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BMW’s Elmar Frickenstein on Autonomous Driving

One of our industry’s leading lights, Elmar Frickenstein, senior vice president for Fully Automated Driving and Driver Assistance at BMW, is retiring on March 31 at the age of 61. By rule, top managers at BMW must retire at this age to make way for younger executives, to keep the brand and the company dynamic and fresh. Mr. Frickenstein kindly agreed to sit for a lengthy interview to discuss the state of the art of self-driving technology, about software and about his automotive electronics legacy.

After earning a master’s degree in computer science, he worked for three years as an avionics system developer and followed that with an impressive 31-year career in electronics and software development at BMW, moving from engine systems to driver information systems to architecture and integration. He was BMW’s senior vice president for Electrics/Electronics and Driver Environment from 2006 to 2016.

Among his many accomplishments through the years, Mr. Frickenstein will be remembered for his involvement 15 years ago in creating SW/HW Integration Steps (I-Step), a pioneering approach to synchronized release management of automotive hardware and software, which was adopted by all BMW brands: BMW, MINI and Rolls-Royce. He played a major role in the development of iDrive, the groundbreaking multi-input HMI for controlling secondary vehicle functions, introduced in 2001 on the 7 Series. Mr. Frickenstein also had a hand in the development ten years ago of BMW ConnectedDrive, which three and a half years ago reached the goal of connecting 100% of new vehicles in all three BMW car lines.

Mr. Frickenstein was an early advocate of bringing software development capability in house. “In order to manage the millions of lines of software code that are deeply embedded into vehicle systems—the infotainment system, driver assistance, the brakes—you have to understand what kind of software you want to integrate. You have to do it yourself. And you have to take a white-box approach.” That means that the carmaker is involved in every development step taken by the supplier, as if the component was developed in house. The development process is completely transparent.

Under Mr. Frickenstein’s leadership, BMW created a software subsidiary company, CarIT, to develop software, functions and a toolchain for BMW.
CarIT is an active participant in open source communities, standardization efforts, funded research projects and collaborations with universities.

Mr. Frickenstein was the driving force behind the Genivi Alliance, which was formed ten years ago to develop an infotainment software platform based on Linux that could be shared with alliance members. BMW brought its third generation head unit based on the platform to market in 2018, and is developing a fourth Genivi head unit for 2021.

**Autonomous Driving**

♦ L2 to L4, What Happens When

Mr. Frickenstein has been responsible for autonomous vehicle development at BMW since 2016, a topic of supreme interest to me and most *Hansen Report* readers. BMW consolidated its autonomous driving development efforts at the BMW Group Autonomous Driving Campus near Munich, where approximately 1,300 engineers are employed. While some autonomous vehicle developers have been quite optimistic in their expectations for how quickly autonomous technology will advance, BMW is taking a cautious approach that leans heavily on safety.

“We can handle Level 2 and Level 3 system development with the skills, people and knowledge we have today,” said Mr. Frickenstein. The carmaker is operating 80 different test vehicles in fleets around Munich and in Israel, the U.S. and China, and is on track to launch a Level 3 system in 2021. But getting safely to full-blown Levels 4 and 5 will take considerably more time. “It is a big challenge,” he said. “As BMW’s head of development Klaus Fröhlich says, autonomous driving is not easy. He compares it to a ‘Mars mission.’

“In 2025 we want to create some end-user functions for Level 4 and maybe in 2028 or 2030 have some urban Level 4-5 systems in the market.” In the interim, by 2021, BMW plans to launch a Level 3 highly automated driving system capable of driving exit-to-exit on motorways, for example, from Munich to Hamburg at up to 130 km/h, an 800 km trip, without the driver having to pay attention to the road, but expected to take over control of the vehicle in a matter of seconds if needed.

Audi’s Traffic Jam Pilot, capable of L3 automated driving on motorways at speeds up to 60 km/h, was introduced with the 2019 Audi A8 but won’t be enabled until it is approved by German regulators. “We believe that regulators will have a solution by the end of 2020, maybe 2021,” suggested Mr. Frickenstein.
Because the system can operate exit-to-exit at high speeds, BMW thinks consumer demand will support a higher price than a system like Audi’s Traffic Jam Pilot does. The higher price is needed to cover the development investment and the added costs for the higher-speed L3 system. “To go from L2 to L3 there are more sensors; we need lidars, radars and cameras. We need a safety critical approach, and we need the compute power.” To minimize the added costs, BMW’s platform is scalable from L2 to L3 and L4.

In 2018 BMW introduced 40 new L2 functions in Europe, the U.S. and China. One of the features, “Hands Off 60,” lets you drive in traffic with hands off the wheel up to 60 km/h as long as you pay attention to the road. The feature is currently only allowed in the U.S. and China.

◆ Greatest Challenges

“The algorithms, the simulation, the AI stuff is brand new for the auto industry,” said Mr. Frickenstein. Simulation is the key. BMW has to demonstrate to regulators that it can drive more than 240 million kilometers accident free. Only 5% of this can practically be driven with real cars. Ninety-five percent has to be done via simulation. “To control the vehicle through all the complex scenarios in an urban setting, you have to handle every obstacle, every pedestrian, every traffic situation and weather conditions—all the corner cases. We created a data center with 200 PB capacity near Munich, where we are collecting all the raw data from sensors in dedicated vehicles,” said Mr. Frickenstein. “We are labeling the data from the cameras, radar and lidar sensors, all of the scenes. We are training a neural network, and with artificial intelligence we are creating our algorithms. We are testing the algorithms in simulated environments through variations of weather and traffic. We then transfer the software to real vehicles for road tests.”

◆ Safety First Guideline

In June 2019, at the International Automotive Electronics Congress in Ludwigsburg, Germany, BMW along with OEM, tier-one and tier-two collaborators will present “Safety First for Autonomous Driving,” a white paper that the authors hope will form the basis for an international standard regulators will adopt. “We want to share it with all companies, as we have done with other electronics and architecture platforms and protocols that have become global standards,” said Mr. Frickenstein.

The white paper will take a holistic approach to the topic, covering all the elements: architecture, sensors, ECUs, software, artificial intelligence, system integration with the vehicle, and testing. The guidelines will adopt parts of the
Responsibility-Sensitive Safety (RSS) model that Mobileye and Intel have offered to the community of autonomous vehicle developers and regulators.

◆ Partners Wanted
Autonomous vehicle development is challenging and very expensive, which is why BMW entered into a partnership with FCA to share the investment burden. The two carmakers, along with key suppliers such as Continental, Magna, Aptiv, TTTech, KPIT, Intel and Mobileye, are working together at BMW’s new autonomous driving software campus in Unterschleißheim near Munich.

“Here at the campus it feels like a tech company where software is dominant,” Mr. Frickenstein elaborated. “We develop with Agile processes based on LeSS (Large Scale Scrum). We have scrum masters, product owners and 80 feature teams. … We hold daily morning standups getting ready for the daily tasks. The teams convene for ‘sprint reviews’ at the end of each sprint. They present their results to all the employees in a kind of marketplace. Then there is the ‘retrospective when the teams share observations from the last sprint and work together to identify measures for improvements in the next sprint. You can drive a car every two weeks with new functions, new bug fixes, new simulation, new tool chains and new approaches.” BMW is open to having more development partners participate in the important work at the autonomous driving campus.

After departing from BMW at the end of March, Mr. Frickenstein will decide what he will do next. Given his experience, sharp intellect, and energetic demeanor he surely has much more to give the auto industry. ◆
Multi-Network Communications for V2X

The automotive industry appears to be moving beyond the religious wars that have dominated the vehicle to everything (V2X) topic over the last several years. Suppliers are developing solutions to accommodate multiple communications standards: cellular for long-range, Wi-Fi, cellular-V2X (C-V2X) and dedicated short-range communications (DSRC). (For this article, the term DSRC also refers to ITS-G5 and WLANp, the terms used in Europe to refer to short-range wireless communications technology in the 5.9 GHz band.)

The motivation for the interest in multi-network communications is best exemplified by the Volkswagen Group. Volkswagen has committed to launching DSRC transceivers on all new models, starting in 2019 with the new Golf in Europe, while Audi has committed to employing C-V2X on its vehicles in China. “We need to be ready for either of those protocols,” said Audi’s top electrical engineer, Thomas Mueller. “We might see a quick break [to DSRC] in Europe and need to make a run for it. And we definitely need to offer C-V2X in China.”

Both Continental and Bosch have begun to publicize the multi-network solutions each is developing. Continental has already won an order for its 5G-Hybrid V2X communications unit that is set to ship in the early 2020s to a customer in China. That order has almost certainly come from Ford. “China is very clearly going the C-V2X route,” said Don Butler, executive director for connected vehicle platform and product at Ford. “That is the way they are headed; it is what we are planning on for China.”

Continental’s architecture uses software and hardware elements that are common to both DSRC and C-V2X technologies. “This allows the OEMs to have a single development solution with the flexibility to provide DSRC in one region and C-V2X in another,” said Rob Gee, who heads the infotainment and connectivity business unit at Continental. To minimize cost, the module will be populated only with the hardware and software elements that are unique to DSRC or C-V2X.

Bosch is taking an all-in-one approach to vehicle connectivity by combining in a single unit C-V2X or DSRC with cellular, plus Wi-Fi.
“Wi-Fi is a very broadband technology; it is quite inexpensive compared with cellular,” said Holger Kussmann, head of engineering connectivity units at Bosch Car Multimedia. Bosch is getting requests from carmakers who want the option of using Wi-Fi to avoid the cost of transferring large files such as over-the-air (OTA) software downloads over cellular networks, and for sending vehicle data back to the carmaker.

While it is theoretically possible to have separate channels in the 5.9 MHz band, one for DSRC radios and the other for C-V2X radios, it is very unlikely that a single vehicle would be equipped with both. Not only would cost be an issue, but if cars have to listen and transmit in both media, they would be using twice as much communications capacity than if one or the other radio service is used exclusively. Using both would be wasteful.

Veniam
Bosch’s universal solution integrates connection management technology from the Silicon Valley startup Veniam. “Veniam’s intelligent networking software is the first solution to enable automakers to take advantage of the millions of Wi-Fi hotspots that are available such as Xfinity, Starbucks and McDonald’s,” said Veniam CEO João Barros. “Carmakers save 30% of warranty costs by doing OTA software updates. With our software they are able to save 40% of their data costs just with the Wi-Fi offload. If we include peer-to-peer transfers between vehicles using V2X technology, we can expand those savings to 90% of their data costs.” Carmakers can set policies in the cloud for choosing which network is best for each use case, depending on cost, safety and latency. Veniam is also exploring joint solutions with Denso, another leading developer of V2X technology.

Veniam has thus far raised $30 million in series A and B funding. Investors include Verizon, Cisco, Liberty Global and Yamaha Motors. There are 53 employees. The company maintains offices in Porto, Portugal; Mountain View, California; New York, NY; and Singapore.

DSRC vs. C-V2X—Like Coke vs. Pepsi
China is committed to C-V2X. Korea is leaning toward C-V2X, while Japan leans toward DSRC. The U.S. and Europe have not yet solidified around one or the other short-range radio service. Ford, Audi and Daimler are advocating for C-V2X. General Motors, Volkswagen, and Toyota are in the DSRC camp. Honda has been demonstrating a system that uses DSRC.
Momentum seems to be building for C-V2X. Safety regulators in the U.S. and Europe who have been in the DSRC camp are now considering requests from multiple sources to allow C-V2X. The 5G Automotive Association has petitioned the U.S. Federal Communications Commission for a waiver to allow deployment of C-V2X technology in the 5.9 GHz radio band. “In Europe there appears to be more openness to a technology neutral approach,” said Ford’s Mr. Butler.

When it comes to the technical attributes of each of the competing V2X radio services there is wide agreement that there is little difference between the two. A communications technology expert at the U.S. DOT who has long advocated on behalf of DSRC told me recently that the technologies are basically equivalent, like Coke and Pepsi. “After watching both of them, and understanding that they both have very, very similar capabilities, I’m looking for that secondary difference that really makes one superior to the other. Until I see that, I’m ambivalent.”

Apart from the technical similarities, the argument for DSRC rests on its history as a technology that’s well proven and ready to go, which is why Volkswagen chose DSRC. Eager to polish its brand following the disastrous diesel-emissions cheating scandal, the carmaker didn’t want to wait for C-V2X to mature to tell the good news V2X story. The U.S. FCC allocated 75 MHz of spectrum for intelligent transportation systems and adopted basic technology rules for DSRC in 1999.

Those advocating for C-V2X are emphasizing its business case. DSRC is old technology, it’s the past; C-V2X is the future. C-V2X will likely get swept along with the 5G wave, propelled not only by the carmakers who are advocating for it, but also by a powerful telecommunications ecosystem. “The telecommunications operators are pushing for C-V2X because it gives them more control and the ability to offer additional services,” suggested Veniam’s Mr. Barros.

Audi’s Thomas Mueller takes a similar position. “Let’s zoom out to the year 2025 or so, when we will have a mature 5G spread all over the place and IoT being implemented. Then the volume of use cases will multiply well beyond pure automotive use cases.”
V2V Critical Mass Less of an Issue
Among the obstacles that have kept V2V implementations off the streets is the acknowledgement that on day one, the benefits of cars talking to each other would be nil. According to Continental’s Mr. Gee, “Starting from zero, if on day one 100% of all new cars are equipped with V2V technology, after 10 or 11 years you would see 70% of the cars in the car park equipped. You take the percentage and square it: 49% is the likelihood of any random cars equipped with the technology meeting.”

Instead of relying on V2V, early implementers such as Volkswagen in Europe will rely on use cases involving direct communications with the infrastructure, for example with road construction crews. “Or by equipping critical intersections to provide left turn/right turn assist or pedestrian movement assist,” suggested Mr. Gee.

Vehicle to Network to Vehicle Alternative
Many excellent use cases can be implemented without V2X radios. More new vehicles are being equipped with embedded cellular modems every year. Some analysts predict that by 2025, 100% of new vehicles will be connected. Carmakers will consider implementing services that depend entirely on cellular communications from the vehicle to the network and back to select vehicles, so called V2N2V communications. For example, a vehicle confronts black ice, blinding fog or stopped vehicles on the highway and instantly transmits warnings through the network to the cloud and back to warn vehicles that are in harm’s way.

Elmar Frickenstein, BMW’s vice president, responsible for fully-automated driving and driver assistance, takes a distinctly different view of V2X from many in the industry. He doesn’t think it’s at all necessary. “We at BMW believe in connectivity over the air, we believe in connectivity to the cloud but not V2V. … If there is connectivity over telematics to the back end, then you can do vehicle to [network to] vehicle communications over the air.” BMW will not implement V2V even in self-driving applications. “We can do all applications with 5G or 4G. There are no corner cases that we cannot do.”

The Hansen Report on Automotive Electronics, February 2019
www.hansenreport.com
Wind River’s Automotive Software Business

Expected to Trend Up

Founded in 1981, Alameda, California-based Wind River released its real-time operating system (RTOS), VxWorks, more than 30 years ago, in 1987, but it took carmakers until the late 1990s to seriously consider the benefits of using operating systems in their vehicles. In addition to VxWorks, the commercial operating systems available at the time included windStream, also from Wind River, pSOS from Integrated Systems, and Windows CE from Microsoft. Standard operating systems such as OSEK and μITRON were also candidates.

Fast forward to today. Operating systems are widely used by carmakers not only in infotainment systems but also in vehicle control systems. And yet, Wind River’s automotive business, which offers not only VxWorks and Linux operating systems, but also virtualization software, services and tools, is delivering annual revenue of only about $70 million with 400 employees, roughly where it was in 2015.

BlackBerry QNX, an operating system competitor of Wind River, generated an estimated $100 million in revenue in its fiscal year ending in February 2018. More than half of QNX’s revenue comes from automotive customers.

While Wind River releases few details about its financial performance, it did say that the automotive business was cash flow positive in 2018 and has been for the past three years, with the exception of two quarters. Of the roughly $70 million in automotive revenue, the portion generated by sales of software products rather than services is increasing. Approximately $20 million came from sales of software products in 2018, which is 5% higher than in the prior year.

Intel acquired Wind River for $884 million in 2008 and sold the company in June 2018 to TPG Capital for an undisclosed price. Elliott Garbus, who until May 2017 was general manager of Intel’s Transportation Solutions Division and before that was part of Intel’s Software and Services Group, the organization that led the acquisition of Wind River, told us that the motivation for acquiring Wind River had little to do with Intel’s interests in the automotive market. Rather, it had to do with Intel’s aspirations to get its chips into phones. Intel had partnered with Nokia around the MeeGo software initiative. Intel wanted a commercial entity to deliver MeeGo to

The Hansen Report on Automotive Electronics, February 2019
www.hansenreport.com
phone vendors beyond Nokia. When Nokia pulled away from MeeGo, Intel then engaged with Samsung and the Tizen operating system. “But by that time Android had started to take off, the opportunity dissipated. Intel didn’t execute cleanly on devices for phones. … The ship had sailed.”

**Primed for Growth**

As an independent entity, Wind River has been expanding its ecosystem by porting its software to processors made by some of Intel’s chip competitors, namely NXP and Renesas. Wind River Chassis portfolio has been ported to the Renesas R-Car family and to NXP’s LMX8 family. Chassis, which the company refers to as its “safe and secure backbone for the software defined car,” includes the ASIL D certified VxWorks RTOS, plus technologies, tools and services to maintain vehicle software systems and manage cloud-based connectivity.

**Wind River Chassis Portfolio**

- VxWorks
- Wind River Linux
- Wind River Drive - Autosar-oriented stack
- Wind River Edge Sync - OTA update and software lifecycle management
- Wind River Diab Compiler - Tool for developing safety related software
- Wind River Simics - Simulate hardware targets
- Wind River Titanium Cloud - Secure, low-latency cloud compute solution

“We are no longer beholden to Intel’s silicon strategy,” said Marques McCammon, vice president of automotive at Wind River. “I can align with Intel when it is appropriate for my customer, or I can align with Arm and its affiliates. I’ve got a lot more flexibility.”

Wind River’s automotive business will also benefit from the recent appointment of two people with estimable automotive experience to its board of directors. Moshe Gavrielov, now executive chairman, was CEO and president of Xilinx until his retirement in January 2018. Mark Fields, former president and CEO of Ford Motor Company, is a board advisor. “On this board I have the focus and attention of people who have lived and breathed automotive,” said Mr. McCammon.
Another advantage of Wind River’s separation from Intel is speed. “As a smaller, independent company our decision-making is streamlined,” said Mr. McCammon. “Since our exit from Intel we announced the partnership with Renesas. We also established a partnership with Autron, a software subsidiary of Hyundai, to develop Adaptive Autosar software for use by Hyundai and others.” Wind River also announced a design win with Ford to support Ford’s OTA strategy with differential update technology.

Wind River is the largest independent embedded software provider in the market, according to VDC Research, with approximately 23% of RTOS revenue and a 53% share of the commercial Linux market. Mr. McCammon believes that with its “strong safety-certification pedigree,” Wind River is well positioned to compete with QNX and Green Hills Software, its two closest automotive rivals. “But unlike those two, our portfolio goes beyond the real time operating system. Linux is also part of our portfolio.” Wind River has the ability to separate safety-critical and non-safety-critical systems using hypervisor software, or it can bridge between VxWorks and Linux workloads with the same proprietary technology it uses in aerospace applications, compliant to ARINC 653.

Automotive Software Market Constrained by Price
According to Mr. McCammon, forecasts for automotive software growth vary wildly, “everything from 5.5% to 15% year over year growth.” He is of the opinion that the growth rate will fall in the range of 8% to 10% per year in the near term, followed by considerably faster growth “as we put smarter, safer cars on the road.” Wind River’s automotive revenue grew 5% year-over-year in 2018.

One of the complexities in forecasting the automotive software market is the difficulty carmakers and tier ones have historically had in valuing software that’s embedded in hardware. Mr. McCammon: “The problem is you can’t touch software. If OEMs buy a microchip, they have analysts who are estimating how much silicon is in that chip. They know the market price of silicon, and they can predict movement in the market and build their pricing models accordingly. Software isn’t tied to any specific commodity. It is knowledge. How do you normalize the pricing of smart people?”

Taking this argument a step further, Mr. Garbus thinks the problem is that the embedded software buyers hold significantly more power than the sellers, making it difficult to get meaningful licensing revenue. “The procurement
people are savvy and they are cutthroat. If they see that the number of units is going up, they will push for deeper discounts.”

Given the growing importance of software as the means by which OEMs differentiate their vehicles, a more equitable balance between buyer and seller will have to evolve, sooner rather than later. Carmakers must learn how to value software fairly, and suppliers must learn how to distinguish their offerings from their competitors’.

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**Nvidia GPU Technology Conference, March 17-21**

Engineers and managers who are interested in Nvidia’s AV and ADAS platforms, artificial intelligence, autonomous driving, simulation and mapping will want to participate in next month’s conference at the San Jose Convention Center in California. Participants in the technical talks, hands-on labs, workshops and demonstrations will come from carmakers, truck makers, robotaxi companies, tier-one suppliers, mapping companies, sensor developers, startups and research institutions. More than 220 companies will exhibit.

**Automotive Session Speakers**

- BMW: Alexander Frickenstein, “Deep Learning for Autonomous Driving at BMW”
- Toyota Research Institute: Adrien Gaidon, “Beyond Supervised Driving” (Toyota’s research on large-scale robot design and human-machine interaction)
- Volvo: Andreas Wallin, “Autonomous Parking on NVIDIA DRIVE”
- TuSimple: Xiaodi Hou, “The Road to 1,000 Meters: New Perception System Breakthrough for Autonomous Trucking”
- MIT: Lex Fridman, “Human-Centered Autonomy”

Please visit [here](#) to register. Use this code to receive a 20% discount: MCXHANSEN.
The Company Profile: Aisin Seiki

**Background**

The business that evolved into Aisin Seiki was established in 1943 to produce aircraft engines for Japan. After WWII ended, the company changed its focus to automotive transmissions, chassis and brake products (and sewing machine parts). After a merger in 1965 with another auto parts company, the new entity Aisin Seiki was launched with a product line that now included clutch and body-related products.

Today, Aisin Seiki claims to be the number-one transmission manufacturer globally, offering manual, automatic, CVTs (continuously variable transmissions) and hybrid transmissions.

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**Headquarters:** Aichi, Japan; www.aisin.com

**FY 2018 Revenue:** ¥3,908.9 billion ($35.7 billion)

**R&D Expense:** 4.7% of revenue

**Capital Expense:** 6.7% of revenue

**EBITDA Margin:** 11.8%

**Operating Margin:** 6.5%

**Employees (Consolidated):** 114,478, as of March 31, 2018

**Sales per Employee:** ¥34.1 million ($311,432)

**Working Capital:** ¥504.7 billion ($4.6 billion)*

**Bonds and Loans Payable:** ¥499.6 billion ($4.6 billion)*

**Total Equity:** ¥1,882.8 billion ($17.2 billion)

**Market Capitalization:** $11.3 billion

**Principal Customer:** Toyota accounted for 58% of sales

**Ownership, Voting Ratio:** Toyota, 24.8%; Toyota Industries, 7.7%; Denso, 4.8%

*As of December 31, 2018

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**Aisin Seiki FY 2018 Consolidated Revenue by Group Company**

- Aisin Seiki Group, 1,776.2
- Aisin AW Group, 1,621.2
- Aisin Takaoka Group, 295.7
- ADVICS Group, 586.5

*As of April 1, 2019

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**Note:** Group revenues, which here sum to ¥4,434.3 billion, include significant trading between the groups. For example, Aisin Seiki manufactures automatic transmission cases for Aisin AW, a tier-one supplier of ATs; Aisin Takaoka manufactures brake discs for ADVICS, a tier-one supplier of brake calipers.
including eAxle. In the last fiscal year, group company Aisin AW produced 9.83 million automatic transmissions. The company sees AT production growing to 13.2 million units by FY 2021.

**Less Reliance on Toyota**
Aisin Seiki is a longstanding member of the Toyota *keiretsu*, the network of suppliers in which Toyota is usually the majority owner and largest customer. Toyota owns approximately 25% of Aisin Seiki. Aisin Seiki has been working to increase sales with non-affiliated OEMs and counts most of the world’s carmakers among its customers. In FY 2014 Toyota accounted for 64.5% of sales; in FY 2018 that figure was down to 58%. In the last fiscal year Aisin produced nearly a million more automatic transmissions than Toyota produced vehicles.

Aisin Seiki’s forecast for FY 2019 includes significantly more business with PSA, Suzuki, General Motors, Changan Automobile and other Chinese OEMs. According to a company spokesperson, Aisin Seiki’s success beyond Toyota is a result of its product reliability, performance and the compactness of its automatic transmissions.

While the company has shown steady growth over the last several years, its new president, Kiyotaka Ise, appointed in June 2018, sounded a cautionary note in his fiscal year-end comments. “Aisin Group is enjoying a growth in demand for mainstay
Aisin Seiki is becoming somewhat less reliant on its business with Toyota. During a three-year period of no growth in Toyota production, Aisin Seiki sales grew at 7.0% per year. Aisin Seiki’s revenue from business with Toyota will fall to 55.2% in FY 2019 from 58.0% the prior year.

Virtual Company System
Aisin Seiki seems to have been caught somewhat flat-footed by the momentum of the global automotive industry’s move toward electrification, automated driving and connected cars. It is making a concerted effort to keep up with not only its traditional tier-one competitors, but also the new challengers bringing advanced software expertise, from start-ups to the tech giants.

To optimize these efforts, the company initiated a restructuring into what it calls a Virtual Company (VC) System. It defines this new structure as “an organization transcending company boundaries that formulates and executes business strategies.” The four operating VCs, Powertrain, Chassis & Vehicle Safety Systems, Body, and ICT & Electronics, hope to improve efficiency by consolidating overlapping efforts among Aisin Seiki products such as automatic transmissions and is displaying strong business performance. However, during this major transformational period, steadily increasing business results are not something that can be expected to continue in the long term, and with the progressive shift toward powertrain electrification there is risk that demand for automatic transmissions may disappear altogether.”

**Aisin Seiki’s Major Customers**

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<th>FY 2018 Total Revenue: ¥3,908.9 billion</th>
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<tbody>
<tr>
<td>Toyota Group</td>
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<td>Volkswagen Group</td>
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<td>Changan Automobile</td>
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<td>Honda</td>
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<td>Others</td>
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**Toyota Car Production by Fiscal Year**

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<tr>
<td>2016</td>
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2016 to 2019 CAGR: 0.0%  
*Forecast
companies, drawing on the best talent within those companies, and sharing resources and research related to automated driving, electrification and connected cars.

Aisin Seiki could not make an executive available to comment for this article, but in an interview with securities analyst Takaki Nakanishi, the company’s executive vice president in charge of finance, Makoto Mitsuya, commented on how Aisin Seiki’s traditional structure has become cumbersome and inefficient:

Until now, the Aisin Group promoted sustainable growth by spinning off into separate companies any businesses that attained growth and then raised its expertise in these particular fields while achieving agile operations. However, this approach also had inefficient aspects. Because each company pursued its own growth, this led to a duplication of human resources, technologies and other resources among different companies. A prime example is that the same products were being produced by multiple group companies.

… The success of our future growth hinges on the VC System…
Electrification products will definitely receive the major share of R&D investments for at least the next several years, according to the company. Aisin has been showcasing EV-related products recently at the Paris Motor Show and at the North American International Auto Show.

♦ One-Motor Hybrid Transmission
Motor and engine cutoff clutch array installed in the torque converter section of the existing automatic transmission

♦ eAxle
Generates electric drive for the rear wheels in hybrid vehicles. An eAxle for 4WD vehicles is under development.

♦ EV Units
Integration of motor, inverter, decelerator and transmission into a single unit

Joining Forces with Keiretsu Partners
Toyota keiretsu partners made a series of announcements in 2018 about new companies, joint ventures and partnerships that combine their strengths and pool resources to address the megatrends currently transforming the industry, especially electrification and autonomous driving.

♦ Aisin Seiki and Denso announced a new 50-50 joint venture company in December called BluE Nexus that will begin operations in April 2019, pending regulatory approvals. The joint venture plans to develop a wide range of driving modules for electric vehicles that combine transaxles, motor generators and inverters. The modules will also be adaptable for hybrid and plug-in hybrid vehicles.

♦ Aisin Seiki combined its subsidiary company Aisin AI with another subsidiary, Aisin AW. Aisin AW’s principal products are automatic transmissions, hybrid transmissions and car navigation systems. AI makes manual transmissions.

Aisin AW is one of 11 Japanese partners cooperating in a project called Transmission Research Association for Mobility Innovation, or TRAMI. Nine of the participant companies are Japanese OEMs. The partners will research the most effective ways to transmit power from engines and motors and all the participants will have access to any technologies developed by the group.
Aisin Seiki, ADVICS Co., JTEKT Corp. and Denso are partnering in a new joint venture that will be formally established in April 2019, called J-QuAD DYNAMICS. The new company will develop integrated control software for automated driving. The purpose of the new software will be to better manage acceleration, turning and braking in self-driving vehicles. The joint venture will be 65% owned by Denso, 25% by Aisin, 5% by ADVICS and 5% by JTEKT.

Together with Toyota Research Institute and Denso, Aisin Seiki is a minor (5%) partner in a new company called TRI-AD, formed in 2018. TRI-AD’s mission is to create fully integrated, production quality software for automated driving.

**Aisin AW**
Established in 1969, Aisin AW, the second largest subsidiary company within the Aisin Group, is at the core of the corporate effort to develop and commercialize zero emissions, autonomous and connected technologies. Its primary products are automatic and hybrid transmissions and navigation hardware and software. The company is number one in automatic transmission market share and number two in car navigation.

Aisin AW reported sales of ¥1,621 billion ($14.8 billion) in FY 2018, with an 8.8% operating margin. It employs approximately 30,000 people at locations in Japan, Europe, Asia and the U.S.
Aisin AW provides voice controlled navigation systems for global carmakers including Lexus, Toyota, Audi, Volkswagen and Porsche. It has developed voice navigation systems for use in China, Europe and North America as well as Japan.

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**Aisin Seiki Navigation System and Software Sales by Fiscal Year**

in millions of units

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software</td>
<td>0.61</td>
<td>0.55</td>
<td>0.53</td>
<td>0.61</td>
</tr>
<tr>
<td>Systems</td>
<td>1.44</td>
<td>1.78</td>
<td>1.81</td>
<td>1.6</td>
</tr>
</tbody>
</table>

CAGR 2016 to 2019

Navigation Software: 0.0%

Navigation Systems: 3.6%

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**Aisin Seiki’s Major Automotive Products**

**Powertrain**
- Automatic transmissions
  - RWD 6-speed for light duty trucks and buses
  - RWD 10-speed for passenger cars
  - FWD 8-speed for passenger cars
  - Continuously variable RWD multistage hybrid
  - 6-speed manual transmissions
  - Dampers for hybrid vehicles
  - Clutch cover, clutch discs
  - Electric 4WD units
  - Electric water pumps for engine cooling, inverter cooling
  - Electric oil pumps for idle stop
  - Variable valve timing
  - Exhaust manifolds and converters
  - Water pumps
  - Flow shutting valves
  - Continuously variable capacity oil pumps

**Pistons**
- Cylinder head covers
- Oil pans
- Timing chain cases with water and oil pumps

**Chassis and Vehicle Safety**
- Parking assist systems
- Disc brakes
- Electric-assist parking brakes
- Brake boosters and master cylinders
- Active rear steering systems

**Body**
- Power sliding door systems
- Sunroofs
- Pneumatic seats
- Grille shutters
- Seat recliners and adjusters

**Information and Communications Technology (ICT) and Electronics**
- Car navigation systems
- Voice activated car navigation systems
- ECUs for:
  - Electric pumps
  - Door systems
  - Chassis
  - Automatic transmissions
  - Brakes
  - Locators
- Sensors for:
  - Electric current
  - Stroke
  - Occupant detection
  - Capacitance (smart door handle)
  - Lexus emblem openers

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The Hansen Report on Automotive Electronics, February 2019

[www.hansenreport.com](http://www.hansenreport.com)
WCP’s Autonomous Vehicles Report

The financial advisory and strategic consulting firm Woodside Capital Partners (Palo Alto, California) published its Autonomous Vehicles Technology Report at the end of last year, and while not perfect it provides a comprehensive look back at the global automotive investment picture from 2015 through 2018. Here are some of the highlights from this 103-slide presentation.

China
China doesn’t yet have much of an impact on Western car markets, but with the advent of electric and autonomous vehicles, that is about to change dramatically.

- China will likely be the largest market for self-driving cars. In 2017, 29 million new vehicles were sold in China, more than were sold in the United States, Japan and India combined.
- The three largest technology firms in China, Baidu, Alibaba and Tencent, are getting into the self-driving car business.
- Baidu, the leader among the three, has formed partnerships with Microsoft, Intel, BMW, Ford and Daimler.
- Baidu said it wants its Apollo autonomous vehicle platform to become “the Android for automated vehicles.”
- In 2017, China overtook the U.S. in artificial-intelligence financing deals.
- Cambricon Technologies, already the first AI chip startup to reach a valuation greater than $1 billion, was valued at more than $2.5 billion after recent round-B financing.

The Lidar Bubble

- The automotive lidar market is overcrowded with competitors hoping to win a significant share of the business. A report WCP produced with Yole Développement in April 2018 identified 32 automotive lidar manufacturers.
- Venture investment in lidar developers accounted for 19% of the $5.8 billion autonomous vehicle total that was invested during the 2015 to 2018 period.
- Lidar is unlikely to see much deployment in consumer vehicles until the price to OEMs drops below $200. While solid-state lidar may ultimately meet this price target, it is unlikely that this technology will meet all the OEM requirements for at least another five years.