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BRINGING DRIVERLESS CARS FROM RESEARCH TO INTERNATIONAL MARKETS

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P R O C E E D I N G S

MR. DONOVAN: Good morning everyone. My name is Cole Donovan of the U.S. Department of State, and it is my great pleasure to welcome all of you to today's discussion on bringing driverless cars from research to international markets and introduce you to Deputy Assistant Secretary of State for Science, Space, and Health, Doctor Jonathan Margolis. As a member of the senior executive service, Dr. Margolis oversees policies and programs in the areas of international science and technology cooperation, international health and bio defense and space and advanced technologies. He has also conducted courses at the University of Maryland, American University, and at the Foreign Service Institute on these areas. Doctor Margolis began his career at the Department of State as an American Association for the Advancement of Science Policy Fellow and has worked in numerous bureaus and divisions at the intersections of science and diplomacy. With that I'll turn the floor over to Doctor Margolis.

MR. MARGOLIS: Morning everyone, good morning, my name is Jonathan Margolis and I do work at the Department of State as the Deputy Assistant Secretary of State for Science, Space, and Health. It is my pleasure to be here today with the Brookings Institution and I really would like to thank Brookings and Ben Wittes especially for pulling together this distinguished panel to talk to us today about autonomous vehicles. Let me also thank my colleagues from the Embassy of Germany here in Washington for their work in bringing together some of the panelists today. The topic for today is one that's near and dear to the Obama administration. I think most of you in the audience know that the Obama administration has placed a huge emphasis on the critical role of science, technology, and innovation. S and T underpins many society goals, whether they're security goals, economic goals, environmental goals, health

goals -- S and T is at the center of them. And today science is global. Many countries around the world are increasing their investments in R and D and that is true both OECD countries and especially non-OECD countries who have aspirations to develop further and build their economies. And in the United States we're facing a situation where we have to start thinking about how our scientists can engage not only domestically but much more internationally, globally, so that they can get access to the best minds that may be out there. Some of which are here, some of which are maybe outside our borders, and the best institutions some of which are here, some of which may be outside of our borders.

In the state department we have a concept that we call science diplomacy. Through it we think about using science to advance our diplomatic goals and using diplomacy to advance our scientific goals. This is very much, the goal here is to use science to address some of the global challenges that may exist out there and the answers to those challenges may come through international collaborations on science. This is part of what Secretary Kerry has referred to as the shared prosperity agenda way of raising economic growth in other countries around the world.

In my part of the State Department, where I work now in the Bureau of Oceans International, Environmental, and Scientific Affairs, we maintain over fifty bilateral science and technology cooperation relationships with other countries, the goal of which, is to advance our science and technology cooperation as part of the broader agenda the state department might have for building its relationships overseas.

One of those countries is Germany. And we're here today in large part because two days ago experts from the United States and Germany met to discuss bilateral science and technology cooperation as part of what we call the U.S. Germany

Joint Committee on Science and Technology Cooperation.

That's one of the ways the State Department advances science diplomacy. And in this meeting that I described that we had two days ago we identified areas of joint cooperation -- one of those areas was immobility. And so the topic specifically that we will be talking about today is very much on the minds of those of us who are engaged in the bilateral cooperation between the United States and Germany.

Immobility is a piece, a central piece of the Obama administration's national innovation strategy. And the discussions that took place earlier in the week, formally between the two governments, discussions that will take place here today, fit squarely with President Obama's prioritization of advanced vehicle technology as part of what will be the soon to be released national strategy for American innovation.

This technology, I think you all know, judging by the interest here today could be a transformative technology. Experts talked about this in terms of not only the technology spinoffs that you might have, but also reducing traffic fatalities potentially -- it says so here, but I'm not sure it's true, but to zero -- the panel will discuss that I'm sure, by 2050. Doing so however will require a major, major investment not only in R and D but a whole range of other issues. In the Obama administration's budget for 2016 it doubles the request for investment in autonomous vehicles and proposes a number of pilot programs to prepare the roadways for safe introduction of these vehicles.

Clearly that's a U.S. priority. But if you think about this in the international context, the technologies that are going to be involved, the applications will go far beyond our borders. And so we need to cooperate with other countries at every stage of the development process, particularly those countries that have major automobile exporting capabilities and manufacturing capabilities. The major

manufacturing companies in countries such as Germany, Japan, the United States, others as well, where the largest manufacturers in the world will need to cooperate on the development of the technologies but also on the diffusion of those technologies and the environmental and health and safety regulations that are going to be part of making this technology as transformative as it can be. And that brings me to this next point which I'm sure the panels will discuss, and that's the enabling environment that will be necessary to create to make the technology work.

We need to work together internationally to make sure that the new market can take advantage of the best approaches towards innovation and technology diffusion -- safety issues, intellectual property rights protection, market conditions, a whole range of things to make this possible. The individuals that we have on this panel today I think, we're in very good hands, I was privileged to be with the group at the beginning where we were discussing about what topics they might be covering. And I think you're in for a real treat today in the sense that the folks that we have here cover a wide range of capabilities, not only from the development of the technologies -- the vision from where were trying to get to using those technologies, the implications for society as those technologies get applied outside of a government context, and then ultimately the international implications of how those international cooperation mechanisms might be necessary.

So with that is kind of the preview of what we're going to do and why we're here today, let me say again how delighted I am to be here to express the State Department's joy at co-sponsoring this event and I'll turn the floor over to Ben now to moderate the session. Thank you, Ben. (applause)

MR. WITTES: Thanks very much, and thank you all for coming out on a

beautiful morning when we would all normally be outside, to talk about driverless vehicles. I am -- well I want to do this as a discussion oriented way as possible, so the panelists have all agreed to sort of dispense with opening presentation statements and we're just going to go right into a conversation. I'm going to introduce the individual panelists as I direct initial questions to them and so as to not gum up your time with repeating information that is lovely pontiff, all available in the handouts that you were given to their full bios.

A couple of things, we will take audience questions and so, as you have a question I'll -- please do wait for a microphone to come find you because we are being recorded and broadcast. And please when you speak, introduce yourself and say who you are and frame things in a form that would be recognizably a question. (laughter)

So I want to start with Jessica Altschul who is Manager of Outreach and Innovation Policy at Daimler North America. And I want to start by defining terms a little bit. We all say the words driverless cars as though, A, we are all talking about the same thing when we say that and B, as though there is some generally recognized definition of a driverless car.

This morning I was driving in a non-driverless car, my son, to where he needed to be this morning and I had to explain to him what a driverless car was. And actually it's hard, because certain levels of driverless-ness have been with us for a long time, anti-lock brakes, cruise control, various autonomy features. And yet, the phrase driverless car connotes a certain total autonomy and so my question is -- what the heck is a driverless car, and what is it in practical terms today and what are we aspiring for it to be in the future?

MS. ALTSCHUL: That's a heavy first question, (laughter) but before I

answer it I really want to thank Brookings for tackling this issue and the other panelists for being here because I think this is definitely an issue that is going to only grow over the next several years and couple of decades and I think it's much bigger than a lot of people recognize and I hope that some of the remarks today will get that point across a little bit, also in the international context.

To answer the question, or attempt to, a driverless car I think may be a little bit of a misnomer. Really what we're talking about is an automated vehicle, and there are different levels of automation. Some of which as you said are here in cars today, especially in some new cars. We're looking at, currently in some of our Mercedes-Benz vehicles, technologies that are far beyond just cruise control, but adaptive cruise control and lane assist, active break assist, these kinds of things that can really take over if you're having an emergency as a driver in the car, to brake for you to avoid an accident. Things like that.

So looking forward, taking that as a current situation, looking forward to say 2025, 2030, we're looking at a level of automation on the SAE scale that could be a fully automated vehicle by that timeframe, which would mean that there still would be a driver but the definition of driver would also change just as the definition of a car has changed in the past fifty years and hundred years and will continue to change as we move forward. So really what we're looking at is a driver who is more of a manager, a vehicle manager. In the heavy duty side, we're looking at a logistics manager sitting behind the wheel, rather than a truck driver. And that role would really be for monitoring and being able to step in if there is some sort of glitch or problem with the system.

But the way that Daimler sees this issue moving forward and our vision for autonomous vehicles in the future is really kind of on the passenger car side a mobile

lounge, which will allow passengers and drivers to have a more relaxed environment as they are getting from home to work, or home to daycare or where ever you need to be, but still be able to take over on a Saturday morning when you really want to drive on a nice country road, something like that.

On the heavy duty side also we, as many of you know, produce freight liner trucks and school busses, et cetera. And just this week we released our freight liner Inspiration, which is a fully autonomous eighteen wheeler heavy duty truck which has a license now to drive in Nevada on its own with a logistics manager behind the wheel for testing purposes and there are two of those on the road now in Nevada. So I think that this has implications for most of us on the passenger car side, but looking at freight management and logistics, it can have huge implications as well, so I hope that starts to answer the question of this progression of autonomy as the years go by. Starting with where we are today.

MR. WITTES: So, it does, beautifully, but I want to follow up on the fully autonomous truck. Because I suspect that a lot of people in the audience walked in here without the sense that there are fully autonomous eighteen wheel vehicles driving around Nevada. And did you know that --because I didn't, when I walked into Brookings this morning. And just tell us about the truck. What does it do, what is a fully autonomous eighteen wheel vehicle mean? And how autonomous is fully autonomous, and what happens if it -- what does it do?

MS. ALTSCHUL: I don't want too into the details, but I will say that for those you who study logistics management, freight, these kinds of issues, this has such -- very -- the implications of something like this for the trucking industry and for freight management in the United States and in other areas is huge.

This car, the truck, will have a driver, not called a driver, who will be more attuned to where other trucks are, where they need to go, what the fuel economy is looking like. Certainly in the future the powertrains for these vehicles, we're looking at fully electric or hydrogen, so this has implications in the environmental sphere as well. So the future of trucking we see, is certainly a large part due to platooning and this kind of automation will definitely help with that. The fuel economy as I said is going to be greatly impacted by platooning and by these kinds of technologies such as the adaptive cruise control, when trucks can stay a certain distance ahead of another and travel at exactly the same speed, regulated not by a person's foot on the pedal but rather by the computer within the truck -- that has enormous implications.

So that kind of a system, I think, moving forward is going to change the trucking industry, it's going to change the jobs, what it means to be a truck driver, what it means to be a logistics manager, and how we get goods in this country from place to place. Especially because trucking accounts for a very large percentage of the gas use in this country, the MPG is obviously much lower on a truck than on a passenger car, and that also is contributing to the wear on the roads, et cetera. All of these issues can be impacted by a level of autonomy that we're moving forward in the trucking sphere.

MR. WITTES: Thanks so, Karl-Josef Kuhn is Head of Reliable Automation and Control, at Siemens Corporate Technology for New Technology Fields. I'm interested in your sense of the research and development necessary to actually accomplish the vision that we just heard. What are the missing pieces? What do we need to develop that we haven't developed and in the spirit of this sort of international side of this conversation, how much of that is U.S. technology, how much of it is non-U.S. technology going to be, and what's the interaction between the two?

MR. KUHN: First of all, thank you for the invitation to this interesting panel discussion. And the road to automation or autonomous cars is not just the road with cars on the road -- it's more because we see more and more autonomous or automated systems in our daily life. So we have it in the military area already, somehow, and we will see it in the next step on the road, but we will see also in private households and factories and so on. So the car industry is recently the driver for this technology, but we will see it in other areas as well. And I want to answer these five focused topics, I want to address for the research area.

It's first of all the safety and the testability of these systems. When is a system safe enough, what is the question about that? If we are looking actually to the standardization we see, the traffic, the ISO26262, and we some figures like the probability for failure is ten up minus nine, might be for autonomous driving or automated driving, the future. It might be by two more or ten up minus eleven or twelve. But never the less there is a probability for failure. Every technical system can fail, and we have to deal with that. But on the other hand, this testability and safety of the system -- how are we tuning that? So the calculations very simply show that one billion kilometers on the road is not for enough for driving to show that the system is fulfilling these conditions. So we have to find new ways for testing, proving and certification. And this cannot be done on a national level. It has to be done on an international level, because human, man can't have to accept this. So there is a need for harmonization, and the way, how we come to that with modeling, with simulation, and so on. So it's not the old we did in the past, bringing the car on the road, just driving several million kilometers or miles and it's done. So it's a change, a paradigm change in testing and system verification.

The second point is the managing interface. Actually, as the Doctor

explained, we do not see the autonomous car on the road in the next years. It will take some time, so we will have more ways to automation, and more functionality which will help the driver to avoid accidents and this functionality will increase in a moment. But when we accept that the driver is a backup for the system, because the technical system is failing, how fast is a driver coming back into the loop? What is happening to the driver during that time? Is he still able to take over the system; how are we supervising the trend? Whether it is possible, that's one. So this is an open question, the question arose today, actually the answer from ten seconds up to fifteen minutes. So you see how big the variance here is and we have to find the right way how we can solve this problem.

Third point is the security and privacy. As soon as a car is driving autonomously, or automated on the road, some manufacturers and researchers are expecting that this is done with a lot of environmental information, got from sensors, from maps and so on. But these data transferred to the car could be corrupt. What is happening then? Who is liable at the end? How are we guaranteeing that the data is there which is expected. And who is liable at the end if this data is not correct? How are we dealing with such problems?

The fourth point is the social and ethic impacts we have here. It's also a research arena, so what is happening if a machine is causing an accident. Actually the drivers are causing accidents, so this is a big difference. Are we accepting in societies and societies are different around the globe? When this is happening that the machine has a choice between two bad situations, every situation is causing an accident, but the machine is making a choice. And the choice of the machine can be followed up because it's programmed. It's the same choice would be done by a human. That’s different.

And fourth, it's the real path for autonomous systems because one of the

capabilities of the autonomous systems is that they are learning. These are not systems which have a fixed state and are delivered to the customer at the end. They will change over their lifetimes. And this is actually happening when we have an autonomous driving or automated driving car, because as soon as this car is using maps from outside of the car, these maps will change over time. So that means the complete system is changing over time. There is some learning in systems. It might be in the car, it might be outside of the car, but the system will never remain the same as it was in the starting point. And how are we dealing with that and how are we guaranteeing that these systems are still safe?

MR. WITTES: Thank you. We are going to return to a bunch of those discreet points momentarily, because I have like a million questions about that. But, I want to hear from Levi Tillemann who is the Jeff and Cal Leonard Fellow at the New America Foundation, author of a book about electric cars and so this is a really interesting element of the story. This is of course not the first time that we have had or tried major transitions from one form of automotive technology to another. Some have been more successful than others and some of them have been promised for very long periods of time without actually materializing in the form that we imagined.

What are the lessons for earlier transitions for, to the current set of transitions and specifically when you think about the experience of the attempt to make the vehicle fleet electric rather than internal combustion engine based, how much does that make you optimistic or pessimistic about grand promises of removing human agency or minimizing human agency from the driving in the first place?

MR. TILLEMANN: Big question, so first of all thank you for having me here. I'm really excited to be part of this discussion. And secondly, before I get right into

the question, I want to talk a little bit about what I think about when I think about autonomous vehicles, which is my experience growing up, driving around in a car. I had ten brothers and sisters, and as you can imagine, that's quite a brood to manage. And so my mom would be sitting in the front, driving around, angling the rear view mirror, trying to look at us and yell at us while she was sitting in the front of the car and manage all of those things at the same time. And so I can very easily imagine an autonomous system being somewhat more safe than the alternative when it comes to big families. (laughter)

MR. WITTES: Humans are really overrated.

MR. TILLEMAN: Yeah, so I will then also say Happy Mother's day Mom, you kept us safe all those years and we really appreciate it. So getting back to my book and the lessons that we can glean from autonomous or from electric vehicles, or autonomous vehicles, you know I think the first thing that I would say is that these massive societal technology transitions don't just happen. They are driven by policy and it's really important to remember that. And what my book is, is it's really an international examination of what policies are effective and what policies aren't effective and how those policies can be applied strategically over the course of decades. It primarily looks at China and Japan and the United States which are the three largest automotive producers in the world. Cumulatively they produce more than fifty percent of automobiles in the global economy. And it comes to kind of an interesting conclusion which is that while all three of these huge economies and the governments that I guess manage them or are regulating them, were pushing for electrification during the period stretching from 2007 to really the present day. There was another factor that happened to have a much bigger influence on electrification and really ended up being the technology driver for the entire global automotive industry. And that was the state of California. And the reason

why, is that the state of California has an institution embedded within their government called the California Air Resource Board, that made it a priority to drive automakers towards electrification. And they did this over the source of decades and they used a very specific set of market based tools paired with mandates in order to make that happen. What they did was they told automakers that if you want to sell cars in California, then you have to make a percentage of them electric, which is a mandate. But that mandate is kind of draconian and potentially very expensive and inefficient. What if a car maker doesn't have particular expertise in electric vehicles? That could force some to develop a whole new set of technical capabilities that maybe they don't want to invest in at that moment.

So the thing that California did to make this system much more efficient is they overlaid a market on top of that mandate and they allowed automakers to buy and sell credits that they were awarded when they sold an electric car. And so then what you had was a market driven mandate, and that resulted in a system that was just much more efficient than it would have been if you had a pure mandate behind the electrification program that California set up.

So I think that this is applicable to the concept of autonomous vehicles, but autonomous vehicles are also very different from electric vehicles. Electric vehicles are great; everybody wants the Tesla model S. I would argue it may be the best sedan in the world at this point in time. But the truth is that what we're aiming towards with electric cars is really a whole set of social goods, related towards climate, pollution, energy security and other things like that. I personally, as you can tell from my introduction, I can see many reasons why an individual might very much want to have an autonomous vehicle, and so I think that they are going to be much more powerful market drivers for

automation than there were for electrification.

Nonetheless, that doesn't mean that we don't have to think strategically about the regulatory aspects and the industrial policy underlying the transition from standard vehicles that we all drive ourselves to autonomous vehicles. And so I think we should take the lessons from California and realize that a very small corner of the global economy if they act strategically and apply policies strategically over a long period of time can actually end up setting the agenda. And that's why forums like this and bringing together the United States and Germany to talk about global cooperation on standards and on a road map for autonomy going forward is so critically important.

MR. WITTES: Thanks, so finally last but by no means least, Sonya Smith is Professor of Mechanical Engineering at Howard University. And I want to ask you about this international cooperation aspect. We -- Jonathan Margolis alluded to it, or talked about it very directly in the introductory remarks. Several of your co-panelists have alluded to it as well. When we think about auto development historically, we don't think of international cooperation. We think of Detroit, or we think of places in Japan or Germany, but these very kinds of local engineering hubs where great cars were built, we think of them in very regional terms. Why is this different and what is the consequence of, A, having a significant global cooperation dimension to this, or B, in a negative sense not having it. Why does the global side of it matter?

MS. SMITH: Well thank you. I echo my panelists, and thank Brookings for asking me to be here. I think as the educator on the panel, I need to emphasize that, part of the answers to these questions, the research and driving the technology further has to do with incorporating students and faculty in global collaborations. At Howard University we are one of the institutions in the Partnership for the Advancement of Collaborative

Engineering Education. And it's a partnership among General Motors, Siemens and some others to catalyze collaborative global projects in education. And so I think that in order to answer these questions and why this is important, we need to not only involve researchers at companies and faculty, but also students as well. One of the things that we do in the PACE consortium is we collaborate on global design competitions. And this involves teams of students and faculty from universities across the globe. The team that Howard University is partnering with is one at RheinMain in Germany, University of Sao Paulo, University of Toronto, and New Mexico State here in the United States. And we're partnering on a global design project, and these students work together in order to answer these kinds of questions. We exchange interns, we have an intern here from RheinMain who is in the audience -- (inaudible) is here. And it's very very rich experience and the students are the ones that are going to be the early adopters and drivers of the technology.

And to get back to your question of why it's important to have a global perspective as opposed to the original silo'd engineering aspects, and we talk about autonomous vehicles, that subject spans all disciplines. It's an interdisciplinary problem, it not only spans policy, it spans engineering, it spans creative design, it also spans atmospheric sciences, et cetera. When you get all of these disciplines together, particularly in an educational arena, it definitely enriches and enhances the educational experience for not only the students here in the United States, but also globally.

MR. WITTES: So I want to just push you a little bit on, why is this truer in the area of autonomous vehicles than it is in other vehicles, or is this just that the scope of the research necessary to do these things is so vast? Why is it that we see these international collaborations involving companies, students, universities in this area, but

we didn't see it when it was -- or maybe we did and we just didn't talk about it, when it was earlier generations of cars?

MS. SMITH: I think that there were different types of collaborations earlier on but as we move, as the vehicles become more complex, the issues become more complex, you need a collaborative and global approach in order to solve the problems. It's not just pipes and pumps from mechanical engineering and software from computer science. You also need policy involved in that. Aesthetics is extremely important, and so we need to reach out to colleagues and disciplines that we might not otherwise incorporate in a design or engineering type vehicle process.

MR. WITTES: All right, so I want to talk about safety. A bunch of people have raised safety and we started with the possibility of the promise of the zero accident fatality road system. This sounds totally fantastical, except that in defense of this completely fantastical hypothesis, I want to point out that this year it is safer to fly in the United States than not to fly in the United States. All kinds of accidents happen in your home, you're actually safer on a commercial airplane, than you are not travelling. (laughter)

So the more you think about that the more interesting it gets. So I mean the possibility of truly radical de-escalation of the violence associated with roads, you don't have to get to zero before you get to something that is really attractive as a policy matter. On the other hand, as we heard, the deaths that do happen will happen because of machines. And as we see in the military context, when machines cause human death as opposed to people causing human death, we get really really uncomfortable with this. And so I want to throw this open to the panel in general, if you have a regime, technologically and policy in which many many fewer people die, but those deaths are

caused without human agency and by programming decisions made remotely and for systems failures, is that a win or is that something that we're going to have great social difficulty accepting?

MS. ALTSCHUL: I guess I'll try to tackle that at first, I think that this is another example of one of the issues that needs to be discussed across country borders. This is something that is cultural, which as we know is different in different cultures around the world, thoughts on these issues as well as the technology et cetera and this is something that the OEMs as manufacturers are really looking at right now and we haven't had to as much before on other technical issues, the ethics of this kind of technology as someone mentioned before the issue of an inevitable crash and what the computer programming should look like for something like that and the liability in a situation like that. The ethics of how to program these kinds of technologies is really tantamount -- paramount. So I think that this is something that we're going to be looking at already this year. One of our board members Christine (inaudible) has convened a group of academia as well as technical experts and representatives from the E.U. and the German government to come together and discuss the ethics of this every couple of months moving forward because it's going to have big implications.

MR. WITTES: I want to just, when I drive down the street and I am, this has never happened to me by the way, but you think about it, you're in a situation where there is no good option. Somebody is going to get hurt no matter what you do and you make a split second decision, there is no policy behind that decision. But it amounts to, I'm going to kill that person not that person, or I'm going to risk that person's life to protect my own life. You don't make a policy -- there is no global policy about that. But when you replace my mind with a computer, you have to have a policy about that, and it's

called code. And it amounts to a policy level decision on the part of the programming to kill X person instead of Y person. And I'm just -- you know, what are the ethics of that?

MR. KUHN: Of course it's a matter of the ethics. But the difference is, if you are able with autonomy to really reduce the number of accidents on the roads, first of all, that's a big advantage. We have to admit this as well. So the second thing is, as soon as a machine is causing an accident, with full transparency we know what is the rule behind it. At least you can follow up the complete process. As long as a human is causing the accident, you know nothing. You have a split second decision as you said, and what is happening there? Who is really able to judge in a split second what is the best choice we have here? And the program, the algorithms, they made a choice, and they made a choice based on the rule system which they have behind them. And as long as the whole process is transparent at least we know what is happening here. And now we have to discuss which kind of rules are behind that. And that is an ethic decision and we have to do it somehow, somewhere. What is better if you have the choice? A or B, both causing an accident, but that's something we have to go on, and then we have to make this decision.

MR. TILLEMANN: Yeah, I mean it's a very important decision and obviously it has to be addressed, and it's a very Washington issue, I think it's an issue that lends itself to a lot of Washington navel gazing and hemming and hawing that this is really important -- (laughter)

MR. WITTES: Don't complain about Washington navel gazing in the Falk Auditorium at Brookings.

(LAUGHTER)

MR. TILLEMANN: We need to think about this really carefully, but

30,000 people die every year in auto accidents. My father died in an auto accident. His father died in an auto accident. This is something that affects us all very personally and if we have the prospect of potentially eliminating 90 percent of those auto accidents, that's a win. And just back to the personal example, my father died because of a mechanical malfunction on his car. There was nothing he could do about it, we were in the mountains in Colorado and he was driving and there was a mechanical malfunction and he ended up going off the side of the road. His dad died because of human error, someone was driving drunk and slammed into him. And if you have the prospect of potentially eliminating 90 percent, 95 percent of accidents or fatalities on the road through autonomy, I think much more important than hemming and hawing over the -- we have to get machines to make these decisions, is to let's save the 27,000 lives.

MR. WITTES: Okay, so I agree with you completely, and I am very Benthamite about reducing death. And when I make exactly this argument in the context of robotic weapon systems, there is a mobilized constituency of human rights activists who take the view that if you can have dramatically greater compliance with the laws of war as a result of fully autotomizing certain weapon systems, they object to it because you have removed human agency from the task of killing. And so I'm wondering if those of us who believe that actually aggregate death reduction is a really really great good that should presumptively trump a lot of other goods, are actually going to have a really tough hill to climb just in terms of social acceptance of the idea that removing people from the chain of command that leads to death is somehow presumptively suspect. What do you think?

MR. TILLEMAN: Well I think that you have to again step back, and although from a policy perspective and from a logical perspective it seems like these

things are apples and apples, I think from a human perspective they look like apples and oranges. What you're thinking about is robots that kill people and the thing that we're talking about here today are robots that transport people and try to keep them safe. So I can understand why there would be a constituency that would mobilize against robots that kill people just like there are people that mobilize against guns and nuclear weapons. And I think that yes, there are probably going to be luddites that are opposed to autonomous vehicles, but at the end of the day, we have to make some pragmatic social decisions and I think the weight of public opinion is going to be on the side of saving lives.

MR. WITTES: So do you find Sonya, that in these educational and development partnerships that the safety and sort of ethics issues associated with safety are kind of front and center of what people are working on, or are they kind of background issues that are concerns but mostly there's just a lot of excitement about the technology?

MS. SMITH: Well there is a lot of excitement about the technology but I would also look at it from a different perspective. Saving lives is not only through autonomy, going to be achieved through reducing the deaths in auto accidents. Autonomy is also going to affect mobility and access to other services that will also save lives. Healthcare is one of them. So I think that in the whole, in the aggregate, that autonomy will not be looked at through the same lens as just saving lives through automobile accidents and those are the sides of the policy issues and holistic issues that we look at through these partnerships.

MR. WITTES: So flesh that out. What's an example of that it's not merely reduced traffic accidents, we've heard about sort of environmental benefits

particularly with respect to fuel efficiency in the truck fleet, but what's an example of great social goods and reduced human suffering as a result of autonomy that is not autonomous vehicles that is not fewer traffic accidents?

MS. SMITH: We don't have specific evidence of, but an example that has been studied and talked about is again, access to healthcare in rural communities. People who are disabled -- they may be able to get access to healthcare to services much quicker through an autonomous vehicle, or an autonomous fleet of vehicles than either waiting for their friend or having to walk or to get to a service. And so that is one life saving result, not a direct design point but it's definitely an indirect benefit of autonomy. And I think again if you look at not only lives saved through reduced auto accidents but also lives saved through personal mobility and access, I think the autonomous argument is quite different from the drone strike, et cetera that you talked about.

MR. TILLEMANN: I'd like to just add one thing to that, which is a couple of years ago I was at the doctor's office and as I was coming out there was a gentleman in his electric scooter, and he was severely disabled, a guy about my age. And I started talking with him and said, hey you've got a really cool electric car there, because I was writing about electric cars. And he said, yeah but what we're really looking forward to in the community of people with disabilities is autonomous vehicles because there are so many things that autonomous vehicles can allow us to do that we just can't do on our own right now. So I think that's a really compelling human argument.

MR. WITTES: All right so one issue that autonomous vehicles necessarily raise is data collection. These are incredibly sophisticated sets of many many sensors, all of them collecting a lot of data and processing a lot of data in order to

make decisions. Data collection gets controversial and it has different cultural baggage in different countries to different degrees and this strikes me as an area where harmonization across borders might be pretty difficult, particularly between Germany and the United States which as many of you know, fight about data lot, not just in the NSA context but also in principally in the business context. So now you have fifteen years from now a giant fleet of big data machines roaming around every city, what are the prospects for A, regulatory harmony on the subject across borders, and B, what are the prospects for cultural queasiness associated with the idea of our cars as pervasive surveillance devices?

MR. KUHN: I will answer to that so, first of all we have to differentiate this sensor or cluster of machines running around the cities or everywhere in the country, they are collecting a lot of data, but what is happening with this kind of data? So is the car relying on data outside of the car to drive autonomously, or must the car also drive without data from outside the car? There is a separation between that what the car needs from outside and what the car is generating by itself, because everything everybody's generating by itself, it can forget immediately after the driving situation. So this is in the research community not quite clear what is the right path for autonomous driving vehicles in the future. The fraction who are thinking about that we need a lot of data from around the car, from the city centers and so on, they then have immediately the problem, what is the privacy and security of published data, because data used from outside the car to drive autonomously can corrupt the car, can corrupt the driving situation. You have again the safety issues and all the same.

Secondly, as soon as the car is sending data outside of itself, who is the owner of this data? Who can use that data? Is it the driver? Is it the car owner? Is it the

car manufacturer? Is it society? These are open questions we have to discuss. Because, and this is a cultural issue as well around the globe. It's not in every country the same. So then we need harmonization anyhow. How we want to regard that in the future. One thing is for sure, as soon as data is available, it will be used, and it will be used for business. It was always the same story in the world. And it will happen here again. So as soon as the data is outside of the car, available, it will be used, that's for clear.

MS. ALTSCHUL: I just want to underline that. I think that this is a perfect time to really explain why this kind of collaboration between governments, between companies and between legislative bodies and corporations makes so much sense. It's really important, of course, informed by academic bodies as well. We do a lot of research with universities around the world and have been for decades. Obviously, most companies do interface with government at different levels, both regulatory bodies, diplomatic missions, executive, et cetera. So these kinds of collaborations are absolutely necessary because we need to make sure that moving forward, the technology is advancing generally at the same pace as a societal adoption. Society's willingness to accept this kind of technology and at the same parallel speed as the laws and regulations, because we want to make sure that these are harmonized, and we have an opportunity with this kind of technology to do so. Obviously cars have been around a really long time. We invented the car almost 130 years ago, and at that time, there was really no need at all for Germany and the U.S. to be talking about safety regulations and automobiles. Now there is an overwhelming need for all of these countries to be discussing this together. So we have a new kind of technology that needs to be addressed societally and legislatively and we have the opportunity now to be doing that

across country lines as informed by the experts with the technology and privacy, data experts as well as the mechanical experts, et cetera. So I think that's something that we can't overlook as this process moves forward. There's no choice but to be working together.

MR. TILLEMANN: And I will also say that automated vehicles are, or autonomous vehicles are just one small facet, one significant facet, of the changing relationship between data and vehicles. We are moving towards a world of connected vehicles, where cars will have huge amounts of media and internet connectivity, an era where you're going to have connections between vehicles and the infrastructure in the city that tell the car how fast to go and what kind of traffic situation is going ahead. And so that's a new stream of data. Cars will be connected to each other via vehicle to vehicle technology, and that is something that is under development, and we have whole regulatory structures that are being built up around it as well.

And finally, you have this uppermost tier of automated vehicles. And so I think we have to think very carefully about data and transportation, and how we're going to manage that emerging relationship.

MR. WITTES: All right. So several of you have alluded to, as distinct from safety issues, what we might call cyber security issues with respect to, you have all this data, you have these systems that are autonomous, both the data streams and the systems themselves that are operating the vehicles like any complex computer system, are subject to attack, as we have seen or in the case of the data, corruption. As we have seen in other areas that we have systematically networked and become very dependent on, these become very attractive targets for hackers of, from the lowest grade to the most state sponsored. Is this a situation where we are now creating dependencies that we will

eventually turn around and say, oh my God, how did we come to give the North Koreans control over our traffic safety -- just to use an example, I'm sure has nothing to do with the news? I mean, why shouldn't we be worried? How worried should we be about the cyber security implications of having basically our cars as, you know -- the operations of our cars as networked instruments, both in their own internal systems, and the data that they're collecting and relying on for safe operation?

MS. ALTSCHUL: My perspective as an optimist also, I actually am not so concerned about this. I think it definitely needs to be done right and this is another area where we need to be talking between private and public sectors, across country borders, to really effectively regulate these issues and make sure we're thinking about them in the right way. I know in our company we have basically internal hackers who are tasked with trying to hack our vehicles all the time. It's amazing, as I've said before, some of the systems which are in your passenger cars today, are already very advanced and already maybe starting to inch up on the scale of automation, such as these kind of lane assist and adaptive cruise control, the braking I mentioned. There are these kinds of issues, even in some of our cars, we have systems that will notice if you're getting sleepy, not by looking at you but by how you're sitting and how you're driving compared to when you were driving when you first started the car. And it will flash a little coffee cup on your dash, to tell you hey, why don't you take a break now?

So those kinds of systems are collecting data on you the driver, and the way that that data is stored is certainly cause for debate. But we think that, I can only speak to our company, but we are, because we're based in Germany, we are probably the most stringent. We're subject to the most stringent data laws, possibly on Earth, so we're confident that moving forward that that's the view we'll take.

MR. KUHN: In talking about this data privacy and security at the end, maybe we have to differentiate between data that is necessary to drive autonomously and not all the data we have in the car. We have a lot of more data, as it was mentioned already. So this kind of entertainment data that is just a free flow of data and every user can decide what he wants to do with that. And this is actually, according to some agreements between the provider and the user end point. And the data we have in the car to drive this car somehow autonomous in the future. It happened already in the past that cars were hacked. So that's a new issue. We know that already. The research arena, it's a known problem. So, and it will happen, this is for sure. So to make further on the right choice, what is really necessary for the automation of the car, and a small amount of data that's more difficult to attack it.

So if you need everything, what we get around from the car, every camera system in the city, then it can be corrupted very easily. If it's just a small amount of data, or maybe no data, that the car is collecting everything by himself, keeping it for himself and deleting it afterward, then we have not such a big issue at the moment. So, and as I said, cars were corrupted in the past already. So you can hack a car and put some wrong data into it. Because in the future we will see with the autonomous link ups we see a different kind of car in the future. Quite sure you can load your own apps down to the car. You have your special driving functions and so on. This will be the future of the car, not just this autonomous driving. This is just one of the functionalities. So as soon as you are bringing new software into the car, it can be corrupt in the car in another way. And this we have to protect. We have to be very very precise. It's not all the data. It's just a few. And as fewer this amount is, it's better that we can protect it. Nevertheless, we have to have the public discussion, what will happen if -- if something is

corrupt.

MS. ALTSCHUL: This is why we see so many redundancies also, I should mention that.

MR. TILLEMANN: And obviously it's not just cars. There are so many facets of our economy where this is a huge issue. The energy system -- I just came from a two year appointment to the Department of Energy and we think about this all the time because all these systems are now connected to networks. And you know, you have someone break through the control system of the nuclear power plants, or even a more traditional coal or gas fired power plants, or into the grid, that can cause some pretty huge problems, so this is definitely a big issue and I think it's an economy wide issue.

MR. WITTES: Exactly. You know, I just read a report recently about commercial aviation and how secure aviation systems are. And the answer seemed to be that they're quite secure as long as they don't interface with the public interfacing, the public facing computer systems on airplanes which are not secure at all. The trouble is, we've now interlaced them, because people like to watch flight data on their little computer screens and so these two systems now interact in ways that create vulnerabilities for the other systems. Let us go to audience questions. If you have a question, flag me and please wait for the microphone. We've got a lot of questions. The gentleman over here I saw first. And please introduce yourselves and please keep questions brief.

SPEAKER: Thank you. I'm Nick Farber. Could you speak to the idea of fully autonomous vehicles in a shared use environment, that is, not as a personal car that I own, but as a fleet vehicle that I use, sort of like the Daimler Car-to-Go, fully autonomous, can deliver packages, can deliver food, can deliver people, can replace

cars, buses, taxis, in an urban environment? It seems likely that paradigm change, really looking at it much differently than trying to replace each individual's car, has a lot more opportunity for quicker implementation.

MS. ALTSCHUL: Totally. I think that when you're talking about fleets, this is something we're already seeing being mentioned a couple times, military use, not only drones, but talking about land vehicles in the military, looking at the fleets there. They are definitely looking at this kind of technology. From a consumer perspective, something like Car-to-Go is kind of a perfect platform for this kind of technology, be it here in Washington, D.C. -- those of you who travel to other cities or in lots of cities around the world, you see these little smart cars which are a little bit reminiscent if anyone has seen the google perception of what an autonomous car will look like in the future, that doesn't even have a wheel at all, but is kind of like a little transportation pod for one or two people. And these kinds of systems are meant for urban environments, like you said, because they're small, they're not for long road trips, and generally go at lower speeds, which I think will definitely contribute to more consumer acceptance of this kind of technology, in an urban environment.

So not only from a safety perspective, but as you said, it has consumer applications as well, these kinds of companies like amazon, or McDonald's are looking at same day delivery in certain cities. You know, get your Big Mac in two hours, these kinds of things. And this is going to be definitely contributing to that kind of an economy moving forward. So we like to think that because we have this multilayered system internally within Daimler, that we have these platforms available, not only everywhere from the small smart car to the 18 wheeler heavy duty freight liner, that this kind of technology can be applied to in different settings and it's just something that, like we said,

we need to work on the regulations, to make sure that we're in lock step.

MR. TILLEMANN: Can I just say one thing on that?

MR. WITTES: Oh yes, please.

MR. TILLEMANN: So I think you hit on a really important topic, and there's a heading in my book, which is, when two plus two equals ten. And the truth is, when you synergize these technologies of car sharing and autonomy and electrification and fleet management and you know, you get all of these terrific possibilities in terms of more efficient uses of capital, urban land management -- you know, imagine if you could just eliminate parking. That is a huge amount of land within the city that we could use for so many productive causes. And so, I think that it's really important for us to think about these issues systemically, and not to just take them piecemeal, and to figure out what are the ultimate implications of potentially bringing some of these various technologies together? And so I think it's a terrific question and something we have to think a lot about.

SPEAKER: My name is Evelyn Smith. I'm with the American Enterprise Institute. My question is for Jessica. You were mentioning that in the autonomous trucks that are being tested now in Nevada, that there's not -- there's still a vehicle manager in the car. So I think there's a public perception that this technology is going to eliminate a lot of jobs, but it seems like that's not the case, at least in the short term. So is there a different level of skill that's required to be a vehicle manager? Is there a different type of job that we think will replace truck drivers or Uber drivers?

MS. ALTSCHUL: Actually, I think that's a good question, and it's exciting for people in this field, because I think we are looking at the elevation of this kind of a career, from a driver to, like I said, a manager, someone who is monitoring all the

systems in the vehicle. This is a high tech job, advanced training. And actually I was at an event here in this room a few weeks ago about advanced industry and the kind of education that is going to be necessary moving forward, or different kinds of industries in this country. And I think that this is a perfect example that unlike the travel agents that we don't see too many of them around anymore, this is a job, this is a career that's going to transform. I don't see layoffs necessarily. I see the elevation of this kind of a career, and especially, because once someone in this kind of a career is trained like this, that provides a lot more opportunity than the current kind of truck driver role. So from the technical perspective, obviously we're going to need a human for the time being, in cars and trucks, even with high levels of autonomy, even ones commercial licenses are granted in certain states and countries. But looking several decades down the line, that's the time that we're looking at possibly no one in the car at all and that's something that Sonya alluded to, with the disabled community. I was at CES earlier this year with the Mercedes Benz F 015, our completely autonomous sedan, and we had a big group of disabled advocates -- advocates for the disabled community who wanted to talk about the implications of this kind of technology for the blind, the deaf, people with severe physical disabilities who are completely unable to manage their own transportation as it stands right now.

MR. TILLEMANN: So, if no one else has something I just feel like I have to -- are there going to be layoffs? Yes. Are there going to be lots of layoffs? Yes. Is artificial intelligence and deep learning transforming the way our economy works? Definitely. Will there be new jobs? Yes. Will there be as many new jobs as the old jobs that we lose? Unclear. So I just think that it's really important that we think about these issues in an eyes wide open kind of way and realize that we are moving towards an era

where computers will be able to do a lot of the things that only a human can do today. And actually there's a huge feature piece in The Economist about it for this coming week and I recommend it and I think it's very well done. And I think that anyone who looks at these issues in a balanced way is going to have to admit that there are going to be a lot of layoffs and there's going to be a huge transition and the kind of job that is available right now to a truck driver will not necessarily be available ten, fifteen years from now. And we have to think about that from a policy perspective and plan for it.

MR. KUHN: I just want to say something about that -- so, the layoffs. There was a simulation I think at Singapore University to replace a complete taxi business by car sharing, both done on a university level first. And then they came to the result that it's possible, the service time for the customer -- the average time is better than with a taxi because it's a shorter waiting time. And then they said okay, but we still need people to relocate the fleet and this was then the third of the taxi drivers -- so two thirds laid off. They made the same simulation with autonomous driving, so then they have to increase the numbers of cars because the cars have to reallocate themselves -- but then there's no drivers.

SPEAKER: Hi I'm Bora Jiang with Nature, and I had a question for Jessica and for Karl-Josef about reliable automation and ethics. So as I understand one of the things that's quite difficult if you're an autonomous car, making a decision between say if you have to brake quickly to save the person in the car, but that could cause a chain reaction or something -- is that it's quite difficult for a computer program to deal with things like counterfactuals and calculating whether it's better to do one thing versus the other. And I wondered what are Daimler and Siemens and engineers who deal with this, thinking about in terms of the right approach to making those calculations. Do we know

that ethical decisions of this kind can actually be reliably automated and reliably computed by machine and do we need to know that before we can have things like a Mercedes -- one of Daimler's marks is doing testing in California -- do we need to know, and how much do we know before we can actually sort of have these ethical questions answered in terms of what the car is capable of doing?

MR. KUHN: The question is not so difficult to answer. As soon as you have an algorithm you know what this algorithm is doing. It's decided before something is happening. The rules are fixed, it's programmed. So you know exactly how the car is behaving, so if he has a choice to make an accident left-right, or the car coming from behind, you know it. You know the situation is known. So the calculation time it's -- so it's just making a selection between a few choices. It's done much faster than the human brain, so you know exactly, this will happen in this situation like this or this or this. So we have to make that transparent, that we want to have this reaction so we can discuss situations before they are happening.

MR. TILLEMAN: So is there an ethical obligation to make the algorithms public? To make the choice to say okay we're choosing if you have a choice between killing a kid and killing an adult, you kill the adult. Or you kill the kid, whatever your choice is? I'm being reductionist, but I mean when you have a tragic choice and you have a prospective engineering answer to that -- is there an ethical obligation to lay it out and to let -- imagine the Washington Post headline or the New York Times headline -- Siemens Engineers killing kid. Do you have to do that or are you allowed to have a proprietary killing kid algorithm?

MR. KUHN: It's a time -- interesting question. But you have to see the following points. So we are making now this excursion explicit. You want to have it in the

public. We want to have it in the parliaments of the world. That's because we have to have at the end -- this discussion or this question you are asking -- physician somewhere in the third world has to do this decision every day. Every day he has to make this decision, as it called morality decision and nobody is helping him with this and now, as we have it been in our public here, we have to decide before. I'm not making that decision; we are blaming the engineer, that's the wrong way.

MS. ALTSCHUL: So I want to add one thing that these decisions will also be adaptive so that they will evolve and they will change and they will also be dependent upon region, government, et cetera the same way the physician in one part of the country in the same situation is not going to make the same decision and so the same will be true of these algorithms.

MR. WITTES: And I would also say that this is an area that calls out for regulatory guidelines -- and for government decisions, I mean we make these decisions every day. We decide how much SO2 are we going to allow coal fired power plants to emit, and that kills people, and I think that when it comes to making these big ethical decisions about how stringently are we going to regulate certain kinds of technologies and who lives and who dies, that is actually the appropriate role of a policy maker in many senses.

MS. ALTSCHUL: And I think that, as you mentioned the transparency issue, this is something that we are discussing within the framework of the ethical debate to begin with and I know that the other German automakers are also having these discussions. It was in the news this week that one of our competitors voiced a concern that they didn't think that the ethical concerns could be surmounted which we disagree with. We think it's certainly worth discussing, but if years go by and there are still no

answers then that's something that we'll have to tackle at the time internationally.

MR. TILLEMANN: I just want to put out that when I reference the problem that the military and the covert agencies have had in attempting to engineer exactly this civilian harm reduction problem, you said, well it'll be totally different because these are robots designed to transport people, not robots designed to kill people. And yet here we are having exactly the same conversation and one of the, I didn't know that --

MR. WITTES: I think that's partially because you're asking these questions. (laughter)

MR. TILLEMANN: I didn't ask this question. (laughter)

MR. KUHN: Still the difference is that in a military system the program is to kill people. The principal problem that you have on the road is different. We want to transport people. It's an exception, it's a situation of accidents, and then it's the decision and not for a normal driver.

MR. WITTES: So which is the company that has decided that the ethical problems are not surmountable?

MS. ALTSCHUL: BMW hinted this week that they are concerned about that.

MR. WITTES: Yes.

SPEAKER: My name is Alan Pizarkski. I'm a consultant and a researcher in transportation, travel behavior and public investment. I'm wondering about the critical interface perhaps between public investment infrastructure and technologies that we're talking about. Are there game breakers? Are there critical interfaces that are important to the future or are you going to be able to (inaudible) this activity autonomously outside of whatever public investments are undertaken?

MR. TILLEMANN: So I think that that's something that has to be studied very carefully and that's actually my next project is look at what that interface is and what are the critical roadblocks from a policy perspective and how we have to get our house in order into order to allow automakers to innovate towards this future that is potentially much more efficient. It's much safer and social optimizing. So that's actually, I would say it's something that calls out for further research.

MS. ALTSCHUL: That's also, I want to bring up here in terms of infrastructure -- the spectrum use issue, which is a little bit of a hot topic here in D.C. if you follow these issues right now and that's something that we feel very strongly about preserving that band of the spectrum for automotive use. And so this is something that even though we're talking about vehicles ten or fifteen years from now, it is going on right now from a policy perspective.

MR. WITTES: And when you're done with the mike, just pass it to the gentleman in back of you.

SPEAKER: My name is Brad Townsend. I'm with ourenergypolicy.org and I just had a question again to touch on the safety issue and it sort of builds on some of what has already been asked -- I think I tend to agree with Eli that the public support would be towards the net reduction, however I do think that there could be potential pushback specifically looking at who's responsible for making those programming decisions, whether that's the company or a regulatory agency. And so I'm wondering what the current regulatory framework looks like in terms of being able to support those types of decisions -- particularly with the international angle as part of it.

MR. WITTES: So I'm sorry -- I'm not sure if I completely got the question -- the question is --

There is a terrific paper by John (inaudible) -- which I think copies of are out there about product liability issues with respect to driverless cars and road liability issues. A lot of what you're describing as a regulatory architecture in this country is not a regulatory architecture. It's a liability and blame assignment after the fact architecture. The question of how you apply that legal system to a system in which the point person on the decision may not be the driver is a very hard one and I don't think we entirely know the answer to it yet.

MR. TILLEMANN: That's right and I would say these systems are embryonic, they are taking shape in some states -- autonomous vehicles are kind of illegal or undefined. In some states they're legal and there are regulatory mechanisms that apply to who drives them, how they're driven, where they can be driven. And then on a federal level you have a push towards defining how regulatory agencies will deal with autonomy. NHTSA is working very assiduously on their connected vehicles' policies right now. But yet this is something that we have to get on and think very creatively about, from a regulatory standpoint starting now because it's coming soon.

MS. ALTSCHUL: And I think honestly -- to piggy back on that -- the framework is set up or at least getting set up. I know the DOT has a 2015 to 2019 multi moto plan for vehicle automation that they're working on between the U.S., the E.U. and Japan are already. This is a working which has already been established. There already have been several meetings, the correct people identified -- these kinds of discussions are well placed already and have started.

MR. WITTES: Another dimension of this is unlike the other area where this kind of automation is really taking place, which is in aviation in one sort or another. You do have a federal state issue here that is peculiar which is that traditionally, the

licensing agency for driving is your state government and now you're talking about the agency's -- the decision making entity being a commercial product that presumably doesn't have a license from the District of Colombia to operate a motor vehicle and so there's a question of how much autonomy does a car have before you really lose the foundations of state licensing rules that have governed car driving for the last hundred plus years.

MS. ALTSCHUL: It's going to be a tremendous undertaking to look at these regulations many of which were established in countries and states decades and decades ago -- even a century ago and look at amending them.

MR. TILLEMANN: And I would say this is --

MR. WITTES: We have a gentleman shaking his head with annoyance, but let this gentleman ask his question and then when you're done, pass to the gentleman who wants to correct me.

SPEAKER: All right, I might like to note that there is a third option when you are killing the kid or the adult, kill the occupants of the autonomous vehicle, that's just a third alternative in the algorithm.

MR. TILLEMAN: I'm sure that will be of great comfort. (laughter)

SPEAKER: My concern is really dealing with the deployment of this technology, because it was my good fortune to be part of the jet propulsion laboratory in the 70s. We had an autonomous vehicle running around the lab in the 1970s. The technology was on its way, it was an engineering model but deployment and where it made sense and the continuity of programs -- none of it came through. So it's 40 years ago and here we are again. To me you need a couple of things to go forward with and I'd like to see anybody respond to this -- one is a specific duty cycle, because that way

maintenance is controlled. That way if you're dealing with electric propulsion technology which you don't have to do, but it could be, that is controlled also so that you know that your system, vehicle systems are operable when you introduce it into the rest of the system. The other is, I believe that there is a hybrid that's in there, and that's what we anticipated long ago. And that is that imagine you're driving along in your BMW Z5 or 6, and you're on a nice country road.

MS. ALTSCHUL: That's okay. (laughter)

SPEAKER: And you're on a nice country road, but you're approaching the town you want to be in. You throw it into automated mode. You sit back and relax. The car confirms that you're in automated mode. You now proceed through a city that you know nothing about precisely to where your destination is. And you go. When you leave, you exit in the same manner, and if you choose take the freeway and forget the nice country road. But that choice is a great way to introduce this technology along with mass transit. And that's the specific duty cycle, because mobility for people that don't have a driver's license, never did or have lost it is critical. So if you work on that -- the hybrid concept and getting mobility for all of the people you get quick deployment and acceptance. That was my comment because I've been in this field.

MR. WITTES: Okay so that hybrid version is the road to acceptance. Thoughts?

MS. ALTSCHUL: I would add another element to the hybrid road to acceptance and that's the last mile, first mile access to a public transit system. That is a perfect way in order to sensitize the public to these technologies.

MR. TILLEMANN: So I would just say that most automakers completely agree with you and we love to talk about autonomous vehicles, because that's sexy.

Autonomous vehicles drive themselves. But for instance if you go and talk to Toyota, they do not use the term autonomous vehicles, they say automated vehicles. The reason why is because there are certain instances in which it's very difficult to write that line of code that decides whether someone kills a kid, or they kill the dog, or the kill the occupants or they kill themselves, or they do something else as yet undefined. But you know, what Toyota likes to talk about is the fact that there are large stretches of highway and road in this country for which autonomous driving is quite simple to program and very safe. And usually that's highway driving. And then the other thing that is relatively easy to do, is low speed urban driving. And you can do that from a technical perspective. It's not that big of a deal. It gets more complicated when you're moving into high speed urban driving in a very dynamic environment, and so I think what automakers would like to see is a system where we can get 80, 90 percent of the benefit of autonomous vehicles while leaving those last critical difficult decisions kind of off the table because you're never going to be driving in an environment where they are likely to arise.

MS. ALTSCHUL: From a manufacturing perspective especially as a German manufacturer, I completely agree with you and that's why our kind of first big stab at this in F 015 which we release earlier this year -- or showed at CES and has been travelling around the world ever since, still has a wheel, a steering wheel. Because in our perspective, consumers are going to want that choice and want to use the car differently on a Saturday morning versus a Monday morning, so not everyone necessarily wants more than one vehicle. So that's kind of the way that we see things as having that comfort and luxury in a mobile lounge to be able to drive it when you want or when you need to versus being able to relax when you don't.

SPEAKER: Thank you for recognizing a mild dissent to your comment

about the federal government versus the states. I was in the house commerce committee as a lawyer for years. I worked on 74 amendments to the Motor Vehicle Safety Act. I kind of know a little bit about this. States have very little control over the equipment in the car. They're licensed drivers but motor vehicle safety equipment like passive restraints which I'm surprised you guys haven't mentioned -- the best example of forcing technology that was a federal proposed rule thirty years before it was finally adopted. I hate to use that number, thirty years. But it took a long time and in a way that forced the technology. So I just wanted to point out, there is some relevance. A1nd in a federal system you never know what's going to happen on the Supreme Court. It doesn't (inaudible) federal issue, a United States federal issue.

MR. TILLEMAN: I think you misunderstood my remark. I did not mean to suggest at all that the states were the primary regulator here. What I meant to suggest was quite the opposite, that the more of the driving function you give to equipment, the more you lessen the role of the state and the more you give to the federal government, the function that we traditionally associated with the state which is the day to day operative supervision of the driving function.

MS. ALTSCHUL: I think it does raise a good point about -- and we see it in environmental regulation, too that certain states are doing certain things to go above and beyond what the federal government does. And if you even keep one half of an eye on the auto industry in the last several decades, you know that we push for harmonization across all states so that we don't have a patchwork of regulations and that will be the exact same issue we're looking at with automated driving as well.

MR. TILLEMAN: I think it goes back to a bigger issue around standards and collaboration and cooperation to make sure that you don't have different

infrastructure in different states that is not going to allow these vehicles to cross lines and countries in places like Europe. And cars frequently travel internationally as well, so I think this whole international aspect is really critical.

MR. WITTES: We have time for one more question and then I'm going to give each of our panelists a chance to wrap up in response either to the question or if he or she chooses to ignore the question, to anything else that moves. (laughter) Sir, in the back.

SPEAKER: Thank you all. This has been an excellent talk and I really appreciate the different perspectives. My name is John Watson from The Nordic Group. My question is, we've kind of danced around this a little bit and there has been some remarks regarding it but the human factors that lead to the acceptance. So we've talked about the Tesla being arguably a superior car to the alternatives because of the design, Uber or car to go, pundits can have as much concerns or anxiety about the service until the second that they use it and it's more convenient. Jessica, you mentioned about the mobile lounge. What other design factors and the human factors that will go into the design of a vehicle that you think will make it acceptable and desirable to the actual consumer, that will lead to acceptance?

MS. ALTSCHUL: This is a really interesting question and I'm glad you brought it up because design is something that can't be ignored when we're talking about consumer acceptance, because as far as the technology and the sensors come and as far as the regulations and laws come, if people don't want to buy it, this is a problem and this is what we're seeing it right now with certain drive trains in California and other states. So we are a luxury car brand and we look at this issue a little bit differently than some mainstream car brands. I pointed to Google with the Google car looking at what

that is versus what our F 015 is, incredibly different. So what we might --the kind of design that we might put in an autonomous smart car in the car to go fleet versus something that a wealthy businessman might buy for his personal use is going to be completely different. But for us it's the luxury, it's the comfort and the privacy of your own space especially when you're thinking about the cultural aspects in the U.S. -- people who generally like their own space and that's why there's some reluctance to beef up the public transport systems in this country. So we're looking at all of that from our luxury perspective and I'm pretty excited about the way that it's going. I'll leave it at that for my closing remarks too.

MR. WITTES: Let's just go straight down the line.

MR. KUHN: One last point to the autonomous driving -- it was an interesting time about five or six years ago. We made a world-wide study, we conducted it in China and Japan, and Europe and the U.S., and we were discussing in the study the point, how much software, how automation we will have on the cars in the next years. And we made some predictions about that, about what will happen in the future. And sorry to say, it was six years ago, we were wrong because now it's already announced that we have the first autonomous systems or automation systems in 27, the 17s and the 18s in the cars followed by 21 and 22 where we have the highway assistance system and where we have the parking assistance system where you don't have to drive your car by yourself in your garage or on the highway. So this is coming very soon and it's coming earlier than we predicted. It was five, six years earlier and I guess that the same will happen with autonomous driving because there is a need for it in the world. And that's the difference to that what you said with your propulsion systems or your autonomous car in your lab. It took also one hundred years until we had a mass road out of electric cars

on the road, because we had that in the beginning of the last century. There were more electric taxis in New York on the road than we had in the combustion engines. They were already there and then they were gone and they're coming again. Now these autonomous cars are coming, and I guess they are coming faster than we think already now.

MR. TILLEMAN: Yeah, I couldn't agree more and so to answer your question, our discussion has been kind of safety, safety, and safety, and the answer to your question is productivity, productivity, and productivity. I mean if you can have a mobile office that allows you to live in Herndon and commute in and be as productive in your car and as comfortable in your car as you are in your office, then that's a real game changer and I think that the productivity gains are going to just overwhelm opposition to autonomous vehicle technology and I think that smart automakers will be thinking about that and thinking about how they can integrate not just entertainment but the rest of life into your vehicle as well.

MS. SMITH: I would just encourage us to think about the autonomous vehicles not just in terms of the direct benefits, reduction in traffic accidents but also the increased access that these types of vehicles can provide and the benefits there too to society as well.

MR. WITTES: With that we are going to have to close and thank you all for coming.

(Applause)

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