THE REALITY OF AUTONOMOUS VEHICLES

By John Esposito

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The age of autonomous vehicles is upon us. The time has arrived when driverless personal automobiles and commercial trucks, vans, and taxis owned by privately-operated tech companies, will take center stage on the landscapes of the United States, Europe, and Asia. Is this a truism or not? Ask the average man and woman on the street and you will undoubtedly receive several different answers: driverless vehicles are already operating in the here and now; driverless vehicles are right around the corner – at best a year or two away; driverless vehicles will not be seen on our roadways for many years to come.

Numerous benefits are touted by automakers, tech companies and software designers that predict the new technology will improve driving efficiency; provide more leisure time in this increasingly populated world; reduce serious traffic accidents, and the aftermath of resulting injuries and fatalities; eliminate or substantially reduce parking congestion; allow for lower fuel consumption; and eventually result in the manufacture of lighter and more versatile vehicles.

Benefits will obviously come with certain obstacles and limitations. The challenges ahead include: artificial intelligence and software functional limitations; susceptibility of vehicles' sensing and navigation systems to address different types of weather conditions, and the avoidance of darting animals; the need for changes to existing road infrastructure; an increase in liability issues arising from

vehicle accidents because of more finger-pointing among parties; increased tort litigation and a backlog of civil cases in our courts; and moral and ethical issues, including the loss of commercial jobs.

There will also be serious privacy concerns once a vehicle's location and position are integrated into an interface to which other people have access. This communication brings the risk for automotive hacking through the sharing of information via vehicle to vehicle protocols, including the potential risk for terrorist attacks by loading self-driving vehicles with explosives.

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In a wide-ranging interview conducted on October 11, 2018 at the State University of New York (SUNY), New Paltz, N.Y., Dr. Scott Le Vine and journalist, John Esposito explore the future of autonomous vehicles.

Dr. Scott Le Vine, AICP/PP is an Assistant Professor, teaching Urban Planning at SUNY at New Paltz. He is a Research Associate (Centre for Transport Studies) at Imperial College in London; and a Visiting Professor at Southwest Jiaotong University (College of Transportation and Logistics) in Chengdu, China. He has authored and coauthored a number of studies on autonomous vehicles and provided expert testimony to various levels of government in both the United States and the UK.

John Esposito: Dr. Le Vine, it is a pleasure to have the opportunity to meet you and speak about the exciting and controversial subject of autonomous vehicles, which is on the minds of so many people these days.

Dr. Scott Le Vine: I am delighted to meet you as well.

JE: Our discussion today will center on the future of autonomous vehicles in society, primarily here in the United States and also Europe and China. The term autonomous vehicles are sometimes used interchangeably when also referring to automated vehicles, driverless vehicles, robot vehicles or robo-vehicles. There is an important distinction between autonomous and these other terms. As we move ahead in the next few minutes, I will ask you to please explain the differences.

Unless any one of us have been living under a rock for the past ten or so years, the population at large has been made acutely aware through the likes of social media that the age of autonomous vehicles is upon us. The big question is exactly when will this new technology become mainstream. The public's acceptance of this new form of automation appears to vary. Some will embrace driverless vehicles at every turn and want to be the first in their neighborhood to own one, not unlike those who are willing to wait in line for ten hours every year for the Apple store in New York City to open so they can purchase the latest and greatest iPhone. Some consumers will completely resist because of their long-held love affair with automobiles and an unwillingness to part with their 5-speed shift. Others will remain on the fence and greet the news of this technology with much trepidation, fearing autonomous vehicles will result in serious injuries and even death should the software and sensor modules fail.

This leads back to my opening comments. Please explain the difference between autonomous vehicles and automated vehicles and how they do and do not constitute a driverless vehicle?

SLV: Well, thanks for having me, John. That's a great question and it is a nuance that is lost in many discussions both by the man on the street and by many who observe this industry. There is a clear distinction. Automated refers to the automation of driving tasks, and there are various levels of automation. Automation runs from no automation where the human is in complete control of everything, the complete driving task, and full automation which is the holy grail. Full automation is where the driver, the human in the vehicle is completely disengaged from the driving task. There may not even be a human inside the vehicle. The vehicle can go anywhere, do anything under its own control. That is automation. Autonomy (autonomous) refers to where the vehicle is getting its source of information. What information is that vehicle using to make driving decisions? Autonomous implies the vehicle is receiving information from its own sensors. Connected is the opposite of autonomous. Connected vehicles speak to each other, speak to traffic lights, speak to other bits of roadside infrastructure and exchange information that way. A connected vehicle can see around a corner if it is receiving information from something which can see around that corner. An autonomous vehicle only has its own sensors what it can physically see.

JE: In your professional opinion, where do we stand today in the evolution of this technology? I understand there are actually five levels of the new automation which will ultimately all coexist on our roadways for the foreseeable future. Separating the available facts from sheer speculation, what is the realistic time frame before we can realistically expect these vehicles to be in everyday use, in both the United States and Europe? Can you try to be specific?

SLV: Well, I can tell you that in planning school the first thing you are taught is: give them a number or give them a date, but don't give them a number and a date. So, it's a really difficult question. You ask about the U.S. and Europe, but I think a more interesting comparison might be the U.S. and Europe versus China. Here there are issues of liability, of responsibility for crashes where there seems to be a different tolerance in China than there is in Western societies. It is plausible to me that you might see things move more quickly in places like China than in North America or Europe.

The answer to *when*, you can get an answer from *yesterday* at Tesla, with some automation, to *never*, as we're unlikely to ever have a vehicle that can drive anywhere, do anything with no human input, except choose a destination. Humans also can't drive anywhere and do anything. It snows and sometimes we don't make our journey. If it's a hurricane, we're not making our journey, etc. So that's unlikely to ever happen in that sense.

What automakers seem to be doing is moving forward quite rapidly with mixed, mushy mixed levels of automation, which is, level two to level three in the five-class categorization you mentioned earlier. That categorization comes from The Society of Automotive Engineers International (SAE). It runs from level zero which is no automated, (you think of the Ford Model T), through level five, which is the go anywhere, do anything, all dancing, bells and whistles driverless car. What we are seeing is automakers move forward with level two, level three vehicles, which can take on some of the driving tasks in some places, sometimes under some circumstances. What automakers and other mobility services seem to be doing in the near future with regards to the highest levels of automation is geo-fencing. This is allowing their vehicles to operate within very well-defined geographic boundaries, like city centers. Manhattan,

for instance, or central Boston or central Phoenix. Within those geographic areas, the road system is extremely well mapped, extremely well digitized so that they have a great control over what that vehicle is doing.

The second thing which we are seeing is automakers planning to roll out these systems as parts of fleets of vehicles so you would use them before you will buy one. Later this year, Waymo, (formerly the Google self-driving car project), plans a rollout at commercial scale, of their driverless taxi service in Arizona.

JE: Will this rollout be on public roads?

SLV: It will be on public roads and open to the public. They have been testing it in Arizona and California and other environments as well. Testing has taken place for many years now. What's new is later this Waymo will expand its service availability from trusted people to the public at large.

JE: Will there be a driver inside the car?

SLV: There's likely to be initially, but certainly the plan is that there will not eventually.

JE: What do you anticipate the five-class categorization level would be for this rollout?

SLV: It depends on what the driver is doing. If the driver is actively engaged in monitoring the vehicle and has power to override a driving decision, that would be a level three or so vehicle. If the driver is simply there as a sort of chauffeur, then that would be a level four vehicle.

The initial deployment is in Arizona. They have been operating on public roads already. What's changing is that they are allowing members of the public to use it on a commercial basis.

JE: In light of three fatalities which have occurred to date with driverless cars, have there been any attempts by either the Federal government or the state government to step in and prohibit the operation of autonomous vehicles on public roads in Arizona?

SLV: I am not aware of any organized effort on the part of any level of government to stop Waymo's rollout in Arizona. As a legal matter, if there's genuine risks to the public, I don't think it would be too difficult for the state to argue that they would preclude such a service from operating, but I don't see any political will at the moment for that. Should things change I think that the legal powers exist, the same ancient legal concepts that allow states to impose speed limits, the same power would allow the restriction of certain technologies if they prove to be a danger.

JE: Is there a specific date for the deployment before the end of 2018 or in 2019?

SLV: I don't know. My finger is not on the pulse.

JE: I understand there are 46 corporations currently working on autonomous vehicles. The tech companies include Uber, Waymo and Lyft and automakers like GM, Toyota and Ford have spent upwards of $6 billion developing driverless technology. Dr. Le Vine, who in your estimation are the leaders in this field?

SLV: It's a great question to ask. Certainly, Waymo, formerly Google, is head and shoulders ahead in terms of the miles of driving tasks that have been done with automated vehicles. The German carmakers are very far along, BMW, Dähler, Audi, etc. There is GM's Cruise division. They are one of the leaders.

JE: From this layperson's perspective, it would appear that Toyota's conservative vision is probably how we could expect the very first wave of autonomous vehicles will reach the public, that is, with human and machine working together for a number of years. This, in large part, is because of certain obstacles which could prohibit full automation, or the holy grail, as you described it earlier, whereby the human driver inside the vehicle is completely disengaged. We can discuss in detail some of these potential obstacles shortly.

SLV: Different automakers take different perspectives. Toyota, for instance, has a relatively conservative perspective. Toyota envisions the technologies we have been talking about, augmenting the human driving experience rather than replacing the driver in the vehicle. Toyota is looking very much at a hybrid

where the human and the machine work together, whereas others like GM, for instance, are looking at a future where the vehicle does the driving and the human does not.

JE: In the past few years several fatalities associated with the operation of autonomous vehicles have made national headlines. On May 7, 2016, the first known fatality involving a semi-autonomous vehicle occurred when a collision took place in Williston, Florida between a Tesla Motors Model S, with autopilot technology, that was being operated by Joshua Brown, and a tractor-trailer. The autopilot sensors on the Model S failed to distinguish a white tractor-trailer crossing the highway against a bright sky. The National Highway Traffic Safety Administration (NHTSA) concluded the crash did not result from a system flaw, but due to a lack of safeguards to prevent misuse.

A second fatality occurred on March 18, 2018 in Tempe, Arizona when an Uber self-driving test car struck and killed 49-year-old Elaine Herzberg, who was pushing a bicycle, filled with plastic bags, across a four-lane road, allegedly by a distracted safety driver who failed to react in time. The police have apparently not indicated who was deemed at fault. Following the accident, the governor of Arizona banned Uber from testing there; and Uber let its autonomous vehicle testing permit lapse in California. Uber also pulled its vehicles off the streets of Pittsburgh, Pennsylvania, the home to its self-driving research and development center.

Then on March 23, 2018 a third fatality occurred in Mountain View, California involving a Tesla Model X, with autopilot engaged. The driver, Walter Huang, was killed when the car crashed into a freeway divider and burst into flames.

Dr. Le Vine, what is your current understanding as to the status of future testing on public roadways by Tesla and Uber as well as other companies and do you have any additional insight on how these accidents occurred?

SLV: All these crashes are fairly well understood as to what had taken place. They all involve situations in which a human was, in principal, responsible for monitoring the operation of a semi-automated system and there was a breakdown in that system that the human did not, for whichever reason, correct in time. And one thing we are learning is that humans are pretty terrible stewards of machines. Machines that fail infrequently. Why? We like to text. We get distracted very easily. Humans are not built to maintain laser beam-like concentration when we're doing a task which seems like it doesn't require our involvement. That seems to be the case in at least some of these crashes. There may have been an over expectation on the driver's part about what the system could do or the human driver was simply misbehaving in the sense of doing another task they should not have been doing at the time.

One of the criticisms of Tesla has been that effectively, Tesla is doing its testing with members of the public, with Tesla owners who opt in and agree to use the system under prescribed circumstances. Their system has limited ability and it chooses to manage how their driver operates in a limited way. For instance, should your hands always be on the wheel? Yes, your hands should always be on the wheel. There have been reports of the Tesla autopilot system not turning off when once your hands leave the wheel for a period of time.

JE: Has Tesla resumed their testing and are they in the testing phase only?

SLV: No. Tesla has continued. Their system is called Autopilot. Autopilot was not turned off. Owners of Tesla are able to drive. It continues to be available for their owners to drive with this autopilot system turned on, in which the direction of the vehicle is controlled through the steering and also the acceleration and the deceleration.

JE: Can the driver then control the vehicle?

SLV: The driver chooses to engage it and then the driver hopefully is not distracted and is monitoring. In principal, Tesla requires you to always monitor because the system is not 100% reliable.

JE: Can the driver can grab the steering wheel if necessary?

SLV: He or she is supposed to. They are under an obligation to constantly be monitoring but again, we are not great at meeting our obligation when the requirement is to constantly observe.

JE: Has Uber resumed testing?

SLV: Uber for a period of time did stop testing. My understanding is that they have resumed testing in other locations. I am not familiar with whether they are currently operating in Arizona.

JE: Your earlier comments about the apparent human driver error or distraction for at least some of these crashes brings to mind an intriguing article I read earlier this year *(The New York Times – Business Section, March 16, 2018 – "When the Self-Driving Car Needs Backup").* The article reports that a company known as Phantom Auto is working on remote control systems at the same time as the major technology and car companies are teaching cars to drive themselves. Developers of self-driving cars see remote control access systems as a necessary safety feature for purposes of addressing "edge" cases – situations that software programs can't anticipate and when a self-driving car cannot help itself. In such cases, Phantom Auto wants to become the OnStar for the autonomous industry. A car in need of help would automatically contact a Phantom Auto center where a remote operator could use cameras and sensors to see what was happening, then maneuver the fully autonomous vehicle out of trouble. Are you aware of what progress has been made on developing remote control systems?

SLV: That is going to require extremely sophisticated communication between the vehicle and the central control station. There are different ways of doing this. One idea which Nissan is pursuing for instance, is when you have a vehicle that approaches a work zone and the vehicle gets confused. It doesn't understand what instructions are being given by the flagger or the placement of cones, so the vehicle says: "Help, I don't know what to do in this situation." In that situation, the vehicle could send a request to a central monitoring station. The central monitoring station could give instruction: "Go this way," and the vehicle goes that way. A much more intensive concept would involve, like would an Air Force drone, the human remote operator being in continuous real-time control of that vehicle. That requires extremely low-latency communication happening on a millisecond time scale. We haven't got

the cell network to do that today, perhaps we will with the 5G cell network that is coming down the pike.

JE: I would like to move on and discuss an aspect of this new technology that will bring consequences. I am speaking about ethics which at some time or place will undoubtedly impact the operation of an autonomous vehicle. Ethics and law often diverge and under certain circumstances when we drive our vehicles today, good judgment may compel us to act illegally. But what about a fully self-driving vehicle programmed to strictly obey the law. A common example that has been used is when a large tree branch falls across our lane of traffic on the road. With no incoming traffic, we currently would move across the double yellow lane into the opposite lane, and then drive around the tree branch before returning safely back to our lane. Conversely, the fully automated car may come to a full stop when it approaches the branch to avoid striking it and not cross over the double yellow line because the vehicle is programmed to obey the law and doesn't have the software capability to react and proceed around the tree branch. In other words, is it even possible to program a fully autonomous car to break the law, as in cases of an emergency situation? What are your thoughts about this hypothetical scenario?

SLV: There are a couple of really interesting points in this question. The first point is what if that tree were to fall directly in front of that vehicle so the vehicle didn't have time to stop. Well, the vehicle is going to hit that tree. That is called a dart-out situation where typically what happens is you are driving down a road and a child darts out from behind parked cars and you have no chance to stop in time before you hit that child. Well, that is still going to happen whether it's the falling tree or the child darting out. Interestingly, in that situation today, you as a driver are not liable if you are able to demonstrate that because of the dart-out, it was impossible for you to stop in time.

JE: I would agree in most cases, presuming of course that you can prove this in a court of law.

SLV: There are a set of legal cases, called dart-out cases.

Now to the second part of this question: what do you do when you come to a road block and you have a double yellow line, which in general, you should not be crossing a double yellow line? There will not be a single thing which is *the* automated vehicle or *the* autonomous car because each manufacturer's system will have unique attributes and operate in its own way, so here there's a race to develop the best algorithm, the smartest algorithm, and the most intelligence. It's quite possible that different manufacturer's systems will react in different ways. The Nissan concept which I mentioned earlier might involve the vehicle setting up an immediate request to a human in a central monitoring station who then gives an explicit override to go around onto the direction of oncoming traffic and then go back into your lane. The basic responsibility that humans have as drivers is to drive reasonably. And that basic responsibility will extend to anything that operates on the roads. The question is what is reasonable? Is it reasonable under the circumstances to remain trapped by that tree across half the road indefinitely or is it reasonable to break that double yellow line and cross even though that is not what the law says?

JE: It does not appear technology has advanced to the point where a driverless car can make decisions like a human driver can in such situations. The issues that quite possibly could arise would not be confined to only ethical concerns, but also could invoke certain legal and moral questions. A specific

example often used to outline these issues is referred to as the "Trolley Problem." Dr. Le Vine, could you please explain this hypothetical case and provide your understanding what, if anything car manufacturers and tech companies can do to address this problem?

[The "Trolley Problem" was originally proposed by philosophers Philippa Foot and Judith Jarvis Thomson. The problem is to imagine a runaway trolley(train) is about to run over and kill five people standing on the tracks. Watching the scene from the outside, you stand next to a switch that can shunt the train to a sidetrack, on which only one person stands. Should you throw the switch, killing one person on the sidetrack (who would otherwise live if you did nothing), in order to save others in harm's way? - The Ethics of Autonomous Cars – Patrick Lin – Technology October 8, 2013]

SLV: This is the "Trolley Problem." It is something that the community is well aware of and discussing. The issue here is once a situation arises where something bad is going to happen, somebody or some thing has to give instructions to make a judgment call, as to, should it be bad in this way or should it be bad in another way. Should it be bad running over the family with the baby stroller or the elderly person crossing the street? And the obvious solution to the "Trolley Problem" is not to get into that situation, and not to get into a do or die situation where there is no way out without harming somebody or some thing. The way to do that is to drive defensively. That's what we are taught from driver's education in high school; and insurance companies encourage us to drive defensibly with discounts, etc. Driving defensively is the strategy to avoid the "Trolley Problem," to avoid having to choose to run over the stroller or grandma with the walker.

JE: Can fully autonomous vehicles, those without any human driver input whatsoever, ever be capable of making difficult and ethical judgment decisions in the dangerous scenarios that you described? Will it come down to no-win scenarios when the day comes where these vehicles are in everyday use?

SLV: Well, you drive conservatively. You choose a safe following distance behind whatever is ahead of you; maintain a vigilant lookout for what's happening on the side of the road, for objects or people that are moving towards your path. Roads are an open system. Therefore, there are going to be balls running out into street in front of vehicles. There's going to be dogs running into the street in front of vehicles. There are going to be jaywalkers. Those are unpredictable open systems. We'll never completely eliminate crashes, fatalities, etc. That is not going to happen. The best strategy we can do is to do much better than humans do. And we can do that by driving defensively, not speeding, driving conservatively, being constantly aware of our surroundings. Humans have two sensors in the front of our face: our eyes. And that is what we use to learn about what's going on around us. The vehicles we are talking about have a 360-degree field of vision, so they have that advantage. These vehicles have another advantage of being able to process information basically instantaneously, again on the order of milliseconds. Humans take something between one and two seconds to react, even in cases of emergency. Those are humans who are not distracted, and then think about someone texting. For lots of reasons we can expect to do better than humans, how much better is a judgment question.

JE: There are other ethical aspects that encompass moral issues. As one expert I read said, "there are going to be deaths, especially in the infancy stages of autonomous vehicles. And like the U.S. space

program, we can expect that people are going to die." I don't necessarily see how you can make fair comparisons using these two examples. Do you?

And then taking a 360-degree turn, some other ethical issues include the financial implications resulting from massive job losses and unemployment among drivers; and certainly, privacy concerns, which we should discuss in a few minutes.

SLV: There are lots of parallels with the space program and there is a couple of important distinctions. Everyone taking part in the space program was an informed, consenting participant. Here, we are testing with lives of the public at stake. A space shuttle is a closed system. This is an open system where everybody walks on sidewalks, and everybody crosses streets and everybody drives on the road. As a legal matter, every driver of every vehicle has a duty of care to all other vehicles around it, to all pedestrians around it, to everything it could possibly come in contact with. What will be emerging over the next five, ten, x number of years is how that duty of care is interpreted with the capabilities of automation beyond what human drivers can do.

JE: A recent study was published by the Eno Center for Transportation, a non-profit think tank in Washington, D.C. The Center was created in 1921 by William P. Eno, who is credited with developing the first traffic plans for New York, London and Paris, as well as helping to invent stop signs, taxi stands and pedestrian safety islands used throughout the world. The Eno Center's recent study found that it would take somewhere around ten percent of all cars on the road to be self-driving before benefits were experienced by all drivers whether they were in a self-driving car or not.

This study lends itself to a number of potential considerations that we can anticipate on roadways of the future manned with self-driving vehicles. It is a reasonable expectation that during the early years of this new automation, present-day human operated vehicles will continue to coexist with self-driving vehicles of different classification levels on all our streets and highways. This then asks the question, if I am seated in a fully autonomous car on the roadway alongside like vehicles, as well as conventional human operated cars, would I be able to adjust the speed of my vehicle, like using 'cruise control' on present-day cars, or would my vehicle be locked-in to a fixed speed no higher than the legally posted street or highway mph limit? I am thinking of a situation where I might wish to pass a human operated car directly in front of me because I am in a hurry and believe the car in front of me is going much too slow.

SLV: It's a great question. With cruise control on your car today, you can set it at 85 mph if you wish, even if the speed limit is 50. Vehicles today allow that. We have the technology, if we wished, to govern speeds so that you can never see the speed limit, but we choose not to do it. It's an interesting design question. Are these vehicles designed to break the speed limit if they are given instructions by the occupant? If there is then a crash, who is responsible? Does the occupant then bear some responsibility because you instructed the vehicle to go 60 mph in a 55-mph zone. I think in the longer term, we'll need to rethink the rules of the road and speed limits. Speed limits are based on the rules of physics and human fallibility, human reaction time, human lack of attention, etc. In the future, the human will be taken out of the equation and it's just the law of physics. So, we'll probably get higher speeds, but I think the idea of a single speed limit for all traffic, at all times, as we have today is unlikely to continue indefinitely, but we'll change it somehow. We'll have to adapt the rules of the road.

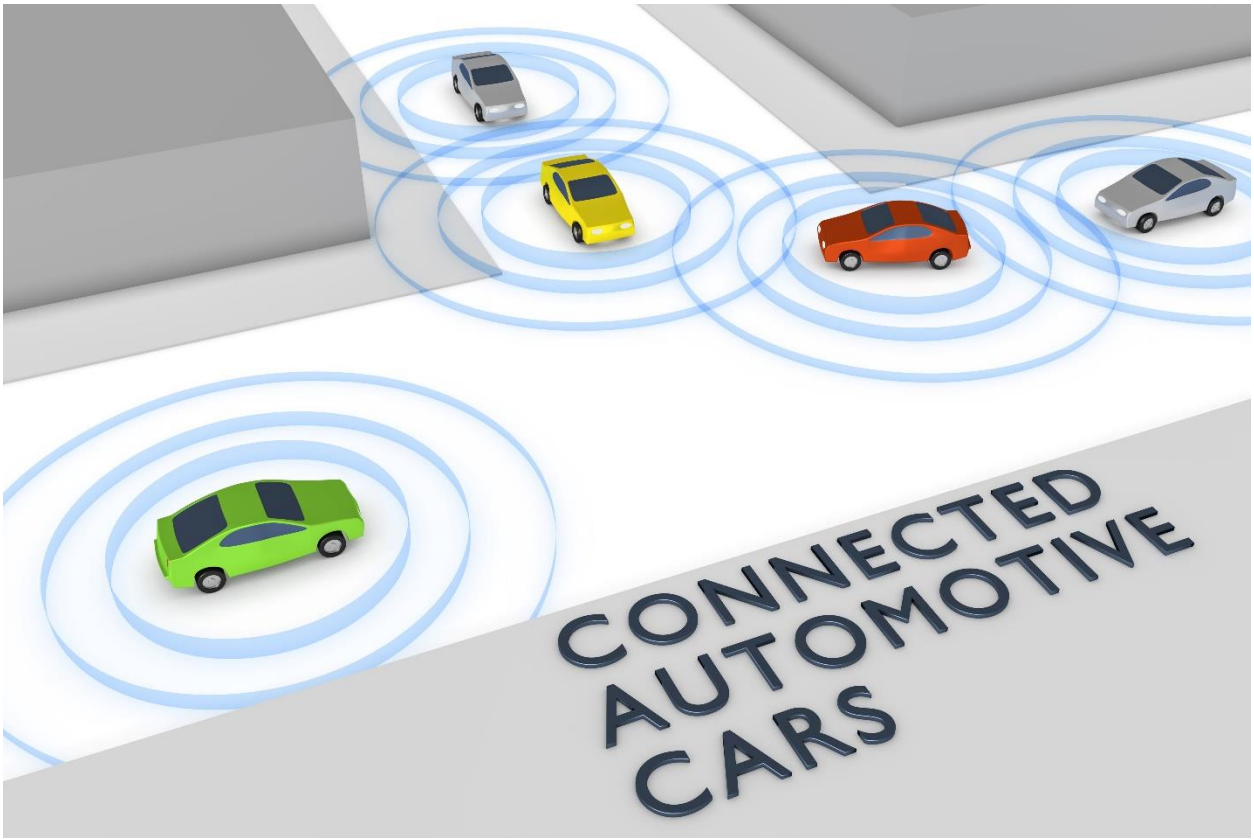
JE: When the initial major rollout of autonomous residential vehicles occur, is it reasonable to expect that these vehicles will be permitted to operate only on less populated roads or country roads, but not in large populated cities like New York, Boston, Los Angeles and Philadelphia? I can't comprehend how state and local municipalities would even be able to enforce such restrictions.

SLV: I think we will see a messy evolution. We can only state that Tesla's Auto Pilot system is not designed for Manhattan's street grid. Tesla's Auto Pilot is designed for freeways and not Downtown Manhattan. On the other hand, for shared taxi services, like Waymo is rolling out in Arizona, demand is not on freeways, demand is not on country roads. The demand is in places like Downtown and Midtown Manhattan. There is a real tension between where the market is that is attractive to them, and what they are able to do in a technical sense. We shall see how that tension is managed over time.

JE: Eventual changes will be necessary, but once again, from a layperson's perspective, I believe several very important issues need to be addressed even prior to instituting speed changes, like establishing new vehicular laws and road rules, and new roadway infrastructure. In addition, computer navigation and car sensing systems must operate perfectly in these new vehicles.

Perhaps the most serious issue that must be addressed came with federal agencies approval of vehicle-to-vehicle communication systems in February 2014. This will allow cars to "talk" to each other so they know where other vehicles are and can compensate for a driver's inability to make the right crash avoidance decisions because of blind spots or fast-moving vehicles. Equally important are the privacy concerns that can result when these vehicles locations will be integrated into an interface which other people will have access. This could lead to the potential for mass surveillance, malware, automobile hacking and possibly the risks of terrorist attacks with self-driving cars being loaded with explosives. These three: privacy, car hacking and terrorism are obviously extremely high priority issues for the public, government and private sectors today, and have been even prior to the advent of autonomous vehicle technology. Before I ask you to speak about these particular hot-button issues and what the plan of action is being discussed to address them, please explain vehicle-to-vehicle communications functionality. You previously mentioned that each manufacturer's system will have unique system attributes and operate in its own way. If this is the case, are vehicle-to-vehicle communication systems at a significant risk of not effectively "talking" to each other because their unique systems may react very differently?

SLV: Vehicle-to-vehicle communications are known as "V2V." We are working on a common language. It would be a Tower of Babel if every vehicle was only able to talk to friendly vehicles. The system would work best if every vehicle is talking to every other vehicle within proximity. At the moment we have a protocol for vehicle-to-vehicle communication which is a bit like every car screaming at every other car nearby and not listening whatsoever. And it's screaming baby talk. It's screaming extremely, extremely limited information. In the future there will have to be Shakespeare talking to each other and getting confirmation: "Did you get my message? Yes, I got my message. So, what are you going to do? This is what I'm going to do." Right now, it's simply we're screaming out who I am, this is the direction I'm going, this is what I speak. Very limited information.



JE: What is presently being explored to address the serious issue of privacy concerns, that potentially can result when a vehicle's location and position is integrated into an interface which other people have access? And more specifically, what are your thoughts about the risk for automotive hacking through the sharing of information via V2V (Vehicle to Vehicle) and V2I (Vehicle to Infrastructure) protocols, including the potential risk for terrorist attacks by loading self-driving vehicles with explosives.

SLV: I am not at the forefront of discussions about security. I think the point you make about a self-driving autonomous car being used as a directed bomb, there's plenty of other ways for terrorists to blow things up. I'd be surprised to see that. I think the point you made earlier is more relevant to this specific technology, which is hacking, which is ways of disrupting traffic or disrupting peoples lives short of some sort of weaponization. There will need to be redundant systems, so the stealth fighters apparently have three or four different decision-making brains, each of which must agree before a decision is made. We will need redundancy built into these vehicles to deal with the hacking situations. In terms of privacy, the lesson of the past ten and fifteen years, people have been willing to part with an awful lot of privacy in exchange for consumer goods and whether that will continue to be true here, my gut tells me yes, but we won't know beforehand.

One other point is that I suggest you think about privacy in these multiple ways. Privacy is between you and family members, you and friends, you and coworkers, etc. It's also between you and the private manufacturer of the vehicle, and the software vendor. It's also privacy between you and the

government and law enforcement, etc., so there's different forms of privacy, each with a completely different set of issues.

JE: Are you aware of the total number of fatalities related to vehicular accidents is this year in the United States?

SLV: It is presently somewhere between 35,000 and 37,000.

JE: Proponents have made the case that these figures will be drastically reduced after driverless vehicles have become mainstream. However, since this has not come to fruition and there is no hard-statistical data to bear this out, how can such a determination be made? These predictions seem to be more conjecture than anything.

SLV: That is an excellent point. The standard headline figure is that driver error is a factor in 94% of crashes. And that comes from police reports. The question is how much of that 94% will be reduced and in what way will it be reduced, and how many new crashes will occur that would not have occurred otherwise. You mentioned earlier the crash with Joshua Brown in Florida, and the lady in Tempe, Arizona with her bike and the Uber, and the Tesla crash in California earlier this year. Those crashes may not have occurred if there was alert human that was driving. So, therefore it is likely that car crashes will change in several ways. Maybe we'll reduce them, my view is we probably will reduce them. But the ones that remain might be more high speed because humans fail in different ways than machines fail. We might end up with new sorts of crashes that we wouldn't have expected humans to get into.

JE: When we were discussing the "Trolley Problem" earlier, you discussed the importance of driving defensively in an effort to avoid difficult situations, such like we were taught in driver's education back in high school. A thought came to me when mentioning driver's education. In the years immediately after semi-autonomous cars become the norm on our streets, a growing population of young people will come of age to begin operating these new vehicles without ever having driven a conventional automobile. This will require a new type of autonomous driving instruction and testing that has never existed. Likewise, such instructions may be a requirement for individuals of any age in our society who wish to operate a driverless car. And just as the generation of young people who never sat behind a steering wheel, an entirely new form of driving instructions may be crucial for older drivers and senior citizens who may be less dexterous than younger people. Do you agree?

SLV: Sure. One of the challenges here is that it is a fast-moving target and government in general is bad at managing fast moving targets. Driving the way we do today hasn't changed all that much in many, many decades, but automation systems are evolving very rapidly, month by month, year by year. The driving test you are doing today could be out-of-date two or three years from now. I think it's very, very tricky to devise driving tests for members of the public. What I think is more likely in the short term are specific tests and requirements for test drivers. I think we are likely to see on a state by state basis, if you're a test driver, this is what you need to be certified in.

JE: Dr. Le Vine, you are a frequent guest speaker to audiences in academia, practicing urban planners, and the automotive industry. You have also provided expert testimony to various levels of government

in both the U.S and the UK. I understand you are a lead-inventor of patent-pending congestion pricing technology for self-driving cars. A decrease or even an elimination of traffic congestion is one of the many perceived benefits expected to come with autonomous vehicles. Many motorists today drive so tightly packed together not permitting another vehicle ample space to get in front of them, or to enter or exit roadways, resulting in traffic coming to complete stop. Could you please discuss this dilemma as well as your patent, and explain how autonomous technology will potentially alleviate traffic congestion?

SLV: Sure. If you go into the mission statement of any State Department of Transportation you are going to find words like "maintaining an efficient and safe transportation system." There is always a trade-off between efficiency and safety and we do the best we can under the existing system where humans are driving. Efficient, meaning to get where you want to go as quickly and cheaply as possible and as safely as possible. There is a trade-off between the two. The more closely I follow the vehicle in front of me, I am taking a bigger risk. If I follow that vehicle one foot behind, right on his bumper, I'm taking a pretty big risk of getting into a crash with that vehicle, but I might save a split-second in time. By choosing how closely I am going to follow the vehicle in front of me, I am effectively choosing a level of safety and how much risk I am prepared to tolerate. I am also choosing how quickly I will get to my destination. So, is it worth it to me, a subconscious decision we make, to shave off a tenth of a second on this journey to follow a little bit more closely behind the vehicle in front of me? Now the patent and technology you mentioned, when you look at how the congested road network operates, it is a little bit like the bread lines in the former Soviet Union. It's first come, first serve. And what happens if there are too many? You wait in line. That's what we do in traffic today. We wait in line. If you've gotten there before me, you are going to get out of it before me and I'm behind you. We look at the Soviet Union's bread lines and we say, how crazy they were to do that. Maybe someday we'll look at our highways and say how crazy we are to operate the way we do. The idea that we have is the technology would allow two vehicles that are in a stream of traffic to swap their places. The idea is Mr. Big Shot, powerful executive, moneybags, is in a rush to get to his next meeting. In front of him, a schoolteacher, has left school for the day and he or she is making their way home and they don't feel like they're in a particular rush. Maybe, Mr. Money Bag's car effectively says to the teacher's car, "I will give you x number of cents or x number of small dollars to allow my vehicle to pass." And maybe the teacher's vehicle in front say, "I'll take the deal." And the two vehicles seamlessly, in the blink of an eye, would agree to swap places in that traffic stream. The vehicle behind that wishes to move ahead would move ahead, and the vehicle ahead gets compensated for allowing that to happen.

JE: I am sure that you are familiar with Peter Calthorpe, an urban planner based on Berkeley, California. A recent article (New York Times, Sunday, October 28, 2018) mentions he is one of the creators of New Urbanism, which promotes mixed-use, walkable neighborhoods. His designs emphasize the proximity of housing, shopping and public space. He is not opposed to autonomous vehicles, but rather with the widespread adoption of personally owned self-driving cars. He rejects the ideas of tech industry visionaries who forecast personal autonomous vehicles will soon be the solution to urban problems like traffic congestion. Conversely, he worries that zero or single-occupied vehicles will lead to more urban congestion and urban sprawl. To alleviate congestion, Mr. Calthorpe has proposed an alternative – autonomous rapid transit (ART) – using fleet vehicles of self-driving vans in reserved lanes on main arteries. Those lanes would allow the vehicles to travel faster and require a lower level of autonomous

technology. A recent study determined that an autonomous rapid transit system, which (according to the article) could be built today, would be twice as fast as a conventional bus and cost a little more than half as much to operate.

What are your personal feelings about Mr. Calthorpe's recommendations for an autonomous rapid transit (ART) using fleet vehicles of self-driving vans?

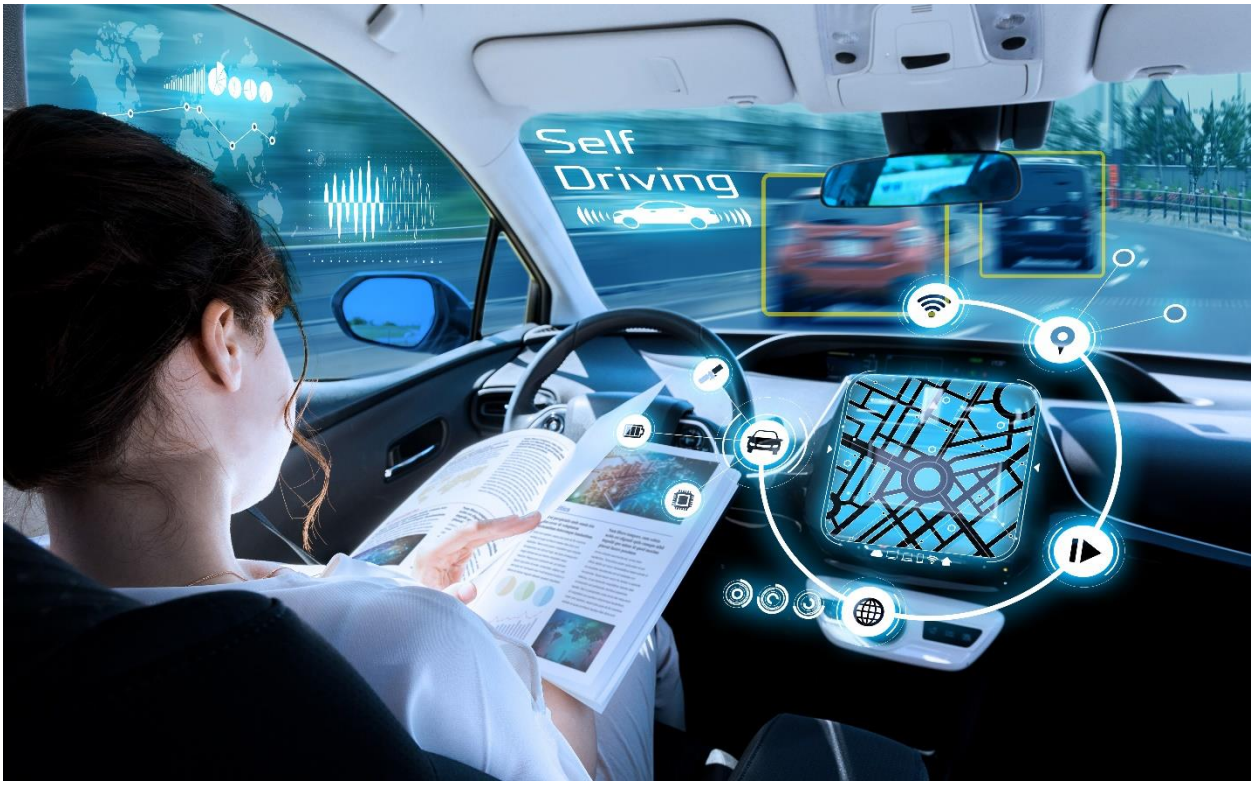
SLV: It is a really interesting vision of the future that Peter lays out. With the technology that you and I have been discussing with autonomous driving, the technology adds onto in a very seamless way the existing system of driving, very roughly speaking, one person, one driver, one car. What Peter is talking about is a much more radical rethink of how this new technology could be used in urban planning. It's attractive in many ways. He talks about the potential for the reduction of traffic. The major downside is, who controls these fleets? Are they run by public transit entities, are they run by private entities, what are their motivations for running these fleets, who does the investment, who takes what risk? It is a much, much different system, it's a much bigger change to the way we live our lives, then a change from driving a Honda Accord yourself to driving a Honda Accord where you're not engaged in the driving task for some or all of the journey, so a much bigger shift.

JE: All of this continues to seem quite futuristic in the present age we live, but I can certainly envision this will someday come to be. The question again is when?

SLV: There is a landrush now to stake intellectual property, so there are an enormous number of patents being claimed by automotive makers, by Uber, etc. I can't tell you what fraction will ultimately be commercially viable. But at the moment there's this rush to stake my claim, this is my idea.

JE: We seem to hear and read more and more about violent road rage happenings on our streets and highways. Can you see this ballooning into a bigger problem when the first autonomous vehicles are introduced, while our roadways continue to be primarily populated by conventional driver operated automobiles? For example, if the autonomous vehicle is not programmed to increase its speed beyond the posted speed limit and the driver of a conventionally operated vehicle becomes frustrated and cannot pass, I can visualize incidents of road rage becoming a real possibility.

SLV: I mentioned earlier that for the foreseeable future these vehicles are going to drive conservatively. They will follow the speed limits as they exist, they will be slow to accelerate and drive conservatively. And that's frustrating. Who wants to drive behind a conservative driver? There is certainly room for frustration. There have been lots of examples of minor fender-benders where automated vehicles get rear-ended. And why do they get rear-ended? For instance, at a stop sign they advance too slowly and the human driver behind expects that human driver in front would go, and the vehicle chooses not to go. The same thing at a stop light. The stop light turns from red to green, the human driver behind expects that human driver in front to go. The automated vehicle (in front), is programmed to wait a half-second, a second, maybe a second and a half. The human driver doesn't expect that and a very small rear-end crash takes place.



JE: If I understand correctly by the examples you have provided, in the early stages of their release, autonomous vehicles will, in fact, be programmed so that you cannot increase the speed of the vehicles, and thus these vehicles will be operating as fully autonomous. Is that your understanding?

SLV: This decision will be made by the General Counsel of Ford, the General Counsel of GM, and the General Counsel of Tesla. It will be a question of how aggressive their legal department is prepared to let you go.

JE: A major topic which is probably quite high on everyone's agenda are the insurance laws and regulation. Insurance is state-regulated as to existing tort systems and no-fault laws. This will undoubtedly require rewrites. Some state laws have comparative negligence liability laws and other states recognize contributory negligence laws where there can be more than one party responsible for an accident. Likewise, traditional underwriting principles currently utilized will presumably require new criteria for writing automobile policies and applying premiums. Liability issues will certainly be tested by the public when vehicular accidents occur. Accidents will continue to happen with autonomous vehicles, even if proponents argue they will be much less with this new technology. There will quite possibly be more finger-pointing in the future as to who is liable for the accident then there is today. For example, is it the driver of driverless vehicle; the car manufacturer of the driverless car; the designer of the driverless car; the other non-automated vehicle car driver; or a number of other contributing parties: the third-party pedestrian or bicyclist who darts into the roadway; animals; road obstructions such as tree branches; and weather conditions? Finally, there is every reason to suspect that when accidents involving autonomous vehicles do occur, it will result in a back-log of civil litigation cases primarily due

to the additional finger-pointing, which will potentially result in reams of new litigation like never seen before. Do you have any knowledge on what the insurance companies are currently doing to prepare for these issues? Any thoughts on these issues?

SLV: Classically, motor insurance is to insure the driver. The individual human, me or you, or any of our colleagues are that driver. It looks like, what seems quite clear is, liability will shift, whether entirely or partially onto some combination of the system manufacturer, the software designer, the sensor manufacturer. It seems the less that the driver is engaged in the task, the less plausible it would be to hold the driver responsible when there is a crash and the more plausible it will be to hold some manufacturer or system designer responsible.

JE: Some of the foreseeable challenges in promoting vehicle automation includes the use of artificial intelligence. There are reports this area of computer science is still unable to function properly in chaotic inner-city environments. When the problem is solved, operating driverless cars will eventually have a bearing on what is called urban sprawl or suburban sprawl. I understand with the advent of autonomous vehicles people may want to live farther away from their workplace. Proponents say taking a fully autonomous car to work will provide more productive time on route, and also result in a potential savings of travel time. As an urban planner, you must be quite interested in what the outcome will be.

SLV: Absolutely. We, meaning everyone involved and studying these topics are very much in the speculation stage. No one knows, is a simple answer. The irony is, where these sorts of shared automated taxi type services are most attractive, like Midtown Manhattan, are the most chaotic environments, where it's most difficult technically to operate. Simple environments are freeways. There are very few pedestrians, there is very limited activity on the side of the road, and the lane you can presume is clear. Freeways are very simple environments where it's relatively easy for these vehicles to operate. One school of thought is that early automation technology is allowing you to, the term of art is, take the driver out of the loop, so drivers disengage, and their texting, or their doing whatever, will be on freeways. So, for the freeway portion of the journey to work, you can be engaged in emailing or whatever, watching DVDs or videos on Netflix and that will, maybe make you to rethink the calculation, what if I live a little bit further from work, and the schools are a little bit better, and the property taxes are a little bit lower, and I get a little bit bigger piece of land for my money. There's certainly some thinking there, but everybody is speculating.

JE: There are other obstacles that must be corrected. Certain limitations may also impede or slow the arrival of autonomous vehicles in the short term. One such issue posing serious consequences that must be addressed is infrastructure. As an urban planner I am certain you recognize that the infrastructure of many roadways will require significant changes to function properly and bring about new rules and regulations. Would such regulations fall under federal control or be run state by state?

SLV: This is a meaty topic on the public agenda, right now. Who is in control of what? Traditionally, the federal government has been in control of vehicle safety and state governments have been in control of drivers licensing and driver safety. Now that the vehicle is a driver, what happens? This is an active issue of discussion and debate. I don't think I will surprise you or any of your readers by saying that everybody seeks to stake their claim. The federal government is seeking ownership of the space and the states will

effectively do what's left over from the federal government. We're seeing there is a new federal policy released last week, a third version, "Automated Vehicles 3.0" *(U.S. Department of Transportation - October 4, 2018)*. The federal government sees it having a bigger role here because of this merging of vehicle and driver.

On the big theme of what are the barriers to adoption, the technical barriers I think are the easy problem. The difficult problem is what will be the terms and conditions, what will the policies be, what will the courts allow, as you said earlier? And number two, what do consumers want, what are consumers willing to pay for, what are other road users willing to tolerate and how is that manifest through State Departments of Transportation, City DPWs, etc.?

JE: Let's recap some of the actual expected benefits of self-driving cars that we have discussed and mention some other examples. Experts believe there will be fewer accidents and thus a reduction of many traffic enforcement personnel; decreased or eliminated traffic congestion coupled with increased highway capacity; lower fuel consumption; enhanced human productivity; and the elimination of parking. Driverless vehicles will also result in improved mobility for children, the elderly and the disabled.

SLV: On point to mention, we haven't talked about parking yet today. In many suburban municipalities across New Jersey, the Hudson Valley and elsewhere, the effective constraint on how much commercial density can be built, is not what the zoning code says is the maximum commercial density. The effective constraint is the parking requirement. Simply by changing how the parking system works, maybe on smaller spaces to get more spaces on a given piece of land, maybe parking remotely, etc., simply by changing how vehicles park you could end up with changes in how much commercial property gets built, and without actually changing the zoning code to say that we permit more building in our town.

JE: I have read reports that the hunt for parking may can be eliminated by virtue of the driverless vehicle dropping a husband and wife off at a restaurant and then self-parking the vehicle and then self-parking in an assigned lot strictly allotted for driverless vehicles.

SLV: This is what carmakers are actively thinking about. Will it be a situation where you drive into the entrance of a parking lot and then the vehicle parks itself within the lot, or will they cruise as zombie vehicles with no one inside it, either not parking and continuing in circulation, or going to an offsite location where parking is cheaper? It's further away from downtown. This is very much in the realm of speculation. I am a city planner. We're just beginning to see city planners grapple with these questions, so answers will emerge over time.

JE: We have spent most of our time discussing residential and commercial autonomous cars, but haven't delved into the autonomous commercial trucking. I can envision the look of total panic and doom on a driver's face operating a conventional car if a fully autonomous 18-wheeler comes barreling around the bend on the north side of a highway, and crosses into the southbound lanes because of a software failure, striking the car head on.

SLV: Individual drivers don't get to decide who the other drivers are. so, it is a question as to how it manifests through our regulatory agencies and democratic processes legislatures. And here, my crystal ball tells me it's going to be a situation where victory has a thousand fathers and defeat is an orphan. If rollout is smooth and if it seems to be a success, then nobody will be wanting to play catch-up and we'll all want to be on the cutting edge. However, if there are more and more crashes and more question marks that we fully didn't anticipate and things are not going well, then I think we'll see much more activism from the public sector. A point I wanted to mention, the Trump administration has taken very much a private sector approach to managing the rollout of AVs. In essence, regulation through liability, you hurt someone and they sue you, rather than a proactive regulatory approach. There are pros and cons to each, but that is where we are in the year 2018.

JE: I'll now ask you to use your crystal ball again and do some forecasting. Let's look ahead twenty years from now. Do you believe it is a reasonable expectation that a 65-year-old man or woman in 2018 will be operating a fully autonomous car twenty years from today in 2038 when they reach 85, presuming they are in reasonably good health?

SLV: If they are living in a major urban area where the Waymo type services that we talked about earlier are in operation, it is certainly plausible within their lifetime. They become really interesting questions near the end of life and also for children. Under what circumstances do you move alone? Many parents wouldn't be comfortable sending a seven-year-old in a robo-taxi by himself to soccer practice. They might be comfortable sending a 12-year-old. And that 85-year-old man and woman. How frail are they? How much care will he or she need to get into and out of the vehicle? That, in part, will determine whether the services that exist will be suitable for them or not.

JE: This has been a very stimulating discussion to say the very least. Is there is anything further you would like to mention beyond all the many aspects of autonomous vehicles we covered?

SLV: On a tangent, you mentioned earlier this question, do we have a love affair with cars, with being in control of our travel and mobility? When surveys are done where the public is asked, do you want an automated vehicle with various capabilities, the majority say yes, and you see things like, younger people say they are more interested than older people, as you might expect. There is consistently, not a majority, a large minority on the order of 30 or 40% of Americans, who say no thank you, I am not interested, I'll do it myself, thank you very much. So, you ask the question is there a love affair with the car? This is a question that researchers are asking right now. As you may know, since 2005 there have been unusual patterns in how much Americans drive. From 2005 until relatively recently, 'vehicle miles of travel,' which is a way of measuring how much people drive in the U.S., trended downwards, which was very unexpected, and more recently since 2014, has begun to track upwards again, which is an historic pattern. The question we are asking ourselves is, have Americans, in fact, fallen out of love with the car? Recently, I had a group of research assistants working on this question by looking at how are we talking about cars in pop music songs. We wanted to ask the question of over the past 50-60 years, has the way that pop music songs referring to cars been changing? Driving in my convertible in the open road, to stuck in traffic, and I'm just going to walk. And what we found, and I'm happy to share the paper, was that there, in fact, is no evidence in pop music of singers becoming more negative towards

the car. If pop music is a reflection of American culture, then it seems that we have not yet fallen out of love with the car. Question mark for the future.

JE: With everything that has been discussed today, it is certainly fair to say there are many benefits to be realized by the public once driverless vehicles become a part of the everyday landscape. There are also clear obstacles, limitations and much speculation which will need to be addressed and resolved by the ultimate decision-makers in various sectors. Any unsolved issues that negatively impact the public's safety will no doubt stonewall any widespread release of fully autonomous vehicles for some time. Dr. Le Vine, do you have final thoughts on this very provocative subject, one that apparently will only intensify in the days ahead.

SLV: There is so much speculation and there is so enormously little hard data for many of these questions, the answer is simply, we shall see.

JE: Thank you very much, Dr. Le Vine, for taking time from your busy schedule today and sharing your expertise on this very engrossing subject.

SLV: Thank you, John. I enjoyed it as well.

John Esposito is a freelance journalist based in New York and New Jersey. His work has appeared in various newspapers and magazines including USA Today, The Star-Ledger, The Philadelphia Inquirer, Greenwich Time, Stamford Advocate, The Record, Downtown-NYC, New Jersey Newsroom, The Irish Echo, UNICO, Rosebud. Mr. Esposito maintains a website of his work at www.PieceworkJournals.com