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TOMORROWTODAY

/// A MOBILE FUTURE

METHODS OF TRANSPORT FOR TOMORROW AND BEYOND

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NETWORKED MOBILITY

/// From the stagecoach to the space shuttle, from the first road signs to modern-day traffic guidance systems. Mobility has always been a driving force. As far as the transportation of people and goods is concerned, the latest challenge in terms of the concepts of tomorrow is to find a balance between environmental sustainability, comfort and efficiency. ///

Photos: ASFINAG, BMVIT, AIT, IV, Photos.com

"THE REALISATION OF SUSTAINABLE MOBILITY is right at the top of the European agenda," according to Wolfgang Knoll, Scientific Manager of AIT. This necessitates the involvement of international partners, so that areas of research can be focused on directly and addressed with sufficient critical mass. "Our researchers are part of national and international networks, which enables them to actively shape appropriate research strategies and identify new approaches in the context of international research projects," says Knoll, referring in particular to the "Mobility Department" – one of five research divisions which make up the Austrian Institute of Technology. The Mobility Department is focused on research into the optimisation of transport infrastructures, innovative transport systems and visionary drive concepts.

"In the Mobility Department we take a holistic approach, looking at transport infrastructure, transport systems and vehicles systematically," stresses Commercial Manager of AIT, Anton Plimon. "Because in light of increasingly unmanageable traffic flows in and around congested areas, we have to accept that existing traffic flow systems have reached their limits. Anyone who has to use Vienna's southeast highway, for example – especially during the rush hour – will know exactly what I'm talking about. So our aim is to completely restructure mobility. Our researchers have been working night and day for some time in a bid to identify appropriate technical solutions."
One key factor, according to Plimon, is of course E-Mobility, which involves looking at a whole range of technologies.
AIT is therefore very much in tune with the ambitious, future-driven concepts of the Federal Ministry for Transport, Innovation and Technology, which has defined "Green Mobility" as the clear objective of all research in the area of infrastructure in an effort to combat the effects of climate change and dwindling energy resources. The primary focus is on electromobility, where both research as well as measures geared towards bringing E-Mobility to the market are being pursued.

Federal Minister of Transport, Innovation and Technology Doris Bures: "By coordinating politics, industry and transit service providers effectively, we will be able to help shape the development of intelligent transport systems across Europe."

BOOST TO NATIONAL ECONOMY

Director of the Austrian Institute of Economic Research and "father" of system evaluation, Karl Aiginger, believes that intensive research into innovative automotive drives could not only lift the national economy, but also provide an opportunity to remain at the forefront of international research activities.

SYSTEMIC APPROACH TO KEY TECHNOLOGIES

"Our predominantly systemic approach towards mobility places us at the very forefront of research in Austria and beyond," assures Wolfgang Knoll, referring to AIT's numerous international partnerships in this area.
"In the mobility sector in particular, we are leading the way in Europe in many areas. Our internationally recognised specialists have the requisite know-how to tackle the wide range of topics which are globally relevant – improvements to transport infrastructure in terms of increased safety and cost-effectiveness in the context of operation and maintenance, optimising co-modal transport systems, which encompass all forms of transport, from pedestrians to private and public transport, and, of course, the development of integrated vehicle concepts featuring electric drive concepts and lightweight construction technologies, both of which are key technologies. This creates synergies for entirely new areas of research".

AIT Managing Director Anton Plimon: "We provide the growing transport sector with an R&D environment which offers companies the latest technologies and methods, as well as years of experience in their implementation, for realising efficient and safe mobility and vehicle concepts."

MAIN ARTERIES

A well structured transport infrastructure is vital both to the population as well as the economy and industry. In terms of attracting new business in particular, the transport arteries are hugely significant. As with all aspects of infrastructure, however, numerous interests have to be taken into account. There may be conflicts between environmental and economic issues as well as between climate protection and conservation. These are all questions which have to be addressed by both politics and science.
"We must now do everything we can to leverage the head start of the domestic supplier and consolidate our lead in the upcoming areas of mobility," stressed Federal Mini-

ster of Transport, Innovation and Technology Doris Bures at last summer's Alpbach Technology Forum, taking the first step by increasing the level of funding for conventional and alternative automotive technologies by 50 percent. As in 2009, an additional 60 million euro will be available this year for this purpose, almost two thirds of which will be invested in new technologies such as electromobility – one of the reasons why leading domestic firms recently set up the Austrian Mobile Power platform in collaboration with AIT.

AIT Managing Director Wolfgang Knoll: "Both national and international scientific networks are benefiting from the expertise of our researchers. They are therefore making a contribution to the global research strategies of tomorrow."

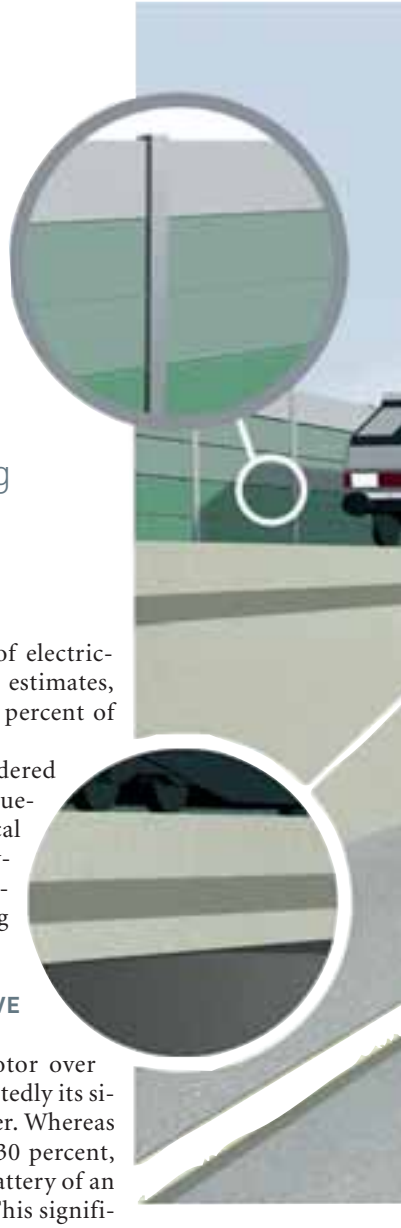
"The government has shown foresight by investing in electromobility," says Deputy Director General of the Federation of Austrian Industries Peter Koren, commenting on the increased budget while also calling for a long-term electromobility strategy for Austria. Networking the automotive, energy and Information Technology sectors along the new value chains for electromobility would also encourage innovation in what is currently a difficult economic climate. The Federal Ministry for Transport, Innovation and Technology also recently drew up a national action plan for transport telematics. Doris Bures: "We want to create an environmentally-friendly, efficient and safe transport system while at the same time strengthening the innovative capacity and competitiveness of the transport technology sector, which is a key branch of Austrian industry."
For example, Austria will be hosting the biggest international intelligent transport systems event in 2012, the ITS World Congress. According to the Federal Minister, the event will provide a platform for presenting the latest developments as well as successfully implemented systems to the world market. "By coordinating politics, industry and transit service providers effectively, we will be able to help shape the development of intelligent transport systems across Europe," says Bures. ///

Peter Koren, Federation of Austrian Industries: "The government has shown foresight by investing in electromobility. However, we are still in need of a long-term electromobility strategy for Austria."

MOBILE MILESTONES

Looking back over the 6,000 or so years since the invention of the wheel and at how transportation has developed during that time, it is astounding how one ground-breaking invention has so rapidly followed another in the last two hundred years. England witnessed a world first back in 1825 when the first rail passengers made the maiden trip between Stockton and Darlington – pulled by a George Stephenson locomotive. The revolutionary story of today's automobile began in Vienna in 1870 with the first gasoline-propelled car built by Siegfried Marcus.
But some technological innovations need time to come to fruition. The electric motor is the perfect example. Ferdinand Porsche patented his electric hub motor in 1896, and the Lohner-Porsche electric car caused a sensation at the Paris World Exhibition in 1900, celebrated for its non-transmission design. A development of his electric motor led Ferdinand Porsche to design the first hybrid vehicle in 1902, where an internal combustion engine built by Daimler was fitted to a generator to drive the electric hub motors.

SOLUTIONS FOR THE MOBILITY OF TOMORROW



/// "Green Mobility" requires that all levels of the mobility system are taken into account - from vehicles and infrastructure through to the transport system. The AIT Mobility Department is supporting this paradigm shift with the help of hi-tech modelling and numerical simulation. ///

MOBILITY IS NOT JUST A BASIC NEED of the human race, it is also a cornerstone of our economic system. However, the goalposts have shifted massively in recent years: global challenges such as climate change, depleting resources and increased transport volumes are forcing us to think outside the box. Transport is now responsible for 34 percent of total CO_2 emissions and continues to show a greater rate of increase than industry or the construction sector.

Transport volumes more than doubled between 1970 and 2004 – and continue to grow. These trends are also amplified by societal change and its side effects urbanisation and overdevelopment, which in turn lead to a greater strain on transport infrastructure. In addition to safety, mobility of the future must also comply with the highest standards in terms of efficiency and environmental sustainability. If we are to rise to the challenge of "Green Mobility", then every level of the mobility system has to be taken into account. The resulting multitude of mutual interdependencies necessitates a heavily integrative approach, a strategy employed by the AIT Mobility Department with the help of modelling and numerical simulation.

GROWING DIVERSITY IN VEHICLE DESIGN

"The trend in the automotive industry," says Franz Pirker, Head of the Mobility Department, "is clearly towards greater efficiency and, consequently, improved environmental sustainability. Electrification and the use of lightweight materials are the key technologies which will get us there." We are already witnessing a shift away from the conventional vehicle towards the various hybrid technologies and purely electrically driven vehicles.

The range of micro, mild, full and plug-in hybrids already available or poised for launch is a clear indicator that Electric Mobility is regarded as our biggest short-to-medium-term hope for environmentally-friendly mobility. The range of vehicles available on the market is about to become more diverse than ever. Petrol or diesel-powered cars will not disappear from our roads overnight, but we can expect the number of electric-powered vehicles to increase; according to estimates, electric vehicles will account for up to five percent of the market by 2020.

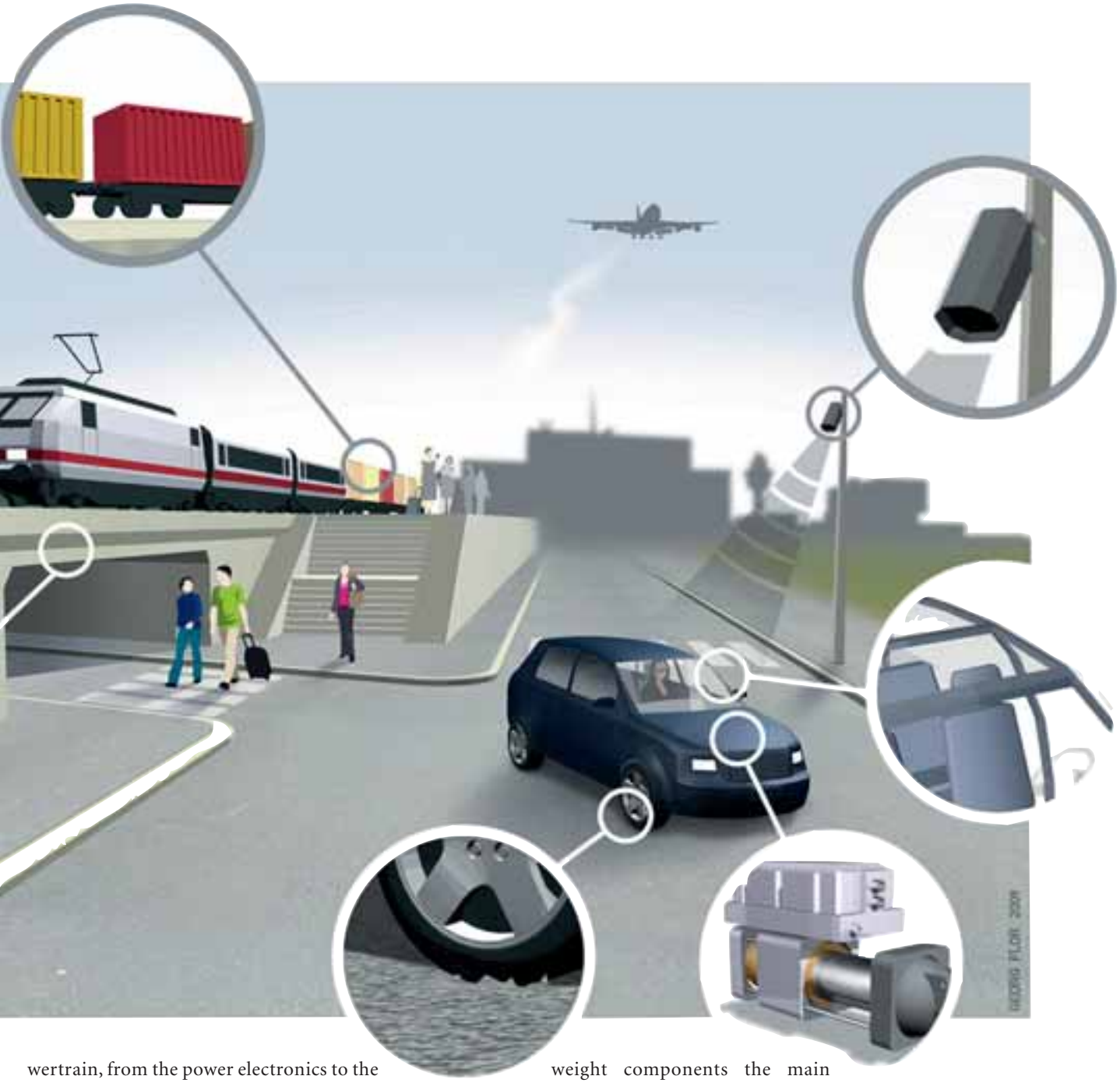
But before Electric Mobility can be considered truly viable in the long term, a number of questions still have to be answered. Technological innovations, from the electric drive and bodywork through to entirely new mobility concepts, will be fundamental in terms of taking mobility to the next level.

GREATER EFFICIENCY WITH ELECTRIC DRIVE CONCEPTS

"The biggest advantage of the electric motor over conventional combustion engines is undoubtedly its significantly greater efficiency," explains Pirker. Whereas the efficiency of a petrol engine is around 30 percent, over 90 percent of the energy stored in the battery of an electric motor is transferred to the wheels. This significantly higher degree of efficiency means, of course, that CO_2 emissions are considerably reduced, which in view of the EU's planned fleet-average emission target of 120 g/km is a very convincing argument.

A key element of the electric vehicle concepts of the future is energy storage. In the field of lithium-ion technology in particular there have been huge leaps forward in recent years. Li-ion batteries have a much higher energy density than the nickel-metalhydrid batteries currently in use, which means they have a much greater range. But there is still a great deal of room for improvement in terms of safety and lifespan before the tried-and-tested technologies already used in mobile phones and laptops can be successfully applied to automotive concepts.

The Mobility Department is involved in numerous national and EU projects focusing inter alia on the development of innovative charge management strategies and research into the ageing of new lithium-based cathode materials. "But it's not enough," cautions Pirker, "to concentrate on the battery alone. The entire po-



wertrain, from the power electronics to the final drive, has to be finely tuned in order to extract maximum efficiency." Electric and hybrid vehicles necessitate a fundamental adjustment in terms of development tools and processes. Using sophisticated simulation methods, experts combine the thermal, electrical and mechanical properties of the various components of the powertrain in order to be able to simulate the entire vehicle as accurately as possible and to optimise it accordingly. In recent years the Mobility Department has positioned itself as a recognised development centre, helping domestic as well as international manufacturers and suppliers adapt to the electric era.

SAFE AND LIGHTWEIGHT VEHICLE COMPONENTS

In recent years lightweight materials have become hugely popular in the automotive industry. The use of aluminium instead of steel means a huge reduction in weight, which in turn has a positive effect on energy efficiency and CO_2 emissions. When developing lightweight components the main challenge in terms of construction is ensuring passenger safety during a crash. The Mobility Department's expertise in this field is concentrated in Ranshofen, a hotbed of research into the latest developments in the lightweight components sector – new aluminium and magnesium alloys, the development of innovative lightweight components and the safe fusion of light metals with other components. In collaboration with an industry partner in this emerging area, a welding process was developed which last year was awarded the Austrian State Prize for Innovation. "Here, too," continues Pirker, "the latest simulation tools are used to develop new alloys and bespoke processes for metal forming and heat treatment."

CO-MODAL TRANSPORT SYSTEMS

The greenest vehicle in the world is not enough on its own to counteract the negative effects of continually growing traffic volumes, which all too frequently are

"Strategically the Mobility Department is focused on new developments in the mobility sector. This allows us to proactively develop innovative methods, solutions and processes which are crucial to the future success of this emerging market. They are the basis for lightweight and yet safe components which will be used in the manufacture of tomorrow's electric vehicles."

Franz Pirker, Head of Mobility Department

Photos: Fotostudio Krischanz & Zeiler, AIT, Photos.com

pushing our transport systems to their absolute limits. According to the European Commission, an estimated 100 billion euro per year are lost to the European economy because of increased traffic and congestion and the knock-on effects. In the Green Paper "Towards a new culture for urban mobility", the EU has responded to this phenomenon and called for a root-and-branch rethink of urban mobility. Optimising the use of various modes of transport will give rise to a co-modal transport system which reconciles the different modes of collective transport and the different modes of individual transport. Co-modality between the different modes of transport is beginning to gain momentum. "At national and international level we already have in place some promising business models for co-modal mobility concepts which combine public transport with electric vehicles, for example," says Pirker. "The big advantage of co-modality is that it offers significantly greater freedom by integrating several modes of transport - from walking and cycling to passenger and freight transport, whether road or rail." But in order to fully exploit this level of freedom, we need intelligent and adaptive traffic management systems which provide information in real time and which are also predictive. Thanks to the Mobility Department's expertise in surveying, analysing and simulating the flows of people and traffic, accurate forecasts about travel times or capacity utilisation can be made, allowing these flows to be directed and routed safely and efficiently. This applies to both passenger and freight transport, since optimised transport logistics and routing can provide industry with an economic advantage relatively quickly. Which is why AIT is currently working, among other things, on "last mile" concepts at the interface between rail and road, allowing the final leg of a journey to be completed as efficiently and eco-friendly as possible with hybrid goods vehicles.

ENVIRONMENTALLY SUSTAINABLE AND SAFE INFRASTRUCTURE

Green Mobility involves much more than just efforts to reduce CO_2 emissions; environmental sustainability must also take into account the acoustic effects of traffic. Noise mapping as outlined in the EU Directive on Environmental Noise as well as the Europe-wide discussion on quiet tyres and road surfaces underline the social significance of noise protection. Electric vehicles are unquestionably quiet in the city, but at higher speeds there is still a rolling noise. "Using modern simulation methods we can very competently address the highly complex issue of noise," says Pirker. "This allows us to come up with effective solutions much more quickly and efficiently compared with conventional engineering methods." For example, the simulation of sound propagation delivers crucial data for the optimum design and placement of noise barriers. Near-field simulation can be used to examine the acoustically complex interaction between tyres and road surface directly at the noise source. AIT recognises the importance of combining different methods, for example Vehicle Infrastructure Interaction Simulation, which models vehicle-infrastructure interaction. This involves "driving" various types of virtual vehicles on model roads.

The integration of acoustic or dynamic models allows conclusions about potential noise emissions as well as the risk of accident on the roads under investigation to be drawn. Infrastructure managers are therefore able to make crucial decisions affecting targeted measures for noise protection and making potential black spots safer. Modelling and simulation will also play a vital role in future, allowing the complex interaction between noise, safety and energy efficiency to be examined holistically and the entire infrastructure system to be optimised.

INGENIOUS PARTNER FOR THE ECONOMY

"Strategically the Mobility Department is focused on new developments in the mobility sector," says Franz Pirker. "This allows us to proactively develop innovative methods, solutions and processes which are crucial to the future success of this emerging market." The AIT is therefore already in a position to provide the industry as well as the government with forward-looking research results for the mobility of tomorrow. The Mobility Department's researchers have made a name for themselves within the global scientific community. Through close collaboration with international research institutes and active participation in EU projects, the extensive know-how gained through years of experience is continually growing, enabling the department to meet its own incredibly high standards of scientific excellence. The interdisciplinary structure of the research teams means that the Mobility Department is able to take a uniquely systemic approach towards mobility. The wealth of expertise available in the department is the basis for the electric drives, light metals concepts, dynamic co-modal transport systems and intelligent infrastructure solutions which will help to make the mobility system of the future safe, efficient and green. ///

"OUR DRIVER, 'EFFICIENCY', WILL HAVE TO BE COMPLETELY REDEFINED"

/// Franz Pirker talks about the implications of innovative infrastructure concepts for the individual players within the mobility system. ///

What will mobility be like in 2050?
Mobility of the future will be more varied and diverse. Every mode of transport - from walking to the latest vehicles and public transport – will be more closely intertwined. If, for example, we are using electric vehicles as a means of transport, then criteria such as available charging stations, range and transfer options will have to be taken into account when planning a route. New doors are opening for the development of an efficient, integrated mobility system. In this respect our driver, 'efficiency', will have to be completely redefined. The efficiency of the individual mode of transport (for example of a vehicle) will have to be assessed as part of an overall system and will therefore be valued differently.

What are the implications for the individual players within the mobility system?
The growing complexity of implementing sustainable mobility solutions will require our customers to think differently. In future, the automotive industry, utilities, transport companies, infrastructure operators, system providers and planners will all be working together. This means that appropriate cooperation and business models will have to be created and developed for all those involved.

What does that mean for the innovation process?
A mobility system of ever growing complexity also necessitates a new innovation process. The development of individual technologies will have specific consequences in the overall system. For example, vehicle technologies (such as lithium-ion batteries), telematics and power supply (smart grids) are all crucial to the implementation of Electric Mobility. The introduction of new vehicle concepts requires additional innovations in other areas of the mobility system. Mobility will therefore have to be revised on an interdisciplinary basis in order to be able to develop sustainable mobility concepts. The innovation process will be shaped by a networked approach to the relevant enabling technologies as well as new partner structures.

What are the consequences for the Mobility Department?
The requirements and implications of new mobility concepts such as electric vehicles will have to be assessed as accurately as possible so that they can be integrated into the overall system as part of a co-modal approach. Our teams are looking into the optimisation of the individual elements on the one hand and, on the other hand, optimisation of the overall system. To be able to handle all of these interdependencies, there is increasing emphasis on the use of simulation. We are developing both simulation tools for future vehicles as well as models for a simulative approach to the interdependencies between modes of transport, infrastructure and transport system. Our vision is therefore the virtual development of safe, efficient and green mobility of the future as well as its implementation in collaboration with our customers. ///

THE VIRTUAL WORLD OF ELECTRIC DRIVES

/// The electric vehicles of the future will be largely designed on the computer. One of the crucial elements of this task is the modelling and simulation of the drive train. ///

ELECTRIC DRIVES form the heart of any hybrid or electric vehicle. To design and develop the complex system consisting of the electric motor, energy storage device, power electronics and controls, it is necessary to take a rigorously systemic approach. "This holistic view in the modelling and simulation process is the strong point of our team at AIT," says drive expert Christian Kral, who has a number of patents and publications in the field of electric motors to his credit. A senior researcher at AIT, he acquired additional scientific expertise during his extended stay as a visiting professor at Georgia Institute of Technology, one of the top universities for electric drive system engineering in the USA.

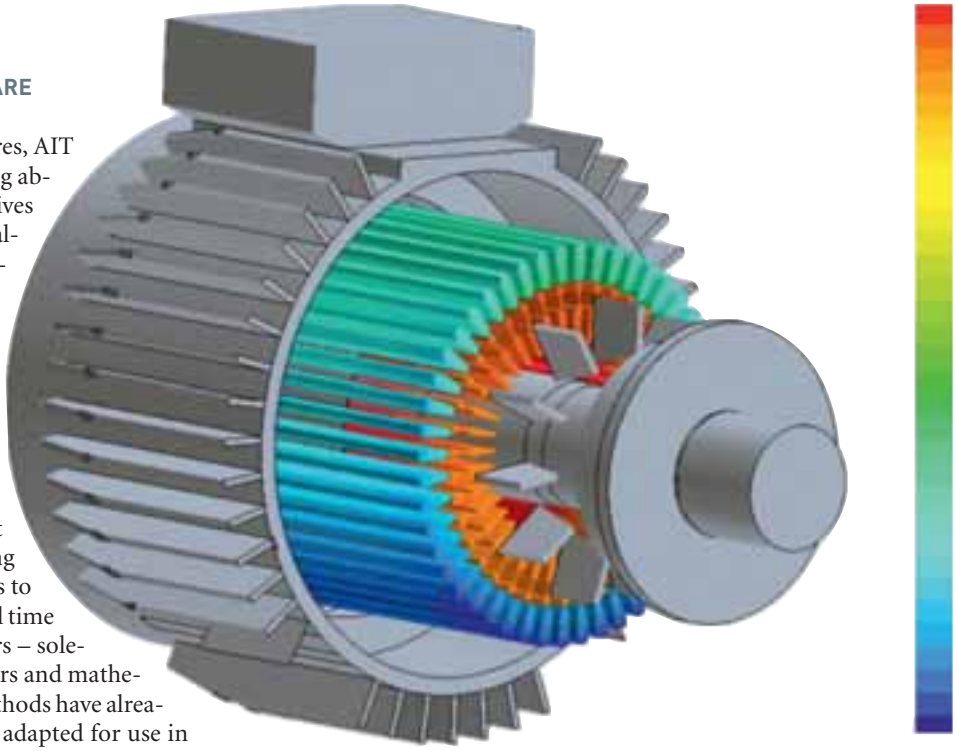
THE MISSION: OPTIMISING THE OVERALL SYSTEM

"Electric motors have specific advantages over internal combustion engines," says Kral. "While conventional petrol and diesel engines have an efficiency of 25 to 30 percent, electric motors reach an efficiency of over 90 percent. Additionally, they can be integrated into the wheel hub or driven via a fixed gearbox without transmission. In an ideal design, such motors will allow periods of brief overload and can therefore be built more compactly." Another key component of tomorrow's electromobility is the energy storage device, which in most cases will be a lithium ion battery. In addition to the electrical and thermal design and ageing properties of the materials, the most important aspect here is that of safety. Finally, the power electronics too must be perfectly configured and the operating and control strategy must be tailored to the vehicle and its drive cycle.

THE SOLUTION: THE VIRTUAL APPROACH

"The range, efficiency, power density and energy efficiency of the drive can only be maximised if all the separate components work together perfectly," says Kral. The drive engineers at AIT use modelling and simulation techniques to master the complex interactions involved. As an initial step, the individual components – from the motor through the battery to the power electronics – are cast in mathematical/physical models and integrated into a virtual vehicle. This is done in Modelica, an object-oriented modelling language that is increasingly being adopted by the development departments of European automotive manufacturers. Individual objects are used to create abstract models of separate components, which are subsequently put together to create virtual drive trains for hybrid and electric vehicles. Christian Kral stresses the holistic approach of this method: "With our interdisciplinary team, we have the resources to combine all the relevant aspects of the drive in a single simulation, which gives us the opportunity to analyse its thermal, magnetic, electrical and mechanical behaviour as well as the interactions between individual components." This vehicle simulation forms the basis for the rest of the design process, which also includes other numerical methods like CFD and FEM.

Christian Kral: "We have the interdisciplinary expertise to combine all the relevant aspects of the drive in a single simulation."



VALIDATING HARDWARE IN A SOFTWARE ENVIRONMENT

Compared to other development centres, AIT offers the significant advantage of being able to optimise all components and drives not only during the design phase, but also as prototypes in hardware-in-the-loop validation. The hardware prototype is hooked up to a simulation environment and can be put through any number of drive cycles without needing to be installed in a test vehicle.

ROBUST COMPONENTS

The virtual approach of the drive engineers at AIT covers not only testing but also machine control and monitoring during operation. A special challenge is to calculate temperatures and speed in real time during operation without using sensors – solely on the basis of operational parameters and mathematical models. Several calculation methods have already been developed and will be further adapted for use in the automotive sector. The team's comprehensive expertise is greatly in demand with Austrian and European manufacturers and suppliers in the electromobility sector. According to Christian Kral, "the use of modelling and simulation in development, validation and monitoring will become more and more important in the implementation of innovative vehicle concepts in the future." ///

RESEARCH INTO THE HEART OF THE NEW GENERATION OF VEHICLES

Hopes of a breakthrough for electromobility are riding to a large extent on lithium ion technology. New approaches are being applied to increase the range, service life and safety of these promising energy storage devices.

With public awareness of electromobility growing, energy storage devices too are increasingly becoming the focus of attention as the crucial element of hybrid and electric vehicles. The nickel metal hydride batteries used by most current hybrid vehicles will not be able to meet the demands of the future. "Pure electric vehicles and plug-in hybrids need batteries with significantly greater storage capacities than current hybrid applications," says Valerio Conte, an expert for electrical energy storage devices at AIT. "Tomorrow's batteries must have a significantly higher energy density if electric vehicles are to achieve an acceptable range." The hottest contender is still lithium ion technology, which is already in use in laptop computers and mobile phones, but which still has considerable scope for optimisation when it comes to battery safety and durability. Together with national and international research partners, the mobility experts at AIT are confronting the scientific challenge of optimising this technology. In the HELIOS and BALI projects, they are studying the ageing behaviour of new materials and searching for innovative charge management solutions for lithium ion batteries.

Valerio Conte

UNLOCKING THE SECRETS OF AGEING

Scientists believe that new lithium-based cathode materials will make it possible to substantially increase the energy density and service life of energy storage devices. In the European HELIOS project, experts from AIT and 17 other partners are searching ways to increase the safety and service life of lithium ion accumulators by improving their understanding of the ageing processes in these devices.

"We are very proud to be part of a high-ranking project consortium in this endeavour," says Conte. "Both key players in the automotive industry such as Opel, Renault and Peugeot and the most important European research institutes in the energy storage sector are involved in this project." The primary task of Conte's team is to compare and validate the different new generation technologies. Cells with different lithium-based cathode materials are subjected to extensive performance and ageing tests at varying temperatures and power profiles. The data gathered by all partners is collected and ultimately incorporated into a model that is able to reproduce the ageing behaviour of the battery cells. This project thus allows the scientists to draw conclusions about the temperature behaviour, service life, recyclability, safety, and life cycle costs of the different technologies. "Ultimately we hope to provide a comprehensive theoretical analysis," says Conte. "This will enable us to predict the effects of our findings at the cell level on the safety of the overall battery system."

ACTIVE BALANCING

But it is not only the materials that need to be perfected. Battery management too still offers considerable room for optimisation. A battery pack consists of hundreds of cells, which, because of manufacturing tolerances and ageing effects, have different capacities. This can result in damage to individual cells due to overcharging or deep discharge. In the passive balancing techniques that are currently in use, weaker cells are protected by converting excess charge into heat, with a consequent efficiency reduction of the system. Together with its industrial partners Infineon and Magna, AIT is currently working on an innovative approach to an active balancing scheme. In the BALI project, sophisticated power electronics and intelligent algorithms are used to "juggle" the charge and ensure that it is always distributed equally across all the cells in the battery. It is belived that this balancing will improve battery utilisation, so that it will increase vehicle range and prolong battery life. The experts at AIT aim to represent this complex charge distribution process in a computer simulation. The first step in creating the simulation is to measure all the relevant properties of the battery cells and integrate them into a numerical model based on empirical data. The simulation will then display the specific effects of active balancing on the most important battery properties. The project has already yielded promising interim results and resulted in two patent applications.

"Intelligent solutions in the field of materials and battery management are a promising approach to increasing the service life, safety and range of lithium ion technology and thus to reducing its life cycle costs," says Conte. ///

Photos: Fotostudio Krischanz & Zeiler, AIT, Infineon, Barnim

REINHARD PETSCHACHER, CTO OF INFINEON TECHNOLOGIES AUSTRIA AG, ON ELECTROMOBILITY CONCEPTS

Mr Petschacher, what is the significance of electromobility concepts for Infineon in general?

In the face of steadily dwindling energy resources and the need to step up our efforts to meet climate protection goals, electromobility concepts are enormously important for us all. Along with communications and safety, energy efficiency is one of the priority issues in our strategy. Electromobility is an important part of this focus. Infineon has outstanding expertise in the fields of power electronics and drive technology, which will pave the way for the advance of e-mobility, and the company is putting its expertise to work both in Austria and elsewhere in Europe.

Are you already working on R&D projects in this field? And where is your special focus?

In addition to countrywide initiatives to promote regional electromobility concepts, Infineon also participates in the Austrian Mobile Power platform. Top companies from the industrial and research sectors and the power industry are cooperating in this project with the aim of putting 100,000 electric cars onto Austria's roads by the year 2020. In Europe, Infineon is a leading participant in the E3Car (Energy Efficient Electrical Car) research project, which aims to increase the efficiency of electric vehicles by some 35%. We are concentrating on semiconductor components and power modules that regulate the supply and distribution of energy in electric vehicles. These are used primarily in the drive train, the inverter and in the lithium ion battery. Our aim is to increase the efficiency of these components.

What role do you see for AIT, as a non-university research institute, in implementing innovation?

We at Infineon place a high premium on innovation. We constantly work on innovation projects and we cooperate both with partners in the industrial sector and with research institutions. AIT shares our focus on the themes of energy efficiency, mobility, and renewable energy sources, and we are already working together on various projects in these fields. One of the things we particularly appreciate is that AIT has a long history of studying energy efficiency and can therefore draw on a broad base of fundamental knowledge on this issue. ///

Peter Schulz: "In order to achieve the necessary mechanical strength, aluminium may be alloyed with silicon and magnesium. The crucial issue is to determine the exact quantities that will leave the material ductile enough for subsequent forming processes and allow fast hardening using optimized heat treatment."

Photos: Fotostudio Krischanz & Zeiler, AIT, Fronius, Privat, Emeraldinsight

THE MATERIALS OF TOMORROW'S CARS

/// In Ranshofen light metal specialists are working on ideal materials for electric vehicles. Material properties as well as process technology are refined by means of experiments and simulations in order to make e-mobility a comprehensively attractive concept. ///

ELECTRIC VEHICLES must be lightweight and yet safe. The challenge is to find ways of combining these two essential but contradictory requirements in one design concept. "We can cut down on weight by using light metals like aluminium and magnesium," says Peter Schulz, an expert for materials development at AIT. "By optimising the material composition, the production processes and the design using algorithms, simulations and validation, very good results can be achieved where passenger safety and component lifetime is concerned."

OPTIMISED PROPERTIES

The materials of components and frame structure should have a high fracture strain, but at the same time possess a certain strength that will prevent it from denting too easily. Just like in conventional vehicles, aluminium alloys are the materials which are most frequently used for electrical cars. In order to achieve the necessary mechanical strength, the aluminium may be alloyed with silicon and magnesium. "The vital issue is to determine the exact quantities which will lead to a cer-

tain strength but will leave the different parts of the frame ductile enough for subsequent forming processes," says Schulz.
Since high temperatures can develop in the engine compartment, it is particularly important for load-bearing components within this area to be creep resistant. As aluminium components soften rather quickly at higher temperatures, the researchers are studying ways to increase the metal's creep resistance by alloying it with suitable elements.

REDUCING ENERGY INPUT AND PRODUCTION COST

In order to find the ideal material composition, Peter Schulz and his team conduct experiments as well as rely on their expertise in the field of simulations. In one of their projects, Through-Process Modelling of Light Metals, the forming and subsequent heat treatment of automobile sheet material is simulated in order to describe the effects of the deformation on the hardening process with less experimental efforts. "For this reason we want to optimise heat treatment in such a way that allows metal to be hardened very quickly while keeping the temperature as low as possible. Lowering the heat treatment temperature results in considerable energy savings during the production process". Optimising these processes is extremely important, as our commitment to zero emissions and e-mobility is a challenge to not only reduce vehicle emissions during operation, but also to lower energy consumption and carbon emissions during the manufacturing process.

THE INTERACTION OF MATERIALS AND DESIGN

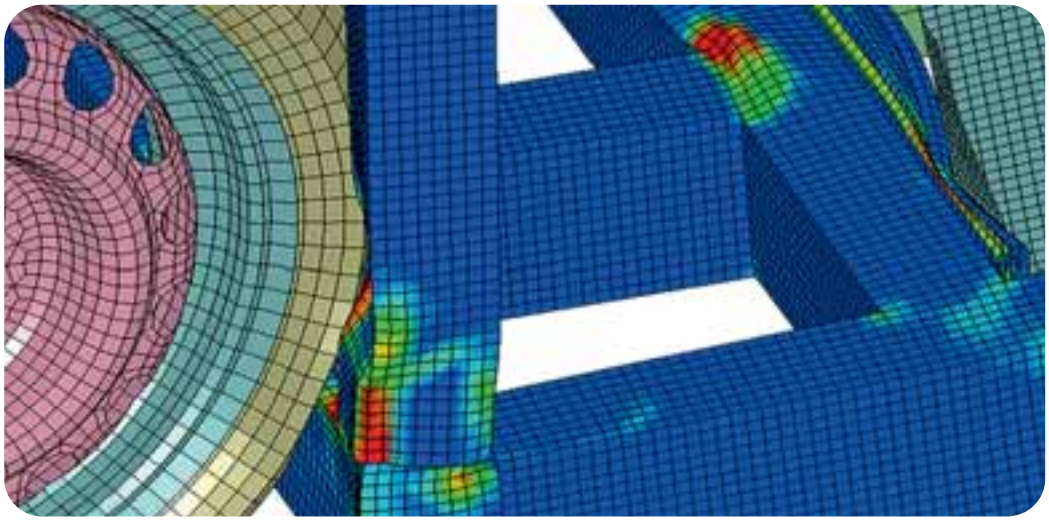
The researchers in Ranshofen use simulation tools and algorithms developed by universities and research institutes to combine microstructural processes with macrostructural process technology parameters for vehicle manufacturing applications. The hitherto applied macroscopic simulations – which, for example, allow researchers to model melt solidification – are combined with microscopic simulations that can show the behaviour of the material at the atomic level during the cooling process. This allows the experts to determine how quickly an alloy must be cooled in order to achieve the desired strength, which depends on the atomic arrangement in the metal. The design process of components and structures is included in these simulations right from the start in order to be able to show the full potential of the alloys to advantage.
In order to provide an environmentally friendly, safe and cost-effective e-mobility with the required vehicle chassis, experts in materials development, process technology and design have to unite their expertise and innovation. "And this," says Peter Schulz, "is where the excellence of our team lies." ///

/// HEINZ HACKL, MANAGER OF FRONIUS INTERNATIONAL, ON RESEARCH COOPERATION ///

Mr Hackl, what direction will the development of Fronius take in the coming years?
We are concentrating on three focal points: internationalisation, to be able to go where the future key markets are, and continual improvement of our internal processes and organisation, to control growth and costs and to offer products of the highest quality. And we are also committed to innovation in our products. Innovation supplies additional impetus for growth and technology leadership. In this way, we can strengthen our brand and offer our customers unique product advantages.

How important is R&D in all this, and what role does non-university research play in your plans?
R&D is enormously important if we want to remain at the cutting edge of developments in joining technologies with lightweight materials like aluminium. When we enter new technological fields, we work together closely with external research partners like AIT to gain valuable input. For example, the expertise of AIT's light metal group in Ranshofen contributed to the development of a new spot welding method for aluminium-steel joints for which we received the Austrian State Prize for Innovation last year. It goes without saying that we will continue to invest heavily in R&D in future in order to consolidate our status as a technology leader on the international level.

What aspects do you value most about your cooperation with AIT's light metal experts?
In our cooperation with AIT, we particularly appreciate the dedicated employees, the in-depth technical knowledge, and the good network it offers. As an independent research centre, AIT has the advantage of having many contacts to other businesses and research institutions. This additional expertise from many different areas has already brought clear benefits for us. ///



SAFE, LIGHTWEIGHT AND INDIVIDUAL

/// Space frame structures have considerable advantages for electric vehicles. They are lightweight and can be manufactured cost-effectively. Light metal experts at AIT are developing methods for designing powerful, safe electric cars using this design method. ///

Electric cars will have a crucial role to play on tomorrow's roads. To ensure the efficiency of these environmentally friendly vehicles, however, their weight must be reduced as much as possible. Light metal experts at AIT are developing new methods for designing lightweight yet safe vehicle structures using aluminium and magnesium alloys. The main focus of the researchers' attention is on space frames – a lattice structure of extruded profiles and cast nodes which involves lower tooling costs than conventional monocoque body structures. This makes space frames particularly suitable for vehicles that are manufactured in smaller numbers, catering to the growing consumer demand for individuality. By modularising the system, space frame structures can be used to manufacture a wide variety of vehicle variants even on a non-industrial scale, i.e. in smaller automotive factories.


Peter Simon

IMPROVING CRASH PERFORMANCE

The experts involved in the "Steyrer 1050" cooperation project focus primarily on the issue of safety. "Although no crash performance specifications have yet been developed for electric vehicles, safety is a very important sales argument," says project manager Peter Simon. The development of suitable finite element methods allows the space frame structure to be simulated and optimised in a cost-effective manner. An approximate calculation of the stresses that occur in curves or during braking forms the basis of the numerically assisted design of the structure. One of the things the experts focus on when optimising safety issues is the battery. "In a head-on collision, the high kinetic energy of the battery is introduced into the vehicle structure," explains Peter Simon. "For this reason, it is necessary to develop a separate crash management system for the entire battery pakkage." The basic idea is to use a crash box positioned in front of the battery that deforms to absorb the energy from the impact.

The energy absorption can be maximised by designing the material to exhibit a "successive buckling behaviour". This is done by deliberately weakening the material in strategic places. But the challenging question is how and where to place these "imperfections". "At the moment, we are developing methods for inducing the necessary weakness in the materials by means of localised heat treatment," says the expert. The AIT researchers will soon introduce the first real prototype designed according to this virtual model: a two-seater electric vehicle for urban traffic. ///

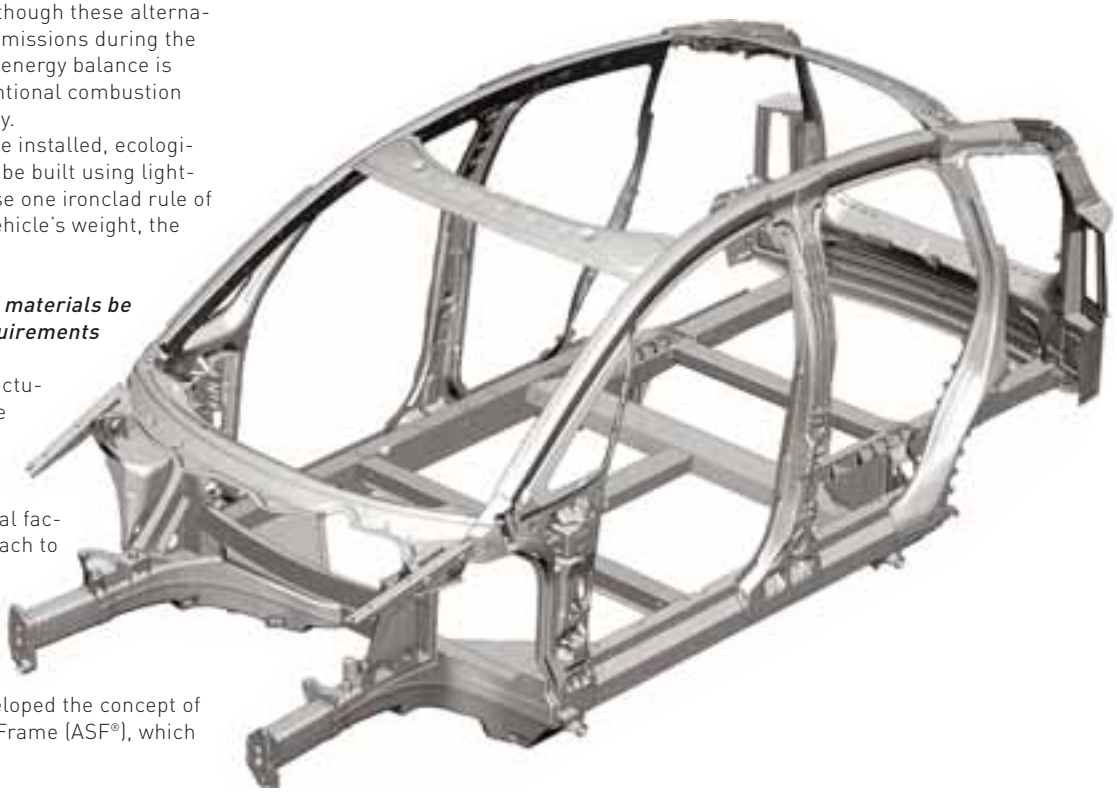
"WEIGHT REDUCTIONS OF UP TO 40 PERCENT ARE FEASIBLE"

/// Lutz-Eike Elend, Head of Lightweight Technology and Process Development at Audi AG, talks about the cost-efficient use of lightweight materials in body design. ///

Mr Elend, how do you expect customer demands on mobility to change in the future?
Their demands are quite clear: lower fuel consumption and lower emissions. Tomorrow's mobility must become more sustainable. But we cannot do this at the cost of lowering our high standards of safety and comfort and the fundamental demand for individual mobility. So future developments will be dominated by the need to ensure individual mobility with a high degree of comfort while using our energy resources conscientiously and efficiently. However, we cannot focus exclusively on the energy requirements of operating the vehicle. Rather, we need to take the energy balance of the vehicle's entire life cycle into account, from the assembly line to the scrap yard.
The current debates about hybrid and electric cars often disregard the fact that, although these alternative drive concepts exhibit low emissions during the vehicle's useful life, the overall energy balance is often poorer than that of conventional combustion engines with improved efficiency.
Irrespective of the type of engine installed, ecologically sustainable vehicles must be built using lightweight design methods. Because one ironclad rule of physics is that the higher the vehicle's weight, the higher its fuel consumption.

How important will light metal materials be in future, and what quality requirements must they meet?
Innovative lightweight body structures involve high demands on the optimum use of all potential lightweight materials and on the necessary joining and production technologies. The crucial factor, however, is a holistic approach to functionality and loading – we need to use the right materials in the right places with perfectly integrated functionality. In the field of aluminium body design, Audi AG developed the concept of the award-winning Audi Space Frame (ASF®), which achieves optimum material efficiency through integrated, functional lightweight design and enables weight savings of up to 40% compared to a conventional steel body. The mastery of hybrid materials and their integration into manufacturing processes will be the dominant features of the promising new functional lightweight design concepts of the future. It is important to make manufacturing technologies available that involve acceptable costs and robust processes while guaranteeing consistently high product quality.

How can the light metal experts at AIT support you in these endeavours?
Today, our experts in technology and process development are working on high and ultra-high strength aluminium wrought and cast alloys with improved properties that will allow us to reduce body weight still further. However, they are not focusing exclusively on optimising the properties of the basic material, but are also looking at ways to manufacture it economically on an industrial scale.
As an institution with both basic and applied materials and process expertise, AIT represents the perfect link between universities, industrial partners and the automotive industry and is therefore in an ideal position to contribute significantly towards application-oriented alloy development. ///



DYNAMIC PLANS FOR OPTIMAL ROUTING

/// Efficient transport for people and goods would be inconceivable today without the help of complex mathematical methods. At AIT, logistics experts develop the expertise that is needed for efficient, cost-effective and environmentally friendly route planning. ///

DUE TO THE INCREASINGLY INTERCONNECTED global economy, transport costs account for a steadily rising proportion of overall product costs. Much remains to be done to lower environmental costs and increase route planning efficiency. "Finding sustainable solutions to these problems is a highly complex task that can only be tackled by an interdisciplinary approach and in close cooperation between science and industry," says AIT logistics expert Jakob Puchinger. A graduate in information technology, Puchinger spent several years as a re-

"Finding sustainable solutions for efficient route planning is a highly complex task that can only be tackled by an interdisciplinary approach and in close cooperation between science and industry."

Jakob Puchinger

searcher in Australia where he gathered extensive optimisation expertise at the interface between basic and applied research.
A reviewer for numerous international scientific journals, he believes that the greatest current challenge in the field of logistics is the use of real-time, dynamic traffic information for optimising route planning. "One possibility is to integrate predicted travel times into our calculations," he says. "The advantage is that fluctuations at different times of the day and night can be taken into account, which is not the case when using conventional fixed travel times." Additionally, it is possible to determine the probability of traffic congestion or additional trips in order to calculate their effects on travel time. More complex still is the linking of route planning with real-time traffic data or additional calls that require immediate response.

SHORTER WAITING TIMES

The actual optimisation potential of incorporating real-time traffic information or traffic predictions into route planning systems is being studied by AIT logistics experts and their partners in the ILOS project. "Ultimately, we expect to achieve significant savings in time and fuel for transport companies," says Puchinger. Real-time traffic information also features in the FLORENCE project, in which researchers are working on predicting the transit times of lorries between various motorway exits and the Vienna railway terminal. "We use sensors to record the time the lorry leaves the motorway and then predict its arrival time at the terminal based on real-time traffic information," says the logistics expert. This information is extremely valuable for terminal operators as it enables them to prepare for the lorry's arrival and thus accelerates the entire loading process. Like many other projects, FLORENCE too uses real-time traffic information from the FLEET system.

THE BEST OF ALL OPTIONS

The most important methods used in route planning are procedures involving "combinatorial optimisation". "These methods are applied in cases that present so many possible solutions that it is simply impossible to list them all," explains Puchinger. "Thus it is necessary to find the optimum solution without filtering the entire solution space." Both heuristic and exact procedures are used for this purpose. Heuristic procedures can be used for quickly scanning the solution space to identify a good solution. Exact procedures help to limit the vast quantity of possible solutions and also enable predictions to be made about the quality of the solution found. When researchers at AIT work with dynamic, stochastic and real-time data, the optimisation methods become even more complicated. "This is why having experts from different specialities – from stochastics to traffic information systems – working together is a huge advantage in the field of logistics," Puchinger says. It takes a sophisticated cocktail of different methods to respond efficiently to the complex and often unpredictable events on the transport routes and to reduce the costs at all levels by means of optimised route planning strategies. ///

In the HealthLog project, AIT logistics experts and the Samaritan Federation of Vienna are exploring possibilities for improving route planning in patient transport

INNOVATIVE ROUTE MANAGEMENT CAN SAVE LIVES

/// AIT logistics experts are developing a new method for a highly efficient patient transport system that takes into account both the current traffic situation and newly scheduled transports as well as other unforeseen events. ///

In the ambulance service, optimal logistic solutions can not only reduce the strain on financial and personnel resources – both of which are typically in short supply – but also save lives. Hence the social significance of using existing logistics expertise and adapting it to the needs of ambulance fleets is particularly high in this segment of the transport industry. In the HealthLog project, AIT logistics experts and the Samaritan Federation of Vienna aim to explore possibilities for improving route planning and to develop appropriate methods for implementing such improvements. "Our goal is to develop reliable routes so that route planners can quickly and easily respond to unforeseen events that do not form part of their typical routine," says expert Irmgard Zeiler.


Irmgard Zeiler

EXPECTING THE UNEXPECTED

Historical data shows that the Samaritan Federation knows about approximately 60% of upcoming ambulance trips one day in advance. The remainder consists of additional trips that must be integrated into a tour at short notice. There must be enough ambulances on standby for such extra trips – but not so many that efficiency is reduced. This is a fine organisational line to walk, and planners have so far relied exclusively on empirical data. Now the system is set to be improved and simplified using mathematical optimisation methods. The biggest chal-

Photos: Fotostudio Krischanz & Zeiler, AIT, Uni Wien, Arbeiter-Samariter-Bund

lenge for the logistics experts is method development. "What we need to do here is link a dynamic route planning system with stochastic – i.e. random – data. This concept is so new that we have hardly any existing expertise to fall back on," says Irmgard Zeiler.

BREAKING NEW METHODOLOGICAL GROUND

In their innovative stochastic approach, researchers are concentrating on a combination of methods consisting of data analysis, modelling and operations research. "Stochastic data analysis allows us to draw conclusions about travel time distributions from real-time traffic data provided by the FLEET system," the mathematician explains. "This also allows us to include congestion and delays in our route planning and respond quickly to unforeseen situations." Additionally, historical data is compiled to allow predictions about the probability of extra trips at different times of the day or year. In stochastic modelling, both unchanging and random components are integrated into a formal model for subsequent calculation. The methods of operations research, which combine mathematics with computer science and business management, are the key to the optimisation process: "Based on the formal model, we can ultimately draw conclusions about potentials for improvements and savings," says Zeiler. ///

/// RICHARD F. HARTL, PROFESSOR OF PRODUCTION AND LOGISTICS (VIENNA UNIVERSITY), ON IMPROVEMENT MODELS IN ROUTE PLANNING. ///

Professor Hartl, what are the new approaches you expect to see in traffic logistics?

In the past few years, we have been able to observe a paradigm shift in transport logistics in which greater emphasis is placed on rich vehicle routing – the inclusion of various practical aspects into classical route planning models. This applies in particular to the use of information sources that have become available as a result of recent technological developments. For example, the combination of GPS data with historical traffic information and real-time traffic data enables us to deploy vehicle fleets with substantially greater efficiency.

What research topics do you plan to focus on in future?

One of our objectives will be to work on improving route planning in dynamic and stochastic planning environments in which customer orders only come in during the course of the day and neither the order volumes nor the actual travel times are exactly known. Another approach deals with optimal regional coverage in order to be able to provide fast response to urgent calls. This is a crucial issue in health care logistics, where ambulances must be strategically stationed and emergencies must be assigned to the most suitable vehicle in order to minimise the time required for an ambulance to reach the patient.

How effectively is the university cooperating with AIT in this field?

Vienna University and AIT are ideal partners in the HealthLog project. We have comprehensive expertise in mathematical methods and route planning, while AIT has long years of experience in compiling floating car data and mapping traffic conditions in real time. The joint development of meta-heuristic and exact solution methods and the task of combining them into hybrid procedures present extremely demanding and exciting challenges. ///

OPTIMISED TRAFFIC FLOW

/// Our traffic infrastructure is increasingly being taxed to the limits of its capacity. Intelligent solutions for guiding and controlling traffic flows can make an important contribution to improving efficiency and lowering emissions. ///

Dietmar Bauer: "Data analysis, modelling and simulation can be applied to analyse the current situation and adapt the infrastructure accordingly."

Photos: Fotostudio Krischanz & Zeiler, ÖBB, Photos.com, Wiener Linien

OUR CONSTANTLY INCREASING TRAFFIC VOLUMES have consequences for every individual in our society. Congestion on the roads results in high emissions and delays on bus and train routes – hardly something that will increase the appeal of these environmentally friendly means of transport. Hence it is necessary to increase their efficiency by optimising the overall system. "Data analysis, modelling and simulation are valuable tools for this purpose," says Dietmar Bauer, one of AIT's experts for the modelling of pedestrian and traffic flows. "They can be applied to analyse the current situation, adapt the infrastructure accordingly, and distribute the demand more efficiently by providing real-time information." Bauer, who holds postdoctoral qualifications in mathematics, spent time as a researcher at the prestigious Yale University as well as in Sweden and Australia to gain international experience in the field of statistical data analysis and at AIT contributes his expertise in statistics to the solution of transport problems.

FROM MEASUREMENTS AND ANALYSIS ...

Every optimisation process begins with precise data measurement. Individuals or vehicles are counted at a measurement cross-section or tracked anonymously. The spectrum of techniques applied for this purpose is very broad, ranging from infrared sensors and light barriers to video cameras, GPS, and mobile phones. These measurements result in large numbers of data records, which are subsequently analysed and intelligently com-

bined. "Data analysis allows us to visualise the status quo of the traffic system and transmit it to road users in real time," says Bauer. This can be done using instruments such as the FLEET traffic analysis system developed by AIT. FLEET uses GPS data from several taxi fleets to create a snapshot of current traffic conditions for the entire road network of Vienna every 15 minutes and to calculate expected travel times on the individual routes.

... TO MODELLING AND SIMULATION

However, data analysis also yields information about how the traffic system functions and thus forms the basis for the development of simulations that model the traffic system and provide a glimpse into the future. The input consists mainly of passenger and vehicle numbers as well as information about the behaviour of individual road users such as subjective route choice. The simulation uses this data to predict expected utilisation figures and identifies the areas that must be improved in order to optimise the capacity of the traffic system. In this way, infrastructure can be optimally planned and road users can be efficiently guided to their destinations. According to Bauer, an important element of the research efforts is the calibration and validation of the models used. "The predictions of the simulation model must be compared with conclusive real-time data – only in this way can we filter out the parameters that must be adapted in order to draw realistic and useful conclusions."

One of the particular challenges lies in the optimisation of co-modal traffic systems, as this requires individual motorised traffic and public transport systems to be combined in a single model. In addition to individual route choice, the model must also include the choice of transport mode, which in turn depends on a range of additional influencing factors such as cost and travel time. Therefore, the project PACE-MODE uses a co-modal approach to examine the factors that influence people in their choice of transport to the Vienna International Airport. The project will help both passengers in choosing their means of transport as well as transport and airport operators in optimising the transport system.

INTERNATIONAL RECOGNITION

"The core competence of our team at AIT lies in the breadth of its expertise – from data acquisition through data analysis to simulation and the modelling of pedestrian and vehicle flows," says Bauer. "One of our advantages is that the team comes from a strong academic and international background and has an extremely interdisciplinary structure." Against this background, the traffic flow experts were able to attain international recognition within a relatively short time and to establish cooperation with relevant European research groups. With its comprehensive expertise in the field of co-modal transport systems, the team has made a name for itself as the first port of call for the major domestic infrastructure providers such as Asfinag, Austrian Railways and Wiener Linien. ///

MICHAEL LICHTENEGGER, EXECUTIVE DIRECTOR OF WIENER LINIEN, ON URBAN MOBILITY CONCEPTS.

Mr Lichtenegger, in your view, what are the most interesting challenges for tomorrow's mobility in urban areas?

Urban public transport will provide more than transport services in the future and will include additional customer services along the route. Modern cities are environments characterised by mobility, and the spheres of work, leisure and transport are increasingly beginning to overlap. More and more people are multimobile – they do not limit themselves to moving from A to B during rush hour. Hence the seamless integration of different means of transport – cars, bicycles, urban public transport, long-distance rail transport – will pose a new and interesting logistical challenge along with the need to optimise the energy efficiency of transport. One of the great challenges for Wiener Linien will be to convince an even greater number of potential passengers of the advantages of public transport. The only way to achieve this is to extend the range of services we offer, starting with new tram and underground lines, customer-oriented services, positive brand acceptance, and a focus on the service attributes that our customers care about the most.

You recently won the Austrian State Prize for the "Rave" project. What were the outstanding features of this EURO 2008 project?

The "Stadion" stop of the U2 underground line was specially designed for event traffic. The entrances and exits for "normal" operation, with stairs and lifts at both ends, remain closed during events. For large events, there are four additional entrances and exits on each platform to facilitate the smooth flow of large numbers of people while ensuring the greatest possible degree of safety. The third track means that when one train heading for the city centre departs, another empty train is already pulling in on the other side of the platform. With an interval of two minutes between trains, this system allows us to move 24,000 passengers per hour. In the "Rave" research project, which was sponsored by the Ministry of Transport, Innovation and Technology, Wiener Linien cooperated with the Austrian Institute of Technology to develop a system that uses objective measurements to allow the station operators to control the flow of passengers onto the platforms. ///

INTELLIGENT INTERMODAL MOBILITY

/// The linking of individual mobility data with current traffic information results in intermodal route suggestions in real-time, getting commuters where they need to be on time. ///

For many commuters it's an all too familiar story: the daily journey into work is often hampered by traffic jams on the roads or delays in public transport caused by road works, accidents, technical breakdowns or bad weather. Researchers at AIT working on the PROVET (Prediction of Individual Route Choice in Intermodal Transport Systems) project are developing an intelligent, intermodal traffic information system, providing real-time alternative route suggestions for road users when disruptions occur causing delays along their usual route. "The main difference setting it apart from conventional traffic services is that the traffic information provided is context specific covering all modes of transport. Suggested routes are derived from monitoring the commuter's individual habits, which means the system is better received than traditional routing systems", says Katja Schechtner, expert in co-modal traffic information systems. "Commuters receive personally relevant information automatically and promptly rather than having to waste time finding out about the current traffic situation on their route and it saves them having to work out an alternative route."

Katja Schechtner: "The main difference setting PROVET apart from conventional traffic services is that the traffic information provided is context specific covering all modes of transport."

MOBILITY DATA VIA SATELLITE

The implementation of the intermodal assistant requires clarification of certain complex questions. This involves the system not only having to identify the current location of the road user but also which mode of transport he or she is using to travel to his or her chosen destination. To answer these questions, the experts use sophisticated methods known as Mode Detection and Profiling. The aim of Mode Detection is to use GPS data to automatically recognise all modes of transport used on the particular route – this is of course particularly difficult on short journeys in the city or when differentiating between buses and trams. Profiling, on the other hand, analyses historical motion data in order to extract more information on the commuter's preferred routes. In order to develop the relevant methods, the GPS mobility profiles of selected commuters were recorded over a six week period. In addition, individuals using different modes of transport were tracked on predefined routes. A combination of mathematical-statistical methods and spatio-temporal analyses enabled the experts to deduce the correct mode of transport based on various factors such as velocity and stop/go patterns. Initial validations showed that, using algorithms developed at AIT, it is possible to identify the points of interchange and to segment the routes according to the mode of transport used.

REAL-TIME DATA

In the next phase, it is planned to link individual mobility data with real-time information on the current traffic situation in order to inform the commuter about traffic jams or delays along the preferred route and provide tailored alternatives. "In principle", explains Schechtner, "what we really want to achieve with this personalised and situation-aware additional function is to use existing traffic information systems more intelligently, making them more user-friendly". The "intelligent intermodal assistant" could therefore become a valuable add-on for smart phones or navigation systems within the intermodal traffic system. ///

USING MATHEMATICAL METHODS TO REDUCE NOISE LEVELS

/// Acoustics experts at AIT draw on a wide range of innovative methods in the development of effective noise barriers, quieter road surfaces and more environmentally-friendly transport systems. ///

Manfred Haider: "Reliable assessment of the functionality of noise reduction devices is a fundamental prerequisite for the most effective use of existing and emerging systems."

Photos: Fotostudio Krischanz & Zeiler, ASFINAG, Photos.com

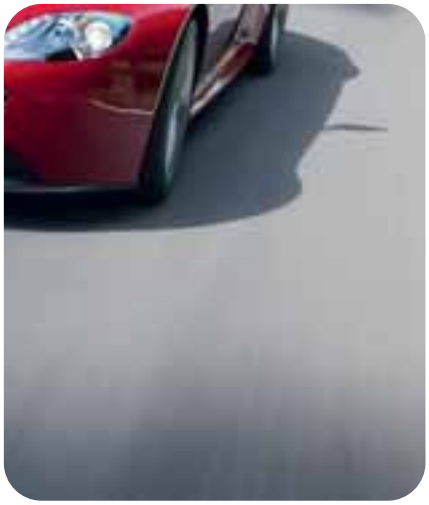
EVER-INCREASING LEVELS OF MOBILITY mean additional noise pollution. Traditional noise reduction devices (NRDs) such as noise barriers cannot always be used and neither do they always have the desired effect. They are also often in increasing conflict with other requirements such as the need to provide drivers with a clear view or ensure local residents have enough natural light and sunlight.

"Using noise barriers in urban conurbations causes particular problems and is often impossible although these are the very areas with the greatest need for noise reduction", explains AIT acoustics expert Manfred Haider. The well-known scientist and sought-after specialist in the field of noise abatement research focuses on the question of how the origin and spread of traffic noise can be prevented or reduced as close as possible to the noise source. His work includes, for example, examination of the acoustic characteristics of low-noise road pavements or the effectiveness of innovative noise barrier configurations. Together with his team he is involved in numerous international research projects in the field of noise abatement.

Specialists from AIT play a leading role, for example, in projects such as the EU co-funded QUIESST project, in which researchers from all over Europe are working on the optimisation of existing NRDs and on the development of new assessment procedures for noise abatement measures. "Reliable assessment of their functionality is a fundamental prerequisite for the most effective use of existing and emerging NRDs", says Haider.

The team of experts has been using complex methods to work on this task for several years now. "For urban planners wishing to implement additional measures such as add-on elements for existing noise barriers or special noise-absorbing road pavements, it's important to be able to quantify the anticipated benefit", explains the researcher. "At AIT, we are able to map the achievable benefits on a scientific basis and therefore support new innovative products."

CLOSE TO THE NOISE SOURCE



In future, NRDs in close proximity to the noise source will become increasingly important. That is why researchers are working both on optimisation of structural noise abatement measures and the issue of tyre-road interaction. The simulation of the interaction between rolling tyres and road surface requires detailed mathematical modelling of the complex geometric structure of the pavement. Road surface texture also has an important influence on other properties such as skid resistance. The acoustics team is therefore collaborating closely with AIT pavement experts, who are able to draw on an extensive database for modelling. Manfred Haider and his colleagues use this mathematical surface model as input information for the simulation of emitted sound fields. Such realistic simulations of the actual physical processes allow the researchers to identify key parameters for effective noise prevention solutions and predict their degree of effectiveness.

The internationally acclaimed expertise of the AIT acoustics specialists in the field of low-noise road surfaces has also been used in the EU key project SILENCE. Some of the innovations investigated – such as porous asphalt – are being increasingly used throughout Europe. Such pavements, which are already widely used in the Netherlands and Germany, allow sound waves to permeate a short distance into the road surface where friction causes them to be partially absorbed into the open-pore matrix. The current challenge is to extend the life of low-noise road surfaces, which requires further optimisation, particularly for use in countries like Austria where there are harsh winters. Researchers at AIT are focusing on this area.

SOLUTIONS FOR COMPLEX PROBLEMS

An important factor contributing to the international acclaim enjoyed by AIT in the field of acoustics is the combined focus on currently used methods as well as those still under development. These range from sound field simulation to modelling of road surfaces through to simulation of traffic flows as emission sources. The key here is the close interdisciplinary cooperation between the various research groups at AIT. "This enables us to combine our acoustics knowledge with the know-how of our colleagues working in pavement monitoring or in traffic flow analysis right from the start", says Haider. This interdisciplinary approach allows for detailed investigation of complex problems leading to efficient solutions.

Together with the experience of the individual researchers, it is this interdisciplinary approach that makes the AIT acoustics team such a competent partner for national and international research institutions and industry customers. ///

KEEPING TRACKS ON NOISE

/// A dynamic simulation platform developed within the "Emission Simulation" project provides the basis for optimising traffic noise analysis and prediction, leading to more environmentally-friendly transport. ///

Sara Gasparoni: "We are working on a simulation platform that provides the basis for detailed noise analysis and prediction and can also be used to address many issues related to traffic emissions and environmental impact."

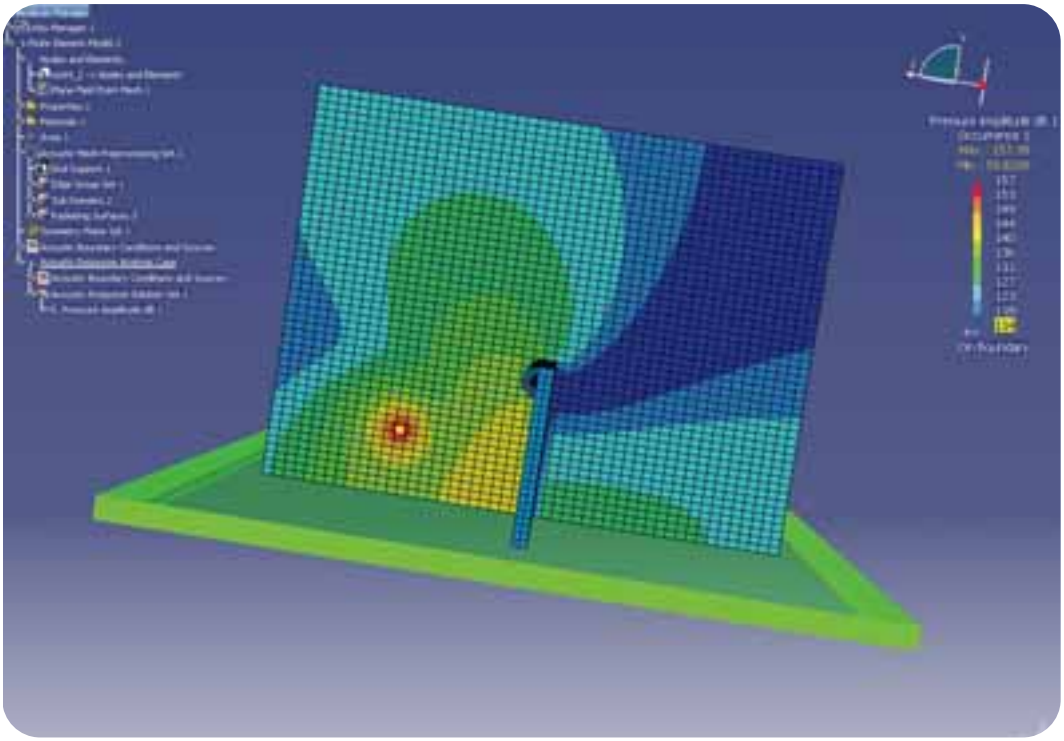
Photos: Fotostudio Krischanz & Zeiler, AIT, ASFINAG Photos.com

OBTAINING DETAILED INFORMATION on traffic noise emissions would normally involve continual noise level measurements along very long road sections. Using simulations to perform the same task has many methodical and practical advantages: "It's our goal to simulate complex situations at microscopic and macroscopic levels, where until now there has been insufficient information available", explains simulation and acoustics expert Sara Gasparoni. That is why the new simulation models for noise reduction barriers designed at AIT also take into account structural add-on elements or special designs and are able to assess their effectiveness in the near-field and far-field of the sound source. Tyre-road interaction also causes a relatively complicated acoustic situation, in which the road surface structure itself plays a key role. Researchers at AIT use near-field simulations to capture the sound propagation in this area in all its complexity.

OPEN FOR NEW KNOWLEDGE

The goal of the "Emission Simulation" project is to develop a modular system of simulation methods, which can be used not only to evaluate the effects of existing noise abatement measures in detail, but also to assess the emission reduction potential of previously untested alternatives.

"All our expertise as well as future scientific findings will be combined in this comprehensive concept", says the researcher. This is a future-oriented strategy, which also takes account of new trends such as the predicted sharp rise in the number of electric cars. A considerable amount of noise emissions from these vehicles are in fact not engine generated but are caused by tyre-road interaction. "Our models are very realistic, particularly in this area", says Sara Gasparoni.



THE WAVE-LIKE NATURE OF SOUND

In order to be able to simulate complex noise fields as accurately as possible, the simulation experts use amongst others the "Boundary Elements Method" (BEM). This numerical method allows the sound propagation to be simulated at various points, both in enclosed spaces as well as outside. This means it is possible, for example, to model the sound field close to the tyres and road surface or the effects of noise barriers. However, the wave-like nature of sound means that, depending on the distance from the sound source, noise field models of differing complexity need to be employed. The BEM is particularly suitable for recording and describing noise phenomena such as interference and diffraction, which tend to occur in near-field situations. "That's why this method is of particular relevance for us in the field of microscopic simulation", explains Gasparoni.

WORK AT MICRO AND MACRO LEVELS

Results from these microscopic simulations are integrated in a platform, which also enables a realistic simulation of the macroscopic situation. "At this level we can use simpler models, which serve to integrate geometric and acoustic parameters such as those of the noise barrier, the tyres or the road surface into the simulation", explains the researcher. An important element of this innovative simulation system is the real-time traffic data from the FLEET traffic analysis system, which allows the correlations between traffic flow and emissions to be analysed in detail.

In contrast to other frequently used simulation models, which depict a situation at macroscopic level and use assumed average values for many parameters, the new system also takes scientific findings about detail components into account. This means urban planners, road maintenance companies, the road construction industry or vehicle and tyre manufacturers are able to introduce significantly more effective measures. "Ultimately", says Sara Gasparoni, "this will be a highly differentiated, dynamic and effective simulation platform promoting environmentally friendly transport. It will not only enable precise noise analysis and prediction but can also be used to address many issues related to traffic emissions and environmental impact." ///

/// WERNER KAUFMANN, HEAD OF THE NOISE ABATEMENT DEPARTMENT AT ASFINAG, ON THE QUEST FOR POTENTIAL NOISE REDUCTION METHODS. ///

Mr Kaufmann, what do you see as the biggest challenges facing ASFINAG with regard to noise?

Basically, we need to accommodate both growing demand from residents with regard to concerns about noise levels and health with the wishes of our customer – the driver – together with avoiding the construction of new housing too close to motorways.

Which innovative noise reduction methods do you think are most efficient?

Since, in comparison with other EU states, a large number of people in Austria are already protected by noise barriers in the ASFINAG road network, we are currently focusing on an area demonstrating high potential for noise reduction – noise emission caused by tyre-road interaction. It's really important that the planned EU legislation on the use of low-noise tyres is implemented as soon as possible. We also have high hopes for the development of low-noise road surfaces. We're using an increasing number of add-on elements for noise barriers and we invest heavily in the optimisation of these devices. We're keen to see improvements to the barriers with regard to noise absorption and noise transmission.

How does the cooperation with AIT help you?

In all these projects, we need to collaborate closely with a team of expert researchers. With its expertise, AIT helps us in making optimal use of the noise reduction potential of noise barriers, tyres and road surfaces and in the development of innovative products. ///

INNOVATIVE SOFTWARE TOOLS FOR IMPROVED ROAD SAFETY

/// Innovative risk analysis and simulation methods can be used to identify potential accident black spots in the road network, thus leading to improved road safety. ///

THERE ARE AROUND 40,000 ACCIDENTS INVOLVING PERSONAL INJURY every single year on Austria's roads. Many are caused by excessive speed, drunken driving and dangerous overtaking – yet on many road sections the pavement conditions and road geometry also play an important role. Research teams at AIT have developed intelligent software tools – MARVin (Model for Assessing Risks in Road Infrastructure) and VBSA (Virtual Black Spot Analysis) – enabling analysis of risk potential in the road network and road accident simulation. These analyses and the resulting measures taken can go a long way towards improving road safety and lowering the risk of road accidents.

COMPUTER-AIDED RISK ASSESSMENT

Computer-aided risk analysis is based on road geometry and condition data provided by AIT's mobile high-tech road-testing laboratory RoadSTAR.

An extensive database provides detailed information on parameters such as skid resistance, rut depth, road surface texture, longitudinal profile, transverse evenness and curvature as well as transverse gradients for all motorways, dual carriageways and the majority of main roads in Austria.

Using the risk analysis tool MARVin, these road parameters are linked with accident data registered by Statistik Austria (the official Austrian federal statistics body) over the last fifteen years via simultaneously recorded GPS coordinates. Complex mathematical and statistical analyses were used by researchers at AIT to identify and objectively analyse basic correlations between road parameters and accident risk. "MARVin allows us to input data on a section of road know to be dangerous and to search the entire road network to identify sections of road characterised by similar parameter combinations and thus identify potential accident black spots", explains transport infrastructure expert Peter Maurer.

SIMULATIONS REVEAL POSSIBLE ACCIDENT CAUSES

MARVin has already been used successfully in several international research projects and there is considerable interest both within the car manufacturing industry as well as amongst road maintenance companies and road safety authorities.

Results from the analyses were also used directly in the drafting of current Austrian transport directives. Yet scientists at AIT have already thought one step ahead. By integrating the RoadSTAR data in a simulation software package, the points already identified by MARVin as being safety critical can now be analysed in more detail.

"Virtual Black Spot Analysis allows us to model dangerous road sections using live data on the road condition and the road geometry and simulate various types of driving manoeuvres", explains Maurer.

In the interests of safety, virtual cars, lorries or motorbikes are made to pass critical road sections at different speeds in order to obtain more information on vehicle behaviour in different driving situations and road conditions.


Peter Maurer

Photo: AIT

Vehicle safety features such as anti-lock braking systems (ABS) or electronic stability programmes (ESP) can also be taken into account.

The main objective of these simulations is to identify possible accident causes and to effectively make potentially dangerous road sections safer, for example by implementing targeted construction measures or introducing speed limits.

Both of these innovative tools aimed at accident prevention offer road infrastructure operators an important decision-making basis in the risk evaluation of future road construction projects as well as in the planning of targeted repair and maintenance work. ///

NETWORKING AND SUCCESS

/// The laws of globalisation not only apply to business but also to research and development – here too, networking and cooperation are key to remaining competitive. ///

"CLOSE NETWORKING with leading players in the international research arena is a key challenge on our roadmap to the future of research", says Wolfgang Knoll, Scientific Managing Director at AIT. "Each of our five departments therefore has the clear goal to act as an interface between national science and industry and to drive international networking", explains Anton Plimon, Commercial Managing Director at AIT. This strategy has already been proactively pursued for some time now by the Mobility Department since many of the research fields in which Franz Pirker and his team are involved can only be developed in an international context.

NETWORKING AT ALL LEVELS

As a partner in the European research associations FEHRL (Forum of European National Highway Research Laboratories) and EARPA (European Automotive Research Partners Association), AIT contributes innovative topics in the field of transport and automotive research, thus actively shaping future EU research and funding programmes. AIT cooperates at a global level for example within the framework of the International Energy Agency (IEA) in the field of "Plug-in Hybrid Electric Vehicles".

A best-practice example of cooperation at national level is "Austrian Mobile Power", which is an open platform for the coordination of Austrian activities in the field of electromobility. AIT plays a pivotal role in the founding consortium as research partner alongside national industrial key players Siemens, AVL, KTM and Magna.

KNOWLEDGE COOPERATION

Through their involvement in numerous research projects, the experts at AIT have gained extensive know-how in their core fields of expertise. Cooperation with European research facilities with a focus on other research areas leverages this knowledge – with clear benefits for all involved.

An example of such cooperation is AIT's involvement in the EU project TYROSAFE (Tyre and Road Surface Optimisation for Skid Resistance and Further Effects) in which it leads a consortium of six European research organisations aimed at consolidating the knowledge and resources of the individual partners from various fields of transport research.

There is also special focus on cooperation with universities on strategically relevant topics, e.g. with the University of Kassel in the field of lightweight design or with the Eindhoven University of Technology and the Georgia Institute of Technology in the field of electrical machines. Active cooperation and exchange visits with this leading American university provide intensive knowledge transfer in the field of research and scientific methodology. "This ensures that our research work will continue to live up to its reputation for scientific excellence in the future", says Wolfgang Knoll. ///

Photo: Verbund

/// WOLFGANG PELL, CHIEF RESEARCH OFFICER OF VERBUND, ABOUT THE FUTURE OF ELECTROMOBILITY IN AUSTRIA. ///

Mr Pell, your company is responsible for coordinating the "Austrian Mobile Power" (AMP) platform – do you already have all the key partners on board and committed to getting 100,000 electric cars on to Austrian roads?

It's an open platform, which by its very nature is meant to grow and that's exactly what it's doing. The leading companies in the key technologies are of course already on board.

What significance does the AMP platform have – nationally as well as internationally – in coordination in the field of electromobility?

We see ourselves as initiators in Austria and have also been at the cutting edge in Europe right from the start.

What role does research in general and the Austrian Institute of Technology in particular play in this project?

The whole focus is on innovation so of course research has to play a central role and come up with new ways of meeting the challenges of the future. AIT is the largest Austrian research organisation and was co-initiator of Austrian Mobile Power.

Apart from working on the AMP project do you also have other joint research projects with the Austrian Institute of Technology?

The combination with mobility is fairly new so it's rather exciting. We're already working with the AIT Energy Department on a number of joint projects such as smart grids.

"WE ARE COMMITTED TO CLOSE RESEARCH COOPERATION WITH AIT"

/// Thomas G. Habetler, Professor at Georgia Institute of Technology, School of Electrical and Computer Engineering, about cross-border research cooperation with the AIT Mobility Department. ///

Photo: private

Professor Habetler, why has Georgia Tech chosen AIT as a cooperation partner regarding electric machines?
Georgia Tech and AIT have had a close research cooperation for more than a decade. The primary reason for this is the similar research interests and an excellent working relationship between the scientists involved from both institutions. Georgia Tech represents one of the few universities in the US with an active program in electric machines. At the same time, AIT has an excellent research staff in this area. AIT's outstanding activities and reputation in the field of condition monitoring of electric machines led to the initial cooperative efforts. As the cooperation developed, discussion and work began across a variety of topics in electric machines, especially as applied to mobility and transportation issues.

What are the benefits of an exchange of researchers between Georgia Tech and AIT?
Certainly from my point of view, exchange of researchers has the effect of disseminating ideas and methods among the two organisations. The true transfer of knowledge does not occur to a full extent merely by short meetings at conferences, or via the telephone. It is only when researchers spend time together, solving problems of mutual interest, that the real benefits of the interactions occur. It is often said, and is especially true in research, that the whole is greater than the sum of its parts. Too often, great research advances are hindered by researchers who work in a vacuum. ///

PROJECT PARTNERS OF THE RESEARCH COOPERATIONS PRESENTED IN THIS ISSUE:

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BALI:
Infineon Technologies Austria AG, Magna Steyr Fahrzeugtechnik AG

FURTHER INFORMATION: AIT – MOBILITY DEPARTMENT

Franz Pirker
Head of Mobility Department
TECHbase Vienna
Giefinggasse 2
1210 Wien
Tel.: +43 (0) 505 50-6233
Fax: +43 (0) 505 50-6642
E-Mail: franz.pirker@ait.ac.at

Staff: 130
Research Areas:
- Future Integrated Vehicle Concepts
- Transportation & Infrastructure Solutions