VEHICLE electronics

The monthly magazine for automotive electronics engineers

Baidu robotaxis licensed to operate fully autonomously

China has granted Baidu licences to operate a fully autonomous robotaxi service in Chongqing and Wuhan.

Apollo Go, Baidu's autonomous ride-hailing service, is now authorised to collect fares for robotaxi rides completely without human drivers in the car.



Baidu robotaxis can operate without humans

Amid increasing regulatory approval of the expansion of autonomous vehicles (AVs), the permits are said to reflect regulatory authorities' recognition and trust in Baidu's autonomous driving technology.

"This is a tremendous qualitative change," said Wei Dong, vice president at Baidu. "Fully driverless cars providing rides on open roads to paying customers means we have finally come to the moment that the industry has been longing for. We believe these permits are a key milestone on the path to the inflection point when the industry can finally roll out fully autonomous driving services at scale."

The permits were granted to Baidu by government agencies in Wuhan and Chongqing's Yongchuan district. Both cities have been pioneering approaches to intelligent transportation in recent years, from developing infrastructure to updating regulations for AVs.

Having received the permits, Baidu will begin to provide fully driverless robotaxi services during daylight in designated areas in the two cities, with five Apollo robotaxis in each city.

To receive the permits, Baidu's robotaxis have undergone multiple steps of testing and licensing, starting from testing with a safety operator in the driving seat, to testing with a safety operator in the passenger seat, before receiving authorisation to operate with no human driver or operator in the vehicle.

The robotaxis come with multi-layer mechanisms to ensure safety.

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AMD partners ECarX on digital cockpit

AMD and mobility tech company ECarX are working together on an in-vehicle computing platform for electric vehicles (EVs), expected to be in mass production for global rollout in late 2023.

The ECarX digital cockpit will be the first in-vehicle platform to be offered with AMD Ryzen V2000 embedded processors and AMD Radeon RX 6000 GPUs along with ECarX hardware and software.

Combining the experience in automotive digital cockpit design of ECarX with AMD computing power and visual graphic rendering capabilities, the companies aim to deliver an innovative in-car experience. The digital cockpit will launch with features including driver information mode, head-up display, rear seat entertainment, multiple-displays, multi-zone voice recognition, gaming and a 3D user experience.

"As car companies seek to deliver immersive experiences and intelligent features for their next-generation electric vehicles, the AMD-powered ECarX digital cockpit will address these needs for the global automotive market," said Rajneesh Gaur, corporate vice president at AMD. "We are excited to work with ECarX as our first strategic ecosystem partner in China."

Ziyu Shen, CEO of ECarX, added: "The global automotive industry is transforming towards an intelligent future at an unprecedented pace with demand for computing power and graphics capabilities rapidly increasing. With this collaboration, we will further enable OEMs and tier-one suppliers to enhance their digital cockpit experiences as they seek to create greater consumer value through intelligent connected cars."

The technology to support the EV market is a growth opportunity, according to analyst firm Strategy Analytics.

Reliability check for V2X chipsets



Autotalks has selected ProteanTecs' health and performance monitoring to enhance reliability of the Tekton 3 and Secton 3 chipsets to support 5G vehicle-to-everything (V2X) communications.

ProteanTecs' cloud and edge analytics provide actionable insights and predictive data about the chipsets' performance and quality, during production testing and in lifetime usage. The company provides monitoring for adas, electric vehicles and autonomous applications.

By incorporating this part of its zero defects programme, Autotalks is giving automotive OEMs the ability to monitor reliability predictively with greater certainty.

"Autotalks sees reliability as a key requirement since the prime goal of V2X is automatically braking the car to avoid a crash," said Alberto Burger, vice president at Autotalks. "Our chipsets are the first to support ISO 26262 Asil B system certification. ProteanTecs will give us the data we need to assure rigorous quality with predictive in-chip monitoring."

Gal Carmel, ProteanTecs general manager of automotive, added: "Autotalks' V2X chipsets are ushering in the new era of road safety and shaping the future of mobility. Their sensors must operate robustly at high ambient temperature for roof installation."

Jaguar opens EMC testing laboratory

Jaguar Land Rover has opened a facility to test vehicles for electrical and radio interference.

The EMC laboratory at Gaydon in the UK aims to ensure vehicles meet current and future legislation and quality standards for connectivity and electronics.

The latest Range Rover Sport, which launched in May, was the first vehicle to undergo a bespoke testing programme at the in-house facility.

A critical aspect of vehicle performance, EMC is the ability of electrical equipment and systems to function correctly in their electromagnetic environment. It works by limiting the unintentional generation, propagation and reception of electromagnetic energy to reduce the risk of unwanted effects such as electromagnetic interference.



Jaguar test chamber in Gaydon

JLR's laboratory has two anechoic chambers: an electrically quiet rolling road that enables engineers to test vehicles at speed, as well as equipment to assess the performance of individual components, such as batteries or electric motors.

Bluetooth, GPS, wifi, 4G, 5G, adaptive cruise control, wireless charging and blind-spot monitoring are examples of vehicle services and features that the facility will test for EMC.

"The importance of testing our vehicles for electromagnetic compatibility cannot be underestimated," said Peter Phillips, senior manager at Jaguar Land Rover. "Opening this new testing facility is an important step forward for the business and it will play a crucial role in helping us deliver quality, legal and customer satisfaction."

With advances set to increase the number of electric powertrains and the range of digital and cloud-based services on vehicles, from software-over-the-air updates to autonomous technology, testing for EMC is crucial.

Qualcomm ups Scorpio in-car experience

Mahindra is working with Visteon to improve in-vehicle experiences on the all-new Scorpio-N, using the third-generation Snapdragon cockpit platforms from Qualcomm.

Mahindra's connected artificial intelligence (AI) technology uses Visteon's SmartCore cockpit domain controller technology based on the Snapdragon platforms.

The Scorpio-N has a 17.8cm colour driver information display and 20.3cm infotainment system with navigation. Leveraging the scalable AI-based Snapdragon, the Scorpio-N provides personalisation and natural interaction between a car and its driver, as well as virtual assistance, ultra-HD, and immersive audio and visual experiences.

A key component of the Snapdragon Digital Chassis technology suite, the cockpit platforms are designed to support higher levels of computing and intelligence needed to enable contextual safety use cases for drivers and passengers, which includes facilitating driver monitoring and object detection, as well as helping ensure the security of personal and vehicular data.

Additionally, the platforms feature a suite of wireless technologies to support multi-mode cellular connectivity, Wifi 6 and Bluetooth.

"The consumer of today expects and demands that connected, intelligent and smart technologies play a greater role in the automotive experience," said Uday Dodla, Qualcomm senior director in India.



Scorpio-N uses Snapdragon cockpit platform

Andes and Green Hills deliver Risc-V safety platform

Andes Technology and Green Hills Software have teamed up to deliver an automotive safety platform for Risc-V.

The collaboration brings together the Asil-certified AndesCore 25 series Risc-V processor family with Green Hills' automotive safety offerings to support applications that require safety, security and efficiency.

The software from Green Hills will include the safety-certified μ-Velosity rtos, Asil-certified Multi development environment with system-level debugging and analysis tools and C/C++ optimising compilers, and Probe for JTag and trace target connections.

The combined hardware and software platform is designed for SoC companies and end-users to create 32 and 64bit Risc-V-based SoCs targeting critical functions requiring ISO 26262 Asil B to D.

Andes is the first Risc-V processor IP vendor to receive Asil-D process certification for hardware and software.

"AndesCore Risc-V processor IP with safety enhancement has already been adopted by several early customers due to its unique and competitive value," said Charlie Su, Andes CTO. "The exciting partnership with Green Hills enables us to further offer comprehensive and robust development support for our customers."

The functional safety-enabled offering from Andes and Green Hills is expected to be available for general licensing before the end of this year.

The AndesCore 25 series is a family of CPU IP cores based on AndesStar V5 architecture incorporating Risc-V technology. Its five-stage pipeline is optimised for high operating frequency and performance, but with a small gate count.

The series supports optional single- and double-precision floating point instructions. It also offers branch prediction for efficient branch execution, instruction and data caches, local memories for low-latency accesses, and ECC for L1 memory soft error protection.



Elektrobit designs cockpits on Qt

Elektrobit and Qt are collaborating to make it easier for car makers to develop digital cockpits.

The combination brings together the Qt Device Creation framework and the NXP i.MX 8 applications processor with Elektrobit's EB Tresos software for Autosar development and user interface engineering services.



Bringing together Qt framework, NXP processor and EB Tresos software

The offering provides a turnkey approach for car makers seeking to develop human-machine interfaces (HMIs) using off-the-shelf software and hardware.

As driver demand for immersive digital experiences and features grows, the digital cockpit has become a vital and appealing component. The market is expected to hit a CAGR of 13 per cent until 2027, according to researcher Mordor Intelligence, and all automakers are seeking more efficient and affordable approaches to develop in-vehicle experiences.

The Qt-Elektrobit offering is one of the first commercial products enabling HMI runtime on the Autosar architecture. It eliminates the costs, complexities and time requirements of using a hypervisor, and can run on a single, multi-core processor.

This streamlined approach helps accelerate the development process and speed time to market for HMIs. The Device Creation framework enables the creation of rich user interfaces for embedded platforms.

The EB Tresos Autosar architecture stack adds to it security and safety capabilities, supporting requirements up to Asil-D on limited-resource microcontroller units, as well as on multi-core SoCs.

The offering includes access to Elektrobit's user interface engineering services team. Additional functional software from third parties such as Continental can be integrated, such as Linux instrument cluster, software-defined radio, driver monitoring and e-travel companion.

"We are pleased to collaborate with Elektrobit to integrate our HMI development software with Elektrobit's field-proven Autosar software and integration expertise," said Miao Luo, head of automotive at Qt. "This pre-integrated approach provides the fastest and easiest way to produce software-defined vehicles."

Jörg Scherer, director of user experience at Elektrobit, added: "Elektrobit is proud to bring our decades of deep experience in Autosar, along with our ECU software and services to this collaboration with Qt. Together, we're bringing HMI runtime into Autosar, making it easier for OEMs to develop advanced cockpits for their next-gen vehicles."

Foretellix and IPG speed adas testing

Foretellix is cooperating with IPG Automotive to reduce development costs and time to market and increase the safety of automated driving systems.

The combination of Foretellix's Foretify verification and validation platform and IPG's virtual vehicle simulation environment CarMaker can be rapidly deployed by development teams.

The combined toolchain enables large-scale virtual testing to accelerate the development and deployment of adas. Bugs and edge cases can be discovered faster.

Foretify determines, generates and optimises the set of test scenarios needed to ensure test coverage for the user's adas or AD stack. It orchestrates the execution of the scenarios and interfaces with CarMaker, which runs each of the tests in a realistic simulation environment.

CarMaker provides the high-fidelity virtual vehicle, sensors, traffic objects and 3D environment.

It can run faster than real time with few resources in HPC environments.



Euro NCap 2023 rules increase adas test requirements

Next year's changes to the Euro NCap tests, which have a focus on vulnerable road users (VRUs), will necessitate different adas testing platforms and targets, according to AB Dynamics.

The 2023 protocols will result in more than 200 different VRU test scenarios that could be selected as part of the official rating test. Euro NCap has thus updated its list of approved testing equipment ahead of introducing a suite of new test scenarios for 2023.

"There is an industry need for improved adas platforms and targets as Euro NCap looks to expand its protection of VRUs," said Andrew Pick, AB Dynamics' director of track testing systems. "We have worked closely with the industry, including Euro NCap test laboratories and vehicle manufacturers, to develop products that enable the testing of current and upcoming regulations. The quantity and complexity of testing are increasing rapidly and the platforms and targets are essential to conducting this testing efficiently."

Traditionally, the industry relied on ground-fixed, belt-driven platforms to move VRU targets but this required the entire infrastructure to be moved to test a different scenario. The introduction of the 2023 protocols will result in more than 200 different VRU scenarios that could be selected as part of an official rating test.

The introduction of motorcycle test scenarios has also necessitated a move from ground-fixed systems to mobile as the adas platform needs to travel faster and longer.

AB Dynamics' newly approved LaunchPad 80 is capable of test speeds of up to 80km/h and uses a rapid-change 800Wh battery pack. The platform can conduct all current and upcoming motorcycle test scenarios.



LaunchPad 80 is approved for use in official Euro NCap testing

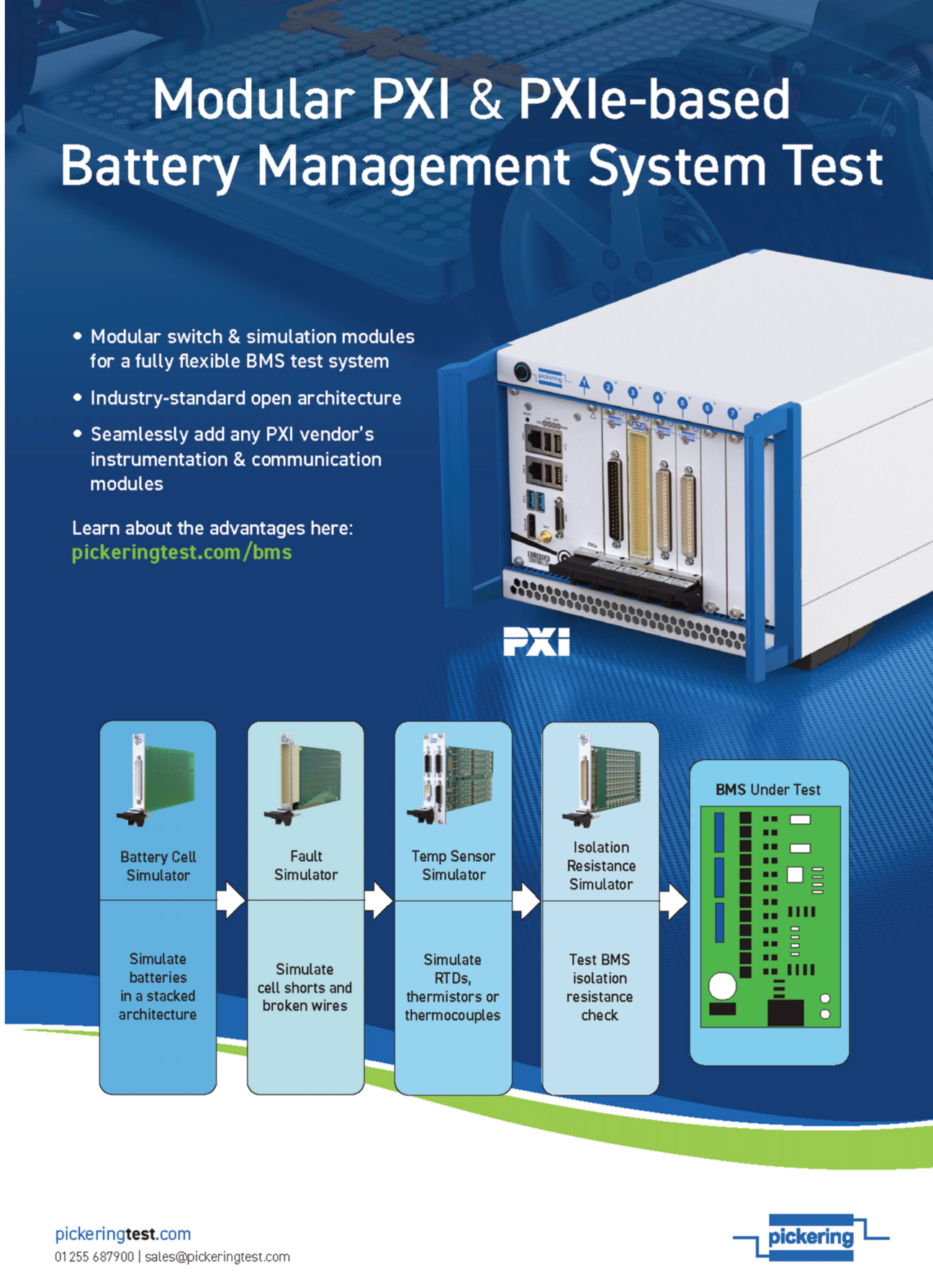
The car-to-car crossing straight crossing path test is another example of one of the upcoming scenarios due to come into effect in 2023. The scenario simulates two vehicles approaching an intersection perpendicular to each other. The test vehicle's driver assistance system will inhibit it from pulling away from rest if it detects a collision with the other vehicle.

In this scenario, AB Dynamics' Soft Car 360 piloted on the GST platform would represent the target vehicle. The speed and direction of the test and target vehicle need to be accurately controlled to meet at the intersection at the right time to fulfil the test requirements. The firm's driving robots provide repeatable inputs to the test vehicle and path following software enables it to be choreographed with the target.

To gain approval for its products, AB Dynamics had to submit in-house performance figures to show they met the required specifications. It also consulted with Euro NCap laboratories and vehicle manufacturers to submit test data to prove the products worked reliably and consistently.

Additionally, it conducted back-to-back tests of its LaunchPad system against the incumbent soft pedestrian target (SPT) and achieved identical results. More than 250 test runs were presented for review.

"Since 2018, there have been well over 100 vehicle types that have been star-rated by Euro NCap using AB Dynamics' vehicle target, the Soft Car 360," said Pick. "Our products are a proven robust way to prepare for Euro NCap testing and are used by Euro NCap laboratories and the world's leading vehicle manufacturers."



Intel tastes self-driving tractors at vineyard

Intel is working with Federated Wireless and Blue White Robotics so self-driving tractors at a California vineyard can automate repetitive tasks and free workers to take on higher-value responsibilities.

This shows the possibilities that open when the company pairs a high-bandwidth, low-latency private 5G wireless network with edge computing devices.

"As we look to the future for autonomous agriculture, we're extremely optimistic for what 5G edge can enable for customers, helping them create new business and revenue models," said Caroline Chan, Intel vice president,

A farmer plots the tractors' routes. The tractors move across the vineyard in two shifts around the clock, navigating their way through fields without any humans at the wheel. Sensors on the tractors detect obstacles in their paths, while other sensors steer them around anomalies.

Working together for more than a year, the companies put the autonomous tractors to work on repetitive tasks – weeding, mowing and applying herbicides – in the farm's five square kilometres of grapevines.

Federated Wireless deployed a private wireless network to overcome a connectivity obstacle on the premises, which, like most farms, is far from urban areas and does not have ample cellular or broadband connectivity coverage across all the acreage. That lack of connectivity means no sensors to collect real-time data from farm equipment and no way to automate farm tasks.

Powering the private wireless network was an edge server with a six-core Intel Xeon D-1528 processor using Intel Smart Edge software that linked the autonomous tractors and sensors.

Meanwhile, Blue White Robotics (BWR), an autonomous devices specialist, delivered the kit that converted existing John Deere tractors into the fleet of self-driving machines.

"BWR approached us with a specific problem," said Bhupesh Agrawal, director of private wireless networks at Intel. "They had a fleet of autonomous tractors in rural farmland, but these machines couldn't talk with each other as there was almost zero connectivity on the farm. Without connectivity, there is no opportunity to process real-time data."

Agrawal and his team want to scale the technology into citrus farms and nut farms, while iterating along the way.

Dense clusters of nut trees such as macadamia – a commercially critical crop to California – present complex scenarios beyond neatly trimmed hedgerows of grapevines.

Agrawal looks at these farms not just as bunches of plants and trees, but as fonts of information.

"Each is a data source that will drive an insatiable appetite for compute demand at the edge, but only if we can properly capture and process those data while delivering bigger impact to our customers, our partners and the community that we live in," he said.



The technology was demonstrated at the recent Intel Vision event

Delta integrates Infineon devices in inverters

Delta is using Infineon's CoolSiC devices to improve energy transition in its bi-directional inverters, a hybrid three-in-one system that integrates solar, energy storage and charging of electric vehicles.

This helps EVs provide household emergency backup power.

The bi-directional inverter can supply power to charge EVs and home batteries, while acting as backup power for unexpected outages.

Products from Infineon include the 1.2kV M1H CoolSiC EasyPack 1B modules and 1.2kV CoolSiC D²Pak seven-pin surface mount device.

This three-in-one system was realised in a package measuring 425 by 865 by 160mm. With an output power of about 10kW, the system allows a maximum continuous current of 34A and achieves peak efficiencies of more than 97.5%.

"With the company's devices, we were able to integrate three applications into one system, which allows us to take a giant leap towards green energy," said Raymond Lee, director of Delta's PV inverter business unit.

The EasyPack module has integrated NTC temperature sensor and press-fit contact technology. The module has a low-inductive design with small switching and conduction losses.

Other components from Infineon in the system include devices using CoolMos C7 and TrenchStop 5 IGBT technologies. Additionally, the 1.2kV CoolSiC mosfet in a surface-mounted package is part of this system. This uses XT interconnection technology for its thermal properties, as well as the Kelvin source concept.

"We are proud to be a big part of this project, representing a major milestone on the road to carbon neutrality," said Peter Wawer, president of Infineon's industrial power control division.



Delta has integrated CoolSiC devices into a bi-directional inverter

The devices include a 3μs short-circuit resistance, and the mosfets provide full slew rate (dV/dt) control as well as a benchmark gate threshold voltage of 4.5V. They are also robust against parasitic turn-on and can be operated with a turn-off voltage of 0V.

A robust body diode enables hard commutation. The package creepage and clearance distances are 6.1mm. Additionally, the package allows direct integration into PCBs with natural convection cooling without additional heat sinks.

ECU market to see 7.2% CAGR till 2030

The automotive electronic control unit (ECU) market is expected to garner $58.3bn at a CAGR of 7.2% by 2030, says Market Research Future.

For automakers, the need for electric and hybrid vehicles is predicted to be a profitable growth potential. Major luxury car manufacturers are introducing electric versions of their vehicles in response to rising environmental concerns and an increase in fuel prices.

Governments are implementing incentives and laws to promote the purchase of EVs, which will accelerate the expansion of the ECU industry.

Various government mandates for reducing fuel usage coupled with the growing need for a better mileage of cars among consumers should offer opportunities.

However, the rise in complexity and the number of ECUs may act as market restraints over the forecast period.

Due to rising need for in-vehicle communication and entertainment systems in passenger cars, rising disposable income, and rising auto production in this region, it is anticipated that Asia Pacific will take the lead in the global market for automotive ECUs.

Because of the rise in installation of the electronic systems in passenger cars, SUVs and light commercial vehicles, North America is anticipated to experience the highest CAGR of 6.0% over the projected period.

The report lists the key players in the ECU automotive market as Denso, Delphi, Bosch, Hyundai Mobis, Continental, Lear, Hitachi, Panasonic, Magneti Marelli, Pektron and Takata.

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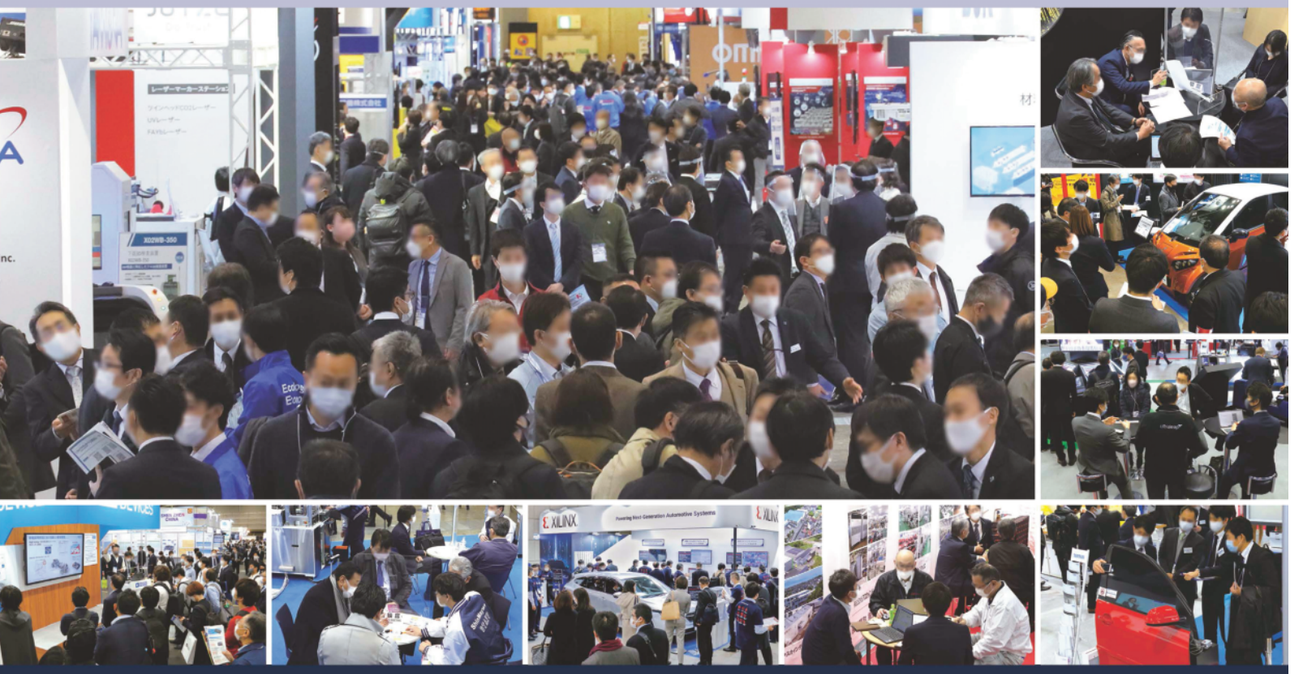
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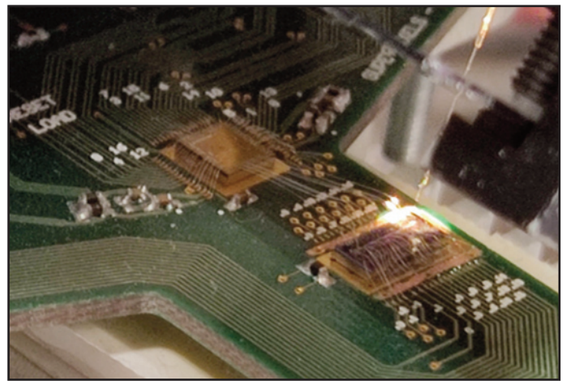
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Device manipulates light signals on chip

A joint optical wireless research project could benefit self-driving vehicles and portable devices.

The study by the Politecnico di Milano was conducted with Stanford University, the Scuola Superiore Sant'Anna in Pisa and the University of Glasgow, and was published in *Light: Science & Applications*.



Photonic processor benefits autonomous vehicles

The researchers have found a way to separate and distinguish optical beams even if they are superimposed and the form in which they arrive at their destination is drastically changed and unknown.

This operation is made possible by a programmable photonic processor built on a 5mm^2 silicon chip. The processor can receive all the optical beams through a multitude of microscopic optical antennas integrated on the chip, to manipulate them through a network of integrated interferometers and separate them on distinct optical fibres, eliminating mutual interference.

This device allows information quantities of over 5000GHz to be managed, which is at least 100 times more than current high-capacity wireless systems.

Similar to what happens in optical fibres, even in free space light can travel in the form of beams having different shapes, called modes, and each of these modes can carry a flow of information. Generating, manipulating and receiving more modes therefore means transmitting more information.

The problem is that free space is a much more hostile, variable and unpredictable environment for light than an optical fibre. Obstacles, atmospheric agents or even the wind encountered along the way can alter the shape of the light beams, mix them and make them at first sight unrecognisable and unusable.

"A peculiarity of our photonic processor is that it can self-configure very simply, without the need for complex control techniques," said Francesco Morichetti, head of the Photonic Devices Lab at the Politecnico di Milano. "This allows scalability to new versions of the device, capable of handling many beams at the same time, further increasing the transmission capacity. It is also able to adapt in real time to compensate for effects introduced by moving obstacles or atmospheric turbulence, allowing the establishment and maintenance of optimal optical connections."

To exchange information in any situation, while in the car, doing sports or in remote areas of the planet, the most natural and flexible way is to use devices that communicate without cables through free space, wireless.

"There are many applications in other areas that require advanced processing of optical beams, including high-precision positioning and localisation systems for self-driving vehicles, sensors and remote object recognition, portable and wearable devices for augmented reality and new investigation techniques for biomedical applications," said Andrea Melloni, director of Polifab, the Politecnico di Milano centre for micro and nanotechnologies. "These are research areas of great interest in which the Politecnico di Milano participates with leading roles within European projects and in collaboration with industries."

As with cable transmissions, in which an epochal technological leap took place with optical fibres, for wireless communications too, it is expected that optical connections will soon represent a new frontier.

"The ability to manage immense flows of information on miniaturised chips is a peculiarity of integrated photonics," said Marc Sorel, professor of electronics at the TeCIP Institute of the Scuola Superiore Sant'Anna. "This synergy places Italy in a leadership position on photonic technologies for communication, sensors and biomedical."

Funding comes from the European Horizon 2020 Superpixels project, which aims to create sensor and imaging by exploiting the on-chip manipulation of light signals.

SAFETY IN THE AIR

Lei Poo looks at the importance of security in wireless battery management systems



The full benefits of wireless battery management systems (WBMS) can only be achieved if system security can be assured from process to product.

The challenges about the technological and business benefits of WBMS seemed daunting, but the rewards are too promising to ignore.

Wireless connectivity's many inherent advantages over wired or cabled architectures have already been proven in countless commercial applications, and BMS was another clear-cut candidate for cord cutting.

The prospect of a more lightweight, modular and compact EV battery pack – finally liberated from its cumbersome communication wiring harness – has been roundly embraced. By eliminating up to 90% of the pack wiring, and 15% of the pack volume, the entire vehicle's design and footprint can be streamlined significantly, as can its cost, development complexity and associated manual installation and maintenance.

Standard

There are numerous challenges that need to be overcome to achieve the promises that WBMS offers. Wireless communications need to be sufficiently robust to interference when the car is driven, and the system must be safe under all conditions. But robust and safe design alone may not suffice against a determined attacker; this is where security comes into play.

Sources of interference change depending on where the car is driving (for example, city versus rural) as well as whether someone is using another wireless device in the car that operates in the same frequency band. Reflections within the battery pack can also degrade performance depending on the material used for the pack housing the battery cells.

There is a significant possibility that the WBMS signal could fluctuate, potentially disrupting communication under natural conditions, let alone in the face of a malicious actor.

If the communication was somehow interrupted, the car could revert to a safe mode with reduced performance to allow the driver to act, or, with complete loss of communications, come to a safe stop. This can be accomplished by proper safety design, which takes into account all possible failure modes and implements end-to-end safety mechanisms that address random failures of components.

But safety design does not consider the possibility of malicious actors who might exploit the system to their advantage, including taking control of the car remotely. This was demonstrated by researchers on a moving vehicle during the 2016 Black Hat conference, using remote access via the vehicle's gateway. Thus, wireless robustness and fail-safe design are not sufficient; they need to be accompanied by security.

This demonstration was a valuable lesson, showing that future wireless systems in cars need to be designed so they cannot be leveraged as another remote entry point. In contrast, conventional wired battery packs offer no remote access, so to gain access to battery data, a hacker would need physical access to a high-voltage environment in a vehicle. Additional security challenges can arise throughout the EV battery life cycle, as shown in Fig. 2.

These use cases define the various functions a WBMS must support. For example, preventing unauthorised remote access is one consideration during EV deployment, but more flexible access is needed during manufacturing. Another example is in serviceability, where right-to-repair laws require a way for car owners to fix issues that stem from the battery cells or the associated WBMS.

This means a legitimate way of updating software in the WBMS must be supported and the update mechanism should not compromise the safety of the vehicle when it leaves the service centre.

Also, EV batteries are sometimes redeployed to the energy sector when they no longer meet EV performance standards. This requires secure ownership transfer of the EV battery from its first life to the next life.

Since the batteries are devices without built-in intelligence, it falls upon the accompanying WBMS to enforce the proper security policies that best serve the EV battery life cycle. Secure erasure of first life secrets is needed before transitioning to a second life.

The ISO/SAE 214342 standard on cyber-security engineering in road vehiclest was officially released in August 2021. It defines an exhaustive, end-to-end process framework, with four levels of cyber-security assurance. Automotive OEMs and suppliers are rated on a scale from one to four, with four denoting the highest level of conformance, see Fig. 3.

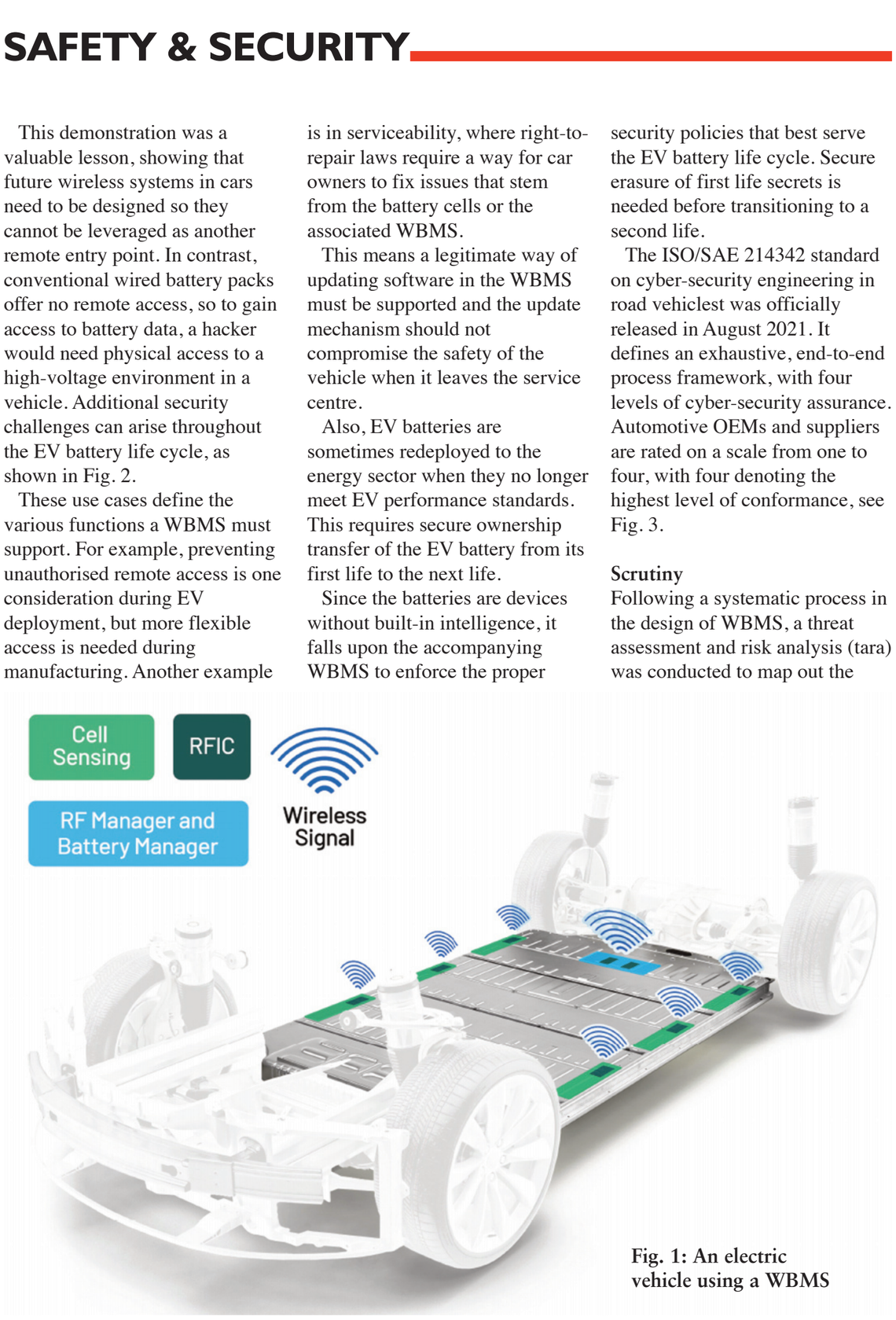


Fig. 1: An electric vehicle using a WBMS

Scrutiny

Following a systematic process in the design of WBMS, a threat assessment and risk analysis (tara) was conducted to map out the

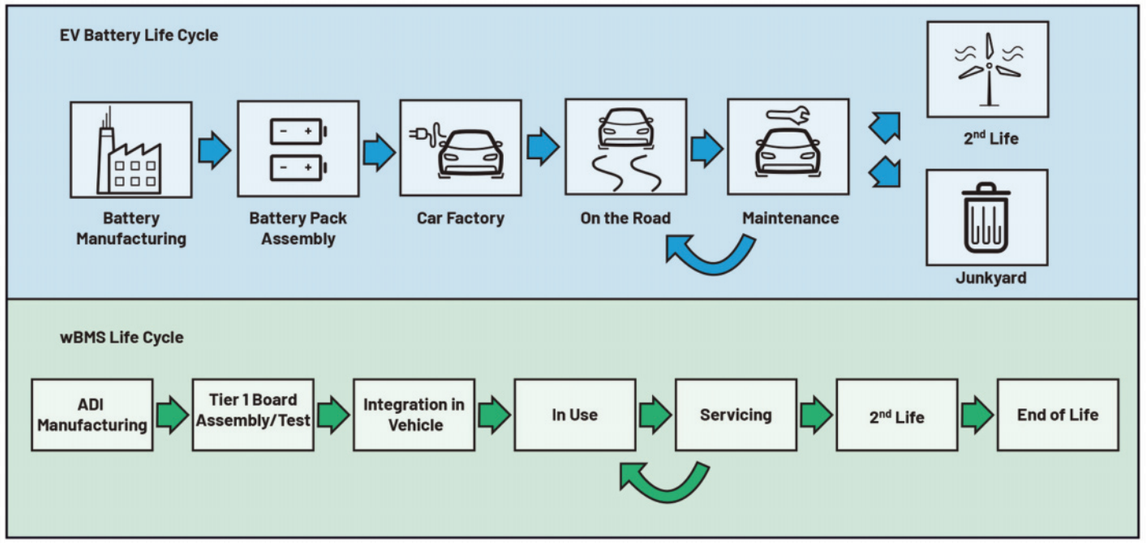


Fig. 2: EV battery life cycle and its associated WBMS life cycle

threat landscape based on how the product would be used. By understanding what the system does, and the various ways it will be used over its lifetime, it can be determined what key assets need protection and from what potential threats.

There are several choices of tara techniques, including the well-known Microsoft Stride method, which attempts to model threats by considering the six threats abbreviated by the word “stride”: spoofing, tampering, repudiation, information disclosure, denial of service, and elevation of privilege.

This can then be applied to the different interfaces of the components that make up the WBMS system, as shown in Fig. 4. These interfaces are natural stops along the data and control flow paths where a potential attacker may gain unauthorised access to system assets.

Here, by role playing the attacker and asking how applicable each threat is on each interface and why, possible attack paths can be mapped and it can be determined how likely the threat is to happen and how severe the consequences may be if it succeeds. This thought process is then repeated across the different life cycle stages as the threat likelihood and impact may vary depending on the environment the product is in, for example, warehouse versus deployment. This information will point to the need for certain countermeasures.

Take for example the wireless channel between the wireless cell monitors and WBMS manager during deployment, as shown in Fig. 4. If the asset is the data from the wireless cell monitors, and the concern is the leakage of the data values to an eavesdropper, then it may be desirable to encrypt the data when they pass through the wireless channel.

If the concern is about the data being tampered with as they pass through the channel, then the data may need to be protected with a data integrity mechanism, such as a message integrity code. If the concern is about identifying where the data came from, then a method for authenticating the wireless cell monitors to the WBMS manager is needed.

Going through this exercise identifies the key security objectives of a WBMS, as shown in Fig. 5. These goals will require some mechanisms to be implemented.

Very often, the question of how far to go in selecting the mechanisms to achieve a particular security goal is asked. If more countermeasures are added, it would almost certainly improve the overall security posture of the product, but at great cost, and possibly add unnecessary inconvenience to the end consumer using the product.

A common strategy is to mitigate the most likely threats that are the easiest to deploy. More sophisticated attacks that tend to target assets of higher

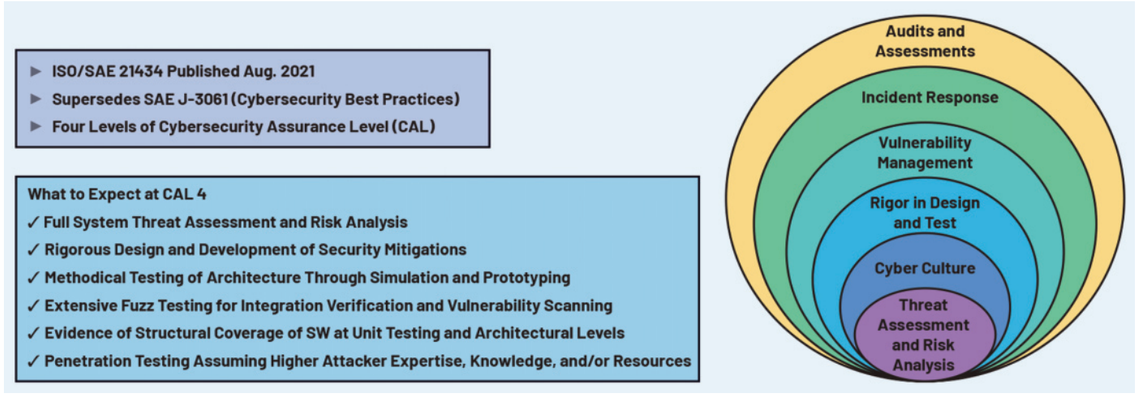


Fig. 3: ISO/SAE 21434 framework and cyber-security assurance level-four expectations

value will likely require stronger security countermeasures, but these may be extremely unlikely to occur and hence yield low returns if implemented.

For example, in WBMS, physical tampering of the IC components to gain access to battery data measurements while the vehicle is driving down the road is extremely unlikely, since one would need a well-trained mechanic with deep EV battery knowledge to do gymnastics on the car parts while the car is in motion.

An attacker in real life would likely attempt an easier path if one exists.

A common type of attack on networked systems is a denial of service (DoS) attack, depriving the user of product utility. A portable wireless jammer could be created to interfere with WBMS function (hard), but an attacker could also let the air out of the tyres (easy).

This step of reconciling the risks with a set of appropriate mitigations is known as risk analysis. By weighing the impact and likelihood of the relevant threats before and after suitable countermeasures have been introduced, it can be determined if the residual risks have been reasonably reduced. The result is one where security features are incorporated only because they are needed and at a cost level acceptable to the customer.

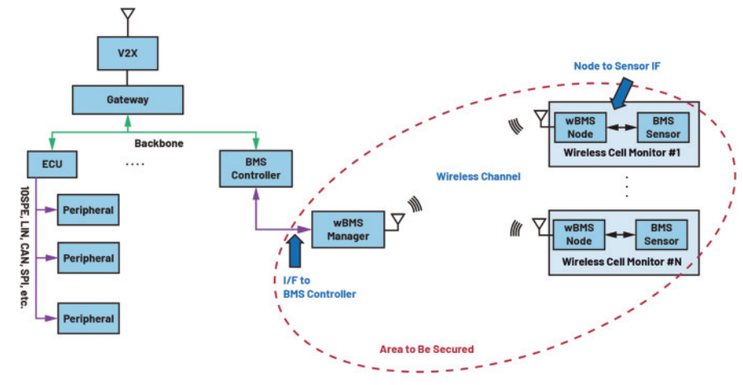


Fig. 4: Threat surface considerations for WBMS

The tara for WBMS points to two important aspects of security: device-level security and wireless network security.

The first rule of any secure system is keep the keys secret. This means both on the devices and in manufacturing operations.

Device security should take into account the hardware, ICs and low-level software on the ICs, and ensure the system can boot securely from immutable memory into a trusted platform for code to run. All software code should be authenticated prior to execution, and any in-field software update require authorisation by pre-installed credentials.

Rollback to a previous and possibly vulnerable version of the software should be prohibited after the system is deployed in the vehicle. Additionally, debug ports should be locked once the system is deployed, thereby eliminating the possibility of unauthorised backdoor access.

Network security is targeted at protecting the over-the-air communication between a WBMS cell monitor node and the network manager within a battery pack enclosure. Security starts at network joining where membership is checked for all the participating nodes. This prevents random nodes from joining the network even if they happen to be physically close.

Mutual authentication of the nodes to the network manager at the application layer will further secure the wireless communication channel, making it impossible for a man-in-the-middle attacker to masquerade as a legitimate node to the manager or vice versa.

Furthermore, to ensure only the intended recipient can access the data, AES-based encryption can scramble the data cryptographically, preventing information leakage to any potential eavesdroppers.



Fig. 5: Security objectives of WBMS

Keys

As with all secure systems, the heart of security is a set of cryptographic algorithms and keys. Nist-approved guidelines mean choosing algorithms and key sizes that align to a minimum security strength of 128bit that is suitable for data-at-rest protection (for example AES-128, SHA-256 and EC-256) and uses algorithms found in well-tested wireless communications standards such as IEEE 802.15.4.

The keys used in device security are typically installed during manufacturing processes and never leave the IC devices. These keys, which are used to ensure system security, are in turn protected physically by the IC devices both in use and at rest from unauthorised access. A hierarchical key framework then protects all application-level keys by saving them as encrypted blobs in non-volatile memory, including the ones used in network security.

To facilitate mutual authentication of the nodes in the network, a unique public-private key pair can be provisioned and a signed public-key certificate put into each WBMS node during manufacturing. The signed certificate allows a node to verify it is talking to another legitimate node and valid network member, while the unique public-private key pair is used by the node in a key agreement scheme to establish a secure communication channel with another node or with the BMS controller.

One benefit of this approach is easier WBMS installation without needing a secure installation environment, as the nodes are programmed to handle network security automatically after deployment.

In contrast, past schemes that use pre-shared keys to establish secure channels often required a secure installation environment and an installer to programme the key value manually for the communication end points.

To simplify and lower the cost of handling the key distribution problem, assigning a default common network key for all nodes in the network was often the shortcut many took. This often resulted in a hard lesson learned when a break-one, break-all disaster occurred.

As the OEM production scales, having the ability to leverage the same WBMS with varying numbers of wireless nodes across different EV platforms and to install at different manufacturing or servicing sites that are necessarily secure favours the distributed key methodology that simplifies the overall key management complexity.

Conclusion

The full benefits of WBMS technology can only be achieved if security can be assured from device to network, and over the lifetime of the EV battery. Security, in this light, requires a system-level design philosophy, encompassing both process and product.

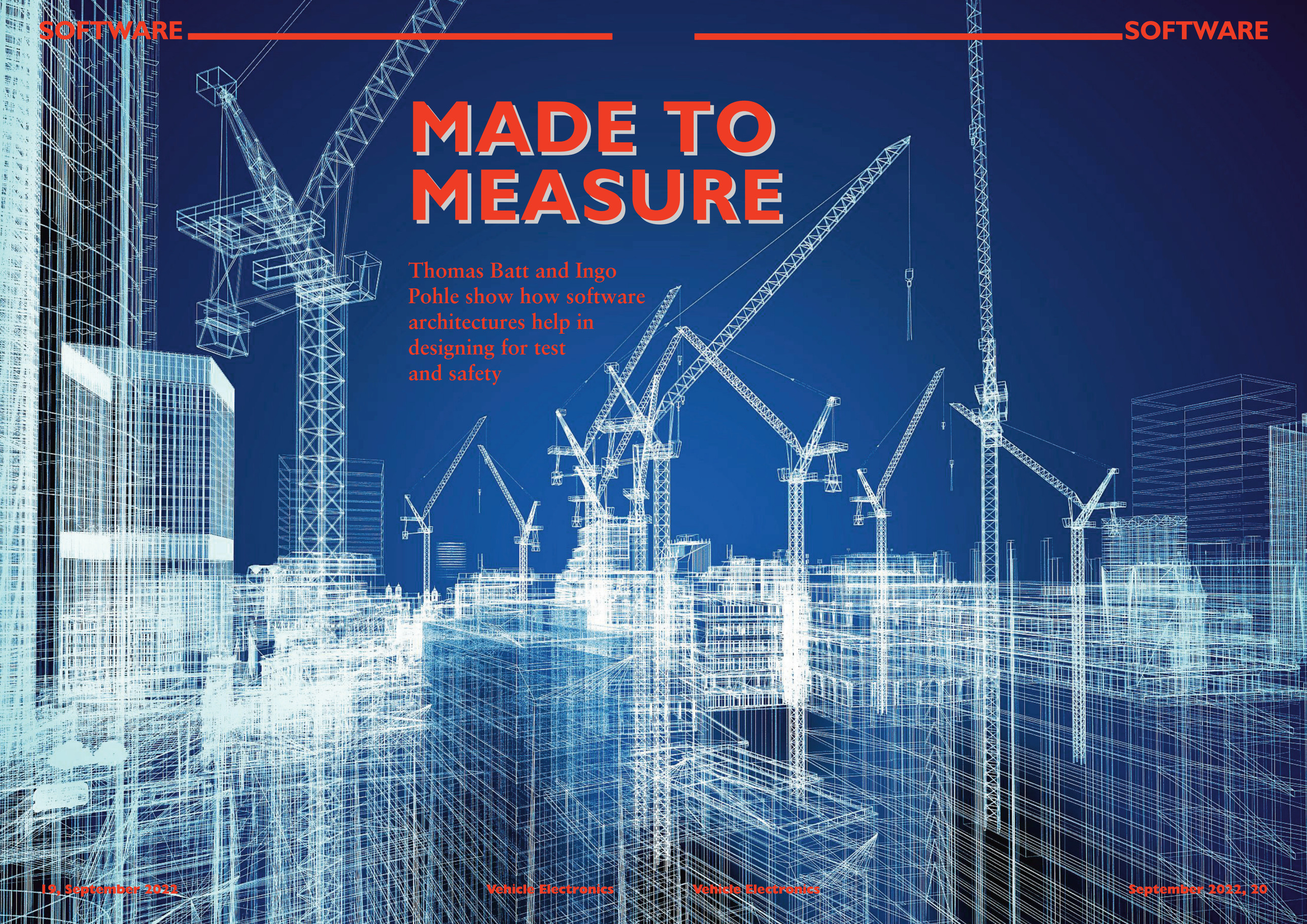


Lei Poo is director of system architecture at Analog Devices

SOFTWARE

MADE TO MEASURE

Thomas Batt and Ingo Pohle show how software architectures help in designing for test and safety



Vehicle Electronics

Connected devices and systems have become an integral part of everyday life, and this is taken for granted. Finding the fastest way to a destination with a smartphone, reading the news on a tablet while sitting on the sofa, or controlling smart heating with a smartphone app, these systems make life more convenient.

This gain in convenience, however, calls for more stringent security and safety requirements, which have to be managed by those developing such systems. This is especially true for autonomous driving where efficient safety concepts are top priority.

Skills

Increasing product complexity and more powerful hardware have resulted in a growing scope and complexity of software in embedded systems. Software implements the major part of functionality in most systems. Embedded software development

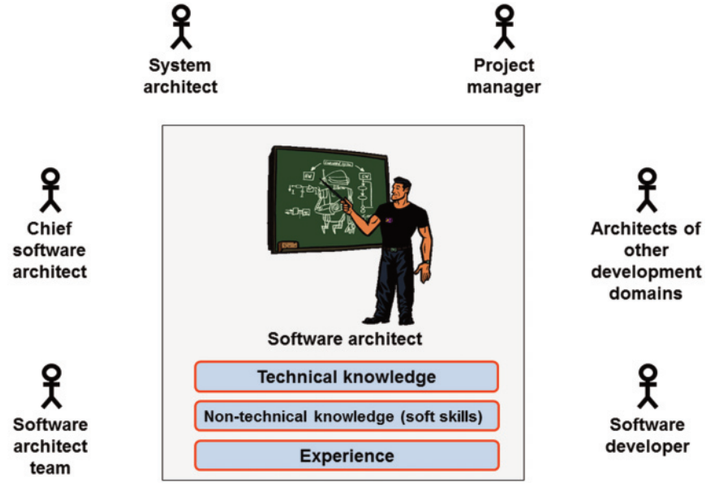


Fig. 2: Software architect

divisions are growing continuously.

This becomes particularly obvious in the automotive sector and in the current labour market. Mercedes Benz, for example, plans to generate most of its revenue through software-based systems from 2030.

Software development is no longer a one-person show but done in large teams distributed over multiple locations worldwide.

Over the past few years, embedded software has gained in significance dramatically in most companies in the embedded industry, even in mechatronics. But this is only the beginning.

Agile

Agile software projects use evolutionary software architecture development, among others, based on test-driven software development techniques. These are the two main approaches:

- Functional architecture: The software system is represented by functions or features and their dependencies.
- Component architecture: Develops a rough draft as well as several detailed drafts containing a fine-tuned structure of the software.

Know-how

Software architects who meet the requirements of their responsible

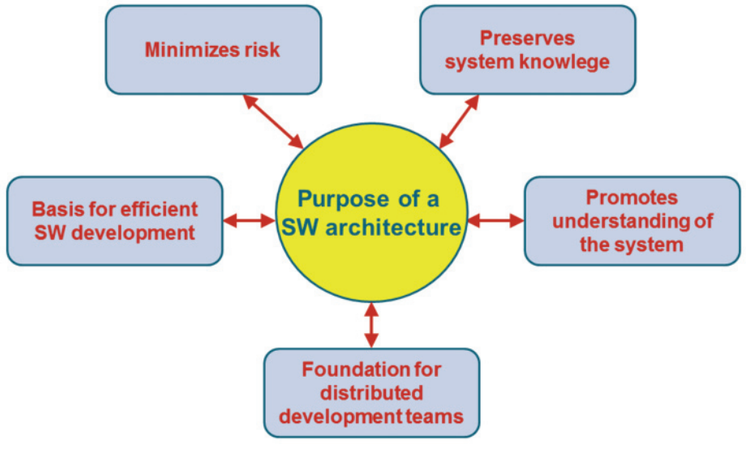


Fig. 1: Software architecture fit for the project

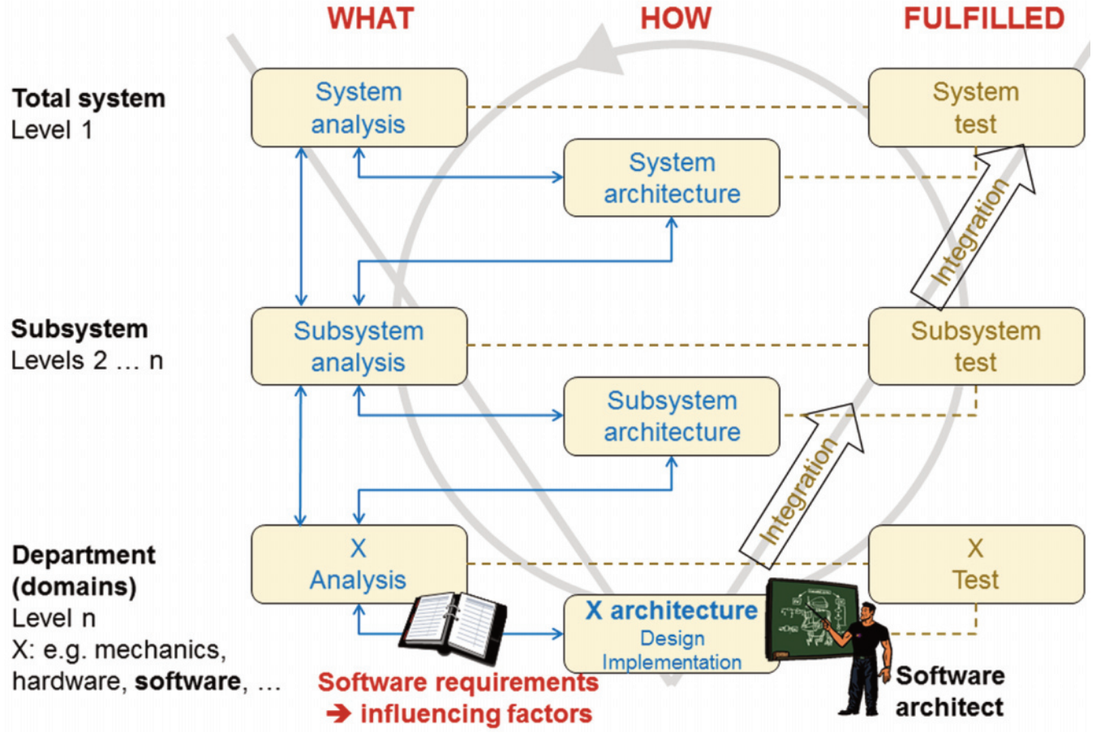


Fig. 3: Design process for embedded systems

jobs need extensive know-how covering key aspects, including a basic understanding of the software architecture.

At an abstract level, the architecture is a bridge between the requirements and the implementation of software.

In software, the architecture describes the rough structure (also modules and classes in exceptional cases) consisting of, for example, software components, software layers, software subsystems, interfaces and their dependencies.

For these architecture elements, it is also possible to describe interactive and individual behaviour.

The runtime architecture is another key element of the software architecture.

Everyone with the required know-how can take on the role of the software architect in a company.

However, for a really professional approach, the individual role should be preferred. One or more software architects are involved in a project depending on its size.

The software architect coordinates everything with multiple roles in the project and therefore requires technical and non-technical knowledge; the more experience, the better.

The role of software architect should probably not be assigned to an inexperienced university graduate; it calls for an extroverted, innovative, decisive and experienced personality.

Design

The design process describes the development process of the software. Every company has to identify and implement the process that is most suitable for them. The software architect plays a key role in defining this process.

Based on a V-model type representation, the design process can be applied to the development of a complete embedded system, that is not only to the development of software.

Requirements

In analytic processes, analysts – in most cases also the architects – on the individual levels identify and

document the respective requirements (what). These requirements are the basis for creating the architectures (how).

Based on a subsystem architecture, the software architect develops the architecture for a subsystem in coordination with other development domains at the same level, for example hardware development.

In line with the requirements, the test team develops test cases to prove correct implementation later in the development process. This is also done at different levels.

Design for test and design for safety are basic topics in the context of software architectures.

Influence

The software requirements – functional and non-functional – are derived from the X analysis (here: software analysis) shown in Fig. 3.

By analysing the influencing factors, the software architect determines the relevance of the requirements for the software architecture, the changeability of the requirements in the future, and the derivation of consequences for the software architecture.

Non-functional software requirements include software quality attributes of the software, such as portability, maintainability, reliability, safety and security, resource requirements, performance, and real-time compatibility.

Some quality attributes are consistent, others can also have opposing effects.

With this in mind, the following question can be asked: Which requirements have a stronger impact on the architecture – functional or non-functional?

The correct answer is non-functional requirements.

Consequently, the software requirements and the resulting influencing factors are the most essential design basis for the software architecture, besides the subsystem architecture.

Communications

With a comprehensible software architecture documentation, the software architect provides the foundation for a project for all stakeholders and thus full traceability for everyone involved in the project, ensuring the continuity of the company.

Documentation is also the communication basis that should be continuously coordinated with the stakeholders.

The most important stakeholder here is the software developer who refines the software architecture in detail and finally implements it in the target

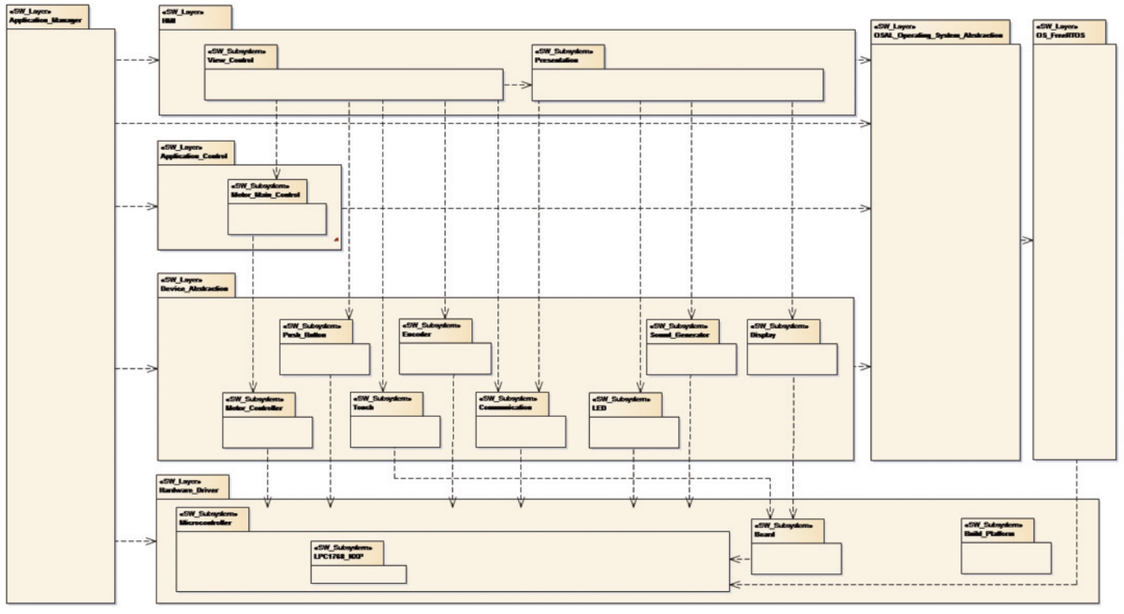


Fig. 4: Exemplary layered software architecture

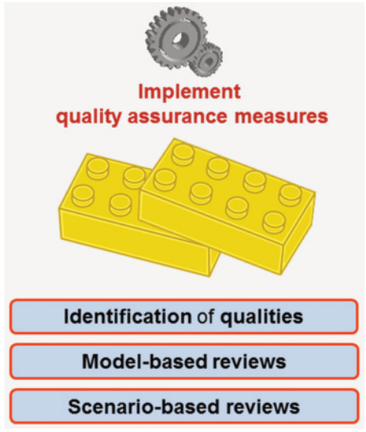


Fig. 5: Quality assurance and assessment

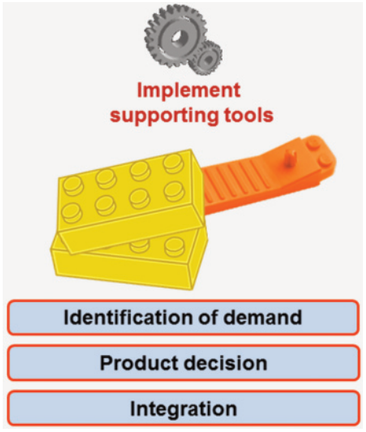


Fig. 6: Use of tools

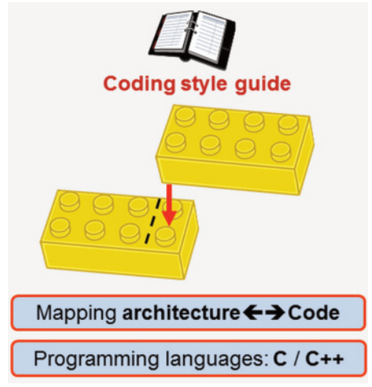


Fig. 7: Coding style guide

programming language. Other roles such as in the test team have legitimate interest in the software architecture. Implementation cannot be verified as correct unless the requirements are known.

The UML unified modelling language is the notation for documenting various views and aspects of the software architecture and refining them in design, up to automatic code generation.

The package diagram shown in Fig. 4 models the different software layers.

Principles

Everyone's whole life is determined by rules, even if some people think they don't have to stick to them. Everybody has been confronted with the Covid pandemic and the related regulations and rules. Even with Lego, there are rules on how to fit the bricks properly.

The software architect with continuously growing knowledge draws the style guide for software development, describing the rules along which the software architecture should be developed. Those rules cannot be applied to any architecture as they depend on specific requirements. Applying rules to a software architecture enhances the software quality in any case.

High cohesion is an architecture design principle. It aims at reducing redundancy by processing logically related tasks in one architecture element instead of distributing similar tasks across multiple architecture elements.

Specific design principles have been published that can be applied to embedded software architectures. Software architects can implement the design principles in a real system by means of software architecture patterns.

Patterns

Based on their technical knowledge, software architects develop the software architecture. Doing so, they use their pattern catalogue. In general, patterns are known, proven, rated and adjustable to recurring issues. For example, aspects such as functional safety and reliability have to be considered and taken care of in safety-relevant systems.

In systems that provide fully automated support (think of automated driving), safety and reliability are the key to the success of a product.

Using patterns can be a challenge in software architecture development.

For example, only square bricks are available, but one requirement might be a rounded outline. This could be solved by means of a graduated assembly of the bricks – according to the Lego principle – in one or several rows. As this is not the first generation to develop software, patterns have already been created for almost all areas of software development and even for the development of software architectures.

One example is the layered pattern, strict or not strict. Fig. 4 shows a non-strict software layer architecture. Non-strict means it involves cross-layer accesses,

which is particularly helpful for embedded software to achieve the required performance. This example also contains vertical layers in addition to the classic horizontal layers.

Quality

The software architect is responsible for the software quality and quality assurance. The quality attributes have to be defined before developing an architecture. The software architect knows the impact of these attributes on software architecture, and the software test team knows how to prove them. By the way, attributes cannot be tested into a product at the end of the development process.

In the context of quality, there is a differentiation between internal quality (for example, software architecture) and external quality, or what the customer sees.

Process quality has a major impact on product quality. To get back to the Lego analogy, all bricks have to be assembled such that they support the structure, otherwise it will collapse as soon as additional expansions are made. This is also true for software architectures – they have to fulfil all quality requirements and provide all functions that were defined before.

Software architectures were expected to remain functional for 20 years or longer in the past. Today, they are under continuous expansion and improvement due to emerging requirements, regulations and laws. For this reason, the development process needs to accommodate this aspect as it is key to the further development of a product.

Reviews with other architects and stakeholders are the easiest way to assure the quality of the software architecture. They serve to assess whether the architecture complies with the required quality attributes. The architecture documentation generated by means of a UML model is a suitable basis for a review.

In a scenario-based review, participants go through pre-defined cases with the architecture. For example, if an architecture is required to be portable in terms of hardware, this process includes an exchange of hardware to prove the software architecture can meet this requirement. The SEI has developed an extensive method to this end, called ATAM, for architecture trade-off analysis method.

Software quality attributes	Implementation consequences for the software architecture
SAFETY (Functional safety)	▪ Continuous failure observation ▪ Failure-dependent execution of correct – failure handling – failure recovery ▪ Failure logging ▪ Status – Generation, test, evaluation, reaction ▪ Protection of – Boundary values – Data memory content and boundaries – Program code execution / runtime ▪ No use of dynamic memory ▪ No use of software components if they are – unknown – without source code – not certified

Table 1: Safety, from a perspective of relevant software quality attributes

Software quality attributes	Implementation consequences for the software architecture
RELIABILITY	▪ **Redundancy** (multi channels) – Redundant data storage – Redundant program execution – Safe data types (uint32_t ➔ safe_uint32_t) ▪ **Diversity** – Software (different solutions) – Development tools (different solutions, tools) – Human (different solutions, tools and persons) ▪ **Status evaluation** ▪ **Protection** ▪ **Fail-over handling** ▪ **Recovery** ▪ **Dynamic memory management** is not allowed

Table 2: Reliability, from a perspective of relevant software quality attributes

Further quality assurance methods are, for example, prototypes or mathematical models performing simulations or determining metrics.

Tools

The software architect is responsible, or at least co-responsible, for the tool environment for software development.

He or she knows the tool market, identifies the demand, develops tool requirements, evaluates and finally selects the tools. In a company that does not have a tool group, the architect is also in charge of tool integration.

The tools should make work easier for everyone involved in software development. Especially for software architects, it can't hurt to be a bit egoistic here, as they might benefit the most.

Tools make the work of the software architect easier for: requirements management; version and configuration management; modelling; generation of documentation and programme code; build systems; static analysis; and dynamic analysis.

Implementation

The software architect passes the entire architecture, or parts thereof, on to one or several software developers for further refinement such as design and implementation. The coding style guide, created by the software architect with the software developers, shows how the software architecture is implemented in the target programming languages. Typical target languages for programming embedded systems are C and C++.

In C++, the software architecture can be represented efficiently in the programme code by means of namespaces.

The software architect and software developer have to make sure the defined software architecture is preserved over its entire lifecycle and not programmed to death, also referred to as software erosion.

If the software developer identifies a need to change the architecture, all related decisions and the changes to the architecture are coordinated by the software architect in charge.

Software quality attributes	Implementation consequences for the software architecture
SAFETY and RELIABILITY	▪ **Hardware protects hardware** – Clock protection – Overvoltage and undervoltage protection – Overcurrent (and undercurrent) protection – Temperature protection ▪ **Software protects hardware** – Processor tests – Memory tests, checksum protection – Memory boundary protection (stack) – (Peripheral) register value protection / observation – Input value boundary protection / observation

Table 3: Safety aspects

Software quality attributes	Implementation consequences for the software architecture
SECURITY (Manipulation from outside) ➔ Access security ➔ Data security	▪ **External accesses**: – As few as possible, but only protected – As many as necessary – Protected access is mandatory ▪ **Security of critical application parts**: – Bordering by partitioning ▪ Use of (assumed to be) **secure protocols** – https, ipsec, ssl, … ▪ **Encryption** – Data and data memory content – Program memory content ▪ **No use of software components** if they are – unknown – without source code – not certified

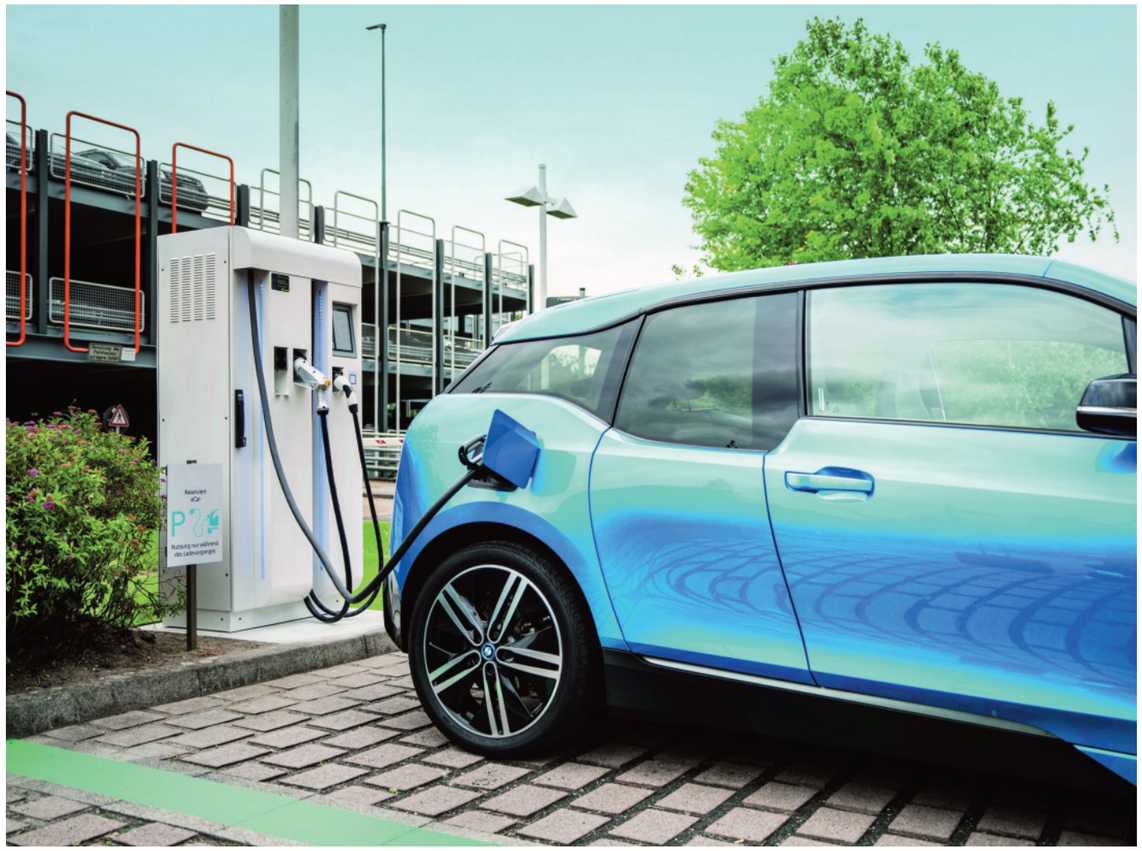
Table 4: Security aspects

The higher the requirements on safety, security and modularity of a product, the more critical and significant the role of the software architect in the entire development process.





Ingo Pohle is managing director and Thomas Batt is senior manager for training and coaching, both at MicroConsult



WORKING TOGETHER

Nilesh Wani discusses collaborative manufacturing for the EV supply chain

Disruption in the automotive and transportation industry is well underway through autonomous vehicles, shared mobility and digital connectivity.

A quick analysis of electric vehicle (EV) sales and projections tells an interesting story about the big disruption in automotive industry. Those who were lackadaisical about EVs are now planning to invest billions of dollars to introduce them realistically into the consumer market.

These EVs may be powered by only battery, hybrid (internal combustion engine [ICE] plus battery), micro-hybrids, and so on; the word xEV covers all versions.

The primary reason for the exponential growth will be a reduction in battery price to $100/kWh. This will make xEVs affordable with good range. It is expected that after 2025, even without government funding, xEVs sales can sustain on their own.

Shared mobility is getting more acceptance across the globe because of the convenience and economics. Uber, Ola, Lyft and Didi are major players in shared mobility with billions of dollars invested.

With the expected advent of robo-taxis, the business model will transform from a taxi service to value-added service provider. Digitally connected robo-taxis will provide a backbone for context-based services such as online shopping, help in finding restaurants in the vicinity, and so on. By 2030, robo-taxis are expected to increase their share in the ride-hailing market exponentially.

Only 12% of cars today are equipped with embedded connectivity, and monetisation is still weak, less than $1.5bn in revenue. But the importance of cars as part of a connected network is growing: the percentage of consumers ready and willing to change car brands for better connectivity doubled between 2017 and 2019. In the premium segment, many OEMs have already installed fully connected infotainment systems in all their new vehicles. These are used to provide in-vehicle services to drivers and data sets to third parties.

In addition to these trends, the vehicle market is becoming electrified (e-mobility) quickly, significantly disrupting the market as:

- Consumer demand is shifting in favour of e-mobility
- Faster-than-anticipated improvements are being made in key technologies
- Urbanisation is increasing across the globe, creating more pull for green mobility
- Regulations are accelerating at national, regional and city levels.

Because of these major changes in the world, the auto industry is having to focus rapidly on investment and restructuring their manufacturing for electric vehicles. Companies such as GM, Ford, VW and BMW have shared their plans to sell electric vehicles only by 2035 to 2040 in the USA and Europe.

Ecosystem

These changes are also affecting their suppliers. A primary reason for the big change in supplier ecosystem is because of the change in powertrain content. Electric and electronic content is going to increase many folds thanks to e-drives. The supply chain chart shows the impact on component supplier's content.

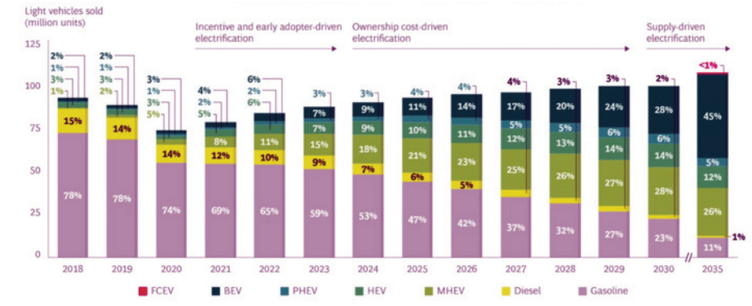
Over the past 30 years, supplier content included in a vehicle has increased steadily. The average supplier content in a new automobile is about 65%. The old concept of captive suppliers (those owned by and solely serving a particular carmaker), such as Delphi or Visteon, no longer applies.

As xEVs attain mass-market status, automakers likely will tap the consumer electronics industry for the latest technology, rather than waiting for traditional parts makers to catch up. Consumer electronics companies such as LG Electronics, Toshiba, Bosch and Panasonic will be able to exploit their economies of scale to reduce the cost of in-vehicle electronics.

Likewise, a secure and stable supply of batteries is required by automakers who will look to battery makers such as LG Chem, Panasonic, Samsung, Toshiba and Hitachi. That trend has already begun. In 2017, Honda announced a joint venture with a Hitachi subsidiary to produce EV motors. General Motors is working closely with LG Electronics and LG Chem, which produce key components for the Chevrolet Bolt.

The powertrain components for an EV are markedly different from their ICE equivalents. OEMs follow a wide range of strategies when sourcing powertrain components from almost full vertical integration to full outsourcing, with varying degrees of design ownership and outsourced components. The lower complexity and lower potential for differentiation in the EV powertrain lends itself to future commoditisation.

Electric vehicles will be a focus area for automotive OEMs and their ecosystem of tiers one and



Source: BCG analysis.

Note: FCEV=fuel-cell electric, BEV=battery electric, PHEV=plug-in hybrid electric, HEV=full hybrid electric, MHEV=mild hybrid electric. Because of rounding, the percentage total for a particular year may not equal 100%.

Global market share of light vehicles by powertrain

two suppliers. OEMs that focus on design, innovation, and marketing who are outsourcing to tier-one suppliers continue to ask for shorter time to market even while complexity drastically increases.

This creates complex collaboration dependencies between the OEM and suppliers to cover regulations, cross-company tracking, and tracing of modules, parts and components. Supply-chain optimisation is key for vehicle manufacturers, while suppliers need to have robust processes in place for new product introductions (NPIs).

Suppliers

Two major challenges for automotive suppliers are the increasing number of NPIs and the decreasing size of the production lots. The increase of electronics and electrical-mechanical components drives the increase of NPIs, and the high level of customisation reduces the manufacturing lot size.

These are a challenge for manufacturing planning and process engineering, as well as for the shop floor, because of the increased number of changeovers. The PCB assemblies and the mechanical assemblies are typically managed in different systems. Coordinating production decisions is difficult if the shop floor doesn't have all the information available in one system.

Inside the manufacturing facility, it's difficult to standardise the planning across production sites to build everywhere. This lack of standardisation impedes sharing knowledge and data between different sites, because they talk a different language at the level of structured data.

The quality engineer is often conducting inspections and tests in different systems. This makes it difficult to synchronise process engineering, testing, inspection and assistance to create one coherent plan. It's also difficult to manage the changes in the design, process or equipment, and to adjust the inspections and the tests to these changes.

The programme manager is faced with the challenge of assessing the time cost. Programme planning occurs very early, and the programme manager doesn't have a lot of the data required to make decisions; they are missing or spread over different systems.

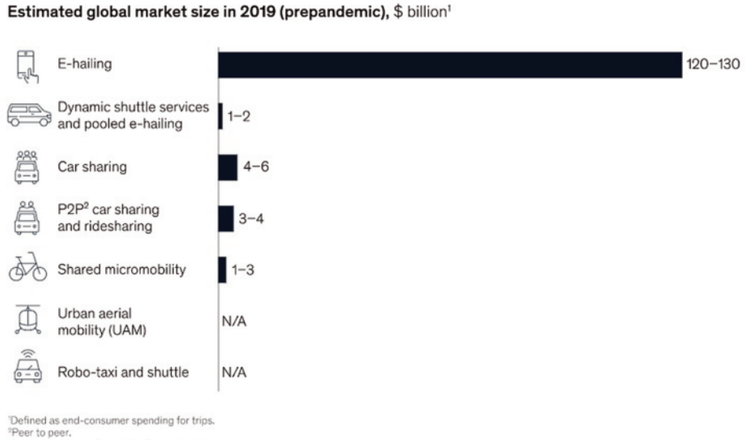
When issues occur, they often occur late in the process, where it's costly to fix them. Often repairs are patched in, rather than addressing the root cause of the problem. When it's late in the process, changes are sometimes impossible to make, and the change impact is difficult to assess.

The IT manager must deal with many systems that are mainly interfaces and bridges. Instead of working on innovation, IT finds themselves just building and maintaining connections.

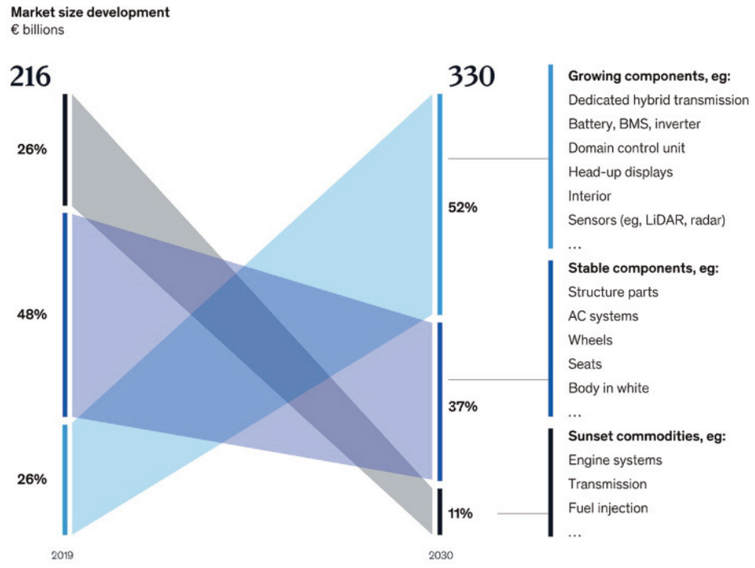
The consistent factor for all these people is they are all working with data in siloed environments. Even if every person has the perfect tool to do the job, synchronising all these pieces is a challenge. Because data transfer is often unmanaged, they cannot be certain if they are using the right information, right revision, right configuration or latest released data. This uncertainty could eventually affect the quality, cost and time to market.

Today, with many people working from home, these problems become even more challenging. It's hard enough to find the data when at the office; it is often more difficult to access them from home.

In a typical siloed system,



E-hailing drove pre-pandemic market for shared mobility (Source: McKinsey)



Electrification will cause a major shift in the entire supply chain (Source: McKinsey)

design information is sent to engineering, then to all the facilities separately. Once the data are in every facility, they must be prepared for manufacturing.

For example, aligning between the bill of materials (BoM) data and the design data must be done to make sure that all BoM parts are accounted for and there are no inconsistencies between the electronic computer-aided design (ecad) data and the BoM.

Another part of data preparation is finding the graphical representation for every component that will be assembled on the PCB. Data preparation is not site-specific. However, typically, all sites do it separately, and this bears a lot of waste.

After performing data preparation, each facility will have to do its own machine programming and create their own documentation and work instructions.

If a problem occurs in a plant in China, for instance, then usually the problem is handled in the facility in China, and none of the other facilities know about either the issue or its resolution. But what if it's time to move the production from China to, say, Mexico? Then probably, in Mexico, they will find the same issue, and they will have to take care of it on their own while re-doing the majority of the work already done in China.

Design and production of mechanical or hardware components for EVs are also facing a disruptive situation; they are affected by what is changing in the electronics that goes along with the components. For suppliers, they need to ensure they can produce these hardware components or the mechanical components much more efficiently than the previous ones, so overall cost is limited.

Collaboration

Because both the mechanical and electronics are needed to make the system work, their design requires both areas collaborating. If suppliers can collaborate with their OEMs much more effectively, they can be assured that the product is of good quality and that other systems in the vehicle are working well with their own system.

Effective management of product and process data, combined with automation and consolidation of engineering tasks, can help reduce engineering time and effort, improve operational flexibility, and ultimately lead to increased manufacturing capacity and profitability.

This standardises the management of product and process data over a single backbone, throughout the entire engineering and manufacturing flow. It can support efficient revision management and propagation of engineering changes across single or multiple sites.

Such a system enables a lean NPI methodology, increasing the production line's uptime and optimising changeover between different products.

Planning processes can be run faster, and people can trust the automated procedures and synced data.

Nilesh Wani is principal consultant for digital manufacturing at Siemens Industry Software



TEST & MEASUREMENT

SUN STROKE

How accurate power analysis helped Solar Team Twente get its car to first place in Morocco



Solar Team Twente last year won the first ever Solar Challenge Morocco. The team squeezed every last watt out of its car's solar power system, ensuring it crossed the finish line of the 2500km course in first place.

Solar Team Twente comprises aerodynamic, electrical, mechanical and structural engineers from the University of Twente and the Saxion University of Applied Sciences in the Netherlands.

Their efforts to improve the efficiency of their car led to triumph in a race that pitted contestants against both each other and the harsh desert and mountain landscape of the north African country.

The basic design of all cars in the race is similar: an aerodynamic wing shape covered in arrays of photovoltaic panels to convert the sun's light into electric power, which is fed directly to a motor driving the wheels.

To win a race like Solar Challenge Morocco, a race car must generate as much solar energy as possible and convert the electricity it generates as efficiently as possible into mechanical power delivered to the wheels. At the same time, it must keep down energy losses: race teams pay minute attention to aerodynamic design to reduce wind resistance.

In the case of Red E, the name given to Solar Team Twente's race car, total wind resistance is the equivalent of a conventional car's wing mirror. The driver must then race as fast as possible, yet not so fast that the car's battery runs out of power when it is not in bright sunlight.

There are four important electrical systems in a solar race car: the array of solar panels; the battery and its management system; the inverter (motor drive), which converts the solar panels' direct current output to a three-phase alternating current supplied to the motor; and the motor itself. The team was aiming for better than 99% efficiency for the electrical power conversion circuits.

Preparing for the race, the team's engineers needed to improve the motor, the battery and

TEST & MEASUREMENT



The car's battery cannot run out of power when not in bright sunlight

the energy generation system if it was to move ahead of its rivals on the demanding African course. Even small improvements can make a significant difference.

"If all the components are just 0.01% better than the competition's, then you already have an advantage before you reach the start line in a race," said the team's Camiel Lemmens. "So, precision measurement is a crucial element of our success."

The team's electrical engineers therefore work continually to squeeze ever higher performance from the car's electrical systems. Achievements have included increasing the amount of energy generated by the PV cells and the energy the battery can store. The team has even produced a more robust and efficient inverter of its own design, replacing the standard commercial inverters used by competing teams.



Yokogawa WT5000 precision power analyser

The team had previous experience of using the Yokogawa WT5000 precision power analyser. This time they needed to complete four crucial tasks. The first was to analyse the efficiency of solar PV cells to allow the team to select the cells with the best voltage and current output for a known photonic input.

Another task was to measure the energy capacity of battery cells and select those that stored the greatest amount of electrical energy.

They also needed to validate the accuracy of the fuel gauge, the car's on-board sensor measuring the battery's state of charge. This system measures current flowing into the battery from the solar panels and flowing out of the battery to the motor. By subtracting output from input, it can calculate the residual charge in the battery. This required extremely accurate continuous measurement of current flows.

The fourth task was to measure the power output of the motor system, including the inverter and the motor itself, at a range of power input values, to enable the team to refine the design and incrementally improve its efficiency. This called for extremely accurate power analysis at a high sampling frequency.

"With the WT5000, we also discovered that the current sensors in the fuel-gauge circuit had an offset, which were making the car's state-of-charge measurements inherently inaccurate," said the team's Rob Krawinkel. "By compensating for the offset, we could confidently provide the driver with a vital extra 1 or 2km of range from the battery at a given speed."

The modular and extensible WT5000 is Yokogawa's most accurate power analyser, with a specified measurement accuracy of ±0.03%. Measurement bandwidth is 10MHz for voltage and 5MHz for current, and the maximum sampling rate of 10Msample/s exceeds the data refresh rate required to validate Red E's fuel gauge system. With isolation, noise immunity and filtering capabilities, its users can make simultaneous measurements on up to seven inputs and view them on its high-resolution 25.7cm touchscreen.

"The WT5000 is a very nice instrument to use, it's intuitive, and it's easy to find your way around the controls," said Krawinkel. "It's also easy to tweak the display so that it shows exactly the measurement outputs you are interested in, like when it clearly demonstrated that our new inverter design outperformed the equivalent off-the-shelf model by a significant margin."

The team's development of its own custom powertrain and components – a feat which relied heavily on the accuracy and precision of the WT5000 – proved to be decisive in the victory and the team is looking forward to further success in the forthcoming World Solar Challenge 2023.



Solar Team Twente won the first ever Solar Challenge Morocco

QUIDS IN



Audi Connect Infotainment package

Keith Mallinson explains why the revenue boost for the automotive industry from cellular connectivity outweighs SEP licensing costs

The automotive industry is being revolutionised by continuous cloud connectivity, autonomous driving technologies, drive train electrification and shared mobility. These transformations are being facilitated in part by the standardised cellular technologies now commonly implemented in connected vehicles (CVs).

The proportion of vehicles shipped worldwide with cellular connectivity embedded is forecast to rise from 46% in 2020 to 76% in 2026.

The commercial ecosystem for CVs has significantly matured since a couple of years ago. The benefits, incremental revenues and costs now associated with the adoption of cellular technologies in vehicles are being reflected in major commercial actions by industry players and in financial markets.

Incremental product revenues at a vehicle's point of sale together with ongoing monetisation opportunities in value-added services and cost savings will parallel what has been achieved in smartphones, where large profits

are reaped beyond initial product sales and recurring network operator service fees in the app ecosystem.

The value of automotive connectivity is created through improved safety features, enhanced navigation, driver assistance and automation, vehicle and driver monitoring such as to adjust insurance premiums, reduced maintenance costs, in-vehicle entertainment services and over-the-air software updates for various systems.

Although the portion of new car selling prices and aftermarket service fees attributable to cellular connectivity was estimated to be $54bn in 2020, total patent royalties paid by automotive OEMs to license the cellular standard-essential patents (SEPs) upon which those capabilities depend was and remains considerably less than 1% of that figure. And that low percentage royalty yield will reduce – despite increasing total royalties as more OEMs are licensed – because that CV market value is expected to grow faster to $166bn or more by 2025.

SEP licensing fees are modest compared with product costs and thousands of dollars in revenues and cost savings are anticipated from connectivity services over a car's typical lifespan of 14 years. Indeed, SEP licensing fees are a small proportion of an estimated average cost of $700 per vehicle for OEMs on telematics and infotainment systems, which are marked-up significantly when sold to consumers as bundled features or optional extras in finished goods car prices.

Examples of additional ongoing revenues to OEMs include £141 per year after an initial free period, excluding mobile operator service charges, to subscribe to the Audi Connect Infotainment package in the UK. Remote services cost an additional £37.

In the Eurozone, Volkswagen charges €75 per year to extend its We Connect basic subscription and €145 for its Plus service. OEMs can receive $30 or more per year from insurance companies for policy holders that opt-in to provide their driving behaviour data.

The value that SEPs confer on a CV has been a topic of much discussion, but consensus on how much the automotive industry should pay to license the 4G, 3G and 2G SEPs that underpin connectivity-based options has recently emerged.



Photo from 5GAA

A majority of these SEPs are licensed by the Avanci patent platform for a one-time payment of $15 per 4G CV, or, from 1 September 2022, $20 per 4G CV. With more than 40 automotive brands under licence including BMW, Ford, General Motors, Mercedes-Benz and Volkswagen, Avanci licenses around 45% of CV shipments. This is unsurprising given the platform is providing a one-stop shop with transparent and predictable pricing that many implementers and government authorities have demanded.

Automotive is now the most significant segment in IoT SEP licensing, with licensing revenues in the low hundreds of millions of dollars, paid to SEP owners mostly multilaterally through Avanci, but also bilaterally to companies including Nokia and Qualcomm.

Cellular technology development is a huge, risky and costly endeavour including large numbers of R&D staff and many companies. For example, Ericsson, Nokia and Qualcomm each invest around $5bn apiece annually on R&D, which is mostly in cellular. Other companies collectively invest billions more. Smartphones generate virtually all the return on this R&D investment, which totals around $15bn in SEP licensing revenues annually.

While CVs valuably exploit various cellular technologies, including prime 4G LTE capabilities such as eMBB for streaming video, cellular



Volkswagen We Connect service

technologies developed specifically for vehicles are also a major focus for standards setting organisation 3GPP and the many companies that contribute patented technologies to its standards.

Cellular vehicle-to-everything (C-V2X) technologies include many features that can improve safety on the road and help enable or enhance adas and automated driving systems. An analysis of 3GPP Radio Access Network Working Group contributions reveals that a significant 5% of these are for C-V2X among many innovations.

Consumers often pay more than $1000 for a new smartphone, plus more per month in network operator service fees, because of the value they obtain from the many free and other services these devices also enable them to obtain including search, navigation and social media. CV pricing likewise reflects value downstream, regardless of whether all that value is captured by the OEM itself.

Yet CVs generate less than one fiftieth of the cellular SEP licensing fees from mobile phones. This is despite OEMs already collecting more than half of their total annual revenues of $2.7tn in 2021 from CV sales.

In comparison, total mobile phone sales revenues are around $500mn annually. Even if every CV produced over the next five years is licensed – including those expected to include 5G – the proportion of licensing revenues from cars is still unlikely to exceed one tenth that from smartphones.

With increasing adoption and value of connectivity in vehicles, there is consensus with acceptance now that the modest SEP royalty charges being widely paid are fair and reasonable. Manufacturers and users of CVs are deriving enormous value from cellular technologies including those developed specifically for automotive use.

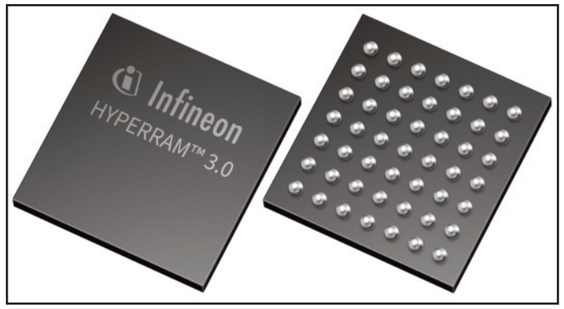


Keith Mallinson is a consultant with WiseHarbor

Chip doubles bandwidth for low pin-count memory

HyperRam 3.0 has been added to Infineon's portfolio of high-bandwidth, low-pin count memory.

The device has a 16bit extended version of the HyperBus interface that doubles throughput to 800Mbyte/s.



This is suitable for applications requiring expansion ram, including video buffering, factory automation, artificial intelligence of things (AIoT) and automotive V2X, as well as applications requiring scratch-pad memory for intense mathematical calculations.

The stand-alone psram-based volatile memory offers a simple and cost-optimised way to add extension memory. The data rates are equivalent to SDR dram but with lower pin-count and lower power requirements.

The increased per-pin data throughput of the HyperBus interface makes it possible to use microcontrollers with fewer pins and PCBs with fewer layers. This provides opportunities for lower-complexity and thus cost-optimised designs to support target applications.

Infineon introduced the first generation of HyperRam devices supporting the HyperBus interface in 2017. The second generation was introduced in 2021 and supports both the Octal xSPI and HyperBus Jedec-compliant interfaces with data rates up to 400Mbyte/s.

The third-generation devices support the extended HyperBus interface enabling 800Mbyte/s data rates.

Devices are available in densities of 64 to 512Mbit. They are AEC-Q100 qualified and support industrial and automotive temperature grades up to +125°C.

They can be ordered now in a BGA-49 package.

EMI test receiver bandwidth extended

To help EMC engineers working in automotive, commercial, military and aerospace applications meet the increasing demand for higher measurement speeds, Rohde & Schwarz is introducing a wideband product that can measure up to 970MHz in real time, while keeping a high dynamic range and measurement accuracy.

With this extension, the ESW EMI test receiver is said to have the largest bandwidth in the industry and become the fastest EMI test receiver.

To speed up measurement time and provide a more careful analysis of interfering signals, the EMI test receiver will offer the possibility to increase its FFT (Fast Fourier Transform) bandwidth to 350MHz with the ESW-B350 option, and to 970MHz with the ESW-B1000 option.

This makes the ESW not only an instrument for RF, functionality, versatility and hardware quality, but also in high-speed testing for pre-tests and general EMI analysis.

With the ESW-B1000 offering 970MHz of FFT bandwidth, the ESW can process the Cispr bands C and D in one shot, even with quasi peak and Cispr average detectors working in parallel, offering a significant gain in measurement speed.

The 970MHz wide spectrum is measured in real time; users benefit from a gapless spectrogram. Infrequent emissions can be observed over a longer time and are detected with a higher probability.

Emissions from equipment under test going through a duty cycle are recorded over a spectrum of 970MHz without missing the shortest pulse.





SMD antenna

A surface-mount antenna from Antenova measures 9.0 by 5.8 by 1.7mm and operates with efficiency in a reduced space on a corner of a PCB.

An advantage of the Agosti SR4G080 omni-directional antenna is its small ground plane needs. Most SMD antennas use the surface of the PCB around the antenna as a ground plane to radiate signal from, so it is the ground plane requirement not the physical dimensions of the antenna that defines the space it needs.

Radiated measurement results show Agosti operating well on small ground planes of 40 by 20mm, 70 by 25mm and 80 by 30mm.

It can co-exist with other antennas within the same device. On board diagnostics (OBDs) and trackers often use 4G LTE with A-GPS for fall-back and the antenna has been tested with the firm's Pharoah SR4L073 antenna.

The isolation of the two antennas means they can operate close to each other in a small device without the 4G signal interfering with sensitive GNSS signals.

Buck converter reduces EMI

A 600mA synchronous buck converter from Diodes has an input range from 4.5 to 40V.

The AP64060Q incorporates a 600mΩ high-side power mosfet plus a 300mΩ low-side power mosfet so high-efficiency step-down conversion reaching 90% can be delivered, and with little PCB space.

The device is for use in automotive powertrains, infotainment systems and instrumentation clusters, as well as exterior lighting.

Quiescent current is typically 90μA, which translates into enhanced light load efficiency. Thanks to the fast switching frequencies this device supports (2MHz), smaller accompanying inductors and capacitors can be selected.

Its synchronous rectification eliminates the need for an external Schottky diode, while use of a peak current mode control and built-in loop compensation network reduces the overall component count.

The proprietary gate driver scheme alleviates switching node ringing without impacting on mosfet turn-on and turn-off times. This mitigates high frequency radiated EMI noise caused by mosfet switching.

Operating ambient temperature is -40 to +125°C. Protection features include overvoltage, undervoltage lockout and thermal shutdown. This device is supplied in a TSOT26 package.

It is AEC-Q100 grade-one qualified, supports PPAP documentation, and is manufactured in IATF 16949 certified facilities.



ISP supports multiple sensor types

Xfuse has developed image signal processing (ISP) technology that supports multiple sensor types simultaneously to fuse data-rich HDR video in real time with low latency.

These location aware data streaming technologies from the Xfuse Phoenix HDR ISP provide engineers with control over the imaging pipeline to advance self-aware robotics, autonomous guided vehicles and machine vision.

For full-autonomous vehicles to navigate roads safely, developers require higher levels of accuracy and reduction of errors in the complex data streaming from multiple sensors. The Xfuse team has more than seven years' expertise developing the real-time ISPs for multi-processor SoCs, multi-sensor guidance modules and software tools.

The Phoenix HDR ISP should let developers fuse video data with output from multiple non-image sensors such as thermal, GPS, lidar, radar and gyroscope, as well as other Xfuse software and tools.

The fully programmable ISP can deliver the flexibility for developers to drive the autonomous machine vision.

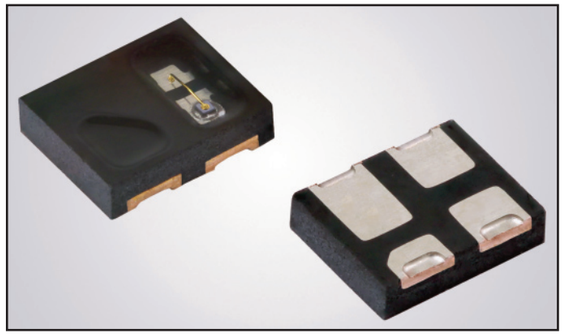
Optical sensor combines three in one

An AEC-Q101 qualified reflective optical sensor from Vishay is for automotive, smart home, industrial and office applications.

The VCNT2025X01 combines an infra-red emitter, silicon phototransistor detector and daylight blocking filter in a 2.5 by 2.0 by 0.6mm surface-mount package.

The device has a compact construction in which the emitting light source and detector are arranged in the same plane. The sensor's analogue output signal at the phototransistor depends on the amount of light emitted by the IR LED and reflected off an object in the sensor's field of view.

A built-in daylight blocking filter suppresses disturbing ambient light, thereby increasing the signal-to-noise ratio. The FAM package reduces crosstalk and has wettable flanks to enable optical inspection of the solder joints.



The 0.6mm profile is 0.2mm lower than previous-generation devices, making the sensor suitable for optical switching in automotive electronic systems. It operates at up to +110°C.

Detection range is 0.3 to 4.5mm, emitter wavelength is 940nm, and typical output current 6.6mA, which represents a typical CTR of 33% under test conditions.

Moisture sensitivity level is three for reflow soldering according to J-STD-020; it is RoHS-compliant, halogen-free and Vishay Green.

Samples and production quantities are available now, with lead times of eight to twelve weeks for large orders.

GaN power tests encoraging for EVs

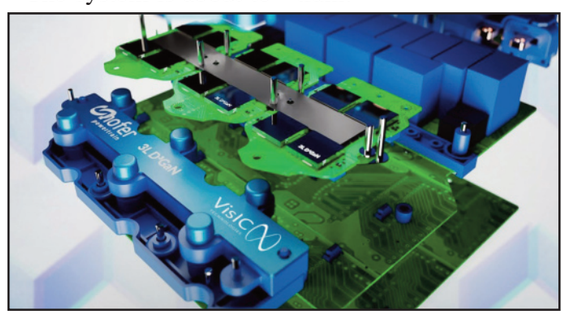
Hofer Powertrain has been encouraged by tests on the latest GaN power electronics from Visic Technologies on electric vehicles.

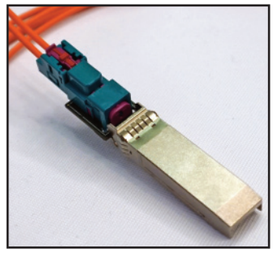
Hofer uses the D3GaN (direct drive d-mode) gallium nitride technology provided by Visic. The efficiency and power density are said to exceed silicon-based technology's capabilities in recent tests.

GaN semiconductors can help improve efficiency and increase driving range and lifetime.

Hofer and Visic aim to develop GaN-based power inverters for 800V electric vehicles.

The system is about to undergo a series of tests in real-world conditions and is believed to exceed expectations, leading to higher efficiency of the entire automotive powertrain.





Optical module

KDPOF has developed and validated the first 1000baseRH SFP module for optical gigabit connectivity in vehicles.

The design of the small form-factor pluggable transceiver module is based on a standard SFP supporting MSA registers via I²C bus. The module can operate at 100 and 1000Mbit/s.

It integrates the whole 1000baseRHC phy and the header connector for SI-POF optical harness.

The SFP supports 1000baseX, 100baseX and SGMII with and without auto-negotiation as electrical interfaces.

It monitors the received optical power, the link margin, the junction temperature and the supply voltages, among others.

The SFP design has been sampled and validated.

KDPOF and Aukua are collaborating to optimise the SFP and make it available in the third quarter of 2022.

Oscillators suit embedded applications

Miniature, low phase noise crystal oscillators from Mercury Electronics are for use in embedded automotive applications.

The surface mount HJ22 oscillators offer 15pF load LV-cmos output at frequencies from 20 to 50MHz with typical RMS phase jitter of 48fs, 300fs maximum.

Phase noise characteristics of -153dBc/Hz at 10kHz offset and -166dBc/Hz at 100kHz offset (49.152MHz output frequency, 3.3V input model) are said to be better than standard oscillators.

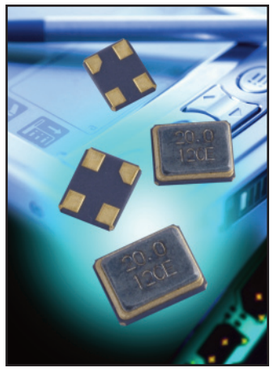
Housed in a surface-mount package measuring 2.5 by 2.0 by 0.9mm, the oscillators are available with 1.8, 2.5 or 3.3V power supply requirements and offer typical current consumption of 3mA, 5mA maximum.

Frequency stability over both commercial (-10 to +70°C) and industrial (-40 to +85°C) can be specified as ±25, ±50 or ±100ppm as standard.

Non-standard frequency stability specifications can be provided if required, for example ±20 or ±30ppm.

Specifications include ageing of ±3ppm/year maximum for first year, start-up time of 0.8ms typical, 5.0ms maximum, rise-fall time of 5ns typical, 10ns maximum, and duty cycle (symmetry) of 50% ±5%. Output enable-disable is provided as standard.

For embedded automotive applications, the oscillators join the firm's HJ series that also includes package sizes of 3.2 by 2.5 by 1.0mm, 5.0 by 3.2 by 1.2mm and 7.0 by 5.0 by 1.4mm.



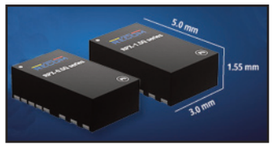
DC-DC variants

The Recom RPX QFN-packaged DC-DC converters now have -Q variants that meet automotive AEC-Q100 grade-one requirements.

They have also been upgraded to include wettable flanks for automated optical inspection (AOI).

The DC-DC converters have an input range up to 36V, and the output can be trimmed from 0.8 to 30V. The RPX-0.5Q variant delivers 0.5A, and the RPX-1.5Q delivers 1.5A, both in a 3 by 5 by 1.6mm leadless, thermally-enhanced QFN package, operating to over +100°C ambient with derating.

This is enabled by integration and 3D packaging techniques using an over-moulded flip chip on lead frame (FCOL) to provide low package thermal resistance while keeping down costs.



The series integrates the necessary inductor and requires external input and output capacitors, scaled for the application, for full functionality.

On-off control and synchronisation inputs are provided with a power good output. Soft start along with full short circuit, over-current, over-temperature and input under-voltage protection is included.

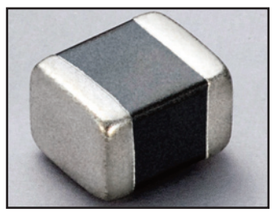
Due to the FCOL construction, EMI is low, and fixed-frequency operation makes additional filtering easier to implement.

Noise suppressors rated at 20A

Chip ferrite beads from Murata are said to be the world's first chip-type noise suppression components to have a 20A current rating.

The BLE32SN series can be used to provide noise suppression in circuits with large current flows, such as the battery charging systems and powertrains of EVs, as well as in industrial equipment.

There was previously no chip-type noise suppression filter that could attain a 20A current rating. This meant multiple chips had to be mounted in parallel, which added to the costs and took up space.



By leveraging structural simulation techniques, engineers have created a proprietary internal electrode design that increases the electrode volume of these chips compared with those using a conventional arrangement.

It has lowered their DC resistance characteristics. Consequently, heat generation is reduced, so less thermal management is needed, allowing further cost and weight savings.

They measure 3.2 by 2.5 by 2mm and can support an operational temperature of -55 to +125°C or -55 to +150°C, depending on requirements.

Diodes protect high-speed links

Low clamping and low capacitance ESD protection diodes from Nexperia can protect high-speed data lines such as USB 3.2, HDMI 2.0, LVDS, automotive AV monitors, displays and cameras.

Additionally, they address upcoming high-speed video-links as well as the Open Alliance MGbit Ethernet applications.

The latest products include the PESD5-V0C1BLS-Q and V0C1-ULS-Q as two-pin single line devices in a compact DFN1006BD-2 package to improve routing flexibility.

In addition, PESD5-V0C2UM and V0C2UM-Q are available as three-pin devices for both differential lines in DFN1006-3.

All variants come in leadless packages to improve electrical performance and signal integrity.

ESD voltage clamping diodes protect data interfaces in automotive subsystems from damage. However, it is important they do not degrade data signal integrity or negatively impact the EMC performance of the systems they protect.

These diodes provide signal integrity because of their low device capacitance, as low as 0.3pF.

For increased design flexibility, they come in dual-line DFN1006-3 and single-line DFN1006BD-2. The latter packages have side wettable flanks to enable automated optical inspection.

These AEC-Q101 qualified devices exhibit deep snapback behaviour combined with a resistance of 0.27Ω, for improved system level robustness and clamping performance in high-speed data interfaces.





Devkit generates dense 3D outputs

Compound Eye has announced early access to its Vidas development kit that generates dense 3D outputs and per-pixel semantic class across a diverse set of on-road and off-road environments.

It uses scalable, passive sensors such as automotive-grade cameras.

Accurate depth can be measured without requiring lidar or radar so vehicles can understand their surroundings in dense 3D and in real time, with applications from in-dash displays to driver assistance and autonomy.

The software runs on an off-the-shelf embedded computer, delivering ten times the resolution of lidar at a ready-to-scale cost.

The system fuses information from stereo parallax, motion parallax and semantic cues in the environment, combining classical computer vision and modern machine learning.

It is built atop standard hardware and is designed with OEMs and tier-one suppliers in mind. For ease of packaging and integration, cameras can be mounted almost anywhere on the vehicle.

The self-calibrating system can be adapted to work with various automotive cameras, and alongside OEM or third-party software.

The early-access kit includes two reference cameras, a compute module, GPS antenna, two Fakra cables and a 12V power cable. Initial installation takes thirty minutes or less and perception outputs can be viewed immediately on a tablet or laptop.

The kit includes Vidas Operator for viewing and recording data and Vidas Inspector for analysing perception outputs.

Smart module delivers LTE connectivity

A multi-mode LTE Cat 4 smart module from Quectel Wireless suits automotive electronics applications as well as retail terminals and industrial devices.

The SC200E delivers LTE connectivity, multimedia functions and support for long lifespan IoT deployments.

Based on the Qualcomm QCM2290 platform, which uses an 11nm process, the module has a 64bit quadcore Arm Cortex-A53 processor at up to 2.0GHz frequency.

Equipped with an Adreno 702 GPU, the module also supports a dual image signal processor (ISP). This ISP enables up to 25MP or 13MP + 13MP dual cameras to work at the same time and 1080p at 30fps video codec capability.

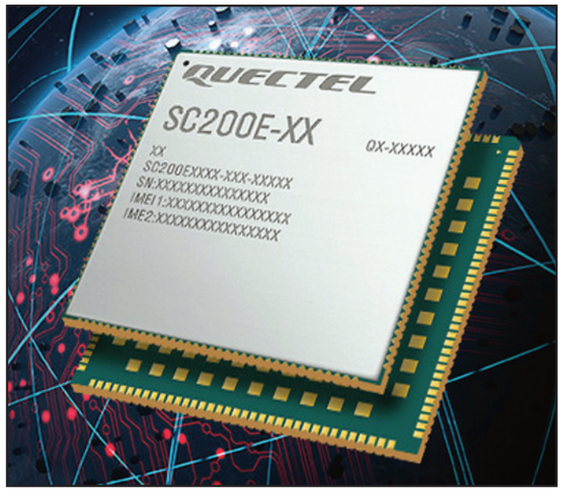
This can help in micro-mobility applications.

The module has the Android 12 operating system (OS) built-in and supports iterative upgrades to Android 13 or 14, which enables IoT devices to stay up to date with the latest features and improvements in the OS.

Additionally, it meets Google's GMS licence requirements.

For communications, it supports multimode LTE cellular networks and short-range wireless technologies such as wifi and Bluetooth, so terminal devices can flexibly access wireless networks according to different scenarios.

In addition, it supports multi-constellation GNSS receivers for GPS, BDS, Glonass, Galileo, QZSS and SBAS to achieve fast and accurate positioning.



The module is pin-for-pin compatible with the firm's SC20 and SC200R modules.

Interfaces include LCM, camera, touch screen, microphone, USB and uart.

There are multiple variants, including SC200E-EM for Emea, Korea, south Asia, Latin America, Australia, New Zealand and South Africa, SC200E-CE for China, SC200E-NA for North America, and SC200E-WF for global regions with wifi and Bluetooth only, all of which are in mass production, while the SC200E-JP for Japan is sampling this quarter.

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