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Hard Times

The difficulties faced by the auto industry have lately been piling up. Carmakers will sell 4 million fewer vehicles in 2019 compared to the prior year, with China and India especially hard hit, according to IHS Markit. (See chart below.)

<table>
<thead>
<tr>
<th>Vehicle Sales by Sales Region</th>
<th>CY 2018</th>
<th>CY 2019</th>
<th>YOY Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASEAN</td>
<td>3,394,012</td>
<td>3,410,073</td>
<td>0.5%</td>
</tr>
<tr>
<td>Central Europe</td>
<td>1,638,768</td>
<td>1,706,418</td>
<td>4.1%</td>
</tr>
<tr>
<td>East Europe</td>
<td>2,688,528</td>
<td>2,582,141</td>
<td>-4.0%</td>
</tr>
<tr>
<td>Greater China</td>
<td>27,533,508</td>
<td>25,490,995</td>
<td>-7.4%</td>
</tr>
<tr>
<td>Indian Subcontinent</td>
<td>4,256,791</td>
<td>3,659,965</td>
<td>-14.0%</td>
</tr>
<tr>
<td>Japan/Korea</td>
<td>6,947,255</td>
<td>6,950,666</td>
<td>0.0%</td>
</tr>
<tr>
<td>Middle East/Africa</td>
<td>4,284,986</td>
<td>3,673,649</td>
<td>-14.3%</td>
</tr>
<tr>
<td>North America</td>
<td>20,720,236</td>
<td>20,309,611</td>
<td>-2.0%</td>
</tr>
<tr>
<td>Oceania</td>
<td>1,290,598</td>
<td>1,203,789</td>
<td>-6.7%</td>
</tr>
<tr>
<td>South America</td>
<td>4,686,044</td>
<td>4,506,365</td>
<td>-3.8%</td>
</tr>
<tr>
<td>West Europe</td>
<td>16,228,855</td>
<td>16,116,159</td>
<td>-0.7%</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>93,669,581</strong></td>
<td><strong>89,609,831</strong></td>
<td><strong>-4.3%</strong></td>
</tr>
</tbody>
</table>

Data: IHS Markit

Strict emissions rules are forcing carmakers to develop electric vehicles that at least initially will cost significantly more than vehicles powered only by a gasoline or diesel engine. Cheating on diesel emissions tests by Volkswagen and others has awakened European regulators and turned consumers away from cars with diesel engines. Feeling threatened by companies born in the digital age, carmakers had no choice but to go all in on vehicle connectivity to compete with Tesla, and to pour billions of dollars into autonomous vehicle development or risk being left behind by Waymo, Aurora, Zoox and the other disrupters. More challenges to incumbent automakers are coming from Uber, Lyft and the other shared mobility providers who make it easier for urban dwellers to live without owning a vehicle. And finally, regulations requiring advanced safety features such as those established in the EU will make driving by humans less dangerous but will adversely affect the affordability of vehicles. (See article on page 11.)

Investment demands on carmakers and some suppliers are extremely high, while returns from those investments will take a very long time to pay off. According to the consulting firm AlixPartners, the major auto companies’ spending on vehicle


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electrification for the period 2019 through 2023 will reach $225 billion. On top of that, the industry will spend a cumulative $85 billion through 2025 on autonomous vehicle development.

Level 4 autonomous vehicles won’t go mainstream for at least another decade, probably longer. Any applications prior to that will be at relatively low volumes. A year ago at the WSJ D.Live tech conference in Laguna Beach, California, Waymo CEO John Krafcik threw shade on the overly optimistic prospects for self-driving vehicles that were being hyped at the time. He said that self-driving is “really, really hard,” and that such vehicles won’t be ubiquitous for decades. He also said cars might never be able to drive autonomously in all weather conditions. Waymo, which began working on self-driving technology in 2009, is by far the global leader.

Forced to respond to a European mandate to cut CO2 emissions by 37.5% between 2021 and 2030, in addition to a 40% emissions cut between 2007 and 2021, carmakers operating there are adding numerous EV models to their lineups. “A survey by Reuters in January [2018] put the industry’s total planned EV-related spending worldwide (including on batteries) at around $300 billion over the next five to ten years,” according to the Economist. The AlixPartners analysis published in June found the average powertrain cost for a battery electric vehicle was approximately $16,000, two-and-a-half times more than conventional powertrains. Without government subsidies EVs will be a tough sell. Sales of BEVs are on the rise; they will account for 11.4% of global light vehicle production by 2026, according to IHS Markit. More spending on charging infrastructure is needed to support that forecast.

**2026 Global Light Vehicle Production by Propulsion Type**

Total: 103,625,009

- ICE 18.4%
- BEV 11.4%
- HEV 6.0%
- MHEV 27.3%
- PHEV 5.3%
- ICE with Stop/Start 31.6%

Data: IHS Markit
With car sales down significantly, carmakers are struggling mightily to remain profitable while investing billions of dollars to develop electric vehicles and cars that drive themselves. “They have had one foot planted firmly on the gas pedal while the other foot has had to slam on the brakes,” declared Henner Lehne, who leads IHS Markit’s forecasting team.

As of December 2019, carmakers had already announced that 80,000 jobs would be eliminated in the coming years, according to Bloomberg News. In November Audi announced it was cutting up to 9,500 jobs by 2025, but would create 2,000 new positions in electric mobility and digitalization. Mercedes’ car division announced it would be cutting 10% of management and administrative positions in the wake of lower profit forecasts.

**Suppliers Are Also Struggling**

Continental has undertaken a massive plan to restructure its product portfolio and organization. The company will spin off its powertrain division, now known as Vitesco Technologies. Aimed at gasoline and diesel internal combustion engine and electric and hybrid powertrain applications, Vitesco’s product portfolio includes ECUs, sensors, actuators and exhaust gas aftertreatment solutions. As a division of Continental, Vitesco Technologies contributed €7.7 billion to sales in 2018 and employed more than 40,000 people at 50 locations worldwide.

As of September 30, 2019, after three fiscal quarters, Continental Automotive Group showed a net loss of €926 million on €33,414 million in sales. Sales were flat compared with the prior year. By 2023 Continental AG will cut 10,000 people from its employment rolls. An additional 5,000 people will lose their jobs between 2023 and 2029.

Hitachi and Honda plan to merge four parts suppliers.

Fallout from the diesel emissions cheating scandal hit Bosch particularly hard. In addition to multimillion dollar fines and legal settlement charges as Volkswagen’s primary ECU supplier, Bosch also saw the demand for its passenger car diesel engine components plummet as stricter emissions testing is implemented in Europe. In August 2019, CEO Volkmar Denner said job cuts in its diesel operations would be necessary. The company sold its Starter Motors and Generators division in January 2018.

Earlier in the year, Mr. Denner said that by 2025 Bosch aims to increase its sales in vehicle electrification tenfold, “to a total of 5 billion euros.” The
A company is working to develop fuel cell technology and AI expertise. Bosch is a partner in Germany’s public-private Cyber Valley initiative to promote AI research. Other partners in the venture include Amazon, BMW, IAV, Daimler, Porsche and ZF.

With a long history as a major supplier of transmissions and braking systems, ZF expanded its product portfolio to include ADAS capability with the acquisition of TRW Automotive and its radar and camera technology four years ago. Like its competitors, ZF is taking a hit from lower global production volumes, especially in China, and from an increase in R&D spending. The company revised its outlook for 2019 from nearly 3% sales growth to somewhere between flat and a decline of 2%.

According to an August 2019 press release, ZF will nevertheless “continue to invest in future-oriented technologies such as electromobility and autonomous driving,” but will “postpone or reduce investments in established areas where the economic downturn is evident.” ZF has collaborated for several years with Mobileye on camera-based ADAS features and recently announced an ADAS-related collaboration with the Israeli startup Cognata. The company took on $7.3 billion in debt this year to finance its acquisition of brake supplier Wabco.

Denso’s operating profit for the fiscal year ending March 31, 2019, dropped 23% from the prior year. The company attributed the decline to its “increase in investments to help secure its future growth toward becoming a leading advanced mobility supplier.” Much of that investment is going to expanding Denso’s software capabilities. It partnered with Aisin, Advics and JTEKT in a new company called J-QuaD Dynamics, focused on integrated control software for autonomous driving. Denso said that by 2025 it will increase its global software development team to 12,000 employees. According to the company it has made expanding software expertise a central focus in several partnerships it formed with startups, venture capital investors and large corporations as it “advances new mobility solutions—both in and outside the automotive industry.”

**Global Vehicle Sales 2018 - 2026**

- 2018 to 2020 CAGR: -2.3%
- 2020 to 2026 CAGR: 2.5%

Data: IHS Markit
According to IHS, global vehicle sales will stabilize in 2020 and from there return to 2.5% annual growth. However, there is a great deal of instability around the world that could cause that forecast to be revised downward. To stay viable and flexible, companies will have to tightly control spending and sharply focus their strategies to make sure they are focused on what they do best while being selective about which customers to serve. ✦
Arm Leads Collaboration for AV Computing Standards

In the automotive world, we don’t hear nearly as much about Arm Limited as we do about NXP, Infineon, Renesas and Intel. Arm has been active in the auto industry since 1996 and quietly over the years the company’s progress has been, well, stunning. In 85% of the SoCs deployed in IVI applications worldwide, the main application processor is based on Arm IP. Arm processors are central in 65% of ADAS SoCs. Every one of the top 15 automotive silicon vendors is an Arm Licensee.

AVCC

While I have been somewhat familiar with Arm, I was a little surprised to see the company taking the lead in creating the Autonomous Vehicle Computing Consortium (AVCC). As they talked with OEMs, tier ones, software vendors and other key stakeholders over the last couple of years, Arm’s automotive vice president Chet Babla and his team became aware of a common theme coming from the autonomous vehicle ecosystem. “We were seeing a lot of proof-of-concept hardware being used to prove autonomous software stacks, and doing a good job of it, I have to say,” Mr. Babla observed. “But people were recognizing that the hardware that was being prototyped wasn’t really suitable to large scale commercial deployment. Our partners were saying that we in the industry need to collaborate and try to recommend potential system architectures.”

Before such recommendations can be made, “We need to understand what are the key compute requirements, the power, the cost, the thermal envelopes of these autonomous vehicle commercial offerings,” Mr. Babla continued. “What is the kind of software API abstraction that will allow these autonomous vehicle software stacks to seamlessly be deployed on different types of commercial hardware implementations?” He saw an obvious need for industry collaboration with the goal of developing an AV computing platform that is implementation agnostic, meaning it won’t be specific to an instruction set architecture, or to a particular silicon vendor’s implementation of compute, or to how the software might be constructed.

AVCC expects to publish initial standards by the end of 2020. Thus far, in addition to Arm, AVCC members include Bosch, Continental, Denso, GM, Nvidia, NXP, Renesas, Toyota and Veoneer. More members well known to the industry are expected to soon join the collaboration.
“Over the past several years multiple autonomous vehicle computing and software platform collaborations have been formed, but this is different,” Mr. Babla said. “A lot of those initiatives tend to promote a particular way of doing something that is perhaps proprietary, or locked to one company. You see some of the names of companies who have joined AVCC. They are ostensibly competitors. What we are trying to do here is find a fundamental approach that is agnostic and allows people to bring their own differentiation.”

Automotive at the Forefront of Innovation
“We think automotive has a really positive contributory role to play in trying to address some of the big macro-challenges around sustainability, urbanization, social inclusivity, digitalization and big data,” Mr. Babla suggested. “Automotive has always been seen at the boring end of the semiconductor market. It is incredible how the industry over the last four years or so has started to be at the forefront of innovation.”

Three big trends are driving automotive innovation: Powertrains are moving away from combustion engines to electric. The digital cockpit is integrating the cluster and infotainment with cabin control systems. And driver assistance is heading toward autonomy. Those are the trends driving the industry toward domain architectures, virtualization, and multiple operating systems, Mr. Babla observed. “Machine learning is being deployed even in areas you might not expect, like the powertrain where it is applied to understand battery usage and range predictions. System consolidation is also driving the need for a single integrated architecture with mixed [safety] criticality, ASIL B and ASIL D.” These technical drivers have instigated an uptick in R&D spending by the automotive electronics ecosystem.

Arm’s Automotive Business
The vast majority of Arm’s automotive revenue comes from the CPU (central processing unit) cores that are part of chips sold to the industry. Arm receives an upfront license fee and a royalty on every chip that ships with its technology. Arm is known for its Classic and Cortex CPUs, but the company is now seeing growing demand for heterogeneous computing involving not just its CPU technology, but also its GPU (graphical processing unit), ISP (image signal processor), and ML (machine learning) technologies.
Arm’s primary business is the development of IP blocks that are used in silicon chips. Arm also offers tooling and functional safety capability to its automotive partners. Customers are asking for early access to models of Arm’s IP blocks so they can begin validation of software prior to the availability of hardware.

Arm’s Business Model

1) Arm licenses technology to chip partners
2) Partners develop chips and ship them to OEMS
3) OEMs sell products containing Arm-based chips

Arm Ltd. Revenue in All Markets
Fiscal year ending March 31, 2019

($ millions)

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Licensing</td>
<td>547</td>
</tr>
<tr>
<td>Technology Royalty</td>
<td>1,098</td>
</tr>
<tr>
<td>Software and Services</td>
<td>191</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,836</strong></td>
</tr>
</tbody>
</table>

Arm is a subsidiary of SoftBank Group Corp.

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EU Safety Requirements Underpin Robust ADAS Market

Years in the making, the European Parliament and the Council recently finalized type approval regulations that protect vehicle occupants and, for the first time, vulnerable road users. As of May 2022 all new model vehicles sold in the EU will have to be equipped with advanced safety systems. The safety regulations become mandatory for existing models from May 2024. Vulnerable road users include pedestrians, cyclists, and users of scooters, self-balancing vehicles and wheelchairs.

Like Euro NCAP, the new European rules will profoundly influence the market for advanced driver assistance systems well beyond Europe.

These new rules apply to all motor vehicles:

- Intelligent speed assistance: Systems to aid the driver in maintaining the appropriate speed for the road environment by providing dedicated and appropriate feedback. It should be possible to switch off intelligent speed assistance, for instance, when a driver experiences false warnings or inappropriate feedback as a result of inclement weather conditions, temporarily conflicting road markings in construction zones, or misleading, defective or missing road signs. When the system is switched off, information about the speed limit may be provided. The system should be always active when switching the ignition on and the driver should always be made aware of whether the system is on or off.

- Alcohol interlock installation facilitation: A standardized interface that facilitates the fitting of aftermarket devices.

- Driver drowsiness and attention warning system: A system that assesses the driver’s alertness through vehicle systems analysis and warns the driver if needed.

- Advanced driver distraction warning systems: A system that helps the driver to continue to pay attention to the traffic situation and warns the driver when he or she is distracted.
- Emergency stop signals: A light-signaling function to indicate to other road users to the rear of the vehicle that a high braking force is being applied to the vehicle relative to the prevailing road conditions.

- Reversing detection systems: A system to make the driver aware of people and objects at the rear of the vehicle with the primary aim of avoiding collisions when reversing.

- Event data recorders: Used for storing a range of crucial anonymized vehicle data retrievable over a short timeframe before, during and immediately after collision (for example, triggered by the deployment of an airbag).

- Accurate tire pressure monitoring: A system fitted on a vehicle which can evaluate the pressure of the tires or the variation of pressure over time and transmit corresponding information to the user while the vehicle is running.

These rules only apply to cars and vans:

- Advanced emergency braking systems: Light duty vehicles must be equipped with advanced emergency braking systems, implemented in two phases. In the first phase the system must detect and stop for obstacles and moving vehicles ahead of the motor vehicle. In the second phase the requirement extends to include the detection of pedestrians and cyclists ahead of the vehicle. Phase two requirements become mandatory for new models beginning in September 2024 and extend to all models from September 2026.

- Emergency lane-keeping systems: A system that assists the driver in keeping the vehicle in a safe position with respect to the lane or road boundary, at least when a lane departure occurs or is about to occur and a collision might be imminent.

While many of these safety features are already available to premium car owners, the regulation will require carmakers to install the features on all new vehicles. In 2018, 25,000 people were killed and 135,000 were seriously injured on EU roads. The Commission expects that the proposed measures will save more than 25,000 lives and avoid at least 140,000 serious injuries by 2038, and they will advance the EU’s long-term goal of moving close to zero fatalities and serious injuries by 2050.
Tactile Mobility’s First OEM Order to Map Road Grip Coming Soon

If vehicles had precise, up-to-the-minute information about how much grip the road surface ahead will provide, vehicle safety could be much improved. For example, the adaptive cruise control setting could be automatically adjusted to a slower speed to account for black ice before the vehicle arrives at the hazard. A year and a half ago the Israeli startup Tactile Mobility began demonstrating software that is able to extract and process data from the CAN bus to create a clean signal that represents the dynamic between the vehicle and the road surface. In practice, that processed data would be sent from the vehicle to the OEM’s cloud and forwarded to Tactile Mobility’s cloud, where data from multiple vehicles are processed using AI and proprietary algorithms and sent back to the OEM’s cloud as a map that details grip level estimates of the road surface, what the company refers to as an example of Surface DNA.

The OEM would then take that normalized data from Tactile Mobility and feed it back to each vehicle where it is “de-normalized,” tailored to each vehicle, for example to account for whether the vehicle is equipped with winter, summer or all-year tires and how many passengers are aboard.

The grip-level map would be updated constantly: “Conditions change even in the same part of the road,” explained Eitan Grosbard, vice president of business development for Tactile Mobility. “The morning is different from the afternoon; it is rainy or not, sunny or not.”

It will take some years before a critical mass of connected vehicles is equipped with the software needed to report grip level data over a wide geographic range. Tactile Mobility’s first OEM customer manufactures vehicles in Europe but sells them worldwide. Mr. Grosbard is in talks with five other OEMs. “Most of them are moving toward commercial agreements. We hope that by 2022 our solution will be in a few million vehicles, and as we move from one production year to another it will start multiplying. By then we will be adding other OEMs into the mixture.”

Tactile Mobility, which has been working with Porsche and Ford, among others, will initially focus on Europe and the U.S. and expand from there.
Another inducement for carmakers to engage with Tactile Mobility is the expectation that their road surface data has value beyond improving the safety of their vehicles. The data could be further monetized. Road authorities responsible for maintaining road infrastructure would likely pay for data that pinpoints the location of potholes and cracks that are badly in need of repair. “We will be buying, selling and using data from a variety of OEMs,” said Mr. Grosbard.

To implement the collection of tactile data, all that must be added to the vehicle’s bill of materials is Tactile Mobility’s software, which instructs an ECU to extract raw data from the vehicle’s existing non-visual sensors via the CAN bus. Without being too specific, Mr. Grosbard conceded that the data collected would be things like wheel speed, RPM and wheel position. No additional sensors would be required beyond what is already installed in today’s production vehicles.

**Vehicle DNA**
Using the processed CAN bus signals like those employed in the Surface DNA mathematical model, the Vehicle DNA model can learn what is happening within the vehicle for the purpose of preventive maintenance. Tactile Mobility has already demonstrated to OEMs and tire manufacturers its ability to detect tire health. “We have the ability to tell you that your tire has worn out and within 500 km or a month’s time tell you that it’s time to replace that tire,” declared Mr. Grosbard.

Next on Tactile Mobility’s development agenda are models to determine engine health, chassis health and suspension health from the same tactile virtual sensor data. Its software has analyzed 10 million km of driving over the course of more than 100,000 controlled drive tests.

The company’s closest competitor is the Swedish company Nira Dynamics. In the next tier of competitors are probably tier-one suppliers like Continental and Bosch.

Founded in 2012 with roughly 25 employees, Tactile Mobility completed its latest round of financing in October, raising a total of $9 million from investors including Porsche and Israel’s Union Tech Ventures, the venture arm of Union Motors, the importer of Toyota and Lexus vehicles to Israel. Headquarters are in Haifa. Representative offices are located in Kirchheim unter Teck, Germany, Singapore and Santa Clara, California. ♦
The Company Profile: ETAS GmbH

**Thumbnail Sketch**
- **Headquarters**: Stuttgart, Germany
- **2018 Sales**: €312.5 million
- **Operating Margin**: Approximately 15%
- **2018 R&D**: Approximately 20%
- **Employees**: 1,400 as of January 1, 2019
- **2018 Sales per Employee**: €223,214
- **Top Customer**: Volkswagen
- **Ownership**: Bosch owns 100% of ETAS
- **Products**: Software, hardware, engineering tools and services for the development of embedded systems; cybersecurity solutions

**Background**
ETAS was established by Robert Bosch GmbH in 1994 and operates as a 100%-owned Bosch subsidiary. Siemens VDO acquired 10% of ETAS for a period between 2000 and 2007, in exchange for the Siemens line of calibration and measurement tools. Bosch regained 100% of ETAS following the acquisition of Siemens VDO by Continental in 2007.

Measurement, ECU calibration and diagnostics (MCD), is today the company’s largest product category, accounting for 55% of 2018 sales. ETAS’s real-time applications and security solutions (marketed under the ESCRYPT brand) are the fastest-growing segments, increasing at twice the MCD growth rate. ETAS’s mission

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*Includes ESCRYPT*
is to provide solutions and services to increase the quality and efficiency of the development and maintenance of embedded systems.

While it does serve other markets, automotive is by far the dominant market concentration for both ETAS and its security subsidiary, ESCRYP'T. Security, real time applications and virtualization have lately been receiving a growing share of the company’s R&D spend.

**Company Strengths**

We asked Friedhelm Pickhard, ETAS president and chairman of the board of management, why ETAS’s customers choose to work with ETAS as opposed to the competition. He offered several good reasons why:

- Customers rely on the quality and reliability of ETAS’s products.
- ETAS works very closely with its customers. “They are involved in shaping our tools,” said Mr. Pickhard. “We have to involve them early in order to ensure that our tools can be integrated in the customers’ tool chains. When a customer buys our tools they can be certain that those tools are designed for their purpose. For example, the ASCMO modeling tool is made for automotive industry experts. ASCET is a proven tool for generating production ready code for safety-critical applications.”

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**ETAS Sales by Region**

<table>
<thead>
<tr>
<th>Region</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>48.9%</td>
</tr>
<tr>
<td>Rest of Europe</td>
<td>8.9%</td>
</tr>
<tr>
<td>Japan, Korea &amp; ASEAN</td>
<td>17.4%</td>
</tr>
<tr>
<td>Americas</td>
<td>12.9%</td>
</tr>
<tr>
<td>China</td>
<td>8.6%</td>
</tr>
<tr>
<td>India</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

2018 Total Sales: €312.5 million

**ETAS Employees by Region**

<table>
<thead>
<tr>
<th>Region</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>75%</td>
</tr>
<tr>
<td>Americas</td>
<td>11%</td>
</tr>
<tr>
<td>Asia-Pacific</td>
<td>14%</td>
</tr>
</tbody>
</table>

Total as of January 1, 2019: 1,400

**ETAS Customers**

This alphabetical list does not include all of ETAS’s customers, and the companies listed are not necessarily the largest.

- Audi
- BMW
- Bosch
- Continental
- Daimler
- Delphi
- Denso
- FCA
- Ford
- GM
- Honda
- Hyundai
- Mahindra
- PATA
- PSA Groupe
- PTT Plc
- Renault
- SAIC
- Tata
- Volkswagen


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◆ No other security company has the deep, embedded automotive experience that ESCRYPT has.
◆ ETAS and ESCRYPT are based in Germany but both have a global presence, including in Canada, the U.S., Brazil, Italy, France, Great Britain, Sweden, Poland, India, Korea, China and Japan.
◆ ETAS supports all stages of the V-Cycle software development process.

![Diagram of ETAS V-Cycle process](source: ETAS)

◆ ETAS and ESCRYPT tools are based on standards that accommodate successful integration with customers’ existing tool chains.

**Vehicle Development Trends**
ETAS works very closely with engineers responsible for developing embedded automotive systems. Since we last profiled ETAS in 2014, one of the biggest changes to impact the company has been the shift in powertrain development by carmakers from internal combustion engines to electrified powertrains. “We have a leading market share in the calibration of combustion engines. We want to maintain this market position as the industry transitions to the electrical area,” said Mr. Pickhard. ETAS has had a strong diesel engine calibration business. “Calibrating diesel engines is complex, involving as many as 100,000 parameters. Electric powertrains involve one-fourth as many parameters. And diesel engine calibration is often specific to each country’s exhaust standards. That is not the case for electric powertrains, so calibration work is declining,” he added.

The other trend impacting ETAS is the growing dominance of software, particularly in ADAS and autonomous vehicle development. “Software tooling and software verification is getting more and more important. We have invested in our validation tools, and our COSYM platform is a result of that,” said Mr. Pickhard.
### Products

<table>
<thead>
<tr>
<th>Software Products and Systems</th>
<th>ECRYPT Cyber Security Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCET for model-based development of ECU application software</td>
<td>Security Consulting</td>
</tr>
<tr>
<td>COSYM for test and validation of software in early phases of development</td>
<td>Multi-layered protection concepts</td>
</tr>
<tr>
<td>EHANDBOOK for providing interactive documentation of ECU software</td>
<td>Integration of hardware security modules</td>
</tr>
<tr>
<td>EHOOKs for efficient insertion of bypass hooks into compiled software</td>
<td>Intrusion detection and prevention for vehicles</td>
</tr>
<tr>
<td>INTECRO for prototyping new ECU functions</td>
<td>Secure OTA firmware updates</td>
</tr>
<tr>
<td>ISOLAR for developing and validating Autosar software</td>
<td>Secure V2X communications</td>
</tr>
<tr>
<td>LABCAR software for HiL tests and validation of ECU software</td>
<td>Secure feature activation</td>
</tr>
<tr>
<td>SCODE to create model-based, structured, and easily understood solutions in ECU software</td>
<td>Secure remote diagnosis</td>
</tr>
<tr>
<td><strong>Measurement, ECU Calibration and Diagnostics</strong></td>
<td><strong>Automotive Embedded Security</strong></td>
</tr>
<tr>
<td>INCA for measurement, ECU calibration and diagnostics</td>
<td>Cryptographic library</td>
</tr>
<tr>
<td>ASCMO for data-based modeling and calibration of complex systems</td>
<td>Transport layer security for embedded platforms</td>
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<tr>
<td><strong>Real-Time Applications Based on Autosar</strong></td>
<td>Security software for ECUs</td>
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<tr>
<td>Engineering services</td>
<td>Embedded intrusion detection</td>
</tr>
<tr>
<td>Basic software and tools</td>
<td>Automotive firewall</td>
</tr>
<tr>
<td>Consulting services</td>
<td>Vehicle access and key sharing</td>
</tr>
</tbody>
</table>

### COSYM

ETAS released its COSYM tools to the market just last year and customer response has been extremely promising, with interest coming not only from Europe and the U.S., but from China and Korea as well. The company expects sales to quickly grow. Using COSYM, developers can simulate and validate the vehicle’s software in a virtual environment in the cloud before the actual hardware becomes available. Because COSYM simulates the vehicle ECUs and networks in software, engineers can deploy this set-up to the cloud and test their software with different parameters and different environments, significantly shortening system development timelines, according to Mr. Pickhard.

ETAS expects that COSYM will play an increasingly crucial role in the development of ADAS and autonomous vehicles. “This will be done in steps. Once we are able to capture the video, radar and lidar data models, COSYM would then use this data for closed-loop simulation.”
Real Driving Emissions Test
The new Real Driving Emissions (RDE) test, initiated in Europe in March 2016, measures pollutants such as NOx emitted by cars while they are being driven on the road. RDE does not replace the WLTP laboratory test, but complements it. Under RDE testing, a car fitted with a portable emissions monitor is driven on public roads and exposed to a wide range of different conditions. RDE testing will be required for all new vehicles sold in Europe by the beginning of 2021.

By the end of 2020, ETAS will be ready to offer a version of its long-standing ASCMO modeling and calibration tool that will let developers run the RDE test in simulation in the cloud, with only a few actual test drives on the road to verify that there is no missing link between simulation and reality, according to Mr. Pickhard. “ASCMO automatic calibration is already used in practice. The verification and validation functions have been prototyped. The required statistical verification is nearly impossible to do on the street, so you have to do it in a virtual space. ASCMO provides the models of an engine; COSYM provides the simulation.”

Runtime Environment Based on Adaptive Autosar
ETAS offers the RTA-VRTE (Vehicle Runtime Environment) based on Autosar. Developed together with the Bosch Group, this basic software framework implements the Autosar Adaptive Platform plus extensions and security components. This platform is integrated with the QNX operating system, based on the partnership that ETAS and QNX recently announced. In addition ETAS offers services including consulting, training and a service hotline as well as development tools.

ETAS got a late start with the Autosar Classic Platform, but its market share has grown rapidly over the last few years, and ETAS is now one of the major providers. With Autosar Adaptive ETAS is all-in from the very beginning of the standardization effort. “We are one of the first companies to have involvement with tools able to test Autosar Adaptive. We provide complete runtime environment software for the domain controller today with RTA-VRTE, with the production ready release for safety critical ECUs planned for the end of 2020. This journey will continue with ADAS frameworks in 2020, too,” said Mr. Pickhard.
ESCRYPT
ETAS acquired ESCRYPT in 2012. ESCRYPT was a spinoff of the Ruhr Universität Bochum’s Horst Görtz Institute for IT Security, a leading provider of security solutions for embedded systems. Now a subsidiary of ETAS, ESCRYPT provides security for the complete embedded vehicle system and infrastructure. ESCRYPT began as a consulting company, and while today consulting is still the dominant source of revenue, sales of software products is growing quickly, especially intrusion protection and key management. According to the company, revenue will be balanced between consulting and product sales in approximately two years.

The ESCRYPT portfolio contains not only solutions for secure data exchange, attack detection and defense for safe firmware updates, but also preventive vulnerability management, risk and hazard analyses, penetration tests of IT systems and real-time analyses, as well as incident and emergency response management.

ESCRYPT’s connection to ETAS offers a unique selling proposition to customers. “No other security company has the same deep knowledge and experience that combines security capabilities with ETAS’s embedded software engineering capabilities,” Mr. Pickhard asserted.

Most security consulting by ESCRYPT is done with OEM customers, but hardware security modules and other cybersecurity software products are sold to the same tier-one embedded system engineers with whom ETAS is engaged. So there are synergies. The ESCRYPT business is growing at the same rate as the RTA business of ETAS.

In December 2019, ESCRYPT announced that it is working with the management consultancy KPMG to support automotive manufacturers and suppliers as they set up certified cybersecurity management systems for vehicle platforms.

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<th>ETAS Competition</th>
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<td>Test (hardware-in-the-loop) and Validation</td>
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<td>dSPACE, in Europe and the U.S.</td>
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<td>HiRain Technologies, China</td>
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<td>OPAL-RT, Canada</td>
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<td>Simulation and Cloud Applications</td>
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<td>Dassault Systèmes</td>
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<td>IBM</td>
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<td>Emulator Test Probes</td>
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<td>Vector</td>
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<tr>
<td>Argus Cyber Security, intrusion protection</td>
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<th>Distinctions Claimed by ETAS</th>
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<tr>
<td>◆ ETAS owns the world’s leading share of the market for calibration solutions for ICEs.</td>
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<td>◆ ESCRYPT is the world’s leading embedded security system supplier.</td>
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<td>◆ More than 1.6 billion ECUs in vehicles on the road run on operating systems from ETAS.</td>
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<td>◆ Every major OEM and tier-one supplier is an ETAS customer.</td>
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<td>◆ ASCET is able to generate production-ready code for safety-critical applications proven in millions of cars.</td>
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Key ETAS Alliances and Joint Ventures

◆ ETAS NI Systems GmbH & Co. KG
On January 1, 2020, this 50-50 joint venture between ETAS and National Instruments will commence operations in Stuttgart, Germany, initially with 50 employees. Combining NI’s software-defined platform and I/O capabilities with ETAS’s expertise in HiL solutions, the JV will design, build and service pre-integrated HiL systems. The JV aims to help software developers working in vehicle electrification and advanced driver assistance systems.

◆ ETAS and BlackBerry QNX Safety-Critical Platform Cooperation
In November 2019, the two companies announced a cooperation to jointly develop and market a safety-critical platform and tools for developing next-generation connected and autonomous vehicles. The platform will be based on the Adaptive Autosar standard and will be compliant to the ISO 26262:2018 standard. The platform will support the trend toward the adoption of centralized computing and multicore SoCs. It will further support the objective of separating software from hardware and the ability to combine software from different sources.

While many ADAS and AV computing platforms have been proposed, it is likely no more than three platforms will survive over the long term, according to Mr. Pickhard. “We will deliver one of them. That is our target,” he asserted. “At the moment, you have one framework that combines an operating system with a hypervisor as a low-level platform. The next level is a vehicle domain controller, which provides an API for higher functions, this is the focus of the Autosar Adaptive Platform. On top of that you have a framework for ADAS functionalities, to abstract them, which includes for example abstractions for neural networks. Then you have the next framework for connectivity, etc. Our target is to combine all these frameworks to one automotive middleware on which tier ones as well as OEMs can provide the applications. As we saw in the computer industry with the PC, not many frameworks (platforms) will survive. The added cost for safety, the cost to write applications in the automotive domain, with automotive volumes, will be simply too high. It looks like in the future there will be perhaps a Chinese platform, one from the U.S. West Coast, and there will be one from us on the market.”

◆ Trust Point Innovations Acquisition
In April 2017, ETAS completed the acquisition of Trust Point Innovations which provides security tools for V2X communications. The company has been integrated into ETAS Embedded Systems Canada, located in Kitchener, Ontario.