Hands off the Steering Wheel

The state of autonomous vehicles in government policies, testing projects – and when these vehicles will likely make it to roads

By Jon LeSage

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Autonomous Vehicles Enter a New Phase

A panel presentation held on July 26, 2014, at Petersen Automotive Museum in Los Angeles represented what I consider to be three of the pillars required for autonomous vehicles to succeed – commitment from engineering, automakers, and government officials. The panel was missing its fourth pillar: a technology supplier such as Google, Continental, or Cisco Systems. Google is playing the leading role on moving driverless cars forward, but other technology giants and Tier 1 suppliers have been quite active in testing projects. Interest and debate over driverless cars and autonomous vehicles ratcheted up a few notches in May when Google announced it will build its own driverless pod-style cars; and for the next two years Google will be testing these prototype self-driving cars.

"Autonomous Car Symposium" at the Petersen museum featured Richard Mason, a senior engineer at the RAND Corp. who led the Golem Group garage team in building three test vehicles for the DARPA Grand Challenge for Autonomous Ground Vehicles. Jason Schulz, partnership manager for Toyota's 21st Century Business Partnerships group, leads a team to research, identify, and leverage new technologies and partner companies. Bernard Soriano, deputy director at California Department of Motor Vehicles, is in charge of the DMV's autonomous vehicles program.

The three panelists discussed where autonomous vehicles stand right now, and what's realistically coming up on the landscape. It's been witnessing an onslaught of attention and debate recently in the wake of Google's announcement. A study was released in July by IEEE based on a survey of more than 200 engineers, researchers, and academicians. The Association for Unmanned Vehicles Systems International and the Transportation Research Board hosted the Automated Vehicles Symposium 2014 in San Francisco that same month; and International Conference on Vehicle Autonomous Systems was held in August in Vancouver. Nissan recently added to the autonomous vehicle dialogue with a more detailed description of what the automaker will be rolling out in the next few years. Most recently, the United Kingdom government announced a trial project funded at 10 million pounds that will see the first autonomous test models hitting the streets of three selected cities in 2015.

Through the DARPA competition over the past decade, Mason had been part of seeing autonomous vehicles evolve from a student robotics project to becoming something very similar to what Google has been testing in recent years with its driverless Prius fleet. Toyota's Schulz gave voice to a perspective expressed by several automakers – autonomous vehicles are part of the overall role-changing identity taking place in the

auto industry. For Schulz, autonomous vehicles represent a major shift for vehicles and automakers, but they're not the only thing.

Soriano described the challenges that California faces overall in transportation – 32 million vehicles registered in the state and 323 billion vehicle miles driven per year. The nation has been seeing about 32,000 fatalities in vehicle collisions each year; and traffic congestion and wasted fuel consumption are factors influencing interest in autonomous vehicles.

When a company tests an autonomous vehicle, they're usually trying out LiDAR sensors mounted on the car's roof, radar, cameras, and GPS. Mason said that the advanced sensors that autonomous vehicles require are currently pretty expensive. It's not yet known how much a driverless car will cost in the future; while a recent JD Power and Associates study found that consumers are willing to pay about $3,000 more for this new technology, it's likely to cost them more. There are projections that by the time it goes into mass production, the additional cost could be between $3,000 to $5,000.

Bernard said that one issue being followed is how autonomous vehicles can bring mobility back to people who've lost use of their vehicle due to factors such as disabilities. Another advantage of driverless cars, as vividly presented during an Audi commercial, is a self-parking system. You can step out of your car and it will find a space and park itself; when you're ready to leave, you pull out your smartphone and call the car to come and pick you up.

As I've discovered recently after reviewing a wave of *Green Auto Market* reader comments, survey findings, media coverage, and social media postings, there's quite a lot of interest and concern about it. Flags were raised by Daimler and safety experts over hackers potentially taking over the cars; then there's the question of who would be responsible in the event of a collision – the automaker, car owner, insurance company, or the state government that permitted these vehicles; and the future of car ownership and whether change is in the air that could be at a historic level similar to the introduction of mass-produced cars in the 1920s.

One observer thinks the real significance of autonomous vehicles has much to do with where transportation policies and practices have been heading in recent years. Carsharing and ridesharing services growing in usage provided him with a telling story (with Zipcar and Uber being the leading examples) – the very concept of vehicle ownership is likely to be vastly different than it was a few years ago, he said.

The possibility of driverless cars has been pondered for year – perhaps since the 1956 General Motors Motorama auto show, where GM's musical short film, "Key to the Future," was shown – and which provides the cover page photo for this white paper.

So, where is all of this headed? This white paper will explore what engineers, automakers, government officials, and technology companies have been doing to move autonomous, driverless vehicles onto roads – and what to expect in the near future.

The Legislative Environment

Bernard Soriano, deputy director at California Department of Motor Vehicles, has been part of legislative policy taking shape and being adopted by regulatory agencies in California. He sits in on a statewide steering committee for Senate Bill 1298, which is setting the structure for California's autonomous vehicle testing and deployment rules that will be released by the end of this year. The National Highway Traffic Safety Administration (NHTSA) participates in these meetings along with state agencies: California State Transportation Agency, Department of Insurance, California Highway Patrol, Office of Traffic Safety, California Department of Transportation, and the Department of Motor Vehicles.

NHTSA is years away from releasing federal regulations, but last year it did release guidelines with five levels for defining each type of autonomous vehicle; Level 0 is no automation; Level 1 is function- specific automation (typical of what we're using right now in vehicles, such as cruise control); Level 2 is combined function automation; this level involves automation of at least two primary control functions operating in unison, such as adaptive cruise control in combination with lane centering. Level 3 is limited self-driving automation, which says that the vehicle can operate by itself in most situations – the driver may need to take over the car when approaching a construction zone, for example. Level 4 covers full self-driving automation. In Level 4, the vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Most of California's regulations cover Level 3 and Level 4, Soriano said.

As part of California's SB 1298, the manufacturer testing standards were approved by the legislature in May and go into effect in September. The state has committed to passing through the second part by the end of this year covering deployment of the vehicles to owners, and rules for operating the vehicles on roads. The state government has been receiving input from residents on their opinions on autonomous vehicles; the top concerns have been liability and "driver" definition – how will the driver be defined for responsibility in the event of a crash and how does the DMV determine who would be assigned with violating state vehicle codes; privacy issues – who owns the data and how is it used, along with cyber security, are also critical issues, Soriano said. Testing

so far has been done by Google, Volkswagen, Audi, Mercedes, Nissan, Bosch, and Continental, in California.

As far as state legislatures are concerned, four of them have already passed bills allowing autonomous vehicles to eventually make it to their roads – Nevada, California, Florida, and Michigan, plus the District of Columbia. It's under consideration in 11 states – Hawaii, Washington, South Dakota, Minnesota, Massachusetts, New York, New Jersey, Maryland, South Carolina, Georgia, and Louisiana. And it's failed in seven states – New Hampshire, Texas, Oklahoma, Colorado, Arizona, Wisconsin, and Oregon.

It all started in Nevada in June 2011. Nevada became the first of four states to enact a law authorizing its Department of Transportation to develop rules and regulations governing the testing of driverless cars on its roads. Nearly a year later, in May 2012, Google, Inc., became the first recipient of a license for "autonomous vehicle." Google received a red, specialized license plate to test autonomous vehicles on the state's roads.

So far, Nevada's role essentially has been initiating the environment for state testing grounds to receive approval. Along with Google, only Continental AG, Audi, Cisco, and IBM, have received autonomous vehicle test plates. In the early phase after the adoption of the state testing program, each company earned an Autonomous Vehicle Testing License and announced their test programs – but they have done very little since then, according to Jude Hurin, a DMV services manager in Nevada. So far, it's a "partial automation" system in the testing phase. It could take another 10 years for the state to move from testing to "total automation" when autonomous vehicles are allowed on Nevada's roads, Hurin said.

Google did a good deal of testing in Nevada at first, but its real testing ground has been California – near its corporate campus in the Silicon Valley area. Nevada may have been a symbolic testing ground to get other states to follow along, Hurin said. Florida passed its test program soon after in 2012 and was followed by California and District of Columbia that same year, and by Michigan in 2013.

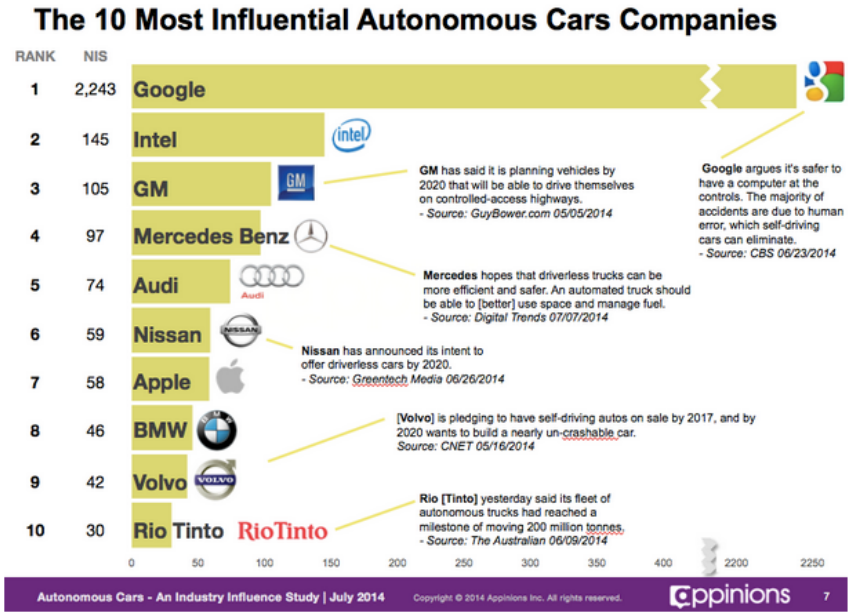
Beyond California, the other states and the District of Columbia are only in the testing process and haven't determined the next phases of permitting fully autonomous vehicles. In Michigan, the legislation did not establish a comprehensive testing program; the legislation permits the testing of autonomous vehicles on public roads in Michigan by either private or public entities that meet the requirements specified in the legislation, according to staff members in the Michigan Department of Transportation. The Michigan law included a requirement that by February 2016, the Michigan Department of Transportation, in conjunction with the Michigan Secretary of State and automobile manufacturers and technology companies, must provide a report and recommendation to the state legislature on potential "next steps" for legislation related to automated vehicles and technology.

Florida has not seen much activity regarding autonomous vehicles since the legislature passed its law a few years ago, says John Lucas, press secretary in the Florida Department of Highway Safety and Motor Vehicles. According to the state's annual report released earlier this year, the "Department will continue to participate in national, state and local discussions to monitor developments, identify best practices, address safety issues, and craft proposed legislation for the safe testing and operation of autonomous vehicles."

In other parts of the country and of the world, limited test programs have been allowed and legislation is being considered. Johnson County, Iowa, supervisors have started to process of allowing driverless cars to be tested on its roads. Japan allowed for its first public road test in 2013 when Nissan rolled out an autonomous vehicle on a highway. The United Kingdom government has announced a 10 million pound trial program; trial programs in three selected cities will start in 2015. Prior to that, the UK town of Milton Keynes allowed for a test fleet of 100 self-driving pods to run between the city's central train station, shopping center, and office parks beginning in 2015. In Sweden, the city of Gothenburg is allowing Volvo to test 100 driverless cars when the testing starts in 2017.

There is a good deal of interest in other parts of the world, Soriano said. Sweden, Australia, New Zealand, Singapore, South Korea, and Canada have contacted California officials to work on their own draft proposals, he said. Traffic congestion is a major issue in these countries, as it is in the US, and autonomous vehicle technologies could be part of the solution, Soriano said.

Players in the Game – Google and Everyone Else



If you look at the chart, above, released in late July by Appinions Inc., it would appear that Google, Inc., is light years ahead of any other company attempting to bring autonomous vehicles to American roads. While it's a bit out of proportion (Intel and Apple are ranked but Continental and Cisco are missing; and who's ever heard of Rio Tinto?), it does appear to be close enough when gauging the influence Google has had on autonomous vehicles. Manhattan-based startup marketing firm Appinions analyzed hundreds of millions of news, blog, forum, and social media posts from April through July of this year – right when details on Google's testing program and pod prototypes were spilling out. Appinions' report analyzed the overall influence trend – and several analysts have agreed about the power of Google in the autonomous vehicle debate.

Google was instrumental in getting Nevada to adopt the first statewide testing program, and its home-state of California followed soon after, where Google put out a fleet of driverless Prius test cars on its roads. In April of this year, Google tested retrofitted Lexus RX 450H SUVs on the streets of Silicon Valley, Calif., near its corporate campus. The SUV's small roof-mounted tower used lasers to map the surrounding area. In May, Google announced it would launch a fleet of autonomous vehicle prototypes that have no steering wheels, or gas or brake pedals, for testing this summer. Google says it's designed and had built about 100 fully autonomous test vehicles; a yet-to-be named Detroit-area manufacturer is said to be building the cars for Google.

After making contact with Google's media room, I was sent to the company's blog posting published on the day of its announcement in May. I think the following blog paragraph sums up Google's philosophy on this topic…… "We're now exploring what fully self-driving vehicles would look like by building some prototypes; they'll be designed to operate safely and autonomously without requiring human intervention. They won't have a steering wheel, accelerator pedal, or brake pedal… because they don't need them. Our software and sensors do all the work. The vehicles will be very basic — we want to learn from them and adapt them as quickly as possible — but they will take you where you want to go at the push of a button. And that's an important step toward improving road safety and transforming mobility for millions of people."

You can view a recent update on Google's test project in this video released at the beginning of August on Maker Camp, a Google+ program that joins young inventors and artists on virtual field trips. Here, the Maker Camp team Skype-visited the Google garage at its Mountain View headquarters and talked with two members of the Google self-driving car team. These engineers described Google X – which stands for making a 10X (10 times) improvement in the world. Other Google X projects include balloon-

enable internet, computer on a contact lens (Google Glass), and giant kites that fly in the sky and bring power down to the lines. The Google staffers showed the highly viewed video from two years ago with a nearly-blind driver being transported in a Prius driverless test car without having to drive at all.

As for recent testing, it's appears to be early in the process – more on campus than sending out a hundred prototype pod cars on the streets of Mountain View. In this video, the Google X team talks about customizing data for self-driving procedures like approaching bumps and holes in the road. Another Google video that's streamed during this program was recently produced and shows the experience of several people riding in a driverless car and dealing with what it's like to need a car for transportation when you have a child in the car; are aging and have less ability to drive like you used to; or are visually impaired. Safety and convenience are emphasized in the video. See the Google+ page to stay updated on what Google is doing with its self-driving car project.

So, why is Google so committed to self-driving cars? Beyond its commitment to road safety and mobility, it does seem to tie into the company's vision of its role in the world. Google's role as a leading global technology innovator comes across simply in its corporate mission statement: "Google's mission is to organize the world's information and make it universally accessible and useful."

The self-driving car project is similar to two other moves made this year by Google, starting with the US launch of its Google Glass product in April for a limited time period and a cost of $1,500. Google Glass is a pair of futuristic eyewear that assists the user in doing things like giving a voice command for Glass to take a picture and upload it to social media pages. In June, Google completed a $500 million acquisition of another company, Skybox Imaging. That company provides commercial high-resolution satellite imagery, high-definition video, and analytics services. Google also owns the most successful smartphone company, Android, and the universal platform for online video streaming, Youtube.

It all started not-that-many years ago (1998) with the now-dominant Google internet search engine; more recently, the commitment of funding, technology, and staffing to self-driving cars signifies Google seeing itself as one of the top technology companies in the world. There will also be revenue streams in providing technology and expertise to the brand-new business of self-driving vehicles – whether or not Google becomes an automaker or just keeps its prototype as a test model collecting data. These prototype vehicles only get up to 25 miles per hour, so the question also remains – If Google enters the self-driving car market, will its vehicles only be used off highways, such as university and corporate campuses?

General Motors Corp. (GM) has been the most experienced automaker in the world of autonomous vehicles. The automaker's vision goes back its musical short movie, "Key to the Future," that was shown at its 1956 Motorama auto show. The movie shows a family of four frustrated while stuck in their car during a traffic jam – and are somehow

able to go 20 years into the future and drive a turbine-powered Firebird. At one point during the trip, a highway-traffic controller seated in a tower overseeing the desert highway directs the driver onto a special lane. The driver is able to let go of the steering wheel (actually airplane cockpit handles, as you can see in the image on this white paper's cover) and allow the traffic controller to guide the trip. The family gets to enjoy beverages and singing in chorus – the trip becomes much enjoyable in the future.

GM is best known for its partnership with a team from Carnegie Mellon University and its Tartan Racing team during the 2007 DARPA Urban Challenge. GM donated $5 million to the project which ended up with the Boss, an autonomous Chevrolet Tahoe, taking first place in the Urban Challenge – beating out entrants from several of the nation's top universities during the 55 mile race course. Since 2000, GM has contributed over $16 million to establish two Collaborative Research Labs (CRLs) at the university, the Information Technologies CRL and the Autonomous Driving CRL.

Prof. Ragunathan "Raj" Rajkumar serves as co-director of the GM-Carnegie Mellon Autonomous Driving Collaborative Research Lab. Rajkumar says that says that cars today house between 30 and 70 computers that monitor and enable various systems. These cars will be better able to communicate with each other and transmit vital safety information to vehicles and drivers.

GM is now testing out Cadillac SRX prototypes at its Milford, Mich., proving grounds. By 2020, GM will launch its Super Cruise feature. It's a semi-automated driving system that drivers will be able to use on highways. GM is using a new high-speed 360-degree simulator to test its upcoming Super Cruiser at the Milford testing center.

It's all about "sensor fusion," says Dan Flores, from GM Communications, Advanced Technology, Powertrain Engineering and GM Ventures. The Cadillac will have ultrasonic sensors, radars, GPS, and computer processors coupled with active safety technology.

The word "autonomous" is defined in many different ways, Flores says. In recent years, all the automakers are adding advanced technology features that can override and increase safety – anti-lock brake systems (ABS), stability control systems, driver warning notifications, and rear-parking assist, are common systems inside vehicles these days.

Fully automated cars are several years away, Flores said, and there's always the issue of being able to give control of the car back to the driver under emergency conditions. "Research projects are much different than mass production," Flores said. "Google has cool stuff, but it's controlled."

While perspectives vary at other automakers, most all of them would likely agree with Flores on the safety and responsibility issues. If the road is covered with ice, it will be necessary for the driver to take control and direct the car to safety, he said. There

probably will always be circumstances that the computer system can't view, comprehend, and react to in safe time.

Flores also spoke about a safety technology in vehicle automation that other automakers share support for – vehicle-to-vehicle communications (V2V). On Aug. 18, 2014, NHTSA released an advance notice of proposed rulemaking and a supporting research report on V2V communications technology. "Safety is our top priority, and V2V technology represents the next great advance in saving lives," said US Transportation Secretary Anthony Foxx.

The rules will give drivers early warnings of approaching danger in vehicles built after 2020. NHTSA predicts that V2V technology could prevent 25,000 to 592,000 crashes and save 49 to 1,083 lives annually when the entire US vehicle fleet has adopted the technology; that would come from adopting Left Turn Assist (LTA) and Intersection Movement Assist (IMT) applications.

Eight automakers -- Daimler, Ford, General Motors, Honda, Hyundai, Nissan, Toyota, and Volkswagen -- have been developing V2V technology in cooperation with the federal government for several years through a group called the Crash Avoidance Metrics Partnership (CAMP). The V2V transmitters and software are expected to cost an estimated $350 per vehicle in 2020; but automakers so far have supported NHTSA's objective.

Automakers have seen these policy issues and technology innovations developing for years and have **set up facilities in California's Silicon Valley** to develop autonomous systems, connected cars, and personal mobility resources. Ford's office in Palo Alto is working on connected vehicles and open-source software; Mercedes-Benz has about 150 employees in Sunnyvale and their latest project has been Boost by Benz, which shuttles kids to and from soccer practice. Volkswagen engineers in Belmont are working on advanced-speech recognition and autonomous vehicles. Newcomers to the auto-making business, Tesla Motors and Google, are based nearby; Tesla in Palo Alto and Google, with its driverless pod car test program, in Mountain View.

On July 17, 2014, Nissan made a splash when its president and CEO, Carlos Ghosn, announced the automaker's launch timetable for deploying autonomous technologies into its new vehicles. These new technologies include automated lane controls and highway traffic management systems that will be introduced over the next four years. The purpose is to demonstrate to consumers the viability and value of autonomous drive systems, which Nissan intends to make commercially viable by 2020.

The 2014 announcement was more modest than comments Ghosn made in 2013 stating that the automaker would bring autonomous cars to roads by 2020. This year, more details were given with more realistic targets than fully automated driverless cars.

"By the end of 2016, Nissan will make available the next two technologies under its

autonomous drive strategy," Ghosn said. "We are bringing to market a traffic-jam pilot, a technology enabling cars to drive autonomously – and safely – on congested highways. In the same timeframe, we will make fully-automated parking systems available across a wide range of vehicles."

In a speech to the Foreign Correspondents Club of Japan in Yokohama, Ghosn added: "This will be followed in 2018 by the introduction of multiple-lane controls, allowing cars to autonomously negotiate hazards and change lanes. And before the end of the decade, we will introduce intersection-autonomy, enabling vehicles to negotiate city cross-roads without driver intervention."

Nissan is taking a stance similar to GM – it will lead the way for other automakers to bring autonomous systems to vehicles, its cars will become safer, and the driver will remain in control of the vehicle. Nissan gained prominent attention last year by showing off its Nissan Leaf driverless car test project. Laser scanners, "around view" monitor cameras, as well as advanced artificial intelligence and actuators had been installed in the Leaf test car to enable it to negotiate complex real-world driving scenarios. Ghosn's announcement in July 2014 offered more specific, realistic automated technologies than the Leaf test model. One of them, self-parking cars, should go over well with consumers; finding a parking space in a convenient manner would alleviate some of the headaches that come from city driving.

Volvo Trucks has participated in the Safe Road Trains for the Environment (SARTRE) a European Commission-funded project. It's a tested concept where several vehicles are electronically linked together in a "road train," with only the lead driver in active control – many times a Volvo truck driver; its testing period took place between 2011 and 2012, says Brandon Borgna, manager, media relations for Volvo Trucks in the US.

The SARTRE project was able to achieve goals with Volvo Trucks and other participants by 2012 – development of a technology for wireless road trains that can improve traffic safety, reduce the environmental impact of road traffic, and improve traffic flow. That involved building test vehicles, car-to-car communication, and sensors for the control of nearby vehicles. A heavy-duty truck leads the road train with a number of passenger cars trailing close behind. The entire road train is interconnected through wireless technology, which ensures that the trailing cars follow exactly in the track of the lead vehicle – as though the train consisted of a single vehicle, according to Volvo Trucks. It allows the driver in a trailing car to relax, perhaps read a book or watch TV, while the car drives itself. Borgna thinks that road trains will take several years to reach the highways in European Union countries.

Volvo Trucks prides itself on bringing clean, advanced, and safe transportation to roads – including natural gas vehicles, and its dimethyl ether (DME)-powered trucks in tandem with its Mack Trucks subsidiary and Oberon Fuels. The SARTRE project seems to be a continuation of its mission of being a leading edge, advanced-technology truck maker.

Volvo's car manufacturing company, which was sold off in 1999 and is now owned by Chinese investors, has also become active in autonomous test projects. Volvo Cars is testing 100 driverless cars on the roads of its hometown, Gothenburg, Sweden, over the next three years. It's an integrated part of Volvo Cars vision of zero traffic fatalities, as it is with the Swedish government, said Volvo president and CEO Håkan Samuelsson. The "Drive Me" program is in collaboration with the Swedish Transport Administration, the Swedish Transport Agency, and Lindholmen Science Park. They're looking forward to receiving feedback from customers driving on public roads.

Andreas Mai, director of smart connected vehicles at Cisco Systems, said his company is working with automakers, automotive suppliers, and governing agencies, to create benchmarks that will shape where autonomous vehicles and intelligent transportation systems will be going. Mai thinks that autonomous vehicles could become a reality in the near-term future. This could happen if dedicated lanes on highways or exclusively autonomous sectors in cities could be established – as early as 2015 to 2019 on highways and 2020 to 2024 in dedicated city sectors. (See his blog post for more of Mai's analysis.)

Cisco has been working on a wide range of connected car and autonomous vehicle projects. The company focuses on making products that transport data, voice, and video on a high-performance platform. Cisco has worked with Continental Automotive on technology connecting cars via wireless networks. Cyber security is one of the top issues that these companies have addressed together, Mai said; Cisco has provided the security software and router hardware to deliver safe connected and autonomous car services. "Cyber security needs to be in place," Mai said. "Without it, people wouldn't trust driverless vehicles."

Here's a summary of autonomous vehicle technologies being developed by automakers and technology suppliers……

- **BMW** has been road testing a modified 2-Series Coupe and 6-Series Gran Coupe customized with a LIDAR system, 360-degree radar, ultrasonic sensors, and cameras that track the driving environment. The prototypes have been run through test tracks without any drivers.
- **Continental Automotive** is working with partners such as IBM and Cisco on a series of test projects. The company has received a wave orders for models equipped with its traffic-jam assist that will go on sale in 2016. By 2020, the company expects to make available a highway-only autopilot system that takes control of the steering wheel and pedals, and has been testing out a prototype autonomous vehicle on public roads. The company provides hardware such as sensors and cameras that automakers use for autonomous driving. Continental's

goal is to be an integrator, gathering hardware and developing underlying software.

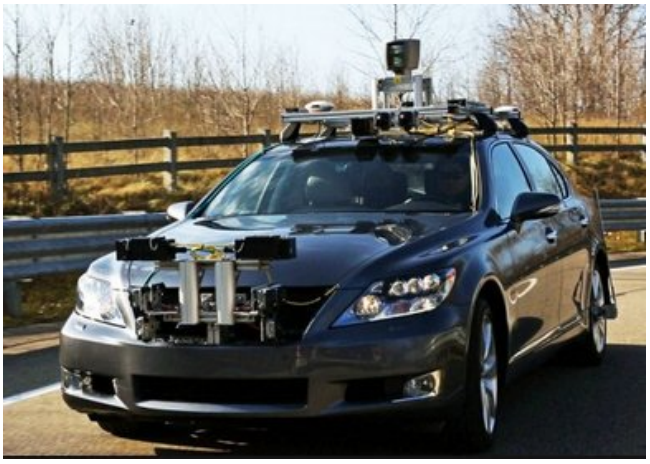
- **Cruise Automation**, a startup company, says it will roll out a $10,000 aftermarket driverless device that so far is only suited to operate on Audi A4 or S4 vehicles. Cruise Automation will install its RP1 highway autopilot system on a 2012 or newer Audi A4 or S4.
- **Daimler AG** is testing out autonomous systems for its commercial truck and passenger car brands. Daimler recently announced it will roll out a commercial truck by 2025 that will be able to steer, brake, and accelerate without a human driver behind the wheel. Intelligent Drive — a system that will become available on its Mercedes-Benz S-Class and E-Class models — combines all driver assistance systems that enhance safety and comfort. A "self-piloted" S500 Intelligent Drive concept car was demonstrated at the Frankfurt auto show and should be available by 2020. As for now, the 2014 Mercedes Benz S-Class is going about as far as what one industry analysts calls "70% autonomous driving." It combines active cruise control, automatic braking, and lane-keeping technologies. The car steers, accelerates, and brakes on its own in congested traffic up to 40 miles an hour.
- **Ford** is testing out an Automated Fusion Hybrid Research Vehicle; Ford is working with University of Michigan and State Farm to test the potential of the systems. Ford is integrating technologies already in place with new scanning and analysis systems. Four smaller scanners come out of the roof like antennas in place of more visibly obvious LIDAR units. Ford is also testing out V2V communication systems that alert drivers about upcoming road conditions. In a side note, Ford's recently retired, **former-CEO Alan Mulally** has moved on to join the board of directors at Google Inc. Mulally joined up with Google as it strides forward in self-driving cars; the previous month, the company launched Android Auto, an intuitive interface with integrated steering controls and other features.
- Last year, **Tesla Motors CEO Elon Musk** said the electric carmaker would bring a driverless car to market within three years, but it would only be 90% autonomous; fully autonomous vehicles would take longer to develop, he said. There's also been talk of Tesla working with Israeli company **Mobileye** to develop vehicle safety systems for its self-driving car. Mobileye's Advanced Driver Assistance System (ADAS), can detect pedestrians, bicyclists, debris on the road, barriers, and construction zones. It can also view traffic lights and road signs. The system works through a combination of forward-facing cameras and low-cost radars. Mobileye says that 90% of leading automakers are lined up to install the company's ADAS systems.
- Aside from having Google independently test out its self-driving systems on Toyota and Lexus vehicles, **Toyota has been testing out its own Advanced Safety Research Vehicle.** It's a Lexus LS used for research at the Toyota Research Institute in Ann Arbor, Mich. It uses forward-looking and side-facing millimeter-wave radar sensors, as well as a 360-degree laser scanner. Onboard

computers use data from those scanners, and data collected from the engine and wheels, to collect data on the car's surroundings, and operate the car's controls.

- **Volkswagen is participating in a Florida test program** by providing an Audi A7 with a Florida plate that read "Self1e." It can automatically keep pace with the vehicle ahead, stop itself, speed up and stay in its lane without the driver's help. In fact, touching the steering wheel or hitting the brake turns off the autonomous system, which could operate up to 40 miles an hour.

What's Being Said Out There – Reports and Surveys

Autonomous vehicles have reached an interest level this year to spawn research studies that reveal how industry professionals and consumers perceive the technologies and their implications. Perhaps the most significant study was released on July 14, 2014, by Institute of **Electrical and Electronics Engineers (IEEE)** that came from a survey of more than 200 engineers, researchers, and academicians active in the field of autonomous vehicles. They believe 2030 to 2035 is a more realistic timetable for when these vehicles will see the light of day.



When survey respondents were asked to assign a ranking to six possible roadblocks to the mass adoption of driverless cars, legal liability, policymakers, and consumer acceptance were ranked as the biggest obstacles; cost, infrastructure, and technology were viewed as smaller challenges. Advancements in technology will be the most instrumental in the continued development of driverless vehicles, with more than half (56%) of respondents believing that sensor technology is most essential, followed by software (48%), Advanced Driver Assistance Systems (47%), and GPS (31%).

"Any time you have a technology that has the potential to fundamentally change our daily lives, laws and policies need to be established to ensure the technology is going to be used properly and benefit humanity. This is especially true with intelligent vehicles," said Yaobin Chen, IEEE senior member and professor and chair of electrical and computer engineering at Purdue School of Engineering and Technology. "Once the foundational elements, like legal liability and policy, are in place, the technology and infrastructure will be there, so intelligent vehicles will become more widely accepted."

When asked to specify the year in which specific equipment will be removed from mass-produced cars, the majority believe rearview mirrors, horns, and emergency brakes will be removed by 2030 and steering wheels and gas/brake pedals will follow by 2035. More than 75% of respondents said that all 50 US states would pass legislation permitting use of driverless vehicles within this time period.

Another prominent engineering association, **SAE International**, has seen enough forward motion on autonomous vehicles to have released a common platform for the global engineering community. On Jan. 16, 2014, the SAE International On-Road Automated Vehicle Standards Committee published "Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems."

The report provides a taxonomy describing the full range of levels of automation in on-road motor vehicles. It also includes operational definitions for advanced levels of automation and related terms. This document provides a foundation for further standards development activities and a common language for discussions within the broader “Automated/Autonomous Vehicle” community, according to SAE International. “SAE International’s technical standards committees are doing a tremendous job in ensuring that consensus based process helps to apply new technology in vehicles worldwide,” said Jack Pokrzywa, Manager, Ground Vehicle Standards, SAE International.

SAE International and Association for Unmanned Vehicle Systems International (AUVSI) announced a new book in late August on autonomous technologies and how they are being applied now, and their future use. “Autonomous Technologies: Applications That Matter,” assists readers in identifying profitable opportunities and avoiding costly misconceptions with respect to civilian applications of autonomous vehicle technologies; the book presents chapters on how air, water, and ground vehicles are becoming ever more used and appreciated. The study goes back to new technologies having been introduced and tested over the years by the Defense Advanced Research Projects Agency (DARPA) Challenges. While military applications have received a great deal of attention, with drones being the most prominent, unmanned vehicles with varying degrees of autonomy already have many civilian applications. Some of these are quite familiar (such as the autonomous vacuum cleaner), while others remain largely out of the public eye (such as autonomous farm equipment). Additional applications and more capable vehicles are rapidly coming to the markets in the years ahead, according to the report.

Clean energy and transportation expert **Navigant Research** recently released “Autonomous Vehicles: Self-Driving Vehicles, Advanced Driver Assistance Systems, and Autonomous Driving Features: Global Market Analysis and Forecasts.” As many automaker management executives have been saying lately, autonomous vehicles are a logical extension of where the technology has been headed in recent years. Cost reductions have helped OEMs install multiple sensors necessary for semi-autonomous vehicles, according to the report. While the industry consensus is that comprehensive

self-driving features will be brought to market by 2020, there are significant hurdles that will need to be addressed; and not all of these obstacles are technological.

More testing will be done to overcome technological challenges related to image processing and sensor fusion; advances in computing power and software are making these more viable. Practical hurdles will likely still be in the way – coming from liability, regulation, and legislation. Navigant Research forecasts that 94.7 million autonomous-capable vehicles will be sold annually around the world by 2035.

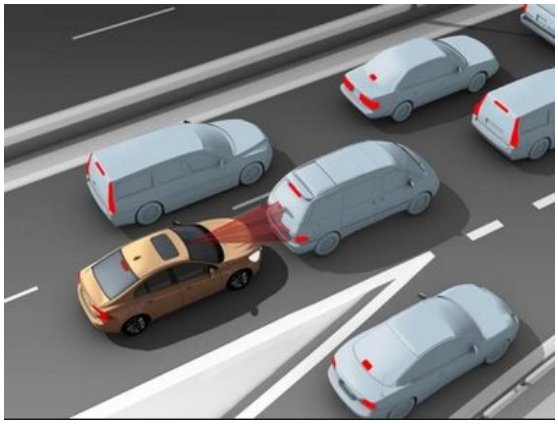
Autonomous Vehicle Technology - A Guide for Policymakers, was published this year by **Rand Corp.'s Transportation, Space, and Technology Program**. The study explores decisions that policymakers are facing.
Key questions include:

- How, if at all, should the use of autonomous vehicles (AVs) be regulated, and at what level?
- What kinds of vehicles should be allowed on the road, and who is allowed to operate them?
- How should the safety of AVs be tested, and by whom?
- How might different liability regimes shape the timely and safe adoption of AVs, and what are the tradeoffs?
- What are the implications of a patchwork of state-by-state laws and regulations, and what are the tradeoffs in harmonizing these policies?
- To what extent should policymakers encourage the adoption of AVs; such as through smart road infrastructure, dedicated highway lanes, manufacturer or consumer incentives?

Feedback from drivers has been made public, too, in studies and in social media communications. In June 2014, Insurance.com surveyed about 2,000 licensed drivers and found that 32% of them would not drive their cars anymore once a self-driving car becomes available. In the survey, 22% said they would be "very likely" to buy a car with autonomous capabilities; 53% would consider buying such a car; 25% would never consider a driverless car.

A recent study by **University of Michigan's Transportation Research Institute** found a good deal of interest in autonomous vehicles by US drivers; they do have concerns about paying too much extra for these vehicles and if they'll be safe enough. The survey found that 68% believe driverless cars would result in fewer crashes; 49% believe they would reduce traffic congestion; but 67% of the survey respondents also said they would be moderately or very concerned about driving or riding in a totally driverless vehicle.

Issues Likely to Shape Resistance and Support



The topic of self-driving, autonomous vehicles has lately been stirring more passionate comments on social media, blogs, and editorial think pieces than anything else seen for years in the automotive and transportation space. Here's a summary of key issues being debated that will influence public policy……

Safety is the top issue named by Google, state DMVs, NHTSA, and many other key stakeholders. A significant example of this priority comes from Mothers Against Drunk Driving (MADD)……. "MADD is excited about the possibilities of self-driving vehicles. We support the development of advanced technology that will reduce crashes, fatalities and injuries on our roadways. Both the self-driving technology and the DADSS (Driver Alcohol Detection System for Safety) technology, which automatically detects a driver's blood alcohol concentration, hold tremendous promise for a safer tomorrow. We look forward to future advancements that will eventually eliminate drunk driving completely."

The liability issues coming from collisions that involve autonomous vehicles are expected to be a battleground for several years – perhaps the most challenging issue once autonomous systems reach mass market. Christopher Parker, vice president – product underwriting for Zurich, one of the world's largest insurance companies, doesn't see insurers carrying the weight in the liability question. "The insurance industry is going to expect the technology industry to carry the lion's share of the exposure," he said. This attitude is being expressed by several of his colleagues in the insurance industry but it's likely to be fought out in legislative lobbying, lawsuits, and public comments on regulatory proposals. **Civil liberties and personal freedom issues** are expected to be a source of legislative and legal debate, especially privacy in this era of individuals having much of what they do tracked and stored in vast databases.

Increasing traffic congestion and improving the parking problem. Instead of fighting traffic and searching hopelessly for parking spaces, drivers could be working on their laptops, reading, or watching more episodes of their favorite TV series. That may very well be a generational issue – as Baby Boomers typically got their drivers licenses at an early age and went on road trips with friends as soon as they could. Millennials are putting off getting their drivers licenses and don't see the point of owning a car – though they do need transportation alternatives.

Demographics are changing as more people move into cities, especially young professionals. Car ownership is a very different story than it was for their parents. California is seeing increases in public transportation use, bicycling, walking, and usage of carsharing and ridesharing services**.** Municipalities are supporting these efforts, such

as Santa Monica and Los Angeles adding the “Subway to the Sea” light-rail line that will connect downtown Los Angeles to the ocean view in Santa Monica. Major cities across the US are seeing more of their residents go without car ownership and using other modes of transportation. New York, Philadelphia, Chicago, and Los Angeles have, in that order, the highest percentages of households without a vehicle. **Zipcar and other carsharing services** are seeing real gains on universities and in urban environments. **Ridesharing company Uber** is facing legislative and legal battles with taxi drivers and taxi companies, but it gaining a lot of user traffic and support in major cities in the US and Europe. GM and Toyota recently announced that they’re offering car purchase discounts to Uber drivers who use their personal cars to do their jobs.

Fuel consumption and air pollution: President Obama during a speech recently cited a study that found Americans spend 5.5 billion hours stuck in traffic each year at a cost of $120 billion in wasted time and gas – or $800 per commuter. Supporters of autonomous vehicles also cite the air pollution issue – with many cars having excess idle time and longer trips than needed due to traffic congestion and lack of data on making better, more efficient route choices.

About the Author

Jon LeSage is known in the auto industry as a writer/editor for *Green Auto Market* and *Automotive Digest*. In addition to media, LeSage worked in market research/intelligence

serving clients in automotive, transportation, and consumer products. LeSage Consulting is a logical continuation of his professional experience and skillset – and his passion for clean transportation – in an engaging, insightful format. LeSage has spoken on industry panels on advanced vehicle technologies and alternative fuels. His monthly *Green Auto Market – Extended Edition* tracks clean transportation, advanced and autonomous vehicles, and urban mobility. Along with news analysis, readers have access to industry metrics such as electric vehicle and hybrid sales, fuel prices, charging and fueling infrastructure, and stock performance on publicly-traded clean transportation companies.