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Seeing Machines Sees DMS Market Intensify

Automotive regulatory bodies in the United States, Japan and especially in Europe are focusing new attention on camera-based driver monitoring systems (DMS) as a way to not only reduce the number of accidents caused by drowsy or distracted drivers, but also as an essential part of semi-autonomous driving systems today and fully autonomous driving systems in the future.

The Euro NCAP Roadmap 2025, released in September 2017, identified driver monitors as a primary safety feature that should be required in order to achieve a five-star safety rating. The organization will incentivize driver monitoring systems that "effectively detect impaired and distracted driving and give appropriate warning and take effective action" to avoid or mitigate a collision. The roadmap initially called for implementation in 2020, but because clear guidelines and testing protocols have not yet been finalized, the requirement could be delayed beyond 2020.

Following a high-profile crash of a Tesla with Autopilot engaged, the U.S. NTSB (National Transportation Safety Board), which lacks regulatory authority, recommended that driver monitors be included as part of semi-autonomous driving features. In its response to the same accident, the Japanese MLIT (Ministry of Land, Infrastructure, Transport and Tourism) stated that because features such as Tesla's Autopilot are not fully automated such systems are not responsible for operating the vehicle safely—the driver is.

Gaining the attention of global OEMs and tier ones is the Australian DMS supplier **Seeing Machines**, of Canberra. With 18 years of research and development behind its product, Seeing Machines was sourced by **Cadillac** to supply the driver monitor system for its Super Cruise highway pilot feature on the 2018 Cadillac CT6. The DMS uses a camera mounted on the steering column and infrared LEDs mounted in the steering wheel to track the operator's eye gaze when the self-driving feature is engaged. If the driver's gaze strays from the road for too long, Super Cruise initiates a series of alerts and warnings; if they are ignored, the system disengages.

Cadillac Super Cruise

Over the past year or so Seeing Machines has booked DMS business with a second U.S. carmaker that will start shipping in mid-2020; a Chinese OEM going into production at the end of 2019; and two German OEMs going to production in 2019 and 2020. “We are pretty much engaged with all the OEMs and tier ones around the world right now,” said Kevin Tanaka, Seeing Machines’ senior director of marketing for automotive. “We have equipment being evaluated at the third major German OEM and at four of the five major Japanese OEMs,” he added. At present, the company licenses its technology to Veoneer and three other tier ones for OEM programs, in some cases as part of the OEM’s requirements. Six more tier ones are currently evaluating the technology, according to Mr. Tanaka.

Inferred driver monitoring, which uses steering torque and braking measurements to infer that the driver is drowsy or not paying attention, has been in cars for more than a decade and deployment is not limited to high-end luxury cars. But without being able to see what the driver is doing, these basic systems can trigger false warnings or fail to warn when they should.

Seeing Machines believes camera-based monitoring is essential for determining the driver’s state of engagement in the driving task and his state of attention if an L3 autonomous system is active. The problem of re-engaging the driver, handing off control of the vehicle if an L3 system shuts down, remains one of the biggest challenges for OEMs implementing these functions. “OEMs are really starting to understand how difficult this is,” Mr. Tanaka noted. “Trying to read and understand the human face, and turn it into something digital that a vehicle’s electronics can understand, is probably the most difficult thing inside the car.”

Camera-Based Active DMS

Seeing Machines’ first generation DMS, which is on the 2018 Cadillac CT6, was largely based on tracking head pose, the direction in which the head is positioned, to determine where the driver was looking. In 2019 the company will begin shipping its next generation of driver monitors, which implement highly accurate eye gaze tracking and eyelid movements—how open the eye is, how many blinks per minute, even the velocity of the blinks.

The second generation DMS, which begins shipping in 2019, uses two sets of 940 nanometer, strobing IR LEDs, one on each side of the CMOS camera. Separating the lighting elements makes the pupil of the driver’s eye appear as dark as possible, which allows the sensors to distinguish it from the iris, providing a higher level of accuracy in determining eye gaze, where the driver is looking both inside and outside the vehicle. Mr. Tanaka explained: “We track each eye individually. By controlling both the lighting environment and the sensor on

every single frame, by utilizing that high quality data that is coming in, we get what is called very high availability. This means that we are processing in real time, and we are able to understand where the driver is looking. Our algorithms create a very tight control loop back to the camera."

Seeing Machines plans to start shipping driver monitoring systems in 2020 with added capability for driver ID to enable personalization of cockpit features such as audio, seat and mirror position.

An important participant in developing the algorithms behind the latest generation system is Seeing Machines' Human Factors Group, which includes physiology and psychology researchers. "They work on developing algorithms that take into account what is actually happening with the human, looking at the face, the eye gaze patterns," Mr. Tanaka said. The Human Factors Group has been working with Euro NCAP and the European Commission pressing the case for specifying driver monitoring systems that are camera based.

Seeing Machines' fiscal 2018 automotive revenue was $8.1 million, nearly 400% higher than the previous year. According to Mr. Tanaka, much of the growth came from non-recurring engineering engagements as well as sales of its software tools. Seeing Machines licenses its scalable software and IP as a standalone product or packaged on its own branded FDM (Fovio Driver Monitoring) chip. The FDM chip is supplied by Xilinx. Depending on volumes and what features and functions are required by the OEM, the systems sell in the range of the low- to mid-hundreds of dollars.

As the driver monitor market accelerates, Seeing Machines targets a market share between 25% and 40%. Competition will likely intensify.

◆ **Denso** has partnered with Xperi Corporation brand **FotoNation** on camera-based driver monitors.

◆ Israeli startup **eyeSight Technologies** partnered with Chinese tier one **Shenzhen Soling Industrial** to develop driver monitors for the Chinese market based on eyeSight's gaze tracking and face recognition technology.

◆ **Subaru's** EyeSight driver monitor uses facial recognition technology from **Mitsubishi Electric** for drive identification.

◆ **SmartEye AB**, from Gothenburg, Sweden, has an IR camera-based DMS capable of eye tracking. The technology was demonstrated in a Mercedes concept vehicle.

◆ **Affectiva**, an MIT Media Lab spinoff, uses artificial intelligence to measure emotional and cognitive states using a combination of RGB and near IR cameras to track facial expressions and head movements. Affectiva Automotive AI is focused on driver monitoring.

◆ Palo Alto, California-based **Eyeris** also applies AI to vision-based face and body analytics for monitoring drivers and occupants in autonomous vehicles. According to a press release from CES 2018, Eyeris customers include Toyota, Bosch, Mitsubishi Motors, Honda and Hella. ◆

New Interoperability Computing Environment Gives Hope to V2X Champions

In October 1999 the U.S. Federal Communications Commission set aside 75 MHz of spectrum in the 5.9 GHz band for intelligent transportation. Before long, it was thought, cars would be communicating with each other and with roadside equipment. Driving would become significantly safer. Traffic would be better managed. Here we are 19 years later, and the promise of intelligent transportation is not even close to being realized.

V2X development has been stymied by the difficulty of building credible business cases. Hopes for government mandates have faded. In-vehicle features that employ the technology won't work until enough other vehicles are similarly equipped or a widely distributed roadside infrastructure is built.

U.S. Department of Transportation officials tasked with searching out and promoting technologies that improve safety and relieve highway congestion are not giving up. One of the difficulties in making use of all the V2X technology sitting on the shelf is the cost to develop applications based on it.

If a state DOT office or business startup were to get an idea for an infrastructure project based on V2X they would quickly come up against the enormously costly software development hurdle of getting everything to work in an interoperable fashion. The cost of bringing good ideas to transportation scale is too high.

Officials in the USDOT think they have found an answer to the transportation industry's interoperability headaches in a new computing architecture developed over the last 25-plus years by Sanford B. Klausner, CEO of CubeFog. Mr. Klausner, who developed the Opus BAS (building automation system) now owned by Honeywell, works from his apartment atop San Francisco's Russian Hill. He has been devoting 100% of his time to creating Cubicon, an architecture that automates M2M networks the way his BAS architecture automated building systems. Thus far as much as $15 million has been invested in the development of Cubicon, including grant funds from the U.S. Department of Commerce's National Institute of Standards and Technology (NIST).

Mr. Klausner describes Cubicon this way:

> Cubicon is a context-based systems language that expresses software using a graphical-based integrated development environment. It produces designs that directly execute on an IPv6-based virtual machine. The VM is a secure system execution engine with real-time performance and small memory footprint for embedding into all devices and things.

A key USDOT official, who was not allowed to be named, told me that he is convinced that the Cubicon integrated development environment with its automatic code generator and virtual machine can dramatically lower the entry barriers standing in the way of V2X applications.

He said: "Someone who is knowledgeable of an application and wants to implement the application in this environment can use the Cubicon toolset to automatically create all the software components that would allow the application to run in any of the physical devices. The virtual machine and the communications protocol are created from the same roots, so they would automatically be compatible. All this is done in a graphical CAD environment, so it becomes much more drag-and-drop visual design as opposed to writing code."

The Cubicon architecture, which addresses the issues of complexity management, interoperability, security and robustness, was being developed for the Internet of Things. But as USDOT officials became familiar with the Cubicon project, they were able to convince Mr. Klausner to initially target transportation. For a deep dive into the Cubicon architecture you can download a tutorial here.

A test and showcase of Cubicon's technology supported by **Intel** and **Arrow Electronics** is in the early planning stages. The work will get underway in the coming months as soon as Arrow's Colorado Open Lab is completed. The team will first build the toolset that creates the Cubicon virtual machine with its memory manager. The toolset will support the creation of state machines and other control strategies from which implementable C code is automatically generated. The Open Lab will then apply the toolset to build the elements of an intelligent transportation system.

In concert with the Colorado Open Living Lab, Jeff Fedders, director of Ambient Science standards at Intel, is establishing a number of IEEE working groups to develop ambient computing and connectivity standards. "One possible work item would be the creation of data object semantic definitions, somewhat like a periodic table of types of Ambient Objects," he said.

It will be many months or even years before any of this new technology finds its way into the hands of ITS developers. The Colorado Open Lab at Arrow Electronics' global headquarters which is still under construction in Centennial, Colorado, won't open until the second quarter of 2019. According to Aiden Mitchell, vice president of IoT global solutions at Arrow Electronics, the alliance team that will be working on the Cubicon test and showcase will be coordinating their work over the next two years coincident with the rollout of 5G infrastructure, which will be required for this new environment. "We have the test bed, we have 19 cities that are anxious to be part of this, and we are now waiting on the IEEE working group to announce the ecosystem so we can start to integrate it into this test bed. We at least want to get the infrastructure up so vehicles can start to interface with it," said Mr. Mitchell.

At this early stage, USDOT officials are "cautiously optimistic until an actual implementation can be observed." The Cubicon technology will be great if it works. ◆

BMW Wants More Self-Driving Development Partners

BMW's business development vice president, Martin Isik, who is leading the effort to expand the carmaker's self-driving platform partners beyond **FCA**, **Intel/Mobileye**, **Magna**, **Aptiv** and **Continental**, enumerated the benefits of membership in the alliance. "The development of the technology is extremely expensive, so one obvious advantage is you can lower the required investment by sharing costs across multiple partners. You also share the risks and the liability. With multiple OEMs validating and homologating the technology, you can make a much better case for it with the regulatory bodies." The suppliers on the team can achieve greater economies of scale by serving multiple carmakers with a single product rather than having to create multiple variants.

The BMW alliance is not exclusive; each partner is free to pursue business outside the alliance. While no official announcement has been made, BMW will almost certainly give production orders to suppliers in the alliance, at least for the 2021 launch of its first generation L3 system, on the BMW iNEXT. The carmaker's next-generation electric crossover vehicle will be capable of driving without operator involvement at speeds up to 130 km/h on German motorways.

Magna and partner **Innoviz Technologies** will supply the solid-state lidar sensor. Mobileye, "the market leader in computer vision," according to Mr. Isik, will supply image processing software. BMW is cooperating with Mobileye on near real-time map localization. Intel will supply multicore processors and some of the software. Continental will likely supply key components for the autonomous driving platform and will assist with the integration of components and software.

An Intel press release issued when Aptiv, then Delphi, joined the alliance stated: "A key role for [Aptiv] will be the integration of the solution delivered by BMW Group, Intel and Mobileye into OEM vehicle architectures. Additionally, [Aptiv] may also provide required hardware components such as sensors. … As an integration partner [Aptiv] will help to accelerate the introduction of autonomous cars from multiple carmakers and offer differentiation to customers."

In parallel with their contributions to the BMW/FCA platform, Intel and Mobileye are developing a different autonomous driving platform on their own. BMW is also a member in Apollo, the open autonomous driving platform effort spearheaded by **Baidu**. China is BMW's biggest market, accounting for 24% of vehicle sales in 2017.

While some software modules will come from alliance partners, the critical autonomous driving functions including sensor fusion and driving strategy are being developed by BMW together with FCA. BMW and FCA both believe that strategic partnerships are critical for the development of these technologies and the platforms look very similar. "We have the same goals and interests," said Mr. Isik.

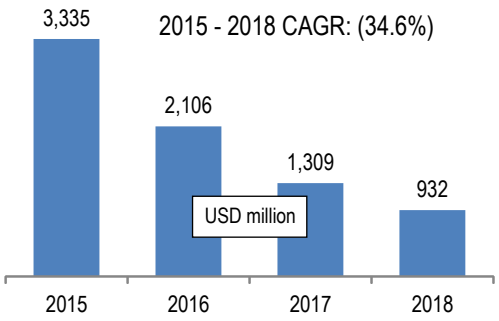
If other carmakers were to join the alliance they could gain access to the platform's proprietary technology by entering into discussions with BMW and FCA.

"Bringing this platform to scale is a massive challenge requiring lots of work and talent," said Mr. Isik. "There are many challenges, not the least of which is proving to regulators that this is safer than human driving." ◆

The Company Profile: BlackBerry QNX

Thumbnail Sketch
BlackBerry QNX is the largest business unit within the BlackBerry Technology Solutions (BTS) product and services segment of BlackBerry Ltd. Fiscal year ends in February.
Headquarters: Ottawa, Ontario, Canada
FY 2018 Revenue: $100 million*
Employees: 550*
Revenue per Employee: $182,000*
Major Products: Embedded operating systems and middleware
Top Customer: Ford Motor Company
Top Market: Automotive software
Key Strength: Functional safety expertise

**BlackBerry Ltd. Revenue and Net Margin by Fiscal Year*

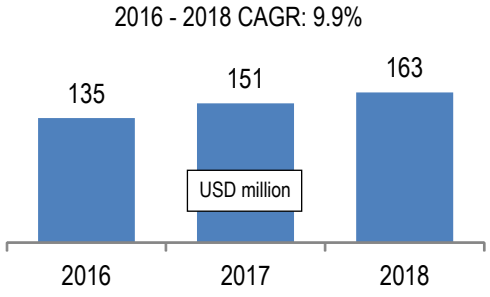


Net Margin*

2015	(9.1%)
2016	(9.6%)
2017	(92.1%)
2018	43.4%

*Hansen Report estimates

BlackBerry Technology Solutions (BTS) Revenue by Fiscal Year



BlackBerry QNX is the largest business unit within the BlackBerry Technology Solutions (BTS) product and services segment of BlackBerry Ltd. Other BTS segments include Certicom, Paratek and BlackBerry Radar, as well as some units advancing emerging innovations such as BlackBerry Jarvis.

Background
In 1980 partners Dan Dodge and Gordon Bell launched Quantum Software Systems, which became QNX in 1984. With the release in 2001 of the first version of the QNX Neutrino operating system for embedded real-time applications, QNX saw the potential for growth in the automotive market, initially in infotainment systems. Today the automotive market generates more than half of QNX revenue. The bulk comes from operating systems and middleware for infotainment and from telematics operating systems. QNX is number one in the world in these products. Most of QNX's embedded software is licensed on a per-unit royalty basis. Dan Dodge

retired from QNX in 2015 and in 2016 joined Apple's automotive team. Gordon Bell left QNX in 2004 and rejoined the company in 2017.

The company also serves the medical and industrial automation markets. Within the past year, roughly, QNX has won business with Baidu, Aptiv, Denso, Nvidia, Qualcomm and Visteon. QNX is aggressively hiring software engineers.

QNX Software Systems was owned by Harman International from 2004 to 2010. Today the business, BlackBerry QNX, is a wholly owned subsidiary of BlackBerry.

BlackBerry QNX Targets Automotive Safety and Security for Growth

QNX has been involved with the auto industry since the late 1990s when it first showed up as the operating system used in telematics control systems made by Motorola for OnStar. OnStar was founded in 1996. Over the intervening years, QNX operating system and middleware applications moved beyond telematics units to infotainment, and most recently to clusters, ADAS and autonomous driving systems.

BlackBerry acquired QNX from Harman with the expectation that QNX's software capability could help BlackBerry recapture a significant share of the smartphone business from iPhones and Android-supported phones. That strategy did not pay off. In September 2016, BlackBerry announced it was exiting the hardware business, and the company's share of the smartphone market had declined virtually to zero by the end of the year, according to Gartner. While BlackBerry still designs and markets wireless handsets, now based on Android, and sells software and services, it now sees itself as an enterprise software company focused on securing and managing IoT endpoints.

Top BlackBerry QNX Automotive End Customers

(Listed alphabetically)

Audi
Fiat Chrysler Automotive
Ford

Others

BMW
GM
Honda
Hyundai
JLR
Kia
Maserati
Mercedes-Benz
Porsche
Toyota
Volkswagen

Major Automotive Products

QNX

Neutrino RTOS
Wireless framework
Platform for infotainment
Platform for instrument cluster
Platform for ADAS
OS for safety
Hypervisor 2.0
Acoustics management platform
Momentus tool suite
Software OTA update management service
Managed public key infrastructure (PKI) service

BlackBerry Jarvis

Cloud-based binary code scanning tool

For carmakers, software has become an essential ingredient in creating customer appeal. Indeed, the share of the vehicle BOM that is software is quickly growing.

Given its solid portfolio of the operating systems and middleware on which software functionality is built, QNX is well positioned to profit from the rise in automotive software.

QNX has been active since its founding with mission critical systems, including nuclear power plants, surgical robots and class III life-critical medical devices. Lately QNX has been gaining notice for the role its embedded software is playing in key autonomous driving platforms including Nvidia Drive and Baidu's Apollo.

As more and more cars are connected, and as more are equipped with higher levels of autonomy, carmakers have become increasingly reliant on QNX's safety and cybersecurity capabilities. In response, BlackBerry recently sharpened its focus on the auto industry. In a December 2017 *Wall Street Journal* article, chief executive John Chen is quoted saying that "the auto sector is Blackberry's best chance for revenue growth." In a keynote speech delivered one month later at the North American International Auto Show, Mr. Chen declared that automotive is a big part of BlackBerry's larger strategy to provide the security backbone for the emerging Enterprise of Things.

BlackBerry claims to have the industry's broadest portfolio of products to protect vehicles against cybersecurity attacks, and the best-in-class functional-safety certified operating systems, tools and other products for autonomous and connected vehicles.

QNX began an impressive accumulation of safety certifications in 2009, most recently for its ADAS and instrument cluster platforms and hypervisor. (Please see list on page 14.)

The demand for functional safety is encompassing more and more of the vehicle. QNX is seeing functional

Distinctions Claimed by BlackBerry QNX

- Number-one telematics operating system
- Number-one infotainment software supplier
- 100% success in meeting SOP deadlines
- As of June 2018, QNX software was embedded in 120 million cars.
- The leader in safety-certified, secure and reliable software for the automotive industry
- Offers the broadest portfolio of software products and tools to protect vehicles against cybersecurity attacks
- With Denso, BlackBerry developed the world's first HMI platform for use in virtual cockpits.

safety requirements not only for its infotainment system, cluster and ADAS platforms but also for hypervisors and communications gateways, even for audio safety alerts.

In June 2018, QNX announced three new safety-certified automotive software products: Hypervisor for Safety, Platform for ADAS 2.0 and QNX OS for Safety 2.0. A derivative of IEC 61508, ISO 26262 is the functional safety standard for automotive electrical and electronics systems.

QNX Safety Certifications	Year Awarded
QNX OS certified to Common Criteria ISO/IEC 15408	2009
QNX OS certified to IEC 61508	2010
QNX OS certified to IEC 61508 and Common Criteria ISO/IEC 15408	2012
QNX OS compliant with IEC 62304	2014
QNX OS certified to ISO 26262 ASIL D	2014
QNX OS certified to ISO 26262 ASIL D and IEC 61508 SIL 3	2014
QNX Platform for ADAS v1.0	2016
QNX Platform for Instrument Clusters with Graphics Safety Monitor certified to ISO 26262 ASIL B v1.0	2017
QNX Platform for Instrument Clusters with Graphics Safety Monitor certified to ISO 26262 ASIL B v2.0	2018
QNX Platform for ADAS v2.0	2018
QNX Hypervisor for Safety certified to ISO 26262 ASIL D	2018
QNX OS for Safety v2.0 certified to ISO 26262 ASIL D and IEC 61508 SIL 3	2018

Part of the QNX operating system's appeal to developers is its similarities with Linux. "From a developer's perspective, we are a lot like Linux," noted Grant Courville, vice president of BlackBerry QNX. "QNX and Linux are both Posix compliant. QNX's utilities are a lot like Linux's, but you can't get to ASIL D on Linux. So when developers are asked to prototype something that is automotive grade, we are the logical choice."

QNX Competitors

OS/Platform Provider
Alphabet (Google)
Green Hills Software
Wind River (Intel)
Mentor (Siemens)
Microsoft
Sysgo AG

OTA Update Management Providers
Aptiv
Intel
Samsung
Verizon Telematics
OEM-developed solutions

Hypervisor

Perhaps BlackBerry QNX's hottest automotive product right now is its hypervisor. "Everybody is building these domain controllers, and all of them need hypervisors," said Mr. Courville. QNX Hypervisor 2.0, a real-time Type 1 hypervisor, was launched in June 2017. Many carmakers are developing cockpit domain computers, which

combine the control of the vehicle's infotainment system and the cluster on a single SoC. The hypervisor software maintains necessary separation between safety-critical functions such as speedometer, odometer and gas gauge, and non-safety critical functions such as audio streaming. The instrument cluster interfaces with critical driving systems and thus needs to be both safety certified and secure. Type 1 hypervisors run directly on hardware, in this case the SoC.

"Hypervisors can be used to separate multiple different operating systems," said Mr. Courville. "A carmaker might want to run classic Autosar beside a QNX virtual machine. Some are going to hypervisors because they want an added level of security, or they want to isolate that Android- or Linux-based system from the rest of the car. With a hypervisor you can control access to anything that the Android system tries to access." QNX expects to start seeing licensing revenues from hypervisors in 2019.

QNX Platform for ADAS 2.0
This software platform supports advanced driving assistance system modules, including sensor fusion systems. The platform's safety-certified and secure software can make use of special-purpose hardware (accelerators) for vision processing and deep neural-network-based machine learning algorithms.

QNX OS for Safety 2.0
This software platform is designed to support mission-critical, safety-certified systems for connected or autonomous vehicles. It is based on BlackBerry's most advanced and secure QNX SDP 7.0 operating system.

OTA Update Service
Leaning on its estimable experience delivering software updates to BlackBerry phones, QNX is offering an over-the-air software update management service for carmakers. QNX has already booked customer orders.

BlackBerry Jarvis
In January 2018 the company introduced BlackBerry Jarvis, a cloud-based, static binary code-scanning tool that identifies vulnerabilities in automotive software. With Jarvis carmakers are able to scan raw binary code such as C++ applications from third-party suppliers quickly and efficiently while providing insights on ways to harden cybersecurity defenses and comply with industry standards. Static analysis of computer code is performed without having to run the code in a program.

BlackBerry Jarvis was used internally by the company and has been extended for use by carmakers and automotive tier ones.

BlackBerry has been running trial programs with Jarvis at some of the world's largest carmakers. "The response to Jarvis has been extremely encouraging," said Mr. Courville. "Every demonstration we have done with an OEM has led to a pilot."

A study of BlackBerry Jarvis by JLR found that the code assessment tool could accomplish in seven minutes what it took human researchers 30 days to do. Ford will also use the tool. Once customized, customers will pay for Jarvis on a pay-as-you-go basis.

Partnerships

Ford

Ford is QNX's most significant partner. Ford's Sync 3 infotainment system is largely based on QNX software. Since its work on Sync 3, QNX's relationship with Ford has strengthened. In March 2017, after BlackBerry had made the decision to transition away from its handset business, Ford agreed to take on 400 BlackBerry employees, most of whom are software engineers. "The engineers came not from QNX but from BlackBerry," noted Mr. Courville. "They had a little bit of automotive experience, but Ford saw an opportunity to acquire a critical mass of talent that knew Linux, knew QNX and knew Android." Ford received $154 million from Canada to keep those employees in Canada. The engineers remain in the same building in Waterloo, Ontario, where they worked when they were part of BlackBerry. Hundreds of engineers have since been added to the Ford team in Waterloo.

In FY 2017 Ford reached a non-exclusive agreement with BlackBerry to license QNX OS, hypervisor and audio processing software, as well as Certicom and other security software, directly from QNX, rather than through third parties. According to QNX, Certicom allows silicon chips used in ECUs to be injected with private keys and certificates to create a Root of Trust.

Ford is forthcoming about the role QNX safety-qualified software will play as the carmaker transitions to domain architectures. In a recent discussion we had with Chuck Gray, Ford's global director of electrical and electronic systems engineering, about which standards Ford is supporting, Mr. Gray said, "We've been public about having a strong relationship with QNX. They offer a very robust, reliable and safe operating system. We use it where we feel it is necessary in critical systems. With domain controllers it seems like a very

strong choice to allow multiple systems to run on single ECUs or even single chips, to give us the safety function we need."

Jaguar Land Rover
In March 2018, BlackBerry and JLR announced that the companies had entered into a multi-year agreement to collaborate and develop technology for the carmaker's next-generation vehicles. BlackBerry will license QNX and Certicom technology to JLR and assign a team of engineers to support the development of new ECU modules, the first of which will be part of a next-generation infotainment system.

Baidu
In January 2018, BlackBerry and Baidu signed a statement of intent to make QNX's ISO 26262 ASIL-D certified operating system the foundation for Baidu's Apollo autonomous driving platform. The two companies will also work to integrate Baidu's CarLife, the leading smartphone integration software for cars in China. Among hardware/software platforms, Baidu's open Apollo platform, which has the blessing of the Chinese government, is very much in the lead in China, with more than 100 supporters there and elsewhere.

Nvidia
In January 2018, Nvidia announced that it will base its industry-leading self-driving platform on QNX's safety-critical real-time operating system. Nvidia's Drive platform has broad support among the world's autonomous vehicle developers.

Aptiv
In September 2017, BlackBerry reached an agreement with Aptiv to supply the QNX operating system on which Aptiv's CSLP (Centralized Sensing, Localization and Planning) autonomous driving platform is based. Scheduled for launch in 2019 on a BMW high-speed highway pilot system, CSLP is being developed by Aptiv and Mobileye.

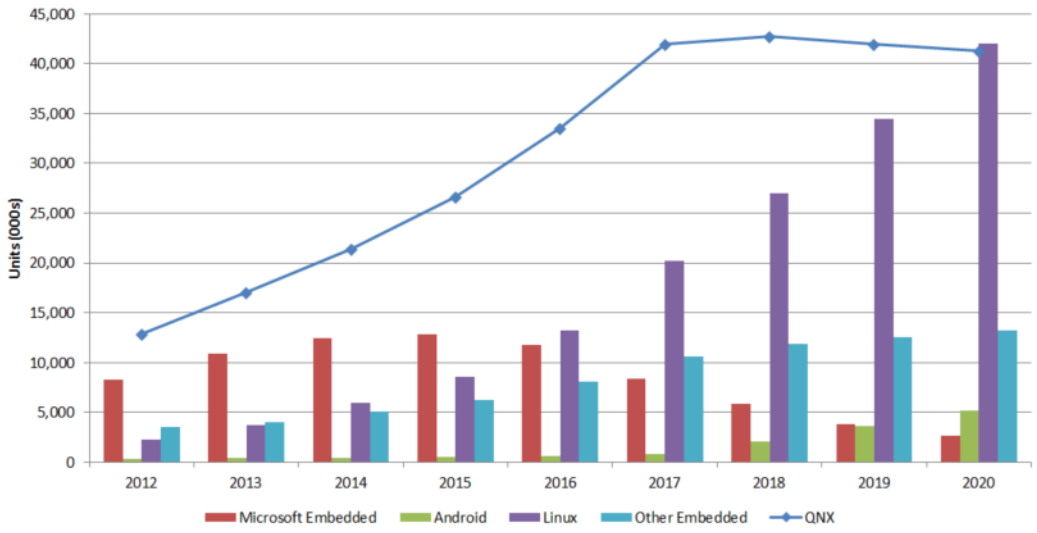
Denso
In December 2018, Denso and BlackBerry announced that they had jointly developed the world's first integrated HMI platform. The platform will employ QNX's hypervisor for virtualization and an Intel Atom processor.

BlackBerry QNX Autonomous Vehicle Innovation Center (AVIC)
BlackBerry established AVIC within its facility in Ottawa as a way to promote collaboration with small and mid-sized companies, tier ones, universities and the public sector in developing and testing autonomous vehicles. The center includes a large garage area, lab and two test tracks. In addition, QNX is licensed to test autonomous vehicles (with a safety driver behind the wheel) under real world conditions on Ontario roads.

Infotainment
QNX has for many years been the leading supplier of infotainment operating systems. But according to Strategy Analytics, QNX's year-to-year increase in unit sales will peak in 2018 at roughly 43 million as the company shifts its focus to hypervisors and functional safety platforms. Linux operating systems have been on the rise but will also soon peak as Android operating systems rapidly emerge.

In China, according to Strategy Analytics, QNX has the leading infotainment OS share among international carmakers at 60% but only has a 5% share among domestic carmakers. In China, Android is by far the leader with 95% of the market. ◆

Global Infotainment Operating System Market Share



Source: Strategy Analytics

China Speeds Ahead, According to Roland Berger Study

Automotive Disruption Radar (ADR) is the Roland Berger consultancy's biannual analysis of market trends related to disruption in the global automotive industry, especially in electric vehicles and automated driving. The findings of the fourth and latest report are based on a survey of 14,000 car users in 14 countries (Belgium, China, France, Germany, India, Italy, Japan, Netherlands, Russia, Singapore, South Korea, Sweden, UK and USA).

The results are scored along 26 indicators, grouped into five topics:

- Customer Interest: Do people want autonomous vehicles and to what extent
- Regulation: What are the regulatory conditions
- Infrastructure: How developed is the infrastructure for autonomous vehicles
- Technology: How far advanced is the technology for autonomous driving
- Industry Activities: Which solutions have been announced or already exist

The report found that no country is moving as aggressively as China in all aspects, and "with this pace ongoing, China will soon become the leading auto-tech nation."

In the Technology and Industry Activities areas, China's performance was strong, notably in its successful partnering with foreign companies. For example, BMW's and Honda's cooperation with Baidu in its Apollo autonomous driving platform; Audi's partnering with Huawei on AD for the Chinese market; and Daimler's adoption of Baidu's connected services for MBUX.

ADR also noted increasing adoption of electric vehicles—39% of Chinese customers indicated they would buy an EV to replace their use of public transport. And, "despite having a huge road network, China doubled its charging infrastructure in the past year, from 2.5 charging stations per 100 km of roadway to 5.7."

EV Sales Evolution

	EV Sales Penetration Apr. 2017	EV Sales Penetration Sept. 2018	EV Sales HY 2018 000 Vehicles	Growth Rate HY 2017 vs. HY 2018
China	1.40%	2.90%	387.7	102%
Western Europe	1.30%	1.70%	119.2	31%
USA	1.00%	1.50%	123.5	37%
Japan	1.10%	0.90%	25.6	-14%
South Korea	0.50%	1.40%	12.7	167%

Data: Roland Berger

The complete ADR4 report, published in September, is available on Roland Berger's website.