Autonomous Vehicles

Considerations for Personal and Commercial Lines Insurers

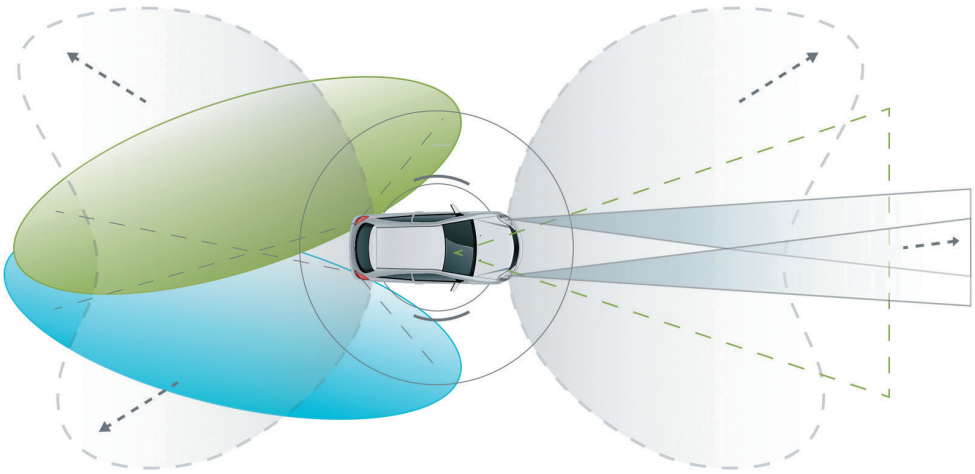
Munich RE

Executive Summary

Since the early 1960's the insurance industry has been a major force behind the most significant advances in highway and vehicle safety including electronic stability control requirements, seat belt use and automobile crash worthiness. Now, autonomous vehicle (AV) technologies offer an opportunity for us to advance another milestone in vehicle safety, going beyond keeping people safe in a crash to avoiding the crash altogether.

According to the National Highway Transportation Safety Administration (NHTSA) more than 32,000 fatalities occurred in the United States as a result of vehicle crashes in 2014, with human error as a primary cause. Analysts agree that Autonomous Vehicles (AVs) have the potential to dramatically reduce human error and, therefore, the frequency of vehicle crashes. Savings related to economic costs, including accident-related, fuel and productivity, vary widely. McKinsey estimates savings at US$ 200bn – US$ 1.9tr by 2025, while Morgan Stanley puts savings at US$ 1.3tr.

In October 2010 Google publicly announced plans to develop automated vehicle (AV) technology with the aim of preventing traffic accidents, reducing carbon emissions and helping people make better use of time spent commuting. Since then much has been written and reported with regard to AVs, resulting in a wide range of estimates attempting to predict the timing of their widespread adoption and quantify their impact.



Many AVs in development use a combination of cameras, sensors, GPS, RADAR, LIDAR and an on-board computer. These technologies work together to map the vehicle's position and its proximity to everything around it.

There are uncertainties: How will autonomous cars perform amongst a mix of autonomous and manually-operated vehicles? How will AVs impact people whose livelihoods depend on driving, like truck and taxi drivers? Will driving skills diminish and, if so, what will be the impact to road safety—if any?

As the debate about the social and economic benefits of AVs continues, the insurance industry is contemplating the impact, particularly as it applies to liability exposures.

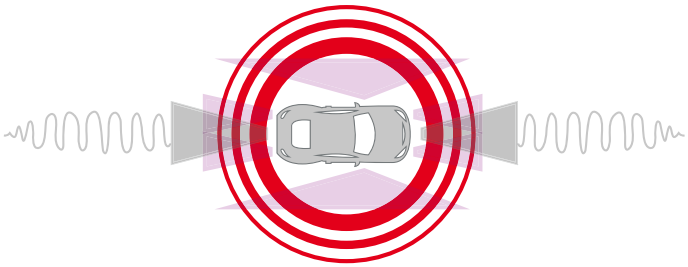
Who will be liable when an AV is involved in an accident? Will liability shift from driver to manufacturer as vehicle control shifts from human operator to autonomous systems? Will accident-related liability exposure all but disappear? How will we manage cyber liability exposures that arise from the cameras, sensors and computers integral to AV technology, or from vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems?

Besides liability, how will AVs impact the tools underwriters use to evaluate risks? What new products will be needed, both for traditional auto manufacturers and suppliers faced with new risks and for new entrants into the AV supply chain?

Regulation and legislation will also be important factors for insurers as AV technology evolves. The Insurance Institute for Highway Safety (IIHS) predicts that even with a theoretical 2016 government mandate for some crash avoidance and lane-keeping safely features, large-scale integration into the US fleet is almost 25 years away. Some industry analysts warn of the risk that autonomous technologies will impact insurers sooner than expected.

Our role as insurers is twofold: to enable a technology that has the potential for significant positive impact on vehicle and highway safety while also helping our clients to recognize and manage the impact of AV technology on their businesses. Insurers and reinsurers who understand the issues will be in the best position to stay ahead of market disruptions and capitalize on opportunities.

Working with a network of knowledge partners that include research, industry and academic organizations, combined with Munich Re's vast knowledge network, we aim to anticipate these changes, educate our stakeholders and develop innovative insurance solutions to manage the impacts of AV technologies for ourselves and our clients.



Autonomous Vehicle Technology: Evolution of Insurance Exposures

Analysts agree that autonomous vehicle technology has the potential to create significant safety benefits by reducing driver error. There is debate over the timeframe for complete integration of fully autonomous vehicles on US roadways. However, data from tests conducted by IIHS show vehicle safety systems that are considered the building blocks of fully autonomous vehicles, have been successful at reducing accidents.

Source: iStock

At the same time, AV technology could give rise to new and potentially costly liability exposures with characteristics that emerge along with the technology's evolution from partially to fully autonomous.

With no historical data on which to base any firm conclusions, our examination of these evolving exposures, the parties that might be affected, and how the interested parties might address these exposures is based on reasonable assumptions regarding the technology, the distribution channels used to get the product to market, how the product will ultimately perform and how it will be used by the consumer.

In addition, our analysis aligns with five levels of automation outlined by NHTSA, in which vehicles operate progressively more autonomously.

We believe the exposures will change over time as AV technology is adopted by the public. In general, as control of the vehicle shifts from manual operator-controlled to automatic computer-controlled, liability may shift from the operator to the manufacturer of the technology. How actual liability scenarios play out will, of course, be decided by the courts on a case-by-case basis.

Therefore, our examination of exposures during Levels 1–3, where the vehicle may be operated manually or autonomously, focuses on vehicle operators. At Level 4, where the vehicle operates in autonomous mode, we focus on exposures to the manufacturer. We explore coverage implications, liability, underwriting, and data and analytics from these perspectives.

NHTSA's Five levels of automation

(Level 0) No automation
The driver is in complete control of brakes, steering, throttle, and motive power at all times.

(Level 1) Function-specific automation
Automation of one or more specific control functions. Example: electronic stability control or pre-charged brakes

(Level 2) Combined function automation
Automation of at least two primary control functions designed to work in unison. Example: adaptive cruise control in combination with lane centering

(Level 3) Limited self-driving automation
Full control of all safety-critical functions transitioned between driver and vehicle, depending on conditions

(Level 4) Full self-driving automation
Vehicle can perform all safety-critical driving functions for entire trip. Driver provides destination or navigation input, but is not required for control at any time during the trip.

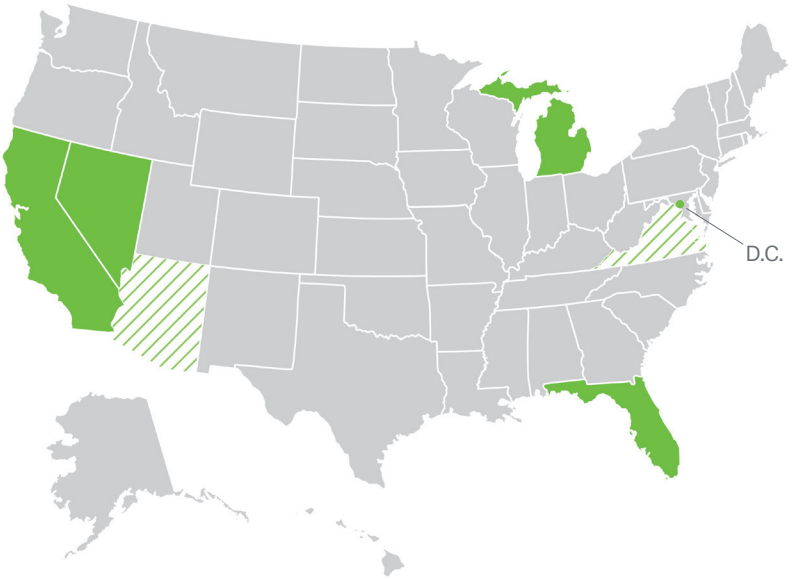
Source: National Highway Transportation Safety Administration, "Preliminary Statement of Policy Concerning Automated Vehicles"

Six states and the District of Columbia currently allow testing of autonomous vehicles on public roads. Many other states have legislation at various stages of development.

Source: Insurance Institute for Highway Safety/Highway Loss Data Institute

Various requirements; testing up to level 3; prohibits equivalent of level 4

Authorizes testing; requirements are basic or undefined



Implications for manufacturers

To date, Arizona, California, Florida, Michigan, Nevada, Virginia and the District of Columbia (D.C.) allow testing of autonomous vehicles on public roads. Generally, test vehicles are dual control and can be operated fully automatically, or operated manually by the operator. Most of the states require a licensed operator to be in the car and ready to take over the controls at any moment. Florida's and D.C.'s laws provide liability protection for the manufacturer. Other states' draft legislation addresses liability in various ways or not at all.

As AVs move out of research and testing environments and into the consumer marketplace, consumer and commercial insurance coverage will likely be impacted, particularly liability coverage.

Liability increases with autonomous functionality
As public acceptance grows and AVs progress from partially to fully autonomous, liability for loss caused by the AV may shift from the operator of the AV to the manufacturer of the AV technology. Assigning liability, in turn, will likely hinge on whether the driver or the component part/technology caused the accident, or some combination of the two. Whether current automotive product liability case law will apply remains to be seen and outcomes difficult to predict. In any case, it could be costly for manufacturers to defend against lawsuits.

Assigning liability may be more complicated during Levels 1–3, when the operator is more likely to be driving the vehicle, than at Level 4 when the computer is likely to operate the vehicle.

The exposure to liability may depend on the amount of control allowed to the operator: the more autonomous the vehicle, the more exposure to the manufacturer. Operators of fully autonomous vehicles will need to make sure that they maintain the AV properly and avoid tampering with the AV operating system to avert assertions of liability against them. How actual liability scenarios play out will, of course, be decided by the courts on a case-by-case basis.

Increased scrutiny leads to greater reputational risk
Recent surveys of public acceptance with regard to fully autonomous vehicles indicate that while drivers would consider purchasing AVs (especially if they could reduce insurance premiums), many are skeptical that a computer can make better decisions than a human behind the wheel. Therefore, any serious loss involving an AV will likely be carefully scrutinized and widely reported in the news media, which presents a potential reputational risk to the manufacturer of the technology.

Cyber liability exposures arise
The potential for hacking a vehicle's computer system to gain information or to cause injury or disruption presents significant data security exposures. While those exposures exist today, the auto industry has acknowledged the growing potential for cyber security threats as vehicles become more connected to each other and to the Internet or other networks.

Liability exposures could arise, for example, from the collection and storage by the AV systems of data and personal information that is protected under state or federal laws. The potential also exists for widespread harm from hacking or cyber attacks.

Currently, auto manufacturers require indemnification from their "downstream" vendors and subcontractors including dealerships, repair/installation facilities, etc. This practice may be carried forward and extend to autonomous vehicle manufacturers of the future, however their vendors and subcontractors may change as the technology evolves.

Liability shift may occur
During Levels 1–3, there may be little change in terms of the necessary products liability and/or products recall/withdrawal coverage to protect the manufacturer's interest. Traditional general liability coverages that clearly distinguish parts and components the manufacturer produces from those that are outsourced and that contain products-completed operations coverage may prove to be sufficient.

Additionally, vehicle manufacturers may require hold harmless agreements with autonomous component suppliers. A scenario in which the autonomous system is 'bolted on' to an existing production vehicle may be no different from any new technology introduced into a car today, i.e. new braking systems, new transmissions, etc. If the technology can impact safe operation of the vehicle, the manufacturer of the component may have a traditional products liability and product recall/withdrawal exposure.

The impact to liability will likely become more apparent as vehicles transition to Level 4, when fault may be more clearly attributed to the technology. Since the autonomous system is operating the vehicle, liability exposure may, in turn, shift from the operator to the manufacturer.

Underwriting classes revisited
Underwriting for products liability and/or products recall/withdrawal covers during this stage of the product may be the same as for any other product. Currently class codes exist for computer manufacturing and auto manufacturing. However, since there is a computer technology involved within the auto manufacturing process, there is potential for a hybrid insurance classification to be developed that contains features of both classes.

Generally speaking, underwriters classify vehicle parts into either "critical" or "non-critical" depending on their function in the vehicle. For example, brakes are considered a "critical" component whereas interior lights would be considered "non-critical." The computer component that allows the vehicle to act independently will likely become more critical and be classified as such, especially as the vehicle becomes more fully autonomous.

Product knowledge ramps up
The underwriter will need some comfort level with—and understanding of—the vehicle's reliability and functionality. In order to gain consumer acceptance, AVs will need to handle situations like construction zones, road and bridge closures, all weather conditions, and more. But if, in certain conditions, the car will not function autonomously, i.e. blizzard conditions, the underwriter will likely want to have a complete understanding of those conditions and their impact on vehicle operation.

The underwriter will also need to understand the shelf life of the autonomous system and what diagnostics are in place to keep the autonomous vehicle running as intended, and will likely rely on those diagnostics to notify the vehicle owner when the vehicle must be maintained or, eventually, replaced.

Liability comparison

Level 1 — Level 2 — Level 3			Level 4
As long as AV systems and operator share control, liability hinges on determining which was in control at the time of an accident	Increased reputational risk New cyber liability exposures	Downstream vendors' and contractors' liability emerges	AV systems control the vehicle. Liability shifts to manufacturers, including downstream vendors and contractors Reputational risk levels as AVs become established Cyber liability exposure remains high

Risk management considerations & recommendations
Any problems with the operation of the product would likely be a setback to adoption of the technology. If losses occur, it will likely be critical to determine whether the vehicle was being operated by a human driver or the AV system, since this technology may eventually impact everyone who operates a vehicle on public roads. Media coverage will likely be extensive as the technology evolves from experimental to a consumer product.

Therefore, from a risk management perspective, manufacturers should consider:

- Creating simple and conclusive schemes to record when the driver overrides the AV computer.
- Reputational risk insurance coverage as media focus on autonomous technology grows.
- A disabling function as a response to any attempts to alter or enhance the software.
- Requiring hold harmless, defense, indemnification and additional insured language on all contracts with downstream vendors and sub-contractors.
- Clearly defining maintenance procedures to be followed by the operator. If the AV operating system detects a problem that is not addressed by the owner, it should disable autonomous functionality to prevent potential loss.
- Preventing the moral hazard that arises when the operator has little or no exposure for a loss by developing an insurance product that includes both the manufacturer and the operator on the policy in order to align the financial interests of the operator and the AV manufacturer.

Implications for commercial and personal operators

By reducing accidents caused by human error, the market for liability coverage, and perhaps the coverages themselves, may be impacted significantly, not just for manufacturers but also for vehicle owners and operators.

Personal auto insurance providers have publicly acknowledged that advancements in vehicle technology and safety features including the development of autonomous or partially autonomous vehicles represent a significant business risk.

Regardless of the impact on the size of the market for liability coverage, participation in the liability market may change significantly.

Liability shifts with autonomous functionality
As with manufacturer liability, responsibility for loss will likely be assigned based on whether a human driver or the AV system was operating the vehicle at the time of loss. Exposure for loss may still be largely borne by the owner/operator during Levels 1–3, as the vehicle will more likely be controlled manually. No substantive change in coverage for the driver/owner of the vehicle is anticipated.

At Level 4, the majority of responsibility will likely shift to the manufacturer in circumstances where the operation of the vehicle is handled solely by the AV system. However, the operator may still be required to maintain the vehicle, and liability could attach to the operator for a loss arising out of a failure to maintain it properly.

There is also a potential for the vehicle to be considered a permissive user or an agent of the operator, thus making the operator responsible for a loss.

As with manufacturer liability, personal and commercial liability ultimately will be decided by the courts on a case-by-case basis and, as such, is difficult to predict with certainty.

Image: Flickr/Steve Jurveston/CC BY 2.0

Coverages shift with liability
As vehicle safety improves during Levels 1–3 of AV development, traditional bodily injury and property damage liability coverage as well as optional and mandatory physical damage coverages, uninsured/underinsured motorist coverages and personal injury protection (no fault) coverages may not change significantly. This is because it may still be necessary to determine whether the driver, the component part/technology, or some combination of the two, caused an accident.

One may envision that any shift in the coverages, may not occur until automation reaches Level 4.

During this phase liability to the operator or owner may decrease significantly. Auto physical damage coverage may increase due to costlier after market replacement parts.

Development of this phase and the nature of insurance coverages will likely be heavily regulated, perhaps bolstering coverage requirements.

New coverage options may emerge
Physical damage covers are designed to protect the vehicle owner from losses that cause damage to the vehicle, including collision, theft or vandalism and other perils. Some notable coverage considerations that may emerge as vehicles add parts and systems that make them more autonomous include:

Physical Damage Coverages (First Party)

- Stated amount physical damage coverage: This valuation method, which pays the lesser of actual cash value, repair cost, or limit listed as a result of a covered accident, may become more prevalent due to the potentially high replacement and/or repair cost as a result of an accident.
- Exceptions to the "mechanical or electrical breakdown or failure" exclusion: Traditional personal and commercial auto policies generally exclude loss due and confined to mechanical or electrical breakdown.
- Revamping of the audio, visual and data electronic equipment coverage exclusions: Traditional personal and commercial auto policies generally exclude any electronic equipment that reproduces, receives or transmits audio, visual or data signals, with an exception for equipment permanently installed. The original focus of this exclusion was sound systems and communication devices (i.e. citizens band radios, cellular phones, etc), however, since visual and data signals are a major component of AVs and will likely be costly to replace, revisions to the exclusion are likely.
- Custom equipment/furnishings: As the technology evolves and less input from an operator of the vehicle is necessary for safe operation, the "living space" of the vehicle could start to resemble living quarters, complete with entertainment systems and furnishings not typically associated with a traditional auto.

Liability Coverages and Physical Damage Coverages (Third Party and First Party)

- Weather-related exclusions: Due to potential weather-related limitations of AVs on snow or ice covered roads, insurers could implement weather-related operation limitations and exclusions.
- Radius of operation and road-type limitations and restrictions: Insurance coverage may specify certain distances or types of roads, such as public roads.
- Failure to maintain or adhere to self-driving AV protocols: Since these vehicles are highly technical and complex, they will likely be held to rigorous technical standards that may require maintenance on a routine basis.
- Cyber liability coverages: AVs employ wireless communications systems to communicate with other vehicles or networks. Manufacturers may need coverage for the risks of cyber attacks, hacking, and breeches of data privacy.
- Resurgence of no-fault type coverage: If assigning fault in an auto accident involving autonomous vehicles proves difficult and time consuming, resulting in delays in compensating injured victims of auto accidents, there could be a resurgence of no-fault type coverage.

Tools of the trade may change

Underwriting tools will also likely be impacted as AVs become more common. Today's underwriter relies on a number of tools to evaluate a risk. One such resource, a driver's motor vehicle record (MVR), is very important when underwriting an account requiring automobile insurance. As manually operated vehicles (MOV) and AV technologies merge, will certain infractions shown on an MVR be seen more frequently? Will others decline? Is a traffic violation such as running a red light treated differently for an MOV versus an AV? Until vehicles become completely autonomous, MVRs will likely remain a key tool in analyzing the exposure any driver presents.

Just as certain losses among today's MOVs may lead an underwriter to decline an account, the same will likely be true of AVs in the fleet of the future. Is a fender-bender between two MOVs different from one between two AVs? What if, when MOV meets AV, the AV is at fault? Does this claim indicate a systemic problem that the underwriter should analyze further? Careful observations and analysis of any emerging trends will be critical to expanding or restricting the underwriter's appetite.

Like any new technology, the cost of repair or replacement is typically higher initially which, in theory, will increase the cost of coverage. However, this will likely be offset by the drop in frequency of claims. Over time the cost to produce the technology should decline. In the long run, many analysts agree that safer roads will likely lower the cost of insurance significantly.

Data remains key
Industry analysts seem to agree that an AV will be inherently safer than a MOV and, as such, would generate a lower frequency of crashes. Assuming severity remains stable or declines, pure premium (the product of frequency and severity) would decline and it would cost less to insure the vehicle.

However, in order to properly determine how much safer an AV is and to calculate the appropriate insurance premium, one needs to analyze a sufficient sample of accurate historical data to compare to MOVs.

Recent advances in telematics systems, which record driver behavior and other data electronically, offer new and more reliable sources of data compared to driver-reported information. In order for these new data to successfully translate safety enhancements into lower insurance rates there must be a sufficient amount of quality data available for analysis.

Telematics systems provide new data that can be used to price auto insurance more accurately. These data points recorded by and accessible from the AV's system can be analyzed and potentially used in rating.

Miles driven
More time on the road indicates higher risk of loss. A subset of this may be "miles driven in AV mode" versus "miles in operator mode." Fewer miles driven in AV mode may require the insurer to revert to more traditional rating of the operator.

Time of day
Regular driving in heavy (or light) traffic could impact a risk's rating.

Location
Analysis of location data may be blocked by regulators concerned about privacy. Location might also include the percentage of driving time spent on mapped vs. non-mapped roads.

Speed
Instances of excessive speed could be recorded via GPS information.

Driver identification
Even with telematics it is difficult to know who is really driving the vehicle — and it matters to insurers whether parents or their young drivers are behind the wheel.

Hazards/Near-misses
Validation of how well the AV avoids hazards that a human would not avoid could support claims that AVs are safer and lead to lower insurance rates.

Weather data
Knowing what driving conditions were like at the time of an accident could help with claims handling.

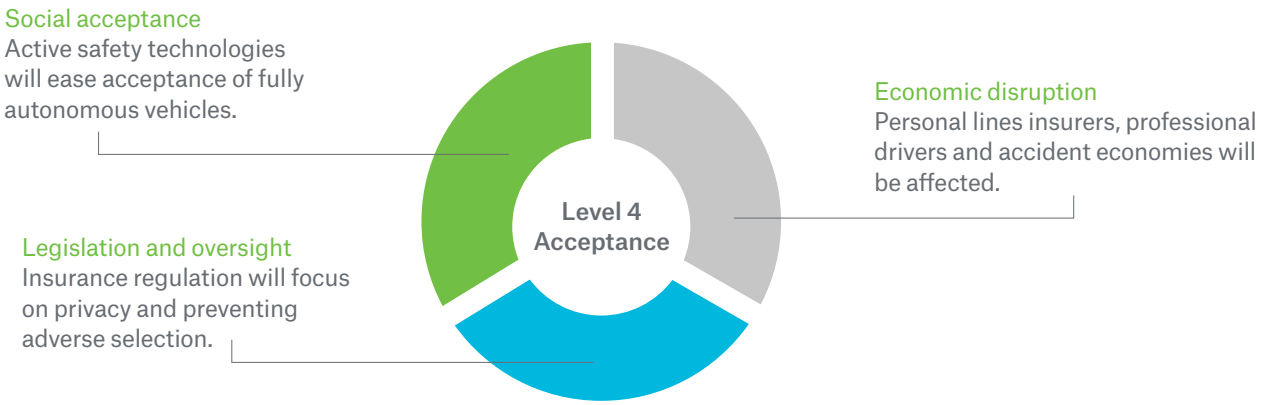
Crash sensor data
Sensor data that can be used to re-construct a crash can also be useful in determining fault.

Data quantity. A sufficient number of road miles should be logged in order to create a credible data set for analysis. What is sufficient? A large auto insurance company can easily rely on a historical data set of 100–150 billion miles driven to produce credible results. Small insurance companies typically don't have that quantity of data, and will likely pool their experience data (with the Insurance Services Office, for example) to create data sets large enough to perform credible analysis.

Data availability. A number of regulatory practices may need to change in order to realize the full impact of AVs on insurance. Regulators currently prohibit insurers from using certain data in their rating models, including location, speed, or other data considered private. This limits the usefulness of the data captured by the AV. The more insurance companies must rely on traditional pricing information, the more insurance is likely to remain the same.

Shared vehicles
The future of autonomous vehicles goes beyond individual vehicle owners to shared vehicles, and to fleets of autonomous vehicles that include cars, trucks, and public transportation. Shared AVs, for example, could be available for rental on an as-needed basis. Insurance might be included as part of the price of rental, thereby easing consumers into the idea of the autonomous functionality in a more economically feasible manner than purchasing a fully autonomous vehicle.

Source: US DOT



Outlook: Many factors will temper development
Development of all of these visions could be impacted by a host of social, economic and regulatory factors that make the timing of a shift to fully autonomous vehicles and the insurance implications of that shift difficult to predict.

Social acceptance
Surveys show the majority of people would not purchase an autonomous vehicle if it were available today, yet they would be willing to spend a little more equipping their next vehicles with features like crash avoidance and lane-keeping systems that are the building blocks of tomorrow's fully autonomous vehicles. It seems the general population isn't ready to give up control of their vehicles or trust that a computer might make better decisions at the wheel.

Even with a theoretical 2016 government mandate in place, IIHS predicts vehicles equipped with crash-avoidance and lane-keeping systems would not reach 95% of fleet penetration until 2039.

Legislation and oversight
NHTSA has outlined its position in its paper "Preliminary Statement of Policy Concerning Automated Vehicles." The organization is currently engaged in evaluating safety and setting standards for in-vehicle safety features like automated breaking systems. It has also issued a set of recommendations for states seeking guidance on safe testing of AVs on public highways. These recommendations include provisions for licensing and testing of vehicles and their operators as well as data recording. Besides studying safety related to electronic control systems, performance requirements and human factors, NHTSA intends to issue a baseline set of requirements to ensure cyber security in AVs.

Driverless vehicle laws and legislation for US states is compiled periodically by the American Insurance Association. To date, enacted legislation has focused on testing of AVs on public roads rather than envisioning AVs in the consumer marketplace.

As AVs get closer to the public, lawmakers will likely pay close attention and introduce legislation designed to protect the public across a wide range of AV impacts, including licensing and certification of vehicles, infrastructure, cyber security and, of course, safety standards. In insurance, regulators may seek to prevent adverse selection and moral hazards, protect privacy and personal information. Litigation associated with determining liability will also likely lead to legislation. As laws are changed, insurance coverages will likely change to meet the needs of customers.

In any case, insurers will likely be impacted, and those who remain informed on autonomous vehicle issues will be better positioned to manage that impact successfully.

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