Plugging in with Kent Helfrich, GM Director of Global Electrical

We recently had the opportunity to talk with General Motors’ Kent Helfrich, who is responsible for the electrical engineering of everything aboard the vehicle with the exception of infotainment/HMI and the powertrain. Mr. Helfrich has been especially busy lately with the launch of GM’s full-size trucks. “With our tremendous amount of new product entering the market, we are very focused on quality; if there is anything that seems to be amiss we all descend on it right away.”

Thinking more long term than this summer’s launches, I asked Mr. Helfrich what help he may need from suppliers.

Because vehicle control systems must increasingly share sensors and actuators, Mr. Helfrich would like to see more flexibility from suppliers to make that easier. “We need to be able to have systems interoperate. Standards like Autosar and standards for serial data communications give us a common vocabulary that allows us to go to a tier one in the U.S., Germany or Japan and have them build our systems. But on occasion we need more flexibility from our suppliers so we can disaggregate systems and recombine elements of them. That will allow us to reuse them in our vehicle platforms.”

With advanced safety systems GM wants to own the intellectual property that fuses the outputs of the various sensors. GM would take the outputs from radar sensors, for example, and the separate outputs from ultrasonic sensors or cameras and use its own fusion IP to make the decisions about what to do with that information. “We want to be able to work with our suppliers to get the best sensors and actuators, but combine them in novel ways ourselves,” explained Mr. Helfrich.

In line with that, Mr. Helfrich wants to be sure that GM’s advanced safety systems...
Roundup: Omron, Pioneer

Omron Automotive Electronic Components (AEC)  
Fiscal year 2013 ended March 31, 2013.  
FY 2013 Sales to External Customers: ¥97.6 billion ($1.02 billion)  
Change from FY 2012: up 14.8%  
FY 2013 Operating Margin: 5.1%, significantly better than the prior year’s 3.2% operating margin.  
Outlook for FY 2014: Omron expects sales growth of 11.1%, to ¥108.5 billion ($1.1 billion), despite an expected decline in sales in Japan. Overseas sales are forecast to increase by 24%. If the forecast proves accurate it will be the first year AEC sales return to pre-great recession levels. Operating margin is expected to continue improving, to 6.5% in fiscal 2014.  
Omron’s automotive sales were hard hit by the 2008 global financial crisis, followed by the devastating earthquake and tsunami in Japan and flooding in Thailand. AEC was restructured in 2010 with the goal of

Outlook for FY 2014: Pioneer expects growth in both OEM and consumer markets but did not provide an estimate.  
Pioneer Corp. reported a total net loss for the year of ¥19.6 billion ($204.9 million) as Home Electronics sales declined 22%. In May 2013, the company sold shares to Mitsubishi Electric and NTT DoCoMo raising approximately ¥9 billion ($94.3 million). Mitsubishi now owns 7.5% of Pioneer; DoCoMo’s share is 6.9%.  
Pioneer will expand its navigation cooperation with Mitsubishi Electric with the development of a multimedia platform and V2V communications.  
Pioneer and DoCoMo already cooperate on location-based services. They will develop a cloud-based platform that integrates probe data from Pioneer navigation systems in cars and from DoCoMo smartphone customers to expand their service offerings. ◆

Smart Parking...  
Continued from page 1

the 18,000 facilities in North America provide real-time availability data. The percentage is even smaller in Europe, where only some 2,300 lots or garages can provide availability information. Mr. Bak expects more availability data will be added over time. “At the scale we are adding either garages or adding availability information, we are on pace to be at 4,000 facilities with availability in North America in the next 18 months,” he said.  
Lexus is also integrating INRIX Parking services, starting with the 2014 IS in Europe. As the new Lexus navigation system, which debuted in the IS, is rolled out to other models, so will the parking application. Lexus offers the parking service only in new vehicles.  
Parkopedia and ParkMe are two of the data providers that supply INRIX with information such as the latitude and longitude of the parking garage, pricing, and, when possible, how many spaces are currently open in a given facility. ParkMe will provide data for the Audi Connect service in the U.S.; Parkopedia will provide the data for Audi in Europe. Parkopedia recently announced that it will also be supplying its parking data to BMW both in Europe and the U.S.

On-Street Parking  
According to INRIX’s Mr. Bak, as the service and real-time availability data become more widespread, INRIX will look to address metered, on-street parking as well. “We plan to add on-street parking into the service within the next 18 months. That is a little more challenging at the moment both from a technology point of view and the ownership of the spaces, whether they are publicly or privately owned,” he said.  
An INRIX solution for on-street availability might use color-coded map overlays to show relative availability on street maps, for instance green would indicate lots of open spaces on a particular block and red or black would alert drivers that those blocks were full.  
Some U.S. cities have smart parking tests underway that rely on sensor-equipped meters to provide real-time availability data, a significant investment when most city and state budgets are already strained. The San Francisco Municipal Transportation Agency (SFMTA) received a $19.8 million grant from the U.S. Department of Transportation for its pilot project SF Park, launched in 2011. In targeted neighborhoods, 7,000 of the city’s 28,000 parking meters are fitted with sensors supplied by Fybr of St. Louis, Missouri (formerly named StreetSmart Technology). In addition to providing availability data, the meters can be adjusted for varying time limits and rates and can accept payment by credit card. ◆
Conversation with Car Audio Writer and Trained Listener, Tom Nousaine

Tom Nousaine is a former contributing technical editor for Sound & Vision and a freelance writer in the field of automotive sound quality. A “trained listener,” he has evaluated more than one thousand factory car sound systems since 1999 and several hundred home and car aftermarket systems beginning in 1988. Mr. Nousaine delivered the keynote address at the Audio Engineering Society’s 48th Conference on Automotive Audio in Munich, Germany, in September 2012. Working for himself, he is able to be refreshingly candid about the state of car audio.

This past January at the Consumer Electronics Show, Bang & Olufsen, Audi and Fraunhofer Institute for Integrated Circuits demonstrated a concept car equipped with what the partnership is calling “a revolutionary 3D sound experience.” According to their press release, “The car has 23 active loudspeakers and more than 1,500 watts of amplification power, driven by a new 23 channel DSP MOST amplifier.” I asked Mr. Nousaine how 3D audio ranks with past advances in car audio.

“On a scale from one to 10, where 10 would be virtually impossible to tell from a live performance, single-channel audio in the car was maybe a one or a two,” explained Mr. Nousaine. “Stereo was probably a six. Multichannel audio is an eight. 3D audio might be a nine. The advantage of 3D audio is the additional speakers along the ceiling of the car, which are supposed to elevate the soundscape so it is a little above eye level. In conventional car audio systems, the ‘orchestra’ seems to be at your chest level or below.”

Mr. Nousaine experienced 3D audio-equipped vehicles at the Automotive Audio conference in Munich. “The 3D audio-equipped cars there all had an immersive experience. You could hear ambience all around you. But they all seemed to suffer from one downplay: It was like the sound was too close to your face, confined to the inside of the vehicle. Everybody has always had problems getting sound to seem as though it is coming from outside the car, from the left and right side and from beyond the windshield.”

Mr. Nousaine doesn’t see any new audio technology on the horizon that will have as big an impact as multichannel and 3D. “But,” he speculated, “maybe somebody could invent a way to make the sonic appearance of the car’s enclosure disappear.”

How Much Is Enough?

Increasingly carmakers are offering premium audio systems with more speakers, more channels and more power. So when it comes to good listening, how much is enough? According to Mr. Nousaine, power is definitely not a differentiator. “Many of the people who market audio only know watts and the number of speakers. Every car, regardless of the audio system’s total power, has a power amplifier that will play the speakers as loud as they will safely play. The amount of power needed depends on the speaker. Some speakers are more sensitive and more efficient than others in producing acoustic output.”

Adding speakers to a car audio system is an easy way for carmakers to add more sizzle, but Mr. Nousaine noted that sometimes the speaker count is inflated by counting separately the woofer and tweeter of a coaxial two-way speaker. “A 5.1 channel system has six channels, (left, right, center, left surround, right surround and one low-frequency-effects channel). Since it’s hard to make a speaker that easily covers the whole 20 hertz to 20 kilohertz listening range, each channel will typically have two speakers, often a six-inch woofer and a one-inch dome tweeter, plus a subwoofer. That’s 11 speakers. A 7.1 channel system [with its two additional rear channels] with a few additional speakers may give some listeners a marginal improvement. Beyond that is probably going to be imperceptible to the listener,” he said.

Perhaps the most important elements of a good car audio speaker are the materials used to construct it and robust packaging. “Automotive grade speakers need to work regardless of the elements, whether it’s freezing or a very hot summer day in a parking lot. Speaker quality has more to do with their ruggedness than how they might sound.”

What Makes an Outstanding System?

In Mr. Nousaine’s view, “It’s not about the individual components; it’s really the whole system. Putting in more expensive speakers or a different receiver might improve the sound, or it might not.” In his experience, branded audio systems usually sound “pretty good,” but almost all of them use commodity-grade speakers. “Since 1999 I’ve tested more than a thousand production systems, and I’d say the best ones were from Bose, and a Harman system was very good too. But regardless of the manufacturer, they all fall in a range from average to a little bit above average,” he noted. Panasonic is among the largest suppliers of non-branded systems, according to Mr. Nousaine.

Mr. Nousaine listens for 38 characteristics when he tests auto sound systems, with each characteristic rated on a scale of one to five. He explained three of the most important attributes of an outstanding system. “The first is tonal balance. A violin should sound like a violin, a bass drum should sound like a bass drum. A female voice should sound natural. Second is stage presence. The stage should be in front of you at eye level and should have some depth to it. Third is dynamics. Modern systems have adequate loudness, but it is still relatively common for systems to display compression artifacts and high volume distortion. Soft passages need to be clear.”

OEM vs. Aftermarket

The market for aftermarket audio in the U.S. has been declining precipitously. “The audio aftermarket is dying,” suggested Mr. Nousaine. “Back in the early car audio days, some aftermarket suppliers made spectacularly good systems. But today most aftermarket systems aren’t worth the money you pay for them. They go very loud and very low, but they don’t sound natural. Aftermarket retailers are good holesaw cutters. They can put speakers in places you wouldn’t be able to. Whether or not that improves the sound quality is another question. Very few aftermarket people know anything about audio. Some are very good but not many. Factory installed audio is much better.”

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The Company Profile...

Texas Instruments

Headquarters: Dallas, Texas; Telephone: 972-995-2011; www.ti.com
2012 Sales: $12,825 million
R&D: 14.6%
Capex/Sales: 3.9%
Interest Expense/Sales: 0.7%
Operating Margin: 15.4%
Net Cash Provided by Operating Activities: $3,414 million

Texas Instruments was founded in 1930 as Geophysical Service Inc., originally to locate oil deposits. In the 1940s it began to develop and manufacture electronic equipment primarily for the military. In 1951 the company name changed to Texas Instruments, and that same year TI purchased a license to manufacture transistors from Western Electric for $25,000. In 1953 the Semiconductor Products division was established and TI secured its first DSP patent in 1982.

Automotive Background

TI has served the auto industry with a broad range of products from semiconductors to sensors and switches, for more than 30 years. In 2006 TI sold its Sensors and Controls business to Bain Capital for $3 billion, but held on to the RFID product group. At the time of the spinoff, the Sensors and Controls business, now Sensata, produced approximately $1.1 billion in sales.

In September 2011, TI acquired one of its rivals, National Semiconductor, for $6.5 billion, a move that strengthened TI’s analog business with some 12,000 additional products. Now fully integrated into TI as its Silicon Valley Analog business, the National acquisition increased TI’s automotive analog business by roughly 20%. National’s automotive sales in 2011 were approximately $110 million. (For more on National Semiconductor, please refer to The Hansen Report Company Profile published February 2011.)

The auto industry accounted for 11% of TI’s sales in 2012, or $1.4 billion. TI’s marketing approach to the automotive industry changed about a year ago. “In the past you had specific product lines going into automotive accounts that were focused only on selling a particular device,” said Jeff Kohnle, from TI’s Analog Solutions marketing team. “Now we are selling solutions involving multiple product lines. We have a huge portfolio of products, not just automotive qualified products, but a whole catalog of 40,000 analog parts we can draw from. Any of that IP we could qualify for automotive.”

The company’s efforts to increase its share of automotive business are organized informally; no one manager is in charge of setting TI’s overall automotive strategy. Rather, the various product lines with automotive interests cooperate informally. “It...
used to be there were only two or three product lines that cared about automotive. Now virtually every TI product line has been making a significant automotive investment,” declared Curt Moore, product line general manager for OMAP (open multimedia applications platform) embedded processors. TI employs a quality director who works exclusively on behalf of automotive applications.

TI’s extensive automotive portfolio includes analog power management, interface and signal chain solutions, DLP displays, ADAS and infotainment processors, Hercules TMS570 safety microcontrollers and wireless connectivity solutions. Along with product documentation, TI offers parts that are compliant with the AEC-Q100 and TS16949 standards, along with SafeTI system design packages, which also help designers comply with ISO 26262 requirements.

What TI especially likes about the auto industry compared to the other industries are the long-term relationships. “Awards for these kinds of products will run for anywhere from five to 10 or even 15 years compared with 15 months or so for some consumer products,” said Norbert Asche, general manager for safety and security products.

OMAP Embedded Application Processors

In November 2012, Texas Instruments announced its decision to disengage from the mobile market, where there are only ten or so large smartphone and tablet customers. Those manufacturers are increasingly developing their own custom chips, and product lifecycles are notoriously short. As of January 1, 2013, TI’s Wireless business segment ceased operations, resulting in the elimination of 1,700 jobs and savings of $450 million per year, according to the company.

Instead, TI is upping its investment in embedded markets, especially automotive, where there are more customers and significantly longer product lifecycles. One measurable outcome: the resources given to Curt Moore’s automotive OMAP product line has grown by five times compared to 18 months ago. Mr. Moore is product line general manager for OMAP, TI’s brand for embedded application processors.

TI’s embedded processor revenues from the automotive market have grown quickly of late, from about $300 million in 2011 to $500 million in 2012. TI’s OMAP processors range in price from $10 to $30 each. Infotainment systems account for the vast majority of TI’s automotive applications processor business thus far, with advanced driver assistance system applications in the minority but increasing.

Among TI’s infotainment customers is Audi. The carmaker is using TI’s Jacinto 5 processor in its leading-edge MIB infotainment platform, which debuted in the 2012 Audi A3. The MIB platform will be rolled out in more Audi models as well as other Volkswagen Group vehicles. While a Tegra processor from Nvidia powers the Multimedia Applications Unit (MMX), TI’s Jacinto processor runs the Radio and Car Control Unit (RCC) in the MIB.

The Jacinto 5 multicore automotive infotainment processor includes an integrated ARM Cortex-A8 core that manages middleware, drivers and applications stack, along with a digital signal processor that powers audio, radio and low-level automotive tasks.

According to a TI press release, the company’s infotainment processors are “designed into more than a dozen automobile manufacturers.”

In January, TI announced that it will by mid-2013 start sampling its latest automotive processor...
Texas Instruments

T effective OMAP processor, the Jacinto 6. The new SoC adds analytics and radio accelerators, along with automotive interfaces and peripherals. According to TI’s Jacinto 6 press release, “Integrating automotive interfaces can decrease an automotive infotainment customer’s electronics bill of materials by up to 25%.”

Interfaces include MOST Media Local Bus and Ethernet AVB. An optional 680 MHz floating-point VLIW (very long instruction word) DSP is available for integration of software defined radio, advanced audio and speech processing. The device offers multiple high-definition camera and video inputs to enable next-generation surround-view camera and consumer devices. QNX, Linux and Android operating systems are supported. Production could start as early as the second half of 2014.

Mr. Moore’s OMAP applications processor business is also focused on advanced driver assistance systems, including surround view and backup camera parking systems, forward-looking camera systems and radar. “Real-time signal processing using DSPs and accelerators is at the heart of what we do,” said Mr. Moore. Already in production with some of these systems, Mr. Moore expects TI will win significantly more business in the future as ADAS features move into mainstream vehicles.

Safety Microcontrollers

TI’s Hercules branded 32-bit ARM-based microcontrollers account for most of what the safety and security MCU business unit ships to automotive customers, the biggest application being braking systems. Sixty-five percent of the world’s braking systems employ microcontrollers from Texas Instruments. TI is a key supplier to Bosch and to Continental, which together ship a majority of the braking systems used worldwide.

“Since 2000 we have been focusing on 32-bit ARM safety controllers. We started with ARM 7 and from there went to Cortex M. Our latest safety offerings are based on the ARM Cortex R4 and R5,” said Norbert Asche, general manager for TI’s safety and security MCUs. Based in Freising, Germany, near Munich, Mr. Asche has been representing TI on braking and safety applications for nearly 25 years, beginning with Teves, then ITT Teves before it became Siemens, and now Continental. Mr. Asche and TI also have a long history with Bosch.

“Our focus has always been around safety,” said Mr. Asche. “Braking was the first application to go to a dual lockstep architecture, where two CPUs on the same chip, oriented 90 degrees from each other, provide redundancy. The 90 degree orientation makes the CPUs less prone to random failures.” Built on a Cortex-R core and capable of 280 DMIPS, the Hercules TMS570 high-performance device’s development conforms to the ISO 26262 ASIL-D functional safety standard.

Compared with software and multicores-based solutions, lockstep CPUs provide faster fault detection and coverage, with little or no performance impact. “The lockstep approach will be applied to electric power steering, advanced driver assistance systems, battery management systems, even transmission and engine controllers,” said Mr. Asche. “Autonomous driving is the development goal for all carmakers. More and more applications are becoming safety relevant.”

In response to the rise in safety-critical applications and the automotive industry’s adoption of ISO 26262, the company has developed what it is calling SafeTI Safety Design Packages, which include not only embedded processors, analog devices and software from TI, but also provide supporting documentation and independent third-party evaluation and certification. “In the past this was done at the system level. Now we are working with a third party to assess and certify at the chip-level manufacturing process FMEDA [failure modes effects and diagnostic analysis],” said Mr. Asche.

Two of TI’s best-selling automotive analog products—a power management IC (PMIC) and a motor driver—are often coupled with a Hercules microcontroller in safety applications. “Our customers like these especially for their watchdog and diagnostics capabilities,” said Cecilia Smith, vice president of TI’s mixed signal automotive business. The motor driver (DRV3201) is used for three-phase brushless DC motor control and features sophisticated diagnostics, protection and monitoring features through an SPI (serial peripheral interface). The PMIC (TPS65381-Q1) is a multi-rail power supply designed to supply...
microcontrollers in safety-critical applications.

Another major automotive application for this business unit’s products is passive entry/passive start systems in which Texas Instruments’ RFID components are applied. TI’s main customers for RFID products are Tokai Rika and Denso. TI claims a 30% share of this market.

Class D Audio Amplifiers

One of TI’s best-selling products is its TAS54xx line of Class D audio amplifiers.

First introduced by TI to the car audio industry in 2005, Class D amplifiers have been relatively expensive and can cause electromagnetic interference. Recently EMC performance has improved along with the Class D’s value. Class D amplifiers are significantly more efficient than Class A/B types, which makes them especially attractive as carmakers work to reduce CO2 emissions and improve fuel efficiency. Class D amplifiers deliver 90% efficiency compared to 40% to 50% for Class A/B amplifiers. Since they are more efficient, less heat must be dissipated so heat sinks and the overall package can be smaller and lighter. TI says it is already the world’s number-one supplier of Class D audio amplifiers in all markets.

Strategy Analytics expects the global automotive OEM market for Class D audio amplifiers to grow from just under $50 million in 2012 to nearly $170 million by 2020 as the market for Class A/B amplifiers declines.

“Not only will Class D audio amplifiers be used by makers of traditional audio systems, they will also be needed as eCall systems are deployed in Europe,” pointed out Ms. Smith. “The eCall audio system will be separate from the vehicle’s sound system.”

TI has developed a reference design for an eCall system that includes its TPA311D1-Q1 monaural, Class D audio amplifier. The European Commission wants eCall systems installed on all new vehicles from 2015 on.

DLP (Digital Light Projection) HUDs Coming Soon

DLP technology was invented by Texas Instruments in 1987, and since 1996 the company has shipped more than 35 million DLP devices, also known as digital mirror devices or DMDs. “We are definitely on a path to take our standard consumer DLP device and make it ready for automotive applications. Our top management has committed the people, the R&D and the capital investment. I am optimistic that you will see DLP technology in a car in the 2014-2015 timeframe,” said Mariquita Gordon, general manager of TI’s DLP Embedded product group, one of four TI DLP product groups.

Carmakers have been keen to introduce head up displays that are brighter and use more of the windshield so warnings and navigation prompts can be displayed as part of the scene ahead of the vehicle where the driver is looking, so-called augmented reality HUDs.

Penetration of HUDs based on today’s LCD technology has been limited. Unlike DMDs, LCDs are not 100% reflective, which makes it difficult to get the reflected image bright enough to cover more of the windshield without overheating the device. “Working with our partners we are able to provide a brighter, wider image, more efficiently using the same or less space in the instrument panel,” noted Ms. Gordon. Even relatively small LCD-based HUDs take up quite a bit of room in the instrument panel, about half the size of a shoebox. Bigger displays require even more space.

HUDs that use a laser light source have had their own problems: the image can appear speckled and the color green is said to have too limited a lifetime for automotive applications. TI’s approach uses LEDs, not lasers. “We are light-source agnostic,” said Ms. Gordon, “so we can use lasers, light bulbs or LEDs. In the case of automotive, that is one of the breakthroughs that enables our technology for HUDs. Automotive-qualified LEDs are available on the market today. Lasers are not quite automotive qualified, and light bulbs are not sufficiently reliable.”

Harman demonstrated a DLP HUD at the Consumer Electronics Show this past January. “That was our reference design and our DMD,” said Ms. Gordon. “It wasn’t the automotive-qualified DMD; DMD samples will be available to support 2015 production.” QNX also featured TI’s DLP technology in a CES demonstration, as did Audi.

A few years after DLP HUDs have been introduced, TI expects DLP technology will be applied to the center column and instrument cluster displays. “With DLP, you don’t have to have a flat screen,” said Ms. Gordon. “You can rear project onto a curved surface that contours with the car. The designers love it.”
don’t overwhelm the driver with information and stimuli. The Safety Alert Seat that GM first introduced last year on the 2013 Cadillac XTS, followed by the ATS and SRX, is a good example of this approach “because it conveys information in a non-fatiguing way,” he said. Drivers get warnings transmitted as a vibration from the seat’s bottom cushion. When the lane departure system cameras detect the vehicle leaving a lane without a turn signal, a vibration on the left or right side of the seat directs the driver’s attention to the side of the lane encroachment. When a potential collision is detected ahead of the vehicle, both sides of the seat vibrate.

GM will continue to bring systems integration in house because it wants to own the IP that links its systems together. “To deliver new features, systems need to interact with each other. We want to have control of that, which means we are going to take over some amount of the software system integration.”

Reuse
The strategy to reuse what has previously been developed, tested and proven underpins a lot of Mr. Helfrich’s thinking. “We have one tool chain, one process and one software product line, globally. We develop a system and then use it over and over again. That is the key to our quality.”

GM is slowly transitioning from its Global A architecture to a new electrical architecture. “Our new architecture is going to be based on Autosar 4.0. Our software architectures within that and our new tool chain and design methodologies will be leveraging all the precepts of Autosar. It gives us a baseline from which to work, but we will bend it so it is compatible with our reuse process,” Mr. Helfrich explained.

“Autosar only goes so far into the elements of design. Autosar is mute on configuration management, change management and the reuse regime you have. GM’s reuse strategy goes across vehicles, across model years and across ECUs. It is dramatically broader than other OEMs’. Even the tools we buy need to be modified in order to fit our reuse regime.”

Challenges
Mr. Helfrich thinks his biggest challenge is “to prepare a platform that is going to be robust to all the stuff that’s coming, so the car is still relevant five and ten years from now. Ten years ago there wasn’t an iPhone,” he pointed out.

Another challenge is figuring out what is the best way to take advantage of all the data that will come, not only from the radar, camera and ultrasonic sensors aboard the vehicle, but from outside the vehicle, from other vehicles and from the cloud.

Organization
Prior to his September 2012 appointment as executive director of global electrical systems for GM, Mr. Helfrich was executive director of electronic controls and software. He shares responsibility for electrical engineering at GM with Matt Schroeder, who handles infotainment and the driver interface; Dan Nicholson, executive director of powertrain embedded controls; and Larry Nitz, who leads GM’s global hybrid and electric powertrain engineering activities.


### GM... Continued from page 1

both those already in development and those we haven’t imagined yet.”

Mr. Girsky added other potential innovations: “Enhanced diagnostics and vehicle monitoring, including cameras that transmit live images to you on demand, to show you what’s happening around your car while you are away from it. ... And we’re exploring new possibilities for the vehicle to communicate with its environment to enhance safety, as well as to simplify and automate elements of the driving process.”

In written correspondence with The Hansen Report, Tim Nixon, executive director and CTO for GM Global Connected Consumer, explained how suppliers might help: “We will continue to invest in cloud-based services including data collection and analysis. We realize there are solution providers we’ll need to leverage to help get us to those elements and toolsets our engineers can utilize. We recognize there are software applications and cloud-hosting platforms that can allow us to put our engineering knowledge to work. ... In some cases we can leverage the wireless and consumer electronics industries for some of that, but since the territory we’re heading into is somewhat uncharted for an automotive OEM, we’ll rely on some dedicated resources and third parties who can help us develop the tools we need.”

Mr. Nixon intends to use a mixture of in-house and external engineering resources. “The trend is to pull more resources in-house for the back-office elements. On the vehicle side, while we will continue to leverage key supplier partners, we recognize the need to get deeper into systems engineering and software development ourselves.”