FORSCHUNG LEBEN

SCIENCE AND MONEY

THE MAGAZINE OF THE UNIVERSITY OF STUTTGART 03 | 2014

University of Stuttgart
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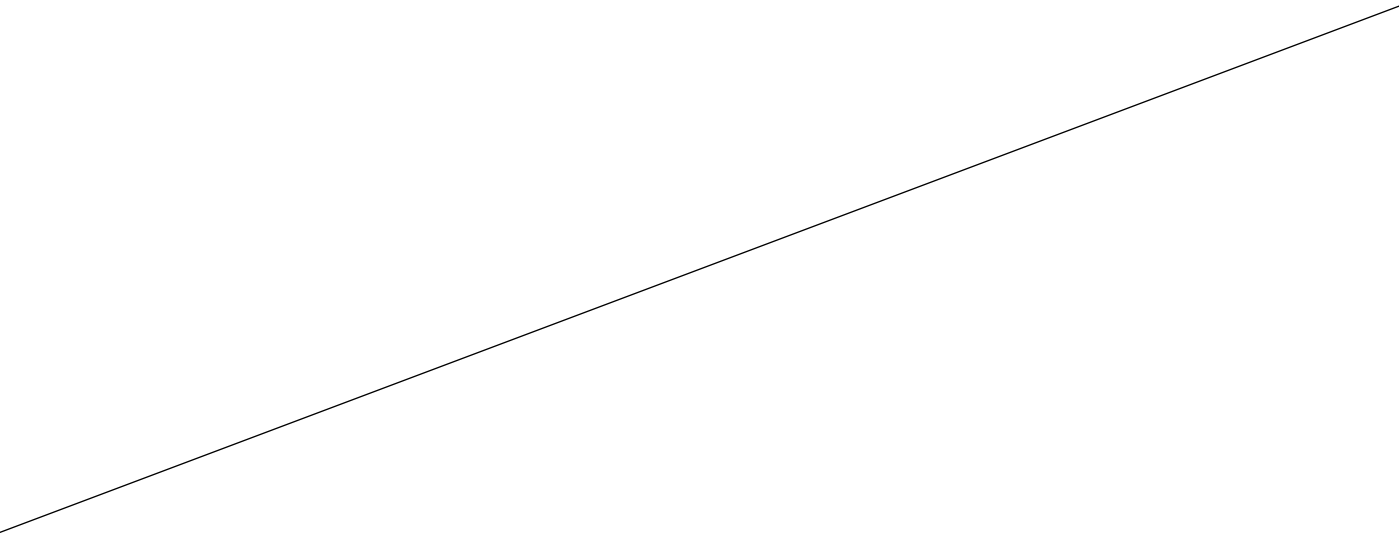

To all our readers,

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Wolfram Ressel
Rector of the University of Stuttgart

The events of the year 2014 offered many occasions for reflection on 'Research and Funding'. Abolition of the 'Cooperation Bans', the future of the Excellence Promotion Program, and the appropriateness of university-level financing by host countries are just a few of the catchwords describing the complex relationships which often give rise to controversy and discussion about the many aspects of the high-quality academic studies in the face of economic reality.
In this, our third issue of LIVING LEARNING, our editorial team has taken transparency as its goal: transparency in the manifold aspects, perspectives and problem areas involved in laying a financial groundwork for top-level learning achievements and making them possible. Whether we speak of the work of the Science Council and the German Research Foundation, or of cooperative ventures between business and learning, or the complexities of transferring knowledge and technology, or the donor-type model of foundation-endowed professors' chairs, you will quickly see in reading this magazine what a diverse effect finances have on learning and how diverse the impact of finances can be on learning activities; and also the variegated financial contexts in which academic work is often carried out. One conclusion applies equally to all forms of financing, however: research can unfold effectively to the benefit of society and its members only within a sustainable economic framework.

You have told us repeatedly in answering our survey about FORSCHUNG LEBEN that you find it both interesting and rewarding to read our newly designed university magazine. We now express our heartfelt thanks to you for your most helpful feedback. We were especially encouraged by your assessment that FORSCHUNG LEBEN hits the mark about socially relevant issues of our day. In taking up the topic of 'Learning and Its Funding', we hope again to live up to this responsibility. We were also very happy to see how often you expressed interest in student research activities. We will gladly take up this and other impulses from you in future issues.

And now: Enjoy your reading!

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Laser expert Prof. Thomas Graf

'Many research findings are worth their weight in gold. The only problem is: too few know it!' says Prof. Thomas Graf, our Vice Rector for Knowledge and Technology Transfer at the University of Stuttgart. He is not only a laser expert with deep insight into the world of rays and fibers, but also who an ace in the processing of patents. **18**

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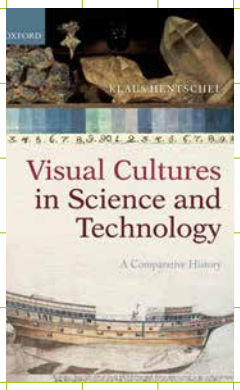
Image sources: Bosch, Faro, institutes, private persons, Regenscheit, Richter



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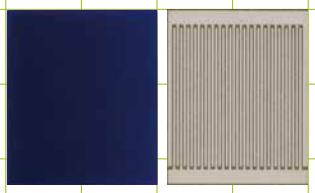

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... Heard in Passing

FROM BIOGAS TO MICROALGAE

Making use of sustainable raw materials is the core of the new Bio-Economic Research Program, funded with 13 million Euros from the government of Germany's Federated State of Baden-Württemberg. Out of a total of 45 research projects submitted for grants, 11 have already been approved for seven institutes at the University of Stuttgart, with a funding volume of two million Euros. The heart of the research strategy is to study bio-economic processes in both value-added cycles and as complete systems.
Primary areas of interest are the production and uses of biogas, the uses of wood-source biomasses, and the application of microalgae in the foodstuff and animal feed sectors.

TOPIC BROCHURE: SIMULATION TECHNOLOGY

The 10th 'Research' brochure traces the course of simulation technology. Its articles provide a glimpse into the visionary fields of application on which the University of Stuttgart's SimTech Excellence Cluster is working, extending from CAD with complex materials through virtual prototyping and comprehensive methods in environmental technology to simulation-based systems biology. This also includes biomechanical issues, the history of simulation technologies, and how they have given rise to philosophical reflections. The brochure can be found at dezernat1@verwaltung.uni-stuttgart.de.

SEVEN AT ONE BLOW

Not just one but seven world records were 'flown' by the University of Stuttgart's electric-powered E-Genius in the Serres Region of France. It reached a speed of 178.1 kilometers an hour along the 100 km round-trip flight and 93.03 km/h on the 500 km round-trip flight. In actual fact, the latter route covered 504 kilometers; the absolute height was 6,376 meters, and the highest flight level maintained for more than 90 seconds was 6,350 meters. It climbed to 6000 meters in one hour and 53 seconds, and the maximum speed on a straight stretch of 15 kilometers was 229.7 km/h.

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BIG DATA

The 44th annual meeting of the Informatics Society (GI) was held at the University of Stuttgart under the friendly eye of Federal Research Minister Prof. Johanna Wanka. The main tropics of the conference, held under the motto of 'Big Data – Coping with Complexity' were the complexities of data, systems, and applications. The Informatics Forum of Stuttgart (InFoS) e.V. staged the event, attended by more than 1,000 visitors, in the name of the GI.

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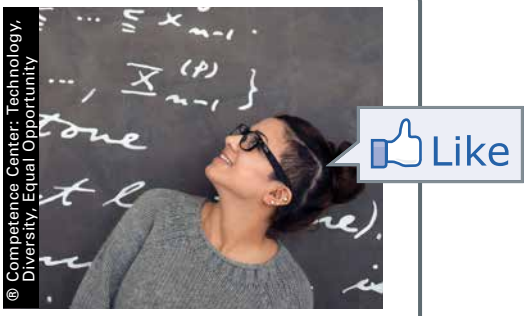

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MORE MINT WOMEN

The University of Stuttgart is the newest partner in Baden-Württemberg's initiative for 'Women in the MINT Professions in Business, Academics and Research'. The target is to increase equality of opportunity and to exploit the potential for new employees in the professions of MINT (Mathematics, Informatics, Natural Science, and Technology). The University itself is currently carrying out its 'Audit for a Family-Friendly University'. It plans to establish its own daycare center for children, with an individualized pedagogic concept for promoting MINT ability at an early age.

The Winning Project …

CASE STUDY LABORATORY FOR A SUSTAINABLE MOBILITY CULTURE

'Future City_Lab Stuttgart: case-study laboratory for a Sustainable Culture of Mobility' is a research project at the University of Stuttgart. Starting in January 2015 it will search for new ways of transferring knowledge. Its model-type, interdisciplinary approach will no longer view human beings merely as sources of information for research but as individuals whom the researchers will accompany on the road to insights. The German State of Baden-Württemberg is funding the establishment of so-called 'case-study laboratories' at institutions of higher learning in the region with up to seven million Euros.

TOPS IN MICROELECTRONICS

® IMS CHIPS

Prof. Joachim N. Burghartz, Director of the Institute for Nano- and Micro-Electronic Systems (INES) of the University of Stuttgart and Director of the Stuttgart Institute for Microelectronics (IMS CHIPS) has been honored with the J.J. Ebers Award. This represents the first time in more than 30 years that this highly regarded technical prize has been given to a European scientist. Burghartz is receiving the prize for his work with integrated circuits on silicon chips and for the development of technologies and applications for ultra-thin silicone chips in flexible electronics.

Outstanding …

MAX-PLANCK RESEARCH PRIZE FOR PROF. JÖRG WRACHTRUP

The Alexander von Humboldt Foundation and the Max-Planck Society have awarded Prof. Jörg Wrachtrup of the University of Stuttgart and Prof. Robert Schoelkopf at the U.S. Yale University the Max-Planck Research Prize in recognition of their pioneering work in the field of quantum mechanics. The two researchers have found a clever way to make use of special rules of the nano-world, i.e. the laws of quantum mechanics, to promote quantum information technology, among other things, as the prize announcement explains. The Max-Planck Research Prize includes one of the highest-endowed monetary awards for research in Germany. Each of the prize winners receives 750,000 Euros for his research and in particular the chance to cooperate with scientists both in Germany and abroad.

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Financing Learning: A Regional and National Challenge

The structure of academic financing has changed dramatically since the mid-1990s. In view of growing monetary and structural deficiencies at institutions of higher learning, important voices like that of the German Rectors' Conference and the Alliance of Learning Organizations of Germany has called for better support of these institutions. This prompts initial surprise when one looks at the development of academic financing in recent years in terms of real numbers. But the reason why it is justified is explained by Prof. Sandra Richter, member of the Science Council and Director of the Stuttgart Research Centre for Text Studies and Department I of Modern German Literature at the University of Stuttgart.

Over the last 15 years, academic policies were guided in Germany as elsewhere by the idea of micromanagement: competition is the best way to achieve efficiency and transparency.
Autonomy Above All: The financial autonomy of the universities was regarded as the prerequisite for both. As time passed, however, such ideas have lost their luster: the competitive atmosphere which, in comparison with the U.S.A. or the United Kingdom, was introduced only cautiously in Germany, has not only ensured better visibility of individual research areas and efficient processes, but has also cost a great deal of money and introduced an often painful shift of resources.

Outside funding is available first and foremost for research activities. Teaching activities, on the other hand, are dependent on a bare subsistence level of normal funding.

Moreover, as the laws governing academic institutions increased in strictness, the universities have shown themselves to be only semi-autonomous institutions. They are cut off from such avenues of financing as student fees or the like; in many cases they must even fear for their foundation grants. At the same time, the following diagnosis is astonishing: according to the Federal Office of Statistics, financial outlays of public institutions of higher learning in Germany rose after adjustment for inflation from 1995 to 2012 by nearly 50%, from about 15 billion to about 22 billion Euros. For Baden-Württemberg in particular the picture is nearly the same: outlays by public institutions of higher learning rose after adjustment for inflation during the same period by about 40 percent, from 2.2 to 3.1 billion Euros. Closer analysis of the categories of expenses at the institutions of higher learning shows, however, that such figures are less rosy in light of far-reaching structural changes. The reason: during the same period of time, outside funding of institutions of higher learning rose far out of proportion to annual basic funding: whereas the share in the overall budget of institutions of higher learning in the year 1995 was only 12 percent, it is now 22 percent. The ratio of basic funding to outside funding has thus shifted dramatically: whereas about 6 Euros for basic funding were matched by one Euro of outside funding in the year 1995, the figure was only about three Euros in the year 2012. Baden-Württemberg follows the country-wide trend in this development. At the University of Stuttgart, where the curriculum is heavily weighted in the direction of engineering sciences and technology, the share of outside funding in the overall budget is actually much higher, and was 34 percent in the year 2012. The way in which funds flow is enormously important for the ability of institutions of higher


© Wolfgang Richter

‘When I was young, I thought that money was the most important thing in life; now that I am old, I know that it is.’

Oscar Wilde

learning to perform. ‘Outside funding is provided above all for research. Teaching activities, on the other hand, depend on a bare subsistence provided by basic funding,’ which is constantly dropping. This has even more impact on the system at a time in which the instructors must cope not only with the steady increase in student numbers but also with ongoing changes made necessary by the Bologna process and the demands which it has imposed on both instruction and studies. Although it is true that basic funding rose country-wide by 24 percent during the above-mentioned period, this was not enough even to keep pace with the simultaneous increase of 29 percent in student numbers. In Baden-Württemberg, in fact, the student numbers rose by 43 percent, while basic funding grew only by 22 percent. The ratio is even less positive at the University of Stuttgart: annual basic funding dropped by 16 percent, while the number of students rose by 20 percent.

PROGRESS: ONLY ON PAPER

To speak of real progress by institutions of higher learning in the sense of a growth of available funds, in spite of increasing budgets, is thus an error. Growing demands in other dimensions of performance by institutions of higher learning – including not only research and instruction but above all transfer activities and infrastructural areas – only aggravate the situation, quite apart from the rising costs of energy consumption, or wage agreement increases for employees. This is accompanied by a blatant bottleneck regarding structural investments and renovations which, according to a current study by HIS Hochschulentwicklung, are up to 40 percent under-financed. The research area too is laboring under inequality between basic and outside funding. Successfully applying for and managing outside funding requires an infrastructure of employees and concrete (research) resources which must first be created and then maintained. Outside funding alone does not guarantee the continuity which is required to operate such infrastructures, since they require highly qualified personnel, operating resources, repairs, and regular service and maintenance. New areas of specialization in research must be financed in advance, older ones must be financed up to their end. On the other hand, outside funding is directed for the most part only to direct, project-specific costs, whereas additional, indirect costs, which must sometimes be subsidized from basic funds, are incurred for use of the university’s infrastructure. In view of the fact that outside funders often bind their grants to complementary services and sustainability declarations by the institutions of higher learning, there is a danger that universities will ‘win themselves to death’, precisely when they are successful: their outside funding increases on the one hand, but fewer and fewer funds are left over to take care of central academic obligations. In addition, the positions financed with outside funds often involve short-term employment contracts and can thus in turn be interesting only on a short-term basis for academically talented persons.

THE FEAR OF RISK ENDANGERS PROGRESS IN LEARNING

Research is changing due to the Outside Funding Imperative: by its very nature, research harbors the risk of error and failure; but failure is not only integral to the advance of scientific knowledge, it is also a basic condition for it. The requirements of submitting applications and providing reports in research projects, however, lead to an ever-greater fear of risk and small-spirited opinions. ‘Risky’ research in grand style is suffocated by below-subsistence basic funding.

A proper balance between basic funding and project funding is indispensable for an effective system of learning. True, some specific disciplines or institutions may be 'more equal' than others in such a balance, but a warning flag must always go up against making such inequality permanent and institutionalizing it. Much the same troubling shifts are observable, for example, in the relationships between universities and non-academic research institutions: in years past, the latter received reliable, growing basic funding as part of the Pact for Research and Innovation while also enjoying by and large the prospect of autonomy thanks to the Freedom in Learning Law, to the disadvantage of the universities. Inasmuch as non-academic research institutions are more flexible in their use of funds and in terms of pay and wages and have a better infrastructure, they make academic research areas look like also-rans. 'The success of the Excellence Initiative and the cooperative ventures of outside groups with universities run the danger of extinction due to the gap between basic funding and decision-making autonomy.'

The success of the Excellence Initiative and the cooperative ventures of outside groups with universities run the danger of extinction due to the gap between basic funding and decision-making autonomy.

To be noted here is that the shift in favor of outside funding also arose from Germany's complex federal financing of the learning system: as a major funder of learning and research, the government is traditionally allowed to fund only specifically targeted and limited-time projects on the university level – and this is even more the case since the Federalism Reform of 2005 put 'Cooperation Bans' in place in the learning area. In light of this, we emphatically welcome the planned change of Article 91b of the German Constitution; it will ensure the federal government of a lasting, institutionally-based source of funds for deserving organizations. From the viewpoint of the Science Council, which has also raised its voice for a change of the article in question, an appropriate and sustainable balance in basic and outside funding on the university level should be a central target of Germany's federal and regional governments in future.

THE GOAL: PARITY WITH NON-ACADEMIC RESEARCH ORGANIZATIONS

Institutions of higher learning will have a reliable perspective only if their budgets can grow like those of non-academic research institutions. In its recommendations on 'Perspectives of the Learning System', the Science Council quantified this growth as lying 1 % above the increase which is always to be expected in learning-specific costs. Recently, Baden-Württemberg made explicit reference to this recommendation in agreeing with the region's academic institutions on an annual increase of 3 % in basic funding up to the year 2020. In view of the looming likelihood of a debt ceiling, this affords a welcome planning security to academic institutions in Baden-Württemberg and gives an important signal. But increasing basic funding is only the first step to enabling academic institutions in future to keep pace with non-academic research institutions. Further steps will be required in order to improve the quality of our academic institutions. That is why the Science Council's 'Recommendations for Career Goals and Paths at Universities' call for 7,500 more professorial positions and a simultaneous expansion of tenure track options. The job of academic institutions, in the eyes of the Science Council, is to make use of financial leeway for developing areas of specialization and

‘When I was young, I thought that learning was the most important thing in life; now that I am old, I know that it is.’

Sandra Richter

polishing their image – internationally as well. If academic institutions are bolstered and positioned in this way, they can cooperate with non-academic research institutions and international partners from a perspective in which both research and instruction will profit. The road ahead, however, is long and is plastered with both monetary and institutional potholes: harmonizing competition and cooperation more than in the past, and ensuring not only that efficiency and transparency set the tone in the world of learning, but also that risk and out-of-the-box ideas serve to inspire research and instruction as well will raise the bar of requirements for researchers, instructors, students and administrative personnel. Money alone, after all, cannot make a university good. To paraphrase the ironic statement quoted above from Oscar Wilde: ‘When I was young, I thought that learning was the most important thing in life; now that I am old, I know that it is.’

The Production World of the Future

'The ARENA2036 Research Campus' describes a new era of cooperation between the worlds of learning and business

Public funding sources and technology transfer are only two of the ways in which universities and research institutes can gain more freedom to act. A third way is direct, long-term cooperation with industry. This is how the key persons in the ARENA2036 research network want to answer the most pressing questions facing the automobile industry in future. What is new here is: the two work out their research ideas together.

The assembly operator presses the 'Start' button, and the robot explores its new workplace. Using sensors, it recognizes the assembly line where it is to put automobiles together day and night, starting immediately. Its electronic brain registers parts and tools and compares them with the programmed data. Only minutes later, the robot understands what it is to do, which models are being assembled here, and what parts it needs to do so. Then it starts production.

Assembly lines like this don't exist – yet. But engineers and programmers are making every effort to turn such automated and highly flexible assembly lines into reality. As Martin Hägele, Project Director for the Research Factory at ARENA2036, says, 'Anyone who wants to develop factories and production techniques of the future must work shoulder-to-shoulder from the beginning with companies in that field.'

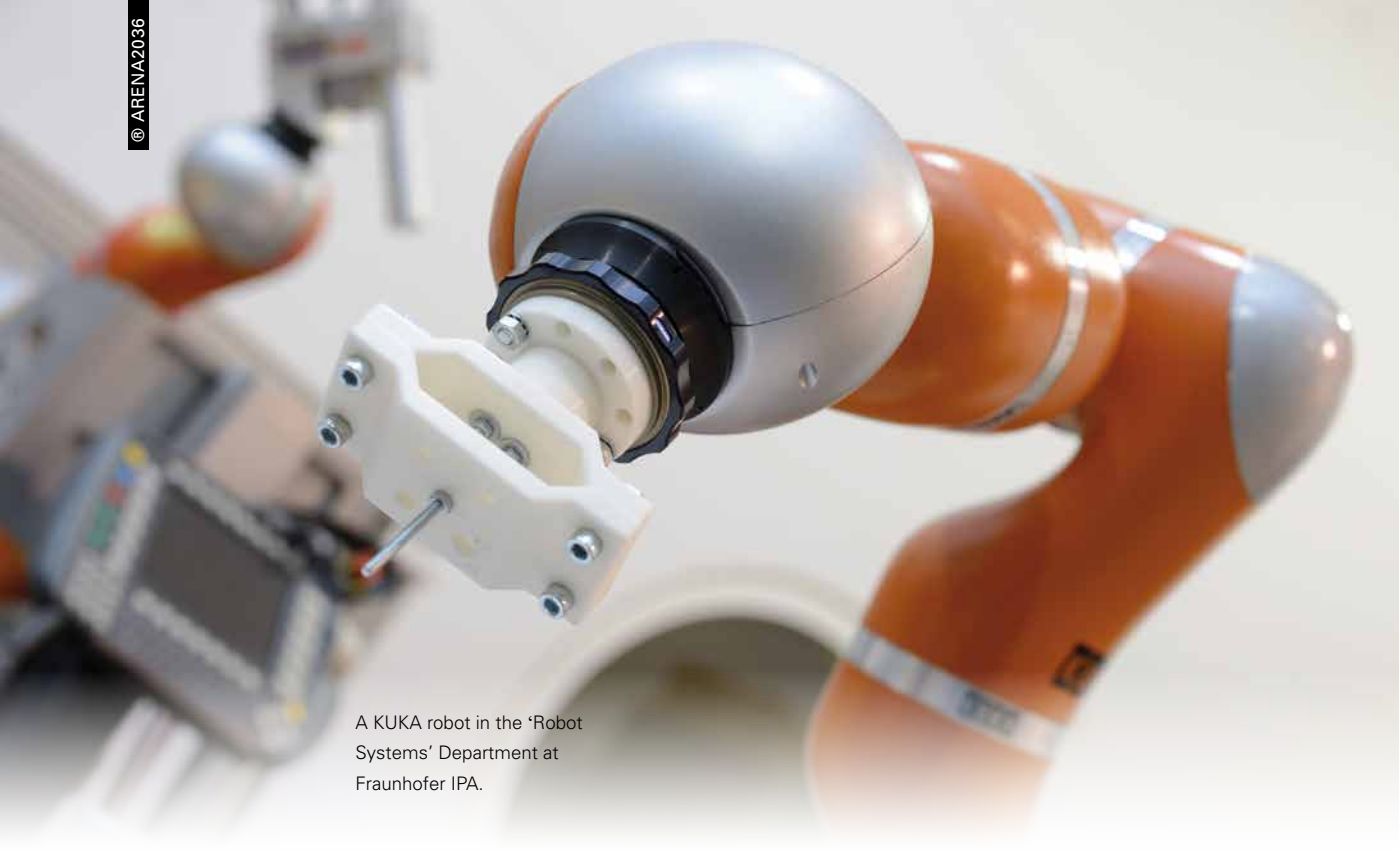
Hägele, who heads the Department of Robot and Assist Systems at the Fraunhofer Institute for Production Technology and Automation in Stuttgart, sees cooperation with industry as a basic condition for successful research and development in production technology. Because applied research for business and industry is a major part of the Fraunhofer Institute's mission, it was one of the founding members of the University of Stuttgart's ARENA2036 (Active Research Environment for the Next Generation of Automobiles), along with the German Institute for Textile and Fiber Research, the German Aeronautics and Space Research Center (DLR), and the Bosch, Daimler and BASF Companies.

The network will ring in a new era of cooperation between companies and research institutions. The founders have set themselves high goals: 'We want to be a bellwether for the automobile industry of the future,' says Peter Froeschle, Managing Director of ARENA2036. He and his team are working on new materials, but also intend to implement their vision of an extremely flexible production process. Concretely, that means: rigid assembly line work must go. Instead, mini-cars, offroad vehicles and luxury motor cars will all be created simultaneously by robots in one and the same production hall.

This paradigm-turnaround is a major challenge for the engineering sciences: it will be pervasive and work-intensive, meaning that scientists and in-company developers can be successful only by joining forces. That means in turn that they must coordinate their research goals at every point with each another. ARENA2036 is to be the platform for this. The scientists and company engineers will take up their joint work at the end of 2016 in a new research 'factory' on the campus of the University of Stuttgart. The company is assigning personnel expressly for this. 'Close meshing like that at ARENA2036 is rare in other publicly subsidized initiatives', says robot expert Hägele. Both sides profit from the constant exchange of information and the flow of joint research work.

BOTH TEAMS WIN

This also balances the tempo of change for each of the partners, says Froeschle, who himself



A KUKA robot in the 'Robot Systems' Department at Fraunhofer IPA.

was a development engineer for many years at the Daimler Automobile Company. The reason: big companies are constantly modernizing their production processes. This makes it difficult for academic institutes to keep step with the times in their work.

But sudden change can be risky for companies too. 'They lose their support structure,' is Froeschle's observation. He is thinking of the suppliers and outfitters who must react more and more quickly to changes at customer companies. Mid-sized companies like Bär Automation in Gemmingen work closely together with such companies. Bär, for example, supplies automobile manufacturers with driverless transportation systems. As of this year, the company is a member of ARENA2036 – an important advantage for Managing Director Ralf Bär. 'Thanks to our partners in industry and academia, the major issues in research are much clearer to us.' This in turn benefits the customer: 'No small company can do it alone.'

As part of ARENA2036, on the other hand, Bär can be part of major research projects, working with competitors and researchers on a level playing field. The developers get a close-up look at important trends in the automobile industry. The projects of ARENA2036 are paid for from a budget maintained by public funds and private partners. Participating companies are to contribute some 30 million Euros in a first phase up to the year 2018. The federal government supports the network with 10 million Euros.

But money isn't the key here: the partners are expected above all to contribute their own resources to ARENA2036. That includes both personnel and ideas for future joint research projects.

Being part of the research network benefits the companies in another way as well. 'The business area acquires people with top training from us,' says Froeschle. Those who get Master's or Doctor's degrees during their ARENA2036 work quickly learn what makes a company tick. And the contacts between companies and research institutions lay the foundation for long-term cooperation. This is a key part of ARENA2036, since the network's goal is not only to carry out planned projects but also to provide impulses for future research projects. A timeline already in place envisions when current programs will be followed by their new projects. The ARENA2036 partners have already chosen their initial projects, which include the areas of intelligent lightweight construction, simulation, digital prototypes, and how to transfer creativity and competence. The researchers also aim at an overview of how production of the future can be carried out more flexibly and reactively with new types of technologies.

MAN AND ROBOT: WHO'S THE BOSS?

Robots in today's factories work mostly in isolation and do only what their software tells them. Their working spaces are protected like high-security areas. They are immediately immobilized if employees inadvertently enter their radius of action. Man is to watch over the robot, not the other way around.

This situation will change radically – as envisioned by scientists and engineers of ARENA2036. In future, there will be no bars between robots and human beings. In the flexible factory of the future, both will work together, often even hand in hand. and one of the ARENA2036 partners. The pre-requisite is that the robot's sensors can allow it to perceive and process what is going on around it. For example, a robot on a rolling platform might come to the human's aid only when needed in a networked and highly flexible factory where large and small vehicles are assembled in the same works hall. Concretely, a worker might easily be able to lift the plastic door of a mini-car alone. 'But it looks different if the car is a heavy limousine,' says Becker. In this case the robot assistant would know that it is needed. This highly flexible type of support may sound at first like a technical pipe dream, but it is much more than that. 'Innovations like this have the potential to revolutionize the working world,' is Becker's belief. Then older employees would again be in a position to perform work which they formerly had to leave to younger colleagues. Such flexible assistance systems might have a place not just in the factory but also in the skilled trades, on construction sites, perhaps even in office areas.

A view of the future 'Research Factory' ... Winfried Kretschmann, Baden-Württemberg's Minister President, and University Rector Prof. Wolfram Ressel at the kick-off event for the ARENA2036 Research Campus.

Driverless transportation system from ARENA-partner Bär.

Martin Hägele (right), Project Director at the Research Laboratory, and doctoral student Thomas Dietz doing research on robots and assistance systems for ARENA2036.

SCREWS WITH FINESSE

To adapt to different persons, the machines would need to communicate. This could take place via a display or by means of graphics and voice commands. Tactile guidance is another, recently developed method in which a human being might guide the robot's swiveling arm as needed for the work process. The robot would memorize the movement and carry it out thereafter on its own. Bär Company already offers a finely-tuned robot that can install a screw with just as fine and careful a touch as a human being. 'This is just the kind of small processes that are important for making production more flexible and that can be tried out and applied within the framework of ARENA2036,' says company boss Ralf Bär. Cooperation between human beings and robots thus becomes flexible: the machine enters the picture when the human being needs help. It stands ready, but does not impose itself. Planning such processes requires intelligent control systems; the ARENA2036 developers are already working on these as well.

But a clear vision is also needed about how much flexibility is possible at all. 'Currently, we're also doing research to find out whether there is a method for determining how flexible a production facility is and how a flexible production system can be planned and equipped,' says Hägele. This is why the ARENA team is developing new methods for testing and later application by production experts. Such theoretical issues are also part of ARENA2036's meat and potatoes. They are the foundation for a deep-seated change in industrial production – and can only be resolved if researchers and companies can continue to work closely together.

Heimo Fischer

Researcher and Businessman

Prof. Thomas Graf: laser expert and outside funding specialist.

He's well known in scientific circles for his work with laser tools. But Thomas Graf's specialties also include technology transfer. Licensing fees bring in generous added earnings for his institute every year – one reason why the University of Stuttgart's Vice Rector for Knowledge and Technology Transfer views business acumen as indispensable in the world of learning.

Like many other researchers, Thomas Graf had to learn self-help at the beginning of his career, especially regarding money. As a Doctor of Physics at the University of Bern, he headed a research group for high-powered lasers for 15 years. His team was highly motivated, but its financing was at a critical stage. The jobs of his first five employees were project-financed, while he himself had a stipendium. The group's funding was ensured for all of four months. Can a scientist be successful under such conditions?
He can. Upon leaving Bern five years later, Graf's team had nearly three times more members than before. The group was fully funded from the outside. 'From day one, I had to pull in outside funding', says Graf, now a professor and Director of the University of Stuttgart's Institute for Laser Beam Tools. The never-ending fight for research funds gave him specialized insights which have grown in perceptiveness over the years.
Graf today is Vice Rector in Stuttgart for Knowledge and Technology Transfer. Much of his experience was incorporated into the University of Stuttgart's strategy for dealing with intellectual property. Many research findings are worth their weight in gold, especially in the engineering and natural sciences. The problem is that not everyone knows it.

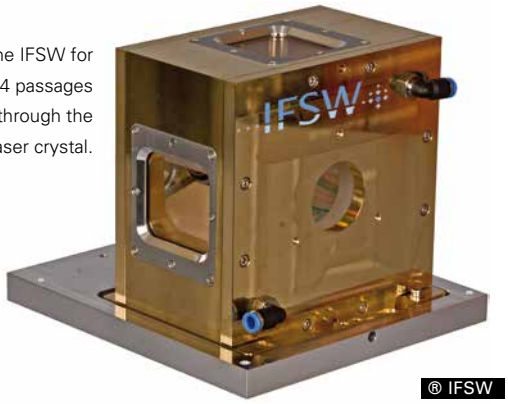
THE DISK LASER MONEY MACHINE

For many years, this has been a source of funds for Graf's institute. His predecessor laid the groundwork for it when he and his team invented the disk laser, which is based on technology for controlling unwanted heat produced by these high-precision units. The technology aroused great interest. Now some 20 licensees, including laser makers like Jenoptik and Trumpf, turn in their fees every year. What's left over at the institute goes into scientific research, while another part goes under older laws still in effect governing academic instructor privileges to the inventors, who thus benefit financially from their success.
Graf will not name a figure for the overall earnings. University institutes license such patents under normal market conditions. Graf's institute can make good use of the money for future innovations. He makes it clear: 'Success requires investment.' Investment first of all in the team. It's important that the best minds stay at the university instead of wandering off to a company where pay is better. Added income also makes it easier for university institutes to reward performance – another way to keep good people. For Graf, motivational team leadership is the basis of all innovation. When his employees make a new discovery, he urges them to publish their findings in respected scientific journals. 'It enhances our profile in both the professional and the industrial worlds,' he says. One reason: even in large companies, experts comb through publications in their search for product ideas.

PUBLISH OR PERISH

The pressure to publish among peers means a cultural revolution for many institutes. In the past, engineering scientists in particular often presented their findings only at conferences and simply sum-

'Many research findings are worth their weight in gold. The problem is: too few know it!'
Prof. Thomas Graf, Vice Rector for Knowledge and Technology Transfer at the University of Stuttgart.



The Pump cavity of the IFSW for disk lasers permits 24 passages of pump light through the disk laser crystal.

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marized the contents in writing. Today, however, such 'paper conferencing' can no longer ensure scientific renown.
New research findings should indeed be made available to the public as soon as possible, and that is the strategy of the University of Stuttgart as well. On the other hand, too much alacrity can be a bad thing – especially in the case of patentable work, which ceases to be intellectual property when patented. That is why it is a good idea to scrutinize every discovery right away for patentability. 'When that's the case, it's important to secure the rights prior to publication,' says Graf. That is where both the University and the Technology Licensing Office (TLB) of Baden-Württemberg's institutions of higher learning come in.
This process can lead to curious situations. Graf tells about the time when, as a young researcher in Bern, he wanted to present presumably patentable research findings at a conference. But wheels moved slowly at the local licensing office. Just as he was about to change his speech so as not to take any risks, he got the green light: 'They called me on the telephone an hour before I was up to say that the rights were secure.'
Research institutes today must work like small companies. That is why the University of Stuttgart, among other things, encourages spin-offs with its Technology Transfer Initiative (TTI). As Vice Rector for Knowledge and Technology Transfer, Graf was one of the first to ensure that courses on subjects like Company Theory and Founding a Company were included in the science and technology syllabus of the curriculum.

THE RISK OF BEING IN THE RED

Large sums of money are required to protect intellectual property. A good patent can easily cost 100,000 Euros. And then marketing the invention often requires that the institutes build expensive prototypes and/or demonstration models and show them at trade fairs, for example, since that is the best way to interest companies.
Oftentimes the invention cannot be marketed quickly enough to bring an immediate financial return, which is why some institutes find themselves 'deep in the red'. If licensing fees are available to them, however, they have a higher 'risk tolerance' and can submit promising patents more often.
Errors in marketing research findings represent another trap. Graf's advice is never to turn over all rights – or even sell them – to a single licensee exclusively, because if that sole owner of the rights loses interest in the innovation, it simply gathers dust in a drawer. Graf believes that the marketing of patents can be an important adjunct to the acquisition of public and private outside funding as a way to ensure that German research remains successful. After many lean years of governmental belt-tightening, Baden-Württemberg's new government shows a welcome willingness to make major adaptations in the basic financing of universities and other institutions of higher learning to increased costs, says Graf. Nevertheless, successful research remains heavily dependent on outside funding, and it is important to know how to acquire such funds.

Heimo Fischer

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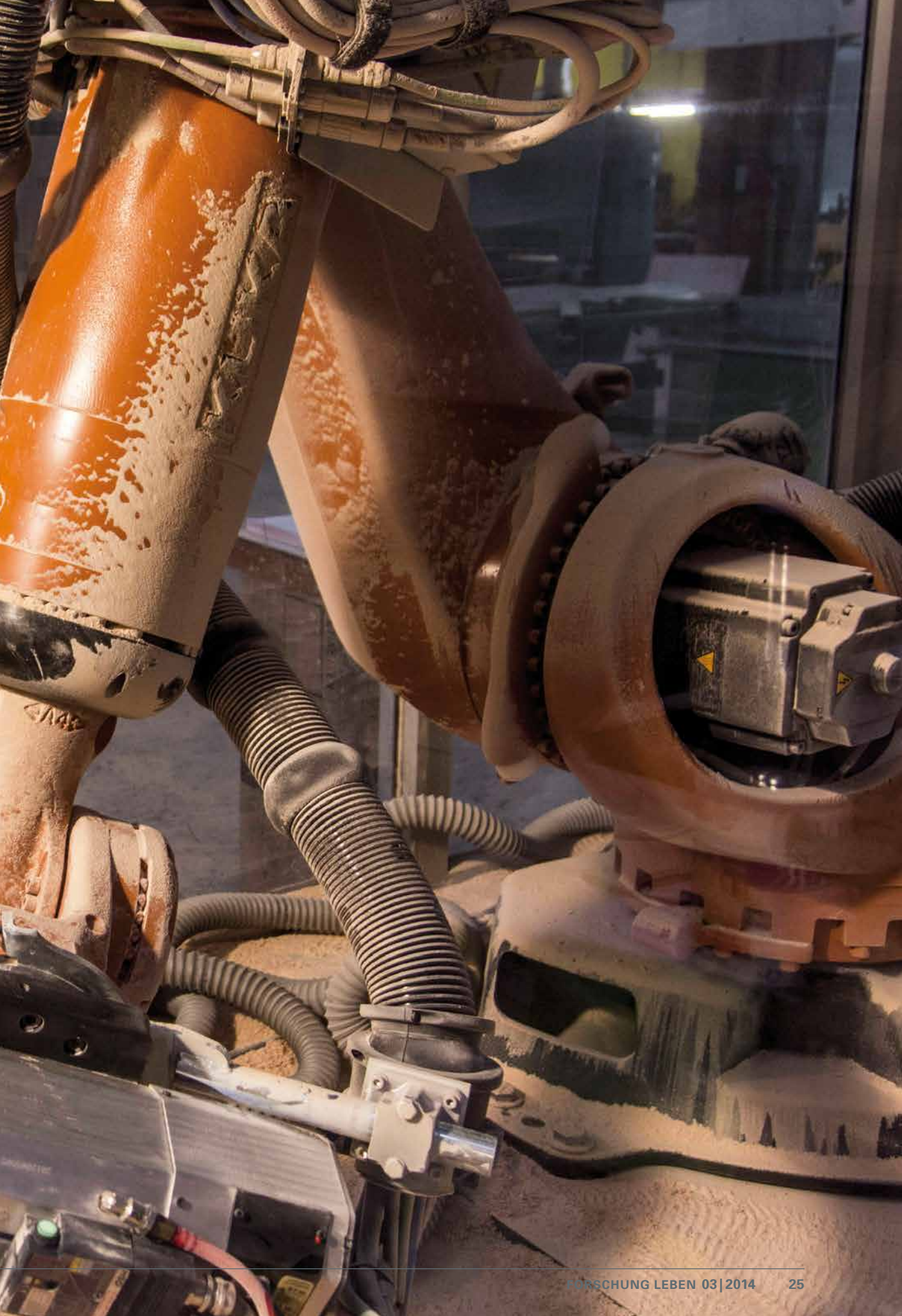
top ARBEITGEBER DEUTSCHLAND 2014
CERTIFIED EXCELLENCE IN EMPLOYEE CONDITIONS

Inspired and Inspiring

What do a sand dollar shell, the ground beetle's wings, and a bird-of-paradise blossom have in common? The answer: all have structures or mechanisms which provide ideas for architecture. A new, transregional special research department at the University of Stuttgart called 'Biological Design and Integrative Structures' is now studying how bionic archetypes can be transferred to models in the engineering sciences and taken as a basis for structural and technological designs.

The new Transregio, for which the German Research Foundation has allocated about nine million Euros, brings together architects and engineers from Stuttgart, biologists and physicists from Freiburg, and Geoscientists and evolutionary biologists from Tübingen. 'Our goal is to develop multifunctional, adaptable but also ecologically efficient structures which go far beyond the bounds of traditional types of structures,' says spokesman Prof. Jan Knippers of the University of Stuttgart's Institute of Structures and Structural Design.
One of the characteristics of natural structures is their multi-layered, hierarchically structured but locally differentiated design with only a few elementary components. This results in high-performance structures with networked characteristics, not least because mother nature makes effective use of resources and leaves completely recycled materials behind.
Our scientists hope to analyze these principles in greater detail and then transfer them to structural designs and other areas of technology. The pictures on the following pages show what can result: an astonishing, fascinating new world of architecture.

In the Picture Robot manufacturing techniques make geometrically distinctive parts possible.

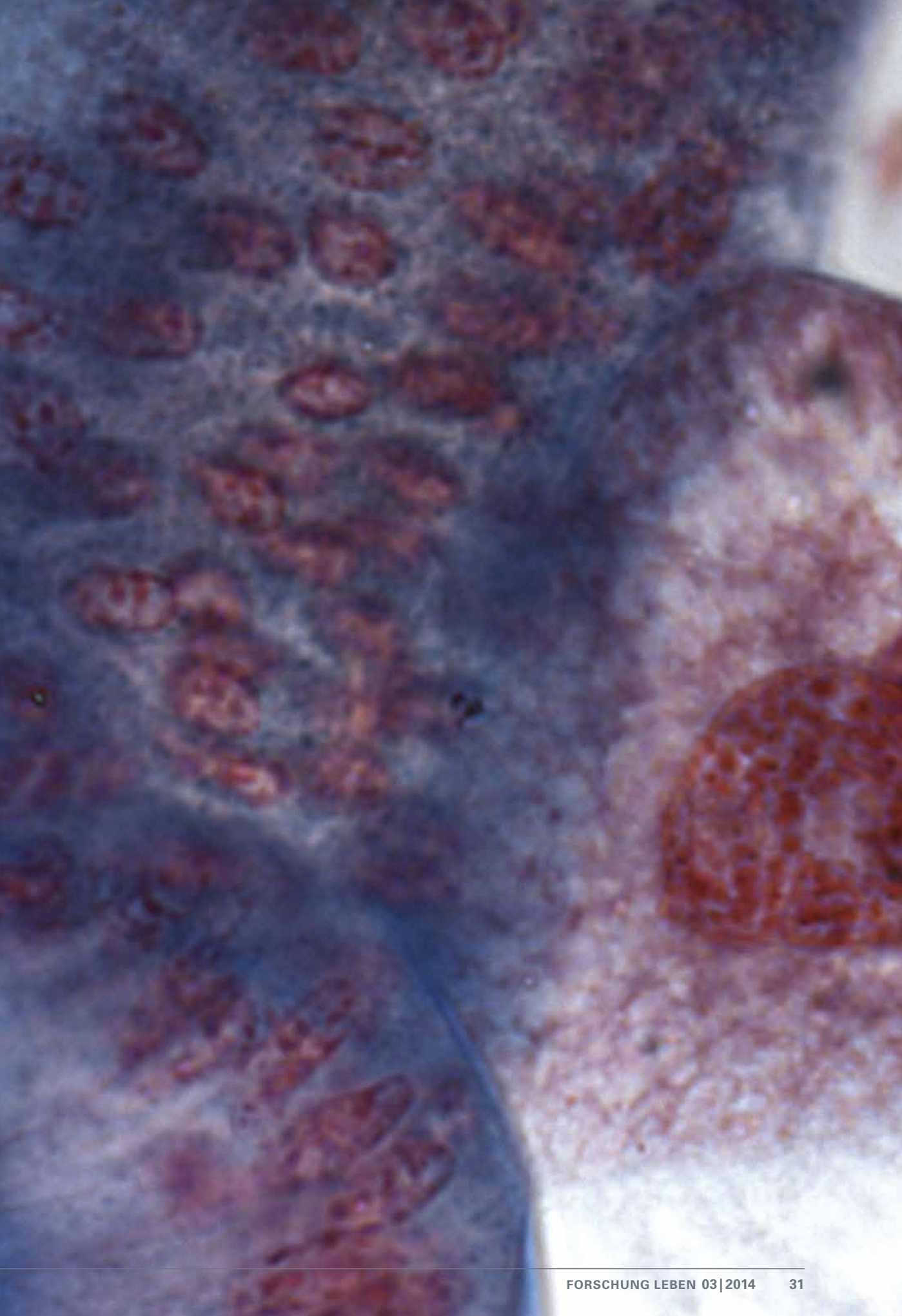


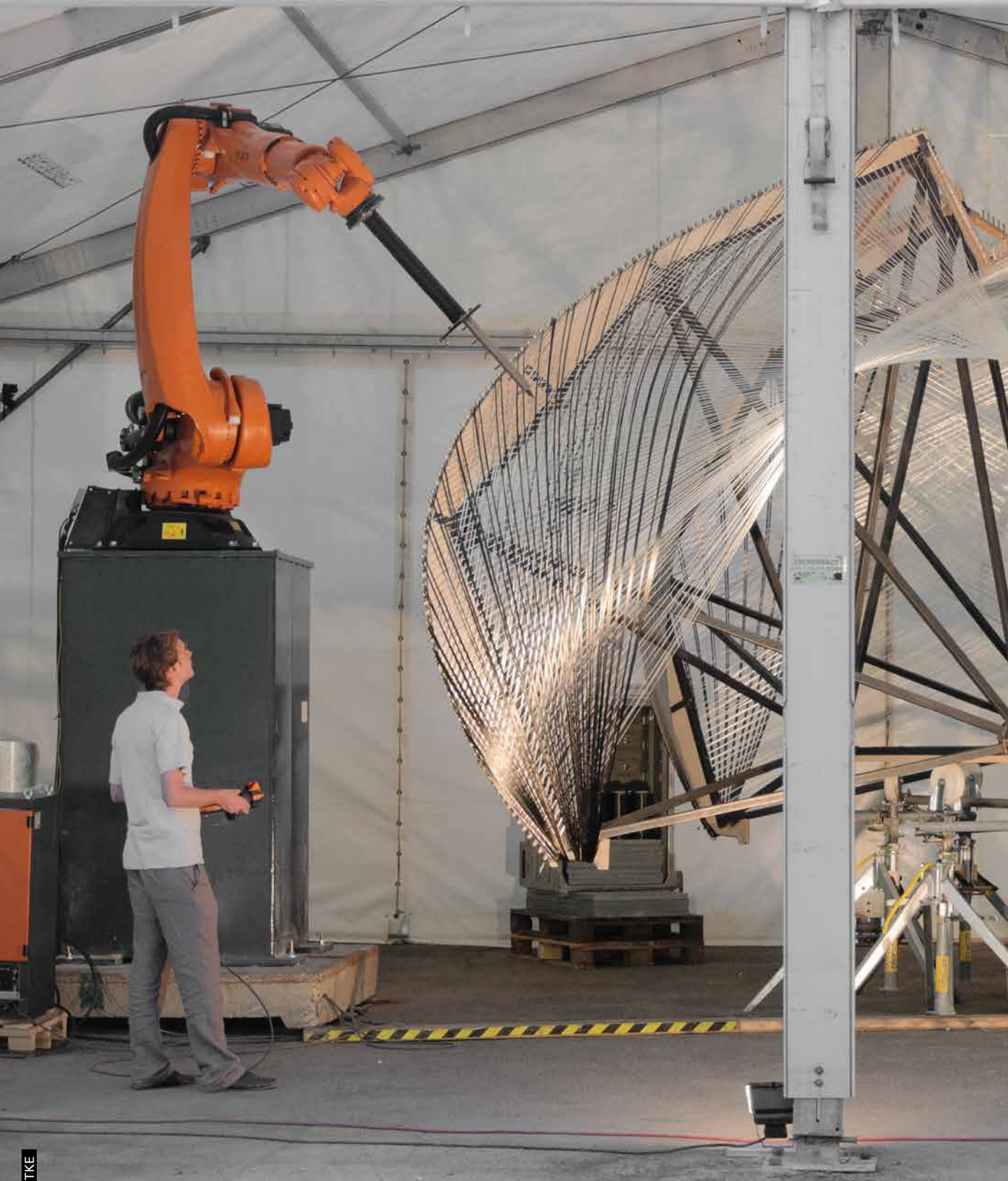
Prefabricated, high-precision parts are easy to assemble on the construction site.

The Forest Pavilion at the State Garden Show 2014 in Germany's Schwäbisch Gmünd: the physiological structures of the sea urchin, together with a chain of CAD processes, results in sturdy structures and a new form of pleasant, expressive architecture.

From nature to structure and back again: The Forest Pavilion at the State Garden Show in Schwäbisch Gmünd nestles comfortably into its surroundings.

The lobster's multi-layered, fiber-based external skeleton has a finely coordinated system of mechanical characteristics.





An automated wrapping process transfers the architectural principles of a lobster skeleton to the structural scale of buildings.

From crustacean to floating beauty: this research pavilion from the year 2012 displays a precisely coordinated, multi-layered fiber structure which permits an extremely lightweight design.

The folding mechanism of the bird-of-paradise blossom was the inspiration for a reactive sunshade of glass fiber-reinforced plastic. The direction of the panels can change smoothly as needed – without wear-susceptible joints or hinges.

The covering wings of the ground beetle Trigonopterus nasutus consist of two fiber layers, making them perfectly adapted to the creature's low weight.

An intricate story: two 6-axis industrial robots cooperate to give a geometric shape to resin-soaked glass and carbon fibers.

Light as a feather even during construction: assembly of elements for the research pavilion 2013/14.

A finished creation: the wing covers of a beetle were translated into a robust, extremely lightweight structure composed of 32 geometrically distinct modules.

Pattern Searches in the History of Cultures

Visual Studies in Technology and Science, or: How to get a Good Picture

Shouldn't the keel of a ship ideally be shaped like a fish's belly? A 400-year-old drawing answers this question by superimposing one shape on the other. For knowledge historian Klaus Hentschel this picture is an especially impressive example of visual culture in technology and science – the role of drawings, photographs and models in research and teaching. In his latest book, this 53-year-old researcher took up many monographs on visual perception and repeatedly found criteria which define visual cultures. They gave Hentschel the answer to a basic question: What makes a good scientific image?

After 10 years of work, this historian presented in October his monograph 'Visual Cultures in Science and Technology – A Comparative History', a 500-page compendium of encyclopedic knowledge in which Prof. Klaus Hentschel was the first to attempt a synthesis of a field of research which is gaining ever more attention: the science of historical images, i.e. 'Visual Studies'. 'Many offshoots of the natural sciences, technology and medicine contain distinct visual cultures,' says Hentschel, a science historian with a background of training in physics and philosophy. But what is it that characterizes these visual cultures? In search of a definition, Hentschel, who since 2007 has headed the Department of History of the Natural Sciences and Technology (GNT) at the University of Stuttgart's Historical Institute, perused nearly 100 individual studies, all of which took up aspects of visual culture – from the Renaissance to the 20th century, and ranging over technology, medicine, the natural sciences, astronomy, geology and botany. Hentschel's goal is to find the way out of a problem confronting historians of science and 'Visual Studies' in particular: how to work on case studies and microhistory without losing sight of the overall picture, as when the focus narrows to portrait photography in the Victorian era.
Through comparative studies, Hentschel identified 12 defining characteristics of visual cultures. Even though the term is used loosely from advertising to science, 'Visual culture remains a term that should be used only when these 12 'layers' are present', is Hentschel's demand.

MOST PIONEERS SWITCHED AREAS OF EXPERTISE

Visual cultures often arose in the past from a transfer between far-removed areas. Thus the above-mentioned ship builder's design from the year 1600 is a good way to describe a tactic found in visual cultures, in which visual analogies serve as a bridge.
Hentschel shows how these transfers come about: pioneers in one discipline of knowledge usually got their start in another area, and then put what they had learned to use in the new one. Chemistry provides an example: Up to ca. 1850 it consisted mostly of formulas. 'The pioneer August Kekul, who discovered the cyclical rings in carbon-nitrogen compounds, had originally studied architecture.' He was thus the only chemist of his time who had the requisite visual and architectural 3D training for thinking in spatial categories. The same is true in modern medicine: the pioneers of imaging procedures like computerized and magnetic resonance tomography came mostly from the fields of astronomy and astrophysics. 'Hardly anyone would suspect such connections,' says Hentschel. But that is where they learned to transform digital measurement results and data into images of spiral nebulas or planets.
Definitions of visual culture, in Hentschel's eyes,

Should a ship's keel be shaped like a fish? A picture from the publication 'Fragments of Ancient English Shipwrightery' (Pepys Library).

also include 'intensive training for beginners. We see this in microscopy courses in biology and medicine, where students still learn today to draw what they see.' Learning to draw teaches the students to observe precisely. 'Sight must be trained in order to recognize patterns.' Only then, for example, can the dermatologist immediately relate certain color and skin symptoms with each other.

'Another dimension of visual culture is the high regard for paneled paintings,' says Hentschel. This can be seen in the existence of illustrated books. 'Many of these are opulent works on anatomy or zoology which required armies of draughtsmen and graphic designers to create paneled paintings.' Another prerequisite is experience in interpreting image sources. 'Scientific images require enormous effort: selection of the right segments, increased contrast, even the insertion of other colors, if necessary.' All necessary for the illustration to show precisely what the researcher has found out. Today's spectacular photographs from space are an example – even though most are shown in the wrong colors. 'Systematizing all this requires a) intensive training, b) a background of knowledge about how an image is created, and c) a critical mind for categorizing the image,' says Hentschel; 'technical photographs such as X-ray images cannot be read by the naked eye alone.'

INDISPENSABLE EXPERTS: ORPHANS OF SUCCESS

Hentschel had already discovered other criteria in his earlier work, when he compared biographies among the first group of spectroscopists and found that the parents of many were musically and artistically inclined or were skilled in some craft – far from being scientists or members of the bourgeoisie so customary in the 19th century. In contrast to the chemists and physicists of that day, who had usually learned at a university, those in this group tended to be graduates of polytechnical institutes.

'Polytechnical academies offered courses in draughtsmanship,' says Hentschel. 'University students tended to be more text-oriented.' Many spectroscopists also had painting or photography as their hobbies. 'That's also the last of my 12 'layers': a person with a visual culture in the sciences or technology is in contact with this area even in his other activities, constantly training his eye further.'

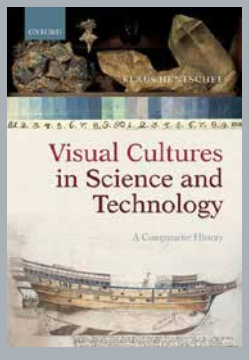
Imagery experts are indispensable in research and instruction. 'Specialists – often the best print

Artist, architect and scientific illustrator: Roger Hayward (1899-1979). Among others, he worked for chemistry Nobel Prize winner Linus Pauling and for 'Scientific American' magazine.

technicians of their time – have always been needed,' says Hentschel. But many luminaries gave no thought at all to thanking those who had paved their way. Others, like U.S. chemist and Nobel Prize winner Linus Pauling, knew the importance of the illustrators for their great success. In the architect and illustrator Roger Hayward he had found just the right person to put his 3-dimensional molecule models into images. 'That too is a part of science,' says Hentschel. Pauling gave massive support to Hayward, e.g. by insisting that Hayward take over the graphic work for his publications. Thus Hayward's name also remained known in scientific circles. Many others, however, were totally lost in obscurity.

Daniel Völpel

Klaus Hentschel: Visual Cultures in Science and Technology – A Comparative History



Oxford University Press, 978-0-19-871787-4

To gain an overview of the often anonymous illustrators, the Historical Institute's GNT Department has built up an international database of illustrators:
www.uni-stuttgart.de/hi/gnt/dsi/.
It contains more than 8,000 scientific illustrators from the invention of book printing up to 1950. '90 percent of our entries are found nowhere else,' says Klaus Hentschel. The reason: art historians who write in reference works name only persons whose work possessed artistic merit – even while belittling the artistic value of many scientific illustrations.

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Millions Rain Down on Stuttgart Linguistics

Special Research Area 732 Solves Linguistic Ambiguities

The liberal arts often have the reputation of being orphaned when it comes to outside funding. But Stuttgart's Department of Linguistics shows this must not be so. The German Research Foundation (DFG) has recently approved some nine million Euros in a third funding period for this 'little giant', the Special Research Area for 'Incremental Specification in Context' (SFB 732). And the Gottfried-Wilhelm-Leibniz Prize awarded to SFB spokeswoman Prof. Artemis Alexiadou in 2014 brought in another 2.5 million. The SFB is working to unravel linguistic ambiguities and innuendos. And it is providing jobs for about 50 men and women researchers, several of them new professors and younger minds.

The trademark of the Special Research Area is the close cooperation between Theoretical Linguistics and Computer Linguistics; this appears in many joint publications and presentations and in concrete applications in computerized language processing, as in the improvement of translation programs. 'SFB 732 has achieved computer-linguistic results in the funding period just ended that go far beyond today's known "baselines",' says Artemis Alexiadou. This collaboration is to be expanded even more in the third funding period. Moreover, the Special Research Area will increase its efforts in future to develop younger talent, for example with a structured doctoral program. Contextual plans also include the application of previous research findings to 'non-canonical data', such as hard-to-classify constructions, little-studied languages and variations, 'jumbled' texts and spontaneous-speech dialogues in order to test hypotheses, for example on the basis of bodies of data from the Internet. Here SFB 732 is making a significant contribution to a one of the University of Stuttgart's new interests in future, the specialized area of 'Digital Culture & Technology'.

'PECULIAR' LANGUAGE CREATIONS

Daniel Hole, new Director of the Institutes for Linguistics and the German Language, explains

what is meant by 'non-canonical data': 'peculiar' language complexes whose subject does not match the verb. An example: the sentence 'The hall stands full of boxes', where it is not the hall which stands, but rather the boxes which stand in the hall. What is behind this grammatical mix-up is a special form of variable juxtapositioning – one of this 45-year-old's special areas; he wrote his professorial thesis about dative cases and variable juxtapositioning in German, and has also studied comparable constructions in Chinese. The insights from this will now be applied to other languages in the context of SFB 732. Since such structures on the whole are rare, their study requires vast bodies of information from the web. 'We need the help of computer linguists to comb through all of them,' explains Hole. This is where the University of Stuttgart's Institute for Natural Language Processing (IMS) comes in: among other things, its researchers have developed tools which can detect enough clues in gigantic bodies of text to make it possible to test the hypotheses of theoretical linguists regarding the use of a word or a construction.

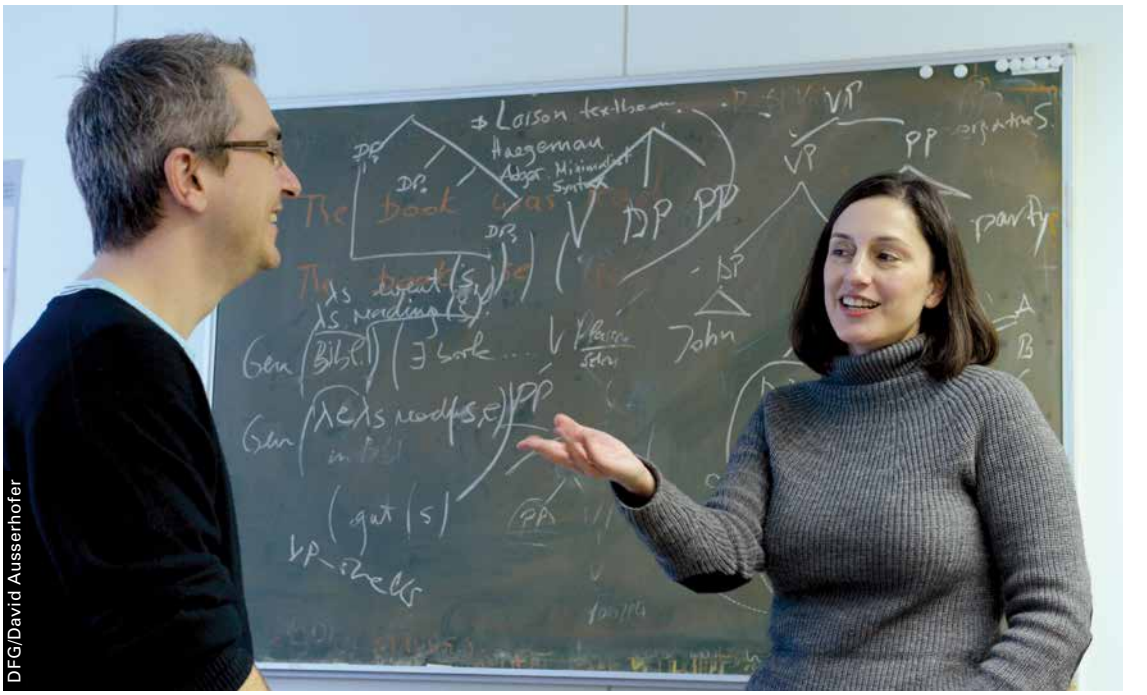
A WINDOW TO THE MIND

It was long the case that attempts were made to compile and describe the different uses of a word or a sentence construction in gigantic databases. 'However, there is too much knowledge in the world, and it is too complex for such a process,' explains Prof. Sebastian Padó, who since 2013 has headed the Theoretical Computer Linguistics Team at the Institute for Natural Language Processing of the University of Stuttgart; at SFB 732 he studies, among other things, the interpretation of incomplete statements. 'Around the year 2000, this resulted in a paradigm turnaround towards a probability-based working mode.' Behind this was a step-by-step approximation towards the meaning of terms based on statistical analyses which take the preceding and following parts of a sentence into account.
This makes it possible not only to test linguistic hypotheses but also to improve automatic translation systems, each of which, as Padó explains, 'is based on a huge bilingual, probability-based lexicon in which the most coherent solution is sought'. In future, for example, a possible principle of search engines might be not only to search for a term which is entered (e.g. 'automobile') but also for related words like 'wagon' or 'cart'. Interaction in the semantic area will be consolidated even further in the third funding period of the SFB 732, for example regarding models of cognitive language processing in psycholinguistics, or predictions about the formation of substantives. 'We're trying to look into the heads of human beings when they process language,' says Padó with a smile.

LINGUISTIC MELODY AS A SIGNPOST

It is not only the composition of a linguistic structure and its place in the sentence which help to unravel nuances, but also the lilt, that is, the linguistic melody. The SFB has been enhanced in this regard since about a year by phonologist Prof. Sabine Zerbian. Her 'hobbies' are Bantu
48 University of Stuttgart languages like Northern Sotho, a tone-based language spoken in northern South Africa. In tone-based languages, the speaker gives different meanings to a word which is one and the same on paper. Depending on the tone used, for example, the Chinese word 'ma' can mean 'horse', 'mother', 'scold', or 'hemp'. In German or English, on the other hand, the melody of speech affects the meaning of a sentence. All this becomes fascinating when both speech systems collide. This is the study area of phonologist Zerbian, who has carried out several studies in

Unraveling ambiguities: Leibniz Prize winner Prof. Artemis Alexiadou is spokeswoman for a highly productive special research area in linguistics.



Johannesburg on South African English, which can sound very different depending on the speaker's ethnic background. In addition to her research activities, Prof. Zerbian mentors younger academics in SFB 732 – together with Dr. Sabine Schulte in Walde – and also directs a doctoral program at the GRADUS Graduate Academy. In addition to the acquisition of basic qualifications, the emphasis here too is on more intensive interrelationships and a better 'meeting of the minds' between Theoretical Linguistics and Computer Linguistics.

A HUMBOLDT PRIZE WINNER AS GUEST

The SFB 732's reputation makes the University of Stuttgart attractive for researchers from abroad as well. For example, the Greek linguistics professor and Humboldt Prize winner Elena Anagnostopoulou chose the Linguistics Institute for her guest professorship. She has been here since July, doing research in the field of grammatical theory, and intends to study so-called comparative linguistic 'argument alternations' using the SFB's facilities. Put more simply, she is looking for an answer to exactly what it is that children learn in their initial speech formation and how children are able to grasp the meaning of words and sentences in such a short time.

Andrea Mayer-Grenu


© DLR

INDUCTION INSTEAD OF OVERHEAD LINES

Overhead lines for trains are failure-prone, often resulting in delays and cancellations. One alternative to this is wireless energy transfer. The Institutes of Electrical Energy Conversion (IEW) and Machine Components (IMA) and the Department of Rail Technology and Reliability Technology of the University of Stuttgart, along with the German Aeronautics and Space Research Center (DLR) are currently studying inductive (non-contact) systems which may one day take the place of train wires.
The researchers base their work on a limited transfer principle already used in e-automobiles and streetcars. It functions like a transformer section; that is, the primary coil is integrated into the line of travel, and the secondary coil is in the vehicle. Energy is transferred via an artificially created magnetic field, promising a reduced noise emission, attrition, repair and maintenance, and energy consumption.

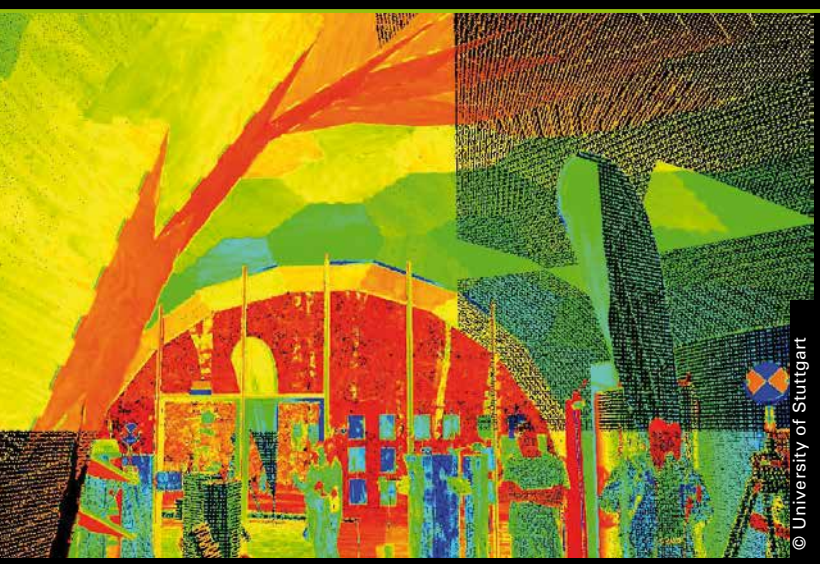
LIGHT PARTICLE AS SWITCH

Components that use light for calculations could make future computers faster and more energy-efficient. Now researchers at the University of Stuttgart's Center for Integrated Quantum Sciences and Technology (IQST) have taken a major step towards the optical transistor: they use a single light particle to dim a weak ray of light. They hope in this way one day to develop transistors for optical computers which can control the movement of light by using another light source.

© R. Goldschmidt

ELECTRO-TAXIS

Five electrically powered taxis have been rolling through Stuttgart since August. They are part of the 'GuEst' Research Project of the University of Stuttgart's Center for interdisciplinary Risk and Innovation Research (ZIRIUS) together with the Research Institute for Automotive Systems and Vehicle Engines (FKFS), the Stuttgart Taxi-Auto Center, the Daimler and Bosch Companies, and DEKRA. The project aims to find the most economical type of electrical power train in taxi operations. Additionally, public acceptance for e-taxis and electromobility in general will be studied with taxi drivers and their passengers.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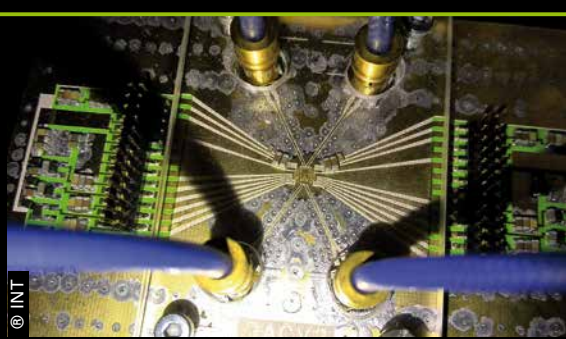
BETTER PREDICTION OF BUILDING DAMAGE

Unstable soil, strain, or jars can cause areas of deformation which at first are mostly unseen in bridges, bulwarks and other structures. Should they spread, however, they can bring down the whole structure in the worst case. In order to detect any damage promptly and initiate remedial action, endangered structures are constantly monitored and analyzed with different forms of technical measuring equipment. Such analysis models have remained linear and quite generalized up to now. But the University of Stuttgart's geodata experts are now developing non-linear models which make it possible, for example, to identify points of deformation on any surface without knowing in advance where there is damage. Not only that: the predictions are faster and more precise.

100 BILLION CYCLES PER SECOND

More and faster internet data travel via today's glass fiber networks and without added costs for new glass fiber cables – a dream of both the telecommunications industry and the political arena. Researchers at the University of Stuttgart's Institute of Electrical and Optical Communication Engineering (INT) are bringing this vision closer: they have designed the world's fastest electronic digital-analog converter, with a rate of 100 billion conversions per second (100 GS/s). Such converters, which are regarded as the key to a fast Internet, take digital data 'words' from intermediate computers and turn them into analog potentials which target optical modulators at glass fiber conductor interfaces.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The Watchful Eye of the Community

New Transparency Rules for Outside-Funded Research

Baden-Württemberg's new Higher Education Law, in effect since April 2014, contains new transparency regulations for outside-funded research. It also represents a bare-bones version of the political demand to ban militarily exploitable research. However, there is a problem: on the one hand, the constitutionally guaranteed, basic right of every researcher to freedom in research must be maintained. On the other, a collective need for information is to be met by the transparency rules. Prof. Volker Haug, Director of the Department of Legal Affairs at the Institute for Economics and Law of the University of Stuttgart and editor of a systematic overview of laws on higher education in Baden-Württemberg, explains why the new law is tricky.*)

Many persons call for a ban of all militarily exploitable research in the name of the so-called 'Civil Clause'. This, however, is neither practicable nor feasible under the constitution: for one thing, the possible uses of many research findings become clear only after the fact. Moreover, civilian uses and military uses are often inseparable and overlapping. And lastly, a legal ban on militarily-related research would represent an unjustifiable intervention in the freedom of research guaranteed by the constitution. This has led to a transparency clause:
If politically unpopular research cannot be banned, at least those involved should admit to it openly. The thought behind this is that society should be able to learn what the scientists whom it funds are doing. After all, they do not carry out outside-funded projects privately or on the side, but rather as part of their job. At the same time, freedom of research is protected here as well, and banning a legally protected activity does not violate basic rights merely when that activity is banned. Rather, such an intervention is already present when the exercise of basic rights is factually restricted or even prevented in more subtle ways.
Jurists in this case speak of a 'prohibitive effect'. That would be the case if a researcher were to waive a specific outside-funded project because of the bright light of public attention which the transparency rules might cast on his – possibly politically unpopular – activities. For that reason the judicial branch was compelled to write transparency into law without creating a prohibitive effect. This is why the new transparency is restricted to the academic community of individual institutions of higher learning. It is accompanied by numerous procedural safeguards. How does all this look in detail?

A COMPLICATED PROCEDURE

Up to now, researchers had to get approval for all outside-funded projects from the Rectorate. This procedure, laid down in the outside-funding guidelines, serves to protect those involved against accusations of corruption. The introduction of these regulations was preceded by sensational events (a key issue: the heart valve scandal) with corresponding criminal convictions. That is the background of the new transparency rules.
It requires the Rectorate to create a registry of all outside-funded projects by April 2015. The registry is to include, among other things, the name of the research project, the names of those participating, a brief description of the project, and the amount of outside funding and names of those providing it. As needed, confidentiality agreements and publication restrictions are also to be applied. The Rector then reports the contents of this registry in summary form to the Senate each year. The Senate may

Volker Haug

demand more details from the project registry. In doing so, the Rectorate must respect company and business secrets and avoid endangering copyrights or intellectual property rights or personal data. This can lead to restrictions or even to a refusal to provide information. If the Rectorate intends to provide the information, the researchers who are affected are to be informed of this.

DISPUTES ARE PRE-PROGRAMMED

It is clear that disputes can arise. For example, the information may not be detailed enough for those seeking it, while they, on the other hand, may be going too far in the eyes of those in charge of the project. For such eventualities, the institutions of higher learning must set up a Trust Commission which then votes on whether and to what degree there is a need for information. The final decision is then made by the Rectorate. It will be interesting to see what impact the new transparency regulation will have on everyday scientific work One question, for example, is what constituency will benefit most from the right to information. The law speaks somewhat nebulously of a 'discourse within the Senate in its function as academic representative'. But if the scientist in question must then be responsible to the community for a specific project, it is not a far step to the prohibitive effect described above. The individual's freedom of research, after all, also applies with respect to the Senate.

RESEARCHERS ARE NOT MONKS

On the other hand, communication and discussion are intrinsic to the scientific process. Then too, the university researcher does not work in monkish isolation but rather within the social network of his colleagues in the community. Problems arise at the latest when this information leaves the confines of the community and triggers public or even political discussions. Experience has shown that in such cases it is possible neither to avoid indiscretions nor to identify those responsible. Only time will tell whether this 'in-house answer' is really linked to a non-prohibitive process for the creation of more transparency. But one thing is already clear: another, wide-ranging 'occupational program' is coming for the Rectorates.

Volker Haug

*) Haug, Volker (Ed.):
Das Hochschulrecht in Baden-Württemberg, Systematische Darstellung (Laws on higher education in Baden-Württemberg, a Systematic Overview), Verlag C.F. Müller Wissenschaft

A Stiff Breeze

One of the most up-to-date wind tunnels in the world, in the service of basic research and industry

Wind tunnels are indispensable for research and development in aerodynamics and aeroacoustics. Following modernization, the wind tunnel operated by the University of Stuttgart's Research Institute for Automotive Systems and Vehicle Engines (FKFS) has unique innovations: gusty sidewinds and air turbulence can now be simulated experimentally.

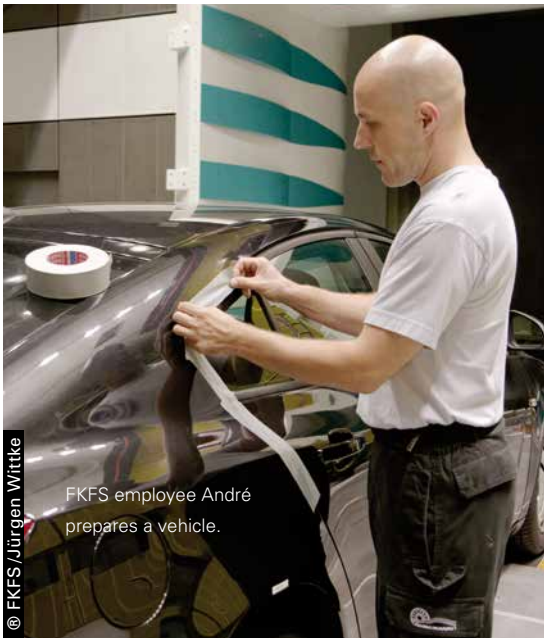
It is difficult to fight against an air speed of 120 kilometers per hour in the measuring hall. The fan in the FKFS wind tunnel sets air in motion up to 265 kilometers an hour. The FKFS has been operating a wind tunnel on its Vaihingen campus since 1989.
It was modernized several times, most recently last summer. 'It now displays trail-blazing new qualities,' says Jochen Wiedemann, Professor for Automotive Engineering at the Institute for Internal Combustion Engines and Automotive Engineering (IVK) of the University of Stuttgart, where he heads the Department of Automotive Engineering. Wiedemann is also on the board of the FKFS, which has the legal form of a foundation and whose roots go back to the year 1930. This constellation ensures that surplus funds earned go into maintenance and modernization of the wind tunnel. In addition to vehicle aerodynamics, aeroacoustics have also come to play an important role in wind tunnel measurements regarding the sounds caused by air flows.

BASIC FUNDING W/O TAX MONEY

The wind tunnel is available primarily to industry and research projects for carrying out measurements. Prior to the latest modernization the FKFS had annual earnings of about seven million Euros from industrial orders. 'Thanks to this model, the wind tunnel is not dependent on tax money for its basic financing,' says Wiedemann. The service offerings are of course supplemented by non-competitive industrial research alliances and basic university research. Above all, the automotive industry is appreciative of this. 'Manufacturers nowadays have their own modern facilities,' says Wiedemann, 'making it all the more important that our wind tunnel can offer technical features that are one-of-a-kind in the world.'
The FKFS team can now present three such innovations at once: 'first', 'besst', and 'swing'. Behind the acronym 'first' lies the tongue-twister 'Fully Interchangeable Road simulation Technology'. The FKFS-wind tunnel is the first in the world to offer a modular-type conveyor belt-type scale system with a turntable: in addition to a five-band system it also has a three-band system with which flow conditions near ground level can be simulated much more realistically. On the other hand, fixing a vehicle in place with the three-band system is more complex, so that the five-band system continues to provide an important option. Changing between the three-band and five band systems is both easy and speedy. Thanks to the turntable it is also possible to study the effect of sidewinds on the vehicle.

GUSTS AND SILENT BREEZES

'Using an integrated six-component scale, we can also measure varying air flow effects in slow motion,' says Wiedemann. ('Slow motion' here means: several times per second.) The 'swing' (Side Wind Generator) technology was developed for generating these sidewinds. Wind gusts can be stressful for a car driver, especially during long trips, because he must constantly steer the car against them. The gusts developed on the Vaihingen



FKFS employee André prepares a vehicle.

Campus can be used to simulate such situations realistically, and the results help to further improve the sidewind stability of a vehicle. 'Swing' consists of eight vertical vanes arranged on a plane at a 90° angle to the air flow – over the entire cross-section of the flow of air. They can be individually rotated in order to generate pre-defined sidewind profiles. The FKFS team hits two birds with one stone with 'besst' (Beland Silent Stabilizer), its third innovation: 'besst' suppresses peripheral eddies on the one hand and creates a 'silent' blast of air on the other. Peripheral eddies at the wind tunnel's garage-door-sized exit opening can generate an unpleasant, low-frequency 'howl' in the tunnel and corrupt aerodynamic measurements. The howling sound is like that heard when driving with an open sliding roof, but is much deeper in frequency.

Aeroacoustic measurements require that the stream of air be as silent as possible. The critical area is the point of transition from the exit opening into the much larger measurement hall. Now the team has succeeded in meeting both requirements with 'besst': flow profiles at the sides of the exit opening ensure the desired effects. 'First we determined the shape of the flow profiles via experiments, and then checked them with simulations,' says Wiedemann. Simulation – that's a key issue which also comes into play in discussing wind tunnels in quite another connection, namely: are wind tunnels still necessary at all in this age of computerized simulations? Instead of carrying out work-intensive experimental measurements, one might think, it should be possible simply to do calculations with a computer. 'Both approaches have their pros and cons – meaning their justification', says Wiedemann. 'With simulations it is possible to evaluate the complete air flow field in 3D, which can be done only with great effort in a wind tunnel.' It would require a great many sensors, and they in turn would corrupt the air flow pattern through their very presence.

'On the other hand, experiments make it possible to test variations in components must faster than in a simulation', says Wiedemann. 'Quite apart from the fact that every simulation requires experimental validation,' which would be unthinkable without the aerodynamic and aeroacoustic facilities of the wind tunnel.

Michael Vogel

© Eppler

Supercomputer Hermit manages one trillion computer operations per second. Starting next year, its computer performance will grow another 400 %.

Super-Parallel

Supercomputing at the Stuttgart Super Computer Center

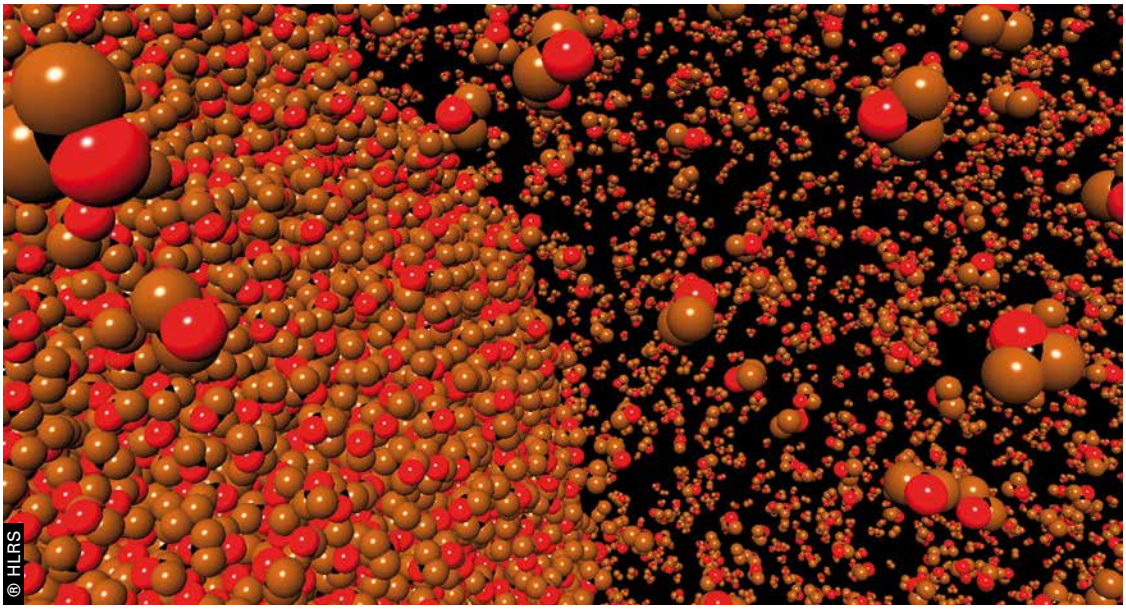
Anyone who wants to simulate the impact of the world in miniature on the world in life-size cannot do it without supercomputers. Scientists at the Stuttgart Super Computer Center (HLRS) carry out research on such issues with the help of Supercomputer 'Hermit'. The facility is not only one of the primary recipients of research funds at the University of Stuttgart, and is also engaged in many outside-funded projects ranging from basic to application-oriented research.

One gram of helium contains an unimaginably large number of atoms – about 150 sextillion. Fortunately, it's unnecessary to understand the interrelationships of all these atoms in many cases in order to use this inert gas technologically. It often suffices to measure and understand its material properties on the macroscopic level: characteristics like the speed of sound, or heat conductivity, On the other hand, many processes in the chemical industry have become so highly optimized that they can be improved only with a much better understanding of material properties and the behavior of materials under specific conditions. This is where SkaSim come in: a project funded for three years by the Federal Ministry of Education and Research (BMBF) under the coordination of Dr. Colin Glass. Glass heads a research group at the HLRS, which is one of a dozen SkaSim project partners from science and industry.

MATERIAL PROPERTIES: CALCULATION VERSUS MEASUREMENT

'Our target is a better integration of molecular simulation in industrial practice,' says Glass. SkaSim, which was launched in July 2013, will provide important prerequisites for this. The concrete aim is to simulate the interplay of gases or liquids on the molecular level so well that exact, detailed predictions of the behavior of technologically relevant materials become possible. 'The aim here is thus no longer to determine the properties and

Simulation of a drop of acetone in a system with simultaneous liquid and gaseous phases. Such processes play a major role in the production processes of the chemical industry.



behavior of materials in the laboratory, but rather to calculate them in advance,' says Glass. And this with a precision often in the thousandths. Methanol and ammonia are examples of such substances, since they often serve as basic substances in the industrial manufacture of chemical products; other examples are substances which are safety-critical, like hydrazine; these are especially interesting for simulation. 'Among other things, hydrazine is used as a rocket propellant,' says Glass. 'But it is difficult to examine experimentally because it is toxic, highly flammable, and caustic. Simulations therefore offer an interesting tack, for reasons of risk as well.'
Usable conclusions with such simulations require computer power. So much computer power that no normal computer is capable of delivering it, but only a supercomputer. HLRS Director Prof. Michael Resch shows what a supercomputer can do with a graphic comparison: 'If all seven billion human beings on earth would spend eight hours doing calculations on the same day of their lives, after 41 years they would have achieved what the fastest supercomputer can do in one second.' With regard to the HLRS, this supercomputer's name is 'Hermit'. And even though Hermit is 34 times slower than the fastest computer in the world today, just three numbers give an impression of the impressive dimensions of its system: Hermit currently consists of 7,000 processors and about 30,000 modular storage units. Just for comparison: a simple notebook contains one processor and one or two modular storage units. Hermit can do a trillion computations per second; next year its computer power will increase by a factor of four.

OUTSIDE FUNDING IS THE RULE

One might say that the whole HLRS is a single, gigantic outside-funded project: the federal government and the Land of Baden-Württemberg together finance its operations with 30 million Euros annually. Another two million Euros come in annually through computer time purchased by industry, and are re-invested. For this reason Resch likes to talk about 'true' outside funding when he really means earned money: 'It's between three and four million Euros a year, which allows us to finance 60 to 70 employees via our projects'. On the whole, around three quarters of the employee positions at the HLRS are financed via outside funding. Since Resch took office in the year 2003 it has proven possible to increase the volume of outside funding some 14 times over at the HLRS.

'One reason is that we have a very innovative core team; but another is the Stuttgart area itself,' says Resch. 'Research and development are not isolated acts in this region. There is a major willingness to carry out research jointly in outside-funded projects – not only in industry but also at the university, as in the engineering faculties.' He has not seen this to the same degree at many other supercomputer locations.

Currently, the HLRS team processes about 35 projects annually, half of which are funded by the European commission. The other half is distributed over funds from the Federal Ministry of Education and Finance, the Baden-Württemberg Ministry for Science, Ministry and the Arts, and the German Research Foundation. 'The contents range from basic research to application-oriented research', says Resch. One such application-oriented project example is FORTISSIMO, whose aim is to provide smaller and mid-sized companies access to supercomputers without them needing to be familiar with the details of the system. More in the area of basic research, on the other hand, is the HLRS 'Simulation Technology' project, in the context of the Excellence Cluster. We are working out basic theoretical principles of programming here, along with the uses of computer systems with very large numbers of processors, says Resch.

The key issue is 'parallel programming': for a supercomputer to use its calculation power to the full, its programming code must be super-parallel. 'Today we can do this with several thousand processes running simultaneously,' says Resch. 'In the case of interesting issues in future, however, a supercomputer will need to be able to work with 100,000 or even one million processes simultaneously.'

Michael Vogel

Strategies for Successful Aging

Research Funds Bubble Up to Make Society Friendlier for the Old

Burdensome field assignments sap the strength of service technicians in just a few years. But valuable know-how is lost if they change jobs. Educational researchers at the University of Stuttgart are working with companies from the region in a publicly funded project to learn how these specialized employees can do their jobs up to retirement and pass on their competence to younger persons. That is, the researchers of the Institute of Sports and Health Sciences are studying how older human beings can remain healthy longer and even grow healthier.

Demographic change has fully engulfed the worlds of business and society. Whether on the job, in the health care industry, or in urban construction: there is more and more interest in taking this revolution into account. This is one reason why both the European Union and the Federal Ministry of Education and Research (BMBF) are providing large sums of money to fund research studies on successful aging. Machine and systems engineers in Stuttgart's flourishing economy sense not only the increasing lack of qualified younger job applicants. Above all, they must organize their workplaces in such a way that older persons can do their jobs until they retire. One area which is acutely affected by this is that of service technicians, who in the rule are highly qualified professionals. 'No machine is sold today unless the manufacturer includes service, repairs and maintenance in the sale,' explains Prof. Bernd Zinn, who directs the Department of Vocational, Business, and Technical Education at the University of Stuttgart's Institute of Educational Science and Psychology. 'The biggest problem is: on the average, these technicians are "fed up" with their psychic and physical stress after ten years.' They are fed up with constantly traveling around the countryside to 'put out fires' in companies where the air is thick with tension because some machine has broken down. 'That has moved us to search in our project for alternative solutions,' inasmuch as industrial services are a central field of business for machine and systems engineers.

Against this background, companies like Trumpf, Voith, Festo and others have joined a research team at the University of Stuttgart in applying to the Federal Ministry of Education and Research for funds for a program on 'Company Competence Management in a Time of Demographic Change'. Out of 14 projects with 200 applicants, this project, 'Making Best Use of the Potential of Older Employees Via Life-Phase-Oriented Competence Development' (EPO-KAD) got the nod, with funding of about 1.5 million Euros in all. The impulses and overall coordination for this came from the Stuttgart International Performance Research Institute.

Concretely, the Ministry of Education and Research called upon the project partners to initiate 'new concepts, strategies and models for a form of competence management which is demographically aware, business-oriented, and professionally appropriate.' The partners are expected to develop, test, and review avenues of solutions. In line with this, Zinn's team will set up and test a 'Service Learning Lab' by the time the project ends in February 2017. This is necessary because the technicians' many assignments give them a wide-ranging, implicit understanding of where to find errors and how to eliminate them. This is often difficult to express in words or work instructions. 'We are working out a concept for verbalizing this experiential knowledge and passing it on to younger, less experienced technicians.'

THE CUSTOMER'S PERSPECTIVE DECIDES

The second project partner at the University of Stuttgart is Prof. Reinhold Nickolaus, Director of the Institute of Educational Science, and his Department of Vocational, Business, and Technical Education. He is an expert on competency diagnostics. 'We document the competence levels of service technicians in two areas of work,' says Nickolaus: 'Professionally, regarding their ability to analyze errors, and socially, regarding how they cope with conflicts and shape communication processes.'

One central social requirement here is an empathy for perspectives. This means an ability to understand the other's point of view and react appropriately in situations involving conflicts, communication or coordination.

Nickolaus and his team test this competence by exposing service technicians to a situation with a set of standard requirements and analyzing their reactions via video. This is followed by interviews. 'We do this at the beginning and end of the Learning Lab to find whether there have been learning effects.' The team of pedagogues analyzes professional abilities by asking the technicians to find and eliminate an error in a simulated technical system. 'Our simulations are very authentic,' says Nickolaus. In principle, it should be easy to apply both of these techniques in companies.

THE PROBLEM OF MOBILITY

A similar procedure is followed by Prof. Wolfgang Schlicht, occupant of Chair I for Sport and Health Sciences at the Institute of Sports Sciences. And with very good results: last year, he acquired outside funding totaling 1.1 million Euros for three demographic projects. 'It certainly has something to do with the overall surroundings of the University of Stuttgart,' says Schlicht. 'For example, an urban development project can only be carried out with the help of architects and their expertise.' He is thinking here of the autonomMOBIL Project with its stipendia for five doctoral students, funded with 300,000 Euros from the Fritz and Hildegard Berg foundation. Using the city of Stuttgart as an example, this interdisciplinary team of urban and landscaping planners and researchers on aging and the health sciences hopes to find out by the end of 2017 how the city of the future must look if older human beings are to remain active and even have better opportunities for their activity. 'The most critical variable of all is mobility,' is how Schlicht describes the starting point. This applies to physical activities like running or bicycling as well as to local public transportation. Intimately related to this is also the whole issue of good physical functionality, which deteriorates when mobility is lacking, as well as participation in daily life. Major donors of project funds have not always been so generous

Teams of urban and landscaping planners and aging and health science researchers are using the city of Stuttgart to find how a city area must be designed so that older persons may remain active.

regarding the issue of an aging society. 'Successful aging is a term which emerged relatively late in the field of gerontology,' says Schlicht. Only in about the mid-1990s did it became clear that aging must be studied as an individual life phase with many positive elements. Now the question, is, 'What does this mean?'

THE DARK SIDE OF OUTSIDE FUNDING

While Schlicht can devote himself with his 12-member team to this highly relevant issue, all positions on the team but one are financed by diverse limited-term outside funding projects. This constellation makes the institute's work more difficult. If he had the same budget at his disposal on a regular basis, things would be much easier, says Schlicht. 'The work of acquiring outside funding has grown by leaps and bounds.' And: 'Outside-funded projects are aligned very individually to each donor's respective goals.' This was also the case with the EU's PREVIEW project, funded by a total of 9.5 million Euros, which seeks to prevent the onset of type 2 (age-related) diabetes in its early stages. 600,000 Euros have now been granted to Schlicht and his team as one of twelve groups working in this worldwide consortium. Type 2 diabetes is regarded as one of the diseases with greatest impact on society. It usually results from a diet high in fat and sugar, paired with too little physical activity.
PREVIEW's target is to show that such age-related diabetes can be prevented by a strategic change in life style. To this end, the highly obese test persons in the study are asked not only to change their diets to protein-rich foods but also to be physically active at least 75 minutes a week. The challenge for the Stuttgart team is to motivate the participants to this change in lifestyle. Closely allied to this is another project for which Schlicht and his team have been granted about 150,000 Euros by the Ministry of Education and Research. They are to analyze the factors in dietary and active behavior which are behind chronic illnesses like diabetes or cardiovascular diseases.

FREEDOM IN FINDINGS

'We're always on the lookout for the application-oriented approach. It comes from the health sciences, where the aim is always to make a concrete, practical statement about improving health,' says scientist Schlicht. The conditions set by donors therefore do not bother him. Schlicht declares that he has free rein, even when the findings of a study go against expectations. As one example he names the view favored in the EU that footways are very important for cities. 'We have shown that this factor statistically has little importance, in spite of its real impact on public health, and even though the effects of demographic change on society have much greater weight.'
The EPO-KAD project partners remain similarly relaxed. 'True, the Ministry of Education and Research has set a clear direction, namely competence management in demographic change, and how to deal with employees as a resource,' says social scientist Prof. Zinn. Nevertheless, he does not feel that his freedom as a scientist is restricted.

Daniel Völpel

® Thomas Megeath/NASA

In its first scientific mission on board the Stratospheric Observatory for Infrared Astronomy (SOFIA), the measuring instrument FIFILS studies the Orion nebula, about 1300 light years from the earth and one of the most active star formation regions in our galaxy. The picture shows a photo taken by the Spitzer Space Telescope satellite.

The Flying Observatory in Turbulence

Politics and Science Keep SOFIA from a Crash Landing

In every sense, this research aircraft is unique: since 2007, The U.S. National Aeronautics and Space Administration (NASA) and the German Aeronautics and Space Research Center (DLR) have operated the Stratospheric Observatory for Infrared Astronomy (SOFIA) in a converted Boeing 747 SP. After several years of preparation, the 'flying observatory' became fully operational in February 2014. Shortly thereafter, NASA announced its intention to mothball the project. NASA assumes 80 % of the costs and thus finances the lion's share of operating costs for the Jumbo Jet. Following massive intervention from Germany and elsewhere, the U.S. Congress made it clear that NASA remains responsible for SOFIA. Those at the University of Stuttgart heaved a sigh of relief.

The Orion nebula – endless molecular clouds: a region 1,300 light years from earth, where new stars are forming from the condensation of cold gases, and young stars radiate heat, causing a hitherto unseen spectacle of surrounding warmth and the birth of even more stars. All this has been recorded by the Far-Infrared Field-Imaging Line Spectrometer (FIFI-LS) which, on board the SOFIA 'flying observatory', is unraveling previously unanswered mysteries about the origins of our universe. The observatory peeks into regions of the universe never before seen by the human eye, and has thus given birth to the success of the only major German-American research project at present. But it nearly died a sudden death shortly after these glimpses into the Orion nebula during the first measurement flight in May 2014:
In March, NASA surprised its project partners at the DLR and the University of Stuttgart's German SOFIA Institute (DSI) with its budget proposal to the U.S. President that the airplane with the rear telescope window be mothballed in 2015 to make another twelve million dollars available elsewhere. The DSI procures the German 20% share in SOFIA for the DLR. 'The news came only a few days after regular operations had begun,' says

Institute Director Prof. Alfred Krabbe. 'But SOFIA is a prototype, and it's not so easy to shut it down because then the entire team would have to go.' The world of politics was just as surprised as the project personnel. 'There were strong protests against this plan, even among the American public,' says Krabbe. 'The SOFIA flights were extremely reliable and went as planned in the first six months of 2014.' In the six months thereafter, the airplane was completely refurbished in Hamburg at German cost. 'In the U.S.A. I heard lobbyists say things like, 'the Germans are only looking for a good way to get out of it'. Thus it was important that DLR Director Johann Dietrich Wörner immediately emphasized that Germany was not abandoning its obligations and had commissioned the general overhaul. At the same time, Krabbe worked actively to find active advocates, for example via the German Parliament's Task Force on Aerospace and Space Travel. 'We could only provide flanking support,' says this university professor about his role in that poker game.

BUDGET COMMITTEE CALLS FOR CONTINUATION

The interventions – including those of U.S. scientists – brought results: the budget committee of the U.S. House of Representatives rejected the NASA plan and proposed a 70-million-dollar budget for SOFIA. The Senate even wanted to allocate 87 million dollars. At the beginning of June it was clear: SOFIA has been saved. At the same time, the U.S. Congress directed NASA in no uncertain terms not to propose dropping projects until it had reviewed their scientific results. According to Krabbe, such reviews are customary only after five years. 'So I think we won't have any more problems until 2019.' Had NASA stopped funding, SOFIA would probably have been finished, fears Krabbe: 'Everyone would have abandoned it in a hurry, and we would never have had the scientific harvest we're reaping today.' More than 30 people are working for SOFIA in Germany.
It is true that NASA would have been contractually bound to hand over the project to the Germans. 'But whether Germany would have continued alone is doubtful.'
Up to now, both countries have invested some 1.25 billion dollars in the observatory. NASA provided the airplane and the ground facilities, the DLR provided the 17-ton telescope with its 2.7-meter-wide mirror for about 80 million Euros. And Baden-Württemberg and the University of Stuttgart invested about ten million Euros, among other things, in a new building for the Institute of Space Systems on its Vaihingen campus, where the German SOFIA Institute (DSI) is also located. Currently it is planned to operate SOFIA until 2034. For years to come, the observatory will be the only one in the world which can see the far infrared wavelength range of 28 to 300 micrometers. To achieve this, it flies at elevations of more than twelve kilometers above water vapor in the atmosphere.

STILL NO FUNDING FOR NEW MEASURING INSTRUMENTS

More than 20 million Euros have been invested in the telescope's two German measurement devices: GREAT (German Receiver for Astronomy at Terahertz Frequencies) from the Max Planck Institute for Radioastronomy in Bonn and FIFI-LS (Field-Imaging Far-Infrared Line-Spectrometer), developed at the Max Planck Institute for Extraterrestrial Physics in Garching. A team of researchers under Krabbe at the University of Stuttgart's Institute of Space Systems took it over, finished it, and operated it during eight flights. 'We gathered a vast

Prof. Alfred Krabbe (right), on board during a SOFIA flight.

© DSI

quantity of first-class scientific data,' says Krabbe. But the researchers are still not rid of all their money worries. 'We're thinking at the moment about how to finance a new instrument generation,' says Krabbe. Funding of about two million Euros a year would be needed. About the same sum would be provided by astronomic institutes which wish to participate. For Krabbe, SOFIA is unique not only regarding astronomical issues 'but also regarding project positions in Germany.'

The DLR Agency manages all space research projects for the Ministry of Economics. Projects on the ground are financed by the Federal Ministry of Education and Research. But is SOFIA located on the ground, or is it a satellite? The two ministries have argued for years over who is responsible for financing the required instruments.

In spite of everything, astronomer Krabbe thinks that SOFIA will take off in early 2015 for new glimpses of far-off galaxies. And Alfred Krabbe wants to be on board when FIFI-LS is again activated. 'It's like being in a dream to be there and see how all systems work together,' he says: 'the precise positioning of the telescope, the maneuverability of the airplane, the cameras. You fly both in the control center and with the experiment. It's like Houston and the satellite rolled into one.'

Daniel Völpel

Pudding-Perfect

Artificial Materials Created in the NanoBioMater Project House Imitate Nature's Archetypes

Nature produces materials with characteristics that make materials scientists green with envy: lightweight but stable bones, long-lived, hard teeth, jelly-like spinal disks or unbreakable mother of pearl. Since April, researchers from different faculties of the University of Stuttgart have tested a completely new kind of cooperation in the Nanobiomater Project House with the assistance of the Carl-Zeiss-Foundation. Their aim is nothing less than to imitate nature. As a basis for future tissue substitutes, biosensors or minifactories they are using hydrogels – soft tissue with the consistency of a jelly-type pudding.

Every Thursday, the biologists Sabine Eiben and Fania Geiger come together with materials scientist Dirk Rothenstein and polymer chemist Alexander Southan on the first floor of an inconspicuous building at Allmandring 5B. This is where the Project House is located, with its computer room, laboratory and secretarial office. And it is where the ideas are born that breathe life into the name 'NanoBioMater'. 'Nano' in this case stands for the submicroscopic world in which the scientists immerse themselves with their research work, a world many hundreds of orders of magnitude smaller than the diameter of a hair. And 'BioMater' is the abbreviation for the biomaterials which they hope to develop, but is also reminiscent of 'Alma Mater', i.e. the University.
What is new about this cooperation is that the scientists have a place for exchanging ideas and carrying out experiments together. 'Traditionally, "cooperation" usually meant a mutual exchange of samples for measurement purposes,' says Dirk Rothenstein of the Institute for the Science of Materials. It was a 'black box' in the sense that difficulties in the other's discipline were often kept in the dark. Like Rothenstein, the other three team leaders commute between their home institutes and the Project House. 'I need time, of course, to go from one building to the other, but it is well invested,' says Alexander Southan of the Institute of Interfacial Process Engineering and Plasma Technology. Just recently, this chemist saved much time and work by taking over a method used by Biologist Eiben.

BODY TISSUE FOR CONTACT LENSES, SKIN OR BONES

Southan produces three-dimensional scaffoldings for the new materials, i.e. hydrogels. These consist of long-chain molecules which are networked like sponges and swell up when water is stored in their pores. In the case of jelly-type pudding it is the collagen network in gelatin above all which swells up in fluids and gives this sweet treat its wobbly character. Artificial hydrogels are astonishingly like biological tissue, which is precisely why they are not attacked in a biological environment and are well-tolerated by the body. Already, for example, industry is creating contact lenses from hydrogels. The researcher develops the basic long-chain building blocks for such hydrogels and studies whether they can be networked and thus create pores of the desired size.
In such pores, for example, it might be possible to cultivate cells which produce soft tissue like skin and cartilage or hard materials like bones. The latter in particular poses a major challenge for the scientists. Bone replacement materials available on the market up to now cannot approach the perfection of natural bone. They are needed to fill in bone defects caused by accidents, inflammation, or tumors. The technology for producing the ceramic

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Biologists Fania Geiger (left) and Sabine Eiben (right) hope to influence the characteristics of hydrogels by using tobacco mosaic viruses.

materials used now and then by physicians for bone replacement requires high pressures and temperatures above 1,000 degrees Celsius. Bone cells, however, manage this effortlessly at normal room temperature. However, imitating nature is a tricky matter: to create a material as hard as bone, the bone cells deposit crystals of calcium phosphate according to a fixed pattern on the soft tissue outside the cell. The secret to this is proteins produced by the bone cells; they bond with the substance to be excreted in crystalline form and enrich it in such a way that crystals form. The researchers call this natural process 'biomineralization'.

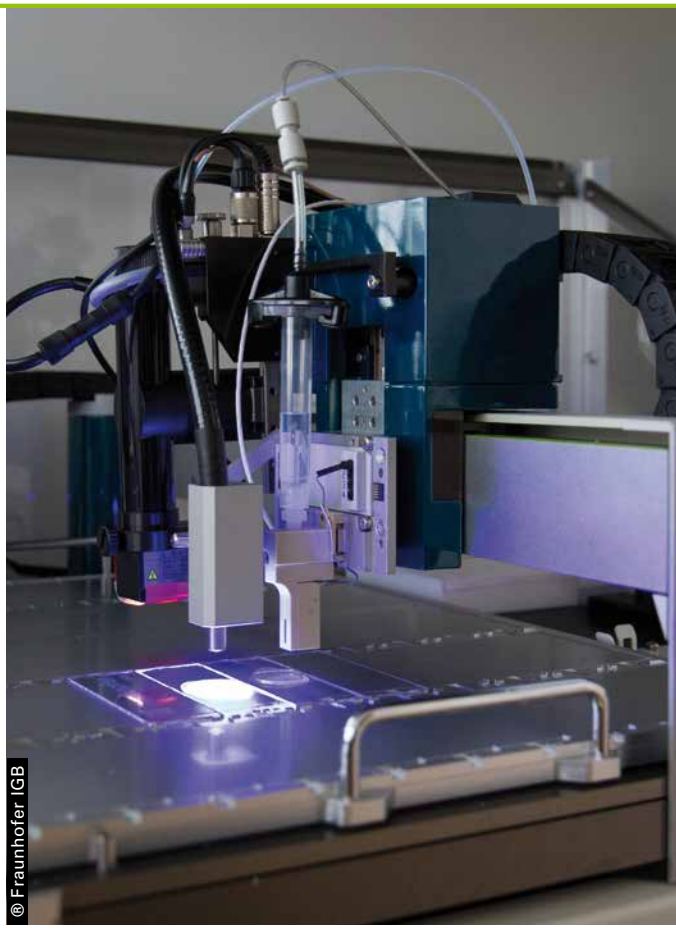
LEARNING FROM THE SEA URCHIN

The mother-of-pearl covering the inner surface of many crustaceans also arises in this way and consists of alternating layers of calcium crystals and organic material. 'This special structure makes mother-of-pearl a very hard, nearly unbreakable material,' says Southan. As a composite material it is twice as hard and 1,000 times tougher than pure calcium crystals. In order to use Southan's soft hydrogels as the seedbed for materials as hard as bone or mother-of-pearl, his colleague Rothenstein first studies biomineralization in the sea urchin. These invertebrate denizens of the sea have an inner calcium skeleton of calcium carbonate, along with hard spines and sharp teeth. Sea urchins can be bred in the laboratory easily and without complications. As the materials scientist explains, 'We study how biomineralization in the larva or the test tube can be controlled with isolated cells and proteins.'

But he also combs through genetically engineered protein particles which can also attract and specifically mineralize calcium deposits. Rothenstein can test several trillions of these protein fragments simultaneously. 'This lets me find out quickly what charges or functional groups are required by proteins to perform biomineralization,' he says. The young scientist can then apply his calcium biomineralization findings in order to generate other hard materials. 'This also lets us create interesting materials for technological applications,' adds Rothenstein. For example, his department has already been able with specifically bonding protein particles to create zinc oxide, used among other things as a semiconductor in transistors, under mild laboratory reaction conditions.

VIRAL ORDER

Sabine Eiben of the Institute for Biomaterials and Biomolecular Systems and Fania Geiger of the Max-Planck Institute for Intelligent Systems are adding a new tool, taken from nature, to the construction kit of innovative materials. The 'hobby' of the two biologists is studying the tobacco mosaic virus, a plant virus harmless to man, and adding it to hydrogels. The 300 nanometer-long rods



A 3D ink jet printer for building three-dimensional hydrogels. One example: the controlled layer-by-layer buildup can create a structure resembling mother-of-pearl.

consist only of genetic material wrapped by a coat protein into a helical structure. The rods bridge the hydrogel with the cells, proteins or other functional groups, to which they allot a pre-defined place in the gel. On the side, the rigid viral rods also increase the hydrogel's stability and influence its pore size – thus widening the spectrum of possible materials.

On the one hand, the two biologists can modify the viral coat genetically so that the virus both binds the desired cells or proteins to its surface and docks onto the polymer network of the hydrogel. On the other, the form of the viral 'scaffolding', on which the bound molecules are presented, can also be modified. The trick here is that the two researchers manipulate the virus genetically. This in turn determines whether the coat protein helices come together in the form of long or short viral tubes. The two researchers have even managed to trigger boomerang- and star-shaped tobacco mosaic viruses, which are unknown in nature, in the test tube. 'It is very difficult to produce and structure stable objects on a nanometer scale,' says Eiben, and adds: 'We can precisely direct the virus, for example, to have an assembly point every 50 or 100 nanometers.'

MINIFACTORIES FOR DRUGS AND CHEMICALS

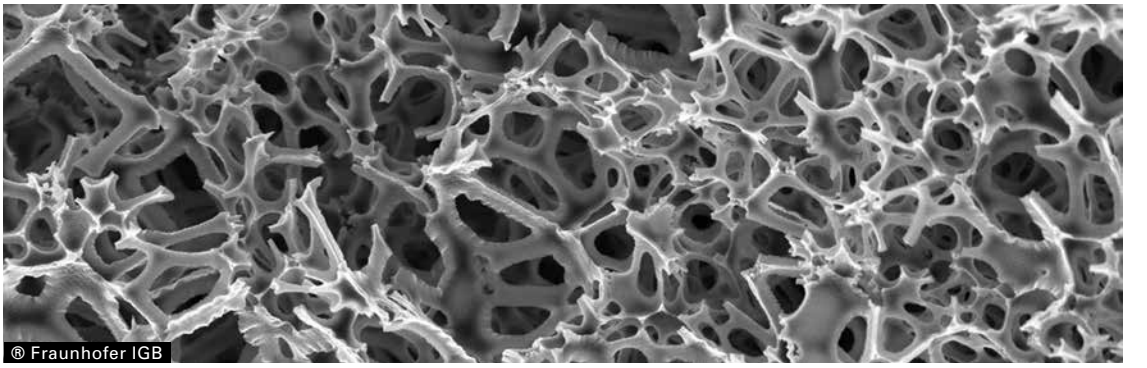
If the Stuttgart researchers want to biomineralize only certain locations in the hydrogel, as for example in the natural archetype of mother-of-pearl, it is important to know how the biomineralizing proteins are spatially distributed within the hydrogel. But Eiben has thought of even more applications for hydrogels in which a pre-defined arrangement of bonding partners with the tobacco mosaic virus is the Alpha and Omega. The hydrogels could be turned into 'minifactories' for drugs and chemicals by equipping them with various enzymes. Such 'assembly-line workers' would then generate the final product in a series of preliminary stages and intermediate steps. 'In contrast to chemical synthesis, enzymes have the advantage of triggering one specific reaction on a "key-and-lock" principle,' says Eiben.

That is why pharmaceutical companies, for example, still use enzyme chains in fungi or bacterial to produce antibiotics, which are then kept in huge bioreactors. This requires that huge quantities of microorganisms be produced and the final product be laboriously cleaned. For its part, the tobacco mosaic virus also brings the different enzymes so close to one another in the natural environment of the hydrogel that the complete reaction chain proceeds uneventfully. Moreover, because they are bound to the hydrogel, the enzymes are not flushed out and can be re-used several times.

MINIATURE DETECTIVES

Biosensors like those known in blood sugar measurement function according to a similar principle. They register an electrical signal generated when enzymes convert a specific substance. Three-dimensional hydrogels would have the advantage over biosensor chips that they can be more densely

A REM image of dried polymer networks.



packed with enzymes, thus increasing their sensitivity. 'For example, we could coat a hydrogel wound bandage with a miniaturized biosensor that would sense whether dangerous bacteria have settled on the wound,' says Eiben. The biosensors could also detect, for example, whether drinking water is polluted with chemicals. And in the production of foodstuffs and medicine, the tiny biosensors could also report whether substances toxic for humans have collected. 'Depending on how and in what ratios we combine the three components, i.e. the hydrogel, the tobacco mosaic virus, and functional molecules, we acquire the widest possible range of materials for different applications,' is how materials researcher Rothenstein sums it up. The Carl-Zeiss Foundation will support the Project House in the coming four years with 750,000 Euros, to which the University of Stuttgart will add another 250,000 Euros. 'The production of functioning materials is an important but also underrepresented branch of research in Germany,' says Judith Schöffler, spokesperson of the Foundation. 'The scientists on the team are well-networked and have an outstanding reputation. Not only that, but the involvement of non-academic organizations smooths the way from basic research at the university to practical applications in industry,' adds Schöffler. The work of the Project House, it is hoped, will culminate in a successful application for a new special research area.

Helmine Braitmaier

Current from Behind

Maximum-Performance Solar Cells Give Industry a Head Start Over Asian Competitors

At 8 to 10 (Euro-) cents per kilowatt hour, photovoltaic current in Germany today is already cheaper than electricity from gas- or coal-operated power plants. It could be even cheaper if generated by maximum-efficiency solar cells made by laser technology.

The scientists at the University of Stuttgart's institute for Photovoltaic (IPV) succeeded a good year ago in making laser-doped rear-side contact solar cells of crystalline silicone with a nearly 22 percent efficiency factor – a world record. However, this high efficiency level is achievable up to now only over a small surface area of 20 by 20 millimeters. But in the new research project funded by the Federal Ministry for Business and Energy, the IPV will now produce such solar cells over an industrially relevant surface of 125 by 125 millimeters, thus making them compatible with mass production.
Standard silicone solar cells have silver contact fingers that shade parts of the cells on the front surface. This prevents light rays from reaching the cell, preventing the generation of electrons, which would much reduce the cell's efficiency. Much higher levels of production are possible with so-called 'rear-side contact' solar cells, in which, as the name suggests, all contacts are on the rear side. The front side, in contrast, remains free and is unrestrictedly available for energy production.
However, this type of solar cell requires very finely structured doping distributions and contacts on the back side. The production of these fine structures normally requires complex and expensive masking steps.
To solve this problem, the researchers at the University of Stuttgart's Institute for Photovoltaic (IPV) have developed a laser process that makes it possible to manufacture rear-side contact cells with no masking steps at all. The laser permits every kind of doping distribution with a resolution of less than three hundredths of a millimeter. This eliminates processing steps previously required in the industrial production of such cells. The project, called 'RückSi-Skal' for short, will show that the cell process can be transferred to the production area relatively quickly. Production of large-area solar modules with an efficiency factor of more than 20 percent should then be possible at a cost of less than 50 (Euro) cents per watt peak (Wp). That will make the production of maximum-efficiency modules in Germany cheaper than 'cheaper' standard PV modules from the Far East – in spite of high subsidies, low energy and wage costs and low social and environmental standards in those countries.

LESS POLLUTION

Attention is being given to the environment in another project currently carried out by the IPV together with the University of Stuttgart's Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA). The focus here is on pollutants contained in the 17 million tons of solar modules present around the world. Although these modules were initially praised as a 'green product', the fact is that bands of solder containing the heavy metal lead were used to produce them.
Depending the technology used, cadmium and copper compounds were also liberated. The scientists in this project want to study how the pollutants escape from the modules and identify any points of vulnerability, with the aim of preventing or at least delaying these emissions.

Andrea Mayer-Grenu

Energy-Efficient Pizza

Guided Hot Air Reduces Heat Loss

Correct heating of deep-frozen pizza calls for science. Up to now, namely, the whole oven was heated even when it contained only one small pizza. That is not exactly energy-saving. The University of Stuttgart's Institute of Mechanical Process Engineering and household appliance supplier E.G.O want to tackle the problem with the help of flow simulations. In future, the items to be cooked will be strategically positioned in a stream of hot air, thus potentially lowering energy costs by up to 40 percent.

In modern hot-air baking ovens, heated air circulates uniformly throughout the entire oven space. This is very efficient when the oven is full and cooking times are long. But with small quantities of food which are only to be heated up, a great deal of energy is lost. 'Just popping' a deep-frozen pizza into the oven costs more than half a kilowatt hour of current; that can rapidly accumulate in a society with more and more single households and fast-food dishes.

Flow Concepts are Tested in a Lab Oven.

For that reason, the researchers of the 'ecoBack' project are pursuing the idea of no longer heating the entire oven space for smaller dishes. The aim is rather to generate a 'micro-climate' around the item to be cooked using a carefully designed stream of hot air which carries heat energy straight into the food as it cooks. A deep-frozen pizza served the researchers as reference object for many computer-aided simulations and practical trials. They studied several variant possibilities for enveloping it with a stream of hot air and compared the different concepts in comprehensive simulations. One especially promising concept involved surrounding the pizza with a kind of 'bell jar' of hot flowing air while keeping the hot air as much as possible away from the oven walls. Heat loss to the outside remained negligible. For a practical trial, the researchers built a laboratory oven equipped with devices for technical measurement, reporting and regulation and a high-performance control system. The experimental results from the trials matched up well with the simulations and are now to be transferred to a demonstration model dimensioned like a real cooking oven.

A VISION FOR THE FUTURE: OVENLESS BAKING

A next step will be to develop this concept even further for using it in commercial baking ovens and adapting it to other types of foods to be cooked: In the long run, the scientists can even envision a baking oven with no housing at all. 'In' such an oven, a roast would be placed on a free-standing tray and directly targeted by hot air from nozzles or similar devices. This would save not only raw materials in the production process but also energy in operation.

FIZ Karlsruhe, BINE Information Service, Bonn/ amg

Between Maecenas and Private Interests

Foundation Chairs Serve to Bridge Science, Business, and Society.

The chairs of 15 professors at the University of Stuttgart – and about 1,000 in Germany as a whole – are financed by foundations or outside funding. These persons are the University's 'face to the world', and often carry out pioneering work in areas which do not (yet) merit a full professorship. In public discussions, however, they represent 'scientific economizing' for many, who see them as a threat to freedom of research. How does this look in actual practice?

The motives for financing a professor's chair are as variegated as the disciplines and models of support involved. Sometimes specific technologies are to be advanced, like those in water-driven power plants, software systems or rail travel; sometimes the therapy of cancer victims is involved. Sometimes the donors hope for an advance in knowledge or hope to provide a solid basis for next-generation researchers, and sometimes they have ideals like protecting the environment or promoting the liberal arts.

Sometimes companies are directly named, like MTU Aero Engines in the area of airplane propulsion systems. But it is more common for the funding to be organized through foundation consortia or to come from individuals with a personal passion. Among the latter is Karl Schlecht, founder of Putzmeister AG in Aichtal near Stuttgart. Around 2000, his foundation initiated a teaching chair for Wind Energy at the University of Stuttgart and in 2012, together with the Heinz and Heide Dürr Foundation, he also made funds available for the Institute for Energy Efficiency in Production (EEP).

Although the 82-year-old businessman made his fortune with specialized construction machines, he was also active as a businessman in two wind energy companies, and still today grows passionate when talking about it. 'Anyone standing on a surfboard, for example, feels how powerful the wind is. Harnessing this energy in a turbine is a fascinating challenge,' enthuses Schlecht. However, this passionate sailboat skipper initially encountered strong headwinds with his idea of a foundation chair: even though the federal government had just rung in an era of energy conservation, Baden-Württemberg's regional government under Erwin Teufel (CDU) at the time said 'No'. In addition, this faculty at the University of Stuttgart, once flourishing under wind energy pioneer Ulrich Hütter, had shrunk considerably since his departure. Nevertheless, after protracted bargaining and a difficult search for a professor, it became reality and took up its work in 2004: Germany's first teaching chair of Wind Energy, with Prof. Martin Kühn as the occupant. Since that time, the wind has turned for this department: the number of team members has climbed from six to 22 since its founding, and the number of students from 52 to 300(!). But even more so for wind energy: whereas some 16 gigawatts of wind power were installed in Germany in 2004, now there are 34. About 23,500 terawatt hours of electricity are generated today from wind energy worldwide. And research has established itself parallel to this, with a corresponding increase in competition. 'That gave Prof. Kühn a great deal of leeway in selecting research topics, because he was the groundbreaker,' says today's occupant of the chair, Prof. Po Wen Cheng. Today there are numerous such chairs. 'Which is why we need to sharpen our profile and concentrate on our strong points.' The latter include measurement techniques like laser-based LiDAR (Light Detection and Ranging) technology, regulation and control systems, and simulation

and modelling. For Chang, who himself worked for many years in the business world, the fact that this concentration can threaten diversity and thus the freedom and independence of researchers as well, poses a challenge: 'The reason why freedom in research is important is that science's prime task is to create knowledge. This does not always lead to direct industrial applications. This freedom characterizes a university as a research institution; without freedom, it loses its very substance and in the end develops nothing new which might lead to innovative applications.'

THE DEBATE ABOUT OFFSHORE WINDPOWER

The chair specializes in research into wind energy in topographically 'problematic' areas like Germany's Southwest, along with offshore systems on the high seas. Both areas meet with skepticism from Karl Schlecht, the founder: 'What happens when the wind dies down and the sun doesn't shine?' was his sharp return to an offshore protagonist at the colloquium celebrating the chair's 10th anniversary. More important to him than research on piecemeal aspects is the furtherance of engineering perspectives and a holistic understanding of the overall system. Nevertheless, the founder stands behind the substantive orientation of the chair, says Cheng: 'Mr. Schlecht may have his convictions, but he also accepts the fact that research work plays an important role in the advancement of wind energy technology.' On the 10th anniversary, Schlecht gave the chair a donation – 'for any research project of your choice'. The anniversary also marked the end of the outside-funding phase. Starting in 2014 the position became a regular professor's chair and is funded by Baden-Württemberg and the University. The name 'foundation Chair' became 'Stuttgart Chair of Wind Energy', 'because the abbreviation SWE is now an established brand name.' For the time being, not much has changed, says Cheng: 'We're facing many technological challenges in creating a sustainable energy system for the future.'

SUSTAINABLE CONSTRUCTION

The junior professor's chair of Dirk Schwede is still quite new; research on Sustainable Construction has been carried out there only since 2013, at the University of Stuttgart's Institute of Lightweight Structures and Conceptual Design (ILEK). It is financed by the Robert Bosch Foundation, which has made about one million Euros available for the next five years, and carries out research above all on construction materials and parts, and on erecting buildings as economically as possible with regard to energy, resources, and recycling following renovation or demolition. These are issues not only in Europe but even more so in Asian threshold countries, where growing prosperity and demands

This freedom characterizes a university as a research institution; without freedom, it loses its very substance.
Prof. Po Wen Cheng,
Chair of Wind Energy, University of Stuttgart

for comfort have unleashed a fury of construction. 'Huge construction projects are shooting up out of the ground there, swallowing enormous quantities of raw materials and energy, but with only middling quality,' is Schwede's outline of the problem. Solving it requires 1) that those in charge think differently, and 2) that ways be found to adapt energy- and resource-saving technologies to the conditions of today's markets and climate. The sustainable techniques developed here are often applied in those countries with highly problematic results, doing more damage than good regarding the overall goal. 'What interests me is how our concepts of sustainable building can function under the cultural, climatic and economic conditions in rapidly developing countries like China or Vietnam,' says Schwede. In particular, he wants to know what functions are required by a facade element in different climates, how to save resources in making it, and how to ensure its recyclability. This gives rise to very different research questions: what appearance should the buildings have, what kinds of ventilation, insulation and glass systems make the most sense? What are their humidity and thermal characteristics, and how long do which materials last?

CLEAR AND PRACTICABLE FINDINGS

The approach here is wide-ranging, and that's no accident. 'The research project must be embedded in the topic area of sustainable use of natural resources, and it must be application-oriented. It should contribute to a solution of pressing environmental problems which have special relevance for developing or transformational countries,' says the call for applications for the Robert Bosch Junior Professor's Chair. Even though he submitted a research outline with his application and has updated it over the years, explains Schwede, 'I have considerable leeway within this corridor.' However, much emphasis is laid on 'impact': 'The research findings must be clear and practicable in actual construction.' Then too, the timeline has a certain impact on the research program. Five years pass quickly when one must first put together a research team, write project applications, and prepare classroom lectures. A 'tenure track' culminating in a full professor's position is not planned. 'In choosing research topics I must concentrate on time limits and easily guided projects,' explains Schwede, 'which is why I work a lot with simulations.'

THE HISTORICAL IMPACT OF TECHNOLOGY

Prof. Reinhold Bauer does not have such concerns. A historian, he occupies the teaching chair for the 'History of Technology', first erected in 2011. It is financed for the next ten years by a grant from the Berthold Leibinger Foundation, and the University has committed itself to fund the ten years thereafter. 'With that perspective we can work for the long term.' Bauer too was primarily occupied during the first years with getting the chair's activities up and running and building up the curriculum. 'This year, we tested more than 40 candidates regarding basic cross-disciplinary qualifications alone. This shows us that the chair has gradually established itself.' Bauer's classes include many future engineers. This interdisciplinary character matches the target set by the Foundation of 'study-

‘The research findings must be clear and practicable.’
Jun.Prof. Dirk Schwede,
Foundation Chair for Sustainable Building.

‘The founder follows the chair’s development with great interest, but stays mostly in the background.’
Prof. Reinhold Bauer,
Foundation Chair for the Historical Impact of Technology.

ing the conditions and consequences of technological change regarding historical causes and effects and the interrelationships between natural science, technology, society and culture in order to answer pressing questions’. Questions such as that of the responsibility of engineers in dictatorial systems like the Third Reich. ‘To counteract fantasies of omnipotence, in the sense of ‘nothing’s too hard for the engineer’, engineers should learn not only technological expertise but also to reflect on the impact of what they do,’ emphasizes Bauer. This goes far beyond an ‘aesthete’ type of educational mission’; it also enhances both the acceptance and the survival chances of the profession: ‘I am convinced that we will have better engineers when they are not only expert professionals but are also able to reflect from different points of view about the meaning of a branch of technology on society as a whole and also to verbalize these consequences.’
Bauer’s team colleague Eike-Christian Heine will now attempt to develop a topic initially planned for a seminar on the history of engineering into a post-doc project. ‘This is the Humboldt ideal: a mingling of instruction with research.’

INNOVATIONS THAT FELL THROUGH

One research question that Bauer puts to himself concerns the reason why innovations sometimes succeed and sometimes ‘fall through’. Here too, in the final analysis, sociocultural conditions and technological effects are at the bottom. Inventions like the first picture telephones or the Wankel engine do not flop because of technological inferiority but because they are out of step with the times or the needs of human beings. And the Ford Model T became legendary not because it was an especially good car, but because of the new assembly line production process that made the vehicle affordable for the masses.
‘Falling through’ was even the subject of Bauer’s professorial dissertation, ‘and has haunted me ever since.’ He often talks about it at different innovation forums or at the German Academy of Technical Sciences (Acatech). These lectures increase the visibility of the chair, as did the first joint meeting of the Society for the History of Technology and the Discussion Group on the History of Technology in May of this year.
In order to attract this renowned conference of professionals to Stuttgart, he even went to lunch with founder Berthold Leibinger. Bauer tells about it: ‘He follows the development of the chair with great interest, and is always well-informed.’ But there are few signs of either Leibinger, who has headed the Trumpf Group for many years, or the foundation established by him during the department’s daily activities. ‘So I occupy a professor’s chair just like anybody else,’ says Bauer.

Andrea Mayer-Grenu

SMEs and the Power of Research

Billions in Research for Smaller & Medium-Sized Enterprises (SMEs)

'Outside-funded research only helps big companies': an often-heard theory, but inaccurate. While it is true that large companies quantitatively set the tone in outside funding, the quality of research projects which SMEs help to fund and which benefit them can certainly keep step. Three examples at the University of Stuttgart underscore the range of topics.

Research and development show the power of Germany's small and medium-sized companies. According to figures compiled by the Institute for Research in Medium-Sized Companies (IfM) in Bonn, the largest family-owned companies invested 3.3 percent of their turnover in 2012 in research and development; that is the highest level of innovation-orientation in all of Europe. Even smaller companies collaborated closely with institutions of higher learning and public research, says the IfM. According to the 'Federal Report on Research and Innovation 2014', published by the Federal Ministry of Education and Research, 564 million Euros flowed last year directly to SMEs in funding for technology-specific programs. This was complemented by another 862 million Euros in SME grants for technology-oriented programs from the Federal Ministry for Economic Affairs and Energy (BMWi). Half of this went directly to the SMEs, the other half to research institutions as part of programs for cooperation with small and medium-sized companies. Thus in 2013 the Federal Government gave a good 1.4 billion Euros to projects involving SMEs – 80 % more than in 2007, and this does not even take grants from the Economic Stimulus Package II into account.
The rest of Europe has also recognized the importance of SMEs for research and development. The EU has simplified application procedures for SMEs in 'Horizon 2020', its new general program for research and innovation (R&D). The EU envisions at least three billion Euros by 2020 for the promotion of R&D in SMEs.
Outside-funded research for and with SMEs is found everywhere among the University of Stuttgart's different scientific disciplines. One example of this is a 'Usability Project' currently underway at the University's Institute for Work Science and Technology Management (IAT), in collaboration with Stuttgart's Fraunhofer Institute for Work Science and Organization (IAO). This is part of the BMWi's 'Digital SME' Initiative. Good usability, or simply 'user friendliness', ensures intuitively usable software, for example. Today, many large companies commission the testing of new products regarding usability or even have their own departments for such tests. 'In our sub-project we are developing and testing services which SMEs can use for improving the usability of software products or better evaluating them,' explains IAO scientist Daniel Ziegler.

INTUITION RATHER THAN COMPLEXITY

Experience has shown, after all, that as products become increasingly complex it is no longer enough to offer added functions or a wider range of settings. Effective use of the product requires that the user can operate it intuitively. The basic theoretical principles of such intuitive operations are found above all in the engineering sciences and psychology. 'In this project, the IAT has used time-tested usability methods to develop reality-based actions and elements which have then been incorporated into service packages,' says Ziegler. Companies often lack an understanding about which usability methods are best for dealing with a specific problem. 'The important thing in many

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Team members Marcus Kannewurf and Thorben Schiemann (left to right).

cases is to recognize operating problems as such – for example, when many queries are directed to the support area regarding a specific part of a program. The manufacturer is often unaware of the how the user may be operating an input screen, for example,' explains IT specialist Ziegler. In analyzing a problem it is often helpful to examine both formal usability factors identified by research and standardized surveys or the user's own observations.

The researchers are now testing their service packages in the field, and project partners include not only the IAT and IAO but also the German IT Association for SMEs and the software provider CAS in Karlsruhe. A total of about ten SMEs are participating as test cases. Those which develop software themselves can choose from three different packages: a one-day workshop, a test of their software according to usability criteria (including suggestions for improvement), or the processing of a concrete issue from a development project, including training for the developers. For companies in need of applications there is also a service package for the selection of document management software; to this end, the IAT and the IAO have installed different systems in the laboratory so the users can get practical experience under tutelage. 'That is what's often lacking when a software purchase decision is made, and problems then emerge later during everyday use,' says Ziegler.

The project will run to February 2015 and be funded with 1.2 million Euros over a period of 36 months. Repeated surveys of the team of developers will be carried out to determine how usability principles were taken over in the minds of the developers. At the end of the project, the services could then be made available to interested SMEs on a long-term basis.

SAVING GAS AND CUTTING WEIGHT

The BMWi combi-project 'Massive Lightweight Construction' also has major relevance for SMEs. Among those benefitting from this industrially oriented research will be metal-processing companies which carry out cold forging on blanks with presses. 'There are many smaller companies in this area,' says Dr. Alexander Felde of the Institute for Metal Forming Technology. (IFU) at the University of Stuttgart. These enterprises face a special challenge: energy consumption and CO2 emissions in cars should continue to drop drastically, but car weights continue to rise due to new comfort and safety components. There's only one solution: take off the pounds! And this, of course, hits hardest in the most massive vehicle elements, i.e. the power train and the chassis. 'A study of the RWTH Aachen's Automobile Institute showed that about 40 kilograms can be saved in medium-priced cars by lessening the weight of their massive metal parts,' says Felde. While it doesn't sound like

much, it's still a good five percent of the overall weight of the power train and chassis. 'That would be a real help,' says Felde.
Naturally, the transmission and joints would have to do their work equally well in spite of less weight. IFU engineer Felde sums it up this way: 'Less material, but the same requirements – that calls for new techniques.' This gave rise to the BMWi combi-project, in which the Stuttgart research institute is at work on three sub-projects, each funded by between 800,000 and one million Euros. On the whole, ten university institutes, five research organizations, six industry associations and 57 companies, 22 of them medium-sized, are participating. The IFU has acquired a new press especially for this purpose; its modern, power-assisted drive technology is just right for the processes involved. The investment of 1.7 million Euros is also being shared by the German Research Foundation.
'This combi-project represents non-competitive, cross-industry research for innovative lightweight construction concepts,' says Felde. It includes all aspects – the materials, the design of demo-components, and the entire processing chain. One of the sub-projects aims to develop a multi-component gearwheel. 'The sprocket is to be very strong, but thin-walled in design, while the inner part is to be weight-optimized,' says Felde. 'In contrast to an integral model, this will make better use of material properties – while saving weight.' In the demo-model, the teams must not only optimize the component geometries but also work out a process for joining the two components.
The second sub-project of the IFU concerns the basic principles and theory of strain hardening in solid structural elements. 'Even today, we can increase strength levels 20% to 25% just by specifically adapting the processing steps for parts which are most under stress,' says Felde. Normally, the industrial world identifies needed processing parameters by means of systematic trial-and-error. In contrast, the partners in this project are seeking a universally applicable answer to the question of how processing parameters can be found without trial-and-error, and then how to test strength distribution. Their method: numerical simulations. Finally, the third sub-project on which the IFU is working aims to push the technological boundaries outward in the solid forging of lightweight-optimized parts. To this end, the team members are already aiming to incorporate the new knowledge won by the other sub-projects into demo-components. 'SMEs have been our constant project partners in research over the years' says Felde. 'And since the IFU sits on many committees, we learn first-hand where the shoe pinches in industry.'

DIGITAL FASHION

Now the scene changes – from (heavy) metal to (airy) cloth. Dr. Thomas V. Fischer of the Center of Management Research of the German Institutes for Textile and Fiber Research (DITF) in Denkendorf is convinced that with the right approach new business models can be found for SMEs even in the textile industry. 'We've been working on this for years in outside-funded research projects,' he says. 'Digital Fashion' is the catchword here – that is, fashion which the customer can configure and individualize on the Internet. 'Here in Denkendorf, we do research on this from different perspectives.' Types of ink for digital printing, localized functionality of substances, technology integration, services, business models ... all involving a vast range of know-how, distributed over three research institutions: the institute of Textile Technology and Process Engineering (ITV), the Institute for Textile

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For persons who are physically hampered, digital textiles improve the quality of life – another option in future for SMEs in the hotly contested textile industry.

Chemistry and Chemical Fibers (ITCF), and the Center of Management Research (DITF-MR). All three institutions have management employee interrelationships with the University of Stuttgart. One of the projects, funded by the EU with 4.9 million Euros, is called 'Fashionable'. It brings together 14 partners from six countries – research institutes, industrial participants, consumer groups, and SMEs. 'Working together with partners from the world of business in earlier research projects, the DITF's institutes long ago laid the groundwork for digitalizing the entire development process with the aid of integrated CAT tools,' says Fischer. This makes it possible to design and manufacture tailor-made clothes on the Internet. 'The advantage of this for companies is that they sell first and produce later in small batches – in the extreme case even one-of-a-kind items.'

As one example of this technology transfer, Fischer names a Belgian shirt maker who was able to stabilize his business, which had been on shaky legs, thanks to information technology and a new business model. Previously, he had partnered research in an outside-funded DITF project. 'Today he makes individualized shirts and also sells his know-how about the production of tailor-made shirts to major fashion houses,' says Fischer.

The aim of 'Fashionable' is to transfer the digital fashion approach to persons for whom individual products are not a luxury but rather an essential; examples of this are persons with physical impairments and persons who are very large, very small, or highly overweight. 'It is estimated that personalized clothing or medical textile products would really increase the quality of life for more than 100 million Europeans,' says Fischer. Persons in wheelchairs or those with muscular or foot problems are examples, and the range of 'textiles' extends from normal clothes to shoes and orthetic products that stabilize or guide parts of the body. 'For example, we have analyzed whole processing chains for different personalized products and adapted each to the philosophy of Digital Fashion – along with the required technology,' says Fischer. One result, for example, was a 3D-CAD system which creates an optimum fit between orthetic products and individual physical sizes.

'Production in the textile industry has now shifted largely towards Asia. Methods like those in Digital Fashion make it possible in part to bring this production back to Europe,' is Fischer's conviction. In particular, SMEs can occupy lucrative niches with these new options.

Michael Vogel

Soundproofing with 'Air Mattresses' –

A 'Laughable' Idea Catches the Eye of Business

High sound-insulation walls of concrete, wood or metal have long lined freeways and turnpikes. But people are usually helpless against the racket created by short-term sound sources like construction sites and open-air events. Now there is help from an inflatable noise-damping wall developed by researchers at the University of Stuttgart's Department of Building Physics together with the Fraunhofer Institute for Building Physics. It is currently being marketed by Ceno-Tec, a manufacturer of special textiles in the city of Greven in Germany's Westphalia, and last-year's winner of the 'Münsterland Innovation Prize' for 'Cooperation Between Business and Science'.

It's morning, shortly after 7 o'clock: A jackhammer punches through old pavement below the bedroom window with a deafening 'rat-a-tat'. Or in an office at 9 a.m., the eye wanders over to the construction site of the new high-rise with its power shovels, its hammering and sawing. Or evening, 9 p.m., home again, with no way not to hear the loud rock music coming from an open-air stage not far away 'Noise affects all of us,' says Schew-Ram Mehra, Director of the Department for Building Physics. According to a survey of the Federal Office of the Environment, four of ten persons in Germany were bothered not only by traffic noise but also by noise from the surroundings and one third by sounds from industry and small-scale trade enterprises. Physicians have long known that noise can cause illness. Even the traffic sounds of a busy street, with a permanent level of 65 to 70 decibels during the day, can increase the risk of a heart attack. At the end of the 1990s, when Shew-Ram Mehra was searching for ways to muffle such temporary noise, he was disappointed. Plastic walls, mineral-fiber cushions, and sand-filled blankets were difficult to handle and needed a frame. 'At some point I thought of the inflatable air mattresses sometimes offered to guests as bedding,' reminisces the Professor for Building Physics, Acoustics and Sound Insulation. I thought, They can help against noise too! 'You're crazy!' said the colleagues he told about his ideal. It was accepted teaching that only thick, heavy walls can effectively muffle noise.

STICK-TO-IT-IVENESS AND CONVICTION BRING SUCCESS

But Mehra, who was born in Afghanistan, proved to be right. After many experiments and improvements with different membranes, thicknesses, inflation gases and compartmentalization it was found that an air-filled noise-protection wall made of a truck-cover-type plastic sheet reduced sound levels by up to 25 decibels. 'These walls dampen noise just as well as a massive wall of concrete, but are 100 times lighter and 8 to 10 times cheaper,' reports Mehra. And when they are no longer needed, the air is easily removed, and the wall can be folded together. Even so, two more years passed before a licensee was found for the product in Ceno-Tec. 'It is difficult to find an industrial partner in Germany who is willing to take a risk,' says Mehra. 'But we were convinced about our idea,' says the graduate electrical technician, 'and were able to show that our product has no competitors.'
At the moment, the inflatable sound insulation walls are being tested, for example, at a German Rail construction site in Rangsdorf near Berlin.

® CENO Membrane Technology

Mobile sound insulation walls hold in the noise from a gas condensation plant in Mülheim.

'We still have to fight and lobby, but demand has clearly risen,' says Benedikt Wensing, Sales Manager at Ceno-Tec: 'From around 30 offers a year in 2008 the number is now about 300 offers a year.' For his part, Mehra is already thinking ahead. Couldn't 'air mattresses' also shut out the loud chatter in large-area offices, multipurpose halls or call centers? The 63-year-old and his team have much research ahead of them.

Helmine Braitmaier

Structural Physics for the Working World

Noise reduction is only one of the many challenges faced by building physics, caught as it is today in the vortex of speedy technological progress, ever-greater user demands, and increased functional requirements for buildings. To make it possible for engineers and architects to keep step with both this progress and their jobs, the University of Stuttgart has offered since 2007 the 'Master's Degree Program in Building Physics for Professionals'. The syllabus includes building and room acoustics, heat insulation, energy efficiency, building technology, climatic issues, legal aspects, and history along with many other aspects of building physics.
A Master's Degree program will be added to this in 2017: the online study course in 'Climatically and Culturally Oriented Construction'. The new offering is linked to the fact that as a consequence of globalization planning principles are being used to create a nearly uniform style of construction in all regions of the world. The researchers in Stuttgart hope to counter this with buildings which conform to each region's respective climate and each country's culture. The goal is to avoid an anonymous and out-of-place style of architecture while reducing the danger of construction deficiencies and damage. The University of Stuttgart has received 570,000 Euros for the conception and design of the new program after participating in the competition for 'Getting Ahead Through Learning: The Open University', held by the Federal Ministry of Education and Research (BMBF).

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www.uni-stuttgart.de/moa/

Those who study at the University of Stuttgart can also found a company. Here the Business Founding Center of the Technology Transfer Initiative (TTI).

Science Creates Jobs

From Electro-Walker to Plant Engineering and Construction

Science not only requires money, it also earns it. What is meant here is not the global players who commission research projects in order to benefit their own innovativeness and competitiveness, but younger startups: companies that succeed with clever research ideas.

It was not long ago that Karl Kübler, Max Kessler and Daniel Reiser were studying automation technology and machine engineering at the University of Stuttgart. During a conversation over beer about e-bikes, the three hit on the idea of transferring this drive principle to a walker. 'At the moment, older persons like my grandmother have difficulties with walkers,' explains Daniel Reiser. 'Pushing them uphill is difficult, and downhill there's a chance that they will go out of control and roll away. But both problems are solved if the device is equipped with an electric motor.' Following up on this, the students at the Institute of Industrial Automation 'tinkered' on 'Rollias', a fully automated, electrically powered walker with a tablet PC. The initial model was difficult to operate and the design left much room for improvement; but now 'Rollias' has grown into an intelligent 'e-Buddy', an electrically powered companion along life's road, who can even glide without a hitch over cobblestones. It is guided by grips with sophisticated sensors. LED lights ensure safety, and the tablet can be used to sketch routes or write grocery lists. The device is designed not only for older persons but can also help rehabilitation patients get back up on their feet faster. 'e-Buddy' took first prize at Baden-Württemberg's 'Elevator Pitch' competition, and Finance Minister Nils Schmid even took a ride across the stage personally with the walker. But this is just the beginning for the three Stuttgart graduates, who have now taken Sascha Katzmann from the University of Hohenheim on board for his business competence. The four have now founded their own company on the campus of the University of Stuttgart and intend to market 'e-Buddy'. 'First we must develop a nearly series-ready prototype so that we can demonstrate the e-Buddy's advantages to potential customers in rehabilitation clinics and retirement homes,' explains Reiser. And also in order to allay the fears of usually older users regarding modern electronics. This requires a change in thought: 'At the University, we were accustomed to seek the best technological solution. But now our customers want practicality above all,' explains Reiser. 'For example, we worked for a long time on fine points in the grips, until we finally arrived at a solution which is easy and safe to use.'

Parallel to all this the company founders must also build up a sales network, find suppliers and production partners, and develop the matching software – all of which costs money. The young company received an EXIST Company Founding Stipendium at the beginning of the year, which initially gave them room to breathe. 'But in order to bring the e-Buddy to series production we need investors, since hardware development is very cost-intensive.'

AUTOMATED PRODUCTION OF CARBON PARTS

'Compositence' has long since left that phase behind it. This systems engineering company, which in 2008 grew out of the Institute for Flight Mechanics and Control, has developed a new process for the production of carbon and glass fiber parts. It's done by depositing individual fiber bands swiftly on the workpiece carrier. This automated technology saves expensive interme-

© Elevator Pitch BW 2014

Finance and Economics Minister Nils Schmid tested the e-Buddy at the 'Elevator Pitch' competition for company founders.

© Compositence

Compositence has developed an automated process for cost-efficiently manufacturing carbon and glass fiber parts.

diate processing and speeds up the production of three-dimensional parts, thus saving not only time but also raw materials and money in the process. The customers come from the automotive and air travel branches as well as the wind energy and furniture-making industries. In 2013 Compositence was awarded Baden-Württemberg's Innovation Prize and now has 15 paid employees on its team.

For Compositence too, the major challenge was to find an investor. Merely developing the prototypes took three years, and that was only the beginning: 'No matter how technologically qualified we are, in the end someone has to buy the product,' says Volker Witzel, who created Compositence together with Karb as a spin-off from the University of Stuttgart. But now they've done it, and the first systems will be delivered this year. In their Leonberg company they make one especially elegant part themselves in cooperation with designer Oskar Zieta: a designer table whose Compositence-created fiber structure gives it a completely new type of surface.

400 COMPANIES IN 16 YEARS

Both of the above two companies received support from the University of Stuttgart's Technology Transfer Initiative (TTI). It has provided consulting services for 745 company-founding projects since its establishment 16 years ago, and 400 of them turned into real companies. The ideas for the companies range throughout industry. ROOMAPS, for example, was born from 'Nexus', a special research area at the University of Stuttgart; it has developed an innovative navigation and information system for smartphones which makes it possible to find rooms in a building or a car in a parking garage – even without GPS or a WLAN signal. And Synapticon in Gruibingen sells flexibly combinable electronic robot modules that network actuators with sensors and sensor control systems and take over calculations and internal communications. Pinion, founded in 2008, was helped by the University of Stuttgart's Institute of Machine Components to develop an innovative gear shift mechanism for bicycles and today is a market leader in this segment. Another example: at Babybe

Pinion has scored with an innovative gear shift mechanism for bicycles.

Company, the Chilean industrial designer Camilo Anabalón and the mechatronics expert Raphael Lang are working on a bionic mattress which can imitate a mother's heartbeat in an incubator for prematurely born babies.
TTI provides financial consulting and information about support programs to those who want to be their own boss, as well as advice about everything that has to do with planning and preparing to go out on one's own, even including drawing up a business plan. Before making the jump, they can prepare themselves to 'go it alone' in the shelter of the TTI's transfer and company founding activities while being relieved of administrative work and bookkeeping. As a result, the first orders can be filled even before the company comes into being. That saves time and money and minimizes risks. Rooms can be rented cheaply right at the Technology Center.

THE NEXT STEPS ARE ALREADY PLANNED

Further steps will be needed to put meat on the bones of the 'company-oriented university' which is envisioned – that is, a university which systematically converts research findings into marketable products. It has already been decided to allocated 200,000 Euros annually for a Knowledge and Technology Transfer Fund at the University of Stuttgart. 'This money can be used in particular for the development of prototypes,' explains TTI Managing Director Prof. Bernd Bertsche. 'It closes the gap between research and future investors who, after all, want first to see whether a product idea is workable.' The next step will then be to set up an Enterprise Center which will combine support activities for founding companies under one roof while also promoting and intensifying research and instruction about how to found a company. 'This is important in order to make it second-nature for the students to think about founding while also giving them an ongoing education about the subject. We intend to set up a Foundation Chair for Entrepreneurship, and we're working with the Stuttgart Media University to plan an advanced course of studies on Intraneurship and Entrepreneurship. The long-term vision is to establish a Business Development Center conjointly with partners from the worlds of business, research, and various associations. It will be a central contact point for all technology-oriented company founding projects in the region. There's still much to discuss before we get there,' says Bertsche, 'but it's worth it, because every new company creates an average of five new jobs.'

Andrea Mayer-Grenu

Finding Out What Holds the World Together

Bosch Director Volkmar Denner

Volkmar Denner, Ph.D. studied physics at the University of Stuttgart in the 1980s and wrote his doctoral dissertation on the theory of solid-state physics. Today he is Chairman of the Board and Technology Director of Robert Bosch GmbH and 'wants to give something back to society'.

? 'You're now part of the bedrock at Bosch; you worked in different management positions, and two years ago you became the 'G1'. What has changed for you?'

› 'The economic situation made things difficult at the beginning. Getting out of photovoltaics forced me right away to make a hard, but I believe unavoidable decision. Many persons feared at the time that we were going to sacrifice the traditional Bosch values, the often-mentioned 'Bosch Way'. It was important to me and the entire management board to carry out the sale of our solar business in line with the Bosch culture. We worked out very specific solutions for the different plants and succeeded in saving a majority of the jobs. It cost us a great deal of money. But it brought us a lot of respect – in spite of all hardships for the men and women affected. Over against this decision, we have set numerous future-oriented portfolio decisions in motion, and the process is still going on. Some of the most recent milestones were taking over parts of BSH Bosch Siemens Hausgeräte GmbH and ZF Lenksysteme GmbH. Both are a good match for our strategic orientation and will bring the company another step forward. But we're also building up brand-new business areas and are developing a start-up culture at Bosch. It's reflected in spin-offs like Bosch Sensortec or our entry into the E-bike business, very much one of my own pet projects. Another new undertaking is the Bosch Startup Platform, where we give company founders from among our employees a foothold – in the form of work rooms and 'shared services' during the starting phase.'

? 'Does that mean that the automotive area will have less weight in future?'

› 'We want about 50% of our turnover to come in the automotive area. That has long been a Bosch target. But even Robert Bosch himself took care to diversify, in spite of the outstanding success of his ignition. As much as possible, we will use the opportunities for growth offered by the automotive branch, which is why our investment in ZF Steering Systems makes a lot of sense. After taking over and consolidating with BSH Bosch and Siemens Household Appliances, our Consumer Goods Division now constitutes 25% of our sales. That will be important for our company in the long run because it is a company area with fully different business cycles than machine engineering or automotive technology and therefore helps to stabilize our portfolio.'

? 'How does Bosch want to position itself in future regarding research and development?'

› 'The intermeshing of research and business in the form of high-performance clusters is a key for innovativeness and competitiveness, not only at Bosch but also for German and European industries as a whole. Our research area has been given the strategic task of working with each of the world's best institutes. That applies equally to our other partners and suppliers.'

'As Bosch's Technology Director, it is important to me to see to it that innovative breakthroughs really do make it to the market. That is why we are very proud of winning the Federal President's Future Prize for our ultra-short-pulse laser technology,

'Technological networking is fundamentally changing the world, and that is why we must network human beings as well.' Dr. Volkmar Denner, 'G1' at Bosch.

one of Germany's most important innovations. The Prize also documents very nicely why such clusters can be so successful: the basic optical research came from the University of Jena and the Fraunhofer institute there; Trumpf, as a leading laser company, was able to produce the ultra-short-pulse laser, and Bosch used it as the basis for a production facility which can make injection valves with never-before-seen precision.
But internally, too, we are networking ourselves and looking for synergies. In Renningen we are currently building a research campus which will offer highly attractive working conditions for the best researchers from all over the globe. Its leitmotif, 'Networking For Millions of Ideas', was not chosen by chance: technological networking is fundamentally changing the world, and that is why we must network human beings as well. Renningen is to be an archetype of how institutions of higher learning, research institutes, the regional Bosch technology centers, and our business units and employees can be optimally brought together. In the process, we are applying the Bosch principles to create inspirational working conditions, such as a brand-new design for offices, communication islands, and WLAN spots even outdoors. We expect to see new kinds of solutions from this creative atmosphere, like the oil burner that our in-company Buderus brand has just put on the market. It is has unparalleled efficiency, because the entire volume of oil is controlled by a single valve, which in turn comes from the automotive technology area. Another example: Bosch and Siemens Hausgeräte have just recently presented a kitchen oven with a Lambda probe. It gives us a unique position on the market. We intend to continue encouraging such ideas.'

? 'What other technologies will make life easier for human beings in future?'
› 'Our guiding principle is 'Technology for Life'; all of our strategies are always derived from this. What that means concretely is: we want to develop products that our customers love, that improve their quality of life, and that help to conserve the earth's natural resources. Last year, for example, we introduced a drive-dynamics regulator for motorcycles, a worldwide innovation. In terms of financing it is still only a small project, but that's not what interests us at the moment. The idea behind it was quite different: two-wheeled vehicles give many persons their first chance at mobility, especially in developing countries. But the vehicles can also have safety problems, which result in a high accident rate and many victims. With Bosch technology, we can help to make life safer for riders of two-wheeled vehicles. And other solutions from Bosch help reduce both fuel consumption and exhaust gas emissions in injection technology.'
? 'One glowing example of a creative juncture

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'The Bosch values are not just on paper; they are part of our lives, and we make every effort to put them into practice.'

between science and business is the University of Stuttgart's ARENA2036 Research Campus, where Bosch is a partner. What do you expect from this cooperation?'

› 'That project is looking for the automobile design of the future, meaning that lightweight structures will play a major part. Granted, this is primarily a topic for automotive manufacturers, but future production technology – a key issue for Industry 4.0 – is also very important for Bosch. That's why Bosch is so interested in ARENA2036, and we're happy to contribute our competence to this joint interdisciplinary venture.'

? 'The Bosch culture deliberately puts the employee in the center of attention. What makes you different from other companies?'

› 'Bosch has a strong culture, stamped by its founder. Even today, Robert Bosch is very present in our company, not only in his statements and legacy but also in his descendants. Before important decisions are made I contact the family's spokesperson, grandson Christof Bosch. The family supports this company, and we for our part heed the interests of the family. The Bosch values are not just on paper; they are part of our lives, and we make every effort to put them into practice.'

? 'What is the role of the Robert Bosch Foundation in this?'

› 'As a non-profit organization, the Foundation is an independent entity. But it is nevertheless very important to our company because it is living documentation of the values that Bosch stands for. Moreover, the company itself donates a great deal of money to projects which serve the public good. And our cooperation with the Foundation has recently grown closer: we're working for the first time on a joint project to battle unemployment among the young in Europe. Over and above projected needs, our company has made 100 additional trainee positions available for young people from Italy, Spain and Portugal. Parallel to that, the Foundation has commissioned a study on the reasons for unemployment – a fascinating project for all involved.'

? 'You studied physics at the University of Stuttgart. Why that subject, and why Stuttgart?'

› 'I've always wanted to understand how things truly work, and what holds the world together, so to speak. That's why I decided on theoretical physics, which studies the mathematical laws of structures and then applies them to other complex issues. The University of Stuttgart's physics department led the field world-wide at the time, with persons like Hermann Haken, the synergetics pioneer, Wolfgang Weidlich, who trail-blazed sociophysics, or my doctoral supervisor Max Wagner, a solids

theoretician. It was an environment that gave us great freedom to delve into related areas, and that's just what I did, studying for example the history of the natural sciences or issues of biophysics. Now I see a certain 'intellectualization' of study, with an immense amount of learning material and quickly tacted examinations at the sacrifice of much creativity. I see that as a critical issue.'

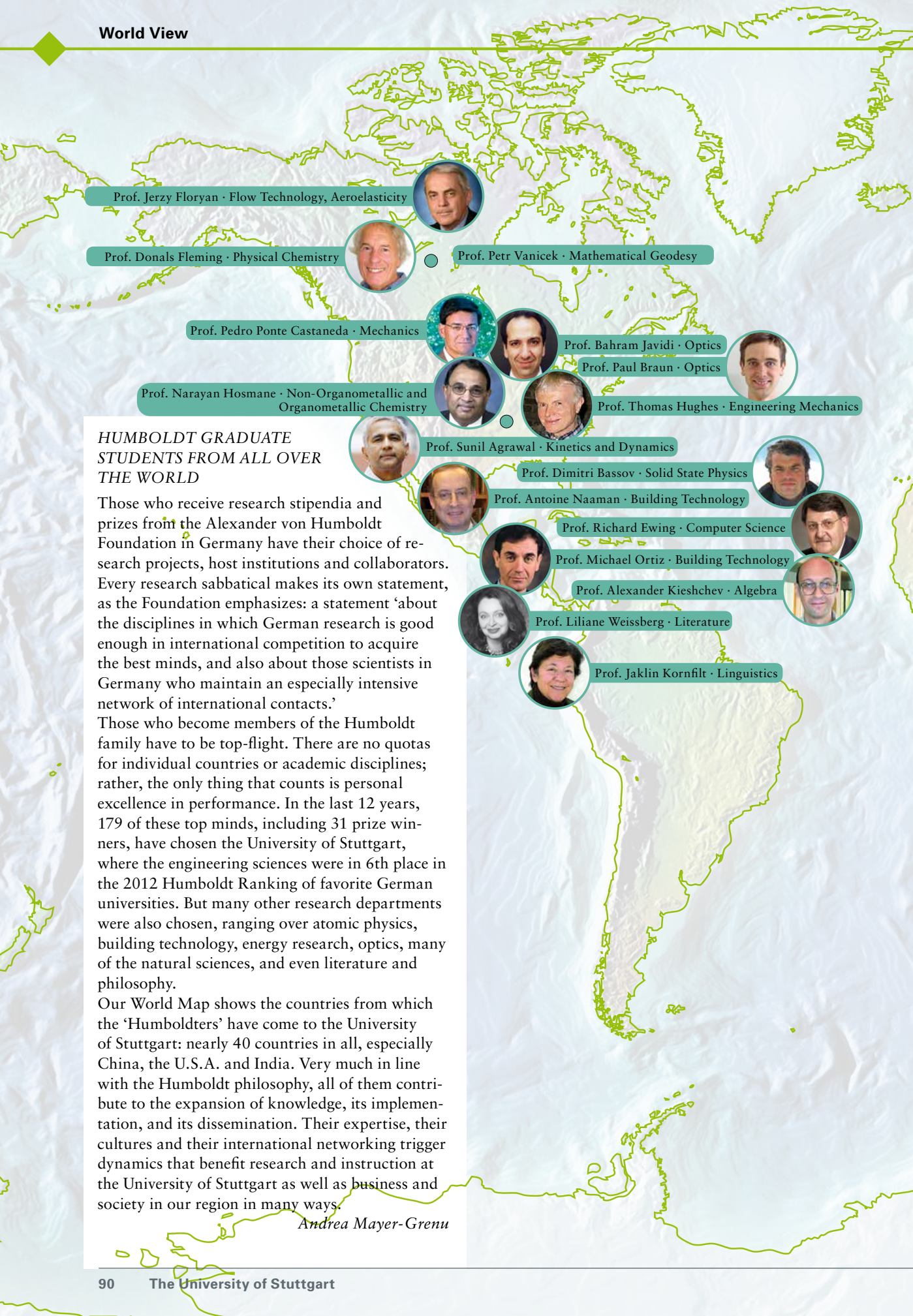
? 'What would have to change?'
› 'If we in Germany want to maintain our reputation for top research, we have to measure ourselves against the best. That doesn't just mean answering examination questions and working hard, but also encouraging creativity. Networking and cross-disciplinary cooperation are also important. At Stanford, for example, professors from all the faculties and disciplines sit down together on their own to discuss joint research activities, and the university always encourages such initiatives. I'd like to see more of that kind of dynamics in Stuttgart.'

? 'You have been Chairman of the Friends Association of the University of Stuttgart since 2010. Why do you take time for this in spite of your full appointment book?'
› 'As one who had a stipendium from the Stipendium Foundation of the German People, I have always seen it as a high duty that we use our talents for the good of society. I have taken this very much to heart, and I constantly ask the members of my team this question: What are we giving back, what lasting footprints will we leave behind? This means not just our business results, but rather our moral and ethical attitude. As Chairman of the Friends Association I want to give something back to the University. But I regret that the number of members has dropped over the years and that we are limited in what we can do to help financially compared with the example of U.S. universities.'

? 'What is your message to the University?'
› 'We of the Friends Association brought up the topic of fundraising years ago. People listened, but concrete action is still missing. Gigantic amounts are required just to renovate buildings – too much for the University to pay on its own. Still, it must do so somehow if it wants to remain an attractive competitor for the best minds. They look not only for high-quality departments but also for buildings, a University environment, and an image which are attractive. Students today are no longer limited to Stuttgart in their choice.'

'Many thanks for this interview!'

Dr. Hans-Herwig Geyer and Andrea Mayer-Grenu conducted the interview.



HUMBOLDT GRADUATE STUDENTS FROM ALL OVER THE WORLD

Those who receive research stipendia and prizes from the Alexander von Humboldt Foundation in Germany have their choice of research projects, host institutions and collaborators. Every research sabbatical makes its own statement, as the Foundation emphasizes: a statement 'about the disciplines in which German research is good enough in international competition to acquire the best minds, and also about those scientists in Germany who maintain an especially intensive network of international contacts.'

Those who become members of the Humboldt family have to be top-flight. There are no quotas for individual countries or academic disciplines; rather, the only thing that counts is personal excellence in performance. In the last 12 years, 179 of these top minds, including 31 prize winners, have chosen the University of Stuttgart, where the engineering sciences were in 6th place in the 2012 Humboldt Ranking of favorite German universities. But many other research departments were also chosen, ranging over atomic physics, building technology, energy research, optics, many of the natural sciences, and even literature and philosophy.

Our World Map shows the countries from which the 'Humboldters' have come to the University of Stuttgart: nearly 40 countries in all, especially China, the U.S.A. and India. Very much in line with the Humboldt philosophy, all of them contribute to the expansion of knowledge, its implementation, and its dissemination. Their expertise, their cultures and their international networking trigger dynamics that benefit research and instruction at the University of Stuttgart as well as business and society in our region in many ways.

Andrea Mayer-Grenu

Total of Humboldt scientists since 2003: 179, including:
Humboldt Prize winners: 31
Humboldt stipendium researchers: 148

- Europe, including the Russian Federation: 49
- Asia: 70
- North and Central America: 16
- South America: 7
- Africa: 4
- Oceania: 2

New Materials in a New Environment

Japan's Hidenori Takagi Wants to See What's Never Been Seen

An absolute novum plays a major role in Hidenori Takagi's life. 'I'm trying to see something that no one else has ever seen,' he says, 'materials with unheard-of characteristics'. Which is why he selected in early 2014 a new research location for the pursuit of his goals. Working together, the Max Planck Institute (MPI) for Solid State Research and the University of Stuttgart succeeded in adding to Stuttgart's reputation as a research location by gaining Prof. Takagi. No little help was also provided when he became the first researcher from Asia to receive one of the highly regarded Humboldt professorships.

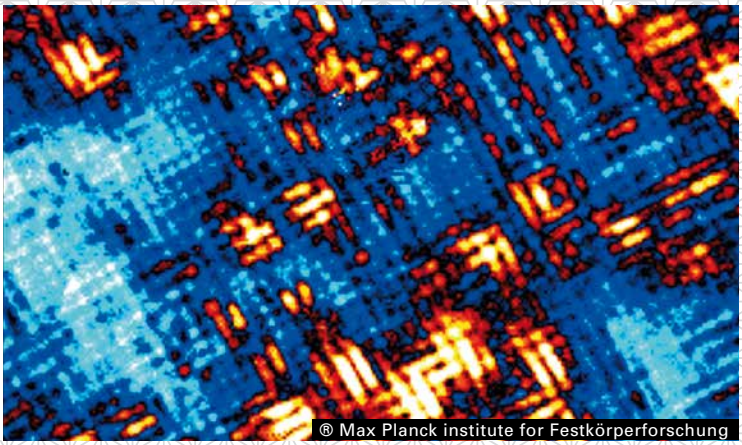
The window in Hidenori Takagi's room looks out on trees. In his few free moments he likes to take a walk in the forest, he says; but he still hasn't gotten accustomed to the many hills. His office at the MPI in Stuttgart-Büsnau still smells new. It is sparely furnished; only the bare necessities are on the desk top – a laptop, for instance, which he needs for his work.

And his research work might revolutionize that very device. The reason: heat generated during the use of laptops and mobile telephones in particular is their greatest hazard. Heat diminishes the ability of chips to perform, and an efficient way of cooling such sensitive electronic systems in compact devices remains a challenge.

This is where on of Takagi's areas of research comes into play: thermoelectrical materials which, for example, might make intelligent use of high temperature differences at different locations to generate electric current. Or current passing through such materials might either generate heat or cool them down. Another area of Takagi's research concerns unconventional characteristics of new materials, like superconductivity or the ability to store information electronically. Computer chips are to become even more productive. The search for such new 'quantum materials' has been a central topic for many years in Prof. Takagi's research. Now 53 years old, he attracted worldwide attention even as a master's degree student in Tokyo by artificially producing a high-temperature copper oxide superconductor in which electrons carried the charge. Until that time this function had been found only in positively charged particles, the so-called 'holes'. Takagi's new development made it necessary to rethink many accepted theoretical concepts. Thus from the beginning it has been one of his primary research goals to find new high-temperature superconductors which can conduct current without resistance at temperatures which are closer to room temperature than to absolute zero (-273° Celsius) – thus opening up fully new fields of application.

TAMING ELECTRONS

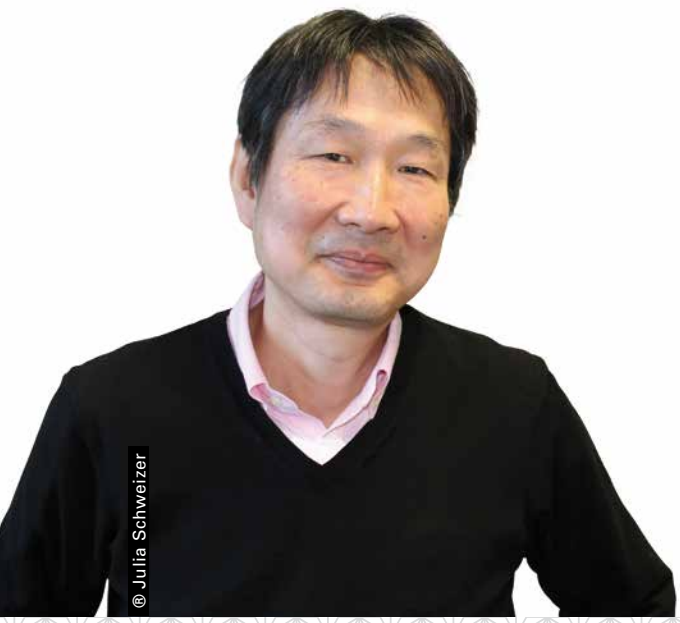
But Takagi's interest in new, unconventional material properties goes much farther, and his discoveries range widely: from application-oriented materials that – contrary to expectations – expand upon cooling to new, exotic magnetic phases, the so-called 'Quantum Spin Liquids'. 'Many new worlds open up when you can control electrons,' he says with an eye on submolecular interplays. First, however, he needs to find the right materials for his project, study them, and in the end hopefully find new functions and applications, even in the field of Green Technology. But a number of years will pass before these materials are found and can be used in actual practice. These are only a few of the reasons why the



An atomically triggered scanning tunneling microscope image of 'electronic material' in a copper-oxide superconductor. Hidenori Takagi thinks it contains the key to high-temperature superconductors

University of Stuttgart hopes that this Humboldt Professor will stay as long as he likes – 'until he retires,' says Martin Dressel, Dean of the faculty, and not just because of Takagi's valuable research: he also attracts other 'luminaries' to one of the world's pre-eminent research facilities in this field. Dressel's vision: 'We could become a beacon!' For example, the University is already creating a Graduate College on 'Electrons in Complex Crystals' together with the Max-Planck Institute; and a special research area is on the horizon.

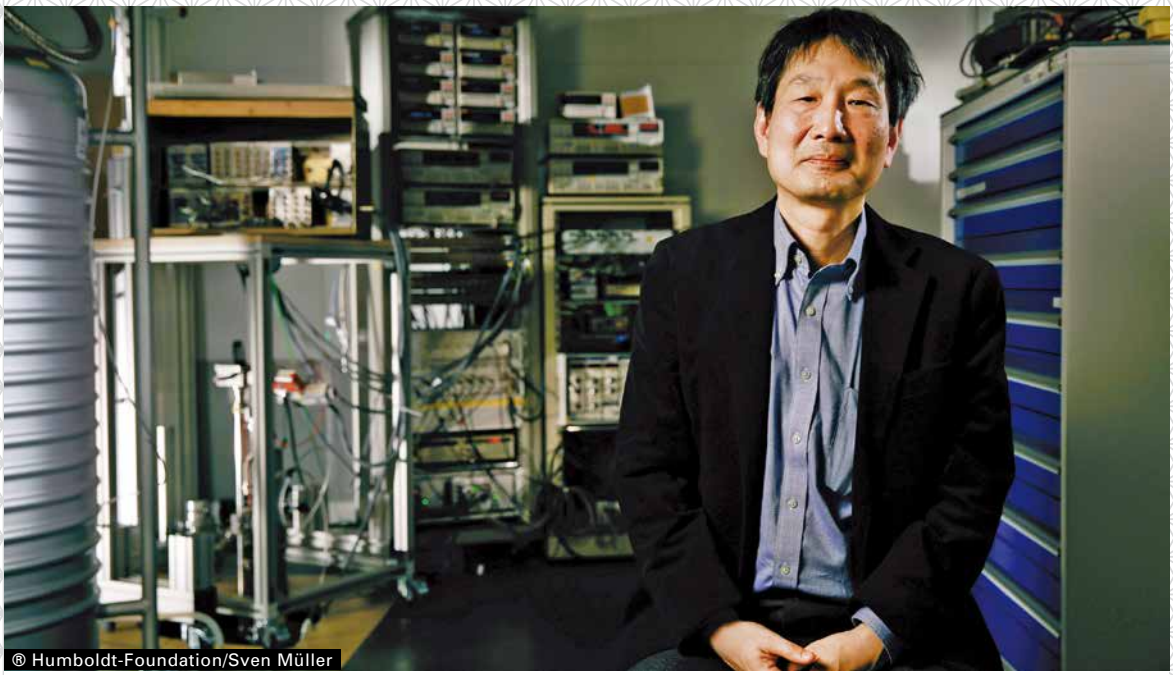
Takagi is also closely networked with other research areas and participating institutions. 'Our cooperation with the Max-Planck Institute has grown stronger,' says Dressel. For Takagi it is important to contribute to both institutions both in research and in teaching. For example, he will hold a series of lectures in the winter semester for master's degree students in physics, and will also mentor their work. Dressel brought this exceptional researcher to Germany together with Professor Bernhard Keimer, Director of the MPI for Solid State Research. Here too, this became feasible via one of the Humboldt professors' chairs offered since 2009 by the Alexander von Humboldt Foundation and the Federal Ministry of Education and Research. Takagi was the first researcher from Asia to receive this, the most richly endowed research prize in Germany, as 'one of the world's most outstanding and internationally networked researchers in modern solid state research and the study of materials,' said the Foundation in explaining its choice. Bringing him to Stuttgart is a glowing example of the University's ability to attract top foreign researchers to Germany.



FIVE MILLION EUROS AND A VOICE IN STRATEGY

Five million Euros are available over five years for experimental scientists like Takagi. The host institutions must pledge to involve the researchers in their strategic planning activities and to maintain the professor's chair. In Takagi's case, this involved inviting him to occupy a university professor's chair and to take over a Director's position at the MPI, with all the related resources and possibilities offered by the Max-Planck Institute.

But the decision for Stuttgart was also easy for him for other reasons as well. For one thing, the MPI and the University are respected all over the world as centers of solid state research, with excellent conditions for employees and wide-ranging support from both institutions. Moreover, Takagi can work here in a broader field of research than in the U.S.A., where he worked for a while at



® Humboldt-Foundation/Sven Müller

AT&T's Bell Laboratories before returning to Japan as a university lecturer and professor. Prior to that he had earned his doctorate in 1989 and had been a research fellow at the University of Tokyo.

His ties to Tokyo and the renowned Riken Institute are just as strong as those to the University of Stuttgart. He goes back to Japan about once a month to give lectures and continue his ongoing research work there, and also see his family.

He sees this 'commuting' as another way to maintain his scientific connections. For example, an exchange program for German and Japanese students and academic researchers is already in the starting blocks. Thus interrelationships are important for Takagi not only between electrons but also between countries, between the MPI and the University, and between the disciplines of physics, chemistry, and the engineering sciences. 'For me, there are no borders,' says Takagi.

Julia Schweizer

Money-Making 4.0

Basic financing, outside funding, foundations ...
All familiar, all limited.
What is needed in future is: Creativity.

Crowdfunding for example: Instead of writing page after page of research applications, scientists can present their projects on the Internet and court numerous smaller donations from private persons. The relevant platforms for such microfinancing already exist. Even though it is sometimes tricky to distinguish serious research projects from nonsense on such forums, crowdfunding is a much-discussed topic for pilot projects of young researchers and for feasibility studies.

The Fraunhofer IPA and the University of Stuttgart's Institute for Energy Efficiency have gone a step further: they are working on a solution for gathering funds to invest in energy efficiency; the money will be used to put already identified energy-saving potentials into practice, and the money thus saved will be used for refinancing. Initial meetings are already underway with banks and private equity organizations.

The researchers view themselves as technological mediators between investors and companies – science between the stock exchange and the SME, so to speak. The idea's feasibility is now to be studied in a research project. With classical EU funding ...

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