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AVL

THE AVL MAGAZINE FOR
POWERTRAIN DEVELOPMENT,
TESTING AND SIMULATION

powertrain & drive focus

» WE PULL ALL THE
LEVERS WE HAVE
TO MAKE OUR CARS EVEN
MORE EFFICIENT. «

PROF. DR. THOMAS WEBER,
MEMBER OF THE BOARD OF MANAGEMENT OF DAIMLER AG
GROUP RESEARCH & MERCEDES-BENZ CARS DEVELOPMENT

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Around the World

.12 The Connected Powertrain

.16 AVL Integrated Open Development
Platform





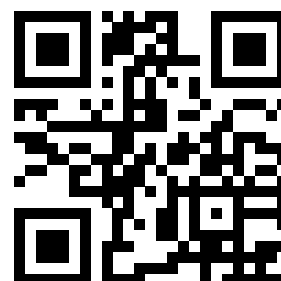
AVL POWERTRAIN WORLD APP

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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Prof.
Helmut List
Chairman
and
CEO AVL



Innovation is the basis of AVL's development activities. We are working intensively on new technologies and methods to make the vehicle drive more efficient and environmentally friendly. This not only concerns the internal combustion engine and exhaust aftertreatment system, but also the electrified powertrain with transmission, electric motor and battery.

To be able to advance these technologies, AVL invests around ten percent of its sales revenues in self-financed research. Our R&D activities are focused on key issues, such as efficiency enhancements in drives for light-duty, heavy-duty and off-road vehicles, while paying particular attention to powertrain cost and driveability. Here, our central approaches involve achieving the greatest level of integration and modularization of components possible.

Crucial to the future development of these drive systems is AVL's Integrated Open Development Platform strategy that enables close interaction between virtual development and testing on the test bed, thus reducing the development time for complex drives considerably.

Thanks to its global reach – and based on these innovations and fundamental technologies – AVL is able to provide its customers all over the world with products and solutions accurately geared to the needs of the local markets.

Helmut List



Interview with Prof. Dr. Thomas Weber, Member of the Board of Management
of Daimler AG, Group Research & Mercedes-Benz Cars Development

» WE PULL ALL THE LEVERS WE HAVE TO MAKE OUR CARS EVEN MORE EFFICIENT «

► **«F»: Dr. Weber, the internal combustion engine today is the driving force inside the automobile. What role do you think will the combustion engine have in the future?**

«Dr. Weber»: We are confident that – alongside the gradual driveline electrification – the combustion engine will still feature prominently on the world's roads. The further development of the internal combustion engine will, of course, continue, though. Despite all of its optimizations so far, the combustion engine still has plenty of potential, which we are determined to exploit! Our mission is to provide high-efficiency and low-emission combustion engines, particularly sustainable hybrid vehicles and electric vehicles powered by fuel cell or battery. Apart from the

drive, we will continue our electrification efforts at the component level, too. This includes electric steering and electric auxiliary units that can be switched off for all of our series.

«F»: **What optimization potential does the diesel or gasoline engine still have? To what extent can the electrification of auxiliary units, for example, contribute to engine optimization?**

«Dr. Weber»: Where the combustion engine is concerned, we still see potential savings of about 15 percent. Besides many other technology cornerstones, the electrification of the auxiliary units is a very important lever for the future. It includes electric steering and electric auxiliary

units that can be switched off for all series. Fuel consumption can additionally be lowered by optimized transmission, aerodynamics and, for example, by electric steering. Measures like these lead to incredibly efficient vehicles like our ML 250 BlueTEC 4MATIC, requiring as little as 6.0 liters for 100 kilometers. This makes it not only the most economical vehicle of its class, it even beats all comparable hybrid SUVs of our competitors.

«F»: **Mercedes-Benz already offers several hybrid-drive vehicles. What significance will the hybrid drive have for Mercedes over the next 10 to 15 years?**

«Dr. Weber»: The hybrid drive is already an integral part of our tripartite drive strategy of high-tech



PROF. DR. THOMAS WEBER
MEMBER OF THE BOARD OF MANAGEMENT OF DAIMLER AG
GROUP RESEARCH & MERCEDES-BENZ CARS DEVELOPMENT

Prof. Dr. Thomas Weber has been a member of the Board of Management of Daimler AG since January 1, 2003. In this function, he has been responsible for Group Research & Mercedes-Benz Cars Development since May 1, 2004. Prof. Dr. Weber was born in Schamhausen on May 26, 1954. Following technical training at the then Daimler-Benz AG, he studied mechanical engineering at the University of Stuttgart and graduated as an engineer in 1980. He was later employed as a Scientific Associate at the University of Stuttgart and the Fraunhofer Institute. He completed a doctorate in 1987 at the University of Stuttgart and joined the then Daimler-Benz AG in the same year. In 2010 he was appointed as Honorary Professor by the University of Stuttgart.

combustion engines, hybrid drives and fully electric drives with battery or fuel cell. All of these drive types will be moving the cars of the future.

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Just how big their respective share will be naturally depends primarily upon customer acceptance and customer demand. Especially where larger vehicles are concerned,

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the hybrid drive and, most importantly, the plug-in hybrid will play a very major part.

«F»: At Mercedes-Benz, hybrid drives are combined with diesel as well as gasoline engines. The “Modulare-Hybridbaukasten” additionally provides various electric motors, batteries and transmissions to choose from. Will every type of Mercedes have its very own “custom-made” hybrid drive?

«Dr. Weber»: When we develop our vehicles, we attach great importance to finding the ideal technical concept for every model. Our modular system was designed in such a way to ensure that we can offer an additional hybrid version for each series in the C-Class and higher – and in this respect we have reached a level of flexibility that even allows us to satisfy regional demands: By offering the E-Class as both a diesel and a gasoline hybrid version, we already have one of the most efficient models in this segment perfectly adapted to very different markets. We also intend to launch the plug-in hybrid, starting with the new S-Class generation. With a fuel consumption of little more than three liters, it will set new standards in the luxury sedan segment.

As for compact cars, from today’s perspective, it would be a good idea to focus mainly on totally emission-free driving with battery or fuel-cell technology. In the A-Class, we have achieved 92 grams of CO₂ per kilometer, which is already extremely low by today’s standards. From my point of view, the move toward zero emissions is obvious and logical.

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World premiere of the Mercedes-Benz S-Class, which will also be available as a plug-in hybrid.

«F»: With its smart fortwo electric drive, Daimler AG also has a battery-powered electric car in its vehicle range – meanwhile in its third generation. How do you rate the prospects of this drive concept? And will its scope of application remain limited to urban areas?

«Dr. Weber»: We view the electric smart as a complete success. By the end of 2012, we had rolled out more than 1,000 vehicles of the latest generation, and for 2013 we intend to produce around 6,000 smart fortwo electric drive vehicles. Obviously, battery-powered electric vehicles will remain ideally suited for application in cities, in other words, in an urban environment. Where the smart is concerned, particularly, vehicle concept and drive are a perfect match. And judging by the sales figures, that's exactly how our customers see it, too. For covering longer distances locally with zero emissions, we are additionally focusing on fuel-cell powered electric mobility.

» WHERE THE
COMBUSTION
ENGINE IS
CONCERNED,
WE STILL SEE
POTENTIAL SAVINGS
OF ABOUT
15 PERCENT «

We see a lot of potential in this field. Not only for compact, but also for larger vehicles, even city buses.

«F»: Daimler has formed an alliance with Nissan and Ford for joint research and development in the area of fuel cell technology. What significance do you

attach to the hydrogen fuel cell as a future power source for the vehicle drive?

«Dr. Weber»: Hydrogen is certainly the energy source of the future and has by far the greatest potential when it comes to zero-emission driving. It is not surprising that practically all of the major automotive manufacturers have meanwhile started to focus on fuel cell technology. Our partnership with Ford and Nissan in this field is a magnificent opportunity to implement this technology in high volumes and to offer it in the global markets at attractive prices.

«F»: What are the key factors determining the distribution and acceptance of the fuel-cell technology, and is there a way you as an automotive manufacturer can influence them?

«Dr. Weber»: We have already demonstrated on several occasions

that the fuel-cell drive is suitable for daily use. Firstly, it is being used by customers on a daily basis, and, secondly, the technology was applied on more than 30,000 kilometers at the "Mercedes-Benz F-Cell World Drive" all around the globe. One of the main tasks in further advancing this technology is to find ways to reduce the costs substantially. But an extensive market penetration depends on other factors, too. Very crucial factors in this respect are the political framework conditions and the availability of an extensive infrastructure – in other words hydrogen filling stations. Other factors include the development of a competitive component-supplier landscape.

«F»: How can synthetic fuels – biomass-to-liquid (BTL) or gas-to-liquid (GTL) fuels – contribute toward reducing fuel consumption and emissions? Will natural gas eventually play a bigger role in this respect?

«Dr. Weber»: Alternative, regenerative fuels are also part of our strategy. Where this is concerned, we are focusing mainly on 2nd-generation fuels, in other words so-called BTL (biomass-to-liquid) fuels which can be made out of waste materials. This has a lot of advantages in terms of sustainability and CO₂ savings. This is because, with BTL fuels, higher yields per hectare can be generated and various kinds of biomass and bio waste materials can be used, which rules out any competition between food and fuel.

With natural-gas powered vehicles, we do still see plenty of potential. Already today, we have the Mercedes-Benz E-200 NGT

BlueEFFICIENCY and the Mercedes-Benz B 200 Natural Gas Drive in our range, which are two highly appealing products. The advantages of natural gas are the low specific carbon content and the low-emission combustion. But to make it even more appealing to our customers, we first need the appropriate political framework conditions along with an extensive infrastructure sui-

of any danger well in advance. At the same time, it provides for optimum flow of traffic. In the EU research project PRE-DRIVE C2X, a study revealed that up to 5 percent of fuel could be saved if all vehicles were equipped with the appropriate technology.

Another very recent example for this is real-time traffic data. By the

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COMBUSTION ENGINES, PARTICULARLY
SUSTAINABLE HYBRID VEHICLES AND
ELECTRIC VEHICLES POWERED BY
FUEL CELL OR BATTERY. «

table for this type of fuel. The challenge is a collective one!

«F»: The connectedness of cars, to the driving environment as well as to other vehicles, is steadily increasing. Can this kind of connectedness – based on driver assistance systems, navigation devices and other new systems – also be used to increase the efficiency of the drive?

«Dr. Weber»: It certainly can. The best example for this would be car-2-x communication – in other words, the exchange of information between different vehicles or between vehicles and the traffic infrastructure. Equipped with this technology, drivers are not only warned

end of this year, we intend to equip most of our vehicle models with this technology. This particular service informs drivers early on about traffic disruptions along their route so that they can adapt the route according to the latest traffic situation. Our customers not only save valuable time, they also curb the vehicle's fuel consumption.

«F»: Alongside powertrain optimization, where do you see the greatest potential for savings? And how important is the vehicle architecture, in other words what roles do light-weight construction measures and materials like composite carbon fiber play?

«Dr. Weber»: We pull all the levers we have to make our cars even more economical and efficient. This

includes targeted lightweight construction, embedded in a vehicle construction that is as flexible and as consistently optimized as possible. In this respect, we rely on an intelligent material mix of high-strength steels, light metal and synthetic materials based on the motto, the right material in the right place. The decision on which material to use and where depends on weight, ecological balance, cost-efficiency and, more than anything else, a material's function.

It is our mission to offer drivers and passengers the highest possible level of safety. So to protect the passenger compartment optimally in the case of an accident, we combine different kinds of materials and can thus make the most of the different advantages each material has. In parts that are considered particularly relevant in terms of safety, for example the B-pillar, we rely on ultra-high-strength steels. We only use aluminum in the body shell, the so-called hang-on parts as well as in the front and rear end. We additionally use mounted parts, like the inner part of the trunk lid in the SL AMG which consists of FRP/CFRP.

«F»: The emotional component is a very important factor where cars are concerned. How do you manage to make the Mercedes a car that will always be a pleasure to drive – despite the economy and environmental compatibility of its drive?

«Dr. Weber»: It works because our development team follows a guiding principle right from the start of every project: to bring together fascination and responsibility. The results are highly emotional products, such as our new A-Class. Here we have developed an exceptionally attrac-



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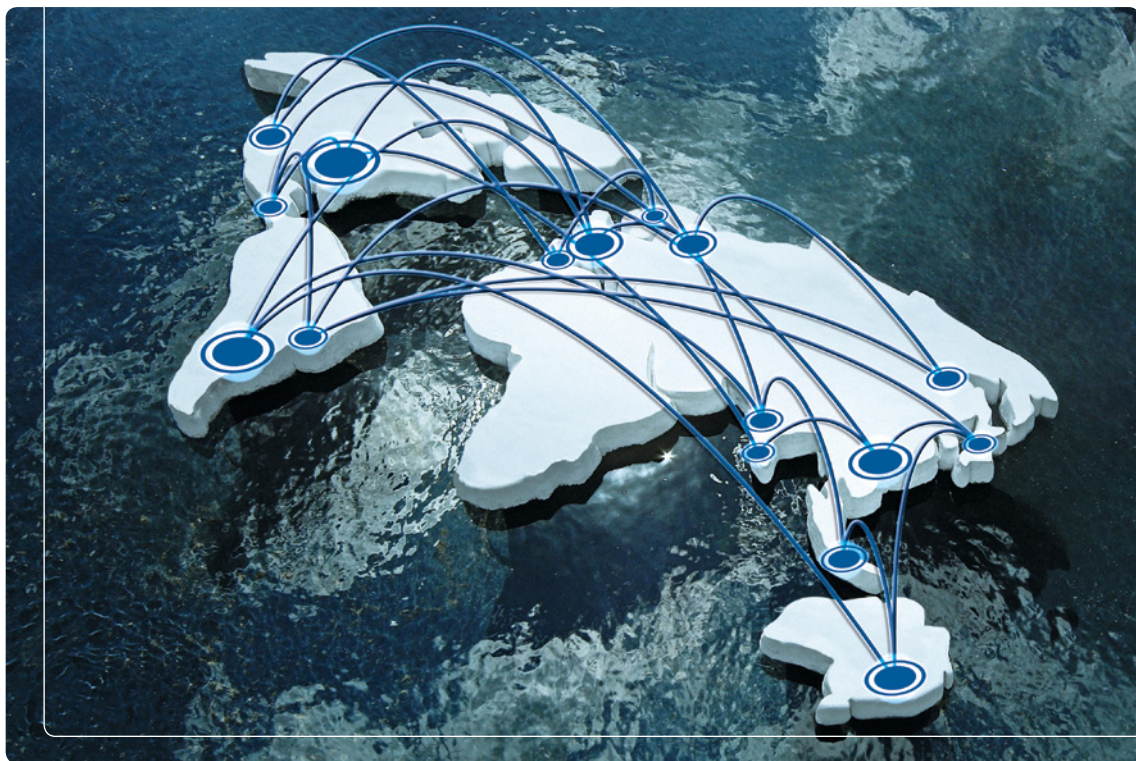
"Mercedes-Benz World Drive" – with fuel-cell drive around the world, the new B-Class Electric Drive and Natural Gas Drive, the smart fortwo electric drive (top down).

tive, sporty compact vehicle, which defines the premium of this segment not merely via its fascinating design. With a fuel consumption of 3.6 liters and 92 grams of CO₂ per kilometer, the new A 180 BlueEFFICIENCY Edition also achieves optimum values when it comes to fuel consumpti-

on. And who ever claims that electric cars and big emotions don't go together has definitely not yet had the pleasure of driving our smart fortwo electric drive: smooth acceleration and maximum torque right from the start; now that's what I call pure driving pleasure – with "zero emissions!" ←

TESTING AND DEVELOPMENT SUPPORT AROUND THE WORLD

Focus spoke to Martin Panzitt, AVL's Director of International Tech Center Management for Powertrain Engineering and Wilhelm Graupner, AVL's Director for Testfield Efficiency. They told us how AVL's global network provides a unique proposition to OEMs to meet local and global demands for both development and testing, especially as they expand into new markets such as those in Asia.



► There are clearly many synergies between testing and development, and the fact that AVL has built up a global network that is expert in both areas means that OEMs can benefit from its expertise in each as well as the cross-

pollination that inevitably occurs between the two. Panzitt describes how AVL has spent the last couple of decades building up this global network so that it is well equipped to help OEMs with a variety of challenges. "It has been a lot

of hard work building up the network but in the last few years we have been able to harvest the advantages we have built up. The maturity of our global reach has required a great deal of investment and training – and that is our major advantage over our competitors."



» WE CAN OFFER SUPPORT ON A GLOBAL AND LOCAL LEVEL SIMULTANEOUSLY. «

MARTIN PANZITT

A global network can sound like one of those amorphous corporate concepts, but Panzitt explains how it works. “Some business you can only do when you are close to your customers. What are their challenges and what do they want to do? It has always been important for us to learn from our customers and the only way we can effectively do that is not to have 30 mini-AVLs spread around the world, but 30 locations doing solution-focused engineering work for the customers that they’re each engaging with. The idea is that there is a network of thinking and local entrepreneurship. It is like an intelligent organism – a true network rather than an unresponsive corporation.” Panzitt identifies some of the different stages that AVL are brought in to the development

process by partner manufacturers, which can be summed up as: product consultant, technology provider, fully responsible development and calibration partner, supplier management interface and troubleshooter.

The troubleshooting role that Panzitt identifies is often needed when a new model arrives in a new market and unexpected things happen. “This is where our local knowledge across 30 global locations can really help OEMs to get problems solved quickly,” he says. “We have a two tier approach to account management so that we can offer support on a global and local level simultaneously. The global account management in particular is something that we are developing right now, making sure that we act in a true spirit of partnership and help our customers to protect their know-how in a highly competitive environment.”

ONE LANGUAGE IN POWERTRAIN

That same, simultaneous support at both local and global levels is also emphasized in terms of testing by Wilhelm Graupner, who states that: “The first step to providing global support to our customers is through

presence – by being where are customers are so that we can help them directly.”

But Graupner also says that AVL also provide the tools that enable OEMs to serve their global markets in the most effective way, regardless of where they are: “We have helped them to standardize their global operation and give them a cost-effective global organization: whether you purchase AVL software and hardware in Russia, Korea or the US, a company knows that it is the same in all places, which helps give them the certainty to make critical decisions. We think of it as ‘one language in powertrain.’”

“We are also actively supporting our customers with 24/7 customer service that is accessible through a number of different means including online documentation, helplines and online training programs. For us, the sun never sets.”

Together, these form a well-integrated combination of localized centers of expertise – that have been guided by customer needs in specific places – along with a standardized global model, helping them with the massive effort needed to tune a large number of vehicle variants in different places.

“We give them the software and tools that speed up the development of the base vehicle and at the same time create the model, data, test and simulation backbone that allows them to calibrate vehicles locally with a minimum of effort.

“The way in which we’ve connected the dots means that it’s a win-win situation both for our customers and for us.” ←

CONNECTED POWERTRAIN – DRIVE SYSTEM COMMUNICATES WITH ITS ENVIRONMENT

Connecting the powertrain with its environment and other vehicles opens up new possibilities to optimize consumption and emission performance in real driving operation. AVL is the perfect development partner for this trendsetting technology.



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The Connected Powertrain takes advantage of 3D satellite navigation, car-to-x information as well as vehicle-internal data (the vehicle battery's state of charge, choice of speed profile, etc.) to optimize the operating strategy.

►Put in greatly simplified terms, the Connected Powertrain principle means that the powertrain communicates with its driving environment in order to make better use of existing optimization potentials. This can contribute towards the further reduction of vehicle consumption and emission levels. Given the major significance of this novel technology, the international AVL conference “Engine & Environment,” taking

mation or adaptive cruise control devices with park distance control. Up until now, the use of this type of information was mainly limited to driver assistance systems and various safety and comfort features. The idea behind the Connected Powertrain concept is this: if the data provided by such systems – and those yet to be developed – are additionally used for the powertrain’s operating strategy, savings can be achieved in

vides for a wide playing field for optimization.

“The Connected Powertrain is all about harnessing different types of environment-related information to achieve perfect interaction between all components of the powertrain. This information from the outside can serve to exploit any existing, yet unrealized potential – for example in any hybrid drive – to enhance

» AT THE MOMENT, NO MORE THAN AROUND 30 PERCENT OF THE POTENTIAL AVAILABLE DUE TO THE CONNECTION BETWEEN THE COMPONENTS IS USED. «

KLAUS KÜPPER,
Head of Drive System Development



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The Connected Powertrain enables the optimized interplay of the five elements of the electrified powertrain and their ideal dimensioning.

place from Sep. 5-6, 2013 in Graz, will be dedicated to this subject.

Modern vehicles today are already provided with a vast number of systems and sensors capable of gathering and processing additional information about the driving environment, for example navigation system devices that include traffic reporting and topographical infor-

consumption and the vehicle’s real-world emissions. This can be used with the classic powertrain – e.g. by applying an optimized gear shifting strategy – or with electrified solutions. Particularly where the hybrid drive is concerned, merely having the option of selecting the most efficient drive system suitable pro-

efficiency. At the moment, no more than around 30 percent of the potential provided by the connection between the components is exploited,” explains Klaus Küpper, Head of AVL Drive System Development.

“The important thing now is to exploit this potential, because it is only through a connected powertrain

that significant improvements can be achieved in those areas that currently present the greatest challenges to the automotive industry, i.e. the lowering of CO₂ emissions, the reduction of real-world driving emissions and reduced costs for electrification components,” says Günter Fraidl, AVL Head of Drive Systems Passenger Cars. “AVL is the perfect development partner for this task, because this kind of drive system is becoming increasingly complex. This is the reason why simulations are getting more and more important, as are modern test-bed and testing environments for validation. Simulations like these, as well as cutting-edge test systems, are developed right here at AVL – and are available to us for the development of these progressively more complex drive systems.”

AUTONOMOUS ENERGY SAVING

The simplest connection between the drive and the driving environment can be achieved by using a state-of-the-art on-board navigation system which also delivers information about the route profile.

Klaus Küpper: “This might be information about gradients or about the road conditions ahead, which enters the central control unit by a standard interface. Other information might include the latest updates on traffic delays and jams. In a Connected Powertrain, even entering your destination might have an impact on which operating mode is best used in a certain driving situation: if your destination is in a city, for example, electric driving should have priority there. In this case, the batteries are given a break and a chance to

recharge particularly during inter-urban operation.” Such geographic information can additionally be useful for the batteries’ recharging and discharging strategy. “Should the vehicle detect that it has to manage a gradient followed by a longer downhill period, it will first drive with maximum battery power in order to discharge the battery. Driving down-

ahead of the vehicle, the vehicle is informed about it and then chooses the best operating mode. For efficiency reasons, a hybrid car would cover this short distance up to the red traffic lights without internal combustion engine and with optimum recuperation.” “As this happens entirely without any effort of the driver, it can be referred to as “autono-

**» THANKS TO THE CONNECTED POWERTRAIN,
WE ARE ABLE TO ACHIEVE SIGNIFICANT
IMPROVEMENTS IN IMPORTANT AREAS:
REDUCTION OF CO₂ EMISSIONS,
LIMITATION OF REAL-WORLD
DRIVING EMISSIONS
AND REDUCED COSTS
FOR ELECTRIFICATION. «**

GÜNTER FRAIDL,
Head of Drive Systems, Passenger Cars

hill, the battery can then recuperate energy to maximum extent.”

In the future, major influencing factors will also be represented in c2x information (car-to-x). In this case, the vehicle communicates both with the infrastructure (traffic lights, traffic management systems, etc.) and with other vehicles. Klaus Küpper gives the following example: “If the traffic lights turn red 400 meters

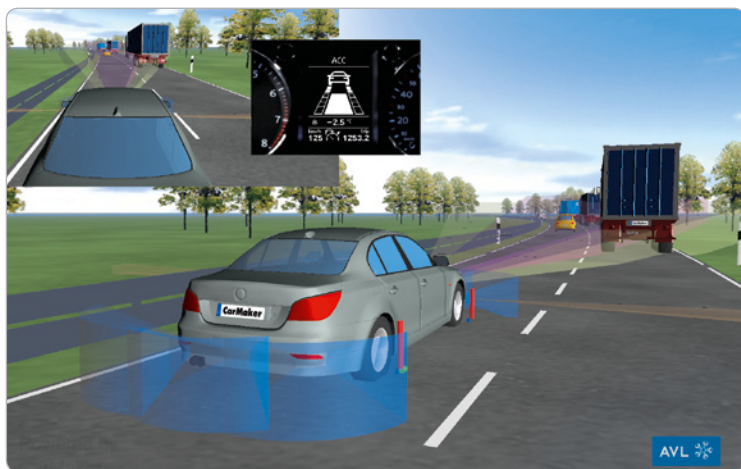
ahead of the vehicle, the vehicle is informed about it and then chooses the best operating mode. For efficiency reasons, a hybrid car would cover this short distance up to the red traffic lights without internal combustion engine and with optimum recuperation.” “As this happens entirely without any effort of the driver, it can be referred to as “autonomous energy saving,” Günter Fraidl added. Autonomous energy saving could also be applied to an acceleration and speed profile chosen by the driver. “This kind of energy flow control within the powertrain takes place below the driver’s perception threshold.” According to the expert, any additional information relating to the driving environment, traffic density, etc. could equally be used to actively support the driver or – in the more distant future – for autonomous driving.

IDEAL COMPONENT DIMENSIONING

For the development of new electrified powertrains, components can be dimensioned smaller due to the

optimize,” says Günter Fraidl. If the vehicle happens to be an electric car that has a range extender, the ideal point in time can be chosen for activating it – via the Connected Powertrain. “Due to the accuracy of the

real-world driving conditions from 2017 onward. The Connected Powertrain can make an essential contribution towards reducing real-world emissions. Klaus Küpper: “As the operating mode is continuously optimized online to suit the current and future driving situation, which is about to occur several 100 or 1000 meters later, it is possible to reduce the emissions in real-world driving conditions. Even with the communication and safety systems already available in modern vehicles, as much as half of the consumption and emission reduction potential can be harnessed. For the other half to be used too, the previously mentioned c2x communication is needed, the majority of which is still in the development stage.”



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The Connected Powertrain requires new development methods: driver assistance systems like, for example, an adaptive cruise control (ACC) can be simulated on the test bed with AVL InMotion.

more highly efficient control capability. This primarily concerns the size of the battery, which constitutes one of the major cost factors in electrification. It also has an influence on the size of the e-machine, yet to a lesser extent. “If the components remain the same size, the Connected Powertrain allows us to give drivers of hybrid vehicles an extended range of up to 15 percent. The driver’s behavior is still the decisive factor though. The greatest improvements can be achieved with a mixture of electrically powered and combustion-engine-powered driving, as purely electric driving is not as technically complex and thus less easy to

predicted energy requirements, it becomes possible to ideally dimension the range extender’s power output. There is always a certain amount of power reserve left in the battery to be able to cover the power peaks. As a result, the range extender may be designed only to meet mean power requirements – and not the driving motor’s peak power,” Günter Fraidl explained.

OPTIMIZED REAL DRIVING EMISSIONS

Due to the statutory requirements, emissions have to be measured in

AVL CONNECTED DEVELOPMENT

Mastering the increasing complexity of the Connected Powertrain requires a multitude of new development and validation methods. “Without state-of-the-art simulation tools and testing environments, which are also capable of simulating modern driver assistance and cruise-control systems, it will not be possible to develop a drive system this complex. We at AVL, however, are in an ideal position: Both the simulation tools and the required test systems are developed by AVL. In the context of Connected Development, we can exploit a great many synergies – for the benefit of our customers all over the world,” says Günter Fraidl, summing up the advantages of having AVL as a development partner for connected drive solutions. ←

» THE IDEAL APPROACH IS INTEGRATED, CONSISTENT AND OPEN «



The Integrated Open Development Platform offers AVL customers a trendsetting new solution that can help them to master the growing complexity in powertrain development.

Interview with Kai Uwe Voigt, Executive Vice President of Instrumentation & Test Systems, and Michael Conrad, Director of Portfolio Management Integration Software Products.

► **«F»:** What new challenges does the automotive industry face in the development of powertrains?

«Voigt»: Vehicles and powertrains are growing progressively more complex. This development is being driven by two factors: firstly, by the consumers' demands for more comfort and safety and, secondly, by the legislation, which is imposing tighter limits on fuel consumption and exhaust emissions. Conventional

mechanical links inside vehicles are being replaced by electronic systems, giving the vehicle the characteristics of a complex overall system with a multitude of flexibly coupled, single components. To develop systems with this kind of complexity, new tools and new methods are required.

«F»: What kind of new development procedure is needed to respond to the changing requirements?

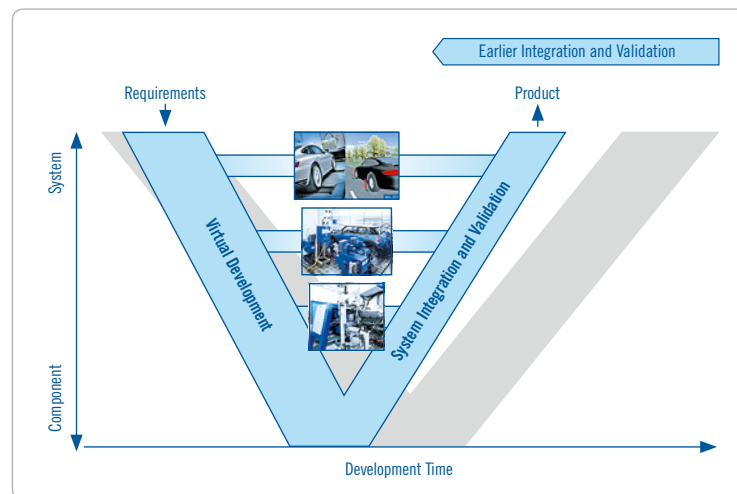
«Conrad»: It is crucial that the increased interaction between each of the powertrain components, the interaction between the powertrain and the vehicle and the communication between the vehicle and the environment – keyword: “connected powertrain” – must all be taken into account during development. Another factor to be considered is that innovation cycles are getting shorter and shorter. I.e., a more complex system must be developed at a faster pace and without ever compromising on the quality. This means that vehicle development today must become more agile: Iteration loops have to be accomplished and concepts validated at an ever increasing pace. One could compare this trend with that in the software industry, which similarly applies much more agile methods of developing software than it did in the past.

«F»: Does this new kind of procedure lead to changes in organization and processes?

«Voigt»: The classic V-Model remains valid. The biggest difference from our previous approach is that now components and sub-systems are already validated as to their compliance with sub-specifications at a

very early stage, i.e. in the V-Model, connections have to be established at all levels between the draft/simulation branch and the integration/validation branch. It helps to imagine these connections as bridges, connecting the two parts of the “V” – and it is these bridges which AVL makes available with the Integrated Open Development Platform.

tion. At the same time, we decided to expand our portfolio of instrumentation and test systems. Today, we offer test bed solutions ranging from component validation to powertrain validation in real-world vehicle operation. This chain of tools provides the basis for AVL’s ability to offer integrated solutions which are being used by a large number of major OEMs all over the world.



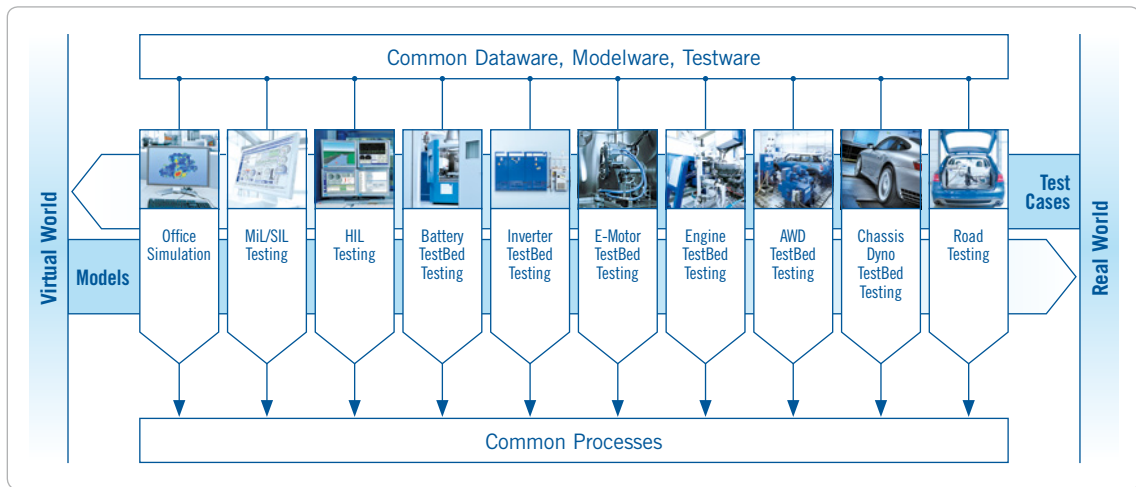
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AVL Integrated Open Development Platform: virtual development on the left side and system integration/-validation on the right side of the V-model are connected through consistent tool chains.

«F»: How did AVL respond to these new demands in powertrain development?

«Voigt»: AVL responded at many levels. To begin with, the company underwent a major change: we evolved from being a pure engine developer to an overall-powertrain developer. As part of this strategic expansion of our portfolio, we were practically forced to deal intensively with the subject of system design and valida-

«Conrad»: We shifted our development philosophy from a product-centered approach toward a system concept. One important move in this respect was the introduction of the software-suite concept in 2009. The demands are now specified at system level and subsequently broken down to the level of individual products. This ensures optimum performance across the overall system. A further challenge is achieving consistency of development systems throughout the entire development process.



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Simulation models, test methods and data are kept consistent across the entire development process.

«F»: What areas of the development platform does consistency refer to?

«Conrad»: It refers to several core areas: these are simulation, test methods and data consistency. Where simulation models are concerned, it is very important to choose a modular structure, so that the models are scalable and able to be employed in differing environments. The second area involves the test methods themselves: here, there is a growing tendency to select real world usage scenarios, which are kept consistent across the entire testing process. The third level is data consistency, i.e. data once captured has to be usable throughout the entire process.

«Voigt»: In this respect, models with real-time capability, where information can be transferred from the virtual to the real world, are of particular significance. The challenge here is to have exactly the right model



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KAI UWE VOIGT,
Executive Vice President Instrumentation &
Test Systems

available at the right time and in the required quality. This requires the consideration of several approaches: On the one hand, there are models based on a modular structure where sub-models are simply replaced with actually existing components on the test beds. On the other hand,

approaches are taken which involve deriving simplified, real-time capable models from more complex ones. Sometimes, semi-physical models are used too, i.e. physical models which are combined with data-driven models. Crucial to this is the consistency of model descriptions and parameterization data.

«F»: Is it possible to assume that there is an increased blurring of boundaries between simulation and testing environment?

«Conrad»: The combination of simulation and physical testing environment is the key to being able to validate concepts as early as possible. Today it is barely possible to specify a component without considering the overall system context, i.e. the load profile of an individual component can no longer be predicted without the system context. And in this respect, the interaction between simulation and testing is a very important factor.

«Voigt»: Both areas have their purpose and value in the development process. There are applications where simulation is more dominant and others where testing is in the foreground. Models, basically, have a limited scope of validity, which is why it is essential to combine real subsystems with virtual subsystems, depending on the development task. Limitations in models can then be compensated by running real tests. In addition, it is precisely the intelligent combination of in-depth, physical understanding in the virtual world and practical experience gained through tests and experiments which results in valuable insights. A decisive factor is always the choice of the right combination of simulation and testing, depending on the task. We here at AVL have one very big advantage: The business units AST (Advanced Simulation Technologies) and ITS (Instrumentation & Test Systems) work together very closely in the development of trendsetting solutions.

«F»: **What methods are used for testing the components and the overall system as realistically as possible?**

«Conrad»: Depending on the phase in the development procedure, various different real/virtual combinations are chosen. The important thing is to have a consistent description of the test scenarios. In this respect, the term “maneuver-based testing” has become established. These tests are based on real world driving scenarios and also on theoretical abuse scenarios where safety measures have to be taken. These maneuvers are used regardless of the development environment – whether

in pure simulation or on a chassis dynamometer.

«F»: **Is the consistent development platform also an advantage in view of the growing diversity of variants?**

«Voigt»: Particularly in the development of variants, applying model-based approaches is a huge advantage. Once the components, on which the variants are based, are modeled and parameterized in detail, it becomes possible to perform variant calibrations, for example, very quickly. Based on models, significant parts of the calibration can be performed purely in the virtual world. Now we face the challenge of providing such methods for customers in an industrialized manner, as product and system solutions.

«F»: **To ensure a consistent development process at the customer's location, is it necessary that all test systems and software tools were produced by AVL?**

«Voigt»: No, that is not necessary. Our customers have made a considerable investment in their existing infrastructure – from modeling tools to test systems. It must be possible for those tool chains, which they already have, to be used in an integrated platform too. So it is no coincidence that we have named our approach Integrated Open Development Platform. “Open” means that our customers can continue using their existing investment in tool chains. This is why AVL is also heavily involved in the standardization efforts being undertaken in the area of development platforms, such as e.g. Product Lifecycle Manage-



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MICHAEL CONRAD,
Director Portfolio Management Integration
Software Products

ment (PLM) systems. AVL is actively involved in shaping these industrial standards, and also incorporates them in its test systems and tools.

«Conrad»: To us “open” also means that our customers are able to use the platform to apply their own development methods. Customers need to be put in a position to develop their own know-how on our systems. For this purpose, we offer a broad portfolio of solutions – from largely pre-fabricated solutions to open development environments, where customers can implement their own methods efficiently.

«F»: **Will it be possible in future to develop modern drives without an integrated development strategy?**

«Voigt»: The mere fact of the increasing complexity mentioned earlier already rules out any chance of meeting such demands without an integrated, open development platform. Ultimately, the integration of processes, tools and organizations is the key to overcoming the major challenges we face today. ←



» ELECTRIFIED POWERTRAINS BRING ALL KINDS OF NEW DIMENSIONS TO AUTOMOTIVE «

Denise Gray is AVL's new Vice President of Powertrain Electrification. She spoke to Focus about her thirty-plus years of experience in automotive and told us why the future for the electrified industry is enormously exciting in a number of different ways.

► **«F»: Welcome to Graz and to AVL, first of all. What did you do before you came to AVL?**

«Denise Gray»: Thank you. Before I arrived in Graz I was living in Silicon Valley in California. I was Vice President of Business Development and Strategy for a start-up company that was focusing on Energy Storage and manufacturing mainly for the Chinese market.

Before that, I was at General Motors for close to 30 years, working primarily in Powertrain and Electrical Systems. My last assignment at GM was Engineering Director of Battery Systems. It resulted in the production of the Chevy Volt and GM's internal design and manufactured battery system.

«F»: Where do you think AVL stands in terms of electrification?

«Denise Gray»: I think that AVL is in an excellent position to be a partner to all OEMs when it comes to



**» I'M CONFIDENT THAT
AVL WILL HAVE A SIGNIFICANT
ROLE TO PLAY IN EVOLVING THE
ROLE OF ELECTRIC POWERTRAINS
AND BRINGING DOWN COSTS
STILL FURTHER. «**

research, design and development as well as testing systems and instrumentation.

«F»: How does AVL help its customers to develop their own electric projects?

«Denise Gray»: AVL has an excellent group of technologists who (1)

understand automobiles (2) understand powertrains (3) understand the requirements that the industry as a whole is tackling – things such as legislated reduction of CO₂, increase in fuel economy, and the need for low cost, affordable solutions. AVL has the longevity of being recognized within the industry and the commitment to continue to contribute to the technological development



of powertrain systems that will ensure our success in the long term.

«F»: What role do you think that electrified powertrains have to play in providing affordable CO₂ reduction solutions?

«Denise Gray»: Electrified powertrains bring all kinds of dimensions to automotive. It is an additional energy source which allows for more capability for the vehicle as a whole. The internal combustion engine has had over a century of development, refinement and focus. And this maturity has allowed it to be a low cost solution as a primary energy source for the vehicle. The electrified powertrain is still many years away from reaching that same level of maturity.

Hybrid vehicles have been on the road for over a decade now for a number of OEMs, and in that time the technology industry has been able to bring the cost down. The cost for electrified powertrains today is on a downward slope. I'm confident that AVL will have a significant role to play in evol-

ing the role of electric powertrains and bringing down costs still further.

«F»: What areas of the powertrain offer the most exciting opportunities?

«Denise Gray»: There is scope across the whole powertrain but it's fair to say that the battery is by far the leading candidate for a reduction in cost. AVL's commitment to investing in resources and technology in this area will make it an increasingly major player. AVL is in a very unique position because we're not tied to today's technology, we're not tied to a certain chemistry or format, therefore, we can continue to be open and innovative.

«F»: How does AVL's global reach help in terms of responding to the needs of its customer for developing new electrified solutions?

«Denise Gray»: AVL is in a unique position because of its vast global footprint. Having a huge presence in Europe, US, and in Asia means that it is well positioned to have an open

ear to regional requirements, regional technology capability, and therefore, be able to understand the global customer needs. We obviously also need to have an ear to other locations and I think AVL is very alert to this. Because we've got people in the company who have worked at vehicle companies and tier 1 suppliers in locations around the world, our projects are focused on solutions for real world problems. That is how you gain the closed loop learning that allow you to mature your analysis, your designs, your test systems that enhance your fuel economy improvements and emission reduction designs.

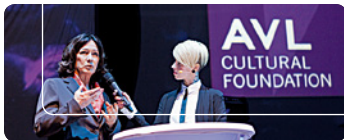
«F»: Automotive has historically been a very male-dominated industry. Do you think that this is changing?

«Denise Gray»: My primary focus is to do a great job and use my skills and experience to get the best possible company results. That said, I am extremely excited for women in technology because I think that new technology is a door that can attract more women into the industry and offer more opportunities. <

The months since the beginning of the year have been all about renewal for the fabulous venue for arts and culture, Helmut List Halle in Graz, Austria. As part of an innovation program, a large number of design measures have already been incorporated, and further projects currently under implementation are certain to captivate audience and organizers in the years to come.

INNOVATIVE, FLEXIBLE, DIVERSE

► To be able to cater to novel requirements of event market and audiences, extensive investments were made in the sound, video and lighting system at the Helmut List Halle. As a result, the hall will now be opening its doors to an even wider circle of visitors and organizers.



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Kathryn List, Manager of AVL Cultural Foundation (left in picture)

Halle had no reason to shy away from an international comparison.

Kathryn List, Manager of the AVL Cultural Foundation, is of the same opinion and had some high praise for the team and the venue for arts and culture: "The Helmut List Hal-



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Helmut List is personally committed to ensuring a bright future for the Helmut List Halle.



helmut-list-halle.com) was also given a fresh new look. Providing a variety of features, such as exclusive sections for artists and event organizers, a sec-



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The manager of the Helmut List Halle, Erwin Hauser, in a podium discussion

BRINGING SOUND TO PERFECTION

Alcons Audio, Europe's leading developer and manufacturer of professional sound systems, found the Helmut List Halle to be the perfect basis for installing an entirely new sound system; incidentally, it is the same model that delivers first-class acoustics at the Opera House in Stuttgart. Manager Erwin Hauser is proud of the hall's state-of-the-art technology. In a panel discussion at the MEET & EAT & LOOK & LISTEN presentation event, he mentioned that the Helmut List

le breaks down the barriers between art and science and is firmly established in the event scene." Kathryn List pointed out that the Helmut List Halle and the AVL Cultural Foundation shared the key features innovation, flexibility and diversity.

MODERN COMMUNICATION TECHNOLOGIES

To be able to communicate the diverse scope of possibilities in a correspondingly modern way, the website (www.

tion where tickets can be bought and detailed information on the events, the redesign efforts have resulted in a modern digital platform.

The HLH Events App for iOS and Android allows you to explore the diversity of the hall on your mobile terminal device. The app delivers a variety of user-friendly features including a user-friendly navigation system, multi-media content, an events calendar as well as augmented reality. These measures will in future help to attract crowds of visitors and international artists to the Helmut List Halle. ←

REDUCING EMISSIONS IN REAL DRIVING

In future, vehicle manufacturers will have to demonstrate compliance with emission standards under real-world driving conditions. This calls for not only a new kind of engine and vehicle development methodology, but also a new generation of portable measuring equipment. AVL can offer its customers both.



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With its mobile testing platform M.O.V.E., AVL provides a portfolio of measuring devices that allows its customers to run all the required measurements inside the vehicle.

► From 2017 onward, exhaust emission characteristics will be assessed in real-world driving – both for initial type approval and later on during operation (in-service conformity). According to Michael Weißbäck, Deputy Vice President Powertrain Systems Passenger Cars, the new regulations – currently being prepared and being introduced from 2017 onwards, complementary to the WLTP cycle – will entail some significant changes in engine and vehicle development: “To comply with the emission limits in real driving conditions, the vehicle’s entire operating range needs to be optimized in view of emissions, while always keeping in mind the interaction between engine, exhaust gas aftertreatment and powertrain. Up until now, the focus was on optimization within the statutory cycles which cover a very clearly defined window of the map.”

NEW MODEL-BASED DEVELOPMENT APPROACH

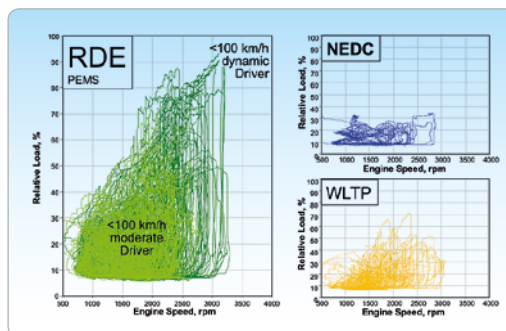
While emission optimization was previously limited to a closely defined driving cycle (such as the NEDC, for example), the engineers are now faced with totally new challenges. The previously applied development methodology has a practical limitation when used to analyze real-world driving emissions. To cover such a considerably expanded scope, it would take a disproportionately great number of test runs if it is based on fully factorial consideration of all eventualities. For reasons of time and expense, however, this is obviously not possible. “This is why we at AVL have developed a new model based approach. Based on empirical/physical models – for

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engine, exhaust gas aftertreatment and the entire system – our approach allows us to optimize development quite significantly,” the expert explains.

AVL experts can draw on a vast database - covering several hundred engine development projects to help them. Added to this, it has data relating to exhaust gas aftertreatment systems and various operation strategies. By combining these empirical data with physical models, the AVL experts can compare different concepts with each other and choose a system at a very early stage of the development. In actual fact, without this model-based approach it would not be possible to achieve this level of efficiency when evaluating the multitude of interactions between the different elements.

As soon as there is a prototype engine, it becomes possible to integrate additional measurement quantities determined on the test bed into the mathematical engine model, thereby improving model precision. Exactly the same applies to the data measured later using portable emissions measurement systems (AVL M.O.V.E) inside the vehicle. “In the end, the quality of our simulation model is high enough for the model-based approach even to be used for variant calibration. The big advantage of this is that exactly the same model is used from the very first system definition through to series production. Over the course of the development process it undergoes continuous refinement,” the powertrain expert says. AVL’s model-based methodology is just as suited for emission optimization in



→ Engine speed/
Load Distribution –
examples of real world
driving vs. test.

complex, hybridized drive systems as it is for classical drive solutions.

ON-BOARD MEASUREMENTS

Due to the real-driving emissions regulations, a significant shift is taking place toward in-vehicle emissions measurement. “With its mobile testing platform M.O.V.E, AVL provides a portfolio of measuring devices that allows its customers to run all the required measurements inside the vehicle. The M.O.V.E portfolio today is almost as complete as the portfolio AVL provides for the test bed,” says Roland Wanker, Global Business Segment Manager for Vehicle Testing Systems. Besides having the equipment for gas and particle emission measurement, consumption measurement and indicating, the M.O.V.E portfolio also includes GPS and video systems capable of capturing the respective driving situation with maximum precision. Roland Wanker: “Using the measured data, developers are able to fully reproduce any driving situation and the associated emission behavior. For use throughout the entire development process, the measuring data are consistent and can easily be integrated into

existing testing environments.” The data measured with the M.O.V.E system are of a very high quality, ensuring good comparability with tests executed on the engine test bed and the chassis dynamometer. “This is a tremendous advantage for an integrated development process. Apart from that, M.O.V.E permits you to record maneuvers in real, on-road driving situations which can later be used in Real-Life Testing with AVL InMotion on the test bed,” he says.

ALL-IN-ONE SOLUTION FROM ONE SOURCE

When it comes to reducing real-driving emissions, AVL can offer its customers an all-in-one solution comprising simulation, system configuration and operating strategy, as well as the required measuring equipment and simulation tools. Michael Weißbäck: “We at AVL are well prepared to handle the future real world emission compliance. AVL’s unique combination of engineering, instrumentation and simulation expertise is a huge benefit to customers working on the optimization of their vehicles’ consumption and exhaust gas emissions.” ←



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Christof Danner's racing team once again took part in the Tuareg Rallye this year with no fewer than four vehicles. This time around, the rally vehicle was equipped with an on-board AVL IndiMicro system. The positive insights gained in the event will be incorporated in the development of a new racing engine for the Dakar Rally this July. For more details, photos and videos, go to: www.avl.com/tuareg-rallye

RING OF HONOR FOR HELMUT LIST

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Helmut List, Bearer of the Archduke John Ring of Honor (on the right) with Rector Harald Kainz.



► Helmut List is not only considered an exceptional figure in business circles: in recognition of his outstanding services and his great commitment in the field of science, the Technical University Graz recently awarded Helmut List, Chairman of the University Coun-

cil, the Archduke John Ring of Honor. "We take great pride in having Helmut List here in our midst, an outstanding figure who has brought a wealth of know-how and experience to the TU Graz for many years," Harald Kainz, Rector of the TU Graz, said, thanking the honoree. ←

AVL UK CELEBRATE 40 YEARS

AVL UK hosted an evening with customers and special guests at Imperial College in London to celebrate 40 years of working with the British automotive industry.

► It was a celebration both of this impressive milestone for AVL in the UK and the strength of innovation, engineering and manufacturing Britain offers the global market. Guests from most of AVL UK's customers came along with VIPs including CEO Helmut and Kathryn List, Richard Higgins (UK Trade and Investment), Alan Jones (Jaguar Land Rover), Graham Hoare (Ford), Uwe Dieter Grebe and Mario Walenta from AVL in

Graz. Representatives from the Austrian Embassy in London and the UK Embassy in Austria also participated in the event. Over 120 people attended and enjoyed the evening. The event was hosted by UK TV presenter and car journalist Quentin Wilson with 'Innovation in the Global Automotive Industry' as the key theme. Helmut List gave an inspiring welcome speech featuring an insight into how he started AVL UK and



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Celebrating 40 years AVL UK: Antonio Ciriello, Quentin Wilson, CEO Helmut List and Kathryn List, Richard Higgins and Matthias Wellers (from left to right).

a reflection on the last 40 years. The Managing Director of AVL UK Antonio Ciriello said: "This successful event received very positive feedback which clearly positions AVL as a partner of choice in the UK". ←

Invitation to the Trend Conference in Graz
Anniversary Conference "Engine & Environment" 2013

THE CONNECTED POWERTRAIN

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

The 25th AVL "Engine & Environment" congress will take place in the Helmut List Halle in Graz, Austria, on the 5th and 6th of September, 2013.

► 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



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

Below: Scan QR code and access the app.



ENGINE & ENVIRONMENT

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; event@avl.com ←

7th AVL International Commercial Powertrain Conference

220 PARTICIPANTS FROM 19 NATIONS AT ICPC 2013



► CO₂ reduction was the key focus of the 7th International Commercial Powertrain Conference,



which was held on May 22-23 in the Helmut List Halle in Graz, Austria. Marko Dekena, Executive Vice

President, welcomed 220 participants at the conference, which united the three industries: trucks, agricultural machinery and construction equipment. Keynote speakers at the ICPC were Sam Burman (Chief Technology Officer, ASHOK/Leyland), Martin Richenhagen (Chairman, President and CEO, AGCO Corporation) and Werner Seifried (Managing Director, LIEBHERR) and Donald G. Hillebrand, President of the SAE. ←

SIMULATION TOOL-CHAIN FOR TURBOCHARGER ANALYSIS

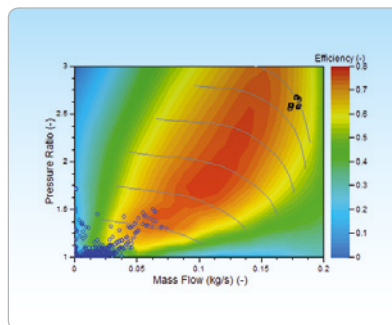
Together, AVL BOOST, CRUISE, EXCITE and FIRE® provide a full range of investigative simulation tools to improve understanding and aid the development of turbochargers.

► Turbochargers have become an integral part of the automotive industry's efforts to enhance existing powertrain and vehicle concepts in order to meet various demands including CO₂ emission reduction. AVL's suite of multi-disciplinary simulation software – BOOST, CRUISE, EXCITE and FIRE® – can offer vital insights for understanding the various physical phenomena taking place in turbochargers. This article takes a look at some examples.

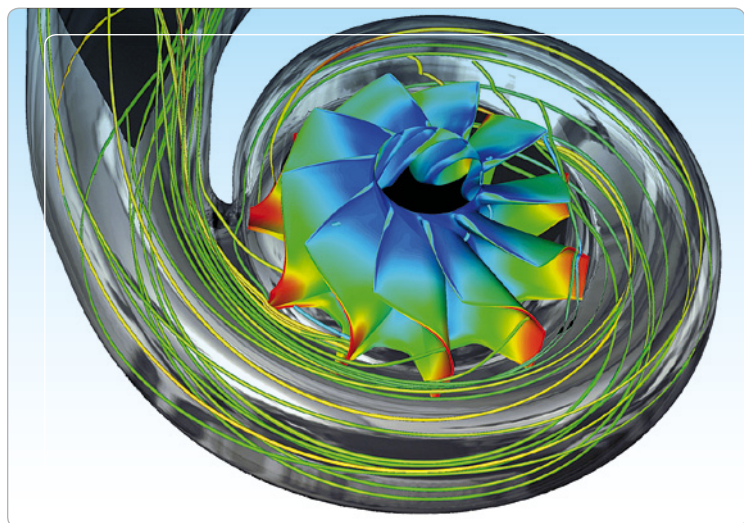
ENGINE PERFORMANCE AND EMISSIONS

CO₂ reduction and a need for improved energy efficiency are the main drivers for charged internal combustion (IC) engines. Turbocharging allows manufacturers to provide downsized engines with high specific power density and, at the same time, to reduce emissions while continuing to deliver the power and performance customers expect.

In addition, it is important to optimize the interaction of advanced turbocharging systems with gas exchange and combustion. Engine performance and turbocharger matching



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Operating conditions in compressor map during a US06 drive cycle



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Simulation of the thermal load on turbocharger components

for IC engines is an established simulation task in the development process. Characteristic engine full and part load operating points as well as transient driving profiles like NEDC or US06 serve as design targets to determine the necessary turbocharger operating conditions.

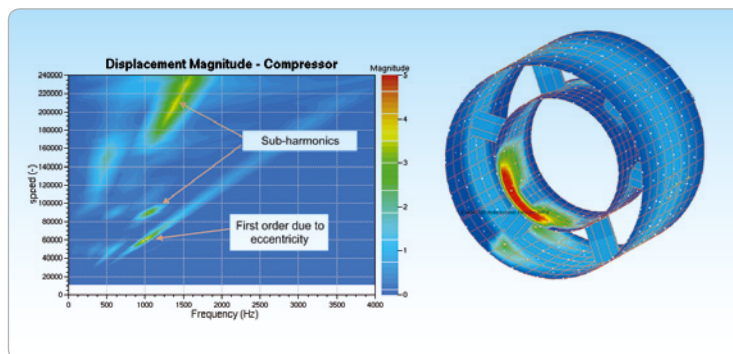
The resolution of turbocharger maps provided by manufacturers is only partially satisfactory. Therefore, a new approach based on detailed physical models was established in the AVL BOOST preprocessor to create extended maps. The use of extended charger maps is an important prerequisite for the optimization of the entire system together with the gas exchange simulation.

The plotted compressor map shows an analysis of the turbocharger operating conditions during an US06 cycle. For the system simulation the AVL BOOST RT engine model was integrated in an AVL CRUISE vehicle model for a middle-class car equipped with a supercharged 1.6 l GDI engine.

THERMAL LOAD ON TURBOCHARGER COMPONENTS

Basic thermodynamic matching of the turbocharger is performed for steady-state operation, continued by the optimization of the transient response using AVL BOOST and AVL FIRE®.

Especially during full load operation turbocharger components are exposed to very high exhaust gas temperatures. AVL FIRE® allows accurate, space resolved prediction of the transient gas temperature field and the heat transfer between the exhaust gas and the structural parts of



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Left: Rotor dynamics – first order excitation and sub-harmonics
Right: Floating bushing – inner and outer bearing oil film pressure at 100,000 rpm

the charger. This information serves as input for the thermal load analysis of the device executed by coupling FIRE® with a structural analysis tool.

ROTOR DYNAMICS AND BEARING ANALYSIS OF TURBOCHARGING SYSTEMS

The investigation of the dynamic stability of the rotor bearing system is an important analysis target for the design of automotive and industrial turbochargers. This requires a flexible multi-body dynamic solution including non-linear models for slider bearings with floating bushings capable of calculating the dynamic system behavior for rotor speeds up to 250,000 rpm.

In order to gain accurate rotor dynamic results for these high rotating speeds, simulation software needs to consider inertia and gyroscopic forces as well as the interaction between the oil film and rotor.

AVL EXCITE considers all these effects with different levels of detail. The run-up calculation

approach supports the detection of critical speeds caused by torsional and bending resonances. The elasto-hydrodynamic bearing model is applied to include the influence of full or semi floating bushing configurations including bores in the bushing to connect the inner and outer oil film of the bearings.

The results obtained with AVL EXCITE allow engineers to find an optimal matching of design parameters for damping of the rotor system, oil mass flow and sensitivity for resonances.

A COMPLETE SIMULATION TOOL-CHAIN FOR TURBOCHARGER ANALYSIS

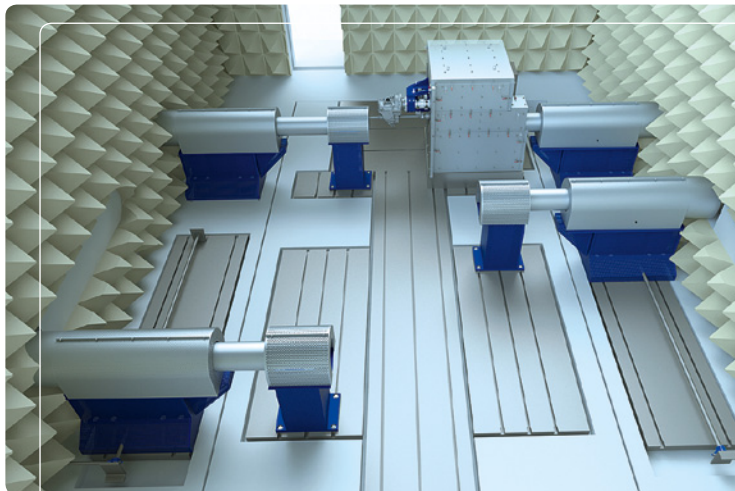
Together, AVL BOOST, CRUISE, EXCITE and FIRE® provide a full range of investigative simulation tools to improve understanding and aid the development of turbochargers. This is an essential part of the overall improvement of IC engines that will continue to be at the heart of the auto industry's efforts at CO₂ reduction and efficiency improvements for the foreseeable future. ←

NVH TEST SYSTEMS FOR THE POWERTRAIN

AVL offers its customers test systems for powertrain NVH optimization – from customized solutions for individual components to complete turnkey systems including facility engineering.

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4WD NVH powertrain testcell with special reduction of acoustic reflections. Due to the way the dynamometers are set up in different rooms, it is necessary to have output shafts with a length of several meters.



► Modern cars – specifically ones with electrified drives – are getting quieter and quieter. This puts greater emphasis on the powertrain and its role as a source of noise. The tools needed to optimize powertrain components as well as entire powertrains in view of their noise and vibrations are called NVH test beds (NVH, Noise, Vibration and Harshness). “These are very different from conventional test beds, mainly due to the sound insulating measures that have to be taken and the way the dynos are set up. With these being a source of sound themselves, they need to be accommodated separately, in different rooms. Apart from that, the individual elements of the test bed, specifically the test cell itself, have to be acoustically decoupled and protected against vibration,” says Joachim Schmidt, Manager of NVH Test Bed Systems at AVL.

Right now, customers of AVL are mainly asking for NVH power-

train test beds, of which there are essentially two different types: transmission NVH development usually requires the use of a 2WD test bed with a highly dynamic electric drive unit, which is installed (acoustically insulated) inside the test cell as close to the tested transmission as possible in order to enable a dynamic connection to the unit under test. Based on software models, the so-called prime mover can simulate the torsional vibration behavior of a variety of engines.

In the case of the second well-established type of NVH powertrain test bed, which is usually ordered as a 4WD version, the applied drive is usually that of the vehicle’s engine itself. If special kinds of measurements are needed, the acoustically dominant engine can be encased and/or replaced by an e-machine. Due to the way the

dynamometers are set up in different rooms, it is usually necessary to have output shafts with a length of several meters, which present a particular constructive challenge. With all the additionally required systems like e. g. battery simulators being available, even hybrid drives can be developed with AVL NVH test beds.

“One of the unique AVL advantages when designing NVH test beds is that we carry out automotive acoustic developments right here in-house. For that reason, we are very familiar with testing tasks – a fact which our customers appreciate very much when we design the test systems together. This puts us in a perfect position as suppliers of complete NVH systems, from the concept to the complete turnkey system, for our customers around the globe,” says Joachim Schmidt. ←

AVL CRETA – THE PINNACLE OF DATA MANAGEMENT

With more than 6,000 users, AVL CRETA is the world's leading data management system in the vehicle calibration sector.

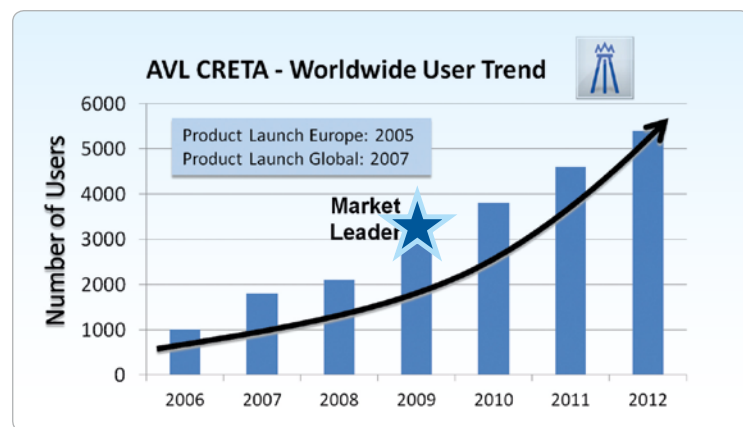
► Increased standardization in the automotive industry is causing OEMs to implement identical powertrain components in a wide range of vehicles. Since vehicle-specific adaptations are required, it is normal to find up to 300 vehicle variants, each requiring individual calibration. Modern vehicles have up to 60,000

Development and Calibration, was the first to have the idea of a tool such as CRETA and shaped the product from its very beginnings. “The task of calibration is no longer doable without a modern data management tool that also supports the development process,” he reports. “For this reason, AVL started development ten

le drivability development. Up to 30 engineers typically work on a calibration project over a period of one to two years – often based in different global locations. Despite the large amounts of data and the number of engineers participating in the project, there must be a guarantee when data is released that all parameters have been processed and that the values of the parameters represent the best possible solutions. It is particularly necessary to have a clearly defined process, when more than one engineer accesses and changes a label to achieve different, possibly conflicting targets, for example cold start versus emissions during engine start. CRETA provides clarity in the process by assigning unambiguous access rights and responsibilities.

Calibration errors and glitches just before delivery can be detected and avoided, and even recalls prevented, thanks to automatic double-checks and simple comparison graphics.

“Today, it is not just about managing the tremendous growth in the number of variants in projects, it is also about clustering the calibration work-packages, which is an indispensable topic to reduce costs and increase quality”, says Gianluca Vitale, skill team leader for diesel engine calibration. “Today CRETA is practically the standard for diesel and gasoline engine calibration”. <



calibration parameters and – depending on the control units – each could possibly contain a few hundred values. In addition to this, the management systems for all powertrain-relevant components (e-motor, transmission, battery, etc.) in modern powertrain concepts must be consolidated into a whole, in order to be able to obtain consistent statements concerning the total calibration status and its quality. Thomas Dobes, Head of Gasoline Engine

years ago on a central process management system for calibration. A huge advantage for AVL while developing this tool is that we deal intensively with calibration on a daily basis and therefore we know the requirements for such a product”.

CRETA supports every step in the calibration process, from base calibration on the test bed up to vehic-



FUEL CONSUMPTION MEASUREMENT ENGINEERS CAN RELY ON

Focus spoke to two AVL experts, Dr. Michael Cernusca and Rainer Schantl, who outlined how AVL has become the leading company in the world for providing the kind of high level accuracy and repeatability for fuel consumption that engineers can rely on under all test conditions.

► Internal combustion engines have gone through such a high level of development over many years that what now seem like relatively incremental differences in performance between engine variants can actually represent significant margins of improvement. Development engineers, though, need to have certainty about their measurements in order to make a true evaluation of this, which is

why they need highly precise measurement tools. The confidence in terms of fuel consumption measurement that they require to make a solid judgment is based on differences of ± 1 g/kWh in engine part load. To put this in context, an efficient modern passenger car diesel engine will require around 200-250g of fuel per kilowatt-hour of energy – at average engine load.

ACCURACY AND GOOD REPEATABILITY

Engine developers all over the world have defined a repeatability of ± 1 g/kWh of the specific fuel consumption, especially in engine part load, as a prerequisite for efficient development & optimization of modern combustion engines (minimum number of measurements at low stabilization and measurement time).

“At high engine loads,” says Rainer Schantl, “it is relatively simple to achieve high accuracy and good repeatability of fuel consumption measurements. But this also happens to be the end of the scale where it least relevant – most legislation, for instance, relates to low flow rates and so this is where it is most vital to provide high accuracy with excellent repeatability.”

Dr. Michael Cernusca says that: “It is important for us to look at this challenge from the point of view of our customer – an engine developer working from a few different types of design. They measure with different settings then they compare which results in the lowest fuel consumption. Development cost is related to how much time is needed to do this engine calibration – and in order to try and reduce their costs, our customers try to reduce their development and test time. New, model based approaches help because they have the potential to dramatically reduce the number of measurements that are needed. However, those fewer measurements must be of highest accuracy and repeatability. This ensures quality data which is again the foundation for the achievable model quality. This is why there is a requirement on high repeatability on fuel measurement; and it is the combination of a measurement device with high performance and the proper setup on the testbed which enables you to reduce the actual time spent in development.”

INFLUENCING FACTORS ON THE MEASUREMENT CHAIN

There are many influencing factors that have an impact on the entire measurement chain. So where do you

start? According to Schantl: “The effort you have to spend to quantify these different influences are almost infinitesimal and this is the reason that we defined five major reasons – or parameters – that can be easily identified and can give a good element of prediction. In other words: we made a complex thing a little simpler.”

These five parameters are:

- 1) Measurement uncertainty of the flow sensor
- 2) Measurement uncertainty based on fuel temperature stability
- 3) Measurement uncertainty based on measurement time
- 4) Measurement uncertainty of the torque measurement
- 5) Measurement uncertainty and control stability & measurement of the engine speed



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Highly precise: AVL fuel consumption measurement systems

Schantl says that it is relatively simple possible to ensure (1) proper accuracy and repeatability of the sensors, but that AVL is the world leader in terms of providing (2) temperature stability of the fuel being measured (better than $\pm 0,02$ °C), which results in a contribution of as little as 0.2 % of the overall measurement uncertainty at low engine part load. “No-one else in the world can match

this to our knowledge, and already minor lower temperature stability results in much higher measurement uncertainty and much worse repeatability – especially in engine part load” says Schantl.

Increased measurement time (3) can only partly compensate lower temperature stability but reduces the testing efficiency. Therefore, AVL’s fuel measurement systems are tuned for short measurement times too. However, Schantl identifies the complex torque measurement (4) as being a further crucial aspect of AVL’s differentiation compared to other measurement set-ups for specific fuel consumption. AVL’s accurate and reliable dyno and control systems mean that an exact reproduction of engine load conditions is ensured.

A LOT OF APPLICATION KNOW-HOW

All these different components of a measurement system also need to be put together in the right way in order for everything to work correctly and with the reproducibility of ± 1 g/kWh. According to Dr. Cernusca: “You need a lot of application know-how – in terms of the correct diameter of fuel pipes, the placement of the fuel filter, the distance between engine and fuel consumption measuring device etc. Crucially, we not only provide the equipment to our customers, but we support our customers at the installation too in order to make sure that no detail is overlooked. AVL is the only one that has more than 45 years experience of this and this is another crucial factor that allows us to achieve the high rates of accuracy and repeatability that are so important for our customers today.” ←

COMPLETE SYSTEMS FOR QUALITY ASSURANCE IN PRODUCTION

AVL offers its customers complete quality assurance systems for engine production – starting with consultancy and planning right through to turn-key testing systems.

► For assuring process and product quality in engine production, AVL can offer its customers a fitting quality concept solution whatever the task at hand. The system portfolio comprises cold test beds (engine is motored) and hot test systems (engine is fired briefly) as well as quality audit test beds. Being part of the production equipment, the demands on the test systems are tough, so high robustness and availability are imperative. “Our end-of-line test systems satisfy these requirements to a very high degree. Added to this are the ease of operation and the convenient options to adjust the systems if any product changes are made to the engines to be tested,” explains Arnold Berger, Business Segment Manager for End-of-Line Hot Test Systems.

AVL’s end-of-line test system and plant & production-engineering experts are already able to advise customers on the concept of their production plant early on in the planning stage. “Almost every customer has different, very specific surrounding conditions such as transport system, interface to unit under test, etc. This means that des-

pite its predefined functionality, the production test system is made to measure for each customer,” Arnold Berger adds.

“Cold testing is a firmly established process in engine production, applied by almost all manufacturers with very few exceptions. With the engine only being motored for a short period of time, it is possible to test up to 1000 engines ‘cold’ per day and test bed. This makes it possible to test the quality of the assembly process at a very early stage,” points out Gabriele Lo Schiavo, Global Business Segment Manager for EOL Cold Test Systems. During the cold test that takes between 90 and 140 seconds (including loading time), sensors determine the values (pressure, temperature, vibration, electrical signals, torques, etc.) which are then compared with statistical reference values in order to detect any mistakes in the assembly or engine components.

Usually, a production involves combining cold testing with the hot testing of a certain number of engines. “Exactly how many engines are tes-

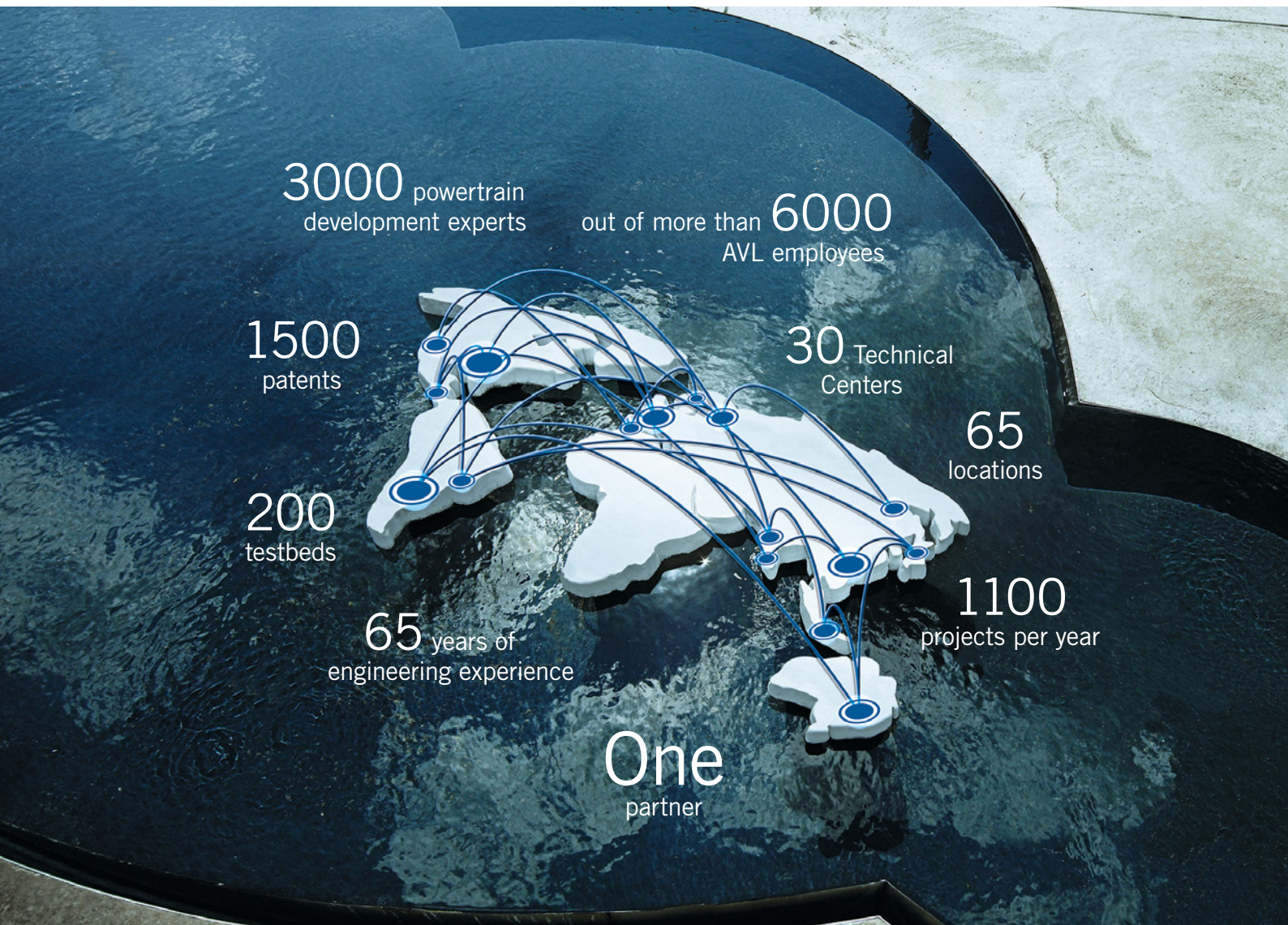


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AVL End-of-Line Hot Test System

ted ‘hot’ on the one hand depends on the application segment (light duty, medium duty or heavy duty). It also depends on how mature the manufacturing process is. I.e. after starting a new engine series, up to 100 percent of the engines undergo a cold (function) test and a hot test. Once the manufacturing quality has been assured, the percentage that undergoes hot testing is very low – about 5 percent. Regardless of that, 1 to 3 percent of the engines are always subjected to a quality audit on the test bed,” says Arnold Berger.

A large number of globally active car and engine manufacturers have already chosen AVL production test systems for their production sites around the world. “We offer our customers comprehensive solutions to assure product and process quality – from concept to turn-key test systems. In addition, the on-site support, which our global AVL network and our local subsidiaries are able to provide customers around the globe at all of their production locations, is a tremendous advantage,” concludes Gabriele Lo Schiavo. ←



AVL GLOBAL NETWORK

ALL FOR ONE, ONE FOR ALL

AVL Technical Centers work as a network and as one team. Each local AVL Tech Center opens up access to a worldwide pool of experts and services, while you are still working with local engineers who are expert in their markets. We develop and test the entire powertrain in close cooperation with customers and partners through a global cross-locational project execution. This is unique. This is AVL.

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AVL



AVL END-OF-LINE ENGINE HOT TEST ENSURES PRODUCT AND PRODUCTION QUALITY

Ensuring product quality for all engine types

The End-of-Line Engine Hot Test System is an integrated part of the production environment and is a key element for ensuring product quality with the minimum effort and cost. A consistent and smart test methodology and test technology is required in order to manage the increasing complexity of the combustion engines in the production process. This system uniquely combines knowledge of manufacturing and assembly processes with modern engine technologies.

AVL Solution

The AVL EOL Hot Test combines manufacturing know-how with engineering knowledge and includes all the required devices and equipment for evaluating pre-defined production faults. The solutions are set up to cover the main requirements of all engine sizes. The optimized EOL automation system with specific test profiles, data evaluation and statistics is covered in one solution package.

The Benefits

- Dependable design & construction
- Hardware & Software engineered for maximum efficiency
- Highest standards for measurement accuracy and repeatability
- Energy-optimized System Layout
- Easy to integrate in manufacturing execution systems
- Trusted by the world's leading OEM's

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