THE CONNECTED VEHICLE IS THE MODEL T OF OUR GENERATION

A REVOLUTION IN MOBILITY

Since the modern automobile was invented, its basic functionality and shape has remained essentially the same. However, the environment in which vehicles operate, and the data to which they connect in order to improve or enhance the driving experience, are changing dramatically.

The connected car has the power to shake up the auto industry as profoundly as the first Model T. The implications for the connected car revolution – and the outlook for its growth – are strongly positive. IHS Automotive predicts that sales of connected cars will grow by six-fold globally through 2020[1]; by that year, says Gartner, 250 million connected vehicles will be on roadways, "making connected cars a major element of the Internet of Things (IoT)."[2] But if connected cars – equipped with internet connectivity and sensor capabilities that can share information with many sources inside and outside the vehicle – are to become as feature-rich and reliable as forecasted, automakers and OEMs must develop the quality connectors and sensors that make connectivity possible. Especially as information is increasingly exchanged both inside and outside the vehicle. Internally, for example, sensors provide feedback that can control how and when a vehicle takes an action. These actions include everything from braking, steering and throttle control, to warnings and route guidance. Externally, information is sensed and transmitted to help vehicles determine position, speed, fuel level, diagnostics and a wide array of other functions. TE Connectivity (TE) is well-positioned to accelerate success for car makers seeking a leadership role in the connected car market.

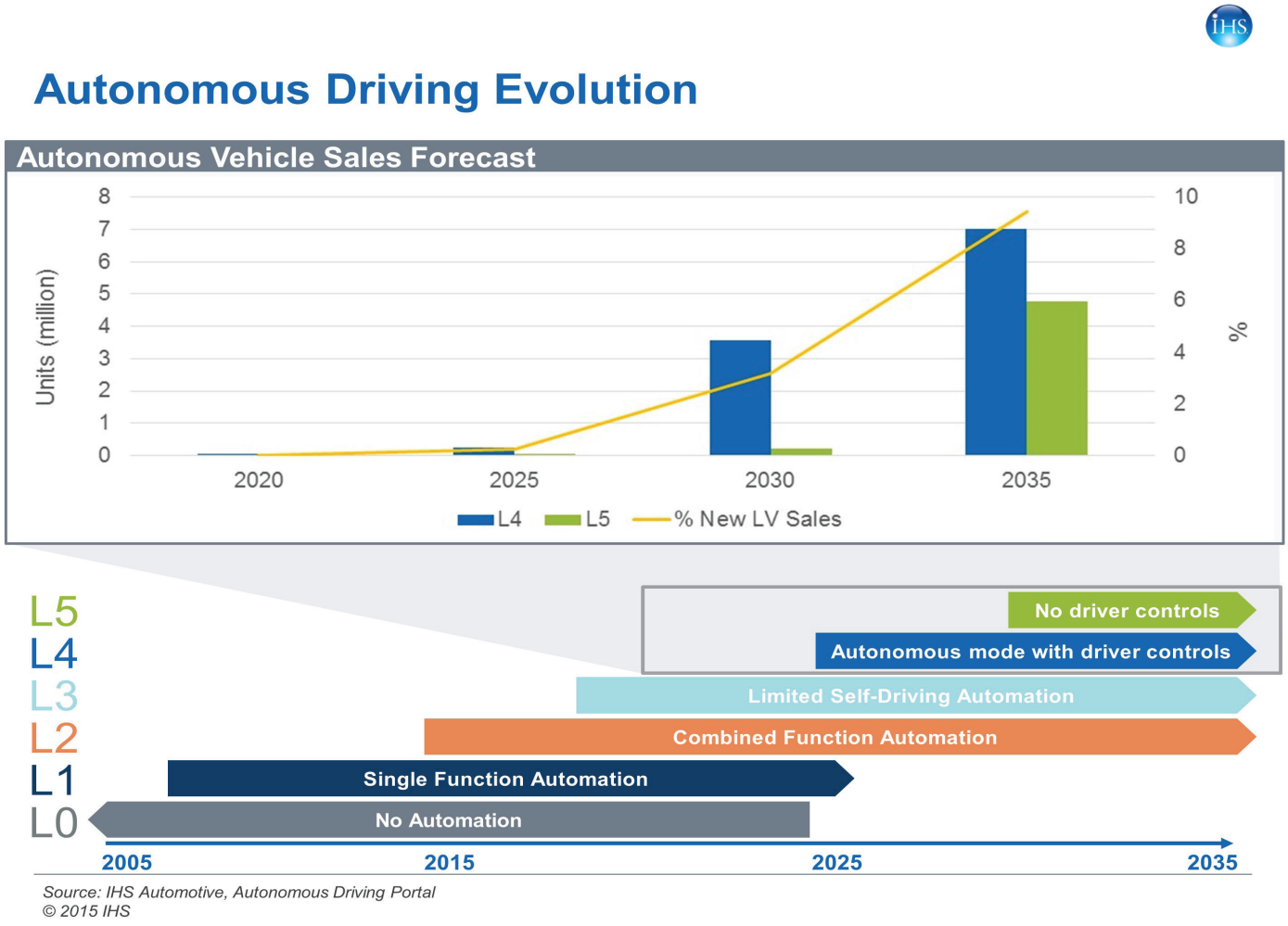
What is driving the connected car trend? Safety, the environment, and lifestyle changes all play a role.

PROPELLING CONNECTIVITY

SAFETY

Cars, while remarkable inventions, can also be dangerous, when driven unsafely. More than 1 million people die every year in automotive accidents globally; car accidents are the most common killer of people ages 10-24.[3] More than 2.3 million people in the U.S. were injured in car crashes in 2013, according to the National Highway Traffic Safety Administration (NHTSA).[4]

Even though cars have become much safer than they were some 50 years ago, their drivers are still a weak link in the safety continuum:, research shows that 90 percent of crashes are caused by human error. U.S. Federal agencies that govern automotive safety are recognizing that smarter vehicles can help reduce traffic fatalities and injuries. The New Car Assessment Program, created globally and aligned with the NHTSA, measures collision safety for car occupants, and is now focusing on advanced driver assistance systems (ADAS) technology as a way to manufacture cars that will help drivers better avoid collisions.



Source: IHS Automotive, Autonomous Driving Portal
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FIVE LEVELS OF AUTOMATION

In 2013, the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) released a policy that includes five levels of automation[5]:

No-Automation (Level 0)

"The driver is in complete and sole control of the primary vehicle controls – brake, steering, throttle, and motive power – at all times."

Function-specific Automation (Level 1)

"Automation at this level involves one or more specific control functions. Examples include electronic stability control or pre-charged brakes, where the vehicle automatically assists with braking to enable the driver to regain control of the vehicle or stop faster than possible by acting alone."

Combined Function Automation (Level 2)

"This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions. An example of combined functions enabling a Level 2 system is adaptive cruise control in combination with lane centering."

Limited Self-driving Automation (Level 3)

"Vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The Google car is an example of limited self-driving automation."

Full Self-driving Automation (Level 4)

"The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles."

ENVIRONMENT

As with safety, automakers, working with government regulators, have made tremendous strides in reducing polluting emissions from cars. The auto industry is currently working to reduce greenhouse gas emissions by 2020, with a focus on vehicle weight, fuel consumption, and improved electrical efficiency. However, inefficient driving habits and traffic congestion are counterproductive to the efforts to make cars more environmentally friendly. Better driving habits can be enabled by data-awareness of both car performance and the environment in which you are driving through. Traffic delays and congestion increase carbon dioxide (CO2) emissions and drive up costs, causing more money to be spent combating pollution. In the European Union, €80 billion euros is spent annually due to congestion.[6]

Car manufacturers are heeding the calls to reduce CO2 emissions. In the EU, by 2021, the fleet average to be achieved by all new cars is 95 grams of CO2 per kilometer.[7] This target is a 40 percent reduction from the fleet average in 2007.[8] A key link between connected cars and greener cars is more efficient routing from point A to point B. When cars are more connected, including to infrastructure, they use less fuel (and pollute less) because there will be less time waiting in traffic (or even non-traffic). For example, technology can aid route optimization to avoid traffic delays and idling.

LIFESTYLE

Consumers who are used to connectivity everywhere they go – at cafes, hotels, home or office – are reluctant to give up this information access when they are on the road and in their cars. As they build greater connectivity into their homes – for example, adding thermostats and kitchen appliances that share data and can be controlled via apps – they not only expect the same convenience and access in their cars, they anticipate their connected homes will also sync with their connected cars. These consumers are comfortable with their mobile devices and rely on them to stay connected and access data, and they look to their cars for the same functionality.

Arguably, more connected cars can help people drive more efficiently and better avoid hazards. For example, access to the Internet brings information to drivers about weather and traffic conditions so they can steer clear of congestion, or choose safer routes in case of weather issues. Car consumers will seek out tools that connect them to more precise information about traffic and routing, carpooling and how many miles they can drive before they reach the next service or charging station.

OEM Criteria

As automakers shift resources toward technology inside the car, they must focus on all of the market drivers above: safety, environmental requirements, and lifestyle expectations. Meeting these requirements requires a far more complex combination of hardware, software, and connectivity and sensor solutions – for example:

- Robust and reliable connectivity and sensor technologies
- Core connectivity – essential, seamless power signal and data
- Reliable performance in harsh environments, such as extreme temperature variations, and vibrations in rugged terrain
- Miniaturization – ever smaller, lighter, and modular components
- Effective, safe, and efficient power management
- Faster data transmission, which consumers have come to expect in their connected homes
- Sensing for improved performance and monitoring

CONNECTED FOR SAFETY

An increasing level of automation means a growing need for more networking of all onboard systems, as well as sensors. Innovators in this field continue to break ground with technologies that support ADAS, such as:

- Headlamps that help drivers better see the road
- Collision avoidance systems that automatically apply the brakes
- A shift in focus from passive safety to active safety, and from warning systems to avoidance systems
- The evolution of parallel parking and chassis control – requiring sensor solutions for fully automated control

As consumers push for the availability of real-time data in their cars, car makers, and technology providers need to guarantee data speeds and availability. For example, vehicles must respond immediately when a signal is transmitted that requires a response. Systems cannot suffer resets or delays – reaction time must be in a fraction of a second. Connected car systems must be capable of transmitting a full gigabyte of information per second under high-vibration conditions if they are to be considered reliable.

To contribute to safety, connected cars must also share supplementary information from WLAN or mobile telecommunication channels between the onboard electronic devices and the infrastructure (V2I) or other vehicles in the vicinity (V2V), which will boost the decision confidence level of the ADAS.

Connected cars can enhance driver and passenger safety even further. For instance, they can feature alerts when children are mistakenly locked inside of an overheated car; they can offer panic alarms in case of accidents or other unsafe situations; or they can include geo-fencing options that send car owners a text if the vehicle travels beyond a set boundary (such as when children drive a parent's car).

CONNECTED FOR GREEN

Regulators and scientists agree: If we are committed to improving air quality, we must improve driving efficiency. This means innovating ways to reduce the time cars are on the road, and also requiring less fuel to operate effectively.

For example, it is estimated that 25 percent of city driving typically involves simply searching for parking spaces. By building parking availability data into navigation systems, drivers can park and turn off cars much faster. In addition, power management technologies and new architectures can also deliver efficiency improvements. All such systems are closed-loop control, and require sensors.

Environmentally friendly driving can also be a result of advanced manufacturing techniques. A vehicle's weight can be reduced by using lighter or less material, thus improving fuel efficiency and therefore reducing C02 emissions. One tactic for using less material in a vehicle is to miniaturize its components. In addition, the use of aluminum and connectivity solutions in vehicles can reduce weight.

As automakers go lighter, they must give extra consideration to areas of the vehicle such as the body, drive systems, chassis, and on-board electrical systems. Higher temperatures and vibrational loads require improved and innovative terminal and connector systems.

CONNECTED FOR LIFESTYLE

To bring car owners the features and functions that optimize driver comfort, improve navigation and guidance, and deliver entertainment, automakers must work with technology vendors to create in-dashboard applications that supply drivers and passengers with cloud-connected information and services. These systems often are referred to as "telematics," and provide two-way communications – to the vehicle and from the vehicle.

These lifestyle and convenience features not only keep car occupants better informed and entertained, they can help boost productivity. When connected cars eventually make the leap to self-driving vehicles, drivers can become more productive, using the time spent in the car for something other than paying attention to traffic conditions. In addition, if improved traffic management technologies reduce time spent in the car, drivers and passengers gain more time for other activities.

Potential Roadblocks

While the technologies and capabilities are in place (and are evolving) to deliver on the connected car in the future, other factors must be addressed in this ecosystem:

- **Security and privacy:** The exchange of data among applications in the vehicle and other systems, such as over Wi-Fi and to connected home systems, raises issues about how this data is protected. OEMs and automakers must include safeguards by making the connected applications and devices less vulnerable to hacking.
- **Internet access:** There is currently a limitation as liability for accessing data across geographies is not clarified and various countries have different regulations. While this may not be an issue for countries like the U.S., Brazil, Japan, Korea or China (as cars are not likely to leave the country), it may be in places like Europe, where there are many countries within a relatively small geographical area.
- **Infrastructure:** Building safer and more fuel-efficient vehicles means little if roadways deteriorate. Traffic management efforts must take roadway investments into account.
- **Autonomous driving buy-in:** To embrace the idea of self-driving cars, consumers need assurance that they are safer than driving the cars themselves. Automakers must demonstrate proof that autonomous vehicles operate with near 100 percent reliability.
- **Economics:** Connected car advances must make good economic sense for car buyers – or connected cars will be seen as a luxury innovation, available to only a select few. Connectivity should be affordable – industry-standard components will further the affordability cause

TE's Role

No matter which technology path OEMs choose to innovate for the connected car, TE can work with them to address their needs. As a leading connectivity and sensors company in the world, TE helps its customers transform their business concepts into smart, leading, and innovative solutions.

TE is a partner in the process of creating connected car systems, engaging with customers earlier in the design process to accelerate innovation as cars evolve. TE products connect almost every electrical function in cars – from alternative power systems to infotainment and sensor technologies. In addition, TE solutions help to meet the evolving challenges and requirements of the auto industry:

- **Data connectivity:** Technologies based on coax, shielded, optical and wireless mediums.
- **Power and data distribution:** High reliability transmission through connecting, switching, protecting and sensing competencies.
- **Sensing:** Data-driven technology to measure position, pressure, speed, temperature, humidity and fluid quality.
- **Weight reduction through miniaturization:** TE Nanos and MCON 0.50 interconnection systems enable a reduced size for electronic components, smaller wires and a reduced total connector package.
- **Weight reduction through shift from copper to aluminum:** When applied to a typical family-size car, the shift to aluminum conductors and TE's LITEALUM crimp can save up to two or three kilograms of weight. This efficiency reduces the weight of the car and is achieved at lower material cost.
- **Reliability and experience:** For many decades TE has supported global OEMs with their electrical architectural needs to enable cars to be safer and smarter – all while adapting to increased technical requirements.

All of these competencies and capabilities are designed to perform in a harsh environment, including vibrations and temperature changes over the lifetime of the vehicle.

A Greater Sense – Data in the Car

To transport passengers safely and efficiently, vehicles need data. Today's cars can sense and respond to changing conditions, inside and out. TE sensors help provide the data for control, adaptation, and response of vehicle functions that increase safety, comfort, and efficiency. Our sensors are designed and manufactured to exacting specifications, often customized for our customers. Together with our customers, we are working to solve today's biggest application challenges in new and creative ways.

TE offers a wide range of sensors for automotive applications, including those that measure everything from position, speed, and humidity (in-cabin, engine air intake) to pressure (brake HPS, urea) and temperature. For example, TE offers a range of humidity sensors designed to improve performance, reduce energy consumption, and increase safety in environments where temperature affects performance. Our fluid property sensors bring real-time fluid monitoring to engines, fuel systems, selective catalytic reduction (SCR) systems, compressors, transmissions, gear boxes, Diesel Emission Fluid or DEF (urea) monitoring and many other applications. The high-performance urea quality sensor is also a urea concentration sensor (DEF sensor), used as an integral part of NOx emission control and compliance strategy.

The Power of TE

TE is skilled at adapting technologies from other industries for products needed by the automotive industry. For example, as consumers request Bluetooth and WIFI connectivity in their cars, TE leverages its Communications business. If car makers run into tough sealing problems, the company leverages its SubCom team/business for solutions due to unsurpassed experience and knowledge in the design, manufacture, and installation of reliable networks in one of the harshest environments on the planet.

TE is a connectivity and sensor company that serves many industries. It is likely that a new issue in one industry has already been addressed in another industry. By leveraging "the Power of TE," we bring experience and solutions from a multitude of industries to our automotive customers, which is a key advantage for our customers. This intra-collaboration further speeds our solutions and drives even greater innovation and value for our customers.

TE is also investing in the future of connected car technologies by devoting R&D to the fundamentals of core connectivity, such as:

- More power: high-voltage connections with anti-arcing and emergency shutoff features
- Relays and circuit protection
- New architectures to handle extra features, gadgets, and power demands
- Bigger and faster data pipes to flawlessly handle exponential growing amounts of data inside and outside the vehicle
- Optical data pipes (fiber optics)
- Conductive data pipes (Ethernet)
- Wireless data pipes (antennas for Wi-Fi, Bluetooth, 4G/LTE, dedicated short range communications)
- More information from sensors to meet increasing demands for closed loop control

COMMITTED TO INNOVATION

TE is committed to offering connectivity and sensor solutions that allow OEMs to bring innovation to the connected car universe – products that are smaller and lighter and offering high reliability performance in ever-increasingly harsh environments. TE relies on advanced materials, contact physics, miniaturization, and new power and data architectures to help OEMs achieve their desired connected car solutions.

To learn more about TE automotive solutions, visit:
www.te.com/automotive

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