



BCG

THE BOSTON CONSULTING GROUP

A ROADMAP TO SAFER DRIVING

THROUGH ADVANCED DRIVER ASSISTANCE SYSTEMS





The Motor & Equipment Manufacturers Association

The Motor & Equipment Manufacturers Association (MEMA) represents more than 1,000 companies that manufacture or remanufacture components and systems for use in motor vehicles and equipment in the light vehicle and heavy-duty, on- and off-highway commercial vehicle markets for the original equipment and aftermarket industries. Motor vehicle component manufacturers are the nation's largest manufacturing sector with a total employment impact of 3.62 million employees – for every direct job in the motor vehicle supplier industry, another five jobs are created.

MEMA represents its members through four divisions: Automotive Aftermarket Suppliers Association (AASA), Heavy Duty Manufacturers Association (HDMA), Motor & Equipment Remanufacturers Association (MERA), and Original Equipment Suppliers Association (OESA).

For more information on the motor vehicle component supplier industry, visit www.mema.org.



The Boston Consulting Group

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A ROADMAP TO SAFER DRIVING THROUGH ADVANCED DRIVER ASSISTANCE SYSTEMS

Prepared for MEMA by The Boston Consulting Group

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Steve Handschuh
President & CEO
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Dear Stakeholder –

Every year almost 33,000 Americans are killed in motor vehicle accidents nationwide. In addition, motor vehicle accidents cause a total of 3.9 million non-fatal injuries with an annual cost to society of \$910 billion, an astonishing six percent of GDP.

The United States has the opportunity to dramatically reduce fatalities and accidents with vehicle technology solutions now known as ADAS (Advanced Driver Assistance Systems). ADAS technology can provide immediate safety benefits and form the pathway to a partially and fully autonomous vehicle fleet that could virtually eliminate traffic fatalities. ADAS technologies alone have the potential to prevent 30 percent of all crashes. Together with autonomous technology, we could reduce motor vehicle accidents by 90 percent.

The Motor & Equipment Manufacturers Association (MEMA) represents more than 1,000 companies that manufacture or remanufacture components and systems for use in motor vehicles and equipment in the light vehicle and heavy-duty, on- and off-highway commercial vehicle markets for the original equipment and aftermarket industries. Motor vehicle component manufacturers are the nation's largest manufacturing sector with a total employment impact of 3.62 million employees – for every direct job in the motor vehicle supplier industry, another five jobs are created.

MEMA and its members work closely with vehicle manufacturers and are leading the way in providing cutting-edge, innovative systems and components for new vehicles that enhance vehicle safety. Motor vehicle component manufacturers have increasingly taken on the research, development, engineering, and manufacturing of advanced vehicle technologies.

Motor vehicle component manufacturers embrace the vision of sharply reducing fatalities. Earlier this year, MEMA asked The Boston Consulting Group (BCG) to study the impact these technologies could have on motor vehicle safety. This research concludes that if every vehicle on the road were equipped with ADAS technologies, these systems would sharply reduce the toll that vehicle accidents take on society. Since the vast majority of accidents in the United States are caused by driver error, not adopting these technologies within the U.S. fleet is a significant missed opportunity. This is especially true considering that ADAS technologies pave the way to partially and fully autonomous vehicles, which could additionally reduce accidents—and their cost to society—by 90 percent or more.

We urge immediate action by stakeholders to enable increased adoption of ADAS technologies. These actions include:

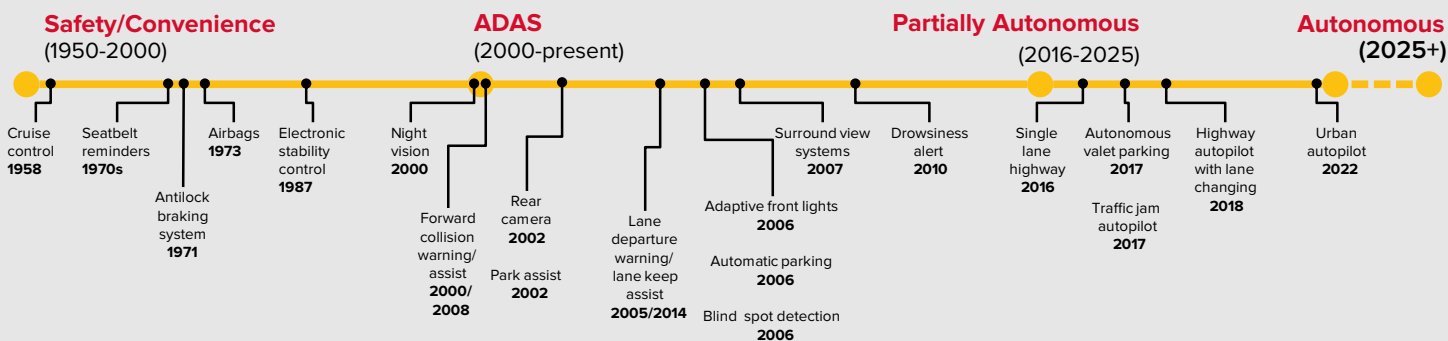
- ▶ Updating the New Car Assessment Program (NCAP) to recognize ADAS technologies.
- ▶ Implementing incentives in the federal tax system and with commercial entities to steer drivers toward safety technologies.
- ▶ Encouraging regulators to collaborate with their overseas counterparts to produce and implement global technical standards that will reduce crashes, property damage, and fatalities on a global basis.

We look forward to working with you to realize the goal of eliminating motor vehicle fatalities and reducing injuries and property damage.

Sincerely,

 Steve Handschuh
 President & CEO
 MEMA

ERAS OF SAFETY TECHNOLOGY



EXECUTIVE SUMMARY

On behalf of MEMA, The Boston Consulting Group (BCG) analyzed the available ADAS (Advanced Driver Assistance Systems) technologies and concluded that if every vehicle on the road were equipped with them, the toll taken on society from vehicle accidents could be sharply reduced.

Relatively few vehicles on the road today have these systems, however, and their penetration of the market is growing at only two to five percent annually.

Since the vast majority of accidents in the United States are caused by driver error, the lack of adoption of these technologies within the U.S. fleet is a significant missed opportunity. This is especially true considering that ADAS technologies also pave the way to partially and fully autonomous vehicles, which could further reduce accidents—and their cost to society—by 90 percent or more.

BCG found:

- ▶ Since 2000, the automotive industry has introduced many ADAS features, and several more are being developed. This study focuses on seven features and combinations thereof that are most prevalent in the U.S. market.
- ▶ ADAS features can be grouped into three broad categories—those that aid the driver, those that warn the driver, and those that assist the driver in performing certain basic driving functions.

- ▶ Taken together, ADAS features and sensor technologies are the building blocks of partially autonomous driving, which in certain scenarios will allow a vehicle to accelerate, steer and/or brake without driver intervention. Some partially autonomous features could be available to the public before the end of 2015.
- ▶ These features could prevent approximately 9,900 fatalities each year in the United States.
- ▶ ADAS features, if widely adopted and properly used, could generate tremendous societal benefits. BCG has calculated that the cumulative safety contribution of available ADAS technologies works out to \$16,307 per vehicle over a vehicle's 20-year life.¹
- ▶ ADAS technologies could deliver a safety return of 98 percent over a vehicle's lifetime, factoring in both economic savings and the avoidance of diminished quality of life.
- ▶ Fully autonomous vehicles, which in most situations could operate independently from human intervention, could reduce accidents even more dramatically, cutting them by an estimated 90 percent and generating a safety return of 439 percent.
- ▶ Compared with Europe, the United States has made far less progress on the regulation front.
- ▶ All stakeholders—vehicle manufacturers; component manufacturers; dealers; regulators; legislators; insurers; rating agencies and consumer publications; industry associations; and consumers themselves—have a role to play in steering consumers toward ADAS adoption.

- ▶ This study concludes that policymakers can take several concrete steps to promote vehicle technologies that promise to greatly enhance the safety of the motoring public. These include:
 - ◆ Updating NCAP standards to recognize ADAS technologies.
 - ◆ Implementing federal tax incentives and insurance premium discounts to help steer drivers toward choosing safety technologies. Government and industry should collaborate where appropriate to reward drivers for purchasing and using ADAS features.
 - ◆ Funding a multi-year highway bill.
 - ◆ Conducting a regular congressional review of progress toward full vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) adoption.
 - ◆ Conducting consumer information programs along the lines of the highly effective “Click It or Ticket” campaign for seatbelt use, which has had a measurable impact on consumer behavior. Stakeholders can collaborate on this effort for maximum impact.
 - ◆ Providing direction and materials for education programs for new drivers on ADAS technologies.
 - ◆ Requiring a national motor vehicle safety inspection program to ensure maintenance and proper functioning of new technologies over the life of the vehicle.
 - ◆ Linking ADAS features with Corporate Average Fuel Economy (CAFE) credits to open multiple paths for consumer and industry investment.
 - ◆ Encouraging regulators to collaborate with their overseas counterparts to produce and implement global technical standards that will reduce crashes, property damage, and fatalities on a global basis. This will allow manufacturers to build scale and thus lower costs.

A ROADMAP TO SAFER DRIVING THROUGH ADAS

Every year, almost 33,000 people are killed in motor vehicle accidents in the United States. Additionally, these crashes cause 3.9 million non-fatal injuries and damage 24 million vehicles.

The National Highway Traffic Safety Administration (NHTSA) estimates the cost to society as totaling roughly \$910 billion² annually, which is the equivalent of approximately six percent of the annual U.S. real gross domestic product. In addition, the toll that motor vehicle accidents take on victims, their families, and loved ones cannot be measured.

Yet car manufacturers and motor vehicle component manufacturers have developed safety technologies that could sharply reduce the number and severity of motor vehicle accidents. The innovations being created and developed by component manufacturers for light vehicle and heavy truck manufacturers present an opportunity to transform vehicle safety and save lives. The most noteworthy of these innovative technologies are advanced driver assistance systems (ADAS) that could mitigate the harm to society caused by motor vehicle accidents.

Policymakers face important decisions about how to best implement and enable the wide array of vehicle technologies that ensure the safety of the motoring public. This report is designed to serve as a roadmap for advanced vehicle technologies and to assist policymakers as they consider steps to improve motor vehicle safety through new technologies.

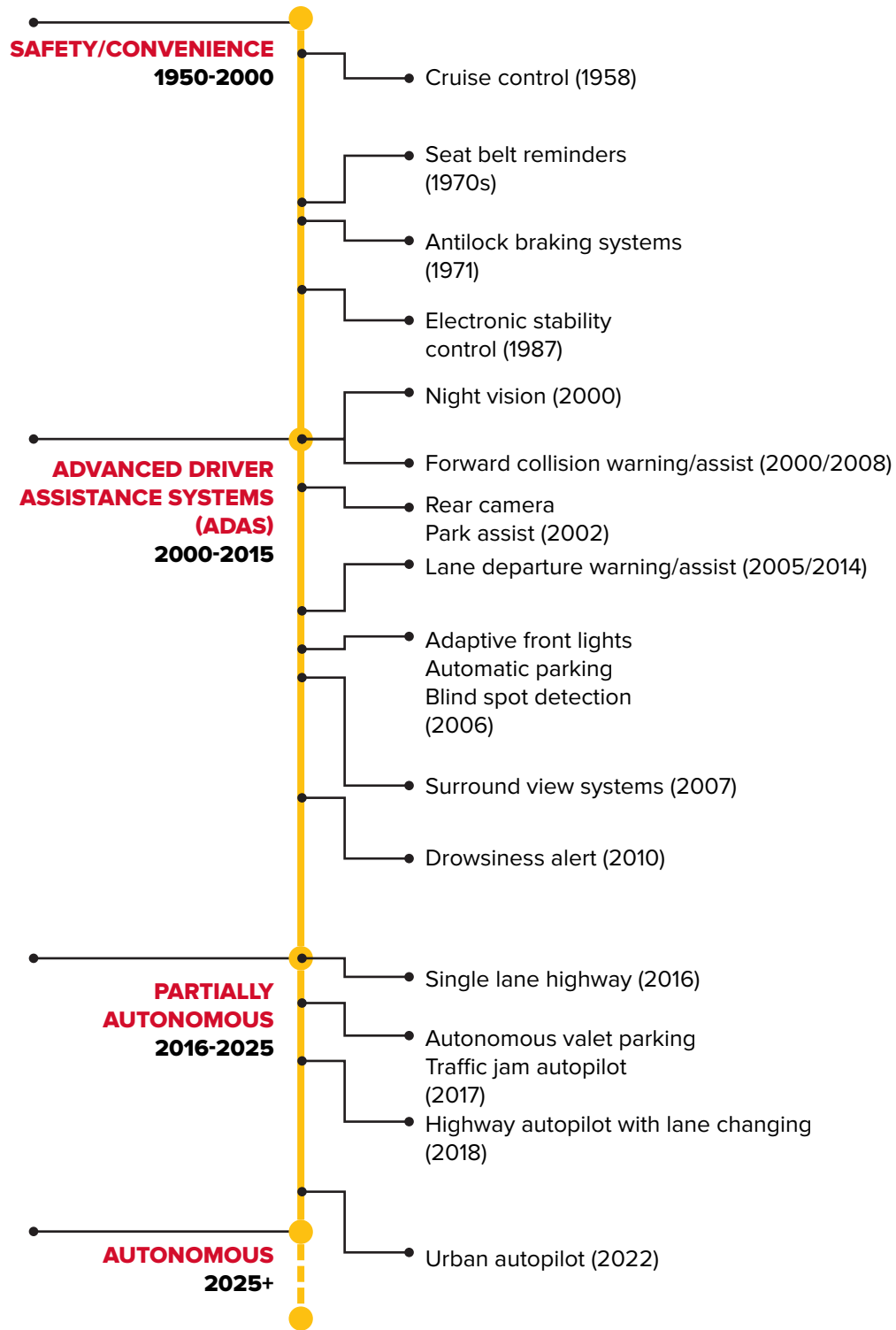
ADAS Features Examined

- ◆ Forward Collision Warning/Assist/ Adaptive Cruise Control
- ◆ Blind Spot Detection
- ◆ Night Vision
- ◆ Lane Departure Warning/Lane Keep Assist
- ◆ Adaptive Front Lighting
- ◆ Surround View
- ◆ Park Assist Features

The Boston Consulting Group (BCG) has analyzed the available ADAS features and concluded they could sharply reduce the toll that vehicle accidents take on society. This transformation is within our grasp but would require:

- ▶ Equipping every vehicle with these transformational, life-saving technologies.
- ▶ Educating drivers on the appropriate driving skills leveraging these technologies.

ERAS OF SAFETY TECHNOLOGY



Source: The Boston Consulting Group

- ▶ The ability to service and maintain these vehicles in dealership service departments or the aftermarket by independent service outlets.

Relatively few vehicles on the road today have these systems, however, and their penetration of the market is growing at only two to five percent annually. This is a significant missed opportunity, especially considering that ADAS technologies pave the way to partially and fully autonomous vehicles, which could reduce accidents—and their cost to society—by 90 percent or more.

Inside ADAS Technologies

The technology to prevent motor vehicle crashes and minimize their impact is developing at a faster pace than ever before in the automotive industry. From 1950 to 2000, Original Equipment Manufacturers (OEMs) and Tier 1 component manufacturers made many structural improvements to vehicles and introduced four major safety systems in the United States: seatbelts, antilock braking systems (ABS), airbags, and electronic stability control (ESC). From 2000 through 2014, the automotive industry has introduced several ADAS features. This study focuses on seven features and combinations thereof that are most prevalent in the U.S. market.

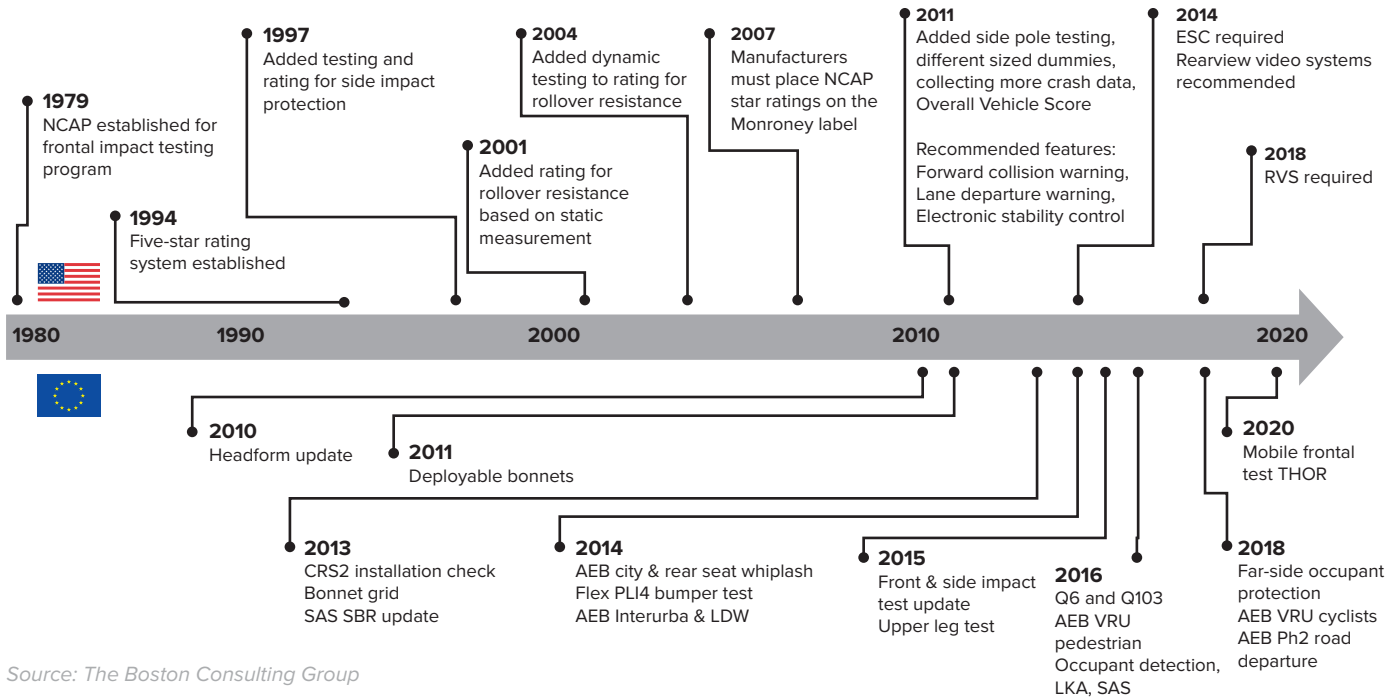
Compared with Europe and Japan, however, the U.S. market has made far less progress on the adoption front, and much work remains to be done. One key component to a greater adoption rate is the inclusion of ADAS technologies in the

Exhibit 1: Regulatory Comparison - U.S. NCAP and EURO NCAP

	U.S. NCAP	EURO NCAP
Org.	Government program <ul style="list-style-type: none"> ▶ Flagship consumer information program of NHTSA, backed by U.S. DOT 	Non-profit organization <ul style="list-style-type: none"> ▶ Backed by seven EU governments, consumer groups, and European motoring clubs
Rating System	5-star rating based solely on crashworthiness <ul style="list-style-type: none"> ▶ Frontal ▶ Side ▶ Rollover 	5-star rating-based crashworthiness and feature assessments along four dimensions <ul style="list-style-type: none"> ▶ Adult protection ▶ Child protection ▶ Pedestrian protection ▶ Safety assist technologies
Advanced Technology	Safety technology evaluated and classified on Safecar.gov <ul style="list-style-type: none"> ▶ Standard (i.e., FMVSS³) ▶ Recommended (e.g., forward collision warning) ▶ Additional safety technology (e.g., forward collision mitigation) 	‘Euro NCAP Advanced’ reward system <ul style="list-style-type: none"> ▶ Rewards manufacturers by publicly recognizing vehicles with advanced safety technologies
Future Plans	Extensive review of all testing and assessment procedures (2012-2015) <ul style="list-style-type: none"> ▶ Goal to “make 5-star rating system more meaningful in terms of real world performance and the advancement of new technology” 	Advanced automatic emergency brakes <ul style="list-style-type: none"> ▶ Pedestrian night and bicycle (2018) ▶ Car-to-car complex trajectory (2018) Additional case studies and consultations <ul style="list-style-type: none"> ▶ Human-to-machine interface guidelines (2017) ▶ Moped/motorcycle crashes (2017/2018)

Source: The Boston Consulting Group

Exhibit 2: Regulatory Timeline for Safety Technology Recommendations/Mandates, U.S. & EU



Source: The Boston Consulting Group

U.S. NCAP program. Globally, this inclusion has proved effective in promoting the adoption of ADAS technologies. For instance, the European NCAP (Euro NCAP), a cooperative of seven European governments, as well as motoring and consumer organizations, has been the most aggressive promoter of ADAS technologies, making several features mandatory for any new cars seeking the organization’s top safety rating of five stars. (See Exhibits 1 and 2.)

Japan NCAP, operated by the National Agency for Automotive Safety and Victim’s Aid, is somewhat less aggressive than Euro NCAP but more actively promotes ADAS technologies as compared to U.S. NCAP. China’s NCAP is making rapid strides after a more recent start and intends to match Euro NCAP’s requirements by 2018. Although NHTSA has announced a proposed inclusion of Automatic Emergency Braking (AEB) into U.S. NCAP, more can and should be done to emulate other NCAP programs.

Three Types of ADAS Features: Aid, Warn, Assist

Many systems integrators and component manufacturers are involved in developing key ADAS features in collaboration with automotive OEMs. Those features include the software that will control their operation and the increasingly rigorous testing needed to validate the new technologies. ADAS features will, of course, be found most often in new cars, but many can be retrofitted to older models. (See the sidebar “ADAS in the Aftermarket” on page 10.) ADAS features can be grouped into three broad categories—those that aid the driver, those that warn the driver, and those that assist the driver in performing certain basic driving functions. (See Exhibit 3.)

Aid features include visual aids such as night vision, rear-mounted cameras that enhance the driver’s rear vision to facilitate parking and reversing, adaptive front headlights, and surround view systems. These features are enabled by technologies such as mono-vision cameras, infrared lights (for night vision) and lasers.

Aid features are not newcomers to the automotive scene. Night-vision systems have been available since 2000; rearview cameras were introduced in 2002, adaptive front headlights in 2006, and surround view systems in 2007. Component manufacturers continue to refine them, and their cost to customers is decreasing at a rate of four to nine percent a year.

Warn features alert the driver to potential dangers through sensory cues such as auditory or visual signals or vibrations. Park assist, which typically activates a beeper when a reversing driver draws near the obstacle behind, was introduced in 2002. Forward collision warning, which warns the driver of a potential collision ahead, first appeared in 2000. Lane departure warning, which typically activates a beeper or causes the driver’s seat to vibrate when the vehicle drifts from its lane, came on the market in 2005.

Exhibit 3: Categories of ADAS Features

ADAS FEATURES			PARTIALLY AUTONOMOUS
	Aid	Warn	Assist
Definition	Aid features improve visibility for the driver by providing additional display or illumination	Warn features alert the driver of potential danger through sensory cues: auditory, visual or haptic	Assist features engage steering, acceleration, and/or brake systems if necessary
Feature (Year)	Night vision (2000) Rear camera (2002) Adaptive front lights (2006) Surround view systems (2007)	Forward collision warning (2000) Park assist (2002) Lane departure warning (2005) Blind spot detection/rear cross traffic (2006) Driver monitoring (2006)	Forward collision assist (2008) Self-park (2006) Lane keep assist (2014) Pedestrian avoidance (2014) Intelligent speed adaptation (~2018)
Technology	Mono cameras Infrared (night vision) Laser lights	Mono and stereo cameras Radar (short) Steering inertia Ultrasonic	Mono and stereo cameras Radar (short and long) LIDAR Ultrasonic
Control	Lower level of system integration; supplier ownership		Driver begins to share control OEM integration High level of system integration

Source: The Boston Consulting Group

ADAS in the Aftermarket

ADAS features are not just for new vehicles. There are over 230 million light vehicles in operation in the United States with an average age of 11.4 years. As a result, the safety benefits of ADAS may not be fully realized for almost two decades if only applied to new vehicles. Under the right conditions, demand for retrofitting older vehicles with at least some ADAS features may be strong and could accelerate the safety benefits to all motorists.

The automotive aftermarket includes all vehicle parts, chemicals, tools, equipment and accessories necessary to keep vehicles on our nation's roads operating safely and efficiently. The aftermarket has a demonstrated track record and is capable of retrofitting, servicing, and maintaining these technologies. As the aftermarket facilitates the adoption of ADAS features, access to vehicle data will be required.

Potential demand for ADAS “aid” and “warn” features provide the best opportunities for adoption and

vary with the cost and ease of installation. In the category of aid features, demand for rear cameras, for example, will likely be high, given that they are easy to install and their cost ranges from \$100 to \$200. Night-vision systems, on the other hand, have low demand potential, because, although they are relatively easy to install, the cost of \$2,000 to \$3,000 per system is prohibitive.

Warning features that can take off in the aftermarket include park-assist systems, which rely on low-cost, easy-to-install ultrasonic sensors. Demand for warning features such as blind spot detection, forward collision warning, and lane departure warning will likely be strong, but because they cannot be installed in every model, they are not likely to sell as strongly as park assist.

Assist features such as systems to enable partial autonomy have low demand potential because of their high cost—\$10,000 or more—and the difficulty inherent in integrating the enabling technologies with current steering, acceleration, and brake systems.



Other warning systems include blind spot and rear cross-traffic detectors, introduced in 2006, and driver monitoring systems, also introduced in 2006.

These features are enabled by technologies such as mono- and stereo-vision cameras, ultrasonic sensors, short-range radar, and inertial steering data, as well as the microprocessors and software that govern their operation.

Assistance features actively engage steering, acceleration, and/or braking systems as needed in order to ensure the vehicle's safe operation. Such features include:

- ▶ Forward collision assist, introduced in 2008.
- ▶ Adaptive cruise control, which adjusts the vehicle's speed to maintain a constant distance from the vehicle immediately ahead of it, introduced in 2007.
- ▶ Self-parking, introduced in 2006.
- ▶ Lane keep assist, which actively returns the vehicle to its original lane when it is in danger of drifting from it, introduced in 2010.
- ▶ Pedestrian avoidance, which warns the driver of an impending collision with a pedestrian and, in some systems, will assist the driver with steering and braking to avoid collision, introduced in 2014.
- ▶ Intelligent speed adaptation, which automatically adjusts the vehicle's speed in response to the driving environment, which is likely to come on the market by 2018.

As in the case of warning and aid features, assistance features are enabled by technologies such as processors and software, mono- and stereo-vision cameras, radar (both short- and long-range), and light detecting and ranging (LIDAR) technology, which uses reflected light signals to assess the driving environment.

The Foundation for Partially Autonomous Driving

Taken together, ADAS features and sensor technologies are the building blocks of partially autonomous driving, which in certain scenarios will allow a vehicle to drive or brake without driver intervention. Some partially autonomous features will soon be available to the public. They include:

- ▶ Single-lane highway autopilot, which enables the car to operate without driver intervention as long as it remains in a single lane. It could be introduced as soon as 2016.
- ▶ Traffic jam autopilot, which takes over vehicle operation in dense, very low-speed driving environments, likely to be introduced as soon as 2017.

- ▶ Autonomous valet parking, which automatically seeks out a free parking space and parks the vehicle, coming as soon as 2017.
- ▶ Highway autopilot with lane-changing, available as soon as 2018.
- ▶ Urban autopilot, which enables autonomous driving at low speeds only. Its developers expect to roll it out in 2022.

At current adoption rates, making these partially autonomous features affordable to consumers poses a challenge and ADAS technologies can play a role. In addition to leveraging the same enabling technologies as ADAS features, partially autonomous features may also require vehicle-to-vehicle/infrastructure/pedestrian (V2X) communication.

Most ADAS features have a slow adoption curve. The install rate in new vehicles of surround-view systems, which first became available in 2010, is projected to grow to only three percent by 2020 from one percent today.

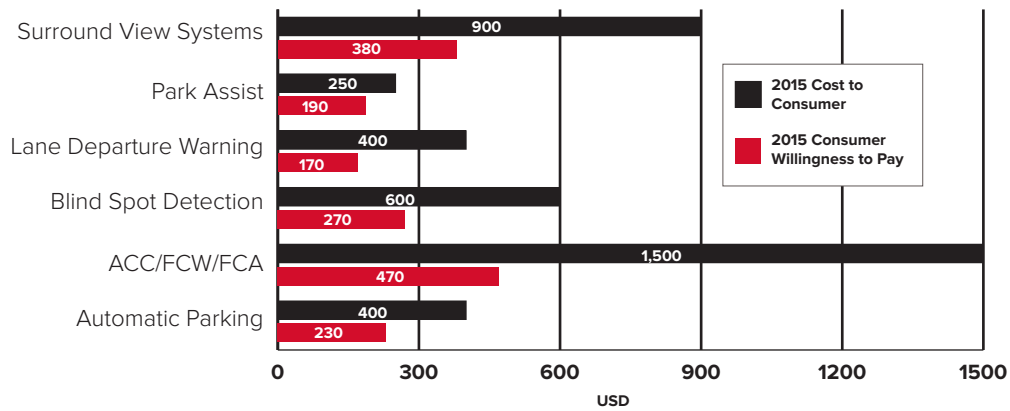
Market Uptake Is Slow

As noted earlier, consumers have been slow to adopt ADAS features, despite their wide availability, because they are unwilling to pay as much for ADAS features as they cost to make and market. For example, according to a recent consumer survey, most car owners said they would be willing to pay anywhere from \$100 to \$400 for blind spot detection (BSD). Its present cost to the consumer, however, is \$595 per vehicle. More market incentives and better consumer information will be needed to close the gap. (See Exhibit 4.)

Most ADAS features have a slow adoption curve. The install rate in new vehicles of surround-view systems, which first became available in 2010, is projected to grow to only three percent by 2020 from one percent today. Their average cost to consumers is expected to fall during that time from \$900 per vehicle to \$660.

In contrast, rearview cameras have rapidly penetrated the market, thanks in large part to legislation that mandated their installation in all new vehicles by 2018 and the inclusion of rearview video systems in the U.S. NCAP as a “Recommended Advanced Technology Feature.” Introduced in 2002, the rearview cameras and parking assist features reached 40 percent market penetration in 2010 and 56 percent in 2015. Rearview cameras will be featured on 100 percent of new vehicles by 2018. Their cost to the consumer, meanwhile, has plummeted from an average of \$722 per vehicle in 2010 to \$550 today. By 2020, the average cost should drop to \$418 per vehicle.

Exhibit 4: Gap Between Current Cost to Consumer and Consumer Willingness to Pay for ADAS Features



Source: The Boston Consulting Group

Even at today's low market-penetration rates, the sensor technologies that underpin ADAS features are standardizing, with manufacturers converging around what they view as the best available technologies. Thus, ultrasonic sensors have become more prevalent for park-assist features and are used ubiquitously, short-range radars are used more widely to enable blind spot detection, and long- and short-range radars are employed in nearly all forward collision warning systems.

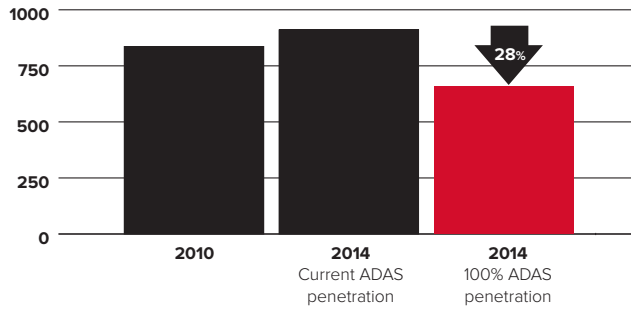
The Value of ADAS Safety Contributions

ADAS features, if widely adopted and properly used, could generate tremendous societal benefits. To quantify the value of those benefits, it is necessary to determine both the number of crashes that ADAS features can prevent each year and the cost to society if those crashes had occurred over the 15- to 20-year life of a vehicle. This cost is what we refer to as the cumulative safety contribution of ADAS features. (See Exhibit 5.)

The safety contribution includes both the economic cost of vehicle accidents and the loss of quality of life suffered by the victims of accidents. Quality of life is effectively the implied value that people place on their continued good health, as revealed by the price they are willing to pay to avoid the risk of death or injury. Consumers, naturally, value quality of life more highly than the sheer economic cost of accidents, and therefore quality of life weighs more than purely economic considerations when consumers decide what they are willing to pay for increased safety.

BCG calculated that the cumulative safety contribution of available ADAS technologies works out to \$16,307 per vehicle over a vehicle's 20-year life. A driver would have to spend \$8,240 to buy these ADAS features. If all new-car buyers made that investment, the features could prevent approximately 9,900 fatalities and 30 percent of all crashes occurring annually in the United States. Therefore, they could deliver a safety return of 98 percent, factoring in both economic savings and the avoidance of diminished quality of life. (See Exhibit 6.)

Exhibit 5: Societal Harm from Motor Vehicle Crashes (\$b)



Motor vehicle crashes cost the U.S. \$910B or 6% of real GDP each year (source: NHTSA 2010 data in 2014 U.S. dollars)

Current ADAS features could save \$251B annually or ~2.5x federal spending on education

Source: The Boston Consulting Group

Furthermore, BCG forecasts that fully autonomous vehicles, which in most situations could operate independently from human intervention, could reduce accidents even more dramatically, cutting them by an estimated 90 percent and generating a safety return of 439 percent. This estimated return posits that fully autonomous capability would cost \$10,000 per vehicle by 2025, assuming full adoption.

These findings regarding the safety contribution of ADAS features (and, eventually, of partially autonomous vehicles) underscore why it is so important for automotive stakeholders to act with urgency to hasten adoption of ADAS features.

Exhibit 6: Potential Safety Return of ADAS and Autonomous Vehicle Technology Adoption



Societal contribution defined as cumulative safety contribution relative to cost of technology. The safety return varies by life of vehicle and discount rate, but is overwhelmingly positive. Given current cost of technology and a three percent discount rate - the 20 year Treasury -, ADAS makes for a wise investment, yielding a safety return of 98% to society.

Source: The Boston Consulting Group

The Role of Major Stakeholders

Legislators

Congress can and should play a key role in spurring ADAS understanding and adoption.

Legislators can continue to shine the spotlight on these transformative systems and support widespread ADAS adoption by encouraging an open dialogue with component manufacturers through testimony and other forums of public debate on the features and benefits of these technologies.

Legislators can directly and positively influence consumer behavior with laws that offer tax deductions or rebates to consumers for purchasing ADAS features and set industry-wide accident reduction targets across a five- or 10-year timeline.

Legislators play a valuable role in overseeing regulatory performance and setting the priorities and budgets of regulatory agencies. One high-impact way to do so would be to increase funding for NHTSA's research into the causes of crashes, which could help strengthen the case for ADAS features. In addition, Congress should make a top-down review of the technical elements necessary for full V2V and V2I (V2X) adoption and implement a roadmap. This would include adoption of ADAS technologies in the U.S. fleet.

Legislators' impact is not limited to just industries and regulators, of course. They can directly and positively influence consumer behavior with laws that offer tax deductions or rebates to consumers for purchasing ADAS features. And they could replicate their success implementing CAFE standards by setting industry-wide accident reduction targets across a five- or 10-year timeline. Indeed, legislators could link ADAS features with CAFE credits, which would open multiple paths for consumer and industry investment by allowing them to make various trade-offs between those two attractive spending options.

State legislators also have an important role to play. At present, a patchwork of state laws govern automotive insurance coverage and practices. For example, some states have high standards for empirical proof of the efficacy of safety features, which prevents some insurers from offering discounts for ADAS adoption. Standardizing state insurance laws to allow such discounts in the absence of detailed empirical proof would almost certainly accelerate market uptake of the technologies.

Exhibit 7: Levers Available to Stakeholders to Accelerate Adoption of ADAS Features

Level of influence	Ease of implementation			
	Educate / Advertise	Regulate / include in Rating	Incentivize	Mandate
Legislators	✓	✓	✓	✓
Regulators	✓	✓	✓	✓
Ratings Agencies	✓	✓	✓	–
Insurance Companies	✓	✓	✓	–
Consumer Agencies	✓	✓	–	–
OEMs	✓	–	✓	–
Tier 1 Suppliers	✓	–	–	–

Source: The Boston Consulting Group

Regulators

Regulators are well-positioned to speed the rate of ADAS adoption. NHTSA, the leading U.S. vehicle regulator, plays a crucial role in the market by developing and enforcing federal motor vehicle safety standards (FMVSS), which mandate the design, performance, and durability requirements for all new vehicles sold in the U.S. market. It is because of FMVSS that all new cars on the market must include, for example, three-point safety belts and airbags. Furthermore, NHTSA manages U.S. NCAP, which sets specifications and performance standards for crashworthiness features that go beyond FMVSS requirements. In addition, U.S. NCAP includes recommended advanced technology features for crash avoidance systems. Used by consumers to compare vehicles and displayed on new vehicle window stickers, the NCAP presents a five-star rating system where one star is the lowest rating and five stars is the highest.

NHTSA continues to promote adoption of safety features. Since the 2012 model year, electronic stability control systems have been required for all new light vehicles, and by model year 2018 all light vehicles will be required to install a rearview camera system. In addition, NHTSA is in the process of updating the NCAP to include AEB systems featuring two system types – crash imminent braking and dynamic brake support. The agency is studying other ADAS features such as lane keeping assist but has not yet mandated these technologies.

Compared with its regulatory counterparts in Europe and Japan, NHTSA has been slower in mandating adoption of ADAS features or incorporating them in five-star safety ratings. As of 2014, Euro NCAP has required AEB systems and lane departure warning in all vehicles that seek the agency's five-star safety rating. Its five-star rating requirements will demand even more ADAS features in the 2016 and 2018 model years.

Component manufacturers are willing to engage and collaborate with U.S. NCAP and Euro NCAP to harmonize certification standards for ADAS features and share data on their installation rates and effectiveness. That effort would simplify

The Key Role of Telematics

“Connected cars”—that is, vehicles with integrated Internet connectivity—store and can communicate many kinds of data. These include:

- ▶ Driver personal data
- ▶ In-vehicle infotainment
- ▶ Inspection data
- ▶ Diagnostic data
- ▶ Vehicle manufacturer proprietary information
- ▶ Intelligent transport system (ITS) information

Connected vehicles are capable of advanced automatic collision notification (AACN), in which a vehicle automatically informs first responders and insurers that an accident has just occurred. In the earliest versions of AACN, airbag deployment would automatically trigger a notification. More sophisticated systems now generate and transmit more data, including the vehicle type involved in the accident, the principal direction of force, seatbelt use, the number of impacts, and whether or not the vehicle rolled over.

As of 2014, 25 percent of vehicles on the road had embedded connectivity. That share could grow to 50 to 80 percent by 2020, especially with action from regulators. A regulation is currently making its way through the European Commission that would mandate the use of ECall, an AACN solution, in all new cars by April 2018. A similar regulation is already in effect in Russia.

Widespread use of AACN technologies in the United States could reduce emergency response times by 30 to 50 percent.

Connected cars and telematics will provide real time access to extensive data from vehicles, making remote diagnostics and “prognostics” possible in the not-too-distant future. With the majority of maintenance and repair service (approximately 70 percent) performed by the independent facilities, there will be a need for the aftermarket to have access to appropriate information.

Connected cars also can prevent thefts. In its earliest incarnations, theft prevention technology relied on GPS to identify and locate stolen vehicles. More advanced technologies use actuators to slow down vehicles involved in a police chase. Because such systems, priced at around \$250 a year or \$400 to \$1,500 for a one-time installation, can prevent thefts and hold down insurance premiums, many insurers offer premium discounts to customers who install and use the technology. Brazil is already moving to mandate the use of theft prevention telematics in new vehicles.

Policymakers and stakeholders are addressing many of these issues in various forums.



Photo credit Justin Cozart

technological development and refinement by setting similar standards for two of the world's largest motor vehicle markets and enable OEMs and Tier I component manufacturers to scale up their manufacturing and spread their costs over a wider consumer base. Finally, component manufacturers support strengthening the existing systems to adopt harmonized standards worldwide. Such a system would allow for international adoption of ADAS technologies and, by doing so, help lower ADAS costs.

Insurers

Insurers, of course, have much to gain from ADAS technologies, which stand to considerably reduce accident payouts. Insurance companies have correspondingly large roles to play in encouraging adoption of the technologies. The most important move they could make would be to expand driver discounts for ADAS features to make their purchase economically compelling, but they first need empirical proof that

Ahead of the Curve: Regulation of Commercial Vehicles

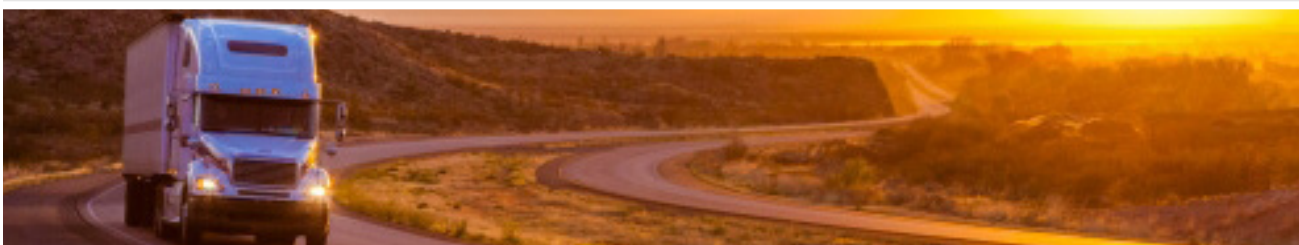
Commercial vehicles represent a large market for ADAS features. Today, ADAS features are available for many types of commercial vehicles, which cover a wide range of weight classes and service applications. The features include forward collision avoidance; adaptive cruise control; blind spot detection; lane departure warning and lane keeping assist; adaptive front lights; and surround-view systems.

European regulators are aggressively promoting ADAS in commercial vehicles, with new regulatory mandates that are more rigorous than the mandate for private vehicles. The EU parliament required electronic stability control, forward collision avoidance, and lane departure warning systems in all new heavy trucks as of November 2013. Technologies facilitating autonomous or semi-autonomous operation of heavy-duty commercial vehicles have been formally introduced in recent months by major players, such as Daimler, Volvo and

Paccar. The early adoption of these technologies will be seen first in truck platooning.

U.S. regulation of commercial vehicles, by contrast, is still behind regulation of light vehicles. For example, ESC was mandated in light vehicles in 2007, to take effect in the 2011 model year. In mid-2012, NHTSA initiated a rulemaking to require ESC on truck tractors and large buses, and finalized the rule in 2015. The compliance date for new, typical three-axle truck tractors is August 1, 2017. All other truck tractors and large buses under the scope of the rule have a longer compliance phase-in period of between three to four years. Congress is considering other legislation that would create incentives for new technologies, particularly for freight carriers who want to expand capacity.

ADAS is a real opportunity to improve commercial vehicle safety. The European Commission estimates that its commercial vehicle ADAS mandates will reduce driving fatalities by 5,000 a year.



ADAS features in fact enhance safety—which is why they need other stakeholders to mandate the collection and analysis of crash data. (For more on this topic, see the sidebar “The Key Role of Telematics” on page 17.) Where proof is available, industry participants have already started providing discounts, such as Allianz insurance, who provides up to a 20 percent discount on insurance premiums for Subaru vehicles equipped with Eyesight technology, a front crash avoidance system.

But their role is not strictly economic. As educators, they can publish articles detailing their research into ADAS features and advertise driver discounts to promote their adoption. Likewise, they can support ADAS research by the Insurance Institute for Highway Safety (IIHS) and its sister organization, the Highway Loss Data Institute (HLDI), and fund academic research into the topic where appropriate.

Rating Agencies and Consumer Publications

As some of the most trusted sources of automotive safety information, market research and rating agencies such as J.D. Power and publications such as Consumer Reports can play important roles in ADAS adoption. Systematizing a rating system for ADAS features and factoring that into overall vehicle ratings would signal recognition of the importance of ADAS features and influence consumer choices. Like Euro NCAP, these bodies could require the inclusion of ADAS technologies and features in any vehicle aspiring to their top safety rating. They could exert further influence by publishing research articles and conducting consumer outreach on the benefits of ADAS features.

The Road Forward

As valuable as ADAS features are in and of themselves, they also serve a vital function as a bridge to autonomous vehicle operation, which will rely on much of the same technology as ADAS. Partially autonomous vehicles will begin to penetrate the automotive market as soon as 2016, and their market uptake will, in turn, encourage the automotive industry and its component manufacturers to speed development of vehicle-to-vehicle (V2V) technology and its allied technology, vehicle-to-infrastructure (V2I) communication, which could form the foundation for partially and fully autonomous vehicles. The two technologies are collectively referred to as V2X. V2X could, for example, enable vehicles to “see around corners”—that is, locate and monitor approaching vehicles—at intersections. It could also be used to warn drivers of road and traffic conditions farther up the road, or monitor traffic lights and other components of the local transportation infrastructure. V2X technology, however, does have limitations as it is a passive warning system, and it will need to be supplemented by active systems with sensor technology. Trials of V2X communication are now underway in the United States, Europe, and the United Kingdom.

A CALL FOR ACTION

A 21st century transportation system and a dramatic leap in vehicle safety is within the grasp of the American public. This system can and will transform how we think of commuting and travel. More importantly, it will have a dramatic impact on motor vehicle fatalities and serious injuries. If the market penetration rate of ADAS increased by just one percent by 2020, the rise would produce an additional approximate \$4 billion in cumulative safety benefits for the five years from 2016 through 2020. To reap the benefits of these transformative technologies, policymakers can take several concrete steps, including:

- ▶ Updating and enhancing U.S. NCAP standards to recognize ADAS technologies.
- ▶ Implementing federal tax incentives and insurance premium discounts to help steer drivers toward choosing safety technologies. Government and industry should collaborate where appropriate to reward drivers for purchasing and using ADAS features.
- ▶ Funding a multi-year highway bill.
- ▶ Conducting a congressional top-down review of the technical elements necessary for full V2V and V2I (V2X) adoption and roadmap implementation.
- ▶ Conducting consumer information programs along the lines of the highly effective “Click It or Ticket” campaign for seatbelt use, which has had a measurable impact on consumer behavior. Stakeholders can collaborate on this effort for maximum impact.
- ▶ Requiring a national safety inspection program to ensure maintenance and proper functioning of new technologies.
- ▶ Linking ADAS features with CAFE credits to open multiple paths for consumer and industry investment.
- ▶ Encouraging regulators to collaborate with their overseas counterparts to produce and implement global technical standards that will reduce crashes, property damage, and fatalities on a global basis. This will allow manufacturers to build scale and thus lower costs.

ADAS features promise to improve safety, enhance driver and passenger comfort, and pave the way to partially and fully autonomous vehicles. At the same time, however, ADAS and autonomous driving raise complex issues related to cyber-security, data privacy, and liability. To keep up with the rapid pace of technological advancement, regulators and legislators must address systemic roadblocks by increasing their collaboration with industry, increasing funding for research, and providing longer-term guidance to stakeholders. The challenge is great for all concerned, but the payoff is even greater. ADAS alone has the potential to save society roughly \$16,000 per car, and fully autonomous cars could generate societal savings of as much as \$53,000 per car sold when they have fully penetrated the market.

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Industry participation:

Several industry participants were interviewed in preparation of this report, including representatives from nine automotive Tier 1 suppliers, three original equipment manufacturers, four government and rating agencies, four insurance companies and non-profit organizations, one automotive aftermarket company, and one technology company. We would like to thank them for their participation.

Endnotes

1. The average age of vehicle in car park is 11.4 years (2014 Polk Data). However, survivability of newer cars is much higher, given higher quality and lower scrappage (IHS, NHTSA).

2. BCG leveraged the data provided in NHTSA's May 2015 study, The Economic and Societal Impact of Motor Vehicle Crashes, 2010; societal cost in 2014 dollars (\$836B in 2010 dollars).

3. Federal Motor Vehicle Safety Standards



The Motor & Equipment Manufacturers Association

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