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**U.S. V2X Mandate Hung Up**

*Spectrum Sharing and Other Issues Mount Up*

The Hansen Report on Automotive Electronics, July/August 2016

The U.S. Federal Communications Commission (FCC) set aside 75 MHz of spectrum in the 5.9 GHz band in 1999—17 years ago—for improving road safety and efficiency through a variety of Dedicated Short Range Communications (DSRC) applications. Over the years, the U.S. Department of Transportation (DOT), state DOTs, and scores of companies have spent hundreds of millions of dollars establishing standards, researching and developing vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2X) technology, and defining and testing use cases. The DOT’s long promised Notice of Proposed Rule Making is now under review by the Office of Management and Budget, part of the Executive Branch.

But in June 2016, the DOT’s plans were set back when the FCC agreed to respond to requests from a broad cross section of Wi-Fi and Internet interests to consider ways that the spectrum set aside for V2X could be shared with unlicensed Wi-Fi equipment. The FCC plans to complete testing by January 15, 2017. As a result, the promised U.S. V2V mandate will likely be further delayed. Phased-in deployment on new vehicles won’t begin until 2019 or 2020, and won’t reach 100% of new vehicles until 2022-23 at the earliest.

With so much time passing from V2X’s conception until now, the DOT’s case for a mandate has thinned considerably. It is reasonable to question if a U.S. mandate will ever come. The arguments against V2X as it is presently conceived have been stacking up.

◆ **Carmakers are not adopting V2V.**

Before the U.S. DOT mandated safety systems such as airbags and electronic stability control, carmakers had already made those features available in a wide variety of models in response to market demand. There has been no such demand for V2V. General Motors plans to make V2V standard equipment on the 2017 Cadillac CTS and hoped that by now other carmakers would have announced their own DSRC-based V2X deployment plans. That has not happened. By year end 2017, roughly 40,000 V2V-equipped CTS vehicles will populate the U.S. fleet of about 270 million vehicles. The chances that one V2V vehicle will find another to talk to will be just one in 46 million, better than winning the Powerball lottery, but definitely not good.
Mercedes plans to install V2X communications in the redesigned 2017 E-Class, launched in Europe last spring and in the U.S. in June. The feature, called Car-to-X by Mercedes, will be available in the U.S. by the end of 2016. But tellingly, that feature will rely on the driver’s cell phone, not on DSRC.

**Newer technology threatens DSRC and its 802.11p protocol with obsolescence.**
Some of the safety use cases targeted for V2V are already being implemented using onboard sensors. Automatic emergency braking is immediately saving lives.

New cellular technology that competes directly with DSRC is coming soon. Cellular connectivity is already destined for ubiquity; all but the least expensive new vehicles will have it. By 2019 or 2020, or soon thereafter, V2V communications features can be part of the 4G cellular offering. Unlike DSRC, which doesn’t have a good business case and must therefore be mandated, the business case for cellular is already strong.

The 3rd Generation Partnership Project (3GPP), which unites seven telecommunications standards development organizations, will make V2X part of Release 14 of the global 3GPP standard. V2X will operate both within and outside of network coverage. That V2X part of the Release 14 standard is scheduled for completion by the end of 2016, according to Qualcomm.

There are at least two versions of V2V cellular communications being considered. Qualcomm is pushing Cellular V2X (C-V2X) and Huawei is pushing LTE-V2X. Compared with DSRC (802.11p), C-V2X offers greater range—more than 450 meters vs. 225 meters provided by DSRC. Qualcomm, Huawei and LG Electronics have made contributions to 3GPP Release 14.

Europe and especially China are leaning in the direction of a V2X solution based on cellular technology. Without the DSRC legacy, China can work from a clean slate. “My bet would be that the Chinese will push forward with LTE-V,” said Russ Shields, chairman of Ygomi LLC. LTE-V is a variant of fourth-generation LTE designed specifically to meet automotive requirements.

“They will soon do a side-by-side comparison of LTE-V and 802.11p. They will show that LTE-V is superior. They will push that out throughout
China as a requirement as early as 2020, certainly by 2021. The Europeans maybe will latch onto the same thing,” Mr. Shields predicted. The Chinese test will be part of the National Intelligent Connected Vehicle Pilot in Shanghai. It is expected that the Chinese will quickly apply V2X to automated driving.

◆ Even with a mandate it will be many years before the safety promises of V2V are realized.
This is the most obvious problem with V2V. “It will take a long time before any real value is derived,” said Alain Kornhauser, professor of Operations Research and Financial Engineering and faculty chair for Princeton University’s Autonomous Vehicle Engineering department. “Not until V2V equipped vehicles account for 70% of miles driven will the chances that two vehicles will be able to communicate be equivalent to a coin flip. Seventy percent times seventy percent equals forty-nine percent.”

For comparison, electronic stability control was introduced in 1995 and required on all U.S. light vehicles beginning in 2011, providing safety benefits from the beginning. According to the Highway Loss Data Institute, ESC won’t get to 70% penetration of the U.S. vehicle fleet until 2019, eight years after it was mandated.

◆ Cybersecurity issues with DSRC are as yet unsolved.
That is the view of two public interest groups who filed a petition with the FCC in June seeking a stay to keep automakers from introducing cars with V2V features. The petition filed by Public Knowledge and the New America Foundation’s Open Technology Group asks the FCC to first create formal cybersecurity standards for V2V before any vehicles are allowed on the road.

Two U.S. senators, Edward Markey and Richard Blumenthal, also recently requested that the FCC consider tighter security standards for DSRC, and that it be restricted to safety applications only.

◆ Warnings won’t be nearly as effective as autonomous solutions.
In its Advanced Notice of Proposed Rulemaking, NHTSA suggested that left-turn assist warnings and intersection movement-assist warnings could prevent up to 592,000 crashes and save 1,083 lives each year. “OMB [Office of Management and Budget] has questioned very strongly their claimed benefits for warnings,” said Mr. Shields.
How the warnings are implemented will be left up to each carmaker. In the Safety Pilot Model Deployment conducted from 2012 to 2014, flashing lights, sounds and seat vibrations were used to alert drivers to potential hazards.

Relying on warnings is difficult. Professor Kornhauser: “How can you possibly convey mission critical information to unaware drivers and get them to immediately react appropriately? The focus should be on automated driving features, not warnings.”

The *Wall Street Journal* in July reported that the Highway Loss Data Institute recently found no reduction in insurance claim rates for cars equipped with lane-departure warning. The reason: drivers find the frequent warning beeps so annoying that they disable the feature.
Cognitive Computing Is Next, Says IBM

Cognitive Computing Is Next, Says IBM

The auto industry has barely begun to benefit from its embrace of artificial intelligence, including deep learning, and now comes cognitive computing. IBM, which has spent much of the last year promoting cognitive computing, has been boldly asserting that it is “frustrated by slow development,” of AI, and that the future now belongs to “cognitive, not artificial, intelligence.”

Katherine Noyes’s helpful article for PCWorld last March, “5 Things You Need to Know About AI Buzzwords…,” defines artificial intelligence as encompassing machine learning, computer vision, natural language processing and robotics.

Cognitive computing, according to an IBM white paper by John E. Kelly III, senior vice president, IBM Research and Solutions Portfolio, is all this and more: “Cognitive computing refers to systems that learn at scale, reason with purpose and interact with humans naturally.” Further, the “underlying computing platform … must encompass machine learning, reasoning, natural language processing, speech and vision, human-computer interaction, dialog and narrative generation and more.” The next step in computing represents, “not just new technology, but the dawn of a new era of technology, business and society: the Cognitive Era.”

IBM began offering cognitive computing solutions to the auto industry a few years ago based on the cloud-based Watson technology platform. Watson’s question and answer technology was made famous in 2008, when it appeared on the television game show Jeopardy, beating the show’s greatest champions. IBM now refers to Watson as the first cognitive computing system.

IBM has been talking to carmakers around the world about its cognitive computing solutions and the Watson technology platform. “We’re finding four areas of greatest interest,” said Randy Cox, who manages IBM’s consulting and services business with Ford, globally. “The first is around early warning detection of quality and safety issues with vehicles in the field.” Watson is able to ingest great amounts of data and find patterns. For example, NHTSA uses Watson to read through its complaints files to find defect trends. Some have suggested that NHTSA is now able to uncover safety issues before the carmakers can.
The second area of carmakers’ interest that Mr. Cox identified is the contact center, where Watson can assist call center agents. “We’ve worked with some carmakers in the early stages to deploy Watson to help [human] agents understand the questions they are being asked and provide the right answer,” he said.

“Number three,” said Mr. Cox, “is the service technician enabler. We’ve had discussions with clients in that area.”

The fourth area of interest to IBM customers is what the company calls the cognitive or intelligent car, one capable of natural language dialog, concierge services, diagnostics, route guidance, interacting with goods and services providers and many other functions that can improve the customer experience.

Cognitive computing promises much. IBM has seen it “turn big data from obstacle to opportunity, help physicians make early diagnoses for childhood disease and suggest creative solutions for building smarter cites.” But IBM is not yet actively pursuing the auto industry’s toughest computing challenge: autonomous driving.

**Nvidia Promotes AI**

In contrast to IBM, Nvidia is laser focused on artificial intelligence and on autonomous and piloted driving. “AI is our key differentiator,” said Danny Shapiro, director of automotive marketing for Nvidia. “Autonomous driving is the most compute intensive automotive application. Being able to take all the sensor data coming into the car, understand all the dynamic and static objects and then be able to pilot the car forward in a safe path—if we can do that we can pretty much do anything else.” In autos, Nvidia’s software platform, GPUs, computing modules, tools, libraries and deep learning expertise are also being applied to natural language processing, facial detection and mood recognition, as well as clusters and infotainment systems.

GPUs have proven essential to deep learning; they are more powerful and more energy efficient than other processors. “Watson is now powered by Nvidia GPUs,” noted Mr. Shapiro. Nvidia processors are also used by Google, Facebook, Baidu, Amazon, Netflix and Microsoft Azure.

According to Mr. Shapiro, numerous companies have shifted to deep learning because of the speed with which they can train their networks. “In automotive, Audi spent just four hours training a neural network on a database of German street signs. They weren’t programming, they were training. They achieved a better level of perception than two years of development for a smart camera-based system for street-sign detection. The way deep learning and neural networks work, essentially the data writes the code.”
Where only one or two automotive companies and NHTSA are currently employing IBM’s cognitive computing technology, Nvidia is engaged with more than 80 automotive companies. “Nvidia began as a gaming company, but the new growth area is artificial intelligence and automotive,” said Mr. Shapiro. In the past 12 months Nvidia’s stock price has nearly tripled. ◆
The Company Profile:
Bosch Mobility Solutions

The Hansen Report on Automotive Electronics, July/August 2016

**Thumbnail Sketch**
Robert Bosch GmbH
www.bosch.com

**Headquarters:** Stuttgart, Germany
2015 Sales: €70,607 million
R&D: 9.1% of sales
Capital Expenditures: 5.7%
Interest Expense: 0.4%
EBIT Margin: 6.5%
Net Margin: 4.5%
Cash Flow from Operations: €5,959 million
Working Capital: €12,357 million
Non-Current Liabilities: €24,964 million
Total Equity: €34,424 million
Employees: 374,778; 55,877 of whom work in R&D
Sales per Employee: €188,267
Ownership: Robert Bosch Stiftung, a charitable foundation, holds 92%; the Bosch family, 7.4%

**Mobility Solutions**
2015 Sales: €41,657 million
EBIT Margin: 7.7%
Employees: 217,009
Sales per Employee: €191,960
R&D Personnel: About 20,000; one-third are software engineers
Products: Broad portfolio of automotive products including gasoline systems, diesel systems, chassis system controls, electric drives, starter motors and generators, car multimedia, automotive electronics, automotive steering systems, services, aftermarket products

*As of December 31, 2015
Background
Robert Bosch founded the company that bears his name in Stuttgart, in 1886. Today the Bosch Group comprises Robert Bosch GmbH and its 442 subsidiaries and regional companies in some 60 countries. Robert Bosch Industrietreuhand, an industrial trust, performs the entrepreneurial ownership functions and holds 93% of the voting rights. The founder’s family transferred most of its shares in the business to a charitable foundation, Robert Bosch Stiftung GmbH, which currently holds 92% of the share capital. Robert Bosch Stiftung supports projects in healthcare, science, education and international relations.

According to the company, its unique ownership structure guarantees entrepreneurial freedom, making it possible to make long-range plans and forward-looking investments without having to also concentrate on short-term results.

Bosch aims for 8% sales growth annually, a rate it has managed to maintain since 2011. Three percent of the growth is expected to come from acquisitions. Bosch Group has a goal to achieve EBIT margins of 7%.

In the fall of 2015, Bosch opened a new research facility in Renningen, Germany, near Stuttgart. With an investment of €310 million, the center conducts research work in electrical engineering, mechanical engineering, computer science, analytics, chemistry, physics, biology, and microsystems technology, not only for automotive but for all Bosch divisions.

Bosch Group’s strategic objective is to deliver innovations for a connected life. Its goal since 2011 has been to become one of the world’s leading IoT companies. More than 40% of Bosch’s electronic product classes include web-enabled offerings, a percentage that’s increasing. Three out of four smartphones worldwide contain Bosch sensors.

Bosch changed the name of its automotive sector at the beginning of 2015, from Automotive Technology to Mobility Solutions, to emphasize the growing breadth of its market and product portfolio that embraces new customers and supplements its hardware business with an emphasis on services. The sector is focused not only on the
car but also on multimodality solutions. In big cities the car will link up with new service providers from outside the auto industry.

**Mobility Solutions**

Few companies in the world cover the gamut of vehicle technology as capably as Bosch. Bosch is a world-class player in nearly every vehicle domain, from powertrain and chassis systems, to car multimedia, to microelectronics including semiconductors, sensors and microelectromechanical systems (MEMS), as well as embedded software and cybersecurity.

Mobility Solutions serves every major carmaker in the world as well as some prominent new entrants including Google and Tesla. The Mobility Solutions sector offers hardware and software not only for automobiles but also for off-highway applications, two-wheelers, shipping, rail transportation and more. In 2015 Bosch set up two new operating units within the Mobility Solutions sector, one for two-wheelers and the other for commercial and off-road vehicles.

Bosch’s automotive product development strategy is mainly focused on advancing its capabilities in three fields: energy efficiency and electrification, automation, and connectivity. Bosch’s automotive R&D investments are focused on sensor technology, automation, driver assistance systems, battery technology and improved automotive powertrain systems.

Among Bosch’s major products, its fastest growing in 2015 were ESP (electronic stability program), where unit sales increased by 25%; gasoline direct injection systems were up 15%; and diesel injection systems grew by 10%. Market development is focused on emerging markets.

**Driver Assistance Systems Leading to Automated Driving**

Bosch’s main motivation for focusing a high proportion of R&D investments on ADAS and automated driving is safety. “Ninety percent of all accidents are caused by humans,” noted Dirk Hoheisel, member of the board of management for Robert Bosch GmbH. “Another motivation is energy efficiency. Driver assistance systems can save a lot of fuel.”
Already a major product category, Bosch expects its sales of driver assistance systems, not including ABS and ESP, to surpass one billion euros in 2016. Sensors account for most driver assistance sales today. In 2016 unit sales of radar sensors are up 60%; unit sales of video sensors are up 80%. Bosch supplies radar sensors to Tesla for use in Autopilot. Bosch produces 76-77 GHz radar sensors; it is not in the 24 GHz radar sensor business.

Approximately 2,500 Bosch engineers are already engaged in ADAS and autonomous driving R&D projects at Bosch, a number that will increase to 3,000 in the next couple of years. Among the research topics Bosch engineers are working on are fifth-generation radar sensors, and mono and stereo cameras.

Bosch supplies monocular cameras to Volkswagen Group for its MQB platform vehicles, which include 12 Volkswagen, Seat and Audi models. Used in concert with a Bosch radar sensor, the Volkswagen application provides lane keeping, headlight control, road-sign recognition, and obstacle and pedestrian detection based on image processing and sensor fusion technology from Bosch.

Bosch also supplies stereo cameras to Jaguar Land Rover. Bosch’s stereo camera is the world’s smallest, according to the company. The distance between the optical axes on its two lenses is just 12 centimeters. “It is a very robust, single-sensor principle that is more than adequate for pedestrian detection and automatic emergency braking,” said Dr. Hoheisel.

In camera image processing Bosch is playing catch-up with Mobileye, presently the dominant supplier with roughly 80% of the market for image processing software, software that’s embodied in an SoC designed by Mobileye and manufactured by STMicroelectronics. Bosch has lately been investing heavily in image processing technology. “The decision to invest a lot of money in video technology was made because not only is it important to our automotive business, but we also need it for our robots and our industrial and security cameras,” explained Dr. Hoheisel. Bosch is also funding third-party development of semiconductor processors that will be applied to some camera use cases.

Bosch anticipates that its present development path will lead to image processing technology more capable than Mobileye’s, within this decade. Mobileye has had the advantage of a database collected from millions of miles of driving test vehicles equipped with Mobileye image processing technology. The data are used to optimize and train Mobileye’s algorithms. It’s a huge entry barrier to competitors. But Bosch is taking a different development approach, one that may well dent Mobileye’s advantage. To augment validation testing on real roads, Bosch is working on an approach that will rely more heavily on simulation and deep learning.
Automated driving will evolve gradually, in a succession of steps. By 2018, Bosch expects to achieve fully automated parking. It will be enough to drop off the car outside the parking garage. From there, the car will receive information about a vacant space from the garage’s infrastructure and find its way on its own, according to Bosch literature. By 2020, the Bosch highway pilot will be ready for production. Highway pilot can take over complete control of the car on stretches of freeway. The feature will rely on just two sensor types, cameras and radar, and will take drivers from exit to exit, hands free. Bosch has been testing highly automated vehicles since early 2013.

In 2015 Bosch and TomTom agreed to collaborate in developing the highly accurate maps required for autonomous driving. TomTom designed the maps and Bosch performed road testing in California, Germany and Japan. The maps will be kept up to date using feedback from vehicles in the fleet that can report recent changes in road conditions, lane configurations, speed limits and other data. Bosch does not have exclusive access to the TomTom maps.

Automated Driving Timetable

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<tr>
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<td>Evasive steering support</td>
<td>Since 2015</td>
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<td>Remote park assist</td>
<td>Since 2015</td>
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<td>Automated valet parking</td>
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<td>Since 2015</td>
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<td>Integrated cruise assist</td>
<td>2017</td>
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<td>Highway assist</td>
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<tr>
<td>Traffic jam pilot</td>
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<td>Highway pilot</td>
<td>2020</td>
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<tr>
<td>Auto pilot</td>
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Connectivity

Bosch’s strategic embrace of the connectivity megatrend will be widely felt throughout the company. Not only does connectivity underpin Bosch’s two other key strategic initiatives—powertrain electrification and automated driving—it will amplify demand for Bosch’s hardware and software, and support Bosch’s drive to significantly grow its service businesses.

At the company’s annual press conference in April 2016, chairman of the Bosch board of management, Volkmar Denner, said, “We are increasingly using connected services to build on our broad basis in the hardware business. … Every sale of hardware should be followed by the sale of complementary services. Bosch’s broad business portfolio offers a particular advantage, as does its competence in software and sensors.”
Bosch is not at all new to connectivity technology. “Connectivity is not necessarily wireless; you have to know how to make things talk to each other,” noted Thomas Kropf, head of the corporate department for automotive integration. “We invented CAN [the ubiquitous, wired, onboard communications technology]. Communications is a core competency.”

The connectivity trend is moving swiftly. “By 2020 nearly every new car produced will have the ability to connect to the Internet,” according to Dr. Kropf. “In Europe, by 2018 carmakers will have to install eCall technology in 100% of the new cars produced. Carmakers will find ways to monetize that requirement. Elsewhere, every car that has embedded navigation will have to be connected. No one will pay for embedded navigation unless it provides updates and traffic services at least equal to what is provided on Apple and Android smartphones. In other regions and especially in the lower priced car segments, connectivity will come by way of the smartphone.

Bosch will experience increased demand for each of the three types of embedded connectivity hardware it produces: CCUs (connectivity control units), connected gateways and head units. The CCU receives and transmits information using a wireless module with its own SIM card. Bosch makes CCUs for passenger cars, two-wheelers and commercial vehicles. Like the CCU, the connected gateway provides access to the Internet along with the addition of traffic management of the onboard networks: Ethernet and multiple CAN and FlexRay networks.”

Other products that will benefit from connectivity will be driver assistance ECUs, multimedia and navigation. “Our vision is to have every ECU in the car connected to the Internet, if not directly then through a gateway,” suggested Dr. Kropf. “Connectivity will add value to every vehicle domain.”

Services
As more and more cars are connected, the market for cloud-supported services is expected to dramatically grow. Just how big will the service market be? Bosch can’t yet say. “There are multiple reports out that offer a huge variety of service revenue numbers,” said Dr. Kropf. “Nobody at the moment really knows.”

While Bosch is still developing service business models, it is already launching some new services. Searching for a parking place in German cities takes an average of ten minutes and accounts for 30% of inner-city traffic. Bosch intends to offer parking services that will reduce some of this traffic. By the end of 2016 Bosch will go into production with its active parking lot management system that helps parking garage operators utilize their capacity better. To determine parking
availability, web-connected micromechanical sensors are installed in the pavement. The result is a real-time parking map.

Some years from now Bosch will offer community-based parking systems that take advantage of the ADAS sensors aboard many vehicles to identify parking spaces on the street as those vehicles drive by. According to Bosch, it can create real-time parking maps using data from just 6% of the vehicles that comprise a city’s traffic.

Just this month, Bosch launched an electric scooter sharing service in Berlin as a wholly owned Bosch subsidiary. The service, which is named Coup, offers 200 scooters that can be located, reserved and paid for with a smartphone app.

In another service, Bosch says it has been lowering operating costs of fleets by supplying a connectivity control unit that automatically transmits driving and service data to a Bosch server for evaluation.

By the end of 2016, Bosch will offer a cloud-based wrong-way-driver alert system that warns drivers when vehicles are detected driving the wrong way on expressways. The software module can be inexpensively integrated into existing infotainment systems or apps.

Integral to its services business, Bosch has been building its own backend. By the end of 2016 roughly 50 Bosch applications will be running on the Bosch IoT cloud. The IoT cloud will be offered to third-party customers starting in 2017. “We won’t be relying on cloud infrastructure from outside the company,” said Dr. Kropf. “That was a deliberate decision. Our customers want their data handled by entities that are completely trustworthy. The Bosch brand provides that assurance.” The Bosch IoT Suite is the cloud’s software platform.

**Bosch Services Categories**

- Diagnostics and fleet management
- Field data validation, a.k.a. connected development
- Safe and secure concierge services, e.g. eCall
- Infotainment and navigation, e.g. multimodal navigation
- E-mobility, e.g. locating charging stations
- Intelligent parking
- Driver assistance and highly automated driving

**Powertrain Electrification**

By 2025, 15% of new vehicles will come equipped with an electric powertrain in addition to a combustion engine, according to Bosch. The electrification trend is good news for power electronics and battery manufacturers, but in the long term, bad news for makers of gasoline and diesel engine components, a market where Bosch has been dominant. Over the coming decades, as IC engines are downsized and electric vehicles take an increasingly larger share of the market, demand for internal combustion engine components will decline in favor of components that
support electrification of the powertrain. That is why Bosch has been and will continue to make major investments in powertrain electrification, to maintain its dominance in powertrain parts.

Bosch offers a portfolio of electrified powertrain systems including traction motors, power electronics and batteries. Thirty production models feature electrification technology from Bosch. Each year the company invests nearly €400 million into the development and production of components needed for the electrification of the powertrain.

Bosch has not yet made an impact on the market for batteries. And in 2015, Bosch announced it was looking for a buyer for its starter motors and generators business, a business with more than one billion euros in sales and 6,500 employees. The sale could be completed later this year. Bosch will retain its production of traction motors for electric vehicles. EM-motive GmbH, in Hildesheim, Germany, is Bosch’s 50-50 joint venture with Daimler, established in 2011 to make traction motors for hybrid and electric vehicles.

According to Dr. Hoheisel, batteries account for 80% of the cost of building an electric vehicle and 60% of the weight. So any major advance in the state of the art of battery technology is sure to have a major impact on the market. One of Bosch’s most important acquisitions of 2015 was the U.S. battery technology startup Seeo Inc., based in Hayward, California. Bosch now has pioneering know-how in the area of solid-state cells for lithium batteries.

According to Bosch, Seeo’s technology has the potential to more than double energy density by 2020—and thus double the driving range—and at the same time reduce costs by more than 50%. Solid-state batteries are less dangerous than today’s batteries based on liquid electrolytes, which are flammable. Bosch anticipates that it will start production of solid-state batteries in 2020.

Bosch has a joint venture with GS Yuasa and Mitsubishi to make lithium-ion batteries. Established in 2014, Lithium Energy and Power GmbH & Co. KG’s mission is to develop more powerful lithium-ion batteries. Technology acquired with Seeo Inc. complements the work being done by the joint venture. GS Yuasa provides the battery cells.

**Robert Bosch Automotive Steering**

In January 2015, Bosch acquired 100% of ZF Lenksysteme, a joint venture it formed with ZF in 1999. With the business now fully consolidated and integrated into the Mobility Solutions sector, the Bosch Group strengthened its position in the field of electric steering, a key technology for automated driving, increased fuel efficiency and electric cars. ZF divested its share of the joint venture prior to its acquisition of TRW Automotive, which also makes steering systems. Electric
steering systems accounted for roughly 60% of ZF Lenksysteme’s sales at the time of the acquisition.

**Joint Ventures**

**KB Wiper Systems Co., Ltd.**, Daegu, Korea, is a 50-50 Bosch joint venture with KCW (Kyung Chang Wiper), which started operations in 2015. KB Wiper supplies complete wiper systems to Hyundai Kia and other OEMs as well as the aftermarket.

**Distinctions Claimed by Bosch**
◆ The world’s largest automotive parts supplier*
◆ First to market with diesel injection
◆ First to market with gasoline injection
◆ First to market with volume produced ABS
◆ Global market leader in MEMS (microelectromechanical) sensors
◆ Global market leader in radar sensors
◆ Invented ESP, electronics stability program
◆ Produces the world’s smallest stereo video camera for automotive applications
◆ Invented the CAN (controller area network) in-vehicle communications protocol
◆ The European market leader of electric-bike systems

*Converted to dollars at today’s exchange rate, in 2015 Bosch produced $46.3 billion in sales. In its fiscal year ending March 31, 2016, Denso produced $42.8 billion in sales. The ZF Group delivered $32.4 billion in sales in 2015, which included just 7½ months of sales from the acquired company TRW. Continental Automotive Group’s 2015 sales were $26.2 billion.

**Bosch’s Major Product Areas**
Gasoline Systems
Diesel Systems
Chassis Systems Controls
Electric Drives
Starter Motors and Generators*
Car Multimedia
Automotive Electronics
Automotive Aftermarket
Automotive Steering
*This business is for sale
GM Advances Cybersecurity Cooperation

In her thirteen-minute opening address to the surprisingly large gathering at the Billington Global Automotive Cybersecurity Summit last month in Detroit, Mary Barra, chairman and CEO of General Motors, mentioned the importance either of “collaboration” or “working together” thirteen times. “At GM, we view cybersecurity, not as an area of competitive advantage ... A cyber incident is not a problem just for the automaker involved. It is a problem for every automaker around the world. It is a matter of public safety,” she said.

Exerting strong leadership, GM has very publically taken the lead in addressing the cybersecurity issue. GM was the main force behind Billington CyberSecurity’s initial automotive summit. Not only did Mary Barra open and close the meeting, but two of GM’s top executives took part as panelists: Mark Reuss, executive vice president for global product development, purchasing and supply chain, and Jeffrey Massimilla, chief product cybersecurity officer. Other top-flight speakers included Anthony Foxx, secretary of the U.S. Department of Transportation; David Johnson, associate executive assistant director for the Criminal, Cyber, Response and Services Branch of the FBI; John Carlin, assistant attorney general for national security, U.S. Department of Justice; and Mark Rosekind, NHTSA administrator.

This powerful group of speakers assembled for good reason. They are especially concerned about safety. “More than 34,000 lives are lost each year on the nation’s highways,” said Dr. Rosekind. “Ninety-four percent of accidents are due to mistakes by humans.” That is why the automotive industry and regulators are so intent on creating vehicles that are increasingly autonomous. Computers are widely expected to drive more safely than humans. Those efforts underway to make driving safer will come to a screeching halt if hackers are able to take control of vehicles and crash them. A major cyber event would hold up progress on safety.

Among the collaborative efforts praised at the conference was the Auto Information Sharing and Analysis Center (Auto ISAC), an organization chaired by Toyota and co-chaired by General Motors, where threat intelligence is being shared among its carmaker members. Auto ISAC members currently account for more than 98% of light-duty vehicles on the road in North America. Auto ISAC recently began inviting select suppliers to join, and thus far nine supplier members have been announced: Delphi, Denso, AT&T, Infineon, Magna, Harman, Cummins, Continental and ZF.
Coordinated Vulnerability Disclosure
Another collective topic widely discussed at the conference was vulnerability disclosure, where large communities of white-hat hackers are offered incentives (bounties) to find and responsibly report cybersecurity vulnerabilities. The CEOs from two venture-funded, Silicon Valley companies who coordinate hacking communities, HackerOne and Bugcrowd, participated in the summit. The auto industry has only recently begun to consider the benefits of coordinated disclosure services.

We followed up with Casey Ellis, CEO of Bugcrowd, by phone. “I am actually quite proud of the [auto] industry, how proactive it’s been. In a very short time it’s gone from having cybersecurity on its radar to actually making it a priority, integrated around product safety. … At some point everyone in the auto industry is going to be doing this, mostly because they are screwed if they don’t.” Bugcrowd is engaged with two automotive clients publicly, Fiat Chrysler and Tesla.

Both HackerOne and Bugcrowd offer bug bounty programs. HackerOne offers hackers in its community between $100 and $1,000, sometimes more, for each vulnerability found. “The average paid on our platform has been the same for a while, $530 per submission, or you could say $530 per bug,” said HackerOne CEO, Marten Mickos. “If instead you brought in a company that does penetration testing, your results will vary. Typically the average is about $5,000 per bug.”

HackerOne was hired to coordinate the U.S. Department of Defense’s “Hack the Pentagon” program in the spring of 2016. That eight-week bounty program cost $150,000 and resulted in 138 valid vulnerabilities, $1,087 per bug found. Prior to that the DOT paid more than $5 million over three years to a single vendor and found fewer than 10 vulnerabilities. The cost: more than $500,000 per bug.

Top earning hackers can earn $250,000 per year, according to Bugcrowd’s Mr. Ellis.

“The typical hacker is a person with intelligence and endless curiosity,” said Mr. Mickos. “They ask how does it work, how can it not work, where can it have a flaw? They don’t need much encouragement. They will go after a new area and learn it very quickly. Most are self-taught; however, we do offer pointers, such as here is a good blog post or an article.”
Two Bug Bounty Program Providers

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*Hackers don’t work exclusively for either company.

Pre-Launch Testing

Bounty programs are generally set up to look at systems that are already in the field. Bugcrowd and HackerOne can also look for vulnerabilities in vehicles that haven’t yet been released. “With something that is cyber-physical, like a car, it is more complicated than for, say, a website or mobile app,” said Bugcrowd’s Mr. Ellis. “The more time and less pressure you can put on a researcher to do that work, the better. If you can find a way to get them access to an environment virtually, that would be ideal.”

Open-Source Cybersecurity

The open-source software development movement was late to arrive in the auto industry but finally it is catching on. Begun in 2012 with initial support from JLR, Nissan and especially Toyota, the Automotive Grade Linux collaboration now includes eight carmakers.

Bug bounty programs are essentially open-source developments. “We collaborate across the globe with people we have not met, people we may not even like,” said Mr. Mickos. “We figured out a collaboration model that allows different people to produce value together.”

Prior to HackerOne, Mr. Mickos spent 15 years in the open-source world, including seven years as CEO of MySQL, until the company was acquired by Sun Microsystems. “MySQL is the world’s most popular database engine. It is used by Google and Facebook, among many others. MySQL was built using a collaboration model, so was Linux,” he said.

Not only can an open-source community test cybersecurity defenses, it can build them. It is counter-intuitive that something that is developed openly can
be secure. Mr. Mickos referenced Kerckhoff’s Principle and Bruce Schneier, 
the foremost expert on cybersecurity, to explain the maxim that security 
through obscurity doesn’t work.

Here is an excerpt from Mr. Schneier’s Crypto-Gram Newsletter: 
“A corollary of Kerckhoff’s Principle is that the fewer secrets a system has, the 
more secure it is. If the loss of any one secret causes the system to break, then 
the system with fewer secrets is necessarily more secure. The more secrets a 
system has, the more fragile it is. The fewer secrets, the more robust.”

Mr. Mickos put it another way: “The bad guys will always attack what you 
built. But if you build it in an open community, the good guys can help you 
secure it. If you build it in a closed way, the good guys can’t help you. … That 
way I am letting the world vet it and tell me what’s wrong with it so I can 
improve it.”

In automotive electronics, the Europeans, and especially the Germans, 
historically have taken the lead on cooperative efforts, for example to create 
standards. But today, with cybersecurity and open source development, the 
U.S. is definitely in the lead. ◆