forward-looking equipment, and then it trickles down over time. But, if you want to attack this problem more quickly, would be to see if there is a way to get these technologies in the smaller cars sooner rather than waiting for them to trickle down through the luxury segment.

With that, I would be happy to take any questions. And thank you for your time.

(Applause.)

MODERATOR BONANTI: Well, thank you, Joe.

Any questions?

(No response.)

MODERATOR BONANTI: Any questions from the web?

(No response.)

MODERATOR BONANTI: You answered all their questions, Joe.

MR. NOLAN: Perfect.

MODERATOR BONANTI: Okay. Well, I -- unless -- is anyone writing anything at this point that needs to have Joe --

(No response.)

MODERATOR BONANTI: Okay. Well, if that is the case, let's thank you again.

And let's start the panel discussion. So, if I can have all of the speakers take a seat.

Okay. Is Chuck Kahane here?

(No response.)

MODERATOR BONANTI: Okay. Well, we will wait for Chuck.

In the meantime, we are collecting questions. Just bear with us about a few minutes. I would like to ensure that Chuck gets actually here, since we are starting a lot earlier than we should.

But, I think -- generally speaking, I think the discussions this morning, coupled with yesterday's discussions, are very enlightening and also provide a fairly good strategic approach and overview of the challenges that the industry is facing, as well as the regulators in this -- in this area.

And, with our collective interest for safety, I think consumers will be beneficial -- will receive a lot of benefit from the ideas and research and approaches that we have taken.

So, no further ado. For the panel. This is for everyone. First question. New light-weighted vehicles are projected to be stiffer. With an aging society, is there a potential for an undesirable interaction? What can be done?

Okay. I will go down the list.

MR. NUSHOLTZ: That is actually a fairly complex question, and you have to understand a lot of aspects of how the crashes occur in the field.

And it depends on the stiffnesses of the vehicles that you are colliding with. So, as you make a vehicle stiffer, you increase the acceleration of the vehicle, which means the rate of energy that is going into the occupant increases, and so you have a potential for increased injury because of that.

However, depending on the severity of the crash, that can also be used to reduce the amount of intrusion. When you have intrusion, you have another source of how you are making contact with the occupant.

So, under low-speed crashes, increasing the stiffness for elder or for younger will probably increase the risk. Under higher-speed crashes, it may reduce the risk.

So, depending on how people drive and what they want to run into and at what speed will depend on the effect of what the stiffness does.

MODERATOR BONANTI: Chuck.

MR. KAHANE: I wouldn't add anything to that.

MODERATOR BONANTI: Yes. Why don't you -- yes. Turn it on. Thanks.

MR. WENZEL: I would just add that

it would be very helpful for us statisticians to have good measures of stiffness of individual vehicles.

And I know Steve Summers has been trying to come up with alternative measures of stiffness for compatibility research. If we could somehow get that data reported by manufacturers by make and model, that will help us in untangling what the effect of changes in stiffness has on safety.

MR. NOLAN: I guess I have got --

MODERATOR BONANTI: You are on.

MR. NOLAN: I have got sort of a cautionary note, is that there is a limit to how small the front end of a vehicle can get to protect the fragile occupant inside, whatever age, and think -- you know, sort of going to the limits.

If we reduced -- took away the engine and just had a firewall with the driver sitting behind it, obviously that would be bad outcomes in frontal crashes, even if you made that front firewall infinitely stiff.

So I think, as an auto-making society, we need to recognize we might be pushing the limits of the fixed amount of frailty in human beings, the speeds we drive and the package size.

So, at some point we have to say this is -- this is the minimum package that we can have, the minimum amount of crush space we can have, because heavily-tuning airbags and restraint systems to barely meet various safety requirements in controlled crash tests probably means they are not being very protective or as protective in the whole spectrum of real-world crashes.

So, there is a limit to how small the package that carries occupants at 60, 70 and 80 miles an hour can be.

MR. VAN AUKEN: Yes, I don't have much data, other than the fact that you don't want to -- the results indicate you don't want to decrease the footprint of the wheelbase or track.

It is okay to reduce the weight, but not the footprint or size of the vehicle.

MODERATOR BONANTI: Okay. Thank you.

MR. NUSHOLTZ: Just let me respond. Just a restatement of what I said before is that stiffness is a poor definition of what you are doing, because you have to deal with the entire force-deflection history, which is a lot more complicated than stiffness.

Vehicles can be very stiff in one domain and then soft in another and that may be better for the occupant, and then very soft in the first domain and very stiff in the second, and that could be very -- that could be worse for the occupant.

So, the term stiffness, you have to be very careful about what you are talking about because you have to deal with the entire force-deflection history.

MODERATOR BONANTI: Okay. Thank you. This is a very long question, so I apologize.

(Off-mic comment.)

MODERATOR BONANTI: No, you don't have to time me, but thank you.

Replications of Dr. Kahane's analysis, done for the ICCT by DRI, adds an analysis of the two separate effects of mass on crash probability and crash outcome.

The analysis shows that while there are some apparently statistically significant relationships between mass and crash probabilities, there are no statistically significant negative effects on mass on crash outcomes.

Are there any theories consistent with this result?

That is the first question.

Does this change NHTSA's understanding of mass and safety?

And then it goes on to say, the

word apparently is used chiefly because of the strong effects of choice of exposure measure or a statistically inferior -- I apologize. Statistical inferiors -- that is what it seems, -- but also because of seeming anomalies such as the apparent harmful effect of mass reduction on pedestrian fatalities.

Do you want me to ask the -- the specific questions that are in here, but I wanted to give you the context.

MR. VAN AUKEN: So, do you want to go through it point-by-point, then, or just try to summarize some -- some --

MODERATOR BONANTI: You can summarize --

MR. VAN AUKEN: Okay.

MODERATOR BONANTI: -- your thoughts on this, but ultimately what it is saying is that there is no significant impact -- negative impacts on -- of mass on crash outcomes. Is that correct?

MR. VAN AUKEN: Yes. The -- if we

were to -- what we found is that the fatalities per accident results, which are both measure of crashworthiness and crash compatibility are relatively flat.

You know, the effect -- you know, if you were to plot this as a slope on a -- versus a curb weight, that that effect is relatively flat, and that is due to, we think, the equalizing effect of the various safety standards and various crash tests ratings and so on, and the effect of the -- the intelligent, you know, vehicle design, engineering over, you know, addressing the physics.

And that tends to flatten out or has addressed a lot of that effect that you might otherwise think would be a sensitivity. And what is left over is a small -- is another effect, which is also in -- in the scheme of things, relatively small, compared to other factors, and that is the crash involvement effect, and we don't really have a good explanation for that.

Theories are that it may be a driver behavior effect, you know, risk-taking, and it could be some other factors, as well, but it is -- we don't really have a good understanding of it. It is -- it is -- beyond the crash physics, it is the precrash effects that are -- seem to be driving the problem at the moment.

MODERATOR BONANTI: Is there anyone else?

MR. KAHANE: This question keeps coming up like a bad penny, and I am wondering why doesn't anybody ask it the other way around? I always hear it this way around.

The -- the increase in crash frequency for lighter vehicles is anomalous, therefore, it is meaningless and then we have this no effect on crash -- on severity per -- injury severity per crash.

Why not ask it the other way around, or say it other way around? These results showing the injury severity per crash is equal across all vehicle sizes is anomalous, and therefore should be discounted and, you know, just take it from there.

I think, simply based on -- on delta v ratios between two vehicles, that -- that light vehicles hitting heavy vehicles, the lighter vehicles have higher delta v's, therefore, will have higher injuries in those crashes, therefore, should also have higher injuries over the, you know, higher injury rates per crash overall.

If you are not seeing that in the data, I would say that is anomalous and I said before that I believe these have to do with reporting rates, are different for different types of vehicles, different sizes and masses of vehicles, and these differences may be so small that they may be very difficult to find in any analysis.

But the problem is that our signal, which is the societal effect of mass reduction is itself so small that it may be overwhelmed by some of these reporting differences.

MR. NUSHOLTZ: I would sort of call it a bad nickel.

MODERATOR BONANTI: You are increasing the cost.

MR. NUSHOLTZ: Yes. Of course. We could go up to a dollar, if you want. They -- every time you look at a crash-to-crash masked, as far as vehicle parameters, tends to dominate over most everything else -- not always, but most of the time -- and as I explained and Chuck explained that, because when you reduce the masses in the larger vehicles you have a slight societal benefit, but that is overcome by the reduction of mass in the smaller.

And so, when you do the integral across the entire space you end up with a small change in societal risk, and you have to be very careful to sort through that, otherwise you can have all sorts of statistical anomalies.

You don't collect your data right. You have linkage between the regulatory responses and the mass, and you have link -- like one example, linkage where I had where drinking actually leaked into a vehicle parameter as if, when you drink, your vehicle also drinks.

So there is -- all of those things can contaminate the results, and I would think that that is an anomaly.

MODERATOR BONANTI: Okay. Thank you.

I have several questions, so this is good.

If vehicle mass differential is truly important, why are OEMs not required by NHTSA to perform a frontal crash test with a specific weight barrier instead of a fixed, unmovable barrier?

That is the first question.

This type of testing could be accomplished by actual vehicle tests or CAE analysis. The results could identify efficient and safe vehicles, as it would take vehicle and restraint system design into consideration.

This is not -- no, I don't want you to speak for an answer, but this is the question. So -- Chuck is the only one that I would think, but this indicates that it is for Jim Tamm or Steve Ridella and may have an answer.

But, to be perfectly honest with you, at this point, we are -- I think we are not going to answer this question. Yes. I didn't read it before I read it.

MR. NUSHOLTZ: It is beyond -- it is well beyond our poor powers to add and subtract.

MR. KAHANE: You should do the Johnny Carson thing and tear it up before without asking it.

MODERATOR BONANTI: It is already on the record. Okay.

MR. NUSHOLTZ: Okay. You are doomed.

MODERATOR BONANTI: Yes.

Is there a correlation between fatality index and vehicle damage in a crash event based on the parameters described this morning?

MR. NUSHOLTZ: Yes.

MR. NOLAN: I think he has got it.

MODERATOR BONANTI: Okay. I am going to read these before I ask.

Personal safety versus societal safety: what will drive the buyers' preference?

MR. NUSHOLTZ: I am sort of speaking for the rest of the universe, including people on Earth and off of Earth. Most people generally like to keep themselves safe first, and then worry about other people -- although not everyone.

And so, when you consider what vehicle you are going to buy, you will consider, if it is your domain, the safety features in that vehicle.

I am certainly not going to argue with that, but an interesting thing to point out is that some of the most successful fuel economy improving technologies actually increase mass while they improve fuel economy.

For example, hybrids, as far as I know. So, maybe -- maybe that will give a little bit of a trade-off in this area.

MR. WENZEL: Yes. And having said that, I mean, the proper perspective of a regulatory agency is societal risk. Right? And so, I don't think anyone argues or questions that.

MODERATOR BONANTI: Okay. What is the best way forward: statistical analysis or physical analysis? What should be considered moving forward, itself

MR. WENZEL: By physical, you mean

yesterday's presentation?

MODERATOR BONANTI: No. Like utilizing physics versus statistics. It says physical, but my -- my assumption, although it doesn't say physics, but physical analysis would also be based on the footprint analysis, based on mass, or looking at statistics.

MR. NUSHOLTZ: There is an ancient Precambrian statement that all statistics are wrong, but some are useful. Therefore, in my mind, and it is basically the way my model is set up, is that you have to have some statistical construction and you have to do that because, at some point, you have to attach yourself to reality.

The only way to do that is through the accident data, and one of the methodologies to do that is through statistics. However, as I pointed out, statistics can give you artifactual results, things which even violate the physical laws.

You can have crashes which will

create people. You can have effects in one vehicle on an -- airbags in one vehicle affecting people in the other vehicle through statistics.

You can get leakage from, say, the regulatory or from the rating task, or people change that, and that shows up as a mass variable.

So, statistics can have all sorts of contamination. You need them both. You can't just say, I am only going to do it one way without the other. Because, if you just do it by the modeling, you can have as many errors with modeling as you can with statistics.

So, you need them both, because you have to attach to reality.

MR. KAHANE: And, again, a lot of things get mixed up. The fatality ratio, fatality risk ratio in a crash of vehicles of two different masses is a completely different story from societal fatality risk.

The effects of mass on societal fatality risk are quite small, as Tom said today, they are quite small compare to the effects of many other factors that affect risk in crashes, such as, for example, the age of the -- of the driver.

And that is something to keep in mind that makes complex trying to estimate what is the -- going to be long-term effect of mass reduction on societal fatalities, when it seems there are some relatively simple concepts that -- such as that when two vehicles of different mass hit, one can have a considerably different delta v than the other.

MR. WENZEL: And I also see that there is a value -- I mean, we are trying to predict what future changes in mass will have on safety.

But I think it is also very useful to go back and evaluate what did happen in the recent past, not necessarily trying to predict the future, but just to see, to evaluate what happened and understand -- try to understand what aspects of what happened had an effect in recent history. And I think that is always useful to do.

MR. VAN AUKEN: I would just like to add also that basically there are three things here that you have to consider. There is the effect of the crash on the subject vehicle, which we have been covering quite a bit with the simple physics models.

But there is also -- you know, weight has the effect on the collision partners, as well, given that there is a crash. And there is also the effect of the crash involvement, so there are three different things you have to consider here, and that is just from the statistical viewpoint.

And, of course, the manufacturers are trying to address all these and trying to engineer their vehicles to address and mitigate all these factors about mass and wheel base and track.

So, this is -- it is a complicated problem and it is not something that you can really, you know, try to draw a lot of conclusions from a simple equation.

And, in addition, there is also the -- the forecasting type models with -- with the simulation-based analysis. There are limitations to that analysis, as well, because you have to -- they are only predicting certain types of crash scenarios that may not be a complete mix of what actually happens in the crash environment.

It is not predicting the pre-crash phase at all, typically. It has been done in the past. And also, there is -- the injury outcome models are incomplete as well.

So there is -- you need both accident analysis and you also need the simulation, the fleet-type simulation analysis. They are complementary to each other.

MODERATOR BONANTI: Okay. Thank you.

Oh, did you have anything?

MR. NOLAN: So, I don't really have anything to add to the debate over should you use statistics or physics. It seems to me the two need to be intertwined, like Guy said.

But I want to throw out a cautionary note. My organization does a lot of analysis, a lot of statistical modeling, a lot of real-world analysis, and the specter of crash avoidance technology's effect on crashes is going to be huge.

And right now, it is very, very difficult to track because these technologies are optional on many vehicles, and they are not VIN-discernable.

So, when you start seeing a 20 percent reduction in one model's fatality rates or crash rates, well, maybe it is because they have got an AEB system, that autonomously brakes, or lane departure warning or blind spot.

And, we are not going to know about it. So, as a society and community, it is something we need to wrap our heads around because future models are going to be rife with confounds of optional equipment that potentially can have a big influence on, not just crash outcomes, but on crash occurrences.

So, it is a big challenge for the industry and I think for government, as well, to try to get some type of VIN information or some crash avoidance information indicated in VINs, because, otherwise, our analyses will be impossible.

MR. VAN AUKEN: I would like to add I agree with that completely. I would recommend that, as well.

MR. NUSHOLTZ: Let me just make sort of a comment with regard to trying to determine things which are related to crash avoidance.

A little while ago I tried to make an attempt to determine what cell phones would do, having seen the number of people almost collide with me while they were on their cell phone.

So, I went into NASS and a couple of other databases, and we did an elaborate statistical model, and we were able to discover that driving with a cell phone reduces your rate of crashes. And so, therefore, NHTSA should obviously implement a law that requires everybody to drive with a cell phone.

It took me about a year and a half to figure out what the error was that had to do with the sampling rate of data inside of NASS. But, trying to figure out these things which relate to what is going to happen before you have a crash, how do you determine something that didn't happen, and that it did not happen is extremely difficult.

MODERATOR BONANTI: Those are

definitely challenges that the agency is considering at this point, especially when crash avoidance is looked at.

However, the situation that you are all here for with regard to mass and accidents and other things, you are still utilizing that based on FARS, isn't that correct? And fatality and injury causation.

So, that leads into what -- where, if the crash doesn't occur, then the data -- that's another issue. The data doesn't exist. Exactly. You are exactly right. So --

MR. KAHANE: We go through a lot of nonexistent data.

MODERATOR BONANTI: Exactly. So, it leads to the next question.

MR. NUSHOLTZ: That is more -- that is more quantum mechanics when you deal with nonexistent data.

MODERATOR BONANTI: Quantum mechanics. There you go. Okay. So, it leads to the next question as to what are the pros and cons for including casualty risk in the analysis as a whole?

MR. WENZEL: Well, since I am the one that did that, I guess I need to answer that question.

One of the biggest problems with using the casualty data is the reporting bias. Not all -- well, not just reporting bias, but not all casualties are reported in the state databases, and then there are -- it is not clear whether a serious injury that is coded as such at the scene of the accident by the responding police officer is evaluated the same by the time the victim gets to the hospital.

A serious injury may turn out to be less serious than the reporting police officer initially realized, or an injury that didn't seem serious at the time of the crash ends in a fatality.

So, the accuracy of the casualty -- or the crash -- or injury severity is suspect in these state crash databases.

The real advantage to using the casualty -- well, there are two advantages. One is that we are not just concerned about fatalities. We're concerned about debilitating injuries, that those tend to be more expensive in terms of insurance purposes than a casualty, crass as that might be.

So, we are concerned about casualties -- or serious injuries, as well as fatalities. And the other reason to look at it is, when we are limited to only using data from a handful of states -- fortunately, there aren't enough fatalities to get the statistics we need, so then we need to turn to the serious injuries, as well, and that's the other reason that that -- that I have done that.

I don't know if anyone else wants to add to that.

MR. KAHANE: Aside from the issue of nobody is exactly sure what is an A injury, looking at the injury data is a great idea.

MR. VAN AUKEN: Yes, I would just say, it is a good idea but, you know, there is also some inconsistencies amongst the state databases as to how they classify injuries.

So, it is at the state level, as well as the reporting individual officer level, at crash level.

MODERATOR BONANTI: Anything from anybody else?

MR. NOLAN: Well, I have a comment that, again, probably isn't directly related to mass and size, but state databases, state data files, you know, are limited to certain numbers of states, and the reporting is -- is fairly slow.

So, you know, whatever effort, again, as a community we can make to get that data to be a little bit closer to real time, I think would be extraordinarily helpful.

MODERATOR BONANTI: Okay. Thank you. We have several questions. I don't know if we are going to be able to get to them all. However, I will ask some overarching ones. That enables everyone to be able to get your comment specifically.

What is the most important safety question outstanding related to the use of weight reduction to improve fuel economy?

I will restate it. What is the most important safety question outstanding related to the use of weight reduction to improve fuel economy?

MR. NUSHOLTZ: That is a hard question to address because I think it answers itself inside of the question.

The most important safety question of weight reduction is safety. Right? And so the question --

MODERATOR BONANTI: Good answer.

MR. NUSHOLTZ: -- is, what type of safety are we talking about? Are we talking about fatality? You might say, well, it is better to reduce injuries, and don't worry about fatality, or let's just focus on fatalities, or let's just focus on harm, what your outcome is, crippling.

So, the question really boils down to what metric are you using, and that might be the question that is asked, but I certainly don't know.

MR. WENZEL: I guess maybe the outstanding is, how the change in the mass distribution of the fleet in the next few years is going to affect fatalities. Right?

And so, if we are seeing a lot of smaller vehicles that become even lighter, what effect will that have, and -- and will the reduction in mass of the heavier vehicles and trucks and so on have a benefit in overall safety.

I mean, I guess, those are sort of the questions. What is the fleetwide effect going to be -- what is that going to look like in the next few years?

MODERATOR BONANTI: Anyone else?

(No response.)

MODERATOR BONANTI: No? Okay.

Knowing there is a regulatory standard on the books now that will likely lead to some lightweighting of vehicles, and it could be on small and large vehicles, these cars will still have to meet crash tests and safety standards.

What is the key takeaway from each panelist with regard to this? The impact on -- from the current standards and moving forward.

I'll repeat it, but it -- yes.

Knowing there is a regulatory standard on the books now that will likely lead to some lightweighting of vehicles, and it could be on small and large vehicles, and these cars will still have to meet crash tests and safety standards, what is the key takeaway from each panelist?

That's the question. I can rephrase it in something different.

MR. VAN AUKEN: I guess I would just add that, you know, there is -- that the -- the -- all the regulatory requirements for crash testing and performance are going to equalize the effect or mitigate any effects of lightweighting.

MR. KAHANE: And from a different perspective, I believe the regulatory impact analyses have estimates in them for how much of mass is likely to be added by various safety standards that are -- that are in the foreseeable future, and that has already been factored into the analysis.

MR. NOLAN: I will answer, perhaps annoyingly, with a cautionary note. When we look at crashes of vehicles that earn NHTSA's highest crash test ratings, IIHS's highest crash test ratings, that are still resulting in serious injury and fatalities in the fleet, those crashes are -- tend to be either something that we are not addressing at all in the crash test regime, or at severities that are much higher than what we are currently running in the laboratory.

So, I think we need to be careful not to say, well, we meet all of these benchmarks, and maybe just barely because, if we are really going to protect people in the types of crashes that we know are killing them now, we need to be able to go beyond that.

And maybe crash avoidance will help, but designing to the minimum, so to speak, probably isn't a strategy for long-term safety.

MODERATOR BONANTI: Thank you. Okay. I think this will be the last question, because we are over time right now, and there are several others. Because we haven't touched on this, that's why I'm asking the question.

California's ZEV mandate requires that the fleet in California and the ten other section -- the ten other Section 177 states that had the ZEV program achieved well over ten percent electrification between now and 2025. Has there been any analysis of how this will impact vehicle weight, including how and where downweighting would be applied and the related safety impacts?

MR. NUSHOLTZ: Just sort of a short response. When you go to electric vehicles, you add weight, and you can add as much as four or five hundred pounds to the vehicle as regards electrification.

So, they -- the issue becomes much more complicated because you have to calculate out the CO2 footprint of electrification because it includes also the CO2 that's generated from coal-fired power plants, and it is also the environmental issues associated with the battery.

So, it becomes -- it ends up being a real complicated problem when you get into it, and it depends on what the objectives are and how it's all put together.

MR. KAHANE: Again, I believe the

regulatory impact analyses that the agency produces have projections of what the mass distribution will be, taking into account how many electric vehicles there will be.

But, as far as we statisticians are concerned, unfortunately, we have no database to look at past performance of electric vehicles and crashes.

MR. WENZEL: And I guess there are other safety concerns about electric vehicles that, you know, people have raised, but I don't know to what extent they have been studied, how first responders open up vehicles that have been crushed that have a lot more electrical current running through them, and how to -- you know, how to identify where the battery is and not hit it with your jaws of life while you are trying to extract victims.

So, there are other issues that, you know, remain to be studied in the future.

MODERATOR BONANTI: Okay. Well, I know that there's a number of other questions.

We are already over time. I want to be cognizant of everyone else's time and I want to ensure that Jim Tamm can provide a closing summary of what his perspective is on this workshop.

But I want to thank the panelists for being open to all the different types of questions from huge, varying degrees, and your insights with regard to data, and your perspectives on the trends are extremely important to this process.

And you have raised a number of issues that the agency is in the process of researching and is in the process of taking into consideration such as crash avoidance technologies and batteries, electric vehicles, safety with regard to emergency responders and other things.

So, again, I want to thank you for your time and effort, and I will pull up Jim Tamm. I think, from my perspective, I think this has been a very good exchange of information from yesterday, as well as today with the audience, and for -- although your -- some of your questions have not been answered by the panels, we will place them in the docket and hopefully for consideration at that time. Okay. Thank you.

(Applause.)

MR. TAMM: Well, thank you to everyone. On behalf of NHTSA, we really appreciate everybody's participation in this workshop, in particular to all the presenters for your preparation.

Really, I think we had a collection of very outstanding presentations and, you know, I think the questions we got from the audience, we asked a lot of really good tough questions, and I appreciate the responses we got in the discussion dialogue it all generated.

We -- looking back at the workshop that we've conducted, we started with some remarks by NHTSA on how the agencies approach determining the feasible amount of mass reduction, the cost for mass reduction, and the effects on safety.

In addition, we discussed some of the complexities associated with each of those assessments.

We presented an overview of the research the agencies have and are conducting, and those included mass reduction studies which really were holistic vehicle mass reduction study approaches on -- to determine the feasibility and cost.

Also, the historical analysis -- I am sorry, the analysis of historical crash data statistical analysis which we talked about today. Also, NHTSA's approach to simulation modeling using lightweighted vehicle designs to assess the effects of mass and size on societal safety.

The agency's work, as well as the work of everyone else, all the research that will be available in these areas is going to be very important as we go forward.

The agencies are going to use the very best available information from all sources to inform the EPA, NHTSA and car joint technical assessment report which is going to be used to inform the midterm review, and will be used for NHTSA's, for sure, '22 to '25 model year rulemaking.

Highway safety is really the core mission of NHTSA, and we believe it is critically important to assess the projected effects of CAFE standards and greenhouse gas standards on safety.

And we believe that the assessment should be data-driven, should be comprehensive based on thorough research and analysis.

Yesterday morning, researchers who conducted holistic vehicle mass reduction studies sponsored by the agencies provided their overviews.

That included the Phase Two study of high development concept Toyota Venza, the

Phase Two study of the low development concept Toyota Venza, and the study of the 2011 Honda Accord lightweight concept.

In the afternoon, Honda provided feedback on the study of the Honda Accord that NHTSA had sponsored. We heard from the Alliance of Automobile Manufacturers on -- comments on engineering and market considerations associated with mass reduction, and also related to meeting the CAFE and greenhouse gas emission standard.

We also heard from representatives of the steel, aluminum and composites industry, and they presented perspectives on the role of each of those materials in meeting standards, as well as comments on the feasible amount of mass reduction, cost and effects on -- of mass reduction on safety.

NHTSA yesterday afternoon also presented an overview of the results of the first phase of a study on societal safety effects of vehicle mass reduction and size, which was using fleet simulation modeling to look at the, basically, crash simulations of lightweighted vehicle design concepts.

And then, of course, this morning we heard presentations on researchers looking at the societal safety from the views, basically from -- and looking at historical crash data.

The presentations, the audience questions and panel discussions highlighted the complexities. I think we saw that yesterday. We saw it again today in looking at each of these issues.

The -- and certainly, we have heard a variety of different views as well on some of the different approaches that can and potentially should be used.

Moving forward, the agencies have -- I am just going to summarize some of the work that the agencies have planned -- are planning to do moving forward related to the feasible amount of mass reduction and cost.

EPA is conducting a study of light-duty truck currently, and NHTSA has posted a synopsis on FedBiz for potential light-duty mass reduction study.

Related to the statistical analysis of historical crash data, NHTSA will be monitoring all -- further trends in vehicle size and mass and in the crash data as we move forward, and there will be an update of the crash database and statistical analysis Chuck alluded to potentially out in the 2015 time frame.

Related to using crash simulation modeling of lightweighted vehicle designs to assess the effects of mass and size on societal safety, NHTSA is intending to continue the work, looking at the future fleet crash simulation studies, so we are going to try to expand that.

So -- and that would include enhancing the occupant restraint models that are used in that modeling for better injury prediction, consider vulnerable occupants such as including risk functions for seniors, include the modeling of additional crash configurations such as side and oblique crashes, introduce new lightweighted vehicle designs and baseline vehicle models as they become available, conduct lightweighted-to-lightweighted crash simulations to explore future occupant protection research priorities.

And really all -- you know, there are two sides to this. One is to quantify what the effects are of mass reduction and size changes, and then, secondarily, -- not secondarily -- most importantly, actions that NHTSA can take proactively in the future to mitigate any issues that are identified.

In addition, one additional item is that we would add more types of vehicles as partner vehicles, such as CUVs.

So, as far as all the information that we heard in this workshop, we are going to carefully consider and review all of the information that was presented. We are going to work with EPA, DOE and CARB as well, in a review of all the information.

As we move forward, we welcome continued input and dialogue on these topics. We believe that the assessments for the midterm evaluation in our rulemaking will be strengthened by carefully considering all of the available information that will be available.

And then, as mentioned, the -- we do have a docket that's open for comments. We will be placing all the presentations in there, as well as questions that were not answered.

And also, on the NHTSA website, we are going to be posting all the presentations. There will also be a recording, audio recording of all the proceedings, as well as a transcript.

I can't promise exactly when that

will be up, but we will try to get the presentations up fairly quickly. And we certainly welcome additional comments to the docket.

So, with that, I just want to thank, again, everybody for participating. We are very pleased with this workshop.

(Applause.)

(Whereupon, the above-entitled matter went off the record at 12:46 p.m.)

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C E R T I F I C A T E

This is to certify that the foregoing transcript

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Before: DOT

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Place: Washington, DC

was duly recorded and accurately transcribed under my direction; further, that said transcript is a true and accurate record of the proceedings.

Neal R Gross

Court Reporter