



HOW AUTOMAKERS ARE **DRIVING INNOVATION**



AUTO ALLIANCE

DRIVING INNOVATION®

THE AUTOMOTIVE INDUSTRY

is a major leader in driving innovation and global technological advancement. Today's automobile represents the most sophisticated technology owned by most consumers, and automakers continuously offer new high-tech content in their products. From the early stages of planning, automakers modernize new vehicles, recognizing that technology provides many solutions to meet consumer needs. Virtually every aspect of today's automobile is now high-tech, using high-tech materials and developed through high-tech processes. As a result, independent observers rank automakers among the world's most innovative companies. Automakers are recognized leaders in R&D investments, both globally and in the U.S. Today, auto companies register many patents each year for their innovative, new vehicle technologies, and employ a highly-skilled workforce to design and build their products.

TODAY'S AUTOMOBILE REPRESENTS THE MOST SOPHISTICATED TECHNOLOGY OWNED BY MOST CONSUMERS.



INNOVATION AND RESEARCH & DEVELOPMENT

AUTOMAKERS DOMINATE LIST OF WORLD'S MOST INNOVATIVE COMPANIES

A recent report by The Boston Consulting Group (BCG), a global management consulting firm operating in 43 countries, found that almost half of the world's top 20 "Most Innovative Companies" are automakers. In fact, for the first time this year's top 20 list included more automobile manufacturers than technology companies. Fourteen automakers are included in BCG's top 50 innovative companies — only four years ago, BCG put eight auto firms on its list. Today, three companies are not only on the list, they're in the top ten, and another company jumped 16 spots to No. 13. One of the world's largest automakers shot up 31 places to 14th overall.

BCG says several factors drive the wave of automaker innovation. Companies are working to increase conventional vehicles' fuel-efficiency, while developing better hybrid and electric models, more efficient power trains and lighter car bodies. At the same time, automakers are building safer vehicles with cutting-edge technologies like self-braking systems and vehicle-to-vehicle communications.

"The increasing acknowledgement of innovation in the auto industry continues a prominent trend from last year."

The Boston Consulting Group,
 "The Most Innovative Companies 2013,"
 www.bcgperspectives.com, 09/13

AUTOMAKERS ARE LEADERS IN R&D SPENDING

To keep pace with ever-growing consumer demands for sophisticated new technologies, recent studies show automakers spend more than \$100 billion annually on research and development (R&D) — including \$18 billion in the U.S. alone. Booz & Co. found auto industry R&D spending climbed \$7.4 billion to \$102 billion in 2013. How large are automaker investments in R&D? For perspective, Booz & Co. reported the entire global aerospace and defense industry spent about \$25.5 billion on R&D — one quarter of what the auto industry spent.

Booz & Co.'s survey of annual global R&D expenditures also found five automakers among the top 20 in corporate R&D spenders. Booz reported one leading automaker spent nearly \$10 billion. Most recently, the European Commission's 2013 EU Industrial R&D Investment Scoreboard ranked another automaker as the world's largest private sector R&D investor, with investments of €9.5 billion.

"Carmakers are rivalling technology companies in the global innovation stakes, ramping up research spending to build greener, smarter and more connected cars."

Henry Foy, "Carmakers Dominate List of Top Business Innovators," **Financial Times**, 9/26/13



AUTOMAKERS ARE LEADING PATENT RECIPIENTS

According to a recent report by the Center for Automotive Research, 3 percent to 5 percent of all patents granted in the U.S. are awarded to the auto industry, a number that has risen to approximately 5,000 new patents per year. Along with companies like General Electric, Google and Hewlett Packard, leading automakers ranked amongst the top recipients of U.S. patents granted in 2012.

"Since 1999, patents awarded to all manufacturing industry sectors have increased in number by only 3 percent. Patents awarded to the auto industry have increased by 10 percent in the same period..."

Center for Automotive Research

AUTOS, COMPUTERS AND ELECTRONICS:

TECHNOLOGIES WORKING TOGETHER

TODAY'S CARS ARE HIGH-TECH DEVICES ON FOUR WHEELS

Today, auto technology on sale allows cars to “see” all around, gathering data on possible roadway concerns and giving drivers eyes in the back of their heads. Since more than 90 percent of crashes involve driver error, automakers created a range of safety systems that aid drivers for brief periods to help avoid accidents. Driver assist systems include lane departure and blind spot warnings, adaptive cruise control, automatic braking, telematics control systems and more.

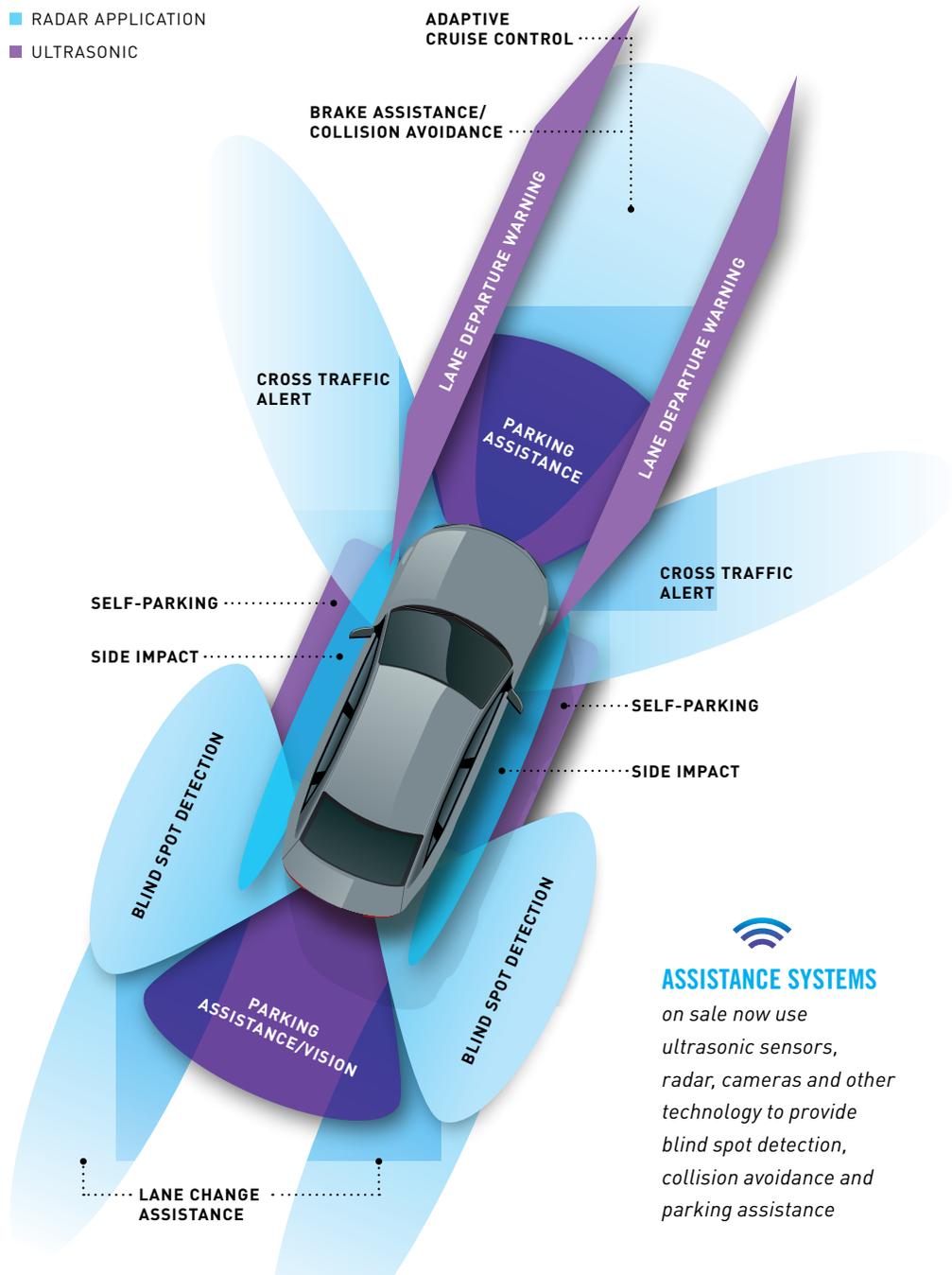
There are three types of driver assists. Warning and alert systems show visual warnings, sound alarms or vibrate the steering wheel (or even seats) to alert the driver to take action. In emergencies, active controls actually manage vehicle systems for fractions of seconds. Driver assist systems may also be vision aides, like cameras or night vision, that help drivers better manage all kinds of situations.

New driver assist systems rely on a range of technologies working together:

- ▶ Ultrasonic sensors use high-frequency sound to measure distances between objects;
- ▶ Radar determines which objects are ahead of a vehicle by sending out and then retrieving radio waves, and comparing the difference between the two;
- ▶ Lidar detects objects by enveloping an area with invisible laser light and analyzing the reflected results. When combined with cameras and other sensors, lidar can create a 3-D view of the environment around a vehicle.

Visit this site to see them in action:

www.YouTube.com/DriverAssists



EXTRA EYES ON THE ROAD... AND A CO-PILOT TOO

“Bristling with sensors and microprocessors, cars... have long been lightening the driver’s workload and improving safety with features like parking assist, lane departure warning, adaptive cruise control and various crash-avoidance technologies.”

Paul Stenquist, “On the Road to Autonomous, a Pause at Extrasensory,” *New York Times*, 10/25/13

CONNECTED CARS

Technological improvements in computers, smartphones, wireless communications and the cloud have converged to advance safety for connected consumers. Connectivity and the internet are changing the world of autos, and more change is coming. The percentage of new passenger cars globally shipping with factory-installed telematics will increase from nearly 10 percent in 2010 to 62 percent in 2016, according to ABI Research.

Looking forward, cars may soon be “talking” to each other and to the roadway. Car-to-car information sharing can alert vehicles miles behind that cars ahead have come to a halt, warning drivers to prepare to slow down. “Smart” intersections will allow stop signs and traffic lights to communicate with vehicles, as sensors report if another vehicle is running a red light. Traffic lights could be synchronized to improve traffic flow — and fuel efficiency — and if there is only one vehicle sitting at a traffic light late at night, the light could be programmed to turn green.

A study by McKinsey Global Institute found that the auto industry will be the second largest data producer by 2015. Much of that data will come from the car itself, through sensors and integrated devices. Additional data will come from connected devices used by a vehicle’s occupants or from third-party sources like traffic reports and weather sites.

“Automakers, not smartphone and tablet manufacturers, stole the spotlight at Mobile World Congress ... with a series of pronouncements about the future of the ‘connected car.’”

Bernhard Warner, “Pricey Apps, Dated Software Might Stop the Drive to the ‘Connected Car,’” Bloomberg Business Week, 2/28/13



AUTOMAKERS BUILDING AUTONOMOUS CARS FOR THE FUTURE

Today’s leading automakers are developing cars that park themselves, brake at the sign of danger and stay in lanes without driver assistance. What once only existed in the imaginations of science fiction writers is now being developed and tested by carmakers in laboratories and on roadways across the globe.

As partially-autonomous functions in vehicles become more common, the leap to achieving fully driverless cars

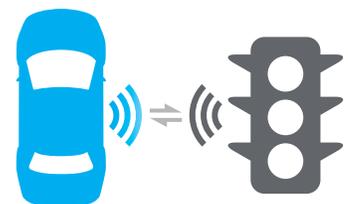
becomes ever smaller. Today’s emerging technology — sensors able to read road signs and traffic signals, while also employing vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems to navigate roadways, traffic and pedestrian hazards — will be available widespread in the future.

Analysts differ on when these autonomous cars will be introduced, but few believe driverless cars in some form are not the wave of the future.

V2V (Vehicle-to-Vehicle)



V2I (Vehicle-to-Infrastructure)



TECHNOLOGICAL ROLE REVERSAL: U.S. MILITARY FOLLOWING AUTOMAKER INNOVATIONS

Not long ago, developments by researchers in the military and space industries found their way into automobiles. But today, prominent scholars are noting a major role reversal: carmakers are leading the way in technological innovations. Though Congress set a goal that a third of the combat fleet be comprised of unmanned vehicles by 2015, *The New York Times* reports the U.S. armed forces is lagging behind today's auto manufacturers.

The newspaper noted automakers leading the military in self-driving technology is ironic "given that today's commercial advances have their roots in research originally sponsored by DARPA, the Defense Advanced Research Projects Agency, the Pentagon's advanced technology organization."

"Peter W. Singer, a Brookings Institution researcher and author of 'Wired for War,' predicts that 'civilian advances will ultimately trickle down to the military, a radical turnaround.'"

John Markoff, "Military Lags in Push for Robotic Ground Vehicles," *The New York Times*, 9/23/13



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THE RISE OF COBOTS

A century after Henry Ford introduced the moving assembly line, carmakers have come a long way, integrating banks of robots, computers and other automation into a high-tech manufacturing process. Today's auto assembly line is "part human and part machine," according to *The Detroit News*.

But "a new generation of smarter, smaller and gentler robots is poised to transform manufacturing again, this time by working alongside their human colleagues."¹ Collaborative robots, or "cobots," now populate factory floors working in tandem with humans to make operations run more smoothly. Cobots are a newer trend, able to assist in a myriad of ways, from moving parts and improving safety to taking on wearisome tasks to improve the health of workers.



"[R]obots work side-by-side with employees — the robots taking on the tedious, back-breaking part of the work, while humans finesse the final assembly."

Meribah Knight, "At Ford's South Side Plant, the Rise of the Machines," *Crain's Chicago Business*, 11/12/13



As consumers demand "connected" cars that sync with smartphones, the importance of computer systems in cars is growing.

CARMAKERS COMPETE WITH SILICON VALLEY FOR TALENTED "CODAHOOLS"

As consumers demand "connected" cars that sync with smartphones, the importance of computer systems in cars is growing. Ernst & Young predicts over the next decade 104 million vehicles around the world will possess "some form of connectivity." *Reuters* reported millions of lines of computer code control important auto operations, from braking to air conditioning. Similar to computers and smartphones, electronic parts like sensors and microprocessors comprise the "backbone" of today's cars.

Automakers are hiring thousands of software programmers — or "codaholics" — who play an even greater role in vehicle design and operation. The impetus to hire "codaholics" is "increasingly pitting Detroit against its technology partners in Silicon Valley," reports *Reuters*. It should not be surprising that the state of California — long considered the nation's high-tech and R&D capital — has the largest number of engineers employed in the U.S. with 62,000. Michigan, however, with a workforce one-quarter the size of the Golden State's, has nearly 60,000 engineers in its labor force.

AUTOMAKERS AND HIGH-TECH MATERIALS

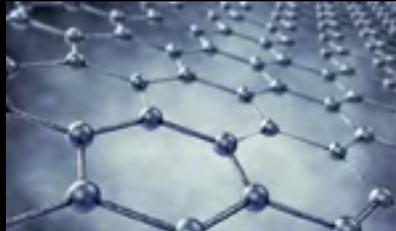
NANOTECHNOLOGY AND NANOMATERIALS

Auto companies are using nanotechnology and nanomaterials to improve the performance of new cars and meet consumer needs along with regulatory requirements. Some car companies have used conductive carbon nanotube composite materials in fuel systems and other auto parts since the late 1990s. Others use nanocomposites in bumpers, making some products 60 percent lighter, but twice as resistant to denting and scratching. Other companies are investigating using nanocellulose, which is light, strong like carbon fiber, but inexpensive to produce using new algae-based manufacturing methods. These technologies will make cars lighter and more fuel efficient.

Examples of the variety of functions of nanomaterial products in the automotive industry:²

- ▶ Tires reinforced with nanoparticles for better abrasion resistance;
- ▶ Car coatings exhibiting greater scratch resistance and improved gloss;
- ▶ Anti-fog coatings for headlights and windshields;
- ▶ Structural plastic parts combining higher mechanical performance with reduced weight.

SAMPLE OF OTHER ADVANCED MATERIALS



Graphene:

Dubbed a “wonder material,” automakers are working to utilize graphene, a form of carbon 200 times stronger than steel, but as thin as an atom. According to The Wall Street Journal, graphene “has ignited a global scientific gold rush, sending companies and universities racing to understand, patent and profit from the skinnier, more glamorous cousin of ordinary pencil lead.”



Aerogel:

First developed by NASA for use in space suits, Aerogel is one of the world’s lightest materials. It’s 99.8 percent air but it is capable of retaining a solid form.

Smartphone Glass:

Some automakers are producing vehicles equipped with chemically hardened glass — or “Gorilla Glass” as it’s called in the smartphone world. The glass is approximately half the weight of conventional laminated glass.

nano•tech•nol•o•gy noun \,na-nō-tek-'nä-lə-jē\

the science of working with atoms and molecules to build devices (such as robots) that are extremely small



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The Alliance of Automobile Manufacturers is a trade association including BMW Group, Chrysler Group LLC, Ford Motor Company, General Motors, Jaguar Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche, Toyota, Volkswagen Group of America and Volvo. Automakers invest billions of dollars in research and development every year.

Find out how Alliance members are making new cars and light trucks safer, more fuel-efficient, and cleaner than ever before at www.autoalliance.org.

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