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5G Networks Won’t Substantially Impact Autos before 2025

5G promises a lot: high-speed Internet access, low latency, exceptional reliability and much more capacity. With 5G, carmakers will be able to deliver fast over-the-air updates, support automated driving, connect to smart cities, and deliver massive amounts of data to the cloud while supporting multiple streams of passenger content via onboard Wi-Fi.

Four years ago the Hansen Report predicted that, “While the cellular communications industry has a timetable to have 5G equipment commercially ready by 2020 or soon after, it will take another several years before the new technology affects vehicle features.” We recently checked in with a number of automotive experts for this update on 5G and learned that our assessment is holding true.

It fits with a report published by the GSMA earlier this year that asserts that in all vertical markets 5G is on track to account for just 15% of global mobile connections by 2025. 4G will continue to see strong growth over the period, accounting for almost 60% of global connections by 2025, up from 43% in 2018. The GSMA is an industry advocacy group that represents the interests of more than 750 mobile operators worldwide.

Carmakers aren’t feeling any pressure to embed 5G modems in their vehicles in the near future, primarily because mobile network operators don’t seem to be in a big hurry to build out 5G networks to support connected vehicles. The initial rollout of 5G networks will instead be devoted to fixed, point-to-point Internet services in a bid to replace cable, fiber and satellite broadband with millimeter wave 5G. You can now have a small cell site in a subdivision and service all the houses via rooftop antennas. The costs to build out 5G networks are enormous, and the business case for creating networks for cars is not yet evident.

The European Union’s connectivity goals for 2025, including 5G coverage in all urban areas, is estimated to cost $500 billion. According to João Barros, founder and CEO of Veniam, “The main problem right now is the business case for 5G is not yet strong enough for telecom carriers to be willing to do nationwide deployment. Build-out will start in dense urban areas and some industrial environments in a very step-wise way.” As 5G slowly comes along, Veniam’s intelligent networking software can help OEMs and mobility providers make use of all the networks that are available—not only 5G but also 3G, 4G, street-level Wi-Fi hotspots and satellite.
“We don’t, at this point, see an urgent need for the capacity and quality of service that will come with 5G,” said Don Butler, executive director for connected vehicle platform and product at Ford. “But as we progress forward, we do see opportunities for use cases that 5G can deliver as we get into automated vehicle operation and cities with smart infrastructure. We are looking at somewhere between 2023 and 2025 before we see a need and opportunity for 5G. Today we are continuing to deploy 4G modems.”

BMW, which is more aggressive in its embrace of 5G than Ford, has announced plans to equip its iNEXT all-electric SUV with 5G readiness in 2021. BMW could assert 5G readiness simply by installing a new chip from Qualcomm that supports both 5G vehicle-to-network communications and short range cellular-V2X communications. That integrated chip is scheduled for production in the 2021 to 2022 timeframe. Ford, which has committed to cellular vehicle-to-vehicle communications, will likely also use the Qualcomm chip.

“Between 2023 and 2024, as 4G capacity gets saturated, we will see a lot of 5G starting to get deployed in automotive,” said Nakul Duggal, Qualcomm senior vice president of product management. “By 2025-2026 everybody will be doing 5G.” Nevertheless, since Qualcomm’s 5G chips are backward compatible with 4G and 3G, Mr. Duggal thinks carmakers should consider deploying 5G in some of their vehicles as early as the 2022 model year, especially in China where plans for 5G adoption are more advanced and automakers have their eyes open for a competitive edge. “If the market goes to 5G, Chinese automakers will be ready to switch over.” The cost of the 5G chips will be higher than the 4G chips.

A very good, in-depth analysis done on behalf of the European Parliament titled “5G Deployment, State of Play in Europe, USA and Asia,” predicts that China will take at least ten years to get 5G completely rolled out nationally. According to the report, South Korea is the world’s top country when it comes to 5G development, followed by China.

According to Joachim Goethel, senior manager for BMW’s Project 5G-Alliance, once vehicles are equipped with 5G connectivity the carmaker could offer advanced features whenever the car is traveling on roadways where 5G networks are operating. “We can adapt functionality according to where the car is navigating. … There is a clear statement that all highways and major roads in Germany must be covered with 100 Mbps service with 5G by the end of 2022.”

Twenty-nine European countries have committed to the development of large-scale testing sites of connected and automated driving on Europe’s roads. According to ec.europa.eu, Europe is currently the biggest experiment area in 5G.
technology. Maxime Flament, CTO of the 5G Automotive Association said, “By 2020 they [EU member states] are planning to have at least one major city in each member state covered by 5G. Then by 2025 they want major highways covered.”

In their consent to the goal of providing uninterrupted 5G coverage for urban areas and major transportation paths, all member states agreed to start by clearing the 700 MHz, 3.5 GHz and 26 GHz frequency bands and reassigning them to 5G by the end of 2020. That goal will not be met. Thus far only 7% of that spectrum has been allocated.

Spectrum allocations have not yet been finalized elsewhere around the world. Three spectrum ranges are under consideration for 5G: low band, usually 600/700 MHz; mid band at 3-5 GHz; and high band at 20-100 GHz. Channel bandwidth is greatest in the high bands. Millimeter wave bands offer the greatest performance, on the order of 20 gigabits per second, but those frequencies aren’t well suited to moving vehicles. Millimeter-wave transmissions have very low propagation distances and require sophisticated antenna systems. The low and mid bands are a better solution for connecting rapidly moving vehicles.

<table>
<thead>
<tr>
<th>Main Frequency Bands for 5G Standards Adopted Globally</th>
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<tr>
<td><strong>Frequency Band</strong></td>
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<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Low Band</td>
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<tr>
<td>Mid Band</td>
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<tr>
<td>High Band</td>
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Source: 5G Deployment report

Further complicating full deployment is the fact that the technical standards for 5G radio services haven’t yet been finalized. Many moving parts have to line up before the auto industry can step into the 5G connected vehicle era. In a wait-and-see mode, carmakers will stick with 4G for at least five more years as they follow the progress of 5G across the globe.
MIT’s Lex Fridman Takes Cautious View of Self-Driving Technology

GM’s Cruise division raised an additional $1.15 billion in financing early this month, which ups the value of the driverless car developer to $19 billion. That is more than one-third of GM’s $55 billion market value.

It seems like a good time to balance this over-the-top exuberance from investors with an opposing point of view about the state of autonomous vehicle development. In a presentation in March at Nvidia’s 2019 GTC conference, MIT research scientist Lex Fridman tempered expectations for a quick return on the massive investments being thrown at self-driving technology development. He believes investors will have to wait at least until 2030, and even then fewer than 10,000 autonomous vehicles will be operating on public roads. The problem is clear to Mr. Fridman: the technology is not ready. Totally new ideas are needed.

Developers have been struggling to move beyond fleets of test vehicles into large-scale deployments in the real world. “Scale is really tough to achieve with human level or even close to human level performance,” said Mr. Fridman. The reason for that, as he sees it, is the lack of sufficient data. Vast quantities of data are needed to adequately train the neural networks to perceive and understand the driving scene in a split second. “Waymo and the other developers are talking about the scale of ten, twenty, thirty million miles, and maybe by the end of this year, if we are lucky, 100 million miles.”

Even when trained with this amount of data, test vehicles fail to perform as well as a human-driven vehicle. “When the vehicle cannot perceive something, when it fails on any part of the pipeline of autonomy from perception to control to planning, then the human has to take over and resolve that interaction.”

To make his point Mr. Fridman referred to The Bitter Lesson, a recent blog post by Richard Sutton, one of the seminal figures in machine learning: “He says the biggest lesson that can be read from 70 years of AI research is that general methods that leverage computation [from data] are ultimately the most effective, more so than fine tuning with rules and model-based optimization methods when the data is somewhat sparse.”

According to Mr. Sutton, “Seeking improvement that makes a difference in the shorter term, researchers seek to leverage their human knowledge of the domain, but the only thing that matters in the long run is the leveraging of computation.”
Because developers aren’t at all close to being able to pile up enough miles of real world testing on public roads to prove that autonomous vehicles are safer than human-driven vehicles, they must instead rely on simulation. “There are two ways to close the gap.” Mr. Fridman suggested. “One way is to improve our transfer learning methods to train on simulation. The other is to improve simulation to where it is hyper-realistic, where there is no difference between the real world and the simulated world. … I am skeptical that we can do that in the next few years.”

**Shared Autonomy**

“The other approach is to give up on the notion of full autonomy and do shared autonomy, which is what Tesla’s Autopilot is doing,” said Mr. Fridman. An L2 system, Autopilot steers, accelerates and brakes automatically within its lane, while requiring active driver supervision.

Conventional wisdom suggests that humans and automation don’t mix well, that humans are not able to supervise automation successfully, they fall asleep, they become distracted, they over-trust the system, disengage and lose their vigilance.

Mr. Fridman and researchers at MIT collected upward of 500,000 miles of semi-autonomous driving in Tesla vehicles, as well as some Cadillacs equipped with Super Cruise. “We collected data from real drivers all around Boston, New England and elsewhere in the U.S., recording video of every single minute that they are driving with two cameras on the driver, one external camera plus other sensors. … In our data set we have people regularly using Autopilot for two-hour stretches.

“Our data show that out of 18,000 disengagements from Autopilot to manual control, during the daytime, 99.8% of the time the driver is the one that chooses to disengage. … We annotated 8,000 of those disengagements that were tricky situations, where if the driver doesn’t respond, a potential crash or dangerous situation could occur. Zero of those times was the driver not able to respond to the situation … zero times did the driver lose vigilance.”

The reason why Autopilot works so effectively, according to Mr. Fridman, is that the human’s life is at stake. The human gets to learn the operation of the system and chooses when to turn it on and off. “The L4 autonomous revolution is based on the idea that drivers are going to lose vigilance,” he noted. “And here is data that says that maybe they don’t.”
No Level 3
“There is only fully autonomous and not fully autonomous. Either you are guaranteeing that you really don’t have to pay attention or you still have to pay attention. There is no Level 3,” asserted Mr. Fridman. “If you play with a gray area, you are playing with danger.”

A research scientist at MIT working on human-centered artificial intelligence, Mr. Fridman is developing and applying new computer vision and deep learning approaches in the context of self-driving cars with a human in the loop.
Roundup 2018: Valeo, Magna, Hitachi Automotive, Faurecia

Valeo
2018 Sales: €19,124 million
Change from 2017: up 3.5%
2018 Operating Margin: 5.7% of sales, if Valeo’s share of losses recorded by the Valeo Siemens eAutomotive joint venture and some Chinese joint ventures is included. Operating margin in 2017 was 7.9% of sales.
Outlook for 2019: Low single-digit growth is likely.

Valeo attributes its lackluster sales growth to the slowdown in vehicle production in China and Europe, especially in the second half of 2018 as carmakers worked to meet new European WLTP emissions testing standards by the September 1, 2018 deadline. Sales to OEMs, which account for 84% of Valeo sales, grew by just 2.9%.

Looking at sales by business group, Powertrain Systems showed the healthiest growth, 18%, over the prior year. Comfort and Driving Assistance Systems increased by 2%, while Thermal Systems and Visibility systems both saw a 2% decline in sales. Visibility (lighting and wipers) is Valeo’s largest business group, accounting for 30% of total sales.

In February 2019, S&P downgraded its outlook on Valeo to negative (from stable) and maintained its BBB credit rating.

For more on Valeo, please refer to the company profile published in the December 2018/January 2019 issue of the Hansen Report.

Magna International
2018 Sales: $40,827 million
Change from 2017: up 11.6%
2018 Net Margin: 5.6%, compared with 6.0% in 2017
Outlook for 2019: Magna expects sales in the range of $40.2 billion to $42.4 billion, which reflects the divestment of its Fluid Pressure and Controls business. Net income is forecast in the range of $2.1 billion to $2.3 billion.

Magna’s top OEM customers last year were General Motors, accounting for 15% of sales, Ford and FCA, each at 14% of sales, and BMW, providing 12% of sales.
Magna’s Complete Vehicles segment is its fastest growing, reporting 70% growth in sales, primarily due to the launch of Jaguar’s E-Pace and I-Pace and continued production of the BMW 5-Series, together with favorable currency effects.

Power and Vision Systems, which includes closures, mirrors, lighting, electronics and powertrain, accounted for 30% of total sales in 2018. Revenue in that sector was up 6% over the prior year, driven primarily by business with General Motors, BMW, Porsche and Jeep.

Between 2018 and 2021 sales in Power and Vision are expected to increase by 2% to 5% per year with the help of continuing demand for dual-clutch transmissions (DCTs), mechatronics, electronics, ADAS, mirrors and lighting. Magna sees future opportunities in E-latches, E-drives, hybrid DCTs and power side doors.

**Magna’s Sales by Business Segment, 2018 vs. 2017 in USD Millions**

<table>
<thead>
<tr>
<th>Segment</th>
<th>2017</th>
<th>2018</th>
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<tbody>
<tr>
<td>Body Exteriors &amp; Structures</td>
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<tr>
<td>Power &amp; Vision</td>
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<tr>
<td>Seating Systems</td>
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<tr>
<td>Complete Vehicles</td>
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<td></td>
</tr>
</tbody>
</table>

**Hitachi Automotive Systems**

*Fiscal year 2018 ended March 31, 2019.*

**FY 2018 Sales:** ¥971,007 million ($8.7 billion)

**Change from FY 2017:** down 3%

**FY 2018 EBIT Margin:** 8.8%

**Outlook for FY 2019:** Sales are expected to be 13% lower, given that Clarion is no longer part of Hitachi Automotive.

Hitachi Automotive attributes its revenue decline in FY 2018 to the slowdown in the North American and Chinese markets, as well as to lower sales of infotainment systems. Adjusted operating margin declined from 5.0% in FY 2017, to 3.9% in FY 2018. Hitachi reduced its R&D spending in Automotive Systems in FY 2018 by 7.4%.
The sale of Clarion for approximately $717 million to Faurecia was completed in March 2019. Clarion’s consolidated revenue in FY 2017 was ¥184.1 billion ($1.6 billion). With Hitachi’s recent reorganization, effective April 1, 2019, Hitachi Automotive Business became part of the new Smart Life business segment. Also part of the Smart Life segment are Healthcare and Smart Life & Eco-Friendly Systems, which includes appliances, lighting and other consumer products.

In addition to the sale of Clarion, the recent restructuring included the sale of Hitachi Automotive Systems Measurement to Polaris Capital Group, and the sale of its commercial vehicle steering business to commercial vehicle brake supplier Knorr-Bremse. Hitachi Automotive also sold off all but 6% of its shares in Hitachi Vehicle Energy, which makes automotive lithium-ion batteries. Maxell Holdings and INCJ now each own 47%. INCJ is a Japanese government backed public-private investment fund.

In a Q3 earnings call, the company indicated that going forward Hitachi Automotive will focus on ADAS/autonomous driving and electrification products and on conventional products in its portfolio only where it can be the global market leader.

**Faurecia**

**2018 Sales:** €17,525 million  
**Change from 2017:** up 3.3%  
**Operating Margin:** 7.3%  
**Outlook for 2019:** The company expects to outperform worldwide automotive production by 1.5% to 3.5% with an operating margin of at least 7%. Faurecia expects global auto production to decline by 1%.

Forty-three percent of Faurecia’s 2018 sales were in its Seating division, with Interiors accounting for 31%, and Clean Mobility (emission controls, exhaust systems), 26%.

Following the March 2019 acquisition of Hitachi Automotive’s 63.8% ownership of Clarion, Faurecia is creating a new business group, Faurecia Clarion Electronics Systems, which combines Clarion with Parrot Faurecia Automotive and Faurecia Coagent Electronics, a Chinese infotainment maker 50.1% owned by Faurecia. Faurecia completed its 100% acquisition of Parrot Automotive, a supplier of Android-based infotainment, in October 2018. The new business group will be based in Japan and provide Faurecia with an opportunity to grow business with Clarion’s key Japanese OEM customers, Nissan and Honda. By 2022 the business is expected to employ 1,650 software engineers and exceed €2 billion in sales. ◆
The Company Profile: Panasonic Automotive

Panasonic Corporation
Headquarters: Osaka, Japan
FY 2019 Sales: ¥8,002.7 billion ($71.7 billion)
R&D Expenditures: 6.1% of sales
Capital Investment: ¥300.5 billion ($2.7 billion) with 57% in automotive
Operating Margin: 5.1%
Net Margin: 3.9%
Employees: 271,869
Sales per Employee: ¥29.4 million ($263,763)
Working Capital: ¥284,643 million ($2.55 billion)
Long-Term Debt: ¥608.8 billion ($5.5 billion)
Total Equity: ¥2,084.6 billion ($18.7 billion)
Market Capitalization: ¥2,355 billion ($21.1 billion) as of 5/10/19

Panasonic Automotive
Headquarters: Yokohama City, Kanagawa, Japan
FY 2019 Proforma Sales: ¥1,414.4 billion ($12.7 billion)
Businesses: Infotainment systems, vehicle electronics, automotive mirrors, electrification systems including lithium-ion batteries
Top Products: Infotainment systems and electrification components

Panasonic Sales by Segment
FY 2019 Sales: ¥8,002.7 billion
Appliances 41%
Connected Solutions 17%
Eco Solutions 20%
Automotive* 19%
Other** 3%

Before eliminations and adjustments
*Proforma, Automotive Solutions plus Automotive Batteries, established April 1, 2019
**Includes non-automotive batteries

Panasonic Sales and Operating Margin by Fiscal Year

- 2015 to 2019 CAGR: 0.9%
- 2015 to 2020 CAGR: 0.5%

Operating Margin by Fiscal Year

<table>
<thead>
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<th>Year</th>
<th>Margin</th>
</tr>
</thead>
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<tr>
<td>2015</td>
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<tr>
<td>2016</td>
<td>5.5%</td>
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<tr>
<td>2018</td>
<td>4.8%</td>
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<tr>
<td>2019</td>
<td>5.1%</td>
</tr>
<tr>
<td>2020*</td>
<td>3.8%</td>
</tr>
</tbody>
</table>

*Forecast
Background
The company was founded by Konosuke Matsushita in 1918 and was incorporated as Matsushita Electric Industrial Co. in 1935, in Osaka. The business expanded into multiple global markets including communications, electronics, appliances, avionics, consumer electronics, batteries, automotive navigation and entertainment systems, and more. Adopting the name of its widely known brand, the company officially became Panasonic Corporation in 2008.

Reorganization in 2013 created the Automotive and Industrial Systems (AIS) company, which combined the automotive infotainment business, batteries, industrial motors and other products into one reporting segment.

Automotive
Effective April 1, 2019, Panasonic split AIS into two segments: Industrial Solutions and Automotive. Panasonic has a long history as a global leader in infotainment; infotainment is by far the largest automotive product line in terms of sales. The Automotive segment will continue to develop advanced infotainment and cockpit electronics as well as ADAS and automated driving systems. Panasonic’s strategy for Automotive Solutions prioritizes profit growth and a reduction in development costs through co-development projects with customers.

The decisive move by many of the world’s carmakers into electric vehicles has created a huge potential market for Panasonic’s lithium-ion battery technology. The creation of the
Automotive Batteries division within the new Automotive segment will allow planners to more sharply focus on key automotive customers. The non-automotive battery business will be served by the Industrial Solutions Company.

**Automotive Batteries**
Within Panasonic’s Automotive segment, automotive batteries—specifically rechargeable lithium-ion batteries for electric vehicles—are showing strong potential for growth. Panasonic, which began producing Li-ion batteries for hybrid vehicles in 2010, is already the world’s top Li-ion battery supplier with automotive battery sales of ¥423 billion ($3.8 billion) in the fiscal year ending March 31, 2019. Panasonic expects that automotive batteries will be the main growth engine taking the Automotive segment to ¥1,577 billion ($14.1 billion) in sales by 2020, and ¥2,500 billion by 2025.

The battery pack now accounts for roughly 33% of the cost of an electric vehicle. That percentage is expected to drop to 20% by 2025, according to Bloomberg NEF.

At the end of FY 2018, Panasonic was already delivering automotive lithium-ion batteries to 12 U.S., European and Japanese companies. One of the most impressive things about Panasonic’s Energy business is the company’s deep engagements with the two carmakers who are leading the way on vehicle electrification: Toyota, among the world’s largest carmakers and the leader in hybrid vehicles, and Tesla, the top electric-vehicle innovator.

According to Panasonic its batteries are superior to the competition not only because of their high reliability but because of the company’s willingness to accommodate customers’ requirements. Panasonic makes both cylindrical and prismatic batteries. Cylindrical batteries are well suited to electric vehicles because of their high energy density. Prismatic types provide high output and high capacity. Tesla uses Panasonic’s cylindrical batteries.
Panasonic, which took a $30 million stake in Tesla in 2009, has been the company’s only battery supplier since then.

♦ Tesla
In July 2014 Panasonic signed an agreement to cooperate on the construction of a large-scale battery manufacturing plant known as the Gigafactory. The agreement called for Tesla to provide the factory and Panasonic to manufacture and supply cylindrical lithium-ion cells and invest in the equipment and machinery with which to produce them. The Gigafactory was built in Nevada, U.S.A. The agreement also called for Panasonic to continue producing cells from its factories in Japan while the Gigafactory ramped up production. Panasonic has been producing batteries for the Tesla Model 3 since January 2017.

In May 2019, Panasonic reported that FY 2019 sales for its Energy business, at ¥696.5 billion ($6.2 billion), were 2.6% lower than forecast due in part to lower than expected production at the Gigafactory. Insufficient utilization and delay in improving operational losses at the Gigafactory put downward pressure on operating profits.

According to Asia.Nikkei.com, “The partners had planned to raise capacity by 50% next year, but with sales of electric vehicles below plans the two companies concluded that major investments at this stage pose too much risk. … Tesla and Panasonic have decided to freeze spending on the Gigafactory … Panasonic will also suspend its planned investment in Tesla’s integrated EV plant in Shanghai. Instead it will supply a small number of batteries from the Gigafactory. Tesla is committed to buying batteries for the cars built at the Shanghai factory from a number of makers.”

In May 2019 Panasonic’s relationship with Tesla was in a state of flux.

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Panasonic Automotive’s Top Customers
Listed alphabetically
Audi
FCA
Daimler
Ford
Honda
Tesla
Toyota
Volkswagen

Distinctions Claimed by Panasonic
♦ World’s top infotainment systems supplier
♦ World’s number-one supplier of rechargeable Li-ion automotive batteries
♦ By 2022 the company expects to be one of the world’s top ten manufacturers of automotive components.
♦ Japan’s top e-bike supplier
Toyota

Being at the forefront of the age of vehicle electrification is risky and expensive, so Panasonic has been on a quest to develop partnerships with leading customers “that understand the superior qualities of Panasonic batteries … and are willing to share a portion of the risk involved,” according to the company’s 2018 annual report.

In January 2019, Panasonic took a big step in that direction when it signed a joint-venture agreement with Toyota to establish by 2020 a new company, initially focused on the automotive prismatic battery business. The company will also conduct research on solid-state and other next-generation batteries.

Toyota will own 51% of the company and Panasonic, 49%. Products produced by the joint venture will be sold to Toyota and to other carmakers through Panasonic. The company intends to become the leader in both battery development and battery manufacturing.

Panasonic currently supplies Li-ion batteries for Toyota’s Prius Prime plug-in hybrid.

Automotive Li-ion Battery Competition

BYD
Contemporary Amperex Technology Co. Ltd. (CATL)
LG Chem
Sony
Samsung

Two Infotainment Platforms: SkipGen and SPYDR

Panasonic is the world’s top supplier of infotainment systems with a broad swath of products, from display audio to high-end infotainment systems that include navigation, and integrated cockpit systems that combine infotainment with the instrument cluster.

Over the past couple of years, Panasonic has been following through on its strategy to develop two infotainment platforms that can be used across multiple customers to quickly develop their IVI systems with minimal engineering investment. SkipGen, announced two years ago at CES, is based on the Android operating system and is aimed at shipment volumes under 100,000 units per year. Serving higher volumes and more complex computing applications, SPYDR, a complete cockpit domain control platform, employs three operating systems:
Android, Automotive Grade Linux and a safe real-time operating system. The platform supports IVI along with applications that have functional safety requirements such as cluster, rear-view camera and surround-view camera systems. SkipGen and SPYDR share a lot of the same hardware.

Panasonic’s first SkipGen customer will launch its implementation this fall. That order is large enough that the product could be customized. Panasonic’s second SkipGen customer will ship next year. It will be pre-validated and ship as is, without customization. SkipGen is based on the Android 8.1 Oreo operating system. Google content and services including streaming media, navigation and climate settings are already embedded and controllable with Google Assistant. Amazon’s Alexa voice assistant can also be embedded into the SkipGen platform.

At last year’s Google I/O conference, Google demonstrated a Ram truck with a 12-inch display. The IVI system was powered by SkipGen. Panasonic has been working closely with Google as it develops the Android Automotive operating system. Panasonic builds the reference platforms for Android and gives access to the platforms to its competitors.

At CES 2019 Panasonic presented SPYDR 2.0, the latest version of its cockpit domain controller. Among its features are these:

- Production-ready hardware
- Three direct-drive displays (cluster, IVI, driver monitor/HUD)
- 4K display resolution support
- Multiple camera inputs with surround view camera, stitching with DSP enhancement
- DMS HUD integration with vertical face scanning to detect driver engagement
- OneConnect connected services platform integration including analytics and OTA updates
- Hypervisor and Google Android P integration

**ADAS**

Panasonic is increasingly finding ways to leverage technologies developed over decades for consumer products, for example cameras, image processing and sensors, in new automotive features, particularly safety-critical applications. “I would say in everything but forward-facing cameras we are a leader,” said Andrew Poliak, vice president of planning and innovation for Panasonic Automotive Systems America. Panasonic’s high dynamic range (HDR) cameras could be used to improve the resolution and accuracy of ADAS in difficult lighting conditions by identifying each pixel in the scene, for example a disabled white car brightly backlit at the end of a tunnel.
“Another example is our ability to offer OEM customers some pre-processing at the sensors themselves before sending image data to a central ADAS controller in the vehicle,” Mr. Poliak added. That might include filtering out image “noise” such as fog or snow at the sensor.

Toyota uses Panasonic cameras for rear view and to detect if a small person is behind the vehicle to prevent back-over accidents. Audi uses camera monitoring systems developed by Ficosa, now a Panasonic subsidiary, to replace exterior side view mirrors. Panasonic cameras are also employed in Audi’s cabin monitoring system.

Panasonic has been making considerable investments in R&D around future ADAS and autonomous driving products and technologies including centimeter-precise GPS receivers, e-horizons and augmented reality for head up displays. “If you combine those three, e-horizon can give you information about the road ahead, centimeter-precise GPS can locate your car in the lane, and coupled with augmented reality HUD, you can show the curvature of the road in foggy conditions for instance,” Mr. Poliak noted. “We are far enough along with these technologies that in our product roadmap we are what we call RFQ ready, and we are responding to RFQs.”

**CIRRUS V2X Platform**

In 2017 Panasonic partnered with the Colorado Department of Transportation to develop a V2X system to improve safety and traffic flow on the state’s highways. The result of that effort, a connected vehicle data platform called CIRRUS by Panasonic, launched at CES 2019. “We’ll be the very first commercial deployment of a cellular and DSRC hybrid infrastructure, including onboard components and roadside units,” said Mr. Poliak.

Ninety miles of Colorado roads today are equipped with both DSRC and CV2X communications. Pending FCC approvals, another 500 miles of road will be added soon, according to Panasonic. The CIRRUS software platform was designed to allow DOTs to deploy V2X at scale for all roadways in a state or region. Data is collected from vehicles using either DSRC or cellular radio, aggregated at a central command center and redeployed to drivers and infrastructure operators.

**Market Changes**

Mr. Poliak shared his insights on how Panasonic’s automotive electronics market has changed substantially since our last profile of Panasonic in 2015.
§ Up Integration
In order to reduce cost and create packaging space for new driver assistance systems and other electronics, carmakers are engaging in projects that integrate multiple ECUs into single ECUs powered by multicore processors. Mr. Poliak noted, “Not only are carmakers integrating the IVI with the cluster, but we are seeing more systems are getting lumped in including HUD, driver monitoring, cabin monitoring, surround-view cameras, telematics, virtual assistants and active noise cancellation. All of these things used to be in separate boxes.”

§ Different Customers
Increasingly Panasonic is engaging with mobility companies such as Waymo, Lyft and Uber along with some of the startups to get insights into future requirements for next generation infotainment systems. “They are beginning to influence vehicle specifications,” suggested Mr. Poliak. “In effect, the OEMs are becoming tier-one suppliers to the mobility companies. They are not yet in a position where they are dictating what the carmakers will build, but they are starting to have a voice with the OEMs on what they need.”

§ Functional Safety
“Another change in the market from 2015 is that almost every product we are involved in these days has functional safety integrated,” said Mr. Poliak, “including rear-view and obstacle-detection cameras, side-view mirror...”
replacement cameras and displays, telematics, cockpit controllers and battery disconnects.”

- **Diversification**

  Responding to the commoditization of infotainment systems, Panasonic is striving to lower costs. Toward that end, it has embraced the Android Automotive operating system platform, with its abundance of off-the-shelf APIs and application software. Panasonic is also looking to diversify its product line. With a long history in electric bikes and as Japan’s number one e-bike supplier, Panasonic has lately been supplying its expertise in e-bike componentry to other makers. Harley-Davidson’s first electric motorcycle, the LiveWire, features cellular connectivity via Panasonic’s OneConnect service. LiveWire’s telematics control unit is also from Panasonic. ◆
EV Cost Comparable to ICEs by 2025, Says McKinsey

In an article published in March 2019, McKinsey & Company presents its roadmap for electric vehicle profitability, asserting that in the next six years not only will mass-market EVs be cost competitive with ICE vehicles, but that OEMs could even see profit margins of 2% to 3% per vehicle.

**Cost walk of ICE\(^1\) to electric vehicle (EV) C-Car in 2019**

Estimated average per vehicle in $ thousands

<table>
<thead>
<tr>
<th>Category</th>
<th>Direct</th>
<th>Indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base ICE-vehicle total cost</td>
<td>14.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Remove ICE-related content</td>
<td>3.0</td>
<td>8.5</td>
</tr>
<tr>
<td>Assumed 50-kWh(^2) battery pack cost at $190–$210 per kWh</td>
<td>9.5–10.5</td>
<td>8.5–10.5</td>
</tr>
<tr>
<td>Difference in indirect cost because of volume</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Base EV total cost</td>
<td>22.5</td>
<td>11.0</td>
</tr>
</tbody>
</table>

\(^1\)Internal combustion engine
\(^2\)Kilowatt-hour; includes battery-management system

Source: McKinsey

**Base electric vehicle (EV) total estimated cost per vehicle in 2025 under the aggressive scenario in $ thousands**

<table>
<thead>
<tr>
<th>Category</th>
<th>Direct</th>
<th>Indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery pack, power electronics and e-motor</td>
<td>27.4–28.8</td>
<td>21.2–22.6</td>
</tr>
<tr>
<td>Reduction in battery-pack cost to ~$100 per kWh(^3)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>10% improvement in battery efficiency, requiring less battery capacity kWh(^4)</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Improvement in power electronics and e-motor through integration and scale</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Reduction in indirect cost from increase in annual production volume to &gt;200,000</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Improvement in productivity(^5)</td>
<td>3.9</td>
<td>6.2</td>
</tr>
<tr>
<td>Base EV cost in 2025</td>
<td>21.7</td>
<td>21.7</td>
</tr>
<tr>
<td>Base C-Car cost in 2025(^6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^3\)Includes average incentive cost of $2,000
\(^4\)Kilowatt-hour; includes battery-management system
\(^5\)Assumes 1% annual productivity improvement—reduced from historical value of 2%–3% because of OEM investments in emerging technologies (e.g. autonomous vehicle, electric powertrain, connectivity, shared mobility)

Source: McKinsey
Other highlights from the McKinsey article:

- A small- to mid-size EV is approximately $12,000 more costly to produce than a similar ICE vehicle.
- OEMs can drive major cost savings by eliminating extra displays, buttons, switches, wiring modules, and additional structural components, as well as by reducing design complexity.
- In 2018 OEMs launched about 100 new EV models and sold two million units globally.
- Mass-market EVs typically sell at volumes between 30,000 and 80,000 per year, globally.
- Regulations in major car markets compel OEMs to produce more EVs and encourage consumers to buy them.
- EVs accounted for less than 5% of sales in most markets in 2018.
- A typical BEV in the U.S. is priced at about $30,000.