

JULY 2012

AVL

THE AVL MAGAZINE FOR  
POWERTRAIN DEVELOPMENT,  
TESTING AND SIMULATION

# powertrain & drive focus

» WE'RE PLANNING  
A HYBRID IN ABOUT  
EVERY MODEL SERIES. «

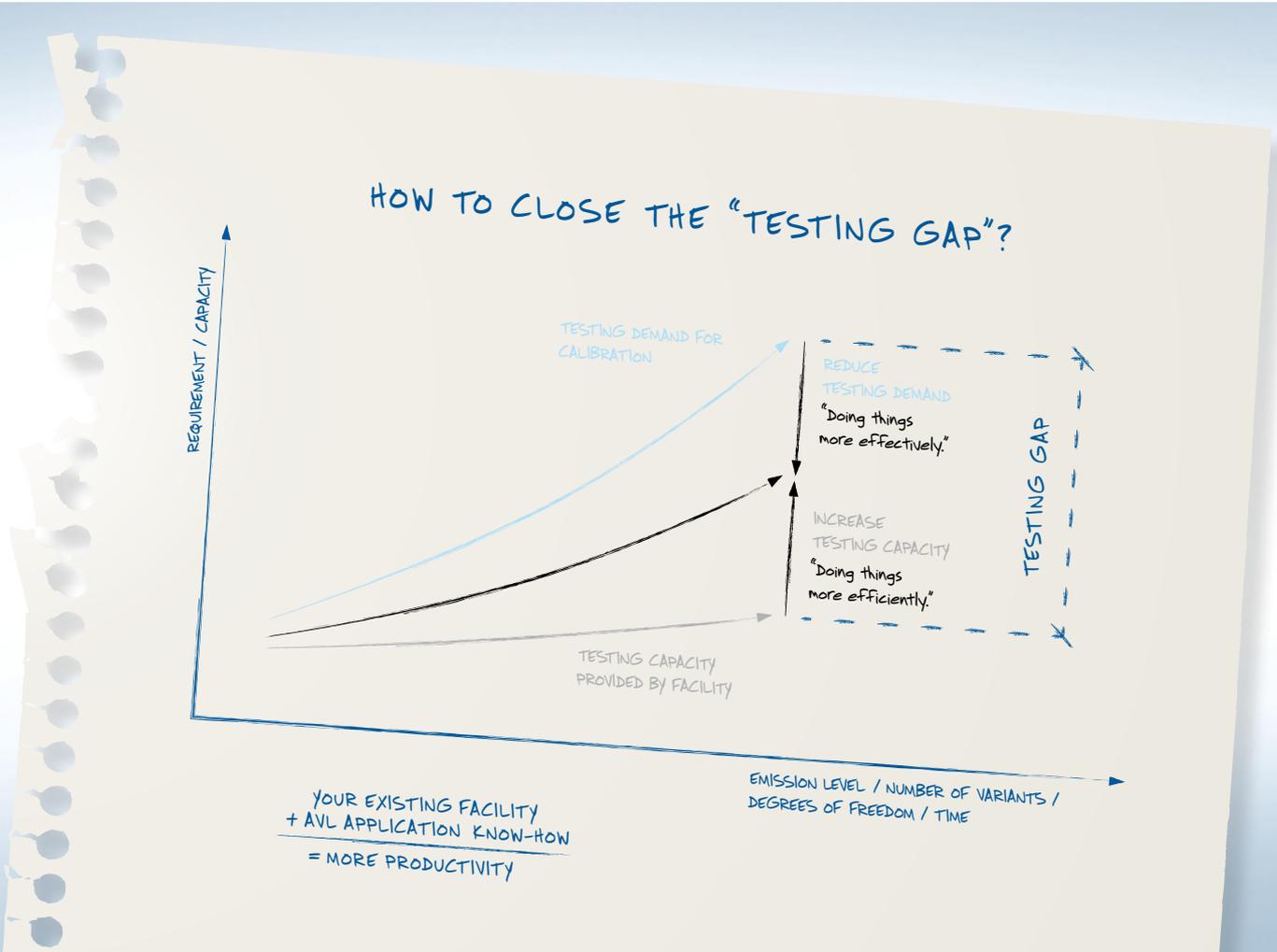
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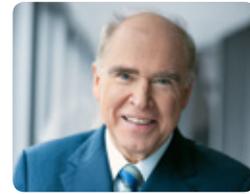
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Prof. Helmut List  
Chairman  
and  
CEO AVL



As a result of the immense pressure to step up energy saving and CO<sub>2</sub> reduction efforts – primarily driven by the legislation – we are currently experiencing increasing diversification and intensification in the applied technologies. This concerns both the internal combustion engine and the electric drive. AVL is excellently positioned in both areas. With its extensive knowledge of the internal combustion engine and the elements of the electrified powertrain – coupled with a profound understanding of the overall system – AVL is able to master the complexity of modern drive solutions.

In the years ahead there will be increased differentiation of drive systems: Until 2020, electric mobility with or without range extender will represent a small but rapidly expanding niche. My assumption is that by 2020 we will be seeing considerably more hybrid vehicles than all-electric vehicles. In all its variations, this drive combination will play an increasingly important role over many years to come. Such complexity and diversity of solutions can only be mastered with model-based configuration and modeling systems in conjunction with new test bed technologies. At AVL, it is this much more intensive interaction between design, simulation and testing which forms the core of our expertise. Working together with you, this allows us to make a significant contribution to lowering CO<sub>2</sub> emissions.

*Helmut List*

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Interview with Mr. Toshiaki Yasuda, President of Toyota Germany

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# » WE'RE PLANNING A HYBRID IN ABOUT EVERY MODEL SERIES. «

► **«F»: Mr. Yasuda, over the last 15 years, Toyota has sold more than 3.9 million vehicles with hybrid drives. When the hybrid pioneer Prius first went on sale, did you ever think this kind of drive technology would be such a success?**

«Yasuda»: We never had any doubt about the hybrid drive concept, but we needed a lot of staying power to make it a real success. It took until 2008 for the first million hybrid vehicles to be sold. We're crossing the four-million mark worldwide in June, and we're very proud of that. For Toyota, the hybrid drive paves the way to tomorrow's mobility, and the sales figures prove us right.

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**«F»: The Prius today is available in its 3<sup>rd</sup> generation, and this year alone as many as three models – Yaris, Prius Plug-in, Prius+ – are going to be added to the Toyota hybrid model range. Will**

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**there soon be a hybrid version for every Toyota model?**

«Yasuda»: We're planning to offer a hybrid version in about every one of Toyota's model series until 2020. But with this year's new launches we are already represented in the most important vehicle classes, so I think we are on the right track.

**«F»: In 2011, the hybrid share of all Toyota models was at around 10 percent. How much do you expect the share to rise over the next 5 to 10 years?**

«Yasuda»: In Europe, we're planning to have a share of 20 percent by 2014, and of course we want to improve our performance in the years to come. The Yaris Hybrid will be a

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Top: The Prius family 2012.  
 Above: The FCV-R demonstration vehicle with hydrogen-powered fuel cell.  
 Right: Toyota NS4 – study of a next-generation plug-in hybrid vehicle.



great help in this respect, because it's our most popular car in Europe and propelling the hybrid drive system into the high-volume B segment at an extremely competitive price.

«F»: This summer, the Prius will also become available as a plug-in hybrid. This follows a global field test that lasted two years and was conducted with more than 600 vehicles. Could you give us an example of how the production version was optimized for buyers based on these lengthy real-world use tests?

«Yasuda»: We took the testers' feedback from real-world use very seriously, and a large number of insights from the field test were incorporated into the production version. For ex-

» WE NEEDED A LOT OF STAYING POWER TO MAKE THE HYBRID DRIVE A REAL SUCCESS. «

ample, take the position of the charge port: In our field test, it was located at the front on the left – now it's on the right rear fender and also has illumination. Even handy details were considered, for instance a special compartment for the charging cable in the trunk. This modification is a good example of our corporate philosophy:

to constantly strive to build better cars for people.

«F»: Another new development in the Prius Plug-in is the lithium-ion battery, which provides an electric range of 25 km. This is a significant increase compared to the "normal" Prius. Do you think the plug-in hybrid with an extended



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With the new Yaris Hybrid, Toyota is propelling the hybrid drive system into the high-volume B segment.

**electric range will in future replace the “normal” hybrid?**

⟨Yasuda⟩: The plug-in hybrid, a version of the “normal” Prius, is interesting for places where there’s a recharging infrastructure for electric cars. You can charge in your own garage today, but there’s still a long way to go before this can be done in the middle of the city. The plug-in offers a real environmental advantage if the electricity comes from renewable energy sources. Germany is on the right track, but still nowhere near its goal. That’s why I think that both types will continue to have their raison d’être for some time.

⟨F⟩: **At the Geneva Motor Show, Toyota unveiled its NS4, a next-**

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» IN EUROPE, WE’RE  
PLANNING TO  
HAVE A HYBRID  
SHARE OF 20  
PERCENT BY 2014. «

**generation plug-in hybrid vehicle. What benefits will the next-generation hybrid drive offer its customers?**

⟨Yasuda⟩: It delivers the same benefits customers can already buy from us now: local, emission-free mobility without range anxiety, naturally even more efficient than the present generation. And like all our hybrid

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vehicles, the NS4 bridges the gap to e-mobility and reflects the long goodbye to the internal combustion engine.

⟨F⟩: **What potential do you see in the further development of the classic internal combustion engine in view of CO<sub>2</sub> reduction? And in future will Toyota be offering a hybrid drive with a diesel engine?**

⟨Yasuda⟩: In our opinion, there’s no point in a combination with diesel for passenger cars, because diesel engines are heavier and their emissions are harder to clean. Just take NO<sub>x</sub> or particulate matter – these are the issues you don’t need to worry about with conventional gasoline engines. In heavy-duty transport, on the other hand, the combination is inter-

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esting. In Japan we've been selling trucks with diesel-hybrid drive for several years now.

**◀F:** Toyota also develops vehicles with all-electric drive, such as the RAV4 EV or the Toyota iQ, which was converted to electric power. Where do you see the ideal application area for all-electric cars?

◀Yasuda: For us, the ideal areas of use for all-electric cars are densely populated urban centers. That will also be the first place to have an adequate recharging infrastructure, and the short distances to the city require less battery capacity, which, in turn, reduces vehicle costs.

**◀F:** In Geneva, Toyota recently presented its demonstration vehicle FCV-R, a vehicle powered by fuel cell. What future do you see for the hydrogen-powered fuel cell car, and when do you expect series production to be based on this technology to begin?

◀Yasuda: As a member of the Clean Energy Partnership (CEP), Toyota already started testing five hydrogen demonstration vehicles in Berlin a few years ago. The first serial production passenger vehicles will be on the market by 2015. We expect the future of hydrogen to be in long-distance or heavy goods vehicles. Until then it will naturally take a while, as the infrastructure issue still has to be solved. The benefits of hydrogen result from the short charging time: Refueling takes just about three minutes and hydrogen is also very suit-



**TOSHIAKI YASUDA, PRESIDENT OF TOYOTA GERMANY**

Toshiaki Yasuda was born on November 15, 1960. After completing his degree at the University for Foreign Studies in Tokyo, he joined Toyota Motor Corporation (TMC) Tokyo in 1983. In 1990, Toshiaki Yasuda came to Germany and, after studying languages, first became member of the Hanover office of Toyota Motor Marketing & Engineering Europe (TMME). Between 1993 and 1996 he was responsible for the UK, Austria and Finland at TMME's European center in Brussels. Toshiaki Yasuda returned to Nagoya in 1997, where he worked in marketing, sales and product planning. He was initially responsible for the Japanese market and later for the U.S. market. From 2005 to 2006 he was personal advisor to President Watanabe. In 2007, Toshiaki Yasuda returned to Toyota Motor Europe (TME) where he served as Lead Executive Coordinator in product planning and marketing. In January 2010, Toshiaki Yasuda was appointed President of Toyota Germany.

able for storing electrical energy. We believe this gives it great potential for sustainable mobility.

**◀F:** Networking cars with their environment and other road users may in future help to improve safety and lead to a further reduction in CO<sub>2</sub> emissions. Is Toyota

**working on any smart systems like these?**

◀Yasuda: Networked vehicles are definitely a growth market and are increasingly becoming communication centers in a networked world. For the NS4, for example, we introduced a Human-Machine-Interface (HMI) that was designed to resemble a smartphone and manages such

basics as navigation functions, A/C, audio, communication and lots more. On top of that, it is capable of “learning” the specific driving preferences of its driver and incorporating this knowledge in driving situations where required. But user friendliness is only one of the advantages. Networked vehicles also have great potential where intelligent traffic management systems are concerned – which is another area to which we are naturally contributing our development efforts. These help not only to prevent accidents, but also congestion and, consequently, unnecessary CO<sub>2</sub> emissions.

◀F: Emotions play a key part when it comes to cars. With its GT 86, Toyota has introduced an affordable sports car with rear-wheel drive. How important is it for a carmaker to also have “emotional”, sporty cars in its model range? <Yasuda>: Even if practically everyone has realized by now how important the environmental aspect and emission control is when it comes to cars, the whole topic is still very emotionally charged. The “fun-to-drive” factor is central when you buy a car, and I’m very pleased that we have been able to achieve this with the GT 86.

◀F: Speaking of emotion and cars, let’s talk about motor sports: This year, Toyota brought for the first time a hybrid race car to the “24 Hours of Le Mans”. Do you think this will give the hybrid drive

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The Toyota hybrid race car for the “24 Hours of Le Mans”.

» I FIRMLY BELIEVE THAT THE ELECTRIC MOTOR HAS A GREAT POTENTIAL FOR SPORTINESS TOO. «



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The GT 86 puts Toyota back into the league of affordable sports cars.

a sportier image and help to make it more widely accepted?

<Yasuda>: It definitely will. Even though we were unfortunately knocked out of the Le Mans race far too early, we still showed that hybrids can become a fixed feature in motor sports and provide for exciting racing duels. It can hardly get more emotional than this. But it’s not just the hybrid drive that will help shape the future of motor sports. I firmly believe that the electric motor has a great potential for sportiness too. You can feel it, particularly at the start. Our colleagues at Toyota Motorsport are doing very well in this respect. Only recently, they set a new record for electric cars at the Nürburgring. <

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► Transmissions offer one of the most important means of improving overall vehicle performance and efficiency and are therefore at the heart of AVL's work across the whole powertrain. AVL has been working in the transmissions field for over 20 years, but the acquisition of Australian



→ The AVL NTC Powertrain Headquarter in Sydney, Australia



# ON A MISSION WITH TRANSMISSIONS

Focus spoke to Australian transmissions specialist Richard Tamba about setting up his own company and the work he is now doing at AVL.

company NTC in 2011 was a further boost to their overall knowledge and skills set. Richard Tamba, the founder, CEO and President of NTC, is now Senior Vice President, Passenger Car Transmissions for AVL.

Tamba had over a decade of experience working in transmission development before he set up his own company in 1995. That was originally called Nautitech, but it later became NTC. His company developed the first ever series production dual clutch transmission (DCT) for VW in 1998. Tamba is listed as the inventor on more than 30 patents.

'Customers in China and overseas were telling us that they loved our work,' he says, 'but they also told us that they wanted some wider engine experience – powertrain work. So we began to develop links with AVL in the US and China. In mid-2010 CEO Helmut List asked whether we could have a more

formal arrangement and the full takeover took place in February 2011.'

Tamba, who prefers to be called Ric ('I only get called Richard when I'm in trouble', he jokes) is passionate about transmissions and the opportunities they present for whole powertrain performance. 'The best opportunity for improving fuel economy in the powertrain is to be found in the transmission,' he says. 'For example, if you go from a four-speed automatic to a six-speed transmission you get an immediate boost in efficiency – adding gears is an easy way to get a 15 percent improvement – but the key and the secret is integrating them and controlling them within the constraints of the other powertrain elements.

He travels the world helping different AVL teams with transmission development opportunities and he is

enthusiastic about working within a multi-disciplinary team. 'With AVL, because we do the whole lot, we all pull together – when the transmission team need to make something work in a certain way, the engine guys pull something out of the bag; when the engine guys need something from the transmission, we help them out – it means that the whole package for the customer really comes together.'

More than anything, though, he is excited about the technologies that AVL are using to revolutionize transmission systems. 'There's fewer mechanical devices in transmissions,' he says. 'Instead, there's more integrated electronics, hydraulics, electric motors and software. There's also a greater mix of technologies. The old days of pure automatic or manual transmissions are over – we're now sharing technologies between them, creating a new breed of transmissions.' ←



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Kurt Gschweitl, Uwe Wiedemann and Volker Hennige (from left) – the leading AVL battery experts with a 28 kWh-High-Voltage battery for an electric vehicle.

# ONE ENERGIZED TEAM

AVL has set up a Global Battery Competence Team to pool and broaden its battery capabilities. Work is underway on innovative solutions that contribute towards environmentally friendly and affordable electric mobility across different countries and business areas. Focus interviewed the leading AVL battery experts, Volker Hennige, Uwe Wiedemann and Kurt Gschweitl.

► **◀F:** Mr. Hennige, in your function as Head of the Global Battery Competence Team, could you give us a brief summary of AVL's global activities in in the development of batteries?

◀Hennige: We cover a very broad scope of activities ranging from the testing of the individual cell to bat-

tery design and its integration inside the vehicle. Given AVL's wide-ranging capabilities, both in view of the battery system itself and the electrified powertrain as a whole, our role as development partner and supplier of battery-related instrumentation and testing systems puts us

in an ideal position to help fill the gap between cell manufacturers and OEMs – this is also why both belong to our growing clientele. In this respect, AVL sees itself as a strategic bridge between the OEMs and the cell manufacturers.

◀Wiedemann: While cell manufacturers do have the chemical and process engineering expertise, they fre-

quently lack the specific automotive know-how – and that’s exactly what AVL can offer them to help them evolve into classic tier 1 suppliers. OEMs, on the other hand, often lack the specialist knowledge about the cell – and this is where we step in with our electrochemical expertise. We help these customers choose the right cell and we design the battery pack accordingly, for example.

**◀F: For a long time, AVL was known as a specialist for engine test beds. When did AVL add instrumentation and testing systems for batteries to its offerings?**

◀Gschweitl: AVL started developing testing equipment for the electrical drive components – electric motor, inverter and battery – at a very early stage. By setting up a cross-divisional Battery Competence Team, it has now proved possible to harness the synergy between the engineering area (PTE) and AVL instrumentation and testing systems (ITS) in the best way possible. There are multiple ways in which our customers benefit from this close collaboration too, as AVL is now able to offer them practically everything from a single source, from cell benchmarking to battery pack design and battery management system development (BMS).

◀Hennige: The synergies we are capable of generating in battery development are really vast. On the one hand, there is the “internal synergy”, since our battery developers are also power users of the AVL test systems, which are the best test systems available in the market. The “external synergy” is generated by the fact that AVL is

the only supplier in the world able to do both: We can offer our customers both the testing equipment and the engineering services.

**◀F: What engineering services does AVL offer in the battery sector?**

◀Hennige: Our work starts with the benchmarking and testing of cells – the smallest unit in the battery. Based on what we know about the cell, we create simulation models which enable us to simulate modules electrically and thermally. This, in turn, serves as a starting point for defining the way the battery is to be designed with regard to its size, weight and vehicle-specific requirements. This also covers the electrical configuration, i.e. which components are required; what kind of contactors, fuses and other high-voltage components. Having completed the design, we assemble the battery, also in the different sample phases. Depending on the project, we can build batteries even in larger quantities – in a range of up to 50 batteries per sample phase.

**◀F: How can AVL help to reduce the currently very high cost of vehicle batteries?**



◀Wiedemann: AVL’s contribution towards cutting the cost is based on integrating modules with a very high rate of reusability. The challenge we face is to reduce the number of components and to use as many identical parts as possible. It is all about achieving a high mechanical packaging density, while keeping the weight as low as possible. It is essential in this respect to integrate efficient cooling concepts, some of which AVL takes from the area of combustion engines. Of crucial importance is the functional integration. An example for this would be a battery module carrying structure with an integrated cooling function, which helps to reduce the battery’s volume and weight.

**◀F: Where does AVL work on battery development?**

◀Hennige: We have several locations where battery development is being pursued with different key focuses: At our headquarters in Graz we have all our battery competences pooled at a single location. Beside Graz, there is Detroit (AVL PEI) which also focuses on batteries, specifically on simulation and pack design. Furthermore,

**» AVL SEES ITSELF AS A STRATEGIC BRIDGE BETWEEN OEMS AND CELL MANUFACTURERS. «**

VOLKER HENNIGE,  
Head of Global Competence  
Battery Team

we have the AVL California Technology Center which is specialized in the development and construction of prototypes and BMS hardware development. The BMS series software development is conducted at AVL Software and Functions in Regensburg. We are currently also in the process of expanding our battery capabilities at our Tech Center in Shanghai. Something similar is also happening at AVL Schrick in Remscheid. Regarding testing systems there are specialists working on automation software for battery testing systems at AVL in Detroit apart from our teams in Graz.

◀F: AVL has achieved great success with its Range Extender. As a battery expert, what is your view of the Range Extender's role in electrification?

◀Gschweitl: With the Range Ex-



tender we are definitely on the right track, because it combines the best of both worlds – efficient electric driving and the high range of a liquid fuel. The Range Extender enables electrification by reducing the battery size and thus the cost of the battery.

◀F: The lifespan of batteries is an important issue in the context of electrification. How can AVL ensure and optimize service life?

◀Hennige: The target is defined very clearly in the specifications which require a service life between 10 and 12 years. To begin with, we choose the ideal cell for each application. Then connection techniques are needed that guarantee durability. Particular techniques are also required to control corrosion, e.g. by means of “breathing” pressure compensation membranes, which allow the moisture to escape the housing.

» WITH THE BATTERY COMPETENCE TEAM, WE ARE ABLE TO TAP THE SYNERGY BETWEEN AVL'S ENGINEERING AREA AND ITS INSTRUMENTATION AND TESTING SYSTEMS IN AN OPTIMAL WAY. «

KURT GSCHWEITL,  
Global Business Segment Manager  
Electrification Test Systems

Another key area is validation: To ensure the service life of a battery in day-to-day operation, each use-case is simulated in detail, and the battery is tested under real-life conditions.

◀Gschweitl: For the EPA (US Environmental Protection Agency) we are installing a test bed that is capable of simulating realistic drive cycles using AVL InMotion. Besides localization – will the vehicle be used in India or Northern Europe? – driving style is another important factor. For these tests, the battery is “built into” a virtual vehicle, making it possible to simulate the subsequent stress inside the vehicle very accurately by using a specially controlled testing system. Battery management is realistically incorporated into the test run too, which makes it possible, for example, to adapt the stress to suit the battery's respective state of charge. In the near future, AVL – along with its partners – will take things even further and integrate mechanical stress on the battery into the test runs too. This is of crucial importance, as the battery's service life can be heavily limited by vibration and the generated interactions while electrical operation continues.

◀F: Does functional safety also play an important role with batteries? How can AVL's experts help to guarantee safety?

◀Wiedemann: Today, functional safety plays a major role everywhere, which is why AVL is superbly positioned in all development areas. Where batteries are concerned, in particular, one must consider very carefully what kind of damage could occur during operation, how often

it could occur and how to respond. For this purpose there are scenarios with defined reaction sequences and different switch-off strategies depending on the risk. In the event of a crash, the entire battery will of course be electrically disconnected from the vehicle immediately. The strategy will be totally different if you are cruising along the highway at 120km/h and, for example, the system measures a reduced insulation resistance. In a case like that, suddenly switching off the battery would be inappropriate. Batteries at AVL are generally developed in accordance with a detailed hazard analysis and risk assessment.

«F»: Safety also plays an important role when testing batteries. What precautions are provided for in AVL's battery testing systems?

«Gschweitl»: With battery testing systems, the danger is invisible. That is why special safety precautions have to be introduced for manned operation. For test bed technicians, a traffic-light system and acoustic warning signals are used to visualize danger and make it audible. An isolation observer is additionally used to check continuously whether the isolation is intact or whether any leakage current is present in the housing – only testing systems produced by AVL have this feature. There are also switching systems which start certain emergency-stop programs as soon as a climate chamber or a test cell door is opened, for example. For battery test bed operators, AVL organizes special high-voltage courses, which we also of-

## » AVL'S CONTRIBUTION TO CUTTING BATTERY COST IS BASED ON THE INTEGRATION OF MODULES WITH HIGH REUSABILITY. «

UWE WIEDEMANN,  
Product Manager Global Battery  
Competence Team



fer our customers in the context of product training. In the case of automated checks, which are frequently run around the clock and for several weeks, it must be ensured that the system is able to handle all types of events of damage. By means of FMEA analyses, a comprehensive error matrix was created and corresponding safety measures were taken that even include the purging of the climate chamber volume with inert gases in order to reduce chemical reaction to a minimum.

«F»: What is AVL's approach to battery recyclability?

«Hennige»: I'd say that before considering the recycling plan we've simply added another step to the cycle – the keyword being "second life". Batteries no longer suitable for vehicle operation are far from being dead. Batteries with a capacity of 80 percent are perfectly suitable for use at home, e.g. as "charging stations" which can be charged by rooftop photovoltaic systems and used to recharge electric or plug-in hybrid cars. In this respect, AVL is planning to offer measuring devices capable of evaluating the state of batteries reliably by using testing routines. For the actual re-

cycling, the battery pack's individual components must be removable, so that they can be separated, if possible, by material type – this must already be considered during battery design.

«F»: Let's look ahead to the future. What kind of new battery technologies are being developed at AVL and when will they be available?

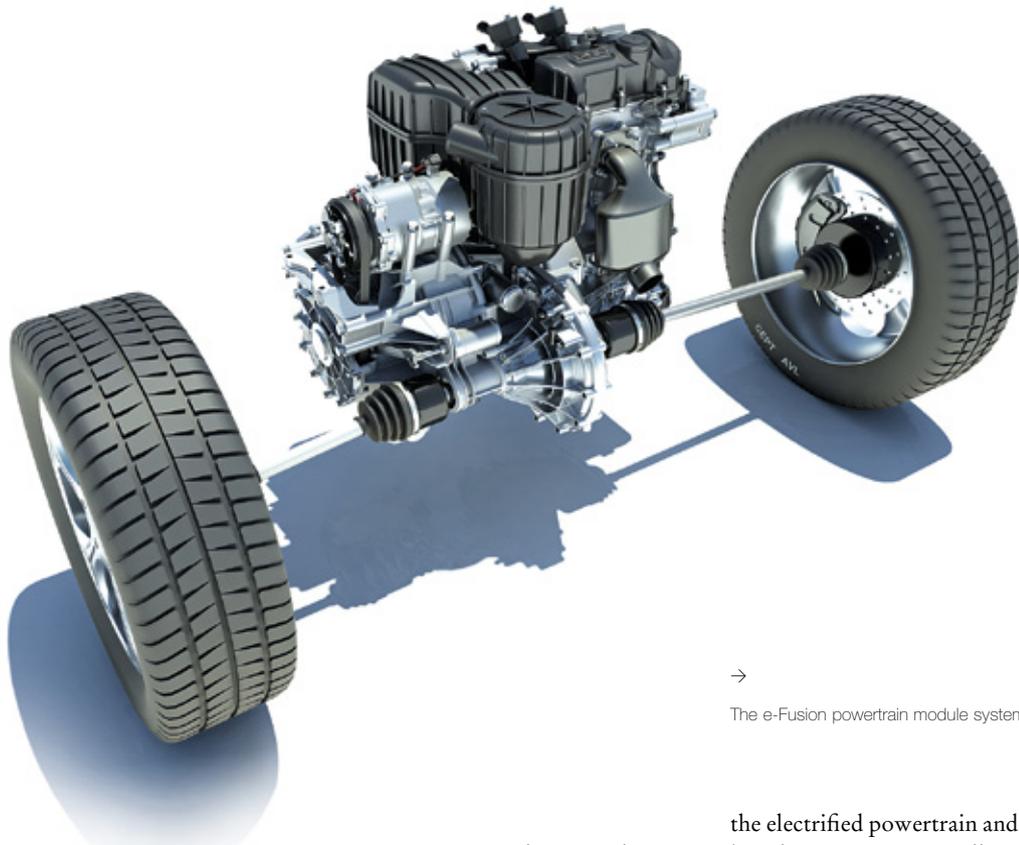
«Hennige»: Batteries today still have a relatively moderate energy density. But if you look at the laws of physics and chemistry, it is perfectly realistic to assume that it would be possible to achieve ten to twenty times the energy density today using an electro-chemical storage unit. What strikes us as particularly interesting is the lithium-air battery, where one of the chemical reactive agents (oxygen) does not need to be stored internally. As with the combustion engine, it is taken from the air. We at AVL are working with partners all over the world on battery technologies of the future which will be ready for use in some 15 to 20 years from now. «

The growing complexity of electrified drive systems usually means a noticeable increase in cost for customers. But AVL has taken steps to counter this trend with our concept of a module-based and versatile powertrain system.

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# AVL E-FUSION

## COST REDUCTION BY FUNCTIONAL INTEGRATION



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The e-Fusion powertrain module system

► AVL's e-Fusion powertrain module system is an attempt to tackle the cost increases resulting from powertrain electrification. "When we were developing the concept of e-Fusion, we wanted to find a way to combine modular design with integrated functionality in order to achieve our aim," says Helfried Sorger, Executive Chief Engi-

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neer, Design, Simulation and Mechanical Development.

"The original e-Fusion idea was born within AVL in the area of the 'classic' combustion engine, about two years ago. The basic principle of integrated functionality was then extended to include all aspects of

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the electrified powertrain and combined to create an overall concept, which would be capable of representing a variety of different drive technologies – from mild hybrid, city and all-purpose plug-in hybrid to the range extended vehicle with drive-through. Depending on the drive configuration, e-Fusion is suitable for a very broad spectrum of vehicles, extending from the A to the C segment."

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## FUNCTIONAL INTEGRATION AS KEY TO COST REDUCTION

Our focus on all five elements of the electrified powertrain – combustion engine, transmission, electric motor, power electronics and battery – means that we are in the perfect position to fuse together innovation across all systems and components into a single concept. “With this project, we managed to incorporate all the good ideas people were coming up with in all areas of AVL. In order to bring everything together in e-Fusion, viewing the powertrain from a holistic point of view was a crucial factor. The innovative TNT transmission approach (transmission new technologies), for example, was put to perfect use, as it helped us pursue development activities tightly interlinked with the combustion engine to find new innovative and very compact solutions,” says Project Supervisor Helfried Sorger. “When opting for integrated functionality, which entails fewer modules and, consequently, reduced costs, modularity is usually abandoned. We set ourselves the task of developing an overarching powertrain concept, which would allow us to represent a broad scope of modularity despite the integrated functionality. For this purpose, it was necessary to rethink existing interfaces – for example between engine and transmission – and practically re-create the powertrain from a functional point of view.”

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Helfried Sorger, e-Fusion Project Supervisor and Executive Chief Engineer Design, Simulation and Mechanical Development

Electrification has been a catalyst for this trendsetting approach. “The electric motor in e-Fusion, for example, replaces the starter as well as the conventional reverse gear and ensures that gear shifts are executed without interruption of traction. The electric motor’s rotor was additionally designed as part of the planetary gear set,” Sorger explained. With the combustion engine, the cylinder head and the crankcase were integrated in a single component; the transmission shaft bearings are partly implemented in the crankcase. With the low-load version, a torsion shaft, which connects the e-machine/transmission system to the engine across the entire transmission via a dry clutch, takes over the function of the cost-intensive dual-mass flywheel. An intelligent operation strategy delivers further advantages: “The concept

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of a power split through the transmission makes it possible to drive using the internal combustion engine as a power source and recharge the battery with the e-machine at the same time. Other hybrid concepts are not capable of this kind of ‘smart charging’ which allows you to use the combustion engine’s excess energy to recharge the battery e.g. during urban stop-and-go driving or at low battery charge,” says Helfried Sorger.

## E-FUSION APPLICATIONS

The e-Fusion powertrain family has a very broad scope of application thanks to its modular design. The possibilities range from mild hybrid and various plug-in hybrid versions to the range-extended vehicle with mechanical drive-through. According to Helfried Sorger, a chief focus in the future will be the application of e-Fusion as a plug-in hybrid, which will take on two major forms: as an all-purpose hybrid and as a city hybrid, specifically optimized for use in urban areas. With regard to the all-purpose hybrid type, the main focus is on application in C-class vehicles. “Here, a 2-cylinder turbo engine, a 40 kW e-machine and a four-speed automatic transmission will be put to use. Using the same configuration, an all-purpose application in the B-segment, also with a possible slightly smaller battery is imaginable,” adds Sorger.

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The city plug-in hybrid is the second major form, which will ideally be conceived as a category A vehicle. The e-Fusion modular design means that we are able to create a performance-adapted 2-cylinder turbo engine with just two speeds that is ideal for city use. The key focus for plug-in hybrid applications is the performance of the internal combustion engine. “If the

dance with the described applications. There are plans for an all-electric range for the plug-in types of between 20 and 25 kilometers. Battery sizes can vary slightly due to the different weight of the vehicles. There is huge savings potential too in terms of fuel economy: “The consumption level for the city plug-in hybrid (vehicle class A), calculated using AVL simulation tools,

specifications. “In terms of practical use, we attach great importance to real world consumption at constant speed: For the city plug-in hybrid (vehicle class A) we predict 3.3 l/100 km at 90 km/h; for the all-purpose plug-in hybrid (vehicle class B) the value is at 4.8 l/100 km at constant 120 km/h. For the all-purpose plug-in hybrid in the heavier vehicle class C, 5.3 l/100km



**MILD HYBRID**

Vehicle class: C  
 Engine: 3 Zyl TGDI 97kW/240Nm  
 Transmission: 6-speed  
 E-Motor: 15kW/120Nm PSM  
 Battery: 1,2 kWh Lilo



**ALL PURPOSE PLUG-IN HYBRID**

Vehicle class: B, C  
 Engine: 2 Zyl TGDI 65kW/160Nm  
 Transmission: 4-speed  
 E-Motor: 40kW/160Nm PSM  
 Battery: 5 kWh Lilo



**CITY PLUG-IN HYBRID**

Vehicle class: A  
 Engine: 2 Zyl TGDI 55kW/140Nm  
 Transmission: 2-speed  
 E-Motor: 40kW/160Nm PSM  
 Battery: 4–5 kWh Lilo

key focus shifts more towards the electric motor, there will be a third application – a range extended vehicle with direct drive-through. For this application, a combination of the twin-cylinder naturally aspirated engine and the two-speed transmission would be the best solution in terms of functionality and cost-effectiveness,” explains the Executive Chief Engineer.

The electric driving ranges and battery sizes are scalable, in accor-

is at 1.7 l/100 km (41 g CO<sub>2</sub>/km in the NEDC); for the all-purpose plug-in hybrid (vehicle class B), it is at 1.9 l/100 km (45 g CO<sub>2</sub>/km in the NEDC) and for vehicle class C at 2.1 l/100 km (49 g CO<sub>2</sub>/km in the NEDC). In combustion with the very small energy storage systems – we are talking about 4 to 5 kWh Lithium-Ion battery packs – the target values were confirmed,” says Sorger, referring to the values defined in the user requirement

are to be expected at 120 km/h constant speed,” explains Sorger.

**COST AND WEIGHT REDUCTION**

Substantial savings in costs can be achieved in comparison to reference solutions available in the market thanks to integrated functionality, which in e-Fusion is applied to all elements of the powertrain. “Although taking into account the battery costs, between 10 and 30 percent savings

## » DESPITE RADICAL FUNCTIONAL INTEGRATION, E-FUSION ALLOWS US TO MAINTAIN A BROAD SCOPE OF MODULARITY. «

HELFRIED SORGER, e-Fusion Project Supervisor

can be achieved with the city plug-in model; as for the all-purpose plug-in hybrid, the savings po-

for very compact dimensions, enabling e-Fusion to easily fit into existing vehicle front-ends.

hicle to not only represent the innovative operation strategy and driving performance, but also to secure fuel consumption values in the real vehicle. In a third, strategic approach, the AVL experts want to extend the modular e-Fusion powertrain system by adding a diesel and a CNG-compatible engine, which would lead to further CO<sub>2</sub> savings potential. Helfried Sorger:



### RANGE EXTENDED VEHICLE

Vehicle class: A  
 Engine: 2 Zyl MPI NA 42kW/71Nm  
 Transmission: 2-speed  
 E-Motor: 40kW/160Nm PSM  
 Battery: 8 kWh Lilo



### PURE RANGE EXTENDER

Vehicle class: A  
 Engine: 2 Zyl MPI NA 28kW/68Nm  
 Transmission: 2-speed  
 E-Motor: 55kW/225Nm PSM  
 Battery: 8 kWh Lilo  
 Generator: 25kW/50Nm



### ELECTRIC DRIVE

Vehicle class: A  
 Transmission: 2-speed  
 E-Motor: 55kW/225Nm PSM  
 Battery: 22 kWh Lilo

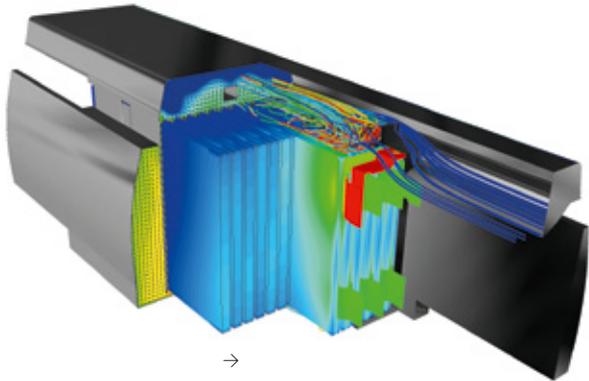
tential is at a comparable level,” says Sorger.

A further advantage is the low weight and the packaging-saving design compared to conventional hybrid drive solutions: a city plug-in hybrid with 2-cylinder engine and dual-speed transmission, e-Fusion including intake and exhaust gas system, as well as the power electronics, weighs as little as 165 kg, which sets a new benchmark in this class. Integrated functionality also allows

### THE FUTURE OF E-FUSION

AVL is pursuing three different paths in the development of e-Fusion: the first involves discussing the individual technology elements and the basic principle of integrated functionality with potential customers in order to implement applications. The second path is to use a demonstration ve-

“The e-Fusion concept shows us that though we can’t achieve the cost reduction required in electrification by taking conventional approaches, the described innovative approaches, which also question the necessity of existing interfaces, are very well capable of making these cost savings feasible. e-Fusion can thus contribute significantly to a more widespread acceptance of economical and environmentally friendly drive solutions in the global market.” <



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CFD Results Li-Ion Battery

AVL FIRE® is a powerful multi-purpose thermo-fluid software. It represents the latest generation of 3D Computational Fluid Dynamics. The software is now also able to simulate batteries.

## AVL FIRE® — SIMULATION SUPPORT FOR BATTERY DEVELOPMENT AND DEPLOYMENT

► Electric vehicle development relies on suitable power storage systems, but also on finding solutions for their safe and reliable deployment. Our advanced simulation tools combined with the expertise and experience of our skilled engineers enables AVL to deliver reliable solutions. Part of AVL's solution is the recently released FIRE® Battery module.

### AVL FIRE® BATTERY MODULE

The AVL FIRE® Battery module is based on the software's multi-physics capabilities which enable it to account for complex physics and chemistry interactions, such as:

- multi-fluid and multi-phase flow
- electro-chemistry
- electro-magnetic
- thermal load of structural parts

Models of different levels of complexity allow comprehensive modeling on cell, module and pack level. AVL FIRE® offers an electro-chemical as well as an electro-thermal model to support both the development and the deployment of batteries.

The electro-chemical model (for Li-Ion batteries):

- allows the predictive calculation of cell performance and thermal information during transient charging / discharging
- delivers detailed, spatially resolved information on thermal-electric quantities
- enables analysis of cell chemistry impact on local and global cell performance
- provides data for parameterization of empirical models

The electro-thermal model enables:

- an examination of the thermal-electric cell behavior based on experimental cell characterization (or output of detailed electro-chemical model)
- efficient thermal analysis on module and battery pack level
- optimization of the battery cooling system

While the electro-chemical model supports scientists and engineers in developing Li-Ion batteries, the electro-thermal model enables them to perform thermal analysis and cooling system optimization under operating loads.

The various possibilities of AVL FIRE® provide strong support for product development. The new Battery module of FIRE® is another innovative AVL tool to help tackle current tasks in powertrain development. ←

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 Optimization of transmission acoustics:  
 whine noise effects on shaft and  
 gearbox housing (left); rattle  
 contribution of gear pairs (right)



# AVL EXCITE HEADS FOR TRANSMISSION ANALYSIS

A new gear contact model in AVL EXCITE makes AVL's simulation capabilities fit for transmissions.

► It is increasingly important to analyze the transmission, engine and driveline together under real operating conditions due to the demand to reduce CO<sub>2</sub> emissions by optimizing the overall system “powertrain”. A more detailed analysis of efficiency, durability and acoustic behavior is also required for the increasing automation of gearboxes, new types like dual-clutch transmissions, low noise combustion engines and the electrification of powertrains.

AVL EXCITE software now offers the possibility of calculating the transient dynamic and acoustic behavior of gearboxes under real operating conditions to support these challenging engineering tasks. The key element of this module is a new 3D cylindrical gear contact model that traces the detailed contact of involute profiles including profile modifications and corrections.

The influence of shaft deflections on misalignment and edge loading in the gear contact is represented by the integration in the flexible multi-body dynamics solver of EXCITE. These effects significantly influence the load distribution throughout the gear mesh as well as effective backlash and consequently also operating properties like transmission error (TE) and variation of effective meshing stiffness. The results provide highly accurate information regarding NVH phenomena such as gear rattle and gear whine.

The simulation can be performed for the transmission alone, for a coupled system together with the engine, or for the transmission as an integrated sub-system of an entire conventional or hybrid driveline model, if interactions between the sub-systems are to be taken into account.

In addition, different levels of modeling (rigid/flexible multi-body dynamics) and of contacts (gears, bearings) allow the appropriate level of detail to be chosen according to the application target.

## SUCCESSFUL IMPLEMENTATION AT PSA

PSA Peugeot Citroën is a long-term user of AVL EXCITE for engine-related NVH and durability analysis. Due to the new simulation capabilities described above, AVL EXCITE has also been used to address NVH in the complete powertrain including transmission shafts, gearing and differential. Together with AVL, PSA carried out a highly successful pilot project to evaluate the acoustic performance (rattle, whine) of a manual transmission coupled with a 3-cylinder gasoline engine. ←

# AVL INMOTION – VIRTUAL IS REAL

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AVL InMotion bridges the gap between test bed tests and the (simulated) real world to give developers the opportunity to run realistic tests on components, entire powertrains and vehicles throughout the whole development process.

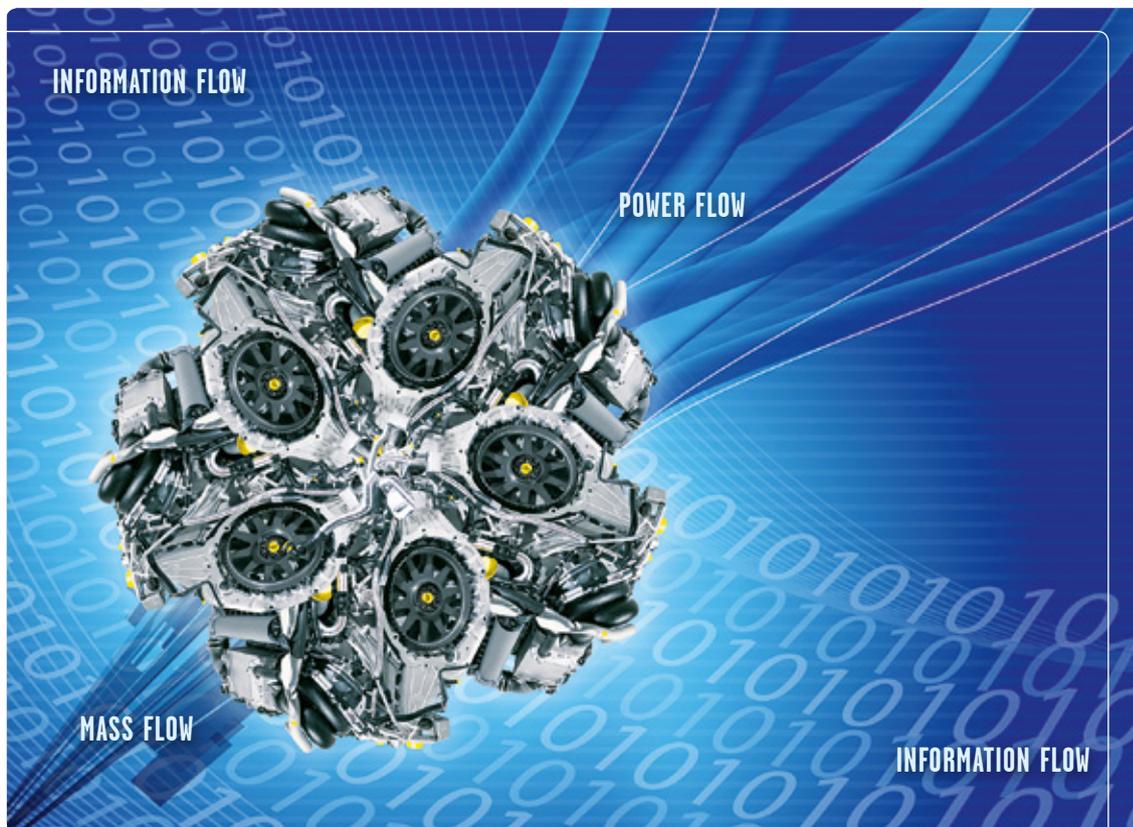
► AVL InMotion is an innovative and powerful software tool for maneuver and event-based testing on the test bed with a practically unlimited scope of application. “The fundamental idea behind InMotion,” says Felix Pfister, the creator of AVL InMotion, “is that the common language – the lingua franca of all engineers involved in the powertrain development process – is driving, in other words the road trial, regardless of whether they are developing an engine, a battery, a transmission or a complete powertrain. To be able to design the vehicle as a whole, it must be possible to test it in its entirety on the

dynamometer too. For this purpose, we embed the different components – whether real or modeled – in a virtual vehicle and its environment, which then undergoes in-the-loop testing in a simulated real-world driving situation.”

## INTEGRATED MECHATRONIC DEVELOPMENT PLATFORM

The modern vehicle has evolved from being a combination of mechanics and electrical engineering into one of networking. This means that development and testing has to

be run on the vehicle in its entirety. This requires the presence of powerful interfaces, enabling the unit under test to interact realistically with its “environment”. “Control of the ‘matter’ interface is ensured by oil, water, air and fuel conditioning,” says Pfister. “The ‘energy flow’ interface is controlled via dynos. Surprisingly, the ‘information’ interface at the test bed has not yet received the attention it deserves due to its role as innovative force and market driver. Instead of having live communication as in a real driving operation, the developers so far have generally had to put up with rather rudimentary ‘rest bus simulation.’ The ‘x-in-the-loop’



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Synergetic testing at the dynamometer: Energy – Matter – Information

approach, pursued consistently by AVL, closes this gap by ‘firing’ the three previously mentioned interfaces in very realistic driving situations, all based on models. This turns the classic AVL test bed into a development environment 2.0 which links the virtual world with the physical one, opening up a whole new world where most of the limitations imposed by the old type of test bed no longer apply.”

In cooperation with Karlsruhe-based drive dynamics expert “IPG Automotive”, and based on its core product “CarMaker”, AVL has developed the first comprehensive solution in the world that enables

the realistic and robust integration of a vehicle moving within a three-dimensional space in a test bed. In fact, there are no limits to the applications that can be tackled with AVL InMotion/CarMaker. Plug-ins (software interfaces for all kinds of testing systems – from engine test beds to powertrain and chassis dynamometer test beds and testing systems for electric motors, high-voltage batteries and inverters) form the link between the real and the virtual world. It’s always about testing under real conditions, whether you want to determine realistic energy flow, consumption

and emission levels or run functional tests (for example on the interaction between hybrid system components or between engine, transmission and brakes) or abuse and durability tests.

For InMotion it is immaterial whether powertrain components are available in real or in virtual form. “The difference between real and virtual world disappears,” Pfister explains. It is even possible to switch to and fro between real and simulated components (“hot swapping”) between two test runs. During hot swapping, the real engine continues to be fed with an unin-

interrupted supply of realistic values (24/7) from AVL InMotion (“uninterrupted IO”). This prevents the control devices or the test bed automation system from going into an error state. It is, of course, also possible to switch between different models. In line with the underlying philosophy of AVL’s Open Development platform, models of widely varying origin (AVL CRUISE powertrain models, customers’ legacy models, Matlab/Simulink control models, etc.) are able to be incorporated in the library. An integrated identical graphical user interface ensures ease of operation. Pfister: “Bringing together the four testing environments – Office, Lab, Test Bed and Road – and giving these a standardized graphical user interface for maneuver-based testing takes the development process to a whole new level of quality.”

## BENCHMARKING

“OEMs are ‘system integrators’: They have to take the individual powertrain development components and turn them into a unique product – the vehicle. Thanks to AVL InMotion, benchmarking these individual components against the Vehicle – the ‘overall work of art’ – can be performed a great deal more efficiently and at a much earlier stage in the development process than previously. The powertrain of Car A, for example, can be integrated into the virtual chassis of Car B and tested in the virtual proving ground in a vast variety of

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Above: InMotion turns the chassis dynamometer into a “vehicle-in-the-loop” test bed.

Below: On the test bed, InMotion can even simulate the effect of driver assistance systems such as ACC (adaptive cruise control).

driving situations,” explains Pfister. “InMotion enables you to test the vehicle’s performance or agility just as well as you would various functional requirements. Apart from that, it is even possible to tune the hydraulic brake system as well as the interaction between engine and brakes on the powertrain test bed, “a topic that is becoming more and more demanding in hybrid and torque vectoring vehicles.”

## OPTIMIZING CONSUMPTION AND OVERALL ENERGY EFFICIENCY

Reducing CO<sub>2</sub> and harmful emissions is one of the most important

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goals of powertrain development – and, even in this respect, InMotion has proved to be the perfect tool. Felix Pfister: “What we particularly need to do is to improve efficiency in real-life operation to about 35-40 percent – today efficiency is at about 20 percent tank-to-wheel. We’ll only be able to do it if we stop thinking in terms of individual powertrain components and start calibrating and optimizing the vehicle in its entirety. The networked overall system is the key to success.”

By running a virtual drive test along the “Auto Motor & Sport Verbrauchsrunde” – an in-use test route of a well-known German car magazine, the real consumption of a passenger car can be determined long before the journalist has taken the test drive. InMotion also distinguishes between different driver characters (anticipatory, sporty, defensive) and determines their impact on fuel consumption.

The same applies for trucks – for example in the form of the “trucker super test.” A real-time-capable 3D model of the route and the realistic virtual representation of the complete vehicle, including tires, helps to determine the vehicle’s “energetic fingerprint” in real life as well as in the legally required cycle consumption in a fast and cost-efficient manner. “Component models that do not exist in reality are integrated into the model library with the help of mock-up mechanisms,” explained Pfister.

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## “GREEN ROUTING” OR THE INTEGRATION OF THE “ELECTRONIC HORIZON”

Future navigation systems will supply the powertrain with information about ascending slopes, curve radiuses, speed limits and even traffic restrictions. Based on experience, they can even forecast which route the vehicle is likeliest to take (most probable path). Information like this can be included in the vehicle’s operation strategy, for example for forward-looking thermal management or for an optimized braking and gear-shifting strategy. For such systems to be brought to the road fast and cost-effectively, InMotion equips test beds with all the necessary capabilities – GPS antenna emulation, GPS route import, sensor interfaces, etc. As a result, it becomes possible to test the impact of ACC (adaptive cruise control) in stop-and-go driving under very realistic conditions. “In the future, peripheral sensors such as radar, lidar and ultrasonic sound as well as GPS system data will play an increasing role in lowering CO<sub>2</sub> emissions in vehicles,” says Pfister, “in this area, our partner IPG Automotive has worked hard over the past years and gained a tremendous competitive edge. Our work follows on seamlessly. It is our aim to offer a tool which enables OEMs to ‘marry’ the vehicle with its environment and optimize it in concert with its entire network.”

## VIRTUAL PROVING GROUND

Another “real-life maneuver” is a hybrid four-wheel drive vehi-



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Felix Pfister turns the classic test bed into an integrated mechatronic development platform

cle with an all-electric rear axle that has black ice underneath its front axle and wants to start uphill. InMotion helps you to determine whether the electric motor’s power is sufficient, even if the electrically powered axle is in a depression of snow or right in front of an obstacle. It gets even tougher if the driver wants to get out of the awkward situation by rocking the vehicle to and fro (“rock cycle”). Driving situations like these can be tested realistically with InMotion, so that any faults can be detected and eliminated.

Abuse tests can also be run on the test bed using InMotion: “If the juvenile driver of a car with dual-clutch transmission decides to do a Hollywood-style handbrake turn, the control system must detect the maneuver, because the car might drive backwards a few meters. If the dual clutch maintained traction in a situation

like that, it could cause serious damage to the engine.” Even active driving dynamics controls such as torque vectoring or brand-specific driving behavior can be adapted to the respective vehicle – quickly and cost-efficiently.

## PIONEERING WORK

According to Felix Pfister: “The maneuver and event-based development environment along with the seamless integration of simulation and test is the key to controlling complexity in pace with the IT industry. Conflicts between the components can be detected and corrected cost-effectively at an early stage. Results, consistent and comparable, delivered throughout the entire development process contribute significantly towards a reduction of development time and risks. AVL InMotion has turned a vision into a reality which has tremendous potential.” ←

Ford of Europe's „Director's Trophy“ was awarded for the first time to a joint Ford-and-supplier team.

## JOINT AWARD FOR EXEMPLARY TEAM EFFORT

► Ford of Europe has, for the first time, awarded their Director's Trophy to a joint Ford-and-Supplier team rather than just an internal Ford team. The supplier is AVL. Our contribution was recognized with the award, which is given every year for engineering excellence in Ford's powertrain division.

Helmut List, for AVL, and Graham Hoare, for Ford, congratulated their respective teams on a highly successful collaboration that has speeded up the engine mapping process by 300 per cent. Michael Blickle and Antonio Ciriello started the project in 2009. It has since produced outstanding improvements in performance for Ford



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Graham Hoare and Helmut List (center), congratulating the Ford-AVL-Team: Simon Palmer, Wilhelm Graupner, Antonio Ciriello, Laurence Bellamy (from left)

at 18 upgraded testcells. There have also been joint publications on change management and testing methodology produced by the joint team.

The results of the project persuaded Ford to build a standard test system and test field operation guidelines based on AVL technology as a new platform for their powertrain lab in Dunton in the UK. This has helped to double AVL's business in the UK annually since 2009.

Project leader Willi Graupner identified the seamless collaboration between PTE, Phil Williams, AVL Europe, represented by Andreas Ney and ITS, driven by Thomas Trebitsch as being key to success – alongside the UK-based account and project-management by Andy Fitt and Danny Burchill. ←

## INNOVATION DAY AT AVL IN GRAZ

A day of fascinating insights into successful innovation.

► The AVL Forum was the venue for Innovation Day 2012. The event focused on questions like: what kind of Styrian innovations have a chance of gaining a foothold in the US marketplace?

As part of the program, Josef Affenzeller provided some fascinating insights into the world of innovation at AVL. A further highlight was the racing car exhibition orga-

nized by Technical University Graz Racing Team who, with the help of AVL, develops and engineers two vehicles in the Formula Student and Formula Student Elektrik classes every year.

Representatives of the Racing Team and many other successful lecturers captivated the audience (around 50 participants) and proved once



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One of the many highlights: the racing car exhibition of Technical University Graz

again that Styrian companies and institutions are world leaders in innovation. ←

# AVL SUCCESS STORY — PROJECT CESAR

AVL has been coordinating a 60 Million Euro R&D embedded system project.



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Embeddes systems are used in many areas: aerospace, automotive, automation and rail

## AUSTRIAN CROSS OF HONOR FOR SCIENCE AND ART FOR HELMUT LIST



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Federal Minister of Science and Research Karlheinz Töchterle and Helmut List

Helmut List was recently awarded the "Austrian Cross of Honor for Science and Art, First Class" by Karlheinz Töchterle, Federal Minister of Science and Research. „Fueled by his drive and passion, Helmut List got things up and running which are of outstanding value," the minister said at the celebration at Graz Technical University. Rector Harald Kainz added: "The Austrian research landscape certainly has a strong ally in Helmut List."

► 54 partners, 10 European countries, 60 Million Euro budget, 28 Million Euro European and national funding – CESAR, coordinated by AVL – has had ambitious project goals: develop methods, processes and tools to decrease costs and effort, manage increasing complexity and maintain high quality in the development of embedded systems.

CESAR, as a "flagship project" of the ARTEMIS funding scheme, is in the spotlight of the European Embedded Systems industry. By successfully coordinating such a large project, AVL has benefited from this participation in many ways:

- It has strengthened AVL's position with OEMs and automotive partners as a well-recognized partner in embedded systems engineering (Volvo, Fiat, Audi, Daimler, Delphi, Infineon...)
- It has provided a knowledge boost for AVL through cross-domain

fertilization (aerospace, automotive, automation and rail)

- AVL has increased its influence on the future of European Embedded Systems research, participation in strategically important research projects (MBAT, pSAFECER...) and committees (ARTEMIS Steering Board, EICOSE, Process IT Sweden)
- Establishment of the AVL safety group led by Dr. Gerhard Griessnig
- Strong influence on AVL's System Engineering and System Modelling
- General baseline for the creation of an AVL Open Development Platform

Contact:

**Project Coordinator:**

Dr. Josef Affenzeller

**Project Manager:**

Dr. Gerhard Griessnig

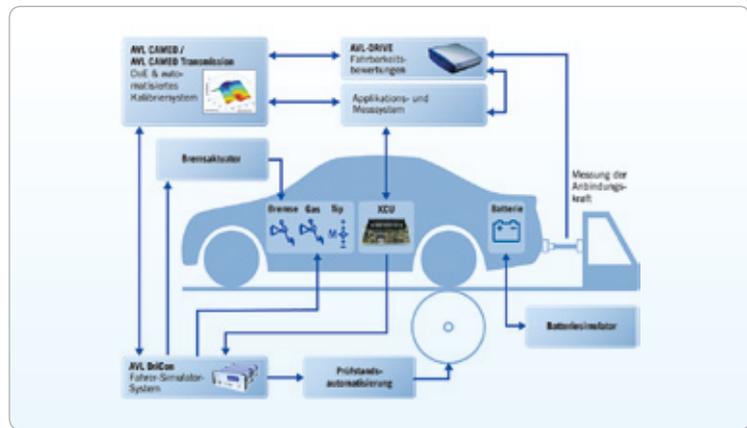
[www.cesarproject.eu](http://www.cesarproject.eu)

AVL is now able to perform hybrid vehicle calibration on powertrain test beds as well as on chassis dynamometers by using a new and innovative methodology.

# EFFICIENT HYBRID CALIBRATION

► ‘Smooth driving’ is what hybrid vehicle calibration is all about. Yet this goal can only be achieved through the perfect interplay between the five elements – combustion engine, e-motor, automatized transmission, control and battery. “To deliver good driveability, it is crucial to ensure that the transitions, for example, between electric mode and combustion engine operation are perfectly adapted to each other. This requires knowledge about the individual powertrain elements, but also about the system as a whole. AVL’s calibration experts combine this comprehensive expertise optimally,” says Gerhard Kokalj, Head of Transmission and Hybrid Calibration at AVL.

AVL has developed a new and innovative methodology to enhance calibration efficiency in hybrid vehicles, which combines simulation, automatized test bed runs and calibration on an office desktop. To begin with, the AVL CRUISE simulation tool is used to create a model of the entire vehicle, upon which virtual tests are run to determine the underlying operation strategy. The resulting base data are saved in the hybrid control device (Hybrid Control Unit, HCU), which acts as a master in the vehicle’s operation strategy. Next, the powertrain or the already finished



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The methodology combines simulation, automatized test bed runs and desktop calibration

vehicle is tested on the powertrain test bed or chassis dynamometer. Using the AVL DriCon driver simulator system on the test bed, an event is automatically initiated every 8 seconds. AVL DRIVE then measures and documents how this affects drivability.

After completing the test run, calibration and optimization activities continue with AVL CAMEO on the office desktop. The shift to the test bed and the desktop considerably shortens the calibration time. In addition, fewer prototypes are needed

and for shorter periods of time. If customers require calibration changes after the final in-vehicle validation, modifications can even be carried out on the desktop – with no need to return to the test bed. “The wide-ranging expertise of AVL’s calibration experts along with this novel methodology enable us to perform hybrid vehicle calibration very efficiently and meet all of our customers’ needs with regard to good driveability, CO<sub>2</sub> reduction, battery service life as well as safety and reliability to their utmost satisfaction,” Gerhard Kokalj added. ←

The ever-increasing complexity of advanced vehicle development is making powertrain calibration more and more time-consuming. But AVL has developed a tool to help calibration engineers focus on what matters most in their work – the results.

## INNOVATIVE TOOLS FOR THE CALIBRATION PROCESS

► Based on a component library with powerful standard modules, AVL fOXLab™ enables its users to accurately adapt their workflow templates to suit their specific calibration tasks. As a result, all post-processing steps can be found in a workflow with a uniform graphical user interface.

AVL fOXLab™ makes it easy to share all workflow templates among all calibration engineers – regardless of their location or third-party tools used. All calibration engineers need is AVL fOX™, which gives them a powerful and professional platform for their day-to-day work activities. By using standardized components, the training effort is reduced to one-off initial training. Thanks to the workflow-specific help feature, knowledge is passed on to all calibration engineers in the company and thus secured.

AVL fOX™ makes it possible to solve a broad scope of calibration tasks as well as reduce the complexity in the calibration process.

Focus on what is essential and get to the core of your calibration work!



→

Standardizing the powertrain calibration process with AVL fOXLab™

### APPLICATIONS

**Diesel engine:** torque and friction loss structure, temperature corrections for warm-up, cold-start, restart, DPF and SCR strategies, idling control, cruise control, OBD for air path, fuel path, basic diagnostics, IUPR, etc.

**Gasoline engine:** torque structure, air path, knock control, cruise control, intake pressure control, catalyst heating, restart, warm-up process, OBD functionalities, IUPR, etc.

### THE BENEFITS AT A GLANCE

**Standardization:** Use of calibration-specific components from the base library to create standardized workflow templates for application tasks.

**Usability:** Sharing workflow templates among calibration engineers is made easy by using a single platform.

**Know-how:** Compiled simulation models and workflow-specific documentation protect your expertise and reduce the necessary training effort – in a very simple and effective way. ←



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FLOWSONIX™ Air: high precision measurement system for air mass flow measurement

# FLOWSONIX™ AIR

The AVL FLOWSONIX™ Air is the first device of the new AVL Product family of ultrasonic measurement devices for fast and precise measurement of gaseous media. It is suitable for a wide range of applications in the measurement instrumentation of test beds.

► The AVL FLOWSONIX™ Air is the first device of the new AVL Product family of ultrasonic measurement devices for fast and precise measurement of gaseous media. The product was launched at the start of 2012 and recent test installations on customer sites – including IAV Berlin and Audi – showed very good results and positive feedback in terms of performance and accuracy.

The AVL FLOWSONIX™ Air is a high precision measurement system for air mass flow measurement based on the ultrasonic transit time measuring principle. The device has high accuracy and fast measurement of intake air of combustion engines at both steady state and dynamic operation conditions in both directions thanks to the specifically developed AVL sensors and the up and downstream tubing.

The system is suitable for single cylinder engines as well as for heavy duty engines up to 700 kW with a maximum air consumption of 3 200 kg/h. Intake air pulsations and intake air reverse flow of the combustion engine are accurately measured by the AVL FLOWSONIX™ Air. Full dynamic behavior is maintained without the need for filters, dampers or silencers.

The AVL FLOWSONIX™ Air perfectly matches the requirements of transient emission and certification test bed applications. Emission legislation defines the dynamic of the complete measurement chain in such applications. When measuring the emission mass of Heavy duty and Off-road engines, the dilution air for particulate measurement must be controlled quickly. This is ensured via the fast analogue signal from the AVL

FLOWSONIX™ Air (Response time  $T_{90} < 10$  ms). Furthermore the low-pressure drop of the device also makes it possible to take highly accurate dilution air of CVS systems with a very high accuracy.

The AVL FLOWSONIX™ Air is used in racing applications for Formula 1 brake test benches to simulate the cooling air for brake discs. The application requires controlling the simulation of cooling with highly dynamic behavior; the AVL FLOWSONIX™ Air is perfectly suited to this application with a response time of  $T_{90} < 10$  ms and a maximum acquisition rate of 1 kHz.

Brake dust is another challenge, making the AVL device preferable for this application, since the device is not sensitive to contamination and is nearly maintenance free. ←

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## NEW CALIBRATION AND REPAIR CENTERS FOR AVL PARTICLE COUNTER

To further improve service levels for AVL Particle Counter calibration, maintenance and repair, two brand new AVL calibration centers have been established in Graz and Detroit.

Two new calibration & repair centers for the AVL Particle Counter ensure high quality

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► Due to the tightening emission legislation all over the world, there has been a sharp rise in the global demand for AVL Particle Counters. The application areas are pre-development, development and certification of advanced combustion engines. “The particle number limit for gasoline engines to be introduced at the Euro 6 stage in 2014 has provided an additional boost,” Herwig Jörgl, Group Product Manager, told *Focus*. “The installed base around the globe is currently at some 380 devices and is still on steady rise. As the AVL Particle Counter satisfies all the legal requirements in accordance with the UN-ECE-R49/83 legislation as amended, our customers include OEMs and even institutions like TÜV.”

As a result of the high demand, special Calibration & Repair Centers adapted to suit the product specifications have been set up at AVL

locations in Graz and Detroit, where maintenance and repair services have been carried out since fall 2011. “The regulations require that AVL Particle Counters, which are used for certification, be calibrated every 12 months. The task requires highly specialized staff and extensive equipment – which is why the services are concentrated at two AVL locations,” Eva Egger, Head of the Calibration & Repair Center in Graz, explained.

To ensure safe transport, special containers are used. Once they arrive at the Calibration & Repair Center, the devices are inspected, which includes a validation. If the measured values are within the tolerance range, this is confirmed with a certificate. If deviations are detected, an adjustment (UN-ECE-R83 calibration) is required. In this case, the device’s dilution system is adjusted with either

3 or 14 dilution rates, depending on the type. The work takes between 8 and 12 hours. As part of the calibration service, the AVL Particle Counter usually undergoes maintenance and is also automatically updated to reflect the latest state of technology – at no extra cost to the customer.

To keep operational downtimes to a minimum, AVL employees proactively schedule the necessary service and calibration appointments for the AVL Particle Counter with their customers on a regular basis. At the customer’s request, AVL can also provide a loan device for the length of the calibration or repair work. “Our two new calibration centers enable us to carry out servicing on AVL Particle Counters all over the world in a fast and uncomplicated way and ensuring high quality,” Eva Egger added, summing up the benefits of the new AVL Calibration & Repair Centers. ←

# AVL MOBILIZES CUSTOMER COMMUNITY

AVL Customer Services started inviting its customers to help shape its range of services in 2010. Meanwhile, the Customer Advisory Board has already had its third meeting, and the positive feedback has shown just how important it was to establish this trendsetting collaboration.

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► AVL Customer Services has set itself the task of not only acting as a bridge between development divisions and customers, but also of translating the AVL product portfolio's value into permanent and solution-oriented benefits to customers. To be able to meet these tasks effectively, and to the utmost satisfaction of its customers, AVL decided to take an unusual step: in 2010, AVL's longstanding experience of customer service led to the realization that customers – whether passenger car manufacturers or producers of large engines – had very similar expectations when it comes to availability and procedures relating to services. “When in 2010 the Customer Advisory Board was established, we dared to do a fairly unusual experiment,” says Jens Poggenburg, Director AVL Global Customer Services. “We deliberately made sure that the first two meetings gave people plenty of freedom and entered into the discussion with a single approach and no specific expectations. What we wanted to do was to present our customers with our offer to help them find solutions, and then see what could come out of it.”

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The third meeting of the Advisory Board in January 2012 was attended by representatives of renowned companies like BMW, Bosch, Daimler, GM, MTU, Umicore and Volkswagen and delivered tangible results. “The customers have become aware of the opportunities the exchange offers, and they can see that AVL is working hard to find efficient processes and methods to make collaboration even easi-



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JENS POGGENBURG,  
Director Global Customer Services  
Instrumentation & Test Systems

er. The customer community is busy sharing views and opinions. The resulting added value benefits all participants and is able to be implemented on a global scale.”

By promoting this discourse, AVL is pushing developments forward which customers regard as necessary, future-oriented and capable of reducing complexity. One outcome of the discussion was that the solution chain from customer to customer (end-to-end) could be made less complicated.

Rolf Prein, Head of Customer Services at AVL Germany: “AVL has reached a size and market penetration that no longer permits questions to be answered directly by a single employee. Today, the employee may bring on board solution partners from a wide variety of areas. This process must be designed in such a way that ensures customers get help fast, but remain unaware of any internal interfaces.” With measures like design-to-service, a global and professional tool landscape, the power to have an influence on product development and customer community collaboration, AVL is redesigning the future of customer services. ←

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AVL Conference "Engine & Environment" 2012

# 95 – 70 – 50 g CO<sub>2</sub>/km EVOLUTION OR REVOLUTION?

How can vehicle CO<sub>2</sub> emissions be reduced efficiently? This and many more questions will be discussed at the 24<sup>th</sup> International AVL Conference "Engine & Environment", taking place on September 13 and 14, 2012 in Graz.

► Legislators around the world are increasingly clamping down on CO<sub>2</sub> emissions. What contribution can and must the combustion engine make to achieve the targets? What is the role of biofuel in this context? Or can the targets only be achieved with revolutionary solutions? What contribution can electrification make with full consideration of CO<sub>2</sub> emissions from power generation?

At the 24<sup>th</sup> AVL Conference "Engine & Environment" these and many more questions will be examined in detail by international experts, and cutting-edge solutions presented. The renowned speakers and panelists include: Axel Eiser (Audi),



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Participants from 20 countries made the 2011 conference a great success. We are looking forward to your participation at this year's event!

Below: Scan QR code and launch app.



ENGINE & ENVIRONMENT

Prof. Uwe-Dieter Grebe (GM), Wolfgang Hall (BMW), Gerald Killmann (Toyota), Dr. Rudolf Maier (Bosch), Prof. Gernot Spiegelberg (Siemens), Dr. Frank Zhao (Geely).

As in the previous year, the "Engine & Environment" Mobile Forum app will keep you informed about all the updates concerning the conference. The free app can be downloaded for Android terminals, iPhones and iPads as well as for BlackBerry devices.

Registration and information about the conference and the Mobile Forum app at:

[www.avl.com/ee-programme-2012](http://www.avl.com/ee-programme-2012)

## 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)





## AVL EFFICIENT POWERTRAINS – 20% LESS CO<sub>2</sub>

Future CO<sub>2</sub> legislation for commercial vehicles will require substantially increased fuel efficiency. Optimizing the whole powertrain system is the key to achieving a CO<sub>2</sub> reduction of 20% and more.

AVL's holistic approach begins with the powertrain, but also extends far beyond it, and includes:

- New powertrain configurations
- Revised engine concepts and specifications

- New transmission technology with advanced shift strategies
- Reduction of friction and parasitic losses
- Optimization of exhaust gas aftertreatment
- Waste Heat Recovery
- Hybrid powertrains optimized for Commercial Vehicle application

[www.avl.com/heavy-duty-on-road](http://www.avl.com/heavy-duty-on-road)