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TESTING AND SIMULATION

# powertrain & drive focus

## » AGRICULTURAL MACHINERY ENGINEERING CAN LEARN FROM THE AUTOMOTIVE SECTOR. «

MARTIN RICHENHAGEN, CHAIRMAN, PRESIDENT AND CEO OF AGCO

.08 High Performance Technology  
Demonstrator: AVL Coup-e 800

.18 High-tech Exhaust Emission and  
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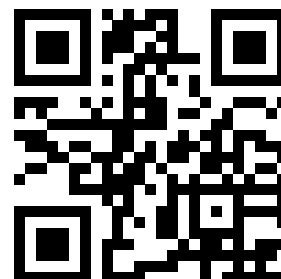
## AVL POWERTRAIN WORLD APP

AVL's new Powertrain World app for the first time provides engineers across the auto industry with insight and information into the latest innovation, wherever they are. Powertrain World is a content-based app for smartphones and tablet devices like the iPad that delivers exactly what it promises – comprehensive information on everything to do with the very latest on powertrains. The content is a combination of different types of articles, images and videos, as well as information on events and products, intelligently categorized and tagged so that the app is easily navigable.

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for auto engineers to  
keep in touch with  
industry innovation.



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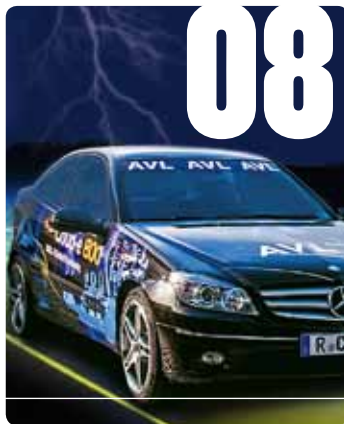
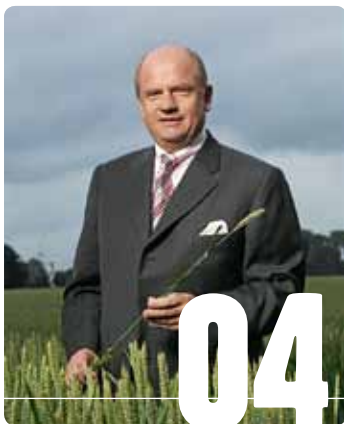
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Prof.  
Helmut List  
Chairman  
and  
CEO AVL



Achieving the future CO<sub>2</sub> fleet limits presents a huge challenge for the global automotive industry. It is imperative to develop drive solutions that lower consumption while remaining affordable and attractive to our customers.

Conventional drive systems still have tremendous potential for improvement in this respect. Efficiency-optimized combustion engines combined with modern transmission systems are capable of reducing carbon emissions by up to 20 percent. Hybrid technology will also contribute significantly to meeting the targets, but only if the technology of all components – from the electric motor to the converter and the battery – are developed further.

AVL is ideally positioned: with our comprehensive component and system expertise, our simulation tools and our state-of-the-art instrumentation and test systems, we are already able to develop hybrid module solutions in the concept phase, which helps to effectively counteract higher costs.

Together with our customers we will continue to succeed in developing affordable drive systems, which are both environmentally friendly and attractive to our customers.

*Helmut List*

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Interview with Mr. Martin Richenhagen, Chairman, President and CEO of AGCO

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# » AGRICULTURAL MACHINERY ENGINEERING CAN LEARN FROM THE AUTOMOTIVE SECTOR «

AGCO, based in Duluth (Georgia), USA, is the world's third-largest manufacturer of agricultural equipment. Being a leading global company, AGCO offers a broad variety of products, which are distributed through more than 3,100 dealers in more than 140 countries. Focus spoke to Martin Richenhagen, President and CEO of AGCO, about developments in drive engineering, the role of alternative fuels and new challenges in the growth markets.

► **«F»: Mr. Richenhagen, AGCO is a globally active manufacturer of agricultural equipment with sales of around 10 billion dollars. Please tell us what kind of equipment your business activities focus upon most.**

«Richenhagen»: In 2012 sales will even be reaching 10.5 billion dollars, making it yet another record year. AGCO's main focus is on wheeled tractors, and we're additionally expanding our range of harvesting equipment rapidly.

«F»: **What is your view of long-term trends in the tractor markets in Western nations and the BRIC states? Do you think there will be a market shift in one way or another, and how will AGCO respond to it?**

«Richenhagen»: AGCO assumes very stable markets with global growth. China, Eastern and Central Europe and Africa have a lot of catching up to do. AGCO is responding to this fact by investing in three factories in China, and is the first manufacturer in our industry to have a manufacturing site in Africa.

«F»: **Does the reduction of consumption, and thus carbon emissions, play a similarly big role in the agricultural industry as it does with passenger cars and trucks?**

«Richenhagen»: Of course it does, however with a slight delay, which has the positive effect of giving agricultural equipment technology a chance to learn from the technical

solutions available in the automotive sector.

«F»: **Do you already have special low-emission engines or filter systems for diesel engines?**

«Richenhagen»: Yes, we do. Where this is concerned, AGCO Power, our diesel engine line, is completely state of the art.

«F»: **AGCO Corporation joined the Diesel Technology Forum in March 2012. What role do you think bio fuels will have as a fuel for agricultural machinery in the future?**

«Richenhagen»: We regard this as a very interesting prospect, and farmers, being the producers of re-

newable energies, are very keen on solutions like this.

**«F»: Powertrain electrification is becoming increasingly important with passenger cars, and also with several heavy-duty type vehicles. Do you think that tractors will someday also have hybrid drives?**

«Richenhagen»: FENDT already developed a prototype together with a renowned university some years ago. I find that particular technology rather unlikely to be put on the market, though.

**«F»: What would you say are the key innovative forces in the area of tractors after the implementation of low-emission engines?**

«Richenhagen»: Where this is concerned, the big issue will be how the tractor can be controlled by the respective accessory equipment.

**«F»: What role do research & development have in your corporate group? Are these activities centralized, or is R&D done in more than one location?**

«Richenhagen»: Research & development is an extremely important area to me personally and, of course, to AGCO. We spend roughly 350 million dollars on R&D a year. In key areas, for example where the Platform Solutions are concerned, we take a centralized approach.

**«F»: How significant are advanced measuring and testing systems for your R&D activities?**

«Richenhagen»: In compliance with the importance we attach to modern measuring and testing equip-



**MARTIN RICHENHAGEN**  
CHAIRMAN, PRESIDENT AND CHIEF EXECUTIVE OFFICER

Martin Richenhagen (\*1952) was appointed President and Chief Executive Officer of AGCO Corporation in March 2004. Since August 15, 2006, Mr. Richenhagen has been Chairman of the Board of AGCO Corporation. He continues to sit on the Board as well as the Committees on Strategic Planning and Succession Planning. Mr. Richenhagen is also member of the Supervisory Board of Phelps Dodge Corporation, where he also sits on the Audit, Finance and Corporate Governance Committees. Previous to that, Mr. Richenhagen was Executive Vice President of Forbo International SA, a Swiss group specialized in the production of flooring systems. And before that he served as CEO of Germany-based agricultural equipment manufacturer CLAAS KgaA mbH, where he was responsible for the entire operations, Export, Marketing, Sales and Human Resources Management. In the years before 1995, Mr. Richenhagen was Senior Executive Vice President of Schindler Holding GmbH in Germany, where he was responsible for the areas Sales, Customers Support and Logistics. In 2009, Mr. Richenhagen became Chairman of the AEM (the Association of Equipment Manufacturers), which has more than 800 members around the world and represents the interests of the industry. Mr. Richenhagen is a Life Honorary Director of AEM. In 2011, he was appointed Chairman of the Board of Directors of the German American Chamber of Commerce of the Southern US, Inc. Richenhagen is married and has three children. He graduated from the University of Bonn and is fluent in several languages thanks to his long-standing international career. In December 2008, Mr. Richenhagen was appointed Honorary Professor to the Faculty of Agricultural Machinery at the TU Dresden.

ment, we invested accordingly in new technology again this year.

«F»: In what areas – engine, powertrain, etc. – do you globally work together with AVL?

«Richenhagen»: We collaborate with AVL in all of the relevant fields such as engine and powertrain.

«F»: AVL is heavily involved in transmission development. What role do modern automatic transmission systems play in tractors or combine harvesters? Are there any trends?

tinguished, but we attach great importance to using the same components.

«F»: Do you also engage in business activities in growth markets like India, China or Brazil? How do the demands there differ? Do these customers require simpler and thus more cost-efficient technology?

«Richenhagen»: In the BRIC regions, the situation varies, but over a certain period of time the standards will ultimately be the same the world over.

**active agricultural equipment manufacturer?**

«Richenhagen»: The challenge we face is to help farmers make advances in productivity by offering them intelligent technology, as they try to meet sharply rising demand for food and renewable energies.

«F»: All over the world, there is a lack of good engineers while the technical demands on the tractor, and, consequently, on the development team are on the rise. What do you tell young people in order to



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AGCO offers a broad variety of products through more than 3,100 dealers in more than 140 countries.

«Richenhagen»: In this respect, we've been setting the trend for years, and were first movers in CVT transmissions.

«F»: You have many different brands in your portfolio: Challenger®, Massey Ferguson®, Fendt® und Valtra®. Are technologies developed jointly for several brands? Or are there certain technologies which help to distinguish the brands from each other?

«Richenhagen»: Our core brands are uniquely positioned and clearly dis-

«F»: Is there such a thing as a high-end market for agricultural machinery, where people demand no less than the latest technologies where cost plays a minor role?

«Richenhagen»: Yes there is. These are the professional farmers who base their purchase decision primarily on ROIC (note: return on invested capital) and the costs over the entire life cycle.

«F»: What do you think are the biggest challenges facing a globally

**get them interested in agricultural engineering?**

«Richenhagen»: Our industry is currently experiencing a major surge in growth, and over the next few decades the demand will continue to be much higher than the supply. AGCO and its brands are global technology market leaders with 2,500 development engineers in all of the relevant markets. AGCO's vision makes jobs for well-trained young people very attractive and our internal human resources development program is really great. ←

A look behind the scenes of the Coup-e 800 project reveals the comprehensive expertise demonstrated by AVL in the domain of pure electric vehicles. The entire engineering project was carried out within the world-wide AVL group, from system design through to component development and software. The result is a high performance technology demonstrator that shows that it is indeed possible to deliver both sportiness and driving pleasure with e-drives.

# AN ELECTRIFYING PREMIERE

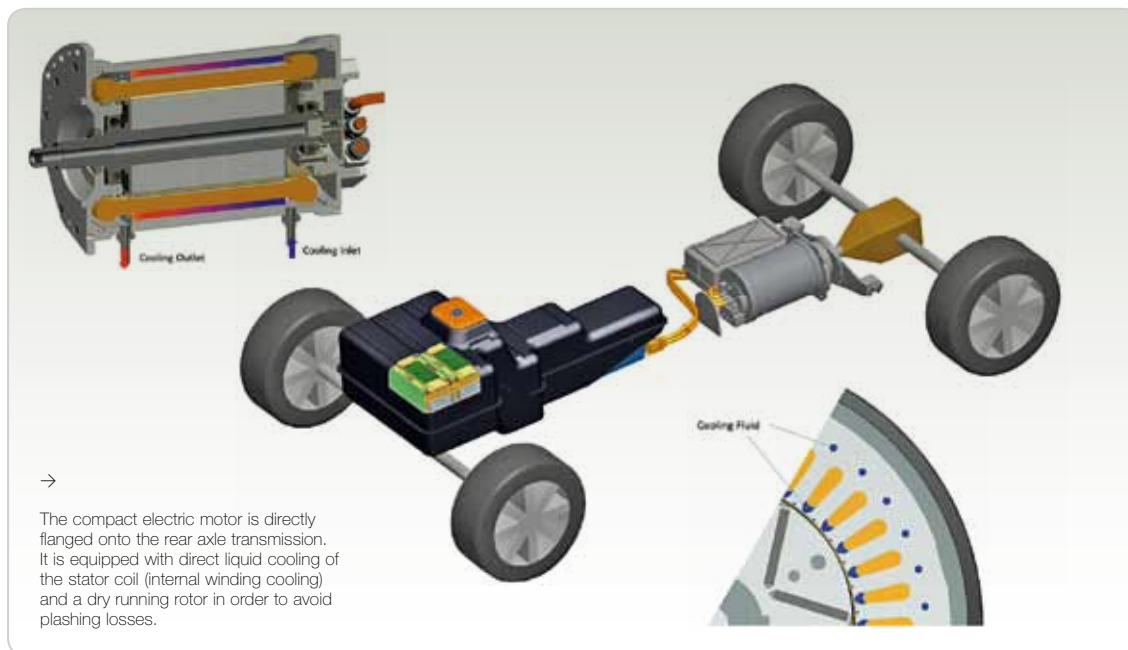


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The high performance demonstrator vehicle Coup-e 800, based on a Mercedes C-Class Coupé.

► “Our aim was to develop a powerful, purely electrically propelled vehicle that fully meets the requirements of sporty drivers. Another aspect we focused on was to ensure that there was no adverse impact on the passenger compartment or the rear trunk volume. But at the center of our considerations was obviously a level of performance that could deliver acceleration from 0 to 100 km/h in 6 s and a maximum speed of 180 km/h,” says Anton Angermaier, Head of E-Mobility, describing AVL’s most recent all-electric demonstrator vehicle, the Coup-e 800. Its development was lead-managed by AVL Software and Functions GmbH in Regensburg.

The AVL Coup-e 800 is based on a Mercedes C-Class Coupé, which, thanks to its rear wheel drive, offers the ideal platform for the sporty AVL prototype. “The name Coup-e 800 is derived from the fact that in certain operating situations we are capable of achieving a system voltage of almost 800 volt. The electric traction motor additionally enables us to get very close to the peak torque of 800 Nm,” Angermaier explains, adding, “The drive segment in which our demonstrator vehicle is positioned can be referred to as the six-cylinder segment of electric mobility.”



## FUNDAMENTAL CONCEPT

Our decision to increase the DC-voltage level from the usual 300-400 volt common in electric vehicles to up to 800 volt was based upon several considerations: achieving electric driving

become very heavy and, due to their thickness, the bending radii would create considerable problems during integration. Larger-sized cells would also need to be put into the battery, or alternatively cells connected in parallel, which would be trickier to han-

» THE DRIVE SEGMENT IN WHICH OUR DEMONSTRATOR VEHICLE IS POSITIONED CAN BE REFERRED TO AS THE SIX-CYLINDER SEGMENT OF ELECTRIC MOBILITY. «

performance above 100 kW would imply an electric current of more than 350 ampere in the HV-power-net (DC), if 600-Volt-IGBT technology is being used in the inverter of the traction motor. These high current loads increase resistive losses in the HV cables; in addition, the cables

dle in the sense of cell management.

During the development of the Coup-e 800, AVL and its development partner Infineon tackled this problem by using 1200-volt IGBT technology

gy and a battery with a nominal DC-voltage of 675 volt. The battery with a gross energy content of around 28 kWh is installed in the same space where the engine and the transmission would normally be. The compact electric motor is directly flanged onto the rear axle transmission, driving the rear wheels without intermediate transmission. Based on this geometric integration concept, a weight distribution of 53 percent (front axle) and 47 percent (rear axle) is achieved.

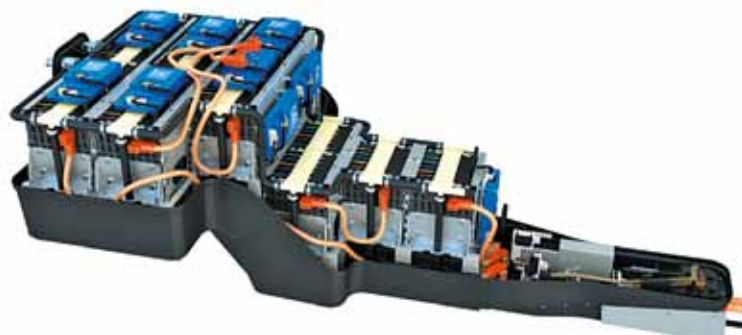
## TRACTION MOTOR WITH HIGH PERFORMANCE DENSITY

The Coup-e 800's traction motor is a permanent magnet synchronous motor. It is equipped with direct liquid cooling of the stator coil (internal winding cooling) and a dry running rotor in order to avoid plashing losses.

This cooling concept is achieved by the use of a sealing-tube, which is integrated inside the synchronous motor's air gap. This innovative cooling system enables a continuous power of 140 kW and a continuous torque of 500 Nm at 2700 rpm with e-motor dimensions no bigger than 390 mm in length and a diameter of 245 mm. Peak torque is at almost 800 Nm. "Our cooling concept optimizes heat dissipation directly at those spots inside the electric motor – in the copper windings and at the edges of the stator teeth – where most of the heat is normally generated. This makes it possible to achieve a very high continuous rating, which conventional motors cooled by a water jacket are only able to achieve temporarily," the AVL electric vehicle expert explains.

## HV BATTERY

The HV battery used for the Coup-e 800 consists of 180 lithium-ion pouch cells all connected in series. Arranged in 15 battery modules, each module controller monitors 12 cells. The battery cell capacity is 41 Ah, which corresponds to a gross energy content of almost 28 kWh at a nominal voltage of 675 V in the HV battery. Angermaier: "With a weight of 255 kg, we have



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The HV battery used for the Coup-e 800 consists of 180 lithium-ion pouch cells all connected in series.

managed to achieve a very high energy and power density while keeping the dimensions compact. This makes the battery ideal for driving a powerful sports vehicle. The vehicle range is between 115 km (NEDC) and 135 km (FTP-72)."

The battery uses an innovative, integrated cooling concept: the cells are cooled via the two cell poles (conductor cooling), a concept which makes it possible to implement efficient thermal conditioning. As no additional cooling plates are needed, very little package space is required inside the battery. Another AVL innovation, which concerns the HV battery is the applied cell connecting method, which is referred to as "clinching".

ANTON ANGERMAIER,  
Head of E-Mobility and Customer Segment,  
AVL Software and Functions GmbH.

» WE HAVE THE IN-HOUSE DEVELOPMENT CAPABILITY FOR ALL CORE COMPONENTS OF THE ELECTRIC DRIVE SYSTEM. «

This technique offers numerous benefits, such as high mechanical robustness, enhanced electrical performance compared to conventional methods as well as cost advantages in production.

## ACTIVE SHORT-CIRCUIT AVOIDANCE

The 1200-volt system in the Coup-e 800 also offers a great advantage when it comes to safety and driving dynamics in the event of failure: in conventional electric vehicles, a failure requires the activation of the so-called "active short-circuit", which yields an undesired (!) braking torque, that may cause critical driving situations. In the case of the Coup-e 800's 1200 volt system, however, this active short circuit is not needed. This is due to the fact that the motor's maximum induced voltage at maximum speed is significantly lower than the threshold voltage of the power electronics. Peripheral components like capacitors are designed in such a way that transitions between regular operation modes and safety shutdown are uncritical. This means that the motor never needs to be switched to active short circuit.



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The Coup-e 800 was one of the technological highlights at the international AVL conference "Engine & Environment" 2012 in Graz.

## EXCELLENT SIMULATION TOOLS

The Coup-e's entire electronics were developed in different AVL-locations spread all over the globe. AVL offers outstanding simulation tools, particularly suited to this task, which were applied over a range of applications in the Coup-e 800. "AVL CRUISE was employed upfront to create the entire system design; by simulating the whole vehicle it was possible to work out the component dimensions. Even the motor's power and torque characteristics were simulated. Based on these simulations, the configuration and dimensioning of all components were defined long before we even started designing the first component," Angermaier explains. Apart from battery development, tasks such as traction motor integration or power electronics development were also completely taken care of by AVL. Another of the prototype's highlights is the way the electric motor is controlled by means of power electronics. Depending on speed, load or efficiency optimization, the controller developed by AVL checks the accuracy of control up to 10,000 times a

second. "Something like this requires not only profound knowledge of the operating system's real-time behavior, but also perfect optimization of the software with respect to run time," the specialist in electric drive solutions points out.

## "OPEN" POWER CONTROL FOR CUSTOMERS

Yet the technology employed in the Coup-e 800 represents just one application for the components and technologies, which AVL has developed for full electric powertrains. "The fact that AVL has all components and technologies available in-house, means that we are also in a position to provide our customers with open development platforms for their own particular electric drive development. If a customer, for instance, wants to develop their own electric motor control system, we can provide them with AVL control electronics with an "open" software package. The OEM

or supplier can then integrate their own algorithms into this environment, for example to give the vehicle its brand-specific features," Angermaier says, describing the advantages of AVL's open power electronics control system, which is currently the only one of its kind in the market.

## COMPLETE IN-HOUSE DEVELOPMENT

With its prototype Coup-e 800, AVL demonstrates that the customer request for a powerful and sporty vehicle can also be met with an all-electric drive system. Anton Angermaier: "Due to the driving performance demanded by the customers, aiming at higher voltage levels in this class seems to be a step in the right direction. Due to the in-house development capability for all three core components of the electric drive system – electric motor, inverter and HV battery – and its control software, AVL is the ideal development partner – from system configuration by simulation all the way to series production." ←



# » SEIZING OPPORTUNITIES TOGETHER WITH OUR CUSTOMERS «

Uwe Dieter Grebe, the new Executive Vice President of the Global Business Development, Sales & International Operations in Powertrain Engineering on his plans on intensifying customer relations, the continued strengthening of AVL's market position and the new opportunities opening up as a result of the CO<sub>2</sub> emission reduction standards.

► CO<sub>2</sub> emissions reduction has been one of the most dominant topics in Uwe Dieter Grebe's career for quite some time. Before joining AVL, he held the position of "Executive Director – GME Lead Executive CO<sub>2</sub> Strategies" at General Motors Europe, where he was responsible for compliance with the future CO<sub>2</sub> fleet limits. His cross-functional activities not only covered the technical level, but also the manufacturer's strategic product planning. "At GME I worked in three different work fields with different effects in terms of time: The long-term component involved defining architecture and technology aspects of future vehicles, so that these would technically be in a position to comply with the CO<sub>2</sub> limits. In the medium term, it was important to define the portfolio. The third area concerned the control of customer behavior by means of pricing. So my job had a technical, a planning and a strategic character," Uwe Dieter Grebe said describing his work at GME in Rüsselsheim where he worked before switching over to AVL Graz this September.

Grebe's connection to AVL dates back to the time he studied at the Technical University in Darmstadt. "AVL was omnipresent at the university. Being a former executive at AVL, my doctoral thesis supervisor, Professor Dr. Günter Hohenberg, maintained very close contacts with the company, which made me familiar with the company very early on," the new AVL executive told *Focus*. Throughout his further career, he constantly remained in close contact with AVL as an engineering partner, which led Grebe to "value the company very highly." When he was offered a position of Executive Vice Pres-

ident of Global Business Development, Sales & International Operations at AVL, Grebe was delighted to accept the offer which he regarded as "fascinating". "In the development of powertrains and the entire integrated systems, engineering

Development & Sales with special focus on passenger cars, it is his task "to establish partnerships with customers and expand them further, so that new solutions can be created jointly". The important thing here is not only to anticipate technical

**» IN THE DEVELOPMENT OF POWERTRAINS AND THE ENTIRE INTEGRATED SYSTEMS, ENGINEERING PARTNERS WILL BECOME AN EXTREMELY CRITICAL FACTOR IN THE YEARS TO COME – AND THAT IS EXACTLY WHERE I SEE A BIG OPPORTUNITY FOR AVL. «**

partners will become an extremely critical factor in the years to come. The reason for this is the growing complexity and the diversity of variants in modern drive systems. All the more important, therefore, will be the role of the engineering partner – and that is exactly where I see a big opportunity for AVL. In future, we will have control over an even greater range of variants, which will make us one of the preferred partners of manufacturers," AVL's new business manager said, who describes his new task at AVL as "hugely multi-faceted."

#### **MAKING AVL A PREFERRED DEVELOPMENT PARTNER**

In AVL's Powertrain System Development (PTE) business unit, Uwe Dieter Grebe's scope of responsibility covers two key areas. In his position as manager of Business

trends for our customers – this definitely requires a technological lead on the part of AVL – but also to focus more on our customers' respective needs. Focusing on customers "means you have to be a good listener and understand their road map and overall conditions so that you can make the most of the existing opportunities together."

Grebe's second key area is International Operations, which includes most of AVL's international tech centers. In this respect, Uwe Dieter Grebe will primarily be in charge of strategic alignment as well as research & development. Technical implementation will remain the responsibility of Robert Fischer, Business Manager of Engineering and Technology, Powertrain Systems. According to Grebe, it is crucial to maintain close contact with customers "whose current needs have to be satisfied in the best way possible, while at the same time it is

## UWE DIETER GREBE

Prof. Dr.-Ing. Uwe Dieter Grebe (47) wrote his doctoral thesis in 1996 after studying General Mechanical Engineering at the TU in Darmstadt. Since 2000, he has been giving lectures at the TU Darmstadt and the TU Vienna. He was appointed honorary professor for Internal Combustion Engines at the TU Vienna in 2006.

Uwe Dieter Grebe launched his career in 1991 as development engineer in Advanced Engineering at Adam Opel AG in Rüsselsheim where he became Head Engineer for medium and large-sized four-cylinder DI gasoline engines following several career stations in serial development and DI gasoline engine construction. In 2004, Grebe joined General Motors in the U.S. where he was head of Global Powertrain Advanced Engineering and also managed the research and development activities in North America. In 2011, Grebe returned to General Motors Europe in Rüsselsheim, where he was in charge of advanced engineering activities relating to the entire vehicle for European models. In his most recent position of Executive Director – GME Lead Executive CO<sub>2</sub> Strategies – he was responsible across functions for meeting the CO<sub>2</sub> targets of the European vehicle portfolio and for the advanced engineering activities for vehicle, powertrain and manufacturing systems within GM Europe. In September 2012, Uwe Dieter Grebe took on the position of Executive Vice President of Global Business Development, Sales & International Operations in Powertrain Engineering (PTE).



necessary to be optimally prepared for the customers' future needs in order to become the preferred development partner."

## **DOMINANT TOPIC CO<sub>2</sub> REDUCTION**

Asked in what areas there was still room to maneuver for CO<sub>2</sub> reduc-

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**» WE HAVE TO LISTEN PROPERLY TO WHAT OUR CUSTOMERS ARE SAYING, SO THAT WE CAN MAKE THE MOST OF OUR OPPORTUNITIES TOGETHER. «**

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tion in advanced powertrain systems, Grebe said that the mainstream powertrain still offered great savings potential. "Both with DI gasoline and diesel engines, we will still be seeing significant improvements. And in this respect, AVL is optimally positioned in all partial aspects – from the combustion process to mechanical optimization. Added to this is the transmission which offers AVL a very big growth potential. In this respect, it is vital to develop optimal solutions all over the world, which meet the varying regional requirements."

Another big field of activity, according to Grebe, is electrifica-

tion with its vast wealth of variants – from the mild hybrid to the all-electric vehicle with or without range extender. Here, its comprehensive know-how and experience puts AVL in a position to identify the perfect solution for each of its customers very quickly. One great advantage of AVL is its ability to simulate all components and the

cal spectrum ranges from thermal management to recuperation solutions and even includes the option of giving the powertrain the ability to look ahead via driver assistance and navigation systems," Uwe Dieter Grebe explained. Unlike its competitors, AVL has a significant advantage in that it can take energy optimization measures like



way they interact in different operating modes. Even when it comes to component selection and design – all the way to serial production – AVL can provide optimal support to its customers. "In this respect, energy management in vehicles is gaining particular significance. I like to compare this with a broker on Wall Street who buys stocks as cheaply as possible to sell them off at exactly the right time. Transferred to the powertrain – and this applies both for mainstream powertrains and electrified drive systems – it is all about generating the energy "cheaply" and then using it at the right time. The techni-

these at a very early stage on the test bed under real-life conditions, which could result in a huge reduction both in development time and development costs.

Uwe Dieter Grebe: "With all measures we take to optimize energy efficiency and reduce CO<sub>2</sub> emissions, our priority is always to make the product more attractive and affordable for the customer. The CO<sub>2</sub> emission reduction standards open up many new opportunities for us, and we will use them with our customers in order to develop modern, efficient and environmentally friendly drive solutions." ←



Bruce Falls, Managing Director of AVL's California Technology Center. The CAL has constructed 47 prototype whole vehicle electric and hybrid electric vehicle builds over the past few years, bringing together different areas of expertise to create concepts for the greener vehicles of the future.



## CALIFORNIA'S VISIONS OF THE FUTURE

Bruce Falls is the Managing Director of AVL's California Technology Center, which has been at the very cutting edge of hybrid and electrification projects for the past few years. *Focus* finds out more about what they do that makes them special.

► Es It is almost five years since Bruce Falls set up the AVL California Technology Center (CAL) in Lake Forest, just south of Los Angeles near the Pacific coast. California, home to Hollywood, Silicon Valley and now many emerging green technology companies, has long been conceiving dreams and visions that have gained global influence. The CAL fits in to this visionary category.

"We started out in 2007 with a core group of engineers who had experience in alternative fuels and advanced technologies, electric vehicles and hybrid technology," he says. AVL saw the strategic importance of having a California facility to support these advanced technology initiatives.

"At the beginning the projects we were involved with were most limited to CAL resources, but now we have

fantastic multi-disciplinary teams across the company that reflect the integrated vehicle systems approach you need in order to make real progress."

The CAL has constructed 47 prototype whole vehicle electric and hybrid electric vehicle builds over the past few years, bringing together different areas of expertise to create concepts for the greener vehicles of the future.

"We're actually completely dedicated to seeing cleaner transport because we think that it benefits everyone," says Falls, "and it's good that the industry has been attempting to catch up with AVL's pioneering efforts, because it shows that something of a consensus is emerging over the fact that hybrids and electrification are the future for the automotive industry as a whole."

California is notorious for its tough emissions legislation and Falls says that this is one of the things that makes it such a good testing ground for other regulatory regimes around the world.

"California sets the highest bar for emissions in the US and one of the highest in the world," he says, "and because the state wants to minimize the impact that vehicles have on the environment that gives us an opportunity to make sure that we're completely on top of our game here. And if we know we're getting it right here, we know it'll work elsewhere. In Detroit and perhaps the rest of the world California is sometimes viewed as a regulatory problem, but I think that we need an attitude adjustment on this – tough regulation can be good for the industry." ←

Anniversary Conference "Engine & Environment" 2013

# THE CONNECTED POWERTRAIN

**INTERACTION OF MECHANICS & SOFTWARE, VEHICLE, DRIVER AND THE ENVIRONMENT**

The 25<sup>th</sup> AVL „Engine & Environment“ congress will take place in the Helmut-List-Halle in Graz on the 5<sup>th</sup> and 6<sup>th</sup> of September, 2013. The congress will be dedicated to modern powertrain concepts in the context of increasing connectivity.

► Connectivity is a key topic for the future in many spheres, and this is also true for automotive technology. The vehicle of tomorrow will communicate with the environment, making efficient, accident-free and perhaps even autonomous driving possible.

The powertrains of tomorrow's vehicles will also be connected; not only will they communicate with the environment (e.g. the driver, other vehicles, and the road infrastructure), but also the connectivity and optimized interaction of all powertrain sub-systems such as the engine, transmission, e-machine, battery and various control systems will become increasingly important. The developers of future powertrains need to answer



Demonstrator vehicles with pioneering AVL technologies at the 2012 conference "Engine & Environment".

Below: Scan QR code and access the app.



a multitude of questions: how should the powertrain be configured to optimally make use of the plethora of data available within the powertrain and also take full advantage of the additional data originating externally? How can vehicle operation with low emissions and optimized fuel consumption be enabled and further enhanced? What form will the sub-systems in future connected powertrains take, and how can they be optimized? How can drivability and operational comfort be optimized in order to guarantee customer acceptance?

These and many more questions will be examined by international experts. Information, registration and app-download at: [www.avl.com/engine-environment-2013](http://www.avl.com/engine-environment-2013); [event@avl.com](mailto:event@avl.com) ←

## 7<sup>TH</sup> AVL INT. COMMERCIAL POWERTRAIN CONFERENCE 2013

► The 7<sup>th</sup> AVL International Commercial Powertrain Conference will be held on May 22/23, 2013 at the Helmut-List-Halle in Graz, Austria. The conference is globally unique and focuses jointly on heavy-duty vehicles, agricultural tractors and construction equipment. It is an important information platform and an attractive forum for the exchange on topics relating to strategies and technologies. The 2013 ICPC

conference is entirely dedicated to CO<sub>2</sub> reduction. As a result, the scope of topics addressed is very broad: market trends, combustion engine optimization with hybrid drive systems, waste heat recovery systems, auxiliary power units, transportation logistics, driver assistance systems and active powertrain control considering the current driving situ-

ation, future transmission technologies, electrification of drive systems and farm implements in agricultural machinery, increases in efficiency in construction equipment by system optimization with new powertrain solutions and many more.

Information and registration at [www.avl.com/icpc](http://www.avl.com/icpc) ←





# THE TOP ADDRESS FOR HIGHTECH EXHAUST EMISSION AND PARTICULATE MEASUREMENT

Increasingly stringent emission standards, new drive concepts as well as the demand for fuel-efficient vehicles with low CO<sub>2</sub> emissions are some of the major challenges engine and vehicle developers have to face these days. AVL, with its exhaust emission and particulate measurement systems, offers high-tech solutions for R&D as well as for certification tasks for all current exhaust emission legislations worldwide.

► AVL is the preferred partner in the automotive industry, with 40 years of experience in exhaust emission measurement. The business unit AVL Emission Test Systems GmbH (AVL ETS) has locations for production and development in Neuss,

Gaggenau, Graz and Plymouth (US). With the iGeneration product family, launched in 2007, AVL ETS has set new standards in exhaust emission measurement technology and can currently offer the most advanced high-tech products on the market.

”The emission measurement technology is driven by two main forces: On the one hand, the legislation with increasingly stringent emission standards and increasingly complex testing procedures and, on the other hand, the demand for more fuel-efficient vehicles and engines and con-



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AVL measuring devices can be optimally integrated in the testbed environment (Picture: the modular AVL Smart Sampler for gravimetric particle measurement)

sequently lower CO<sub>2</sub> emissions”, says Uwe Krummenöhler, managing director of AVL ETS. “In the developing process of these new drive solutions we closely cooperate with our customers and go to the physical limits of measurement technology in order to be able to provide measurement devices and systems that can meet these development objectives. A major advantage of AVL is that we have a large powertrain engineering area within the company. So we know exactly which new measurement systems and technologies are required by the developers. In addition, we immediately receive feedback from our colleagues from the field – which is globally unique“.

The international clientele of AVL exhaust emission test systems is very varied: “Our customers include



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AVL ETS managing director Uwe Krummenöhler (2nd left) and his management team

all developers of internal combustion engines, which are subject to the according regulations - large marine diesel, truck and car engines or small combustion engines in a chainsaw or in a leaf blower for which emission standards have been introduced recently too. In addition, many renowned institutions and agencies such as

the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), the TÜV and many others belong to our customers,” says Uwe Krummenöhler.

## SUCCESS PRODUCT iGENERATION

With the iGeneration AVL provides the most advanced exhaust emission measurement systems for engine and chassis dynamometer testbeds. The AVL high-tech gas analyzers in combination with the new gas preparation unit provide accurate results, reliability and faster response times. The intuitive software platform iGEM offers, in addition to a common operation and user interface, unique interactive and graphical diagnostic functions, network capa-



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Efficient development and certification with AVL emission measurement systems for chassis dynamometer testbeds.

bility as well as plug & play functionalities. But not only the software provides a common look & feel, also the AVL iGeneration hardware has a common concept. All modules and components are based on the same “family-platform”, offering considerable advantages for maintenance and services. With this concept AVL can guarantee a maximum availability of the iGeneration devices. All together customers can save up to 30 percent on total cost of ownership with iGeneration products.

The iGeneration “Flagship” is the exhaust measurement system AMA i60. “This system, which is fitted with analyzers for each individual gas component, is ideally suited – besides various development tasks – for certification of combustion engines in order to meet current and future emission regulations in Europe, the US and Japan,” says Kurt Engeljehring, business development manager for Emission Test Systems.

“Our newest member of the iGeneration family is the multi-compo-

nent exhaust measurement system SESAM i60 FT. With this device up to 30 different gas components can be measured within one analyzer. The SESAM i60 FT is most suitable for the application of engines and complex exhaust aftertreatment systems. In addition to this comprehensive performance range as development tool, the multi-component analyzer can be also used for legal certification of some components,” states Engeljehring.

## PARTICLE MEASUREMENT

AVL is the leader not only in gaseous exhaust emission measurement, but also in the particle measurement technology. With the products Smoke Meter and Opacimeter AVL has set a new industry standard worldwide. Based on the success and the know-how of AVL a whole product family around particulate measurement has been developed. Besides the devices for particle mass measurement, AVL additionally provides the AVL Par-

ticle Counter, a high-tech device for particulate counting. “Due to the increasingly stringent legislation – also in terms of the number of particles – the demand for such solutions is very high: Today AVL’s engine and chassis dyno testbeds are virtually always delivered with particle measurement technology. One advantage is the possible integration of the AVL Particle Counter into the analytics cabinets – even in the case of retrofitting – thus saving valuable floor space in the test cell. Due to the common software iGEM Engine/iGEM Vehicle also the system integration is very quick and easy”, says the emission expert. The AVL equipment for particle mass measurement and particulate counting are of course also available as stand-alone devices.



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Newest member of the AVL iGeneration: The multi-component exhaust measurement system SESAM i60 FT

Another significant advantage is that the AVL Particle Counter can be calibrated professionally and conforming to the law in the newly established AVL service and calibration centers in Graz and Detroit. In these centers the devices are tested and validated.

If the measured values lie within the tolerance, a certificate is issued approving the accuracy. In case of deviation an adjustment (UN-ECE R83 calibration) is required. As part of the calibration services the AVL Particle Counter undergoes maintenance procedures and will be automatically updated to the latest technology standard - at no extra costs for the customer.

## ON-BOARD EMISSION MEASUREMENT

Primarily due to the legislation regarding the "in-use conformity" for commercial vehicles, in force in the US since 2007, the market sees a great demand for mobile emission testing devices. 2013 this legislation will also come into force in Europe for heavy duty applications. AVL offers with the M.O.V.E. PEMS series (Portable Emission Measurement System), which is part of the M.O.V.E. platform for portable measurement technology, a modern system for gaseous emission and particle mass measurement, providing customers with highly accurate results. In addition, the devices are characterized by low power consumption and are "built for the road". Another great benefit is the consistency between all AVL emission test systems, which substantially simplifies the development process and consequently contributes significantly to an improved efficiency.

## EXCELLENT EMISSION EXPERTISE

"With the active participation of the AVL emission experts in many boards in which the methods for emission measurement are adopted, AVL is intensely involved already in the early legislation phase - so we know exactly what the le-

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Picture right: The AVL M.O.V.E PEMS series is a modern portable system for on-board emission measurement

Picture bottom left: The common AVL iGEM software allows easy system integration and provides an intuitive user interface.

Picture bottom right: The AVL Particle Counter is available as stand-alone device or can be integrated in existing systems.



gislators are planning worldwide," explains Kurt Engeljehring. "In addition to this legislative knowledge we also have detailed knowledge of current and upcoming technologies due to our own engine and powertrain development within AVL. This combined knowledge of AVL - which is globally unique - is reflected in our measurement systems. Our customers use the systems a decade or more - for this long period of time a reliable partner is needed, who knows about all future developments and can provide long-term support. AVL measurement devices guarantee a secure investment for the future.

This security of investment is also emphasized by the managing director of AVL ETS Uwe Krummenöhler: "Due to our own engine and powertrain development within AVL, we can identify technology trends in advance and can derive the impacts on the necessary developing tools. This enables us to provide improved measurement devices already in a very early stage and consequently offer our customers a competitive advantage and an early start with their product development. AVL emission measurement systems can provide future technologies already today. Our customers can rely on the highest security of investment and on a partner who proactively and reliably accompanies their projects." ←

# » RACING VICTORIES IN FORMULA ONE AND LE MANS NOW REQUIRE HYBRID «



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Peter Schöggli, Head of Business Field Racing, on the growing significance of electrification in motor racing, the wide-ranging AVL racing expertise and AVL's role in creating the new FIA Formula E championship powered by electric energy.

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► **«F»:** For the first time ever, a hybrid racing car won the 24 Hours of Le Mans race in June 2012. Has this victory marked the opening of a new era in motor racing?

«Schöggel»: In Formula One, it has barely been possible to win races without a good hybrid KERS (kinetic energy recovery system) for the last two years. In the Le Mans Prototype Series (LMP), they did introduce the regulation that allows hybrid drives a little later, but it grants a much higher level of freedom, too. It is quite clear that the regulations in both racing series deliberately favor hybrid drives.

**«F»:** What are the differences between the regulations of the two racing series where you need a hybrid to win?

«Schöggel»: The regulations do have some fundamental differences. The Formula One regulations specify that the hybrid energy boost is limited to 400 kilojoules per lap. The maximum hybrid power output is limited to 60 kW. Depending on the racing track, this achieves an improvement in lap time of up to 0.5 seconds. The Le Mans regulations grant much greater freedom and merely limit the amount of energy that can be transmitted between two braking phases to 500 kJ. So if you have around ten braking phases in Le Mans, you have even more energy you can use. Apart from that, the LMP Regulations allow you to have an electric drive on the front and rear axle. The higher energy, the non-limited output and the electrical



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The AVL Vehicle Simulation Model (VSM) is used successfully by many racing teams.

four-wheel drive achieve much better lap times than can be achieved in the Formula One. Of course there are drawbacks though too, such as

**» THE NEW  
FORMULA ONE  
REGULATIONS  
OPEN UP NEW  
POSSIBILITIES TO  
GENERATE, STORE  
AND DISTRIBUTE  
ENERGY. «**

higher weight and increased cooling requirements.

**«F»:** What kinds of hybrid technologies were used in Le Mans?

«Schöggel»: The variety of technologies applied was surprisingly broad. Audi stores energy mechanically in the fast spinning rotor of an electric machine that works both as a generator and motor. Toyota, on the other hand, stores energy purely electrically in capacitors, so-called supercaps. Both storage systems are connected electrically to the electric motors, which are connected to the wheels. Audi drives the front axle, whereas Toyota drives the rear axle.

**«F»:** With the new regulations, hybrid drive will be playing a much greater role in the Formula One too. What will change in 2014?

«Schöggel»: The maximum amount of energy that can be used per lap will increase tenfold from 400 kJ to 4 MJ per lap. The electric power will double to 120 kW. Depending on the racing track, this will help hybrid drives improve lap times by considerably more

than one second. The hybrid system is becoming part of a very complex energy system with totally new components. From the 2014 season onward, the 1.6-liter turbocharged V6 engine may be linked to a motor/generator. On the one hand, the electric motor can be used to rapidly spin up the turbo and minimize the turbo lag and, on the other, it can be operated as a generator, allowing extra electrical energy to be generated. If not stored immediately, this energy can be converted unlimitedly into propulsion force. It becomes obvious that we are dealing with a very complex way of handling energy in order to make optimum use of a multitude of energy flows. We at AVL Racing have been working very hard on this kind of energy management system in simulations for some time now. The high temperatures generated and the turbocharger's high rotational speeds pose a high challenge.

**«F»: Could you give us a more detailed description of the simulations AVL Racing is working on for the Formula One?**

«Schöggel»: The new Formula One Regulations open up new possibilities to generate, store and distribute energy – and with our simulations, we are able to determine the optimal variant. We additionally simulate the optimal racing strategy, which results from the new hybrid drive. In short, it's all about how to put the energy to optimum use to win the energy battle. We consider all components – engine, battery, electric motor as well as the very complicated control strategies. Even the new electric system linked to the turbocharger has already been integrated into our simulations.

**«F»: Which simulation program is being used for this at AVL?**

«Schöggel»: We use the AVL product AVL VSM (Vehicle Simulation Model). This development tool is being used very successfully by many racing teams, and it plays a leading role in several racing series already. To remain “best of class”, the racing simulation is continuously adapted to the new regulations. New tire types are just as carefully integrated as new turbo engines are, or various hybrid components. Unique is its use on PCs, on AVL test beds and on driver simulators.



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This is how purely electrically driven racecars with variable aerodynamics could look in the future.

**«F»: Is the AVL racing simulation VSM a development tool, or is it also utilized on racing tracks?**

«Schöggel»: Both. There are several processes in which AVL VSM is used. A process starts several weeks ahead of the race. Teams simulate virtually thousands of laps on high-performance computers, optimizing virtually the vehicle settings – chassis, gear ratio, wing position, etc. The racing strategy can also be simulated, such as, for example, the optimal energy utilization in a hybrid system I mentioned earlier: Where should the driver

boost energy – at the end of a straight or from inside a curve? On the racing track, AVL VSM is used to optimize the simulation using current data from the racing car. Racing track data – such as grip conditions – are incorporated into the simulation just as carefully as weather data to optimize the racing strategy. These data are often transferred back to the factory, too, where they are utilized. The third large application area of AVL VSM is on the engine and powertrain test bed.

**«F»: How does the AVL racing simulation program cooperate with the different test beds? And how does the racing team benefit from it?**

«Schöggel»: At the AVL test bed, the VSM simulation is fully integrated into the AVL PUMA test bed software, which enables maximum real-time performance. The high-precision simulation of vehicle, driver and racing track allow the unit under test (an engine or a transmission) to be tested or optimized under realistic conditions. In other words, the engine virtually leaps over curbs. This realistic environment simulation and its exact reproducibility provide the basis for improved performance and service life of the components and the entire vehicle.

**«F»: A German trade journal reported that AVL took part in creating a future fully electric racing series. Could you give us some more details?**

«Schöggel»: The racing series mentioned is the Formula E, which is organized subject to the rules of the FIA. The first races will be taking place in 2013 with larger cities being the potential venues for events. A full racing series is planned for 2014. Commissioned by

FIA President Jean Todt, AVL had the pleasure of making an essential contribution to this new electric racing series.

«F»: Please tell us what role AVL had in the creation of the Formula E regulations.

«Schöggel»: In a team together with the responsible people from the FIA we practically started out with a blank piece of paper. The FIA's goal was to impose as few restrictions as possible in the Formula E regulations in order to expedite future innovation in electric drives – particularly where energy storage and electric drives were concerned. To make the Formula E Championship attractive to spectators, the electric racing cars will achieve top speeds close to what we are used to in the Formula 1 (exceeding 300 km/h); lap times are expected to be faster than those in the Formula 3. Based on these FIA requirements, we carried out some comprehensive simulations of a number of possible vehicle configurations. Due to the expected development costs and safety considerations, the tests very soon delivered certain basic values.

«F»: How is the still rather low energy content of batteries compensated for in the new Formula Electric?

«Schöggel»: For technical reasons, to achieve the energy content of one kilogram of gas, it still takes a battery weighing roughly 80 kg. With one kilogram of gas this does not sound all that bad. But 10 kg of fuel would mean an 800-kg battery. To compensate for the storage system's low energy density, a totally new and highly innovative aerodynamic system with freely adjustable wings was designed, especially for the Formula E. "Driving on a straight line, the wings can be al-

tered, making them as flat as required, while in curves they are adjusted to a steeper angle to create more surface pressure. This generates energy savings of up to 40 percent – with the same lap time and a maximum speed which is up to 35 km/h higher. There



» COMMISSIONED  
BY JEAN TODT,  
AVL MADE AN  
ESSENTIAL  
CONTRIBUTION  
TO THE NEW  
ELECTRIC RACING  
SERIES. «

will also be innovation where battery recharging is concerned: The charging process has to take place inside the pits between two races within a

certain period of time – here, too, the new Formula Electric gives suppliers the attractive opportunity to develop new technologies and present them to a broad public.

«F»: Will in the near future the new technologies developed for the Formula E be used in series vehicles too?

«Schöggel»: One of the FIA's objectives is to use the new Formula Electric to boost the further development of electric drive systems and electric storage systems. An example for this is that the battery must not weigh more than 300 kg. Otherwise it can be designed freely. Here too, the intention is to offer suppliers a kind of playground, where they can present and try out their new technologies. The technologies developed for the Formula E will not immediately be found in a serial vehicle, as they are technologies in an advance development stage, which will still require four to five years of development before they are ready for series production.

«F»: Drawing on its comprehensive electrification know-how, is AVL in a position to develop the powertrain of an electric racing car or even an entire vehicle?

«Schöggel»: We naturally offer our customers and their engineers to work with us in a team, so that we can bundle our capabilities in the areas powertrain development, storage technology and vehicle engineering with the aim to develop the future winning car – from simulation and design all the way to the production of the racing car. ←

# WASTE HEAT RECOVERY IMPROVING COMMERCIAL VEHICLE FUEL EFFICIENCY

Reduction of fuel consumption for commercial powertrains has always been a high priority. Consequently, traditional optimization potentials like combustion system optimization or friction reduction seem to be mostly exhausted. However, a new opening seems to be the recovery of waste heat.

► From the various possibilities of waste heat recovery investigated by AVL, the Rankine cycle has been selected as the likely solution for commercial vehicle applications. After intensive simulation and concept evaluations AVL demonstrated the real world fuel saving potential of such a WHR system on a HD truck engine meeting Euro VI emissions norms. The system tested included one evaporator replacing the EGR cooler and a second evaporator in

After comprehensive evaluations, both, water and ethanol were used as working fluids. In order to fully exploit the potential of the WHR system under real world conditions the development also included a WHR control system for the transient control of the entire system. This was calibrated to achieve the highest efficiency gain in the system, as well as to manage appropriate system durability under transient operation. A key part of the developed closed-



→ It has been demonstrated that a WHR system can deliver a fuel efficiency improvement of more than 5 percent can be.

the exhaust system, downstream of the aftertreatment system. A piston expander was selected allowing flexible operation with regard to choice of working fluid and waste heat sources.

loop model based functionality are virtual sensors (models) controlling the mass flow for the EGR and exhaust steam generators. The developed control software can be applied independently from the selected



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Heimo Schreier, Product Manager  
Commercial Powertrain Systems

working fluid as well as the chosen hardware. It has been demonstrated that a fuel efficiency improvement of more than 5% can be realized by applying such a WHR system. This was possible even on a highly optimized commercial vehicle engine. Consequently it can be assumed that this technology will be applied by OEMs to further improve fuel efficiency respectively to further reduce Total Cost of Ownership for the end customer.

The WHR technology can be applied for both, on-road as well as off-road applications. However, the achievable efficiency gains will depend on the individual load cycle of the application, whereas cycles with a high load factor will provide the highest potential.

Based on the results achieved, AVL is continuing to industrialize the WHR system for commercial engines and to develop the technology towards series production implementation. ←

Operating strategy, driveability, driving range and service life of the battery: when electrified drives are calibrated, all of these features have to be optimized and co-ordinated with one another in the best way possible. A new method developed by AVL now helps to perform calibration tasks much faster and more efficiently – even with all-electric vehicles.

## EFFICIENT E-VEHICLE CALIBRATION

► AVL performs calibrations for conventional powertrains and hybrid drives – but also for all-electric drive solutions, which, in future, will increasingly be put to use in urban transport. As electric vehicles (unlike hybrids) only have one drive motor, Focus asked Gerhard Kokalj, Head of Transmission and Hybrid Calibration, whether he thought that calibrating electric vehicles (EV) was less trouble than calibrating hybrids. “Basically, it is,” said Kokalj. “But in this case, we face many new challenges, the biggest of which is probably the battery range and service life. By taking a new approach, we are trying to make better use of the battery’s energy. The fundamental idea is to temporarily leave the ideal charge range behind in order to temporarily increase its range without damaging the battery in the process. An intelligent operating strategy, which would also process, say, geographical data about the conditions ahead supplied by a satnav has a key role. What is special about our approach is that we at AVL develop the entire strategy within a testing environment – from the simulation on a battery test bed to the vehicle test on a dynamometer in a virtual vehicle environment”.

Another important field is diagnostics calibration which is done to ensure the electric vehicle’s safety and reliability. “Where this is concerned, the entire vehicle is automatically tested in its different driving modes on the dynamometer (speci-



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AVL is improving battery range and service life.

fically the parameters SOC, SOH, electric moment, battery temperature, etc.). The data are then fed into AVL fOX, a special tool for this purpose. Based on these data, the calibrator can then ensure offline that e.g. the bounds of the plausibility corridor for electric moment are not exceeded. Unlike conventional calibration in the vehicle, this can be accomplished much more efficiently and faster than before.”



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Gerhard Kokalj, Head of Transmission and Hybrid Calibration

Calibrators carry out electric vehicle driveability calibrations using HyHab, a methodology developed by AVL. With this new method, which is also applied in hybrid vehicles, the automatic execution of tests on the test bed is combined with offline calibration. This can also give the electric vehicle a very specific character: “By means of filtering, we can attenuate the moment of the electric motor or else achieve a clearly noticeable acceleration. This can give electric vehicles very individual characteristics, spanning from an exceptionally comfortable to a very sporty driving behavior. This aspect is becoming more and more important, as manufacturers want to be able to give future electric vehicles a brand-specific character,” Kokalj concluded. ←



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A great honor for AVL Racing: at the ADAC Formel Masters race at the Lausitzring in Germany, AVL engineer Georg Knoll (right in picture) received the winner's trophy on behalf of the Motopark team. Georg Knoll has been driver Jeffrey Schmidt's race engineer in 2012.

## JOINT VENTURE WITH SET POWER SYSTEMS



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Joint venture in Allgäu: AVL CEO Helmut List with Horst Hammerer, CEO of SET Power Systems GmbH.

► In Wangen, Allgäu (Germany), AVL has acquired the majority stake in the joint venture of SET Power Systems GmbH. This will provide synergies in the areas power electronics, embedded systems and electric motor models. AVL CEO Helmut List: "By combining their profound experience and capabilities, the teams of both AVL and SET Power Systems

put us in a position to drive forward advanced technology solutions for customers all over the world." Horst Hammerer, CEO of SET Power Systems GmbH: "Where electric motor emulation is concerned, we have managed to achieve a clear developmental edge. By teaming up with AVL, it will become possible to extend this lead even further. We are delighted to be part of the AVL Group." ←

## FIRST INTERNATIONAL EXHAUST GAS AND PARTICULATE EMISSIONS FORUM IN CHINA

► The ever more stringent global emissions legislation presents huge challenges for the automotive industry. Many conferences currently focus on this topic – as does the well-established Exhaust Gas and Particulate Emissions Forum. "Up to now, all the good conferences for professionals have been held in Europe. China, however, the world's largest selling market for cars, was never included. But, obviously, who else was to close

this gap if not AVL?," Zhang Hong, Business Manager at AVL China, told *Focus* with a chuckle. And that is how the idea was conceived to bring the AVL Emissions Forum from Germany to China.

"It takes a powerful partner to be successful right from the start with an event like that. A short while ago, AVL signed an agreement on strategic cooperation with CATARC, China's leading automotive technology and



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Experts from all over the world came to the first AVL Particulate Emissions Forum in Shanghai where they exhibited great interest in the presented papers and the testing equipment showcased by AVL.

research center. So we had the partner we needed," Mario Walenta, Managing Director, explained. As a result, an extraordinary conference program with speakers from state authorities, as well as international experts, drew almost 300 participants to Shanghai on October 18 and 19, 2012. "←

## DECORATION OF HONOR IN GOLD FOR DON MANVEL



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Thomas Schnöll, Consul General in Chicago, honored Don Manvel (f. l. t. r.)

In recognition of his meritorious services, Don Manvel, CEO of AVL North America, was recently awarded the "Decoration of Honor in Gold" conferred by the Republic of Austria. The decoration ceremony that took place in Detroit was attended by Christian Buchmann, Member of the Styrian Government, Kathryn List and others who congratulated Don Manvel on his award. Don Manvel has been successfully helping to bring innovative top technologies on the market for more than 25 years – ten of which for AVL. He additionally backs programs and initiatives that inspire young people, such as the robot competition for pupils and the "A World in Motion" program for students, as well as Austrian initiatives in the US such as the network of Austrian scientists in North America. Activities like these are responsible for the fact that Don Manvel enjoys an excellent reputation in business circles, both in Austria and in North America.

## AVL EMISSION TEST SYSTEMS GMBH AWARDED TWO STEVIES®

► In the categories "Best New Product of the Year" and "Management Team of the Year", AVL Emission Test Systems GmbH was recently presented with the Bronze Stevie® Award. The Stevie® Award is one of the most renowned international prizes awarded in the world of business. "By participating in the International Business Awards 2012, our achievements were benchmarked against major international competitors for the first time. We are very proud to have received awards in not one but two categories. The trophies "Management Team of the Year" and "Best New Product of the Year"



for our AVL SESAM i60 FT put us in an excellent position for global competition," Uwe Krummenöhler (right in picture), Manager of AVL Emission Test Systems GmbH, said who was present to receive the awards at the gala event in Seoul, South Korea. <

## BAVARIAN STATE PRIZE FOR ELECTRIC MOBILITY GOES TO AVL COUP-E 800



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The all-electric high performance demonstrator vehicle Coup-e 800

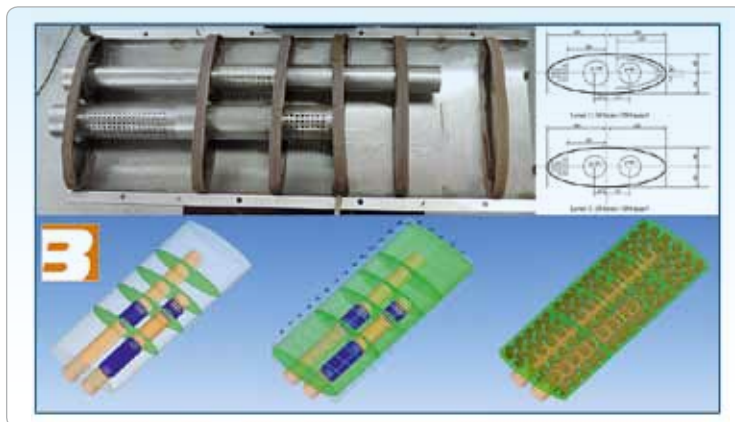
► To speed up innovative developments in electric mobility, the eCarTec Award – the Bavarian State Prize for Electric Mobility – was awarded in eight categories on the occasion of the eCarTec 2012, the international leading trade fair for electric and hybrid mobility in Munich. AVL Software and Functions GmbH



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Awarded: M. Schlecker, W. Schelter, M. Deiml, A. Engstle and A. Angermaier (f. l. t. r.).

was delighted to win the prize with its Coup-e 800 in the category "Drive Technology, System Electrics, Testing Systems". The company has been an AVL software and function development location since 2008. AVL also does research in innovative engine and drive engineering solutions at this location. (see also p. 8–11) <

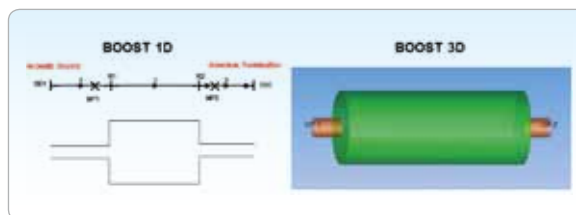
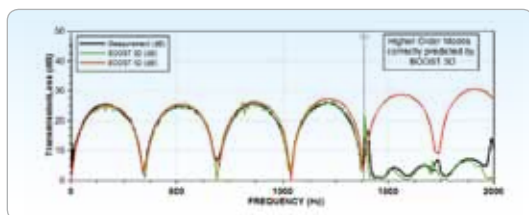


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The modelling is a 3-stage process:  
Geometry definition, mesh specification  
and network generation.

## AVL BOOST 3D MODELER

The new AVL BOOST enables highly accurate 3D Modeling.



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The clear advantage of BOOST 3D: more accurate results at higher frequencies as the higher order modes are well predicted.

► The acoustic simulation of internal combustion engine exhaust systems is an important aspect in early development phases to meet customer expectations as well as the increasingly stringent legislation targets.

In order to calculate the duct acoustics of intake and exhaust systems AVL BOOST offers the following simulation methods: a frequency domain solution for the quick calculation of pre-dimensioning possible without engine data and a time domain solution for the detailed design of the overall system.

For the detailed examination of single components, such as exhaust mufflers, the calculation model has now been enhanced by the advanced “BOOST 3D Modeler”. In an integrated 3D Sketcher, the user generates the geometry, which subsequently is automatically linked with a network of 3D cells. The user does not require prior knowledge of how a system acts acoustically. The direct CAD-import will be supported by the next program version. The main focus of this technology has been for exhaust mufflers but it can also be applied to other

common gas exchange components, e. g. air cleaners.

The modeling of single components in the BOOST model is not only limited to acoustics but can also be used to illustrate 3D effects for charge-cycle calculations. It should be noted that a single BOOST model can be used for both applications.

The BOOST 3D Modeler thus precisely takes into account 3D effects for complex flow components during simulation for the acoustic optimization of the entire intake and exhaust system and for the simulation of charge-cycles in the engine.

# AMA i60 EXHAUST MEASUREMENT SYSTEM

## THE FLAGSHIP OF THE AVL iGENERATION

► A modern exhaust measurement system needs to cope with various requirements. From a legal perspective the system has to handle current and future emission standards such as EPA 40 CFR Part 1065/1066, Heavy Duty Euro VI and Light Duty Euro 6. From a technical aspect it is important to take a close look at additional exhaust gas components ( $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_2$ , etc.) as well as consider the increased use of alternative fuels. The business perspective focuses on the reduction of testing time with faster analyzing methods and significant lower costs of ownership.

The AMA i60 exhaust measurement system has been developed under these specific aspects and has been optimized in every detail in order to perfectly meet the various requirements. In combination with different sampling systems, the AMA i60 is ideally suited for the development and certification of combustion engines in accordance with all global exhaust emission regulations.

The system is characterized by new gas analyzers with faster response times (up to 40 percent in comparison to other systems on the market), optimized gas paths and a compact, modular design. The flexible system allows for easy retrofitting - for example of further analyzer channels or entire streams. In addition, all modules are easily accessible from the front for maintenance and ser-



vice tasks. The time required for maintenance has been reduced by about 25 percent compared to the previous model.

All gas lines and valve manifolds have been improved in terms of minimal gas consumption, which has been reduced by up to 30 percent in comparison to other systems on the market. Due to improved measurement accuracy and repeatability excellent measurement results are achieved. The innovative CLD i60 analyzers meet the strict quenching guidelines of EPA 40 CFR part 1065, hence representing cutting-edge technology in this field.

The intuitive, interactive graphical user interface iGEM is the platform for all iGeneration systems. Due to this common concept the user can easily navigate through all systems and operating errors are minimized. With individual interactive flow diagrams of the system and of all components directly displayed on the user interface, the AMA i60 has set the industry standard.

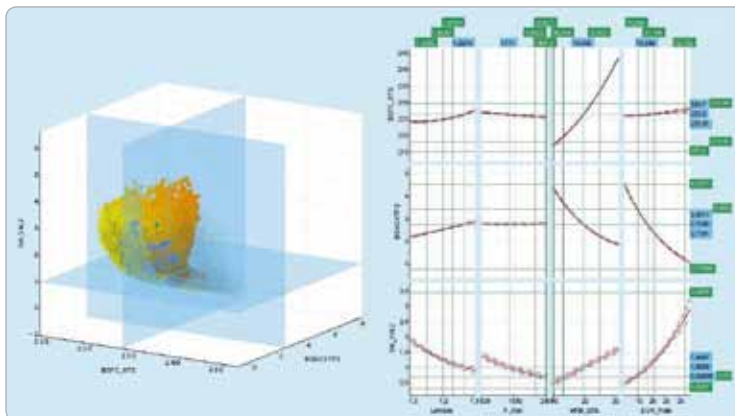
All major diagnostic functions are supported by the device software iGEM AMA and can be automated through an integrated scheduler function. Furthermore, pending maintenance intervals can be displayed on time, avoiding service interruption. A special feature is the intelligent error handling of the system, which provides solutions for fast elimination of operation errors. If further help is required, the complete trouble shooting down to the sensor and valve level can be carried out by remote diagnosis, minimizing down times.

For the conventional exhaust gas analysis the AMA i60 can be individually adapted to the corresponding measurement applications (diluted/undiluted exhaust or gasoline/diesel/ $\text{H}_2$ /etc). Special versions and mobile remote- or stand-alone-units with an optimized system design are offered e.g. for SULEV, EGR and SCR applications ( $\text{NH}_3$ ) as well as for marine diesel ( $\text{SO}_2$ ). Moreover, the combined exhaust gas measurement and dilution system AMA i60 COMBI for small engines and motorcycles is available.

Therefore, more and more users confirm that the combination of high measurement accuracy, easy operation and optimized total costs of ownership makes the AMA i60 the first choice in modern exhaust emission measurement. ←

# AVL CAMEO™ — THE KEY FOR EFFICIENT POWERTRAIN CALIBRATION

The world leader in testbed systems also leads the pack in model-based calibration in the office.



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CAMEO Office offers a quick overview of all optimization possibilities.

► Calibration has long since established itself as a decisive factor in the field of modern powertrain engineering. The extreme complexity of the calibration task, due to the range of powertrain variants or legal requirements, can no longer be managed by conventional means. With CAMEO, AVL avails itself of the world-leading software that universally reflects the complete powertrain calibration process and thus provides considerable support for efficient calibration.

Apart from the normal online calibration, that is the automated execution of test procedures directly on a test bed, the calibration process steps in the office environment are becoming increasingly important. This is where CAMEO Office, as a part of the CAMEO toolchain, comes into its own. The software guides the user

step-by-step to his required results.

The calibration effort is minimized thanks to the use of model generation on the basis of DoE methods (Design of Experiments), model optimization and rapid calculation of control tables and maps, leading to reliable results. Calibration engineers no longer have to rely only on their instincts, but obtain certainty due to statistically sound data. The effort of calibration can be reduced by up to 80 percent compared to conventional methods. Calibration targets such as fuel consumption while remaining within legislative emissions limits can be reliably reached for all operating states of the vehicle.

Thanks to continuous further development and extension of the tools – in conjunction with notable automotive manufacturing clients –

CAMEO has evolved into a well-established, industrial solution, that supports clients in their daily work. This shows that the courageous decision of AVL, who started to work intensively on the subject of calibra-



tion in the 1990s, has proved itself today to be sustainable and correct.

Whoever wants to achieve extremely good calibration results, needs extremely fast and reliable tools – tools such as AVL CAMEO. ([www.avl.com/comeo](http://www.avl.com/comeo)). ←

# AN IDEAL BASIS FOR COLLABORATION

With its Integrated & Open Development Platform, AVL has created a consistent and open solution that contributes significantly towards increased efficiency in development and testing processes.

► “One central aim of the AVL Integrated & Open Development Platform is to provide our customers with software solutions offering data and process consistency throughout the entire development and testing process – from simulation over test bed testing all the way to road tests. Similarly, we will make the user experience and the way users interact with the software as uniform and as simple as possible,” Herwig Schelch, Head of ITS Integration Software Products in AVL Instrumentation and Test Systems, explained. “This ‘collaboration platform’, which is also what we call it, will give us a fast and straightforward way to exchange contents between different devices, test environments and content management systems. These contents may take on many different forms such as simulation models, testing methods and results, configurations, workflows, etc. They may even be supplied by our customers or third party vendors – hence the ‘Open’ in the product name.”

A crucial benefit of the consistency is that simulation models can also be used ‘in the loop’. Already today AVL CRUISE powertrain models, for example, can be used on the AVL Virtual Vehicle engine test bed where, for example, the behavior of a dual-mass flywheel is then simulated under true-to-life conditions. This supports the strategy of shifting tests from the road to the test bed in order to save development time and costs.

**» THIS ‘COLLABORATION PLATFORM’ GIVES US A FAST AND STRAIGHTFORWARD WAY TO EXCHANGE CONTENTS BETWEEN DIFFERENT DEVICES, TEST ENVIRONMENTS AND CONTENT MANAGEMENT SYSTEMS. «**



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Herwig Schelch, Head of ITS Integration Software Products in AVL Instrumentation and Test Systems

The consistency offered by the AVL platform also leads to significantly increased efficiency in calibration work. A solution to meet the challenges presented by the steep rise in the number of vehicle and power-

train variants is to distribute calibration tasks among different development environments (office, hardware in the loop, engine or powertrain test bed, chassis dynamometer or road). Adapted software tools, such as those offered by AVL, create the conditions for smooth collaboration across the entire process.

Even where exhaust gas emission measurement is concerned, consistency between different testing environments has a number of advantages. Tests that are normally performed on a chassis dynamometer can now also be run on an powertrain- or engine test bed, thanks to simple and fast methodology transfer.

“The Integrated & Open Development Platform is being expanded further. In future, it will be capable of integrating all AVL software products available. All of AVL’s business units – Simulation (AST), Engineering (PTE) as well as Instrumentation and Test Systems (ITS) – are working very closely together on this matter. At ITS, the software producing units have been integrated into a business area of its own (‘ITS-I Integration Software Products’) in order to strengthen and intensify the activities,” Herwig Schelch told *Focus*. “Right now our customers are already benefiting considerably from the noticeable consistency between the different AVL software solutions and the many associated advantages in a variety of areas.” ←

AVL's new Powertrain World app for the first time provides engineers across the auto industry with insight and information into the latest innovation, wherever they are.

# WELCOME TO THE AVL POWERTRAIN WORLD

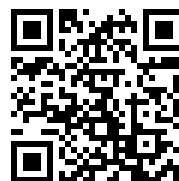
► Powertrain World is a content-based app that delivers comprehensive information on everything to do with the very latest on powertrains. It is available to download now for Android, iPhone, iPad and as Web App for Blackberry and Windows devices.

The content is a combination of different types of articles, videos and information on events and products, intelligently categorized and tagged so that the app is easily navigable. Users can read an interview with an expert in simulation products, find out more about AVL's latest e-car concept and get to grips with the subject of hybrid calibration, and much, much more.

There are three different navigation wheels that can be turned to easily get to the content that interests the user most. The first wheel divides the content into the diffe-



rent powertrain elements, and includes an option for content that addresses the whole powertrain. The second wheel breaks down content into categories of vehicles: passenger vehicles, heavy duty and large engines. The third, meanwhile, categorises content by AVL business area: simulation, testing and



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Download the app now (iOS and Android) and start exploring the Powertrain World, wherever you are.

engineering. It means that the Powertrain World App has something for everyone with an interest in automotive engineering, and makes it easy to find.

The content is regularly refreshed to reflect the very latest innovations, the newest products and cutting-edge expertise in the auto-engineering world. Users of the app can also contact AVL experts directly, meaning that they are able to find out more about what they are most passionate about.

Users can also share articles via Facebook and by email, and add their favorite pieces of content to "My Collection", which means they are also available to read offline. ←



## SPEED UP YOUR PROCESSES

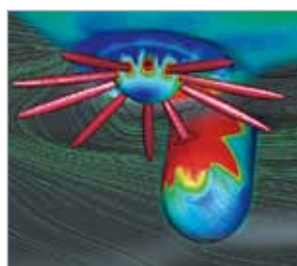


BOOST and FIRE® are the industry's prime choice when reliable results are needed for engine and combustion development.

The intelligent integration of the two software tools enables solutions for even the most complex tasks.

### Your Benefits:

- Verified engine development solutions
- Speeding up your processes
- Less experiments, more creativity
- Tremendous time savings





## AVL VIRTUAL VEHICLE ENGINE TEST BED TESTING REAL ENGINE DYNAMICS



Gear up to launch the vehicle fleet on the engine test bed.  
Shift up to next generation dynamic testing.

- Transfer calibration tasks from road to engine test bed
- Consequently reduce number of prototypes
- Realistic cold start calibration and application
- Driveability calibration and optimization
- Powerful "Engine in The Loop" platform
- Development XiL control systems

High Dynamic Engine Testing with AVL VIRTUAL VEHICLE ENGINE TEST BED enables the engine to generate its own characteristic dynamics. The system allows to load the engine with environment, vehicle and powertrain simulation up to 40Hz, at the same time uniquely no mechanical parasitic influence during start, stop and idle phase. This state of the art Engine Testing System opens the door to new test methods and efficiency boost in engine development.

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