Carmakers Respond to Cybersecurity Challenge

General Motors Out in Front

Today’s cars are porous to attacks by cybersecurity researchers. White hat hackers have managed to remotely infiltrate cars from General Motors, Fiat Chrysler, BMW and Tesla, among others. Today’s cars offer multiple entry points to hackers. Access to vehicle controls can come by way of brought-in phones or the embedded cellular modem, via Bluetooth or Wi-Fi, from tire-pressure monitors, satellite radio, or from insurance and diagnostics dongles that plug into the OBD-II port. In the coming years, more and more cars will have connections, not only to back-end servers directly controlled by the carmakers, but also to outside cloud-service providers via the Internet.

Over the last few years malicious hackers have infiltrated retailers such as Walmart, Home Depot and Target, and major corporations such as Apple and Sony. More worrisome are attacks on infrastructure targets that could potentially affect the safety of millions of people. For example, according to a report in the Wall Street Journal, two years ago Iranian hackers infiltrated the control system of a dam less than 20 miles from New York City.

Passengers in Internet-connected, self-driving cars will be especially vulnerable. By the 2020 model year multiple carmakers plan to introduce Internet-connected cars that feature autonomous driving on highways without the need for human supervision. Carmakers will have to have strong, resilient cybersecurity defenses up and running. Threats will need to be uncovered and quickly fixed via remote software updates.

There is not much time. A lot has to happen on and off the vehicle before the auto industry can say it is well defended from cybersecurity threats. Starting with in-vehicle networks, vehicle architectures must be fundamentally changed. For example, CAN, the Controller Area Network, wasn’t designed with cybersecurity in mind. Ethernet will make the security job easier. But these and other changes to the fundamental architecture of the vehicle can take decades to work their way through the new car fleet.

Still in its infancy, the automotive cybersecurity market will emerge over the course of the next several years. Significant growth in the market for embedded parts and software will start in 2019, as Internet-connected cars with autonomous features are rolled out. Cybersecurity will have a direct impact on the bill of materials, but there are elements of security that would change the way existing systems are designed and architected that won’t necessarily affect the bill of materials.

Jeffrey Massimilla, General Motors’ Director of Vehicle Cybersecurity

Until recently, carmakers have been understandably reluctant to talk publicly about cybersecurity and what they are doing to confront the threat. Jeffrey Massimilla, chief product cybersecurity officer and director of vehicle cybersecurity at General Motors, is the exception. He spoke with us in January.

Mr. Massimilla oversees a global organization of nearly 80 people and the team is growing. “When you start connecting vehicles and talking about autonomous and automated driving controls, having appropriate cybersecurity is a responsibility,” he said. “We are dedicated to building an end-to-end cybersecurity posture and capability for our vehicles and our connected services. Systems are being designed so we can identify threats that need to be remediated and apply updates to those systems.” Mr. Massimilla was given responsibility for all cybersecurity at GM in August 2014. Prior to that, multiple cybersecurity efforts were underway at the carmaker but they weren’t centrally managed. In addition to the vehicles themselves, his responsibilities include...
as HERE, the map company was acquired by Daimler, BMW and Audi in December for 2.55 billion euros ($2.8 billion).

Unlike precision maps from TomTom or HERE, which rely in part on data collected by specialized mapping vehicles and manual processing, Road Database is developed without human involvement, from data collected by production vehicles as they are driven by consumers. “This is purely a software-based process, which is low cost and functions with extremely high reliability,” said Christian Thiel, senior vice president and executive manager for the automated driving business at Ygomi. Dr. Thiel helped to establish the MOST multimedia network. “You can qualify this software to work in systems certified at ASIL (Automotive Safety Integrity Level) D. It can become a component in a safe system design,” he said. Object-to-object positioning accuracy is targeted at less than 10 cm.

**How It Works**

Road data is collected during good weather from production vehicles as they drive. Data aggregation is a two-step process. “First, we access the vehicle sensors, mainly the forward-facing camera, GPS and inertial sensors,” explained Dr. Thiel. “We do our own image processing in the vehicle and compare what we see to our model of the road stored in the vehicle’s database. If we detect a difference, we send that to the server. We don’t send an image; we send object level data. That minimizes the amount of data that must be sent, which keeps communication costs minimal.”

Updates to the static road database can be delivered from the server back to the vehicle in a matter of hours when the vehicle is near a Wi-Fi hotspot. Vehicles with cellular connectivity can receive map updates in seconds.

Images from the perspective of the forward-looking camera can be rendered from the Road Database and these can be compared to what the camera on the vehicle is actually seeing. “In snowy conditions for example, you don’t see all the lanes, you don’t see the stop sign covered with snow,” said Dr. Thiel. “But if we give the vehicle an image of the empty road as it looks normally, by comparison it will be able to use pieces of the real image to match the map’s image and thereby position itself. This is what we as humans are doing, comparing what we are seeing to our knowledge of how things should look.”

In bad weather and at night autonomously driven cars will rely on Road Database in concert with other sensors, including camera, lidar, short-range radar, wide-band radar and possibly short-wave infrared cameras, to position the car in the center of its lane.

In their proof of concept demonstrations, Ygomi and Continental were able to show how maps displaying road geometry and common traffic signs could be built from vehicle probe data. Ultimately the database will include additional detail including curb heights, drain covers, lamp posts, fences and green belts, everything that is relevant for fully autonomous driving. Green belt locations are needed if, for example, during an accident the vehicle has to make a choice between driving into a concrete abutment or off the road onto a surface that will cause less harm.

Continental does not see itself in competition with Daimler, BMW and Audi, the new owners of HERE maps. “We are in discussions with all three carmakers,” said Jürgen Schweiger, Continental’s ITS vice president. “They need Road Database because HERE and the other HD maps are not up to date enough for autonomous driving. Road Database is more precise for autonomous driving.”

Continental has proof of concept projects for Road Database with six of the world’s eight largest vehicle manufacturers, including Toyota. Toyota Central Research also presented the same type of technology at CES 2016. Road Database is scheduled to launch in time for the 2020 model year.
Automotive Open Source Software on the Upswing

Toyota recently stepped up its support of two open source software projects: the Automotive Grade Linux (AGL) software platform and SmartDeviceLink (SDL) — a Ford-inspired open source platform for smartphone apps and car connectivity.

"These standards are very appropriate for our future product plans," said John Hanson, press spokesperson for Toyota. "They fit nicely with regard to giving customers what they want and also securing both customer and vehicle data. Those are two big concerns, and we think the direction we are moving with these collaborations will give us that."

The AGL collaboration is on a roll. Twenty-four new members signed on in 2015, including Ford, bringing the total to 61 members. Twenty-five to 30 new members are expected in 2016. Begun in 2012 with initial support from JLR, Nissan and especially Toyota, the Automotive Grade Linux collaboration now includes eight carmakers, just one fewer than Genivi, the platform collaboration first pioneered by BMW in 2007.

The AGL and Genivi platforms have much in common. Both are based on the Linux operating system and apply similar upstream projects. The two organizations share mailing lists and compare notes so they don’t duplicate efforts on projects. AGL is Genivi compliant. AGL demonstrated version one of its platform at the Genivi Showcase at the 2016 Consumer Electronics Show and wasn’t charged.

Still, there are some major differences between the Automotive Grade Linux and Genivi collaborations which will explain why some carmakers—including Toyota, Ford, JLR, Mazda, Mitsubishi Motors and Subaru—are throwing their weight behind AGL and not Genivi. (See page 8.)

QNX, which has had a dominant position with its proprietary QNX CAR infotainment platform, is also moving into advanced driver assistance systems. But QNX’s dominance will be tested. "Based on what I’m seeing in the market, they will have a rough time," said Dan Cauchy, general manager of automotive at the Linux Foundation. "There is a huge groundswell of adoption for Linux and open source. The same thing happened in the telecom industry. Ten years ago they were heavily dependent on things like VxWorks and other proprietary RTOSes. Now you’d be hard pressed to find switches, routers or base stations that don’t run on Linux."

SmartDeviceLink

Hosted by Genivi, SmartDeviceLink is a standard set of protocols and messages that connect applications on a smartphone to a vehicle head unit. SDL lets drivers interact with approved applications using driver interfaces in the vehicle: a touchscreen, embedded voice interface, steering-wheel controls or other knobs and buttons.

In January 2016, after concluding that SmartDeviceLink was a suitable solution for in-car app connectivity, Toyota

Continued on page 8

Cybersecurity...

OnStar, infotainment systems, GM’s Remote Link app, app shops and GM’s car-sharing initiatives.

In January, GM announced its security vulnerability disclosure program, through which it teamed up with HackerOne, a San Francisco start-up that coordinates researchers’ hacks and pays bounties for security flaws that are identified before they can be exploited. Any security vulnerabilities found by researchers will be turned over to a “red team” at GM, who will quickly develop a response. GM’s ten-member red team includes cryptologists, mathematicians and certified ethical hackers, as well as program management people. “This is a highly technical team that’s able to work with both the general organization and the program teams at GM to explain what we are doing and what needs to change,” said Mr. Massimilla.

GM’s vulnerability disclosure program is an outgrowth of an interaction GM had last summer with the researcher Samy Kamkar, who identified a vulnerability that allowed him to intercept an OnStar account user’s credentials. The researcher was able to impersonate the user, giving him access to OnStar’s RemoteLink mobile app used for unlocking, locking and remotely starting the vehicle. “Within 48 hours of Samy notifying us, we were able to patch the [smartphone] app with an update,” said Mr. Massimilla. “If you tried to use the old RemoteLink it would indicate you needed to perform an update. An update to the car’s software was not required.”

While the company has performed updates on some of its vehicles, GM is not yet able to remotely update vehicle software universally. “Over the air updating is absolutely a priority, something we will roll out over time,” said Mr. Massimilla.

A major problem for the industry is recruiting cybersecurity specialists. Inside and outside of automotive, there are more jobs than people, according to Mr. Massimilla. “There are things GM can do independent of our suppliers, and there are things we rely on our partners to do. Suppliers are an absolutely critical part of our cybersecurity, and they face the same challenge as the automakers, that is, to find the talent that knows how to design systems with security in mind, creating secure lifecycle development processes, understanding good hardware and software design, performing appropriate scans and testing throughout the development process.”

Mr. Massimilla believes that a successful strategy requires a complete organizational mindset. It has to be top down, and it has to be adequately funded and resourced.

Auto-ISAC

GM, along with the Association of Global Automakers and the Alliance of Automobile Manufacturers, and encouragement from NHTSA, has been instrumental in rallying the industry to establish the Automotive ISAC (Information Sharing and Analysis Center). “The great news is that the Auto-ISAC is now up and running,” noted Mr. Massimilla. “Threat intelligence is being prepared and shared operationally. Automakers are committed,

Continued on page 8

The Company Profile... Preh, A Unit of Joyson Electronics

Joyson Electronics

Headquarters: Ningbo, China
2014 Revenue: 7,077 million RMB ($1,076 million)
Finance Expense: 0.89% of revenue
R&D: 6% of revenue
Operating Cash Flow: 738 million RMB
Working Capital: 167 million RMB
Long-Term Debt: 328 million RMB
Stockholders' Equity: 2,470 million RMB
Market Capitalization: 21.5 billion RMB as of 1/27/16
Employees: Approximately 6,400

Background
Joyson Electronics was founded in 2004 by the Ningbo Joyson Investment Holding Co., and was listed on the Shanghai stock exchange in 2011. Among Joyson Electronics’ automotive products are engine parts, interior components, windshield washing systems, exterior mirrors and steering wheels. The company made several acquisitions, notably Preh in 2011. In February 2016, Joyson agreed to purchase TechniSat Automotive, a radio and navigation system supplier to Volkswagen (see page 7), and passive safety supplier, Key Safety Systems, the former Breed Technologies.

Breed was a pioneer in airbag sensors in the 1980s. After rapidly expanding through multiple acquisitions the company went bankrupt in 1999. Carlyle Management Group took the company private in 2003 and renamed it Key Safety Systems. Joyson acquired KSS for approximately $920 million.

Preh was founded in 1919. Until 1988, the company was in the business of making radio and TV components, toys, keyboards and industrial electronics. Its first automotive products were climate controls and sensors; BMW and Volkswagen were among the earliest customers.

Christoph Hummel was appointed president and CEO of Preh Group on January 1, 2016. Reporting to Jianfeng (Jeff) Wang, founder of Joyson, Mr. Hummel is responsible for all Preh businesses, including the newly acquired company TechniSat Automotive, now known as Preh TechniSat Car Connect GmbH. He is also directly responsible for sales, marketing, project management and quality.

According to Mr. Hummel, Preh benefits from the support of Joyson and operates with a high degree of autonomy. “Dr. Roesnick, who was president and CEO of Preh when it was acquired by Joyson in 2011, stated to our employees at the time that, ‘Preh will stay Preh. We will remain the same company. We will have the same culture in the future.’ This is exactly what happened because Joyson has given us great autonomy. By the way, our culture, a culture of innovation we would call it, has become a driving force for the entire Joyson Group.”

Joyson has been supporting Preh with investments. Each year since the acquisition Preh has been able to increase the per-
Preh is highly vertically integrated; a high percentage of content comes from in-house production.

**Development**
- Advanced development
- System design
- Electronics hardware
- Software
- Mechanical design

**Production**
- Tooling
- Assembly lines and end-of-line test equipment (PIA)
- Plastics injection molding
- Lacquering
- Electronics manufacturing
- Mounting
- Laser-etching
- Final inspection

**Purchased Items**
- Plastic resins
- Printed circuit boards
- Electronic components
- Metal components
- Coatings

---

**Preh Sales by End User**

- 2015 Total Sales: €763 million
- Customers of Preh IMA Automation, 10%
- Others, 4%
- Daimler, 5%
- GM, 10%
- VW, 20%
- BMW, 26%
- Ford, 25%

---

**Preh Core Competencies**

- Preh points to vertical integration as one of its most important differentiators in the market. A high percentage of what goes into the HMI and battery management products the company offers is developed and produced in house including tooling, plastic injection molding, electronics assembly, parts mounting, painting and laser etching. In climate control heads, for example, in-house content would be anywhere from 70% to 80% of the BOM. Preh does the injection molding in house for the most challenging components, and it populates the printed circuit boards (with purchased components).

- “The complicated things are mostly done in house,” said Mr. Ehrenberg. The company purchases plastic resins, printed circuit boards, electronic components, metal components and coatings.

- Preh has been developing its own software for 20 years. The company writes the algorithms that govern the haptic-feedback devices the company produces and the climate control algorithms that control passenger comfort. “Software is often the biggest portion of our R&D, and it is growing in importance. We combine this with our [electronics] hardware and mechanical design capability to realize the best performance of complete systems,” Mr. Ehrenberg said.

- Due to its deep and broad in-house know how, Preh can often respond more quickly to the market or to customer requests with innovative solutions. According to Mr. Ehrenberg, this helps explain how the company has been able to grow its automotive business at the rate of 17% annually over the last five years.

- Preh’s products are found in multiple car segments: from the iconic iDrive touchcontroller featured in BMWs, Minis and Rolls Royces, and the center console in the Porsche 911 Spyder, to the center stack (including the climate control panel) in Fords and Lincolns.

- Often Preh competes with companies that are much bigger. To stand apart, Preh emphasizes its medium size and flat organization, which gives it more flexibility, faster decision-making and the ability to be more innovative. Preh also emphasizes a long-term commitment to its employees. “We have a tradition of employees staying a very long time with the company,” said...
Christoph Hummel, who himself has worked at Preh for almost two decades. Last year, Preh’s office in Novi, Michigan, was cited by the market research firm, the Center for Generational Kinetics, as one of the 75 best places for millennials to work in America.

In 2013, Preh acquired Innoventis, a 15-person software provider in Würzburg, Germany, close to the University of Würzburg, giving the company access to graduates for employment.

**Haptics**

With driver distraction a huge safety concern, Preh has been emphasizing its ability to merge active haptic feedback solutions into many different touch surfaces including displays, touch panels and even switches. Haptics implementations require a blending of software, mechanical and electronics capabilities, which together embody Preh’s mechatronic DNA. “We are one of the market leaders for active haptic feedback solutions; we have multidisciplinary teams working to realize those things,” said Mr. Ehrenberg. Preh’s active haptic solutions employ an electromagnetic actuator to provide feedback impulses to the touched surfaces that are similar to the characteristics of traditional push buttons. The actuator is controlled by a software algorithm, which takes inputs from capacitive or inductive force sensors to measure at any time whether the operator wants to make a gesture on the surface or locate and push a button. Acoustic feedback can also be provided and adapted to the customer’s requirements.

**◆ Audi MMI**

Preh’s haptics capability is well demonstrated in the multimedia interface (MMI) touch pad installed in the new 2017 Audi Q7. Developed jointly by Preh and Audi, the “All-in-Touch” touch pad is used to control navigation, multimedia and telephone in few steps. Tactile feedback is transmitted through the MMI’s glass surface. Individual icons can be felt and distinguished; the driver gets the feel of pressing a button. The Audi MMI touch pad also accommodates inputs for handwriting recognition.

The touch pad includes illumination of function icons and backlighting, the latter having to be homogeneous despite different materials: glass touchpad, polycarbonate casing and light guides in the rotary control. “A mechatronics masterpiece,” is how an Audi development chief described the touch panel at a recent conference. Preh has other touch panel developments in the works that it can’t yet talk about.

**◆ Active Haptic Switches**

The force sensors and electromagnetic actuator can be customized to fit a variety of applications. Preh has demonstrated continuous surface (no gap) switches for the steering wheel and a central multifunction controller (similar to iDrive). The multifunction controller, with multiple virtual buttons, can be realized with only one actuator. “You don’t need separate buttons around the control knob,” said Mr. Ehrenberg. “You have one closed surface that has the shape of different buttons on the surface. The actuator underneath gives you haptic feedback like you are pushing separate buttons.” With some concrete projects already in the works, expect to see active haptic switches from Preh in production vehicles in the next two or three years.

**Daimler Touch Control, Steering-Wheel Switch**

Multifunction touch-sensitive switches from Preh will be featured in the soon-to-be-released Mercedes-Benz E-Class. According to a Mercedes press release, the E-Class is the world’s first car to integrate touch sensitive buttons within the steering wheel. Each continuous surface switch panel, one on each side, responds to horizontal and vertical thumb swipes, similar to the way a smartphone works, and can be operated with a gloved hand. Once a desired function is selected, the appropriate touch control button is selected to trigger the function. The steering-wheel switches are used to control the infotainment system and handsfree calling. The touch switches don’t provide haptic feedback.

**Functional Surfaces**

Preh’s customers have been asking the company to come up with ways to integrate a greater number of large displays into the vehicle interior. Going a step beyond black panel displays, where the cluster lights up behind a blank, glossy black surface when the ignition is turned on, Preh has been developing functional surfaces, for exam-
ple black or metallic, behind which icons would appear as needed. The translucent surface could also be made touch sensitive. “The entire center stack surface could be made functional with no-gap switches,” suggested Mr. Ehrenberg. “To make that work there are some challenges. To qualify those functional surfaces for automotive applications, one has to take care of multiple facts, along with the well-known surface requirements, for example having sufficient contrast of the displayed information in bright daylight, the robustness of the touch functionality in the automotive environment or the stability for electromagnetic or electrostatic charge effects.”

E-Mobility
Preh is anticipating fast growth for its E-Mobility business unit. Founded in 2014, the unit is thus far focused almost exclusively on battery management ECUs for hybrid and electric vehicles. Preh got into the business at the request of BMW and is presently in series production with battery management systems for the BMW i3 electric vehicle and i8 plug-in hybrid.

Because the battery management ECU is a safety component, Preh has had to build up its functional safety competencies (ISO 26262), and this experience, plus the fact that it is in volume production, will attract other carmakers to Preh. Preh has E-Mobility R&D teams working in China and Germany.

In addition to its high-voltage battery management ECUs, Preh is developing 48-volt ECUs for which it has already won a production order from a carmaker. While the earliest implementations of 48-volt systems are aimed at the luxury vehicle segment, demand for 48-volt components will in the next several years begin to move into higher-volume segments.

Distinctions Claimed by Preh
◆ Number-one climate control panel supplier in the U.S.
◆ One of the top five suppliers of climate control panels globally, with a 6% share of the market
◆ A leader in haptic feedback solutions
◆ A leader in battery management ECUs for 48V systems

Preh now has much more to offer its customers in Germany, China and the United States. Preh TechniSat Car Connect will report to Mr. Hummel, as president and CEO of Preh Group, although each Preh division will operate somewhat autonomously with separate P&Ls.

The acquisition brings with it some major challenges. As the Hansen Report has reported, the infotainment system market is ripe for consolidation. It is already crowded with many suppliers, some considerably bigger than Preh, including Harman, Continental, and Panasonic. It could be hard for TechniSat to gain share. With Volkswagen facing billions of euros in losses resulting from its diesel emission scandal, it has been pressuring suppliers for givebacks, which could tighten margins.

On the other hand, the product portfolios of Preh and TechniSat complement each other. Plus, Preh can access new markets for TechniSat products with its broader customer base. Mr. Hummel is expecting more growth. There will be no layoffs following the acquisition. “We need all 1,200 people for the future,” he said. “We want to expand that business. We can provide a global footprint, global access to customers. We clearly see the possibility to expand that unit.”

Preh TechniSat Car Connect Locations
Development
Dresden, Germany
San Carlos, California
Shanghai, China
Production
Dippach/Thüringen, Germany
Oborniki, Poland

In February 2016, Joyson Electronics and its subsidiary Preh Holding GmbH announced that they are each acquiring 50% of the TechniSat Automotive Division, a business unit of TechniSat Digital GmbH. Founded in 1997, the business unit has been supplying car radios and radio-navigation systems since 2002 to Volkswagen Group, almost exclusively, including VW, Skoda and SEAT brands. In 2014 the company began mass production of Volkswagen’s MIB (modular infotainment building kit) mid-level infotainment system.

Presently its main product, TechniSat makes the head unit for the VW mid-size platform, including touch screen, NDS navigation, and Bluetooth, MirrorLink and CarPlay connectivity. The soon-to-be acquired company has much in common with Preh. Both companies are German, both are mid-sized, and both are highly vertically integrated. Both have been growing at double digit rates and see themselves as innovative. A complementary acquisition, the two companies can combine to produce complete center consoles. “Preh can do the HMI and TechniSat the infotainment system, including the radio, navigation and the connectivity,” said Mr. Hummel.
and fees have been paid. The auto industry now has an opportunity to get out in front of this before a serious incident occurs in the field, outside the reach of the researchers.” Mr. Massimilla is vice chairman of the Auto-ISAC; the chairman is Tom Stricker, vice president for safety and government affairs at Toyota.

Thus far, Auto-ISAC has 15 members, all carmakers, which together represent 98% of the vehicles on U.S. roads. Membership fees range from approximately $25,000 to $100,000 per year, depending on the size of the company.

“The Auto-ISAC portal is up, enabling members to share information on vulnerabilities and threats,” said Jon Allen, of Booz Allen Hamilton, executive director of Auto-ISAC. “In the next week or two, the OEMs will start sharing what they find, whether it is a vulnerability with a supplier or on an ECU. They can make their submissions anonymously or openly. What we are doing is creating an incident response mindset with the OEMs.” NHTSA won’t have access to the ISAC portal.

One automotive cyberthreat analyst has been hired. He sits in a room at Booz Allen’s cyberthreat intelligence center in Northern Virginia with 20 other cyberthreat intelligence analysts who cover other industries.

According to Mr. Allen, in April the membership committee plans to begin inviting suppliers who meet certain criteria to join Auto-ISAC. Suppliers need to be “working within the environment of the connected vehicle or have impact on a safety-critical ECU.”

Soon the Auto-ISAC will begin recruiting to find a permanent executive director to replace Mr. Allen, whose term will end in six months. Interested parties should contact him at allen_jonathan@bah.com.

**SAE Cybersecurity Guidebook**

In January the SAE published J3061, a recommended practice that provides guidance on vehicle cybersecurity. The 128-page guidebook establishes a set of cybersecurity principles, defines development processes, and provides information on existing tools and methods. “That was the first effort of the industry to come together to create standards for this space; they are very important,” noted Mr. Massimilla.

---

**Open Source...**

announced its intention to “soon” install the smartphone connectivity platform in the Camry. Unlike MirrorLink, the smartphone connectivity platform supported by Volkswagen that simply projects what is on the smartphone to the vehicle display, the SDL platform is template based. That gives carmakers the ability to customize the look and feel of applications in ways that are consistent with the car’s brand and safety and security requirements.

SDL provides carmakers an alternative to CarPlay and Android Auto from Apple and Google, respectively, with whom carmakers must sign agreements that presumably give those companies some control as well as access to car data. With SDL, carmakers can gather their own usage data.

According to Ford, SDL is designed to be agnostic to the smartphone operating system platform, although it currently only works with iOS and Android. SDL is flexible enough to communicate with other mobile operating systems if a new OS emerges in the future, or if a different OS is more popular in a specific global market.

The Ford Sync AppLink feature is based on SDL. AppLink users just need to download the SDL/AppLink-enabled apps such as Pandora, iHeartRadio, Spotify or Glympse. Since SDL communicates directly with the smartphone app, the customer is not required to have the latest level of smartphone hardware or OS, which are needed for compatibility with CarPlay and Android Auto.

Eventually Ford intends to provide its customers with all three smartphone connectivity platforms: AppLink, CarPlay and Android Auto.

According to Ford, other OEMs, including PSA Peugeot Citroën, Honda, Subaru and Mazda, are also investigating the possibility of running SDL on their vehicles’ head units. Further, QNX plans to integrate SDL into its QNX Car infotainment platform. As more carmakers adopt the open-source platform, the potential market for apps based on the standard will grow, which will attract more developers and improve the quality of the software.

According to Mr. Cauchi, there is strong support from Ford and Toyota to get SDL ported to the AGL platform. Discussions toward that end have begun with Livio, the Ford subsidiary managing the open source project. Livio works with SDL adopters to integrate the software into vehicles. The Automotive Grade Linux group reports there are already 90 apps available that work on the SmartDevice–Link platform. Given Toyota’s support and the interest shown by other carmakers, many more apps will soon be released.

**Major Differences: AGL and Genivi**

- **AGL is a complete Linux-based distribution.** Genivi had been focused on developing only non-differentiating middleware and only lately moved beyond middleware with its Genivi Demonstration Platform. “AGL comes with the entire infrastructure in place,” said the Linux Foundation’s Dan Cauchi. “It’s a complete development environment that open source [app] developers can start using.”

- **AGL is “code first,” meaning the code speaks for itself.** “If you are changing APIs, the code is the API, not some document,” said Mr. Cauchi. “If a company is porting a piece of software to an AGL platform, it will work on any of the AGL members’ platforms; everybody is using the same code. It will give OEMs more flexibility to have a single (customizable) platform and be able to switch suppliers.” Unlike AGL, Genivi has a compliance specification. A platform could potentially be Genivi compliant but unable to run code that works on a different Genivi-compliant platform.

- **AGL is fully open source.** Anyone can download the code, so more people can see and test it, and write applications for it. “Genivi is a member-based organization, although now some Genivi projects are done fully open,” said Kyle Walworth, vice president of automotive solutions at Harman Connected Services, and a board member of both Genivi and AGL.

- **AGL is moving beyond infotainment to address the instrument cluster, HUD, telematics and eventually control systems.** “Our idea is to be ISO 26262, ASIL B certification ready,” said Mr. Cauchi. Genivi is focused on infotainment.