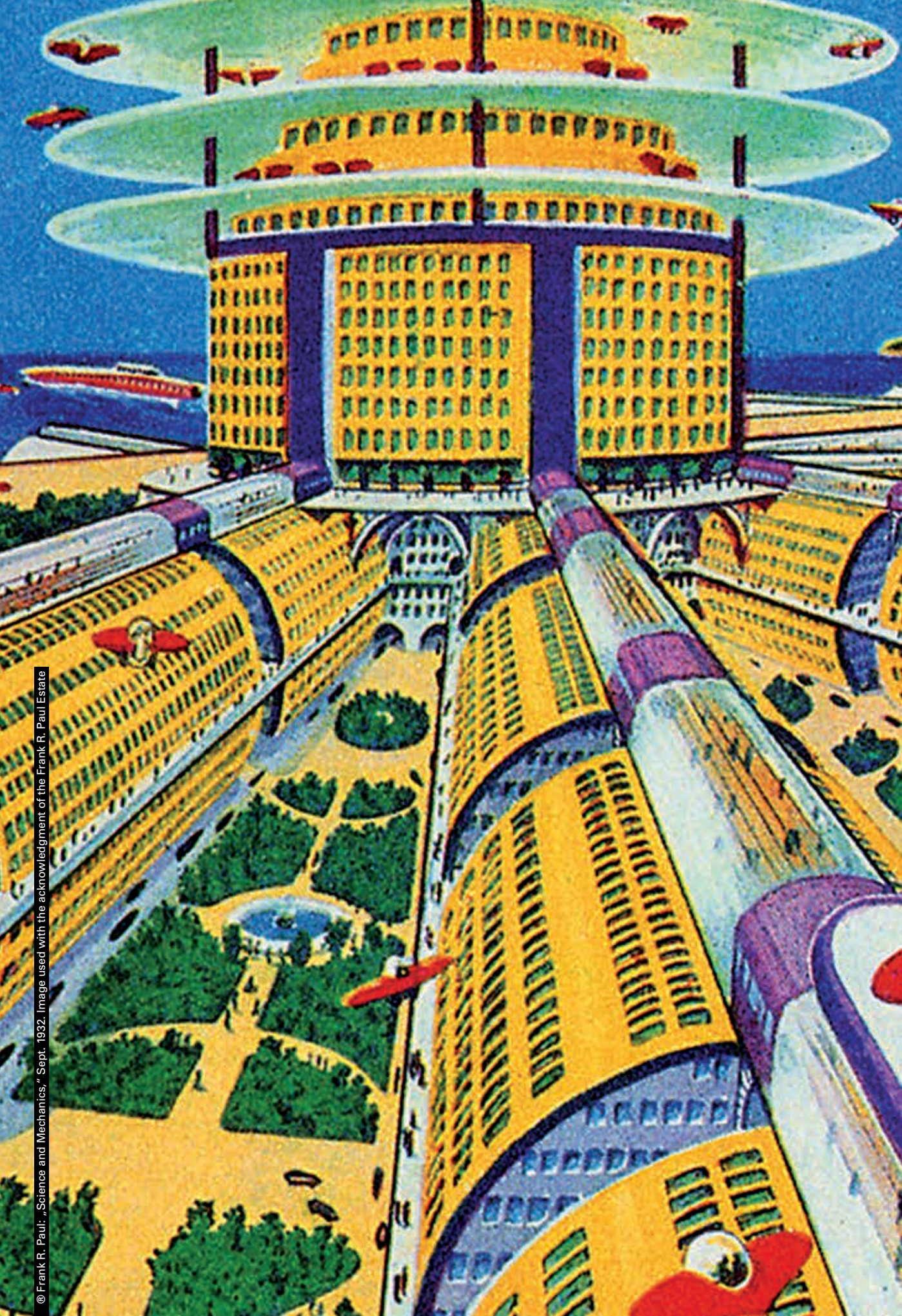
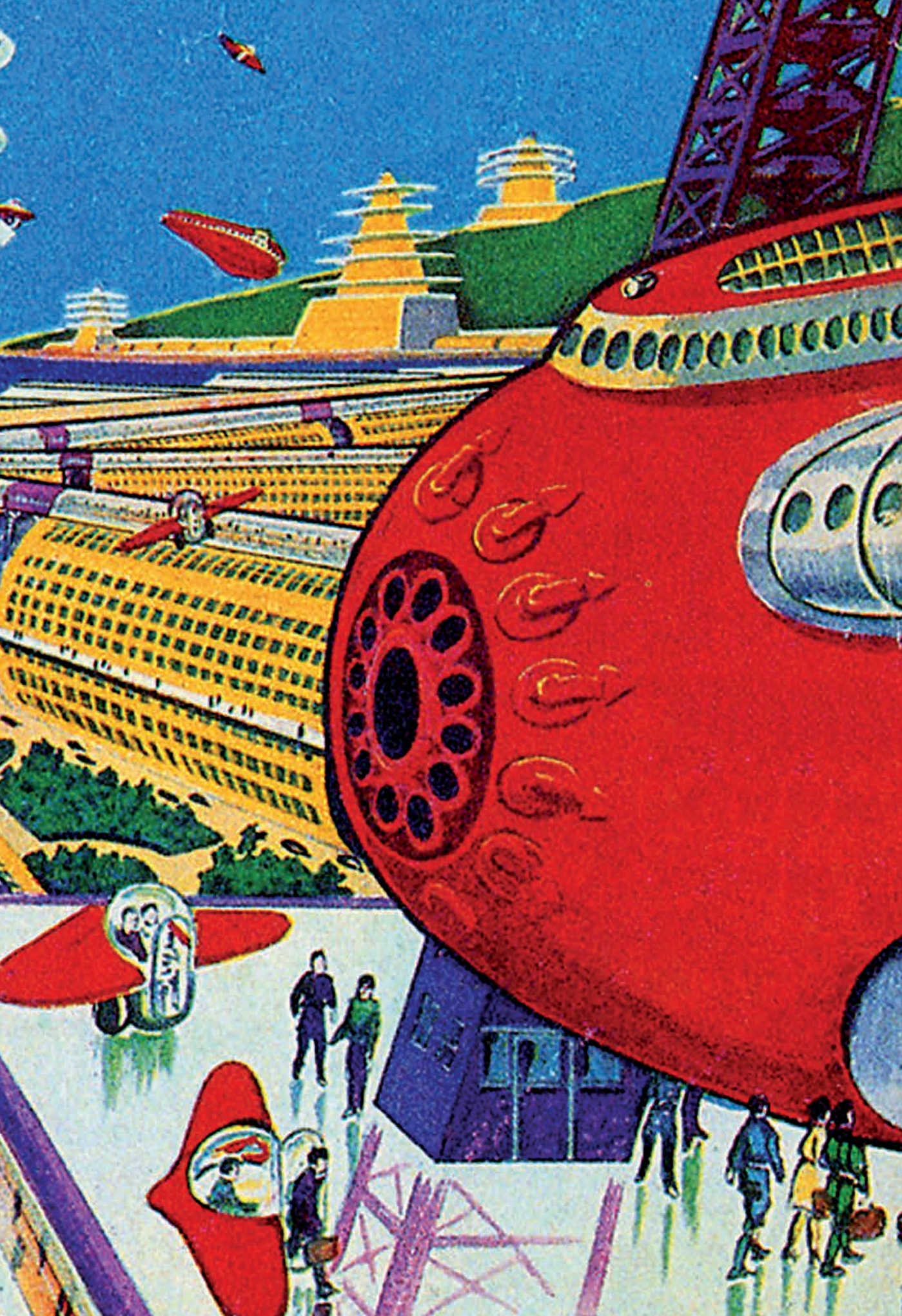
FORSCHUNG LEBEN

THE CITY OF THE FUTURE

THE MAGAZINE OF THE UNIVERSITY OF STUTTGART 04 | 2015

Universität Stuttgart





Cordial greetings to our readers!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Wolfram Ressel
Rector of the University of Stuttgart

The Year of Science 2015 was officially launched in February by Johanna Wanka, Germany's Federal Minister of Research. This time, the Year of Science centers around "The City of the Future" - a theme as fascinating as it is virulent and challenging. The Federal Minister's appeal was correspondingly clear and warning: "If we want our cities to offer a humane and livable environment both today and tomorrow, we must reinvent ourselves both organizationally and mentally."
This indispensable energy for innovation has now taken on the form of a constant in the history of civilizations; we need only look at the historical milestones of urban development, starting with the metropolitan densification of cultural spaces in Asia Minor and the Near East around 9000 B.C., through the Hellenistic Polis, the cities of the Romans, the free cities of the Old German Empire, the Hanseatic towns of the Middle Ages and down to the metropolitan areas of our time: over and over, the dwellers were compelled to re-invent and re-orient themselves in their social frameworks, their basic systems of law, their infrastructures, and their economic systems.

This is no different for us today: we too experience the social, economic and ecological challenges of the City of Today as especially far-reaching. That is why we gladly took up this Year of Science theme "The City of the Future" in our University's magazine - after all, it is precisely our University which generates many impulses and ideas for sustainable living and working in the cities of the future. Take a little time to inform yourself in the articles of this issue about the many-faceted, landmark-type research projects now going on concerning ecologically and socially sustainable planning of cities and spaces, efficient uses of energy, how to deal with fine dust, water infrastructures, and museum culture. And to learn in the guest article by Christian Ude what possibilities for optimization are perceived by a former Burgomaster, a President of the German Convention of Municipal Authorities, and an experienced and passionate urban politician regarding potential forms of optimization in the dialogue between scientists and those with political responsibility. Our wish for you here is that you will find the contents both interesting and exciting, and we look forward to hearing what you think!

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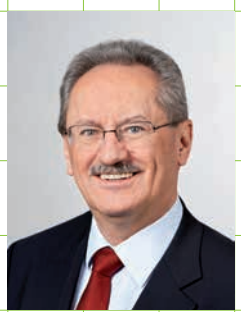

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FACTORY OF THE FUTURE

A new building going up on the University of Stuttgart's Vaihingen Campus as part of the ARENA2036 Project will be devoted to research on production techniques in automotive assembly and vehicle manufacturing. The building will be home to a team developing new research ideas, with members from science and industry. Their insights into development and design research, particularly in the area of lightweight construction, will be tested in practice at once and integrated into manufacturing processes. In addition to office areas, one floor will consist of a workshop offering flexible facilities for research and measurement along with testing equipment for automotive development. The building itself will reflect both innovation and the future-orientation of the research projects.
www.arena2036.de

SUPER-BRAIN AT SUPER-SPEED

The University of Stuttgart's Supercomputing Center (HLRS) has now put a new high-performance computer into operation. The new "Hornet" high-end computer, a Cray XC40 system, delivers a maximum computational capacity of 3.8 petaflops (3,8 quadrillion mathematical operations per second), making it almost four times as fast as "Hermit," the outgoing HLRS supercomputer. In the meantime, "Hornet" has successfully passed the initial stress tests: Every last bit of the system's performance capabilities were squeezed out as it carried out six simulated projects from the areas of aviation and space flight technology, planetary and climate research, environmental chemistry, and other engineering sciences.

FIRST FOUNDATION STONE FOR HOUSE OF STUDENTS

February 2015 saw the festive laying of the first foundation stone on the Vaihingen Campus for the new House of Students of the University of Stuttgart. The building has been designed as the central source of services for all administrative aspects of the student life cycle. The total cost of 10.8 million Euros will be shared by the State of Baden-Württemberg and the University.
Prof. Wolfram Ressel, Rector of the University of Stuttgart, called the new building an "investment in the University's future" and was visibly happy that the students will now find all relevant services brought together in "their own house." "For many talented young people from here and abroad, the idea of studying at the University of Stuttgart is already very appealing. The new House of Students will help to give this attraction an even more concrete form."

RESEARCH HIGHLIGHTS AT THE HANNOVER TRADE SHOW

In April the University of Stuttgart presented its wide range of innovative research projects with great success to an international audience at the Hannover Trade Show in line with the trade show's basic theme of "Research & Technology". The University's kicked off with a trade show booth which demonstrated the latest material-efficient technology for design and processing. The two institutes which participated in the design and construction of this carbon-fiber reinforced lightweight structure, namely the institutes for Computational Design (ICD) and the institutes of Building Structures and Structural Design (ITKE) made the structure a living example of innovative architectural space designs.

Other highlights came from the ARENA2036 Research Program: an automobile which blazes a trail for the implementation of an innovative vehicle concept, and an "audio-seat" of extremely lightweight, rigid carbon-fiber reinforced plastic, from the institutes of Aeronautics Engineering. In this case, instead of loudspeakers to generate sound, the seat itself becomes one.

Physics institute III presented advances in quantum technology, including a diamond magnetometer which can measure very weak magnetic fields with one-of-a-kind precision. Also on hand were "high-wire robots" developed by the institute of Engineering and Computational Mechanics (ITM) and the Institute for Control Technology of Machine Tools and Manufacturing Units (ISW) which had also made an appearance at the EXPO World Fair. The Institute of Machine Components (IMA) presented optimized sealing systems, modern methods of analysis, and research results from sealing technology.

USUS

Der Studierendenblog der Universität Stuttgart

Like

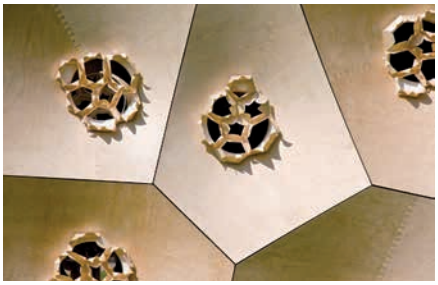
THE U. AS BLOGGER

Recently the University of Stuttgart's new student blog went online under the name USUS. The blog picks up stories from life at the university, written "by students - for students", and aims to open up the somewhat abstract entity called "the U." and make it more accessible. In answer to a call sent out by the University's Communications Department, a team of 10 student authors came together and will write reports at regular intervals under the headings "At the U.," "Alongside the U.," und "After the U.". Tips on coming events are also in the blog: www.uni-stuttgart.de/usus

Distinguished for Excellence …

BERLIN ARTS PRIZE FOR PROF. ACHIM MENGES

Professor Achim Menges, architect and Director of the University of Stuttgart's Institute for Computational Design (ICD) was awarded the 2015 Berlin Arts Prize in the category of "Building Art". In particular, Menges was singled out for his experimental pavilions, including his hygroscopic work for the metereo-sensitive pavilion of the FRAC Orléans Centre and its wafer-thin wooden panels that open independently when humidity rises - "a new road in climate-reactive architecture."



Distinguished for Excellence …

ERC CONSOLIDATOR GRANT FOR PROF. JOHANNES KÄSTNER

The so-called quantum mechanical "tunnel-effect" of atoms makes many chemical reactions speed up at low temperatures and makes them possible even in the ice-cold infinity of outer space. Professor Johannes Kästner's group at the University of Stuttgart's institute of Theoretical Chemistry has been exploring this astonishing phenomenon for several years with the help of simulations. This make possible an unmistakable identification of "tunnel processes" because in simulations the effect can be turned on and off, in contrast to experiments in which it keeps on running. The European Research Council (ERC) has now singled out Kästner with a Consolidator Grant; it will support his investigations during the next five years with nearly 2 million Euros.

Distinguished for Excellence …

PRIZE-WINNING VIDEO RECOGNITION

Driver assistance systems that recognize obstacles in street traffic, visual effects in films like "Matrix," computer-animated characters, and combinations of imaging processes in medicine: all of these technologies are based on a technique which information research technologies have been steadily honing for years: the so-called "optical flow". Professor Andrés Bruhn of the University of Stuttgart's Institute for Visualization and Interactive Systems, a specialist in this area, was recently honored together with professional colleagues with the "Jan Koenderink Prize for Fundamental Contributions in Computer vision" at the "European Conference on Computer vision" in Zurich for a method developed 10 years ago. This is one of the most prestigious prizes in artificial sight science and acknowledges the value of work which the last 10 years have shown to be of great value.

Distinguished for Excellence …

FRITZ LEONHARDT PRIZE FOR A LIFE'S WORK

Professor Werner Sobek, Director of the Institute of Lightweight Structures and Conceptual Design (ILEK) at the University of Stuttgart, received the Fritz Leonhardt Prize 2015 for his life's work. This important international honor is awarded by the Chamber of Engineers of Baden-Württemberg (INGWB) with support from the Society of Consulting Engineers (VBI) to honor outstanding civil engineers who have made unusual contributions by uniting form, function, and esthetics in the engineering arts. The eponym of the prize is Professor Fritz Leonhardt (1909-1999), the world-renowned civil engineer and former Rector of the University of Stuttgart. Among his designs is the Stuttgart Television Tower.

Events …

MORE CITY OF THE FUTURE

The University of Stuttgart will highlight the vision of the City of the Future during Science Year 2015 with numerous high-level events. The kickoff event came in April from the Institute of Landscape Planning and Ecology (ILPÖ) and the International Center for Culture and Technology Research (IZKT) with a symposium on: "Transitory Urban Landscapes - How Many Farms Are Needed in the City?," centering on a discussion of spaces for experimentation and production in the city of tomorrow. Then, on June 15, sustainable consumption in ephemeral times will be spotlighted by Stefan Schridde, Chairman of the Consumer Protection Organization "BRUMMAGEM? NO THANKS!" as part of the discussion movement on "Sustainable Life Environments". On display during Science Day on June 20 will be numerous research activities about the City of the Future, including the Real-Life Laboratory for Sustainable Mobility Culture. On July 2 Carsten Keller (Duisburg-Essen), Professor for Intercultural Education, will speakabout second-generation migrants in a comparison of Germany and France. Last but not least, the University of Stuttgart's annual festivities on November 13 will highlight the City of the Future with a ceremonial address by Professor Gerhard Schmitt of the Chair for Information Architecture at the Zurich Technology School.

www.uni-stuttgart.de/tag/2015/
www.izkt.de

Keep Up That Research!

What practitioners really think about scientific advice - but want to get from it anyway

The challenges and visions for sustainable development in our cities pose joint tasks for politics, the business world, society and science. In his guest lecture, Christian Ude of the SPD describes how politicians experience scientific advisory ideas and what they hope for from the same. He is a former Chief Burgomaster of Munich, was President of the German Convention of Municipal Authorities for several years, and remains active after retiring in 2014, among other things, as an advisor for communal politics in Turkey.

Well, now: I'm supposed to talk here as a "practitioner"! Practitioner. That sounds a bit off-beat in a publication devoted to science. Still, practitioners can at least confirm that they would be lost in the complexities and confusion of the real world without scientific advice. But sorry to say: I'm no longer a practitioner. No, I've left that behind me. My only remaining guideline is what Peter Ustinov once said: old men can be dangerous, because they no longer need fear anything and can thus say what they think. What comes to mind for me as a former practitioner when I think about advice from the sciences? Quite honestly, I think first of all the pieces of advice which it was the worst mistake to follow that a practitioner can make. "Examples please, from different decades, and different disciplines?" Gladly. More, in fact, than you may like.

"GOT ANY GARBAGE FOR ME?"

I had been in office for only a few days when a group of professors paid me their first official visit at the prompting of a concerned university administration. They were waste-disposal experts. I hadn't even known that there were university chairs for such things. They came armed with scientific tables, still on paper in those days because PowerPoint presentations had not yet been invented, and showed me how mountains of waste were growing day and night all over Munich and would eventually bury the city in an intimidatingly high mountain range of refuse. They said it was long past time to heed the administration's too-long-ignored demands, to create one garbage dump after another, and to set up waste-fueled power plants. Then, a few years later, I found myself under pressure in a new situation, created by the advice of expert professors and at the taxpayers' expense: I had to go on my knees at every meeting of the local municipal authorities, begging the mayors of neighboring communities and backwards towns as it were, "Got any garbage for me?" Because in the meantime the unused capacities of the waste incineration plant had become a public fiasco, the costs of burning waste had risen steadily to pay for overcapacity, and the behind-the-times communal politicians out in the countryside were negotiating cheaper conditions all the time for burning their refuse. None of those scientists had foreseen that garbage heaps might shrink due to waste reduction and recycling.

FLIGHTS OF FANCY

An exception? By no means. The airplane passenger forecasts of business consultants, relying on expert scientific opinions, predicted a nearly explosive growth in need. The number of passengers did in fact rise, even more in some cases than had been foreseen. But no one had called attention loud and clear to one thing:
the fact that nothing says the number of airplane flights has to grow at the same rate as the number of airplane passengers. In fact quite the opposite can happen: more and more passengers can be taken care of with fewer and fewer flights. Actu-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“Scientifically trained experts often go too far in what they say.“

CChristian Ude, retired Chief Burgomaster of the city of Munich und former President of the German Convention of Municipal Authorities.

ally, the explanation is relatively simple: airplanes keep growing in size. In fact the A 380, the new elephant of the airways, can swallow hundreds of intercontinental business travelers and tourists; and to save costs, more and more airlines are starting to simply cancel half-empty flights and pack the passengers like sardines in a full-to-bursting machine after they have bitten their nails for a while in the waiting room. “Complete exaggeration,“ you say? Not at all! The number of airplane passengers at the Munich airport has steadily risen In the last five years, but the number of flights has continued to drop. The practitioner is aware of this now - after the fact. But not a single scientists predicted it - before the fact.

SCIENTISTS SAY: “UNLOAD YOUR REAL ESTATE!“

And sometimes the world of scientific expertise goes quite far out on a limb. For example, the prediction that big companies could get themselves into a predicament unless they unloaded their unprofitable real estate in time, meaning: sell off their rows of street buildings, their blocks of houses, and their settlements in order to make more profit. How I have talked until my throat was dry in meetings with the major chairmen of well-known companies to convince them that they should for heaven’s sake hold on to their residential properties and not put them at the tender mercies of speculators in older buildings. It is of course right and good, they answer, for a company to keep its residential properties in good hands and offer places for its urgently needed trained professionals to live in, but business economics specialists, along with industrial consultants and entire armies of analysts simply rule this out. A return of four per cent for residential property is simply laughable and much too low in times of turbocapitalism; in fact, it leaves a company open to a takeover. On the other hand, three or four times as much profit can be made on the American mortgage market, with its innovative financial products like the new subprime papers. Science showed the way, company consultants welcomed this balm for the soul - and tens of thousands of residential units in Munich alone passed into the claws of internationally active real estate sharks who put on a harmless face during their forays for booty and then mercilessly made it clear in practice that higher returns are possible only by putting less money into maintenance while squeezing more money out of rental prices. In later years - you’re right: after the financial crisis! the company representatives then admitted that capital can not only be doubled but also ruined on the stock market, and that it would now be very nice to have a few blocks of houses available for employees looking for a place to stay. But that was all spilt milk. Following the debacle with junk bonds, the only solution left was a flight into “concrete gold,“ meaning buying up everything available on the real estate market with the consequence of completely unrealistic price increases which ruined the residential market for decades to come. And now the business economists are simply shaking a finger at the urban fathers for not seeing the problems of the residential market in time and not providing enough residential space to make it possible to provide all the incoming trained professionals with reasonably priced places to stay ...

THE TRADE TAX: A SCIENTIFIC SINKHOLE

It would of course be a mistake to generalize from such experiences. But it is indeed frustrating to see how often they recur. For example, I remember many colloquies and academic conferences at which the top minds in financial science argued brilliantly for abolishing the trade tax once and for

all because such nonsense no longer exists anywhere in the world and it is a source of communal taxes which will dry up anyway, and because it is driving German businesses abroad. We "practitioners" from the communal prairies had only our intellectually run-of-the-mill, but still real-life experience as a counterargument: that trade taxes exist almost everywhere under other names, that aside from politically motivated or cyclical drops trade tax revenues grow more important every year and currently are serially reaching all-time records - and that far from fleeing Germany, companies are experiencing world-record-setting export surpluses in spite of the demonized trade tax. Luckily, those who make our laws have put more faith in the practitioners than the representatives of research and academia, in spite of their countless runs at finally abolishing the trade tax. That is the only way to explain why Germany's city finances have not broken down completely, but only in structurally weak areas.

IN AND OUT ...

Have I forgotten any other discipline? Oh yes, organizational sociologists and the administrative sciences! For years we were told that we had to turn all of our city administrations inside out, decentralize them, until the very last department set up its own budget, hired its own personnel, and trumpeted to customers with its own company logo and motto that it had the good of mankind at heart (in contrast, apparently, to all the other departments). I observe with interest that now, after the greatest wave of decentralization in administrative history, consultants and professional lecturers are the first to announce that it would be a stroke of genius to centralize human resource decisions and financial processes and above all contract awards because then area of competence could be bundled together - something that every company does naturally. In and out, in and out ...

SACRIFICING FORESTS TO PAPERLESS OFFICES

By no means do I want to forget the information scientists who promised us the paperless office throughout the first half of my 21 years in office - if we would just provide enough money for IT strategy and at least procure a computer for every employee. Now that they all have their own PCs and print out emails by the dozen daily for lack of time, with you on the cc-list only by chance, whole forests have been cut down just for the ever-growing needs of the computer age. In politics, we would speak of broken campaign promises and send our representatives into nirvana - but where to send IT consultants who have disappeared into thin air in any case and whose maintenance and repair contracts have long since expired?

GENDER BUDGETING: WAITING FOR THE FRUITS OF NEW CHIC

There's also more and more skepticism about new philosophies of happiness, even when they are described with scientific authority rather than religious fervor. I felt this mistrust from the very beginning when we were urged - once again by scientifically schooled persons - to open our hearts for "Gender Budgeting," a ludicrous bureaucratic effort to determine for the first time in human history which sex benefits from what percent of public funding. There's no doubt that we should uncover injustice and negligence. But up to now no Gender Budgeting guru has been able to explain to me what practical value comes from the immeasurable efforts of combing through all budget items that could not be achieved in other ways much more simply and cheaply. But of course nobody wants to look reactionary. So keep it up! And all the communes wait like good little children for this "new chic" to bear fruit. Sadly, research projects that truly meet the consulting needs of communal practice would be extremely meaningful and are, in fact, urgent and indispensable.
I name only a few examples:

HOW TO ADAPT DIFFERENT TYPES OF LIVING CONDITIONS TO EACH OTHER?

The worldwide trend to urbanization, to centralization, to the emptying of rural areas also gives us headaches here in Germany and is a central problem not only in booming growth regions with growing population density, increasing needs for

Sadly, research projects that truly meet the consulting needs of communal practice would be extremely meaningful and are, in fact, urgent and indispensable.

Christian Ude

residential space, rental price levels and the many stress symptoms of growth but also in the stagnating and even shrinking communities which have no chance to rejoice in "more room" and "sinking prices" but rather are the first to suffer most from the negative consequences of shrinkage: fewer jobs, less purchasing power, less public financing, poorer medical care, fewer educational and cultural offerings, young people who seek brighter horizons, etc., etc., etc. There's no dearth of analyses of growth and shrinkage problems - but tell me what branch of science can tell the practitioner how to stop today's centrifugation of living conditions and bring them back together? For me personally, that would be research topic No. 1.

MASS MIGRATION ON A CONTINENT WHERE ANYTHING GOES

And secondly: the fabrication of conservatives about life in Germany when they say that Germany is not a land of immigrants, followed by another fabrication of progressives when they say that every immigrant enriches and presents no problems if we just show good will and simple human good manners. Both fabrications are disproven by practical reality in the communes: Germany has been an immigration land ever since the German business world and the Federal Agency for Employment opened the door to immigration with their individual treaties and advertising campaigns - and of course there is a difference between immigration into an employment situation covered by social insurance, and immigration into a societal system. (Not to forget: acceptance of the situation is usually required by the constitution or by humanitarian obligations, but the impact on communes and the social system as a whole is undeniably different from that of immigration into a job market, which should not be demonized).

How to control immigration, and how integration can succeed better in the coming decades than in the last decades, would also be an important research project whose results would practically be lapped up by practitioners. But at present we do not even know how to slow or even stop the flight from rural areas and the flight from small towns in the various areas of Germany - to say nothing of international mass migrations.

CONTROL AND DISTRIBUTION OF PUBLIC FINANCES

And thirdly: common sense tells us that the business outlook and thus the revenues of public agencies will not improve in our lifetimes; rather, they will deteriorate (whether because of business downturns, a European financial crisis, or an international crisis situation). Nevertheless, many communes and regions continue to live from their equity. How is this financial-political challenge to be met? Not with empty promises like those made for decades in the trade tax debate, but with hard-and-fast statements about which revenue streams are to be redirected! This is where the sciences, which are not obligated to trim their sails to every wind of opinion and breeze of demands, could earn major laurels for themselves.
Basically, after all, we practitioners (hopefully I'm again allowed to count myself among them) are waiting for just such pointers.

A good plan is not enough

Martina Baum and Astrid Ley represent a new generation of urban construction in Stuttgart

The urban agenda for coming decades will be settled in 2016 at "Habitat III," the world's most important Human Settlement Conference. The pressing issues there include mechanisms of globalization, social polarization in a time of spatial fragmentation, and high consumption of resources. How is urban construction to meet these changing challenges? Answers come from Professor Martina Baum (Chair of Urban Planning and Design) and Professor Astrid Ley (Chair of International Urban Architecture) at the University of Stuttgart's Urban Design Institute. In filling both positions this famous institute, which celebrated its 50th jubilee last year, has prepared itself for the future.

? The debate about the role of cities has gained enormous momentum. Why just now?

› **Astrid Ley:** In my view, the world has largely resigned itself to the fact that international politics cannot solve pressing global problems at all or only with difficulty. The hope is that if the cities, where more than half of the world's population lives today, take action and play a more pronounced role, then solutions can develop on the local level which will lead to a major transformation from below. Take climate protection, for example: there is now an initiative from more than 40 major cities around the globe which have dedicated themselves to the reduction of greenhouse gas emissions independently of what their respective governments have postulated. There are a few pioneers even in the U.S.A., where national climate policies make progress very slowly. The cities are closer to the problems of climate change and thus more willing to take protective steps.

› **Martina Baum:** Cities are enormous consumers of resources; they generate traffic and burden the environment. But things like social inequality, lack of living accommodations, migration and other problems accumulate here too. At the same time, however, the cities are also a major resource: because they are spatially close-packed and culturally mixed, they provide a venue for cooperation and networks that lead to new solutions. There's a great deal of innovation potential there. This density and this mixed character, by the way, are more and more in demand in the sense of quality of life. The gap between those who work in the city and those who live in the country is a thing of the past; people today are looking for a link between the two. The cities have to adjust to this: they must be attractive and enjoyable places to live, and a place where the European idea of democracy and freedom can be lived out in the public sphere. The spatial and the social levels of a city are inseparably linked.

? What are the major challenges for the City of the Future?

› **Martina Baum:** There is no single challenge; every city has to be looked at individually. In Europe there are cities which struggle with dwindling populations, others with uncontrollable growth, and still others where production facilities are disappearing altogether and people rely on the service sector as the sole employer. Many score points with their attractiveness and location, others suffer from their image.

› **Astrid Ley:** Basically, the intertwining of city-country has become very complex; many of our colleagues speak of "planetary urbanization". To a certain extent, the tendency to globalization leads to a "de-localization" of urban development. The result is that "city" as a clearly-defined, localized entity no longer exists. In the south of the globe,

Researching concepts for the City of the Future (l. to r.): Prof. Martina Baum (Urban Planning and Design) and Prof. Astrid Ley (International Urban Architecture).

cities are stamped for the most part by dynamic growth, but its causes and the related challenges are very different. In Asia, urbanization goes hand-in-hand with vigorous economic growth but also with dramatic environmental damage. A global middle class has sprung up for whom a qualitatively new understanding of "affluence" must be defined. In many parts of Africa, on the other hand, the urbanization process is coupled with unstable political and social conditions, and people are drawn to the cities without a parallel creation of jobs there.

? What solutions can you see?

› **Astrid Ley:** On the one hand, urban architects must focus not only on plans but must also come up with processes. Secondly, we must be clear about the fact that technological approaches are often efficient but not sustainable in impact if they ignore the perspectives and abilities of various users to take action - the young, the old, the migrants ... Case-study laboratories like that of the University of Stuttgart show ways to take these needs into account. We're talking here about a co-production of knowledge that aims at "Empowerment" of the people.
We need not only technical but also social innovations. Approaches like that of "Sharing Economy," i.e. mutual lending, often do more for sustainability than the latest technology.
The communes represent only one of the driving forces among many in this process. The citizens organize and network among themselves and thus influence the political arena. And while urban planners can encourage the positive aspects, they have no control over the process.

› **Martina Baum:** The aim of equal living conditions everywhere, long a goal in the past, is now obsolete. The question for each individual location must be where its "talents" lie, and what strategies and appropriate supportive actions can then be developed to make the most of them. Such a process has not only a spatial, functional and social component, but also an atmospheric one, meaning that people feel comfortable there.
Here in Europe, there must be much more flexibility in architectural ordinances. For example, there are still no types of urban areas where building laws provide equal networking possibilities for living areas and the workplace. Sound suppression ordinances make it almost impossible to have a centrally located woodworking establishment, even when one is available and there is a need for it. Or there are industrial plants that would be willing to put their "greensward surroundings" at the disposal of the public as leisure parks but refrain for reasons of liability.
To create solutions, we would like to have areas that could be used for experimentation and are not restricted in advance by building ordinances. We

Discussing model designs for renovation of an area in Vienna.

need courage, and the freedom for test phases, so that we can see what is promising and what works or not. This often happens today "inadvertently," as is the case now in Karlsruhe at the gigantic subway construction site: The inner city has become almost closed to automobile traffic, but life goes on as before. People must enter the city by other means: with public transportation, on a bicycle, or by foot.

? What should students learn today that's different?

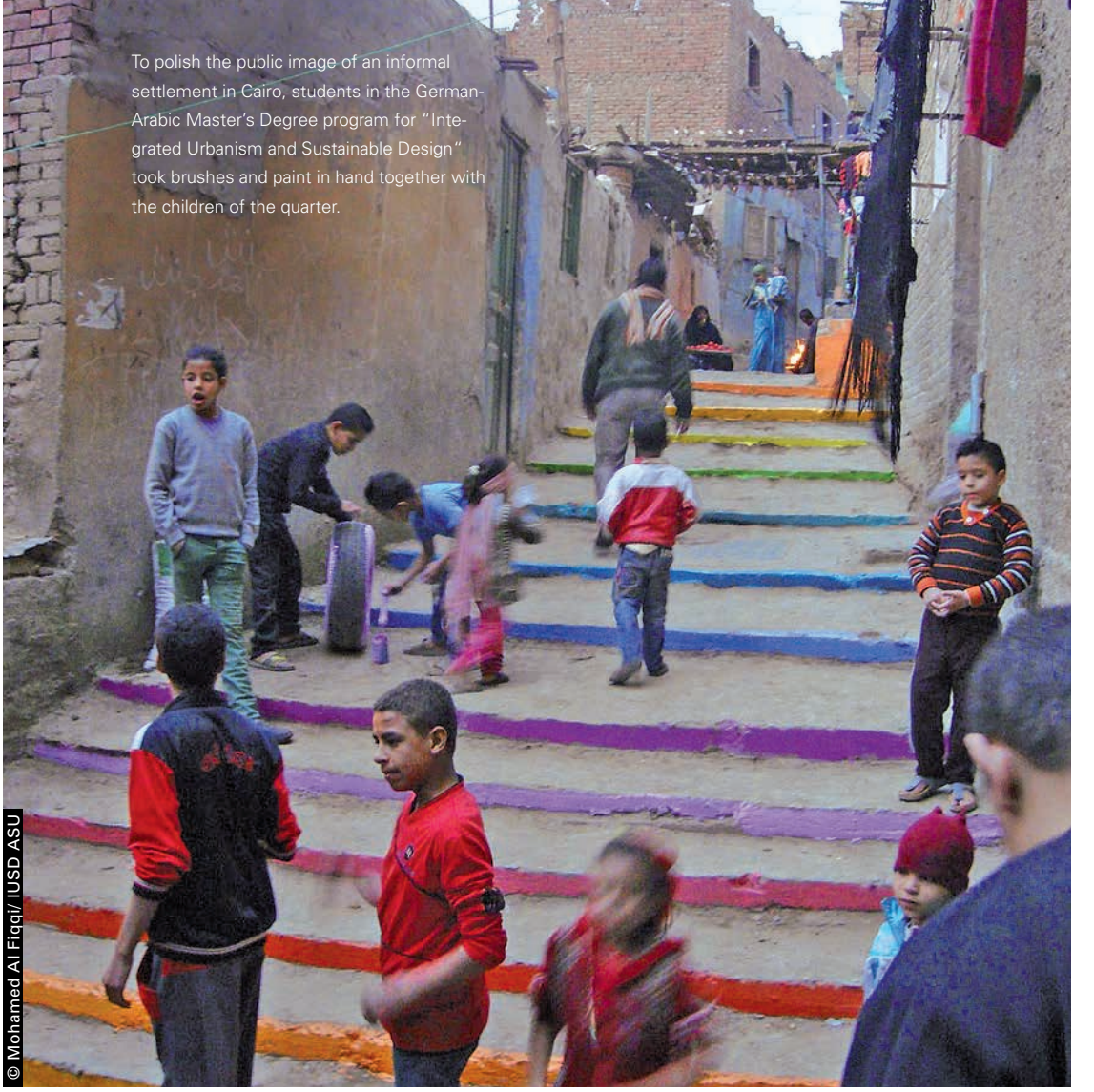
› **Astrid Ley:** As mentioned, it's not enough to develop and implement a good plan and say, "That's it." Urban architects must be able to accompany the process and to think in terms of scenarios. The trick is to integrate the whole range of actors and their wishes, rather than to generate more professional disciplines. But this happens to date only quite sectorally. Our role as urban planners is to moderate this collaboration and give it shape in the form of design concepts.

› **Martina Baum:** An urban planner is simultaneously an observer, designer and process facilitator. Each of these three levels requires specific areas of competence: analysis, creativity, and planning, but even more importantly: communication. Today's education must convey this wide-ranging mind set. There is no one method; the classic moderator's briefcase, for example tends to alienate artistically creative dialogue groups. Instead, we mediate to the students a broad "instrumentarium" from which they can generate the specific method that best fits the respective situation.

? What does that look like in practice?

› **Martina Baum:** In our brainstorming studio "Urban Hybrid," for example, we ask students to draw new potentials out of an "aging diva," namely to make Vienna a more productive city. For example, they are working out strategies for an outlying area in order to bring life and work together in one place, meaning work done not only with the head but also, and particularly, with the hands as well. The students have done this according to the just-mentioned 3-step program. It was exciting to watch them get to know the city, and to see the potentials they were able to coax out of it. Their drafts show how small, nearly acupuncture-type interventions, like tearing down a single building, can open up completely new potentials and change not only the spatial composition but also the role of an area and how it is perceived. The proposals submitted also involve new architectural typologies, with radical mixtures of use, for example, of industrial production facilities and residences. In the everyday world there is often a reluctance even to think about such things. But we intend to persevere and will travel to Zurich in the coming summer semester.

› **Astrid Ley:** In our German-Arabic Master's Degree program "Integrated Urbanism and



To polish the public image of an informal settlement in Cairo, students in the German-Arabic Master's Degree program for "Integrated Urbanism and Sustainable Design" took brushes and paint in hand together with the children of the quarter.

© Mohamed Al Fiqqi/ IUSD ASU

Sustainable Design" (IUSD) we are working Cairo to upgrade an informal settlement. In doing so, the goal is to contribute to an improvement of residential conditions in the area and to persuade the political decision-makers that it's not necessary to relocate the people. Working with the residents, the students worked out courses of action and carried out repairs here and there to improve the outer appearance and thus the image of the settlement. And we in Stuttgart are also tackling international issues of city development. For example, we are involved with the refugee problem and are developing concepts for refugee homes in which the City of Stuttgart's Integration Officer is very interested. As a University we have a certain leeway in such projects that allows us to think "out of the box".

? In spite of all the areas of competence and creativity at universities, many cities remain inhospitable. How can good concepts from the world of science make their way into actual practice in urban architecture?

› **Both (laughing):** Little Strokes Fell Big Oaks! ...

› **Martina Baum:** We do in fact observe that concepts are developed and put into practice but then neither evaluated nor followed out. But precisely this would be an important process. What's more, cities usually lack self-confidence in dealing with investors, here in Stuttgart too. Urban politics are carried out by democratically legitimated representatives of the citizens. They are to represent the interests of the people and shouldn't simply sell a piece of property to the highest bidder, for example.

› **Astrid Ley:** It's often helpful to illustrate good alternatives with small examples. Then, to put the idea into practice on a broad scale, it's necessary to have protagonists who take the risk of going in new directions. When innovative minds in administrative areas communicate with one another, that can in fact get the ball rolling. We see this, for example, in the issue of Urban Food Gardening and how it is dealt with: The first mini-gardens in Berlin were laughed at when they appeared, but now Stuttgart even has offices with contact persons for such gardens.

? What is your personal vision of the City of the Future?

› **Martina Baum:** My dream for the European city is that we will have a living amalgamation of space and society in a multicultural era, and that in spite of all the technical challenges such values as identity and "home town" will remain held high.

› **Astrid Ley:** People used to say, "There's freedom in city air." In that sense I would wish that cities are accessible places that can bloom in their roles as catalysts of social innovation.

Many thanks for this talk!

Andrea Mayer-Grenu put the questions.

The persons:

Martina Baum, architect and urban planner, born 1977, has been a professor for city planning and design at the University of Stuttgart since 2014. She studied at the Bauhaus University in Weimar and the ® Coburg Academy and wrote her professor's thesis at the Karlsruhe Institute for Technology (KIT). She spent several years as a researcher and lecturer, among other things, at the Zurich Technology School (ETH). The practical applications of her interests took her to jobs in well-known offices of consulting engineers in Germany and the Netherlands and eventually to her own business: STUDIO . URBAN STRATEGIES. The focus of her research is on the European city, where she is especially interested, among other things, in the processes of urban transformation and modernization and the development of systems for strategic uses of space.

Astrid Ley, born 1974, has been a Professor for International Urban Architecture at the University of Stuttgart since 2014. Born in Cologne, she studied architecture and urban architecture in Aachen und got her doctorate at the Technical University of Berlin. Numerous research and urbanization projects abroad took her to the Near East and to countries like South Africa. Ley devotes herself in particular to urban architecture in the south of the globe. The starting point for her approach is that many urban phenomena and problems are caused by translocal and global developments, so that they can only be effectively dealt with in this context.

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At home between two disciplines

Antje Stokman unites landscape planning and environmental engineering

Antje Stokman, Professor for Landscape Planning, bridges the gap between "planner" and "civil engineer" in her work on the City of the Future in order to find new solutions with multiple uses. Because of climate change above all, she says, there's no other way to go in the urban centers. As a scientist, she uses the city not only as a case-study laboratory but also as a field for research and experimentation. Originally from northern Germany, she will now conduct research on sustainable mobility together with Stuttgart residents in the coming three years.

When Antje Stokman looks out the window of her office, she is looking straight at her area of research: her eyes take in large parts Stuttgart from the ninth floor of College Building I in the city center. A fascinating scene for someone who is Director of the University of Stuttgart's Institute for Landscape Planning and Ecology (ILPOE), especially for this 41-year-old, who grew up on the flatlands of Lower Saxony. "It was natural to have an interest in issues related to water and coastal areas," she says of her CV. "Now, here in Stuttgart, that has expanded to global questions involving the sustainable city, landscapes, and infrastructure development."
After studying landscape architecture at Hannover's Leibniz University, Stokman accepted teaching positions and projects from the year 2000 on at universities in Hannover, Berlin, Hamburg and China as well as for a firm of planning engineers in Munich. She worked closely with engineers on urban architectural projects in order to find solutions against flooding or for the purification of undrinkable water. What she learned was: "When one gives up the dichotomy and develops technical engineering systems that can also function as biodiverse public spaces, an interesting synergy effect results."

A CITY PARK THAT PURIFIES WASTEWATER

One of her very first projects helped Stokman set foot on this path. While working on it she established the technique of "Forward Research" so dear to her: now she guides students in their work projects towards tasks that both merge into research and promote practical innovations. Her concrete task back then was to find a way to prevent extremely dirty wastewater from polluting waterways in the Chinese city of Changde due to flooding after heavy rains. The city fathers were thinking of a centrally located high-tech waste-water purification plant. But she and her researchers took a different tack: normally, the smallest possible space is reserved for waste water purification and the largest for green growth areas. She and her team proposed a union of both: a large green-growth purification plant designed to be simultaneously a riverbank park. Underground soil filters would be installed in the "Wetlands Park," footbridges would cross above fields of green reeds. A beacon project had been born. "I see it as a very important role for the universities to promote such transfer processes in actual practice, test them under real-life conditions, and develop them even further," says the scientist in her. In Stokman's vision, the City of the Future must cease to simply consume resources in the sense that raw materials like water are transported into them simply in order to remove waste products at considerable expense. The important thing is "to optimize processes of exchange and metabolism within the city," she says. In that way nature becomes a partner who can take over some of the work. Stokman applied in the year 2005 for the position of a

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"It has always been my role to straddle borders between the disciplines."
Professor Antje Stokman

Junior Professor at Hannover's Leibniz University with a wealth of practical experience - but without having written a doctoral dissertation. That she was chosen for the post was a personal triumph for her, since without a dissertation that is the exception. But her previous work made her ideally qualified for this position, located as it is at the interface between engineering, architecture, city and landscape planning, and ecology. Four years later, The German State of Lower Saxony honored Antje Stokman for her interdisciplinary work methods, in which she combines lecturing, research and practical implementation, with the State Science Prize. "It's always been my role, so to speak, to straddle different disciplines at the juncture of issues involving engineering technology, architecture and culture, architectonic problems, and ecological questions" she says.

PAINSTAKING RESEARCH UNDER THE METROPOLIS

Stokman regards it as a must to carry out research where things happen. She spends about one to two months a year on location with her projects, including those in Changde, Lima and Cairo. "My focus is on the development of site-specific solutions together with local project partners and matching technology; the aim is to move from knowledge to action." For Stokman, the work is a true luxury, as she explains: when her partner travels abroad as a mechanical engineer, it is to conferences in meeting rooms or factories. "But I'm out there in the city, trying to understand cause and effect relationships and find out how spaces are used and to get to the bottom of things: 'Where is this water flowing to?' What is growing here?" That means crawling into spaces, getting samples, talking to people."
In 2010 Stokman took over the direction of the ILPOE. But she remained true to her border-crossing nature: she has a chair at the Faculty of Architecture and Urban Planning and is at the same time an Adjunct Professor at the Civil Engineering Department. The topic of case-study laboratories is very dear to her heart because she sees today's change toward a sustainable urban society as a job to be tackled not only with solidly grounded science but also and above all in unison with the people on location.

Field research with students.

CASE-STUDY LABORATORY FOR A SUSTAINABLE CULTURE OF MOBILITY

Under the direction of Antje Stokman, the University of Stuttgart has taken over one of seven case-study laboratories in Baden-Württemberg, the "Future City Lab_Stuttgart" for a sustainable culture of mobility. With financial help from the state, the aim will be to establish a new form of knowledge transfer. The topic of mobility here in the traffic-jam capital of Germany came, according to Stokman the landscape planner, from requests presented by both politics and society. The next three years will be devoted to investigating a sustainable form of mobility for the city with the involvement of the inhabitants and their knowledge, and to carry out case-study experiments.

For example, this might mean that streets would temporarily undergo major changes. Or selected groups of persons would be given incentives to test another form of mobility and report on their experiences. For that reason not only institutions and initiatives from Stuttgart are involved, but also many of the University's institutes, including sociologists, traffic planners, urban architects, and sport scientists. The latter, for example, are intrigued by the question of how to create incentives for people to get more exercise. The aim will be to create "small pilot and beacon-type projects," says Stokman, "in conjunction with the wide-ranging and strategic question of how to make the transition to completely different systems." It's a new experience for her that almost all the project partners are only a few steps away, but one with advantages: "I don't have to go halfway around the world to get something done." And the attractive faculty building in the city center was "one of the primary reasons for coming to Stuttgart," the professor says. "Before receiving the call I had never been in Stuttgart." Upon first entering the Institute she was entranced by the panorama and the topography. "Every day the city and what is going on in it make a different impression, always depending on the weather and the daylight." When working at her desk with a view, Stokman finds time to think about the city as her case-study laboratory. "Here I have a bit more perspective on things, since my true workplace is out there in the midst of urban life.

Daniel Völpel

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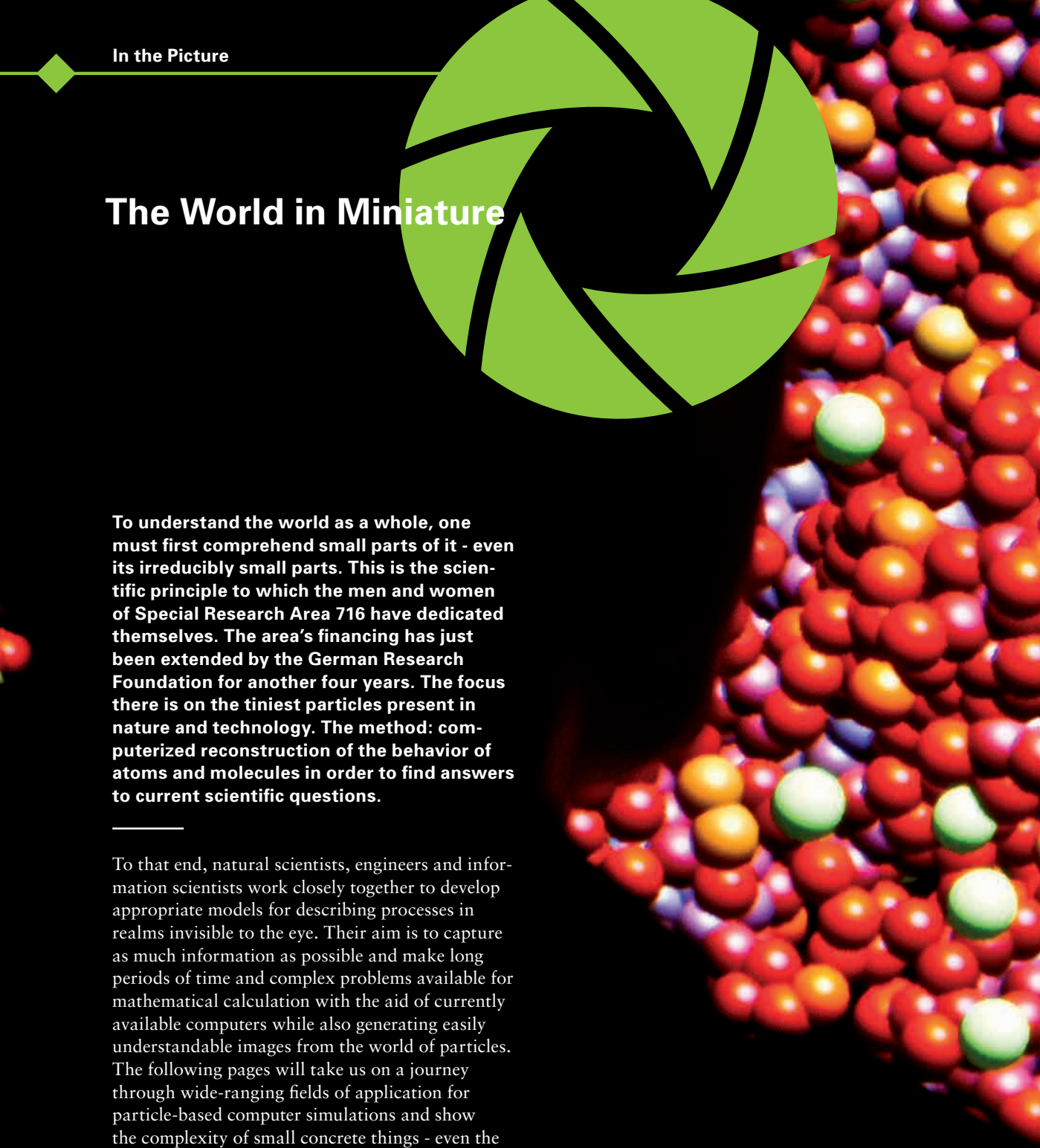
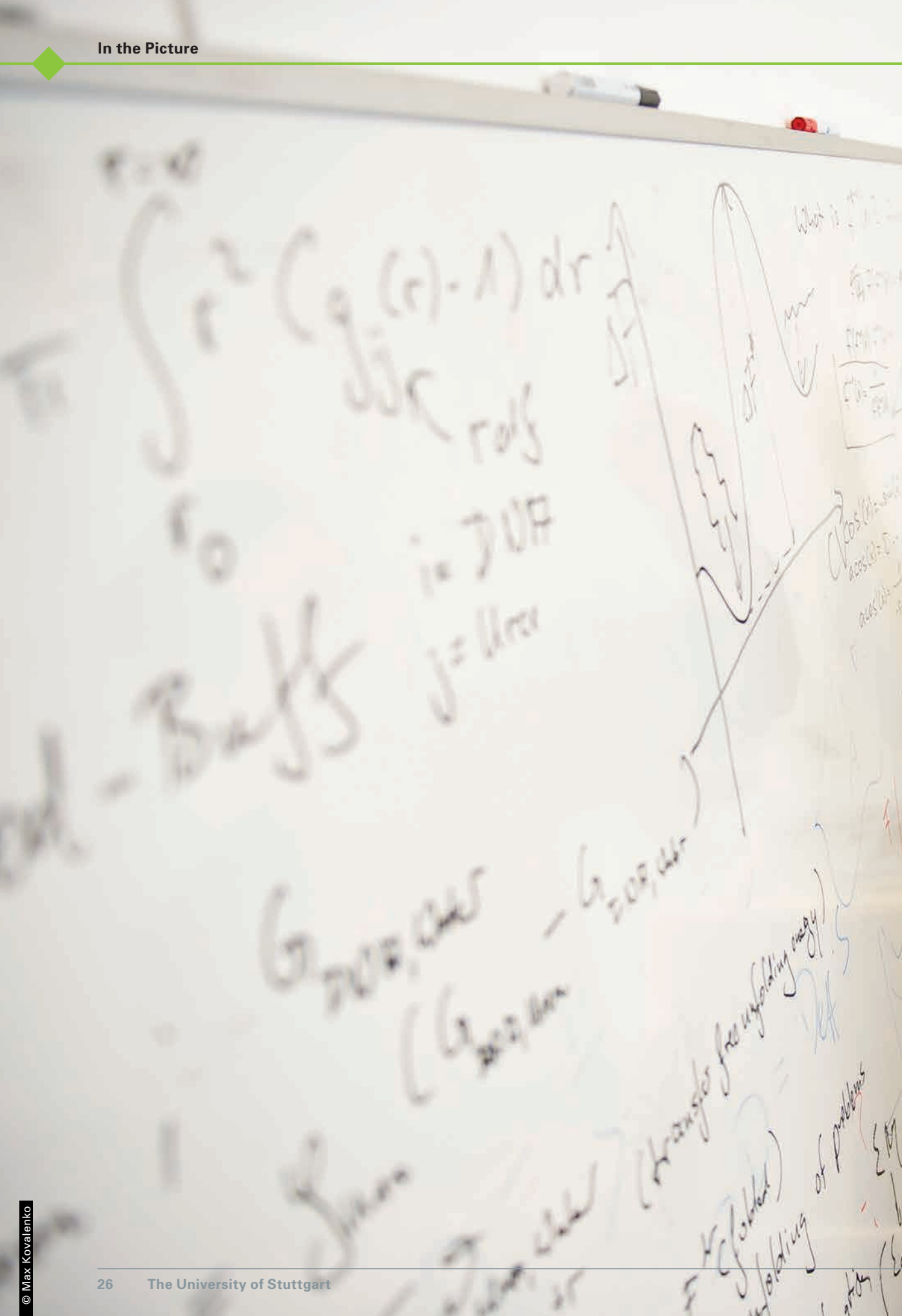
A workshop on "Sustainable Mobility Culture - Urban Space, Mobility and Health".

The World in Miniature



To understand the world as a whole, one must first comprehend small parts of it - even its irreducibly small parts. This is the scientific principle to which the men and women of Special Research Area 716 have dedicated themselves. The area's financing has just been extended by the German Research Foundation for another four years. The focus there is on the tiniest particles present in nature and technology. The method: computerized reconstruction of the behavior of atoms and molecules in order to find answers to current scientific questions.

To that end, natural scientists, engineers and information scientists work closely together to develop appropriate models for describing processes in realms invisible to the eye. Their aim is to capture as much information as possible and make long periods of time and complex problems available for mathematical calculation with the aid of currently available computers while also generating easily understandable images from the world of particles. The following pages will take us on a journey through wide-ranging fields of application for particle-based computer simulations and show the complexity of small concrete things - even the smallest.



Modelling:
Formulas and equations are where digital experiments begin. They describe a system with all of its variations. But what forces are at work among molecules or atoms? Researchers develop simulation models to describe them.

Reconstructing:
A technical knowledge of physics, chemistry, biology and informatics is indispensable for digitally reconstructing a DNA chain. They make it possible to study special DNA structures that may be the cause of cell aging and cancer.

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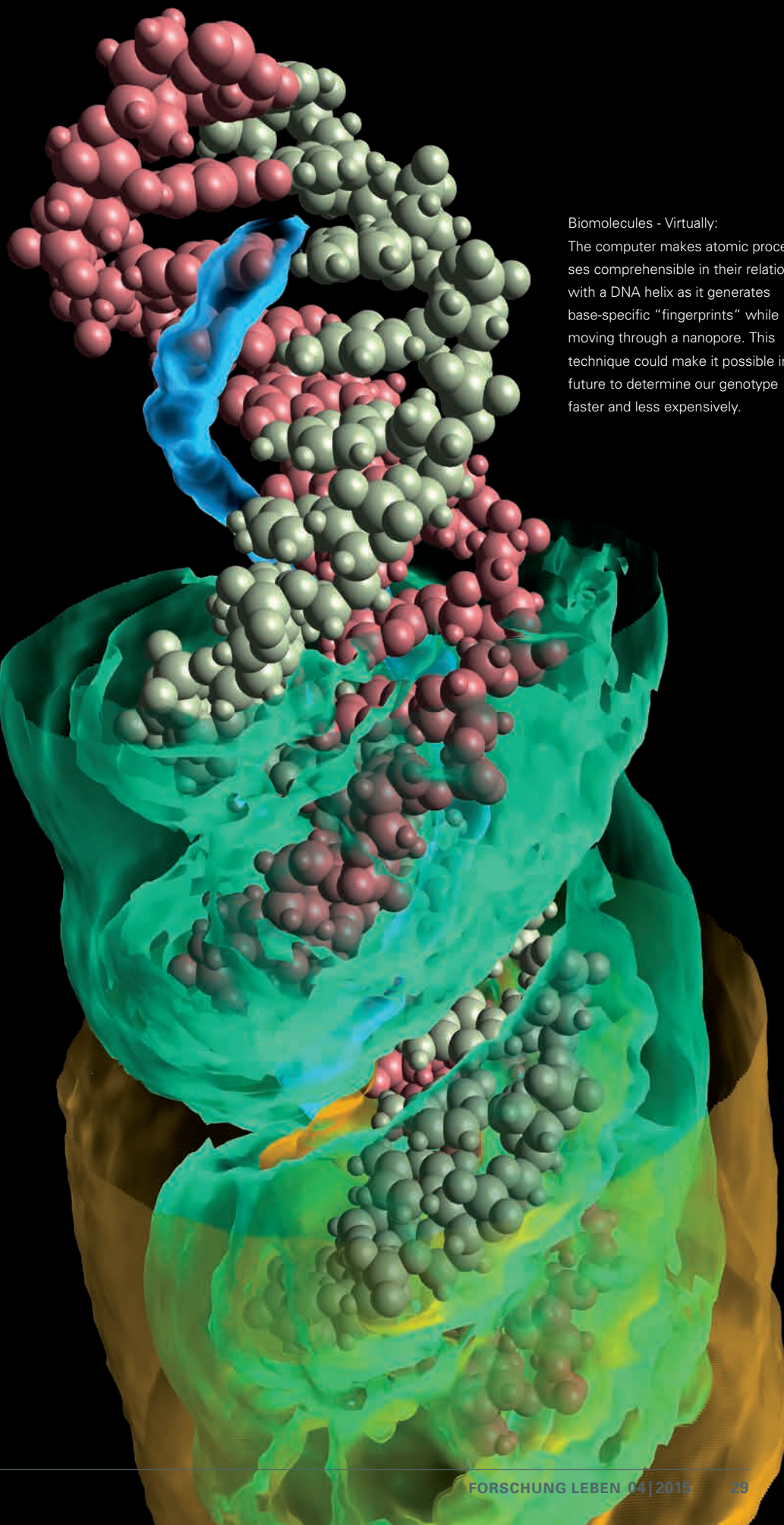
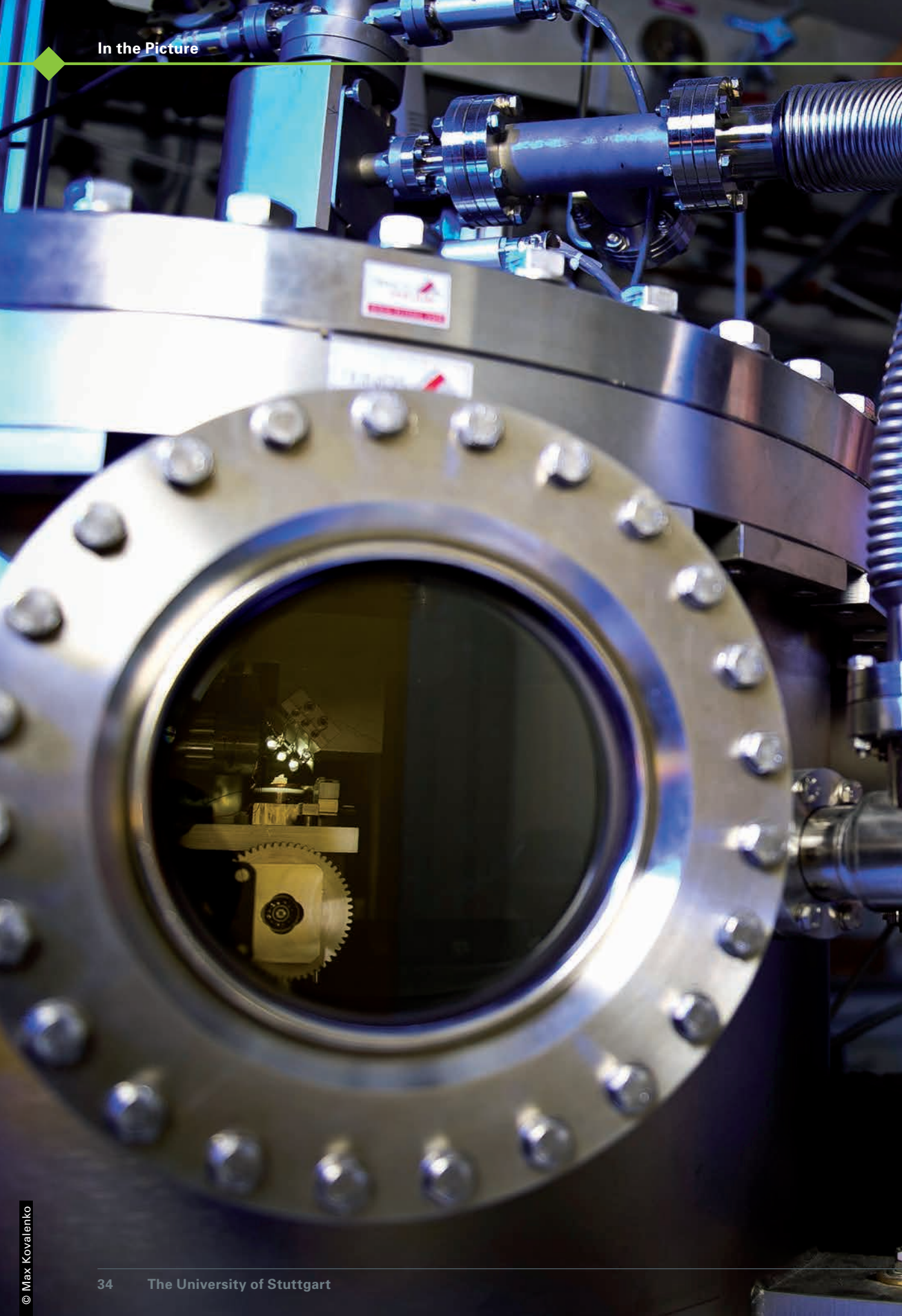
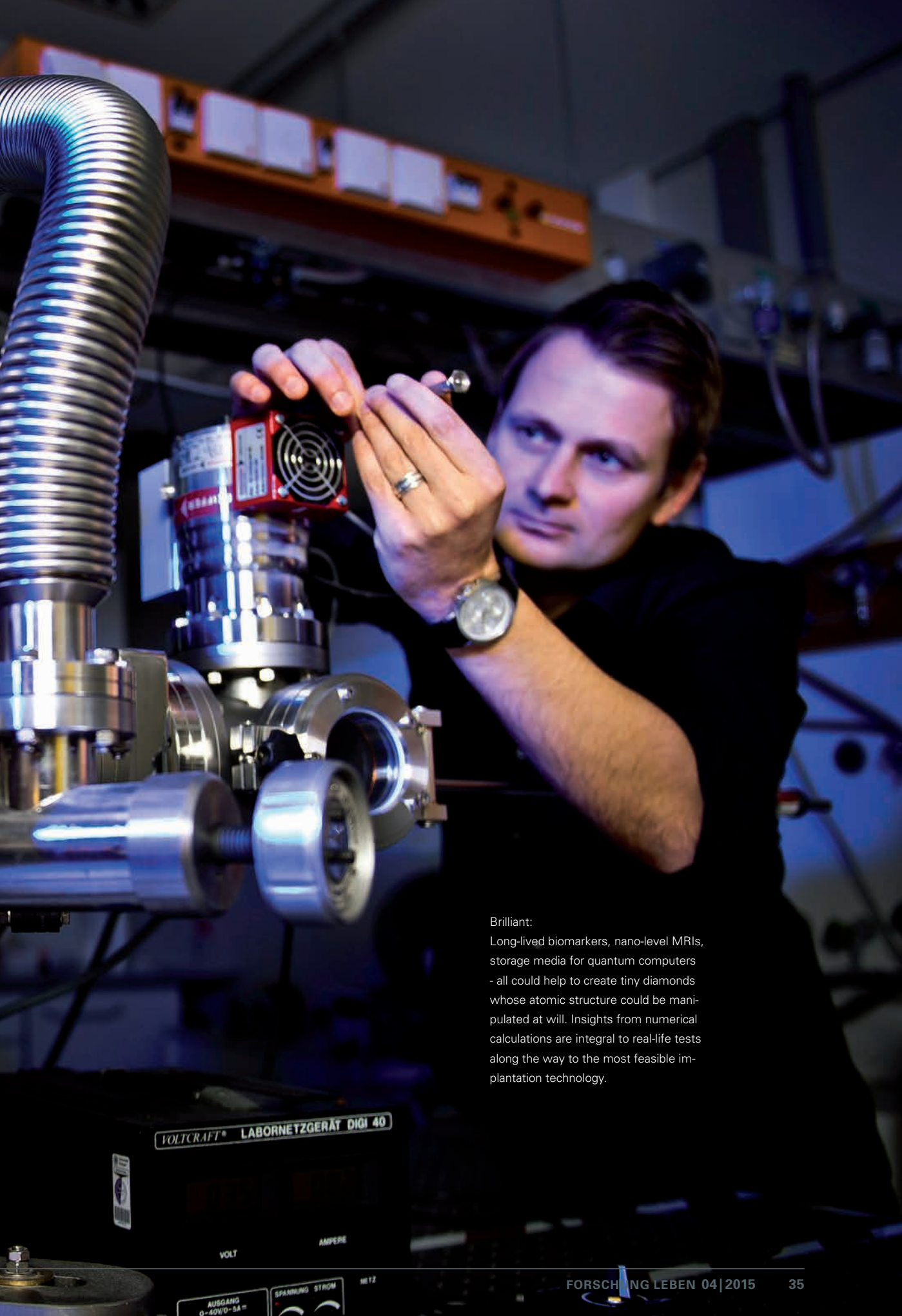


Biomolecules - Virtually:
The computer makes atomic processes comprehensible in their relations with a DNA helix as it generates base-specific "fingerprints" while moving through a nanopore. This technique could make it possible in future to determine our genotype faster and less expensively.

Simulations make countless tests unnecessary, thus saving time and money. But only when digital results are combined with experimental measurement processes does it become possible to confirm research results and gain new insights.

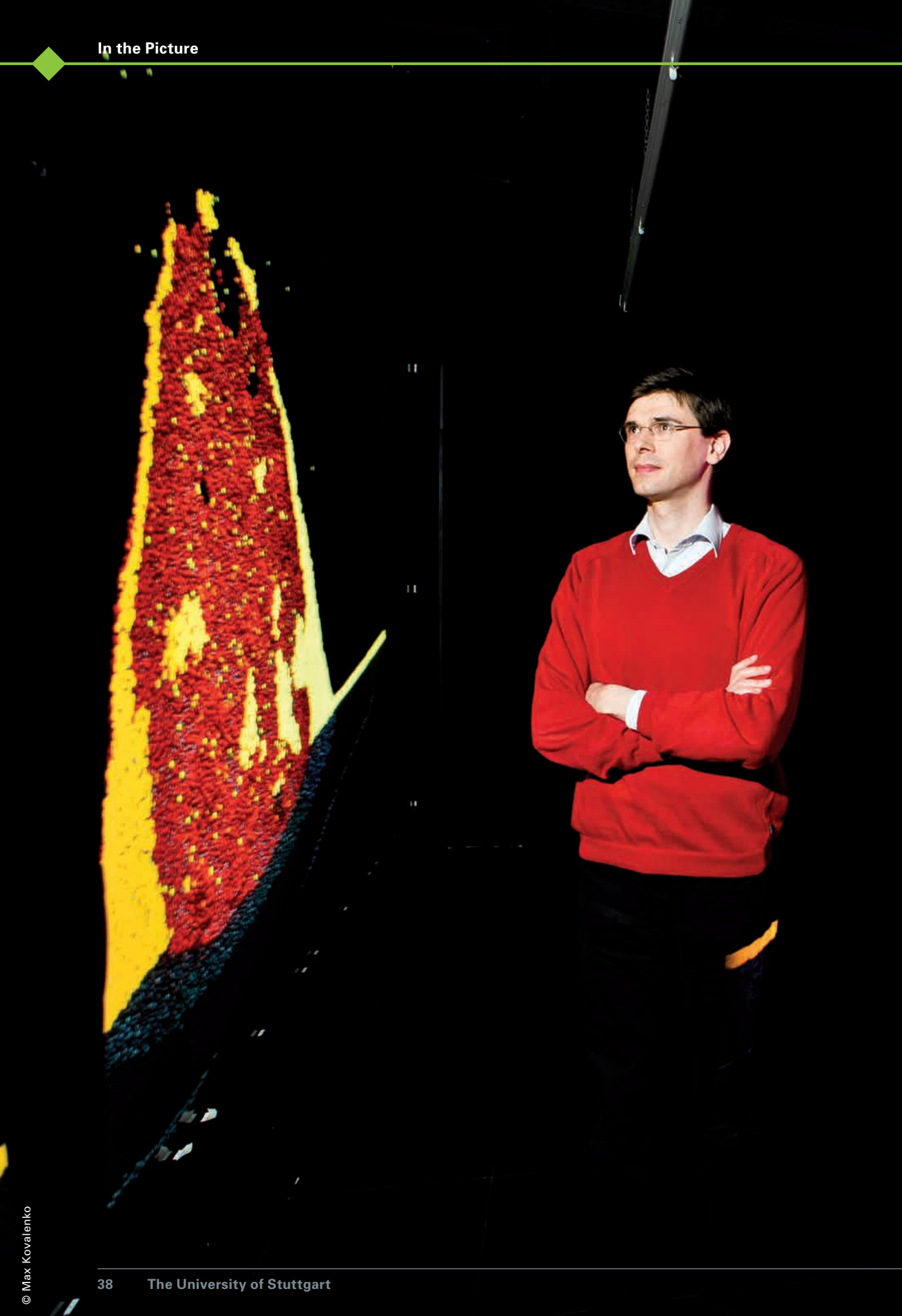
Is the chemistry right?
How must molecules arrange themselves in order for a product to emerge with the desired properties? The center of action is located so deep inside the probe that the naked eye cannot see it.

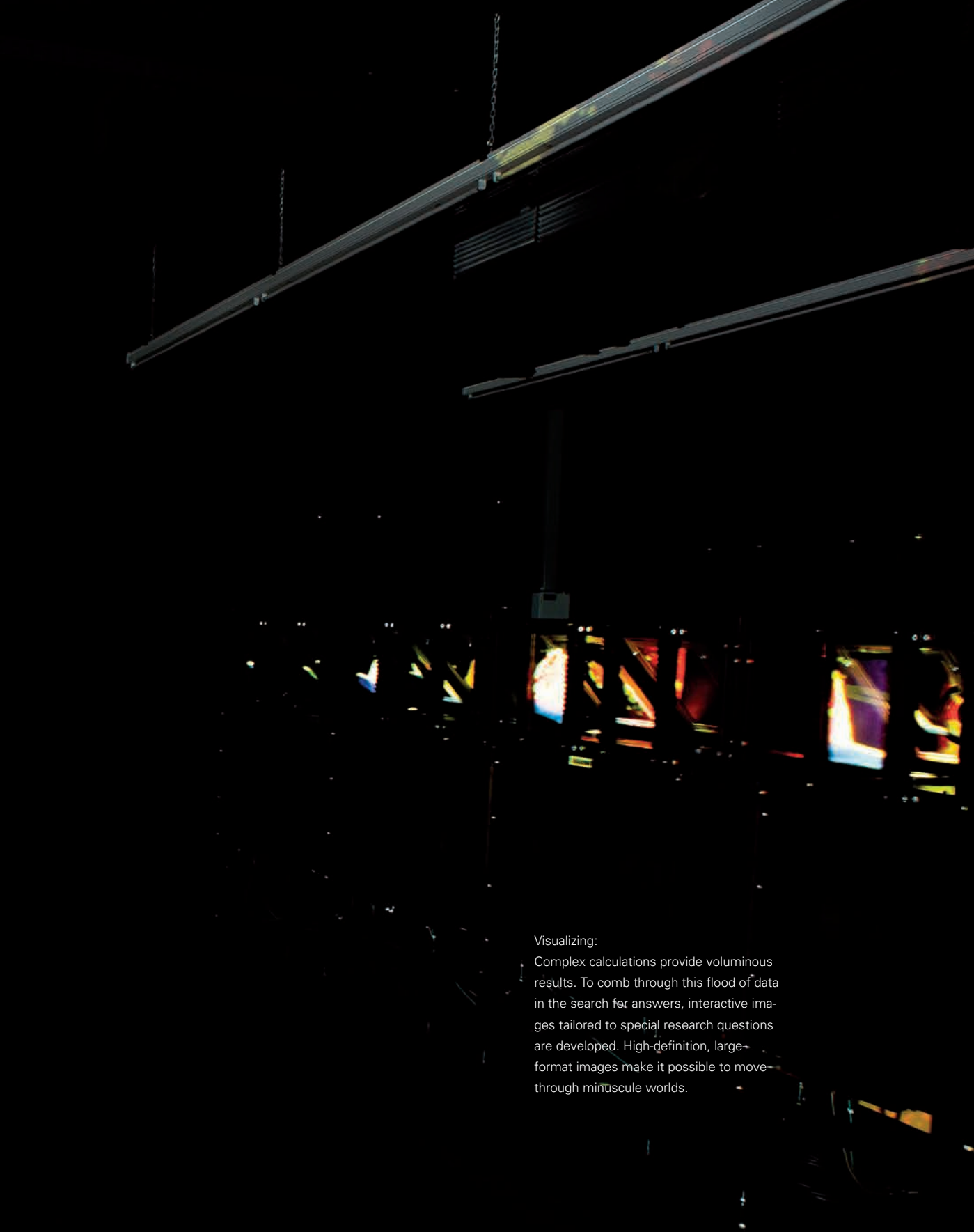




Brilliant:
Long-lived biomarkers, nano-level MRIs, storage media for quantum computers - all could help to create tiny diamonds whose atomic structure could be manipulated at will. Insights from numerical calculations are integral to real-life tests along the way to the most feasible implantation technology.

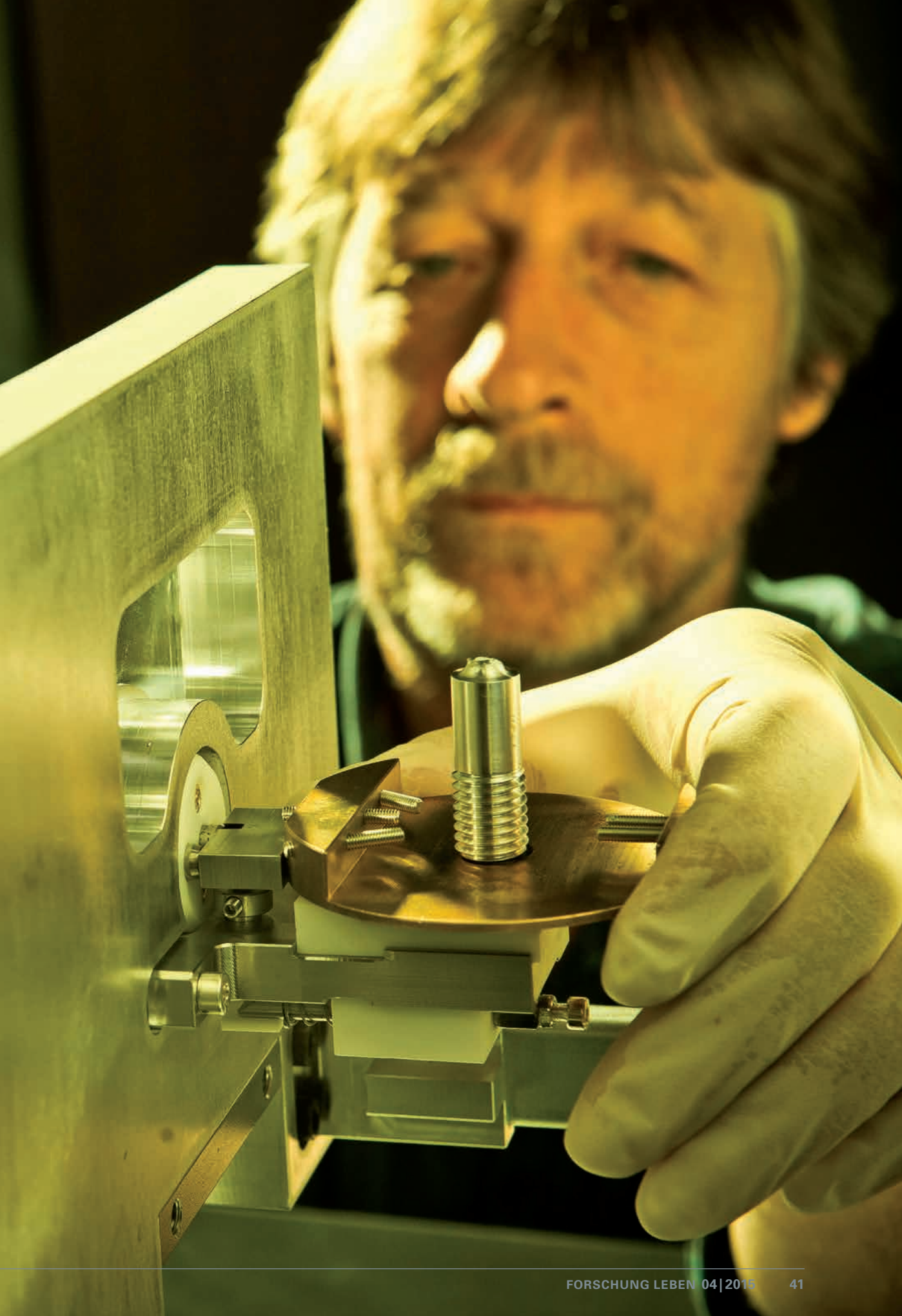
Precision:
Modern lasers create micro-perforations, like the 1,000 holes in this nozzle, which is used to spin microscopically fine fibers for functional textiles. The laser and the material must be matched to each other with precision in order to avoid damage from flying particles. Today it is possible to simulate processes on the atomic level during use of a laser.

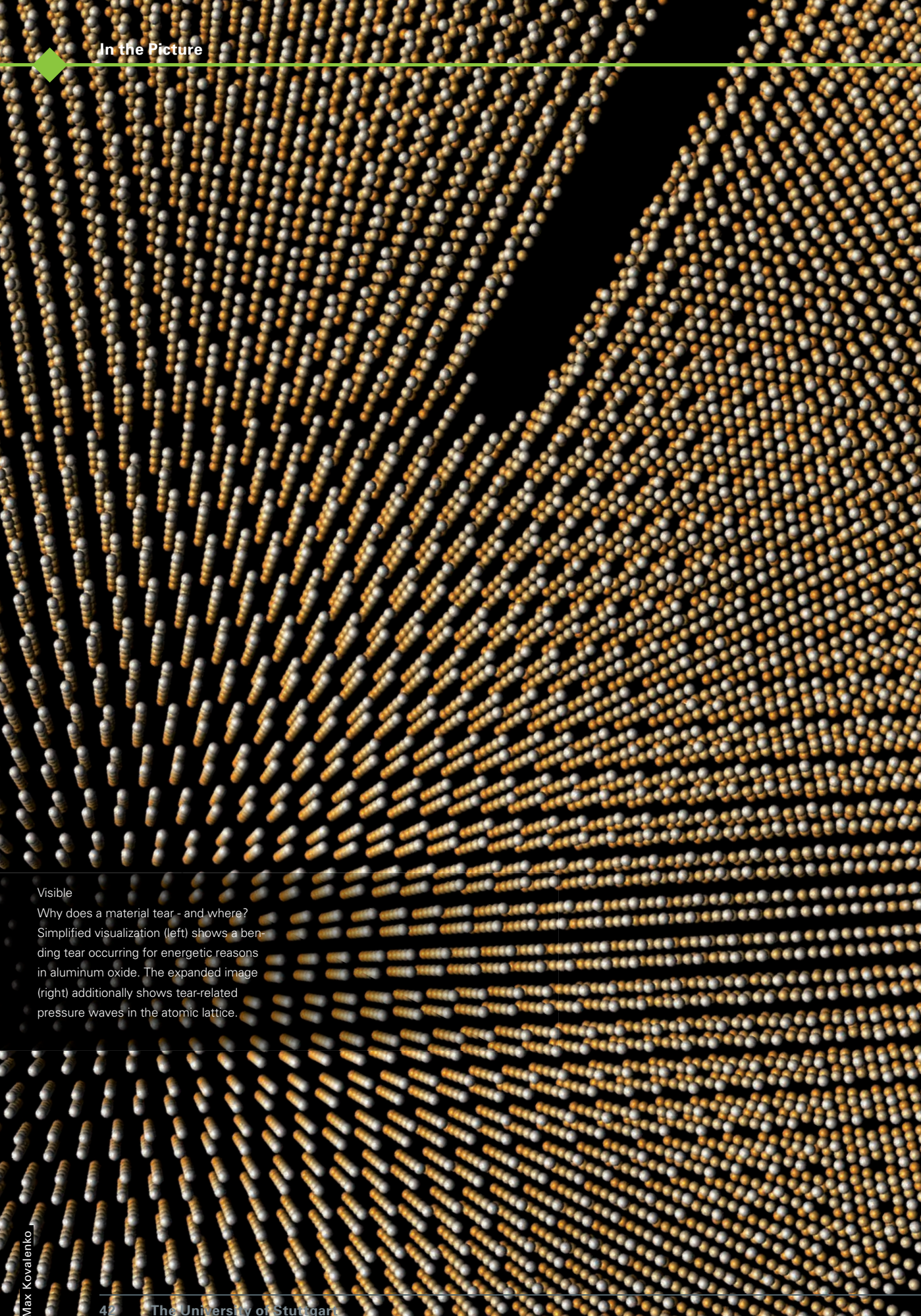




Visualizing:
Complex calculations provide voluminous results. To comb through this flood of data in the search for answers, interactive images tailored to special research questions are developed. High-definition, large-format images make it possible to move through minuscule worlds.

Cracks:
Breakage resistance is synonymous with quality and safety. Whether and how a production material breaks depends on how defects in it begin, develop, and spread. In addition to microscopic studies, precise prognoses today are being virtually generated more and more frequently.





Visible
Why does a material tear - and where? Simplified visualization (left) shows a bending tear occurring for energetic reasons in aluminum oxide. The expanded image (right) additionally shows tear-related pressure waves in the atomic lattice.

Efficient mathematics:
Anyone who wants to reconstruct the behavior of particles must be a juggler - of masses of data. The experts of Special Research Area 716 bring faster algorithms and mathematical tricks to the task; their aim is to minimize the needed calculations and to deep-dive virtually into vast areas and longer streams of time.

With Hermann Hesse through his hometown of Calw - virtually

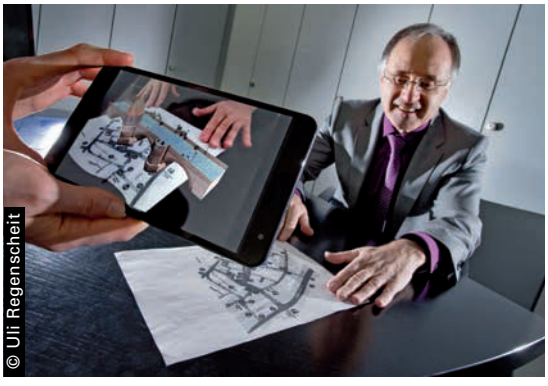
4D models bring historic city development to life at the computer

It can be expensive, even impossible due to war, to maintain the world's historic monuments for future generations. Thus the EU is sponsoring a model project for creating exact three-dimensional models of such historic monuments at the computer. Due to the impressive preliminary work done by Stuttgart scientists, the nearby city of Calw has now become a pan-European test bench for 3D reconstruction of various epochs. When the dimension of time is added, this becomes a virtual walk through history, with benefits for present times.

When talking about his work, 65-year-old Professor Dieter Fritsch grows jubilant: as if he and his companions were in a high-resolution computer game, he leads the way through his virtual model of the city of Calw in Germany's northern Black Forest. This scientist's latest gag: an augmented reality app for the mobile phone. He starts with a plan of the city, deliberately printed out in poor quality. Then Fritsch turns on his smartphone camera and holds it above the plan. The display immediately shows a three-dimensional model of the Nikolaus Bridge - in full detail, including the boxwood pots. "It's fantastic!" enthuses the Director of the University of Stuttgart's Institute for Photogrammetry (IFP). "The camera sees the pattern on the map and knows which model belongs there." And sometime in future it is even planned that Hermann Hesse, who was born in Calw, will stand virtually on the bridge. The literary author, who died in 1962, might then stroll across the market square and talk about his city. But even though Fritsch uses the engine of "Unity," a computer game, for his 3D models, he is by no means playing games: recording the dimensions of buildings, streets or even fountains millimeter by millimeter and then reconstructing them requires special methods and vast experience, both of which the scientists of the IFP have in abundance. According to Fritsch they have been working on precisely this task since 1992. High-resolution aviation photos, stereophotography, laser scanners that record a million pixels per second: "We have a wealth of experience with data acquisition and processing," says Fritsch. "After all, we're a globally certified institute."

THREE-DIMENSIONAL MODELS OF THE WORLD'S HISTORIC MONUMENTS

It was a natural step to join the EU's Consortium for Four-Dimensional World Cultural Heritage Monuments (4D CH World). The target of this EU project, directed by the University of Athens, is to use photographs to generate three-dimensional models of World Cultural Heritage monuments. Vast amounts of pictorial material are available in



Prof. Dieter Fritsch demonstrates his app, which can immediately create a 3D model when his tablet camera recognizes a map section.

Manual positioning of the camera, taking as an example the house where Hermann Hesse was born (now occupied by the Schaber Fashion Store).

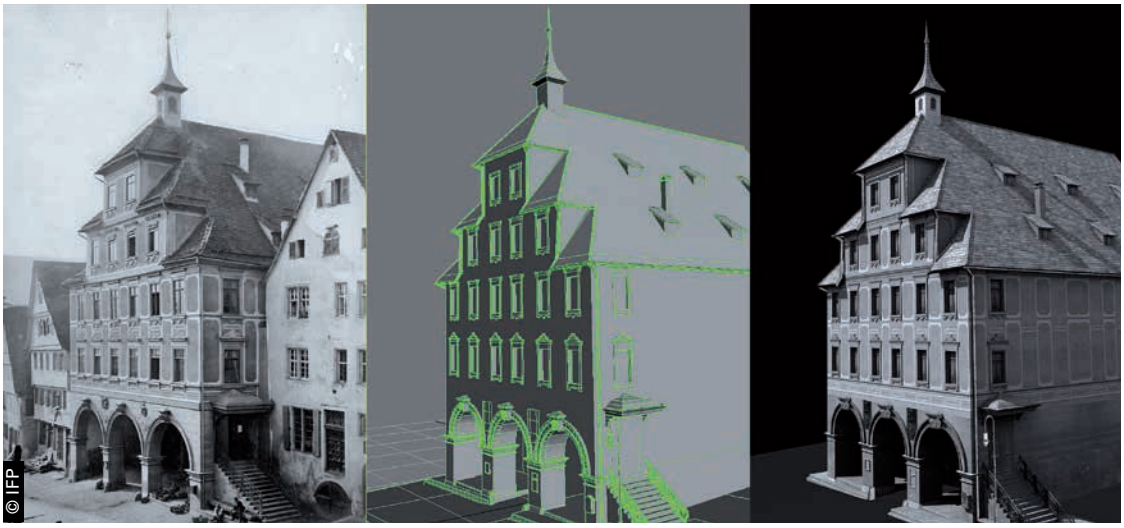
internet databases like Flickr or Picasa. But there's more: the Acropolis in Athens, for example, is to be reconstructed not only in its present condition but also as it looked in earlier times. "Our results will be made available to the European Bibliothek Europeana in order to preserve the cultural heritage monuments digitally," says Fritsch. In addition to the Acropolis, Pompeii and Herculaneum were also originally planned to be research fields for the scientists as so-called "testbeds". But then Fritsch proposed to his partners using his own home town of Calw, which he himself has used for years for measurement experiments and reconstructions. Fritsch's partners were so enthused by the results of the IFP to date that the historic city on the Nagold river has now become the prime testbed for the 4D CH World project.

Precise reconstruction of the entire inner city from pictures poses challenges for the scientists involved: "We at the Institute have developed a software that determines x, y, and z-coordinates for each pixel on overlapping images," explains Fritsch. The program, called SURE (SUrface REconstruction from Imagery), is extremely successful and is used all over the world. Overlapping high-resolution photographs from the air make it possible to process a whole city as a model. The results of laser measurements on the ground provide the exact dimensions of building walls, and photographs of the city make it possible to generate detailed building fronts.

BACK TO THE 11TH CENTURY

The result of all this is an image of the city in its present form. But the researchers also want to go into the fourth dimension: time. To that end the city of Calw has made available 3,600 photographs from its archives. The oldest ones stem from the 1860s. Also available are plans, maps and drawing from the Middle Ages. "We're going to try to reconstruct the city of Calw as far back as the 11th century, when it was mentioned in documents for the first time," explains Fritsch. He and his present team of three assistants hope to be finished by the end of 2017. Also planned in future is to make the city both past and present available to everyone on the Internet for a stroll. After the 4D city model has been completed, there are practically no limits to its practical uses. The city's administration could store information about the condition of the streets or the location of water conduits and thus acquire a comprehensive overview of its infrastructure. When new buildings go up it would even be possible to determine when a building casts a shadow. One type of waste product of the project is already available in Calw: "When I tilt the plane of the 3D model backward, add a two-millimeter pleat on the sides, and print it out on a thin cardboard sheet, children can use this as a cutout pattern to cut and paste the house where Hermann Hesse was born," says Fritsch. He has already printed out 1,000 of these sheets. Origi-

3D reconstruction of the Calw Rathaus as it looked in 1882. Left: photo. Center: parametric 3D model. Right: a texturized 3D model.



nally, the idea for the 4D CH World project was not nearly so comprehensive. "But the possibilities are practically endless."

PEDAGOGIC APPLICATIONS

As a researcher, Fritsch is also thinking about educational uses: "Among other things, we want to reconstruct Hermann Hesse's Calw with this model." And awaken this Literature Nobel prize winner to life. "Then he will be everywhere in the city and talk about it: 'Here's where I attended Latin school. Here is where I watched Calw girls when they went swimming." Fritsch is currently collecting the many anecdotes about the writer on an Internet platform. "Every schoolchild grows up today with a smartphone and a tablet. Once we bring together all these intriguing stories, it will make sense to create a fabulous computer game from them. For children in kindergarten, elementary school, preparatory schools, and adults as well." It will vary according to target groups and different viewpoints and ever-more detailed information. Applications are conceivable for other scientific areas, too, like the history of architecture. And persons suffering from dementia could think back with the aid of virtual images to how things used to look.

Daniel Völpel

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Showing How Literature Breathes

Heike Gfrereis, Director of the Department of Museums at the Marbach German Literature Archives

Heike Gfrereis graduated in German Language Studies at the University of Stuttgart and is still lecturing there today. As Director of the Literature Museums in Marbach, she brings the fresh viewpoints of students to solemn gatherings and confronts scientists by countering with the elemental force of sources.

"The Value of the Original" is written in large lettering in the foyer of the Modern literature Museum in Marbach, 25 kilometers from Stuttgart. In a room of exposed concrete and glass, it breathes spaciousness. In the center stands Hans Magnus Enzensberger's Landsberg automatic poetry dispenser. But no books are to be seen!
The books come two rooms farther on, in the permanent exhibition collection called "nexus," which stands for connection and interrelation. In the glass showcases, lit by hundreds of cold light lamps, stand crowds of authors and thinkers of the 20th century, shoulder to shoulder: Rilke, Hesse, Ernst Jünger, Sebald, Gadamer, Heidegger. And of course Kafka, whose "Process" is one of the highlights of the collection and causes prep-school students to make the pilgrimage from afar to Marbach. In addition to books and manuscripts there are also rows of souvenirs of the authors: letters, postcards, typewriters, even baptismal gowns and other mementos. "Our soul," is how Heike Gfrereis terms these treasures which are intended to create a personal bond with literature and both break down barriers by appealing to all the senses but also establish distance. "They show that literature is something true and real. And that it is not something which is self-evident, but rather a construct: a world of its own." Gfrereis has been Director of the museums on Marbach's "Schiller Hill" since 2001. Prior to that, the 46-year old was an assistant at the University of Stuttgart's Institute of Literature, where she also wrote her doctoral thesis. "Back then," smiles Gfrereis, "German Studies in Stuttgart were stamped by grand old men and were flirting with their own demise. It was an atmosphere in which I labored with the question of how to bring literary studies out of academic circles

As presented by the Marbach Museum of Literature, texts become concrete and palpable in their formation processes.

"Reading from sources often becomes an exercise in a different, more precise form of reading: a revelation." Dr. Heike Gfrereis, Director of the Literature Museums in Marbach am Neckar.

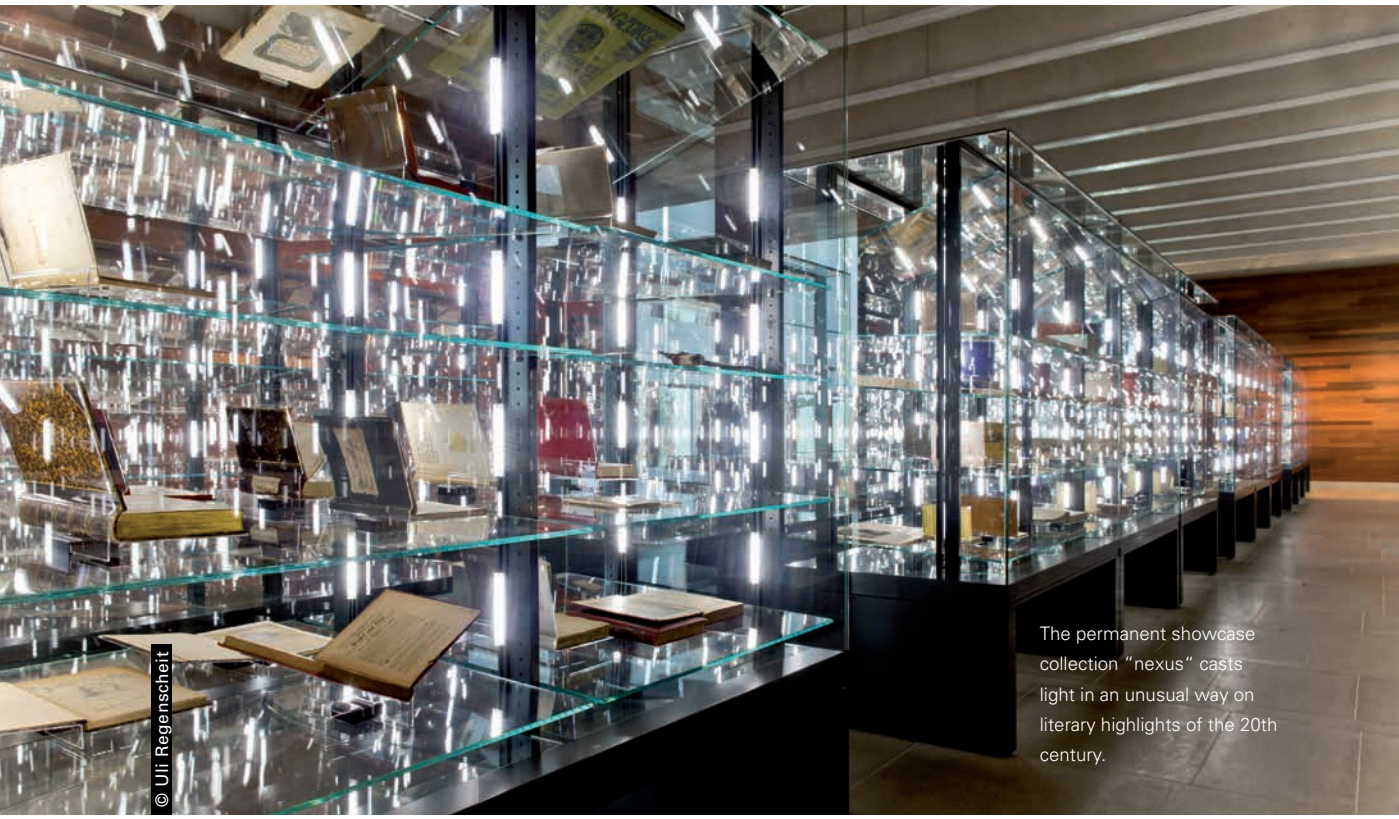
and light a fire with them in the minds and hearts of people." Literary studies have always opened up for me the freedom of thought and the vitality of our use of language. Why should that die out?"
The Marbach Museum of Literature, a department of the world-renowned German Literature Archives, contains the collected historical highlights of German literature from 1750 down to the present and had no less respect in the past as a long-standing authority than today. One of Heike Gfrereis' first challenges was an exhibition commemorating Hermann Hesse's 125th birthday. The German Literature Archives possesses most of the gigantic literary estate left behind by the Nobel Prize winner in literature. The expectations for a major presentation of them in full was overwhelming.

A COUNTER-DIDACTIC MUSEUM MODEL

But Gfrereis, the bustling literature expert, developed a counter-model of the classical, author-dominated exhibition. She reversed the original Latin motto about things which cannot be shown in Hermann Hesse's novel "The Glass Bead Game" and presented handwritten texts showing how the novel is constructed. Gferereis explains: "Materials and handwriting have their own very semantic role, and it has an impact over and above the mere experience of reading a book. "Reading from sources often becomes an exercise in a different, more precise form of reading: a revelation." But creativity is needed to show the meta-level. True to the exhibition's title "Into the Glass Bead Game," Gfrereis suspended the manuscript's pages like a string of beads on a long band. "Hesse wrote a lot by hand on printed pages, revealing a world of writing on one side and a world beyond print on the other." And Hesse later admitted elsewhere that he deliberately wanted to counter the Third Reich by turning the pages over.
This approach leaves public favorites like the writer's watercolors lying in a drawer. Or presents them in glass showcases just like manuscripts instead of hanging them up on a wall, as usual. It's confusing, but it works. The Marbach museums receive 60,000 to 80,000 visitors a year, "and it's precisely the modern collections that manage to interest people once more for classical literature."
This radical style of presenting literature has sparked a regular boom on the museum scene. "A whole series of literature museums are now going up, in Vienna, for example, and in Frankfurt and America. And we're acting as advisors for literature archives in Georgia and Moscow."

SOCIAL CONTACT AS LONG-TERM TASK

But even so: bringing literature down to the grass roots level, making it a permanent feature in the cultural landscape of the Central Neckar River region, remains a long-term task. "Literature exhibitions tend to intimidate potential visitors,"



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The permanent showcase collection "nexus" casts light in an unusual way on literary highlights of the 20th century.

as Gfrereis well knows. "We have to constantly find new ways to lower that barrier." That applies to themes, too: for example, the "Book that Moves" exhibition in the autumn of 2015 will aim to show exactly the mobility, the entry into other worlds, that is possible with books. The second avenue of approach is an adjunct program which opens the museums to the landscape lying all around and to the famous authors who lived there: the fortress of Hohenasperg (Schubart), the city of Ludwigsburg (Schiller) and the Michaelsberg Hill (Mörike).

Or again, the Museum Director puts the focus on literature in connection with wine in the context of an actual wine-sampling event. And to reach out to schools, she initiated a show-and-tell by children with objects left behind by the authors Erich Kästner and Michael Ende. She also works closely with the city of Marbach, which often lets stores remain open for business on Sundays during exhibitions in the literature museum. Gfrereis is convinced that "No museum today can survive with exhibitions alone." On the other hand, cooperation with other museums in the region needs more work. Even though the cultural program of the region lists Marbach as an "Outpost," Stuttgart remains far away, so that "it is hard to become part of the cluster of museums there." But the gap is being bridged through exchanges with the University of Stuttgart, where Heike Gfrereis has now been named Honorary Professor. The Marbach Archives are an important drawing card for literary studies in Stuttgart, especially for the "Stuttgart Research Center for Text Studies" which was established in 2014 and works to network methods of classical hermeneutics with the information possibilities offered by both material and digital media. Becoming acquainted with the archives is obligatory for the students, "because without archives, 'material studies' of literature remain merely a matter of theoretical discourse." And many trainees and museum "Ciceros" (guides) come from the University to experience first-hand that it is quite possible to find a job when one has made a personal choice for the study of literature.

REFRESHING PERSPECTIVES FROM THE OUTSIDE

In return, the students often bring the refreshing perspective of outsiders with them into the Museum, as was the case during a small exhibition of texts by Eduard Mörike. The young people, at first a bit at a loss in dealing with this Swabian lyrical writer, took refuge in humor. At short notice, for example, they visualized Mörike's famous poem about the rabbit, the hen and the egg in the form of fried eggs. "Categories of humor like that make it clear that it is permissible to take a few chances rather than blocking one's view by constantly looking for a deeper meaning in literature. Reading literature means: thinking for oneself, being critical, not hushing in prayer," says Gfrereis.

What is more, researchers from all over the world find themselves drawn here. "Marbach is a one-of-a-kind global location for Germanistic discoveries," says Gfrereis proudly. For example, the nearness to Marbach was a decisive criterion for Humboldt scholar Liliane Weissberg from Philadelphia's "Penn" University to select the University of Stuttgart for her research sabbatical.

REVOLUTIONIZING THE REVOLUTION

New impulses are planned this year from a top-to-bottom reorganization of the permanent exhibition: it will follow up on the "Little Revolution" of 2006 by once again turning what was then new on its head. The number of collections has grown by leaps and bounds, especially due to the purchase of the Suhrkamp Publishers' archives. Added to that are spectacular new acquisitions concerning living authors like Hans Magnus Enzensberger, Botho Strauß, Peter Handke or Martin Walser. Room is needed for their presentation. But another form of reception is also concerned. "We want to focus in future even more on writing." Only 333 of the current 1,300 exhibits are to remain. That will make visitors look more intensively, and each exhibit will become more significant.

Instead of a stack of papers from Kafka's "The Trial" only a few individual pages will then be on display. "We want our archive to show how literature breathes and thinks," says Heike Gfrereis. So it's no surprise that the new permanent exhibition is to be called "The Soul".

Andrea Mayer-Grenu

Stuttgart Research Center for Text Studies

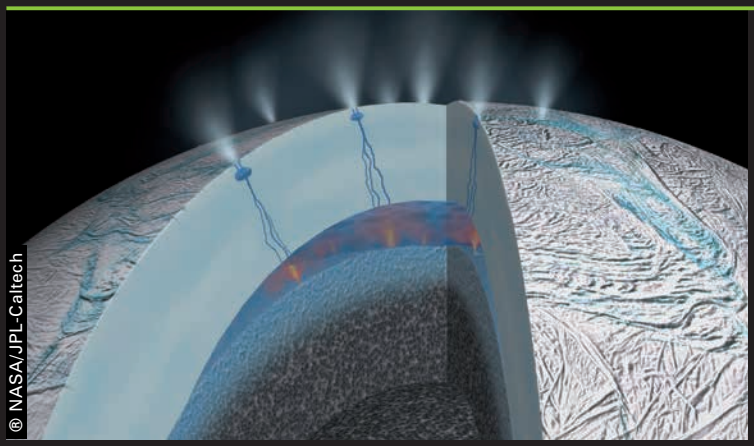
The Stuttgart Research Center for Text Studies devotes itself to a methodical reflection concerning new approaches in text-oriented studies and also aims to help build bridges between different approaches in text-based disciplines as they seek to unlock, describe, and interpret the secrets of a text. It has three key areas: Hermeneutics, Material Studies (together with the German Literature Archives in Marbach) and Digital Humanities (together with the University of Stuttgart's Institute for Natural Language Processing). The target of the Center is to carry out high-level, interdisciplinary, networked research in the areas of the textual sciences, to fortify instruction in these areas, and to encourage and support the next scientific generation. *red*

A PIPEFUL OF PROTEINS

Proteins are made up of many thousands of atoms. How these are arranged determines how the protein functions and helps to determine whether an organism falls ill or remains healthy. For that reason, techniques for studying the exact form and dynamics of proteins in their natural surroundings are much in demand. Now an international research team gathered by the University of Stuttgart's Professor Jörg Wrachtrup and the Chinese Academy of the Sciences has taken a long step forward in this area. Using a diamond sensor, they have found out how to make individual proteins visible in their natural setting. The new technique will make it possible in future to transfer conventional nuclear magnetic resonance tomography to individual cells and their intrinsic parts, thus improving medical diagnostics.

COLD HIGGS IN A NEW LIGHT

Working with an international team, physicists of the University of Stuttgart's Physics Institute 1 showed the first direct, experimental proof of the Higgs Mode in superconductors. The Higgs Mode describes a state of excitation state in direct analogy with the Higgs particles which were recently found in the world's largest experiment, the Large Hadron Collider at the CERN European Nuclear Research Center near Geneva. But while CERN's particle accelerator is a good 27 kilometers long, the Stuttgart researchers needed only an experimental setup of the size of a kitchen table.



LIFE ON ENCELADUS?

Saturn's moon Enceladus seems to harbor hydrothermal activity - making it more likely that many places on this satellite offer appropriate environmental conditions for living organisms. This is shown by new data analyses of the European-American Cassini Huygens Mission, in which scientists from the Universities of Heidelberg and Stuttgart are participating. These researchers have discovered microscopically small grains of rock, first demonstrated near Saturn, as the first clear-cut clues to hydrothermal activity on an ice-covered moon. In such a case, seawater penetrates the stony crust and reacts with it, leading to the exit of a hot, mineral-enriched solution. Their research results were published in the scientific magazine "Nature".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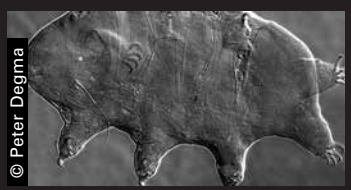
HIGH-WIRE BEES

The world exhibition "Expo 2015" in Milan is scheduled to run until October 31, 2015 under the motto "Feeding the Planet: Energy for Life". The German pavilion there gives visitors a peek into new and surprising approaches to solutions for feeding future generations. A highlight of the exhibition: "Be(e) Active," a show in which visitors immerse themselves in a wide range of living landscapes and can view Germany from the perspective of flying bees. This attractive show is made possible with the help of both high-wire robots and software developed at the University of Stuttgart. The technical system represents a complex of research and development work. As the University's Rector Professor Wolfram Ressel explains, "The University of Stuttgart took industrial technology which is already in use and expanded it so that the extraordinary challenges here were met with a combination of up-to-date research insights. It's a great pleasure for us that the University of Stuttgart followed up its success at Expo 2010 in Shanghai by taking part here in Milan in 2015 as the German pavilion's exclusive research partner."

THE PANTHER OF THE ALPS


© Peter Degma

They are survival specialists like the rest of their species, but spotted on the back like a panther: a new kind of waterbear (moss piglet) was found by a team led by the Stuttgart tardigrade researcher Dr. Ralph O. Schill during two excursions in the Italian and French Maritime Alps. A description of the Alp Waterbear, named Echiniscus pardalis (lat. pardalis, panther) was published in April in the renowned taxonomic journal of the Natural History Museum in Paris.

TERABYTES IN SECONDS

Germany's TERAPAN Consortium (Terahertz Communication for Future Personal Area Networks), of which the University of Stuttgart is a member, demonstrated in March a multigigabit data transfer carried out at a frequency of 300 gigahertz. Used for the first time on these high-frequency bands were controllable antennas that open up applications for future wireless communication in buildings, for example in intelligent offices and computer centers. Use of the terahertz frequency spectrum (300 gigahertz to 3 terahertz) makes wireless communication links possible that can transfer terabytes of data in only a few seconds.

Visions for the City of Tomorrow

Quality of life counts. And sustainability. And innovativeness

Researchers around the world are asking themselves how the city of the future might look. It should offer quality of life, be intelligently controlled, and in readiness for an era of scarce resources. The University of Stuttgart is partnered with the Fraunhofer Institute for Work Science and Organization (IAO) in a number of projects with a common target: to make cities fit for the future.

From a bird's eye point of view, cities look chaotic. Hundreds of thousands of people swarm here and there, work, consume, eat and sleep among more or less systematically arranged buildings. Vehicles choke the streets. Everything seems to function by chance. But just as no ant scurries through an anthill without its own tasks and destination, our cities too are marked by a strict order of tasks and targets of the inhabitants.


Nora Fanderl
© Jens Eber

This functional system is now faced with the megatrend of a constantly growing world population, more and more of whom additionally live in cities. The City of the Future must find meaningful answers to the threat of traffic chaos and dwindling resources.
A Sisyphean task? Possible; but Nora Fanderl already has potential solutions for many of these challenges. Fanderl, an architect at the Fraunhof IAO and a member of the Task Force for Urban Systems Engineering, studies among other things successful city renovation projects all over the world and integrates the resulting insights into visions of future cities. "The top question is: How can we ready cities for the future through efficient concepts and innovative actions?" is how Nora Fanderl sums up the focus of her work. The concept of readiness for the future in this sense includes an efficient use of resources and extends to mixed-use quarters where space is created for different functions and activities. Researcher Fanderl has already brought together concrete visions for the City of the Future in the project "Tomorrow City: City Insights" ("m:ci"). Four factors were identified as especially important: next to quality of life and the minimization of waste and emissions, it is above all important to promote the innovational character of city quarters. As Nora Fanderl explains, "Innovation here means open governance structures that leave room for the widest range of key performers to create their own designs."

AN OUNCE OF PREVENTION IS WORTH A POUND OF CURE

A fourth factor is resilience, meaning in this context the concept of taking precautions to make cities safe and stable against all types of crises. This may mean both protection against natural catastrophes and the creation of decentralized and reliable infrastructure networks.
As Nora Fanderl says, "It is important to convince people of the need for these developments." For example, waste avoidance and innovative mobility concepts can only be promoted if people are actively involved in the developments and decision-making processes and experience added value from the innovations. In "m:ci , ideas for the City of the Future are subjected to interdisciplinary reflection with the aim of carrying them over into concrete project development. The structure of "m:ci" is that of a network of communes, industrial partners, various Fraunhofer institutes,

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Illustration of the City of Tomorrow (for example: Berlin).

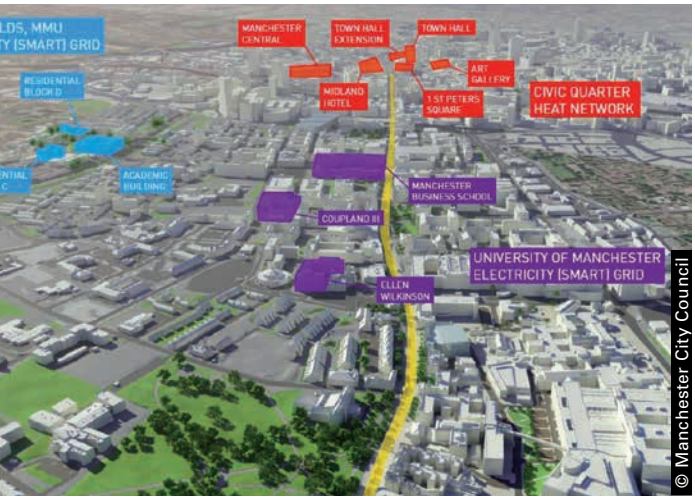
and the University of Stuttgart as a cooperation partner. The first project phase in 2012 involved an analysis of what characterizes sustainable and future-viable cities. The cities evaluated were Berlin and Freiburg in Germany, as well as Tokyo, Singapore, Copenhagen, and New York.
The second phase will run with this as a basis to the end of 2015. As architect Fanderl says, "We want to design cities for future viability on the basis of insights into the factors and indicators which condition sustainable city development." Important here among other things are industrial partners who want to use research results to develop future-oriented, economically reliable products. The direct dialogue between companies and key partners in the communes makes it possible to develop solutions that match urban needs.

PRACTICAL IMPLEMENTATION HAS BEGUN

Concrete projects are now underway. For example, an urban coalition of Freiburg, Ludwigsburg and Norderstedt (Schleswig Holstein) has joined with the "City of Tomorrow" network to pursue the target of turning existing industrial areas into sustainable business quarters and using this experience to develop a transformational model for similar areas. And just this year the cities of Reutlingen and Chemnitz joined hands in a project called "Smart Urban Services" to build up an innovative sensor-infrastructure. Another project in which the University of Stuttgart and the IAO are intensively involved is at work creating a so-called "innovation District" in the Canadian city of Burlington. The city fathers there are concerned about the need to offer an attractive locale for young, talented persons and highly promising companies and thus set the city apart from comparable business locations in the region.
Nora Fanderl has found that "There are many small, localized companies there today, but no spatial clusters with drawing power for potential innovators." Together with her task force she has created a modular concept for the "Burlington Innovation District". As she explains, "An Innovation District is marked not only by industry and research but requires most of all an environment with quality of living." That means, for example, not only child care centers but also cafés and recreation areas. Now "labs" are appearing in Burlington where young, innovative companies can share computer services, for example, or draw energy from an intelligent, decentralized mains supply.
As 30-year-old Fanderl explains, "Such projects require 'star' allure." On the one hand, creative professionals von Burlington should be drawn by them, but companies too should find an environment in which they can test new products in everyday life.

SMART STUDENT CENTER

Die Entwicklung hin zu zukunftsfähigen Quartieren betrifft allerdings nicht nur industriell geprägte Areale. Im Projekt "Triangulum", in dem das IAO die Führungsrolle unter 22 Partnern übernimmt, wird etwa das studentische Zentrum "Manchester Corridor" in ein "Smart-City-Quartier" umgewandelt. Das Viertel in der nordwestenglischen Stadt erhält ein autarkes Energienetz, Fahrzeuge mit Benzinmotoren



Manchester's "Manchester Corridor," a student center with about 72,000 students, is undergoing transformation into a Smart-City-Quarter.

werden in dem Stadtteil mit seinen rund 72.000

However, the development to future-oriented city quarters affects more than areas with an industrial character. In the "Triangulum" project, in which the IAO has the leading role among 22 partners, the student center "Manchester Corridor" is being transformed into a "Smart-City-Quarter". This suburb of the city in northwestern Britain is receiving a self-guiding power supply network; vehicles with gasoline engines will no longer be seen in future in this city area with its roughly 72,000 students. Instead, electric vehicles, bicycles and an urban e-tram system will dominate the scene.

Not only Manchester but also Eindhoven (the Netherlands) and Stavanger (Norway) are implementing previously developed plans In Triangulum Project, which is subsidized by the EU. Parallel to this, so-called "Follower Cities" will work out their own visions during the first three years of the project, which started in February 2015, and then carry out concrete steps. Among them are Sabadell in Spain, the Chechen capital of Prague, and Leipzig. In Leipzig's western suburb of Plagwitz-Lindenau in particular, a former industrialized quarter will aim not only to attract startups but also to create affordable residential areas and appropriate office spaces. In the process, Leipzig will aim from the start to implement concepts for intelligent power supply networks, mikro-mobility, or even innovative avenues of financing for young companies.

Jens Eber

Affordable residences can pay dividends

Stuttgart researchers study investment incentives for builders

Residential space is steadily growing harder to find in some regions of Germany. Rents are rising to a point where many can find it difficult to afford their apartments. At the same time, the construction of publicly subsidized apartments has dropped drastically in recent decades. A study by scientists at the University of Stuttgart's Institute of Construction Management (IBL) showed ways to make it more appealing for investors to build publicly subsidized apartments.

Laws and national subsidies in Germany governed the construction of publicly subsidized apartments up to the end of the 1980s. The construction of publicly subsidized apartments dropped once this practice was abrogated. In addition, older groups of buildings were privatized more and more.
This prompted the IBL's scientists to ask what would make it attractive for private investors to include publicly subsidized apartments in their projects. As Sarina Wanke, an academic employee of the IBL says, "Rents for publicly subsidized apartments have to remain low, but thus lower the return on a project as a whole." Even when the cost of construction is low, it is not covered by the expected rents. So what possibilities does the government have to make it economically attractive for private investors to put up publicly subsidized apartments? Sarina Wanke followed this up in a Master's Degree dissertation supervised by Institute Director Professor Fritz Berner. The paper studied different incentives, with a focus on two basic points: the first concerned financial resources - for instance in the form of cheaper credit or a rebate for the purchase of public properties, as is already the case in some cities. The second might take the form of tax benefits, for example a type of special depreciation for publicly subsidized apartments or new provisions in the building laws. Then communes could already include special areas when they zone areas for use and when planning construction. In addition, building project owners might be allowed to put up larger buildings than originally planned, provided that they would put up publicly subsidized apartments in return. And investors could be offered project-related building plans. Another suggestion went even farther: to offer project owners streamlined procedures for accelerating the permit process and the overall planning period. Or the communes could approve exceptions in areas where change freezes prevent new construction or renovations - again with the proviso that subsidized residences are created.
Based on a concrete building project, the researchers were able to show in theory that the incentives are effective. But general statements about which of these "levers" would function best, were not possible. It is rather the case that the various measures must be tailored to the concrete projects as well as the financial resources of the respective commune. However, the study did come to a clear conclusion: there is an urgent need for the government to ensure more publicly subsidized apartments by means of regulations and incentives in the form of law. However, this can come about only in cooperation with private investors.

Daniel Völpel

Flexible Buildings That Learn

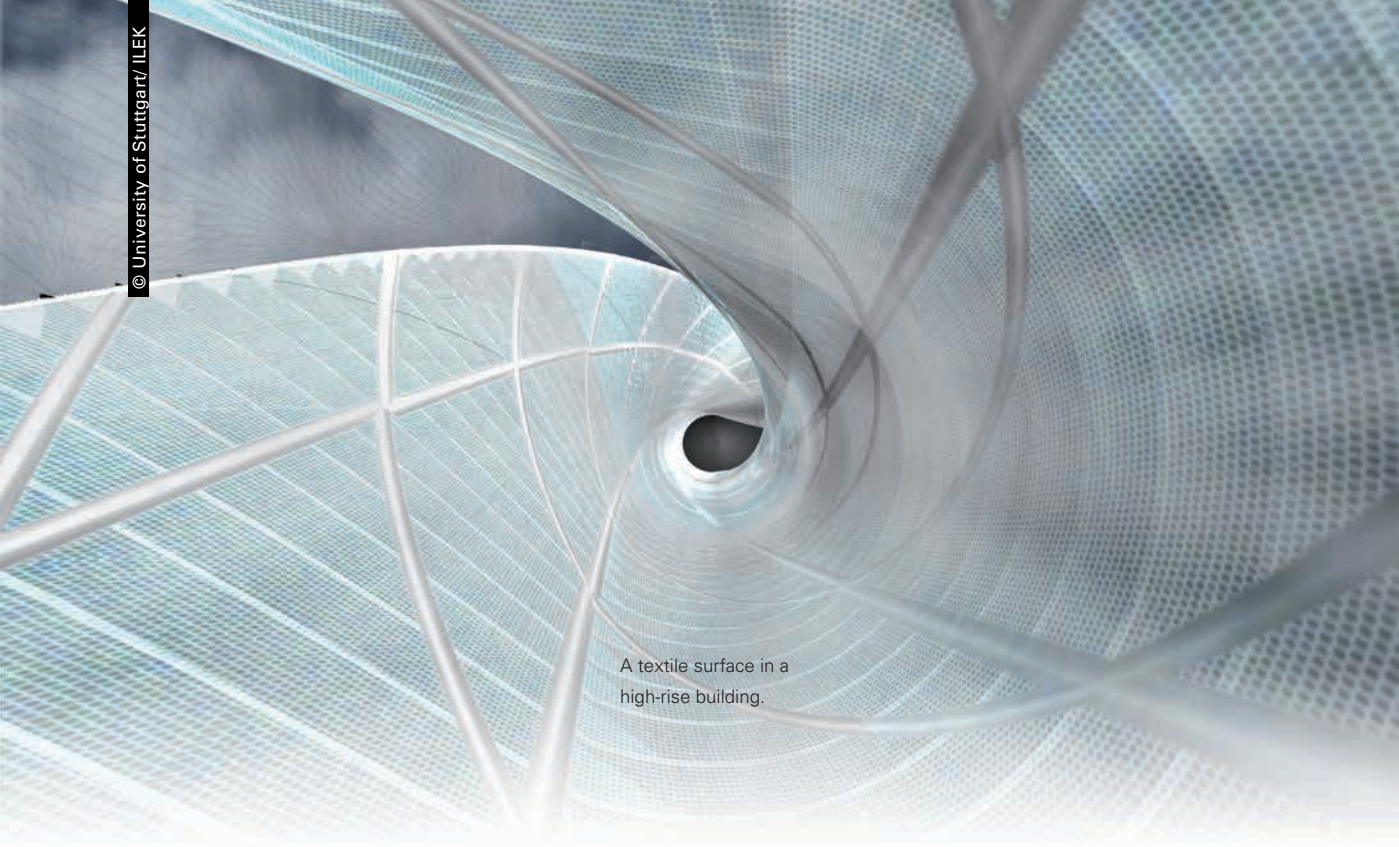
The House of Students of tomorrow is made of concrete, air, and changeable facades

The construction sector currently faces numerous problems: it consumes large quantities of resources with enormous CO2-emissions, thus producing over the long run a great deal of special wastes, and cannot continue as in the past in the face of population growth and climate change. Scientists at the University of Stuttgart are therefore developing answers such as recycleable and resource-saving facades, windows that darken themselves, and new kinds of concrete.

Two billion - that's how many children will grow up around the globe in the next one-and-a-half decades and go looking for an apartment of their own to move into. New apartments for two billion - that is the number that haunts researchers at the University of Stuttgart's Institute of Lightweight Structures and Conceptual Design (ILEK) as they try to develop innovative types of construction. Institute Director Profess Werner Sobek calls it a "scientific exigency on the basis of a moral obligation" in speaking of this gigantic number. So much student housing can never go up by conventional means. As an architect, civil engineer and scientist, Sobek defines his building target as "Triple Zero," a threefold nought: no energy consumption, no waste, no emissions. It will be a long road to that goal, and there is no patented solution for the vast range of possible residential areas. The key is rather to assemble a "reserve supply of solutions" in order to react to population explosion, dwindling raw materials, and global warming, says Sobek. "It's a race against time."
This race does not begin in the world of construction simply with use of a building, but rather during its construction. As Sobek explains, "Concrete is the most-often used building material in the world. CO2 emissions in the production of cement exceed those of the world's entire airplane travel." Were it to become possible to reduce the use of concrete, this would have enormous consequences. And the ILEK staff is working on it. As Sobek explains, it might be possible to optimize the outer geometry of a building area in order to use less concrete, and he points to a room ceiling as an example. "But who wants to walk on an undulating floor?" For that reason, he and his team of researchers are focusing on the inner life of concrete building elements by installing variously arranged hollow spaces with varying diameters. Sobek says, "We optimize the interior of a concrete element and talk about it as 'gradient concrete." As in a bar of chocolate filled with puffed rice instead of caramel, the outer shape remains unchanged, but mass is saved. As Sobek says, "Often 50 per cent less consumption of concrete is possible." Intensive research was required to find out what materials can be mixed with concrete, says Dr. Walter Haase, Director of the Group for Lightweight and Adaptive Systems at ILEK. At the moment, three of the Universitys institutes - the ILEK, the Institute for System Dynamics, and the Institute for Production of Construction Materials - are jointly developing a robotic spray manufacturing process for creating walls and ceilings. The structure is too complex to be managed by hand. Haase explains: "We have the means of production, and we can separately simulate what the ideal ceiling should look like. Now the trick will be to put both together. Then a construction company will be able to introduce the process."

SKYSCRAPERS WITH TEXTILE WALLS

Gradient concrete not only saves resources but also leaves less construction waste behind. 60 percent of all refuse in Germany comes, according to



A textile surface in a high-rise building.

Sobek, from the construction sector. of all refuse in Germany comes, according to Sobek, from the construction sector. Today it's normal to cover an outer wall with concrete, then glue insulation panels to it and plaster it.
"15 to 25 different building materials inseparably glued together, meaning: we're producing special wastes. Hundreds of thousands of cubic meters a day in Germany alone," says the architect. For that reason, the facade of the future should not only consist of materials which can be separated and recycled, but those materials should also be more versatile than today. His research team is experimenting with textile materials for skyscrapers in order to reduce high-rise weight. "We're aiming at five to ten kilograms per square meter of wall, instead of today's 100 to 400 kilograms", says Haase. 10 years of research culminated last year in 15-centimeter wide elements that insulate against heat and noise just as effectively as a concrete wall.
In addition to lightweight construction, the ILEK team is also focusing on energy optimization. "Facade behavior remains unchanged in spite of constantly changing conditions on the outside and inside," says Sobek. "So we are actually hoping for facades that can switch themselves and adapt to what's happening on the outside and inside."
One approach to this is being taken by ILEK Junior Professor Dirk Schwede: he creates air chambers behind both the inner and outer facade walls, each with a layer of insulation. Both air chambers are linked jointly to a fan. When it is turned on, the air circulates - circumventing the insulation and conducting either hot or cold air. When the fan is turned off, the facade insulates normally. "Like gradient concrete, this is a revolutionary approach in construction work," says Sobek. He estimates it will be three to four years before the first experimental houses with "switchable" facades go up.
Haase and his team are also testing a similar principle with fluid glass in window panes in an EU-sponsored research project. It involves a glycol-water mixture circulating between two panes of glass. To protect a room against the sun's rays or darken it, a colored pigment is added to the mixture. The sun warms the fluid. If it is routed through a heat exchanger, the energy becomes useable.
"Adaptive windows" containing a layer of liquid crystals are now undergoing trials in a test building in Stuttgart's Vaihingen suburb. When variable electrical current is applied to the pane, it can be continuously darkened. Without current it appears to be a normal tinted window. Here too, material and energy are saved: the maintenance-free pane can be tinted continuously in individual segments, thus eliminating the need for a high-maintenance blind.

Focus on Human Needs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How can technical management and environmentally friendly construction methods be aligned with the needs of their users? That is the research question of Jonas Löser, an architectural sociologist. "The energy revolution should not put humanity at a disadvantage," is how he reduces it to basic terms. "After all," he says as a member of the scientific team at the University of Stuttgart's Institute for Social Sciences, "we humans spend 85 percent of our daily life in closed buildings. How we construct them has an influence on work processes, on life satisfaction, on comfort." The concept of "sustainability" first appeared in the construction sector in the 1990s, and was long equated with environmental protection. But that is too short-sighted for Löser: the emergence of low-energy houses has brought with it the danger that buildings will be technically "over-controlled", meaning that the users can no longer regulate light, ventilation or temperature at will. The possible consequence: they feel uneasy and try to override the systems. "Humans are not rational, like technology," says doctoral student Löser. "Even when an air-circulation system does the same job, humans still want a window." Löser regards it as questionable whether architects and civil engineers are aware of the social needs of users and accept them as central and intrinsic to their planning processes. Human beings must be a central factor in planning: they should be at ease, feel safe and sheltered, be able to use their building appropriately, and value it - especially because buildings are structured for a service life of 40 to 60 years.

That is why Löser is working to find out what role is played by the three dimensions of sustainable construction - ecological, economic and social. He started by studying the laws that apply in each case: the German Energy Savings Act EnEV, other building laws and ordinances, and the DIN and ISO standards. In almost all cases, the building owner pays very close attention to economic sustainability, meaning costs benefits. "But the social component," says Löser, "tends to be neglected." From December to February 2015 he put questions online to architects from Baden-Württemberg who were planning buildings in the business, public and social sectors, such as offices or kindergartens. In contrast to residential construction, the future users were not taken into account in these construction projects. A first look at the answers from more than 1000 participants made it clear: social sustainability is in fact subordinated very much to the other two dimensions. Now Löser wants to find out what helps or hinders engineers regarding social sustainability in their building work. Helpful ideas might result from this, not only for architects and owners of new buildings but also for those who make the laws.

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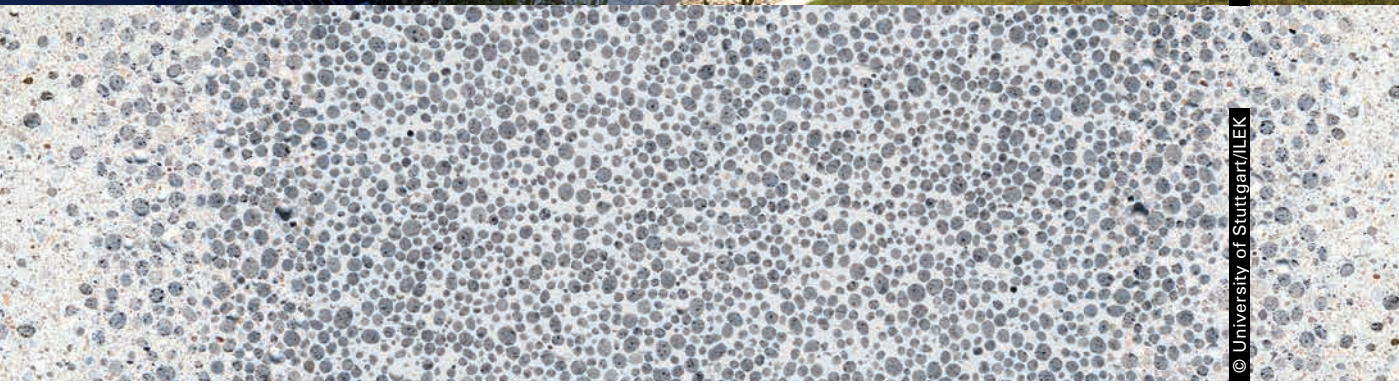
The B10 Active House in Stuttgart's "Weißenhof" settlement produces twice as much energy as it consumes, thanks to an ingenious energy concept and a self-teaching building control system.



A gradient concrete wall construction.

A GRADIENT CONCRETE WALL CONSTRUCTION.

One intelligent building control system is already being tested under everyday conditions. The recyclable B10 Active House designed by Werner Sobek in Stuttgart went up in 2014 and meets all requirements of the "Triple Zero" concept. "The basic reason why buildings don't react to weather changes and hardly at all to changes in their interiors is that they lack the requisite intelligence," explains Sobek. That led a group of former ILEK students to develop a control system for heat, cold, air circulation and electric power. It functions by "looking ahead", i.e. by procuring forecasts from the weather service, and it also learns the habits of its user. It can be changed individually via mobile phone or laptop. According to Sobek, one law firm that tested the system for a year saved 30 percent of its energy costs Now the system is being developed even further in the B10 House as the research team monitors all of its energy flows. "Basically," says Sobek, "everybody can afford a system like this, and it takes effect immediately." The overall investment required is about 1,000 Euros - instead of the 1,000 Euros per square meter of residential space normally required for energy renovation. As Sobek says, "That means far more leverage" - especially regarding the estimated 34 million houses and apartments in Germany which are in need of renovation. After all, the cost of modernizing energy use in all of them would amount to nearly three quadrillion Euros - another gigantic number that impressively describes the need for innovative solutions.

Daniel Völpel

The City as Storage Tank

The energy revolution's success requires that buildings absorb energy

For buildings to be mostly energy-autonomous - alone or in clusters - or even act as buffers in a "Smart Grid", energy storage cells are indispensable. New research projects aim to give new momentum to this issue, which has been something of a wallflower in the energy revolution up to now.

The energy revolution ushers in both a new energy mix and uncertainty: sun and wind generate electricity in abundance, clouds and windless days far less. Unfortunately, the power demands of private households and industry ignore the weather. Thus even today there are periods when less energy is required than could be produced. In addition, energy production is increasingly decentralized due to photo-voltaic systems, solar-thermal heat, wood-burning systems, geothermal energy, and heat pumps. In both cases, the rule is: tendency rising. As Professor Harald Garrecht, a civil engineer and Director of the University of Stuttgart's Institute of Construction Materials (IWB) says, "The more regenerative energy is in the mix, the more important it becomes to store it." On the one hand, "energy storage tanks" can provide a buffer for surplus locally generated energy until it is needed it; on the other such "tanks" could support energy providers in an intelligently controlled future network - the Smart Grid - to buffer solar or wind energy. For example, they would supplement Germany's large pump storage power stations, which can be expanded only to a very limited degree. And such power plants cannot buffer energy on a small scale with sufficient flexibility.

But it is a long step from this insight to practicable implementation. As Garrecht says, "Up to now we have the problem that all energy storage technologies are quite expensive, and too little research has been done on operating them on a daily basis during typical load fluctuations and in conjunction with the heating and energy-generating technology of a building or cluster of buildings." In some cases even the basic technology is still lacking.

WHAT MAKES SENSE ECONOMICALLY?

After evaluating various systems, two Master's dissertations at the University of Stuttgart's Institute of Construction Management (IBL) have also come to the conclusion that these systems do not make economic sense at this time if regarded basically as energy storage devices. In the context of research commissioned on storage systems in buildings, the dissertations studied mechanical storage systems involving, for instance, pressurized air or pressurized gas storage along with lead batteries and hydrogen storage systems. "None of these variants could be economically operated Under present conditions," says Michael Hermes, a member of the IBL's scientific team. "The government would have to offer similar incentives like those for photo-voltaic power systems in order to spur broad market acceptance." Hermes sees pressurized air storage devices as a "wallflower" technology with much future potential: "Given more intensive research, a market introduction of this type of storage technology would require the lowest subsidies of all the technologies which we analyzed." Pressurized air storage systems use surplus electric current to compress air so that it can be stored in quite small tanks. Later, this air can be burned together with natural gas to drive a gas turbine. Today only a few pressurized air storage power plants exist on a large technical scale.

Professor Harald Garrecht, seen here at a test bench of the University of Stuttgart's Institute of Construction Materials.

ELECTROCHEMICALLY, KINETICALLY, OR CONCRETELY?

Together with the Technical University of Darmstadt and Akasol GmbH, the Institute of Construction Materials is currently studying three energy storage technologies more closely. The program, called "Settlement Building Blocks for Today's Residential Areas - New Impulses for Networks of Energy-Efficient Technologies" was launched last December and has three sub-projects focusing on three types of energy storage devices: concrete (IWB), electrochemical (Akasol), and kinetic (TU Darmstadt). Akasol has years of experience in the development and implementation of lithium-ion-battery storage systems for both stationary and mobile applications. Electrochemical storage devices with capacities of roughly six to 30 kilowatt hours are already in existence today, usually paired with photo-voltaic systems and mostly in single-family houses. Now Akasol want to find out whether this is possible on the scale of a building cluster.
This is also the goal regarding the applicability of kinetic storage devices, in which a flywheel mass is used for energy storage, in building clusters. The major advantage of this technology: the energy can be tapped very quickly.
Finally, Harald Garrecht and his IWB colleagues are currently studying the suitability of concrete storage devices as energy buffers for buildings ranging from the single-family homes to whole building clusters. As Garrecht explains, "Concrete functions as a storage medium because it has a high specific heat capacity." For example, the floor slab of a building could be used for this purpose, but only at a low temperature. Other materials, like paraffin or certain salts, have much greater storage capacities. They are also used in pocket warmers: when squeezed while in their fluid states they immediately coagulate and emit heat. Energy storage devices with this kind of phase-change materials could be built on the same principle of reversibility.

PARAFFIN WITH POTENTIAL

Garrecht illustrates the potential of paraffin, for example, with numbers: "A storage device with a volume of one cubic meter can hold enough paraffin to buffer 70 kilowatt hours; that's the energy contained in about seven liters of heating oil." Such a storage device with a volume of two cubic meters in a single-family home could operate autonomously for about four days in connection with environmental heat or a heat pump. The numbers make it clear: the problem consists not only of the storage device's cost but also the storage densities, which in turn determine the needed floor space. As Garrecht emphasizes, "These approaches always require thinking in terms of the system as a whole." In other words: the key is a proper mix of energy production, storage, and regulation in the building or cluster of buildings. "The requirements

for a new building are completely different, for example, from those in which the facade and roof are protected as historical monuments." That makes it difficult to install a photo-voltaic system or insulation. The trick with every building is to make the most intelligent use of energy flows in the building and its environment. In Garrecht's view, concrete and phase-change materials are of interest here "because they can be developed at a reasonable cost and continue to offer much potential for optimization." Before the end of the year, he and his colleagues intend to set up different demonstrator storage devices in order to carry out model calculations and simulations while getting experience in operating them. "The dynamics of energy storage and subsequent use have a make-or-break character with these technologies," says Garrecht, "and that cannot be simulated - or only to a limited degree - without a database gathered from trial runs."

Michael Vogel

Materials research and cultural heritage protection

The entire island of Reichenau and its cloister have been listed by UNESCO since 2000 as a World Cultural Heritage location. Preserving the one-of-a-kind wall frescos in the St. George Cloister Church of Oberzell there is a major challenge due to the island's special climate and its many visitors. Now an interdisciplinary team of restorers, mineralogists, chemists, engineers, microbiologists, materials scientists, engineering physicists and others are searching for a sustainable solution to the problem.

Dirt collection on the painted surfaces increased steadily after a comprehensive restoration in the 1980s, and mold funguses and salts have continued to endanger the delicate frescos. Until now, however, attempts to improve air quality in the rooms met with only modest success. This prompted Dr. Dörthe Jakobs of the Regional Office for Preservation of Cultural Heritage and Prof. Harald Garrecht of the University of Stuttgart's Materials Analysis Department to initiate a more intensive study of the wall materials, the mortar and the frescos and their reactions to variable climatic conditions in the rooms on the basis of a research project funded by the German Federal Foundation for the Environment (DBU). The aim will be to study both the influence of changing seasons in terms of weather, tourism and use and specific peripheral effects of cultivation of neighboring farmland. A core target will be to stabilize the room climate in line with the needs of the church, the crypt, and their furnishings. (Ed.)

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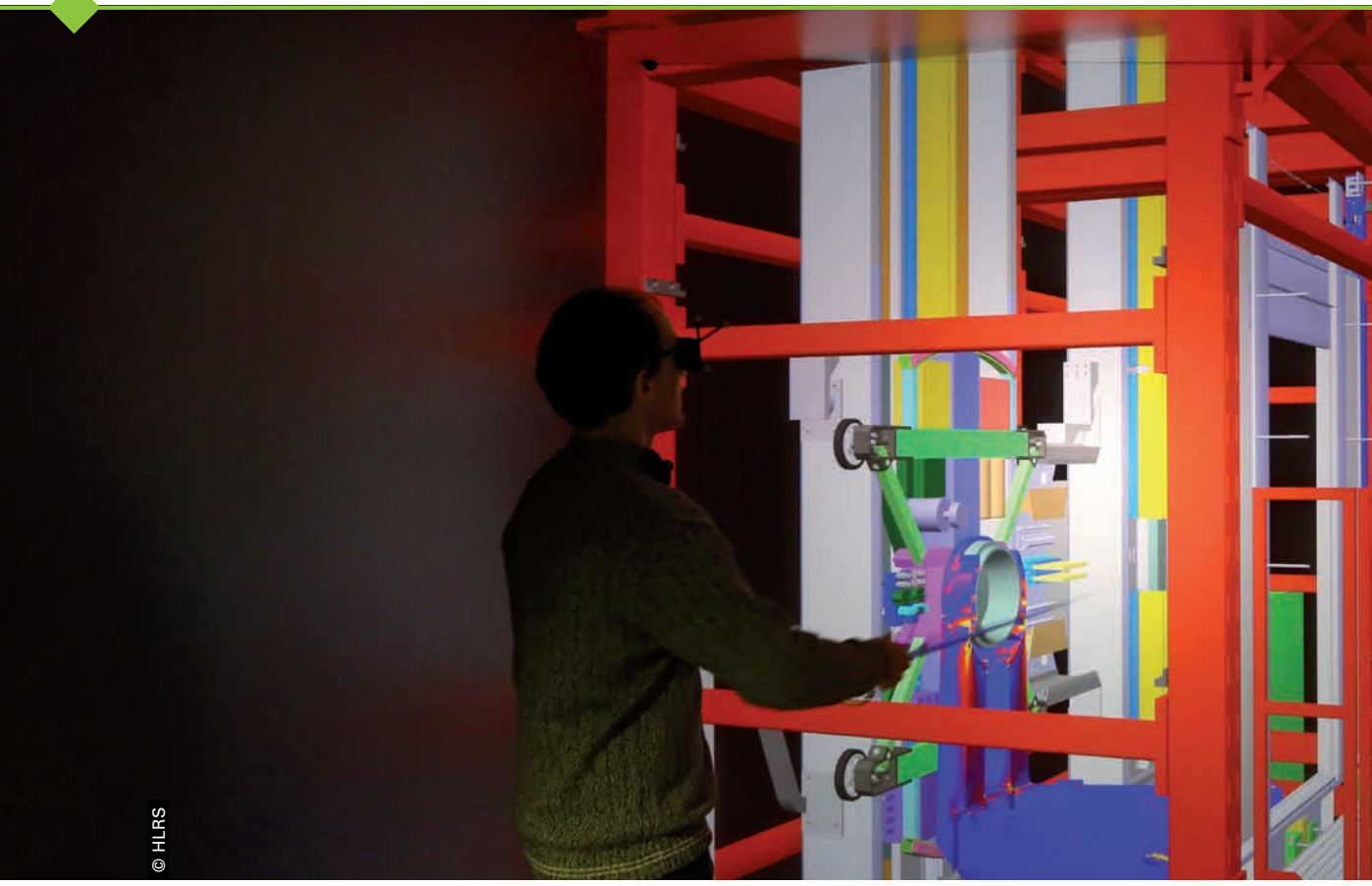
Everything that Dr. Uwe Wössner (right) does with building models at the Supercomputer Center's touchtable is repeated in the virtual reality world seen here behind him - and vice versa.

Virtual Building Blocks

High performance computers create new tools for architects and planners

When developing new products - in this case buildings, city areas, and regions - architects and urban space planners do not even come close to exhausting their technical options in comparison to vehicle developers in the automotive industry. That is why Uwe Wössner does research at Stuttgart's Supercomputer Center (HLRS) on simulations for speeding up the planning, styling, and construction of buildings and even cities and making the process more intuitive. His cooperation partners are schools of higher learning and companies.

"Just playthings," one might think of the model buildings on the touch-sensitive table. This "touchtable" - an over-dimensioned tablet PC on legs, so to speak - is located at the Vaihingen campus's HLRS. The bottom of each model building on the table has a label linked to that model's CAD data. Using this data, the CAVE - a room with 360-degree 3D projection - generates views of the models in which the viewer can walk around freely. "The building models on the table are miniaturized, but their three-dimensional projection is on a scale of 1:1," explains scientist Uwe Wössner, a Doctor of Engineering at the HLRS. "When an architect or an urban planner moves through this kind of virtual setting he gets a much better idea of a building or a row of buildings than any other model can convey." Working together with the University of Stuttgart's faculties for architecture and city planning, Wössner and his colleagues developed this technique for visualization of 3D data just in the last few years. Even though it represents a major step forward, Wössner is not yet satisfied: "We aim to make simulation a standard tool for architects and planners of urban and other spaces," as it is already in the automotive world. Interactive simulation today means the ability to vary the data of detailed 3D models and experience the resulting changes very quickly in the virtual world. "Up to now, for example, the procedure with new construction projects has been to draw up a basic blueprint and commission a firm of consulting engineers to do the calculations for fresh air



ventilation or noise management," says Wössner. If the planner is dissatisfied with the calculations, he has no choice but to change his design and send it back again to the consulting engineers for calculation. For instance, if a new autobahn noise protection wall is planned, numerous optimization loops may pile up until a satisfactory result has been reached.

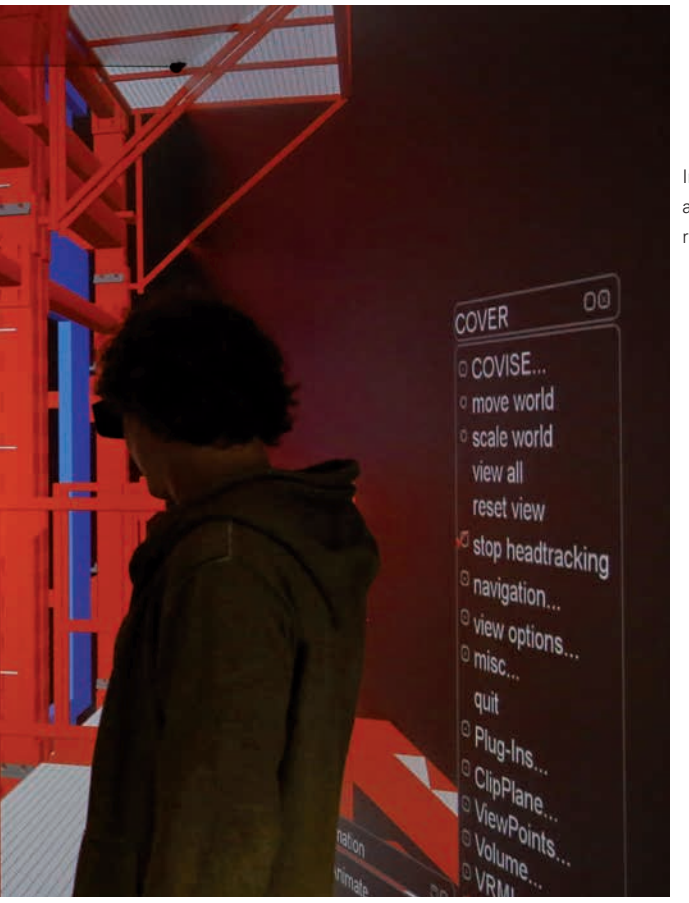
PLANNING CHANGES WITH A PUSHBUTTON

"What we want, on the other hand," explains Wössner, "is to help make it possible with our research to adjust the shape and height of that noise protection wall in future and evaluate it right during the planning phase at the touch of a button."

To simulate such problems, scientists like Wössner break down the digital 3D model of structures and their surroundings into manageable small-volume elements. Then they allow air, for example, to flow into the simulation of one of these small, virtual cells and calculate the effect on neighboring cells. For the computer, this simulation of air currents means that its processors must communicate more intensively with one another. "The more we can keep this communication work to a minimum, the faster we get the results", says Wössner. When a building in a simulated city area is moved on the touchtable, for example, this is repeated after only a few seconds in the virtual 3D environment. But the complexity of calculating such operations can quickly become enormous: whereas a single normal computer can calculate climatic conditions in an individual room, a university computer is required to simulate that of an entire house. And simulation of an urban climate is possible within an acceptable time only with a supercomputer.

INSULATION AND ELEVATOR SHAFTS

Working with scientists of Vienna's TU and the Technical University of Wiesbaden, the HLRS research team has already simulated this kind of complex scenario in urban and spatial planning. "This tool makes it possible to process not only issues of design and physics but also economic ones", says Wössner. One example would be the insulation of all buildings in a city in order to improve the commune's overall energy balance sheet: the city's water and power supply authorities know how much energy is consumed by each building and how it is heated. The building's age is also known from building code documents. After all this information is entered into a digital model of the city, it becomes possible to simulate the benefits that would result if all older buildings were now



Interactive simulation of a new elevator in a virtual reality environment.

insulated. As Wössner says, “That would enable urban administrations or decision-making authorities to see whether this approach is worthwhile - or whether the energy balance sheet might not benefit more if more photo-voltaic systems were to be installed, or if more rows of buildings were to be connected to the gas mains.“

To be sure, urban planning and spatial design are not the only points of departure for the HLRS scientists as they seek to exploit the possibilities offered by modern automotive development. “While it is true that architects design buildings with CAD programs, they still do so for the most part with 2D plans, and only rarely in 3D models,“ says Wössner. “In future, so-called Building Information Models will be used.“ Then building data will include not only the dimensions of rooms and walls but also, for example, the composition of the walls and even the physical characteristics of the masonry and the plaster - e.g. thermal conductivity or sound conduction. Bringing together all this data will facilitate the wide range of adjustments required during the planning and operation of a building. “We’re working with the Wiesbaden Technical University to link this kind of Building Information Model with virtual reality environments,“ says Wössner. The aim is for changes in the virtual reality environment to appear immediately in the CAD drawings, and vice versa - without the need of manual input.

Thyssen Krupp offers an example of how companies can benefit concretely even today from such visualizations. It manufactures elevators, among other things, and in this context is developing brand-new concepts for reducing maintenance and transportation times as well as spatial requirements in a building. The HLRS virtual reality environment has an important role in this. “Thanks to it,“ says Bankolé Adjibadji, a research engineer and project director at Thyssen Krupp Elevator Innovation GmbH, “we can show and discuss the functions and outward appearance of our elevator concepts without expensive, time-consuming prototypes. “That reduces costs and shortens market introduction times for the products because we can implement innovations more quickly.“

Michael Vogel

No Waste, No Noise, No Dirt

Ultra-efficient factories will bring production back into the city

High-speed urban growth will also affect the factory of the future. Production plants are slowly drifting back into population centers in order to shorten employee's travel times as they come to work. To keep these production plants from spoiling people's life quality, they must work especially cleanly. How to achieve this is being researched by Professor Alexander Sauer, Director since January 2015 of the University of Stuttgart's Institute for Energy Efficiency in Production (EEP) together with the Group for Development of Efficiency Systems at the Fraunhofer Institute for Production Technology and Automation.

Although it stands in a residential area, the big building is very unobtrusive. It is no higher than a family house, with softly colored facades. All around it is a garden with a pond. People dressed in work clothes are scattered around the grass during work breaks. The area could almost be a leisure time oasis. But only at first glance, because work is going on inside. "This is how production plants might look in the distant future," says Professor Alexander Sauer, Director of the Fraunhofer Institute for Production Technology and Automation and the University of Stuttgart's Institute for Energy Efficiency in Production (EEP). Together with other Fraunhofer institutes and industrial partners, Sauer is carrying out research on the idea of an ultra-efficient factory: a production plant which runs only on renewable energy, generates neither waste nor noise, and whose products are completely recyclable. And which can merge effortlessly into any residential area.

What Sauer describes is still only a vision. A vision so distant and fantastical that it's hard to believe his idea. But he and other scientists remain convinced that future industry will have no other choice but to gravitate more and more towards ultra-efficient production.

One reason for this is metropolitan growth all over the world. Greater Tokyo, for example, has almost 40 million residents - as many people as in half of Germany. Residents in Shanghai, New Delhi or Mexico City today can no longer travel daily through these population centers in order to reach a production plant on the city's periphery. "As a result, we see industrial plants moving their locations more and more towards the center." But this harbors dangers such as poor-quality air, noise, and heavy-duty traffic.

The trend is therefore towards production plants with "a more human face". The first companies are already experimenting with this. They paint their outer walls colorfully and create parklike grounds. In doing so, they are attempting to integrate their locations into the cityscape. However, "Delivery traffic still remains an unsolved problem," says Sauer. Depending on what products are being manufactured, dozens of trains or trucks must be unloaded daily as they bring materials. Perhaps one day they will reach their destinations by tunnel or be able to deliver lightweight materials by drone. But it will be a while, admits Sauer, before that happens.

There's even more to say in favor of the ultra-efficient factory. Fossilized sources of energy like coal and gas have their limits, and the problems of man-made climate change are also making it necessary to reduce carbon dioxide and other greenhouse gas emissions. "We will never reach our future economic targets unless we de-couple resource consumption from growth," says Jörg Mandel, a Doctor of Engineering and Director of a project sponsored by Baden-Württemberg's Ministry of the Environment which has precisely

Ultra-efficient factories are to function so sustainably that they do not disturb neighboring residents.

this goal. Ultra-efficient factories will hopefully function in future only with non-fossilized energy. The energy revolution in Germany is at least bringing this target somewhat closer. According to the will of the federal government, 80% of all energy generated is to come from renewable sources by 2050.

The concept of the ultra-efficient factory goes even farther. It envisions that companies will generate energy as far as possible on location. For example, companies could again locate themselves more on the banks of rivers. Not, however, in order to discharge wastes into them, as was the drawing card aim in the past, but in order to generate electricity from hydraulic power, or with their own windmills or solar plants.

Many presently unused sources of energy are also present in any production plant. Sauer insists that the energy generated during production should be captured and stored so that it can flow back immediately into the production process: "That functions more or less effectively depending on the type of operation," he says. In a production plant where metal is melted down, for example, the useable heat given off has a higher temperature than in a plant to which modules are merely delivered for assembly.

Companies interested at present in the ultra-efficient factory project are above all those with a high rate of energy consumption. One of them is metal refinery Rieger in Steinheim, in Swabia's "Alb" hill district. "Energy consumption represents one-fourth of our total costs," says Senior Owner Franz Rieger. The production plant uses electrochemical techniques to coat metal surfaces and make them more resistant. The parts delivered by customers are immersed, for example, in successive baths where copper, nickel and chrome are electrochemically precipitated. This requires interim rinsing cycles. Although the process now runs for the most part automatically, Rieger and his son Alexander are constantly on the lookout for new possibilities for increasing the efficiency and effectiveness of the process and preventing mixtures of chemical substances from passing from one immersion basin to the next.

THE CONCEPT INCLUDES ALL PRODUCTION FACTORS

When all is said and one, the concept of the ultra-efficient factory embraces much more than a set of instructions for saving energy. "It extends to all production factors", says Professor Sauer: materials, human resources, capital and output - everything required to keep an industrial process running must be trimmed for greater effectiveness and less consumption of resources. That can be achieved, for example, with new production techniques, the installation of a decentralized energy supply, networked storage systems, or even

completely new techniques of energy production. "Energy Harvesting" is one of the methods which may one day make it possible to "harvest" tiny amounts of energy from surrounding temperatures, air currents or vibrations. The current thus won can power low-output devices on location or flow into the super-fast recharging batteries on which many development centers are now working.

The principle of "recuperation" is similar. It is already used in automobiles with incipient hybrid technology, where the energy generated during braking is captured and fed into the battery. From there it powers a second, electrically powered motor which relieves the load on the vehicle's combustion engine. Similar solutions would be possible in production plants where heavy objects must be cushioned when lowered to the ground. This energy could be harvested and used elsewhere. High-bay racking systems would be a possible field of use.

Small, previously unused amounts of energy are also important where questions of networked production are involved - a central element of the ultra-efficient factory. The idea behind this type of production is that all stations involved in the production process are in constant contact with one another. A robot worker will know the location of materials which it has ordered. In addition, the electronic system must record every movement to make it clear what is being produced, when, and where.

This will require hundreds if not thousands of sensors. Should that require the installation of electric cables in advance, it will no longer be worth the trouble. "But it looks different when sensors can power themselves," says Sauer: if they were able to convert vibrations or air currents into electricity, they could be used easily and flexibly at any location in the production area.

Next to production, other uses of energy play a key role in the ultra-efficient factory. The potential is enormous, but many companies have still not recognized this. That was made clear by a survey carried out by Sauer's institute together with the Fraunhofer IPA, the German Energy Agency, the Rhineland TÜV Association, and the German Industry Federation. More than half of the smallest and smaller companies said that energy efficiency had only a minor role for them. 40 percent of medium-sized and large companies assigned major relevance to the issue. Many of those questioned gave as a reason that amortization times were too long.

Professor Alexander Sauer, the University of Stuttgart's new Director of the Institute for Energy Efficiency in Production.

ENERGY EFFICIENCY HAS ROOM TO GROW

But it is still the case in many companies that energy efficiency is given little serious attention when products and processes are in preparation. "It is often screened out to keep planning processes from being even more complicated than they are now," says Sauer. But that may change due to smart, networked business models that closely monitor energy consumption, among other things. These cyber-physical systems would be in a position to calculate energy consumption in all parts of the production area in advance and coordinate this with actual production. Sauer

Energy and efficient use of resources will also play a major role in the production plant of the future, which is now under study at the University of Stuttgart as part of the ARENA2036 project.

names the theoretical example of a plant shop in which smoke develops during a smelting process. Today, in a case like that, the expelled air is permanently suctioned out of the hall or, in the best case, sensors detect the gas and then turn on the air evacuation system. In contrast, a networked production system would calculate the time for opening the oven with the help of sensor signals. The air evacuation system could be ramped up even before the firing process ends, and the smoke would have no chance to spread. This would not only save energy but would also protect the health of the workers. Similar methods could be used reduce emissions of harmful substances – an especially important issue if production plants and residential areas are to come closer together.

Material handling methods will also play a key role in the ultra-efficient factory. The basic principle is that everything which enters the plant may leave it only as a product. No waste is to land later in the incineration unit or at a special-waste site. Everything left over is to go back into production. This project therefore also involves issues like material circulation loops or a decentralized supply of raw materials.

Thrifty use of materials can begin, for example, with very simple processing steps. When metal parts are stamped, they leave metal remnants behind.. This could be avoided, for example, if the required parts were to be formed from the beginning in the right size after the materials have been smelted.

Waste also arises from the delivery of components. Every day in many production plants, machines must shred hundreds of kilograms of cardboard packaging which previously contained sensitive parts. Even if the cardboard remnants are to be recycled, the accumulation of packaging wastes will be avoided from the very beginning in the ultra-efficient factory. For example, components could be delivered in reusable packaging, which would go back and forth between the sender and the recipient. Inserts of biologically degradable plastic would protect the parts. Up to now, plastics have mostly been produced from petroleum. But materials based on vegetable oil would not only decay more easily but could also be quickly regrown. Recycling has already been a central issue for company man Rieger on the Swabian Alb for many years. When the waste water produced during electroplating processes is collected, a metal-containing sludge is produced and in former times landed at disposal sites for special wastes. This procedure can not only be worrisome for the environment but also wastes valuable raw materials. “We’re talking about synthetic ore,“ says Rieger. The proportion of raw materials in electroplating wastes is usually greater than in the rock layers of a mine. For that reason the company has been looking since the 1990s for ways to recycle such materials in stead of throwing them away.

It is still a long way to the ultra-efficient factory, says Rieger. But change always occurs in many small steps. With this in mind, his company put a solar energy system into operation a good four years ago and switched production last year to green electricity.

Production expert Sauer cannot say when the ultra-efficient factory will become reality. But technical leaps can often come unexpectedly. One example is the 3D printer, with which ever-more complicated components can take shape. Sauer smiles. “Why not a whole factory building someday?“

Heimo Fischer

Energy From Kitchen and Garden Wastes

Spurring biogas production with organic waste bin laws

Green electricity from biogas! Sounds good, if it weren't for all the talk about energy foodstuffs - corn above all - that are fermented for biogas. Don't they take up valuable farmland that would be better used for planting eatable crops? The question becomes moot when operators of biogas facilities make biogas from biological wastes that accumulate daily in the kitchen and garden. Since January 1, 2015, communes are obligated by law to collect them separately. Will a "biogas Boom" follow the expected increase in biological waste?

According to the Federal Office of Statistics, Germans last year threw some nine million metric tons of spoiled fruit and vegetables, old bread, other biological kitchen wastes, and cuttings from trees or lawns into their brown garbage containers or brought them to biological collection centers. Currently, it is estimated that another two to five million tons of biological wastes could be added if every household had an organic waste bin in front of the door and its biological wastes no longer landed in the bin for residual wastes, the family compost heap in the garden, or the sewers. According to the Federal Office for the Environment, however, 48 percent of private households in Germany still did not have an organic waste bin in 2012.
About 60 percent of all collected biological wastes rot without exploitation of their energy in composting systems and end up as natural fertilizer on fields. "Instead of classical composting, biogas production with subsequent composting will come more and more to the fore," prophecies Martin Kranert, Professor at the Department of Solid Waste Management and Emissions. What's behind this is what experts in the field call "bio-economy". It could reduce dependency on petroleum by producing both consumables and energy from replenishable raw materials. These, in turn, would be used sparingly and utilized completely, as far as possible, including the biological wastes.
In July 2014, Baden Württemberg's Ministry of Science launched "Bio-Economy", a research program with a focus on the uses of biogas, biomasses from wood, and micro-algae as a source of nutrients. The University of Stuttgart is carrying out 11 of the program's 45 projects. For example Lea Böhme, a member of Kranert's department, is doing research to find out how much biological waste each person in Baden-Württemberg does in fact produce.

IT BEGINS AND ENDS WITH WASTE SORTING

To do so, doctoral candidate Böhme goes to different waste disposal plants in the Stuttgart area and sorts through organic waste containers and residual wastes bins brought there by waste collection trucks, each from its own designated settlement area. "We still don't know how much biological waste is in fact accrued, because attention is usually paid only to the amounts collected from organic

Environmental engineers Lea Böhme and Anna Wagner (left to right) aim to convert biowastes into valuable gas.

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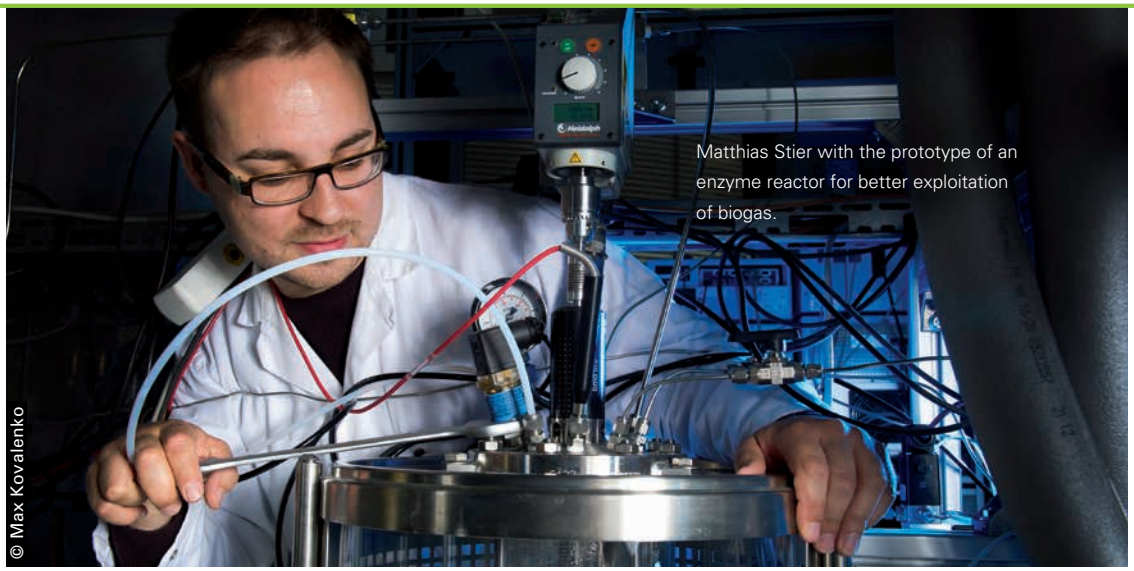
waste bins and greenery cuttings," says Böhme. As an Engineer for Environment Protection Technology, she also wants to know the composition of what is in the "brown containers" and how it changes during the course of a year. "In winter I find mostly kitchen wastes in the organic waste bin; in the spring and summer I find large quantities of grass, and in autumn mostly leaves," says Böhme. She then links this data to characteristic features that influence what lands in the organic waste bin. It depends, for example, on whether an urban area has many single-family homes with large garden areas or whether mostly childless families or singles live there. Tree branches and twigs from bushes, for example, do not ferment into biogas as well as kitchen wastes. "Biogas producers can apply this data to areas occupied by similar units in future in order to estimate how much and what type of bio-wastes can theoretically be expected and then determine accordingly how best to adapt their facilities," reports Böhme. "To ensure that biological wastes are in fact collected as they accrue, waste disposal companies will have to make organic waste bins available inexpensively, and people will have to sort their wastes correctly," states the 27-year-old matter-of-factly.

BIO-WASTE IS NOT ALWAYS BIO-WASTE

For example, plastic bags in the organic waste bin could disrupt the delicate process of putting biological wastes to use in the form of biogas and compost. Even unadulterated biological wastes give the bio-system operators headaches: "Depending on the composition of biological wastes, we find enormous variations in the quantities and quality of the biogas which is produced", says Anna Wagner, who is carrying out yet another project in the bio-economy program.
Wagner, a doctoral candidate in Kranert's department, carefully examines the biogas waste-processing plants - for example to determine the quality of the basic material undergoing degradation by microorganisms into biogas in air-tight fermenting containers. She also studies the quality of conditions for the microorganisms and how much energetically useable methane is present in the biogas. Her aim in doing so is to determine how the operators of biogas plants can reduce maintenance to a minimum while still producing large quantities of high-quality biogas, using less electricity, and making efficient use of biological waste materials. In contrast to the wet fermentation of liquid manure, gas from biological wastes, whose dry contents can amount to as much as 30 percent of their substance, is usually processed with dry fermentation.
Wagner studies the three most common types of fermenters: both horizontal and vertical plug-flow fermenters, in which a "plug" passes through the biological wastes within two weeks, and a



Matthias Stier with the prototype of an enzyme reactor for better exploitation of biogas.

© Max Kovalenko

"garage"-type fermenter which is filled to the brim with biological wastes and emptied out again after the fermentation period has ended. "I doubt that any one technology will turn out to be the most efficient", says engineering student Wagner. The important thing is rather to gain an overview that shows which technique makes the most sense in which situation. For example, biosystem operators normally squeeze the fluid out of fermented residues and use it as liquid manure on planted fields. The solid fermentation residue which remains is aerated on compost heaps and then processed by microorganisms once more into compost. But as Wagner explains, "Cattle-raising areas which produce large quantities of liquid manure for fertilizing the fields have no use for this presswater." In this case a "garage"-type fermenter might make more sense, since it produces less liquid. Matthias Stier takes the idea of bio-economy yet a step farther: "75 percent of biogas remains unused," says the Director of the Interfacial Technology Group at the Institute of Interfacial Process Engineering (IGVP). The reason: only about half of it is methane, which is usually burned in block heating and power stations to generate electric current and heat. Most of the rest consists of carbon dioxide which escapes unused from the smokestacks. Biogas-generated heat and current are also not always purchased by consumers, as when the block heating and power station is far distant from the buildings to be heated, or when a surfeit of current from solar energy systems is already flowing through the mains on hot summer days. As Stier says with emphasis, "In that case we burn the biogas senselessly".The ideal solution would be to feed unused biogas back into the natural gas network. But then methane would have to be isolated and compressed in a complicated process. According to the Association of Biogas Producers, only 144 of 7,850 biogas plants took this route in 2013. Together with scientists from the Leibniz Institute for Catalyzation in Rostock and the University of Halle, Stier is conducting research to find how surplus biogas can still be put to use. In the context of a project funded by the Federal Ministry of Education and Research they create methyl alcohol (methanol) and formic acid by allowing methane from biogas to react with the unused carbon dioxide.

USING BIOGAS TO THE FULL

Methanol and formic acid are important raw materials in the chemical industry. But methanol also serves as fuel in racing cars and can be used in fuel cells to produce current whenever it is needed. And formic acid is used by beekeepers, for example, to treat bees for protection against varroa mites, and it also serves to decalcify washing machines. "The major advantage of liquids over biogas is that they need not be transported in high-compression containers," says Stier. Although chemists have tried for decades to produce methanol from methane, the yield to date has been disappointing. Instead, it is possible to produce roughly four times as much formaldehyde from methane. Formaldehyde is used, for example, in the furniture industry. It therefore occurred to the project's associated scientists that this "roundabout" route might be useful, and they combined chemical catalysis with an enzyme reaction: The soil bacterium Pseudomonas putida produces an enzyme which converts formaldehyde into methanol and formic acid. After isolating the enzyme, Stier created optimum conditions for it to work in a reactor and developed methods for isolating the methanol and the formic acid from one another. Last year, the results prompted the Baden-Württemberg Foundation for Energy and Climate Protection to award its First Prize to this young researcher.

Helmine Braitmaier

© Doppelmayr

Urban high-wire systems like the network completed in 2014 in La Paz, Bolivia, are playing a greater role in the urban public passenger transportation systems of thickly populated metropolitan centers. Scientists in Stuttgart want to make this concept more flexible by extending it to goods transportation, thus relieving congestion in German streets as well.

Up in the Air

Hybrid high-wire systems could become part of public urban transportation

High-wire systems are often tourist attractions. But scientists in Stuttgart also see in them a potential solution to urban traffic problems. Still, there are obstacles.

Pallets loaded with packages, swinging their way above the Stuttgart valley below and bringing their contents to the city center – quite a realistic scenario for Konstantin Kühner, Director of the Task Force for Destructive High-Wire Testing at the University of Stuttgart's Institute of Mechanical Handling and Logistics (IFT). "We envision trucks delivering their packages outside the city to a terminal with an automated warehouse. If there are no passengers for the high-wire system, then the packages will be transported. We could save many trucks in the city in that way." Such a high-wire systems could be developed within one year, and building it would take another. Provided, of course, that the project is given the green light. But precisely there is the rub. Although this means of transportation is one of the world's safest, can cross heterogeneous types of terrain cheaply and effectively, is relatively quiet, and consumes little energy, putting it into practice often stumbles "over the hurdle of its own novelty, since there is almost no experience of it in urban spaces, and basic planning for it is almost nonexistent," says Kühner. He and his colleagues aim to change this with a research project. A first step has already been taken by winning approval from the Federal Association for Logistics. Now the researchers are hoping for further funding. They want to study how a hybrid high-wire system that can transport both people and goods compares with other forms of transportation in terms of technical, economic and ecological criteria. No such comparison has been carried out to date, and parameters must first be established which will enable urban planners to carry out a general evaluation and comparison. In addition to issues involving construction, operating costs, transportation capacity, and availability, an important question will also be whether suppliers would support such a systems changeover. It is precisely the combination with goods transportation which the researchers view as both an opportunity for growth and environmental friendliness. For many years, major cities have operated smoothly-functioning bus systems that bring people to higher locations - meaning that urban planners have had no reason to change their way of thinking. "Offices which have experience with urban high-wire systems are almost nonexistent," says Kühner. Nor has an interface yet been developed between high-wire builders and urban planners. The same is often true of changeovers to other forms of transportation because existing high-wire systems are not freely accessible and are not directly connected with city transportation systems. "But better connections would be possible today," says Kühner, and points to ski resorts. Finally, no funding is presently available from public administration coffers. But Kühner is hoping for fresh wind in this area, not least because at the end of 2012 the German State of North Rhine-Westfalia became the first to explicitly name high-wire systems in its Public Transportation Law (ÖPNV) and thus ranked it directly as worthy of funding. "It would be great to have a law like this in Baden-Württemberg as well," he says. "But perhaps the idea will not be taken really seriously until a major city builds a high-wire system."

Julia Schweizer

Is space an alternative when the City of the Future becomes too crowded? Years will have passed by the time astronauts embark on their way to Mars. But scientists at the University of Stuttgart are already developing life-sustenance systems to ensure nourishment and oxygen during missions which may last for years.

It looks so easy in the movies: astronauts sit there comfortably in a stylish lounge, and if one of them has sudden hunger pangs, he just presses a button. After a few seconds of humming and buzzing, a tasty meal is in front of him. Jens Bretschneider and his colleagues at the University of Stuttgart's Institute of Space Systems (IRS) can only smile at such Hollywood ideas. The reason: astronauts on their way to Mars will probably have to do without veal cutlets with French fries and salad. Researchers at the IRS are coming step by step closer to the optimum space diet: not least in importance on the menu will be: algae, fresh-grown on board the spaceship! Bretschneider reaches into his desk drawer and pulls out a package of dark-green granulated material. "These are spiruline algae, try them!" says Bretschneider, a doctoral student from Dresden, and shakes out a few grains into the visitor's hand. The dried algae taste nutty and a little salty. Nothing that would rejoice a gourmet, but certainly an important, natural source of protein.
Bretschneider uses a simple example to answer the question why nutrients like algae, unusual at least for the European palate, should be part of the basic menu during space flights: a flight to Mars will take about 300 days, after which the astronauts will conduct research on the planet for about the same length of time and then fly back for nearly another year. That quickly makes it clear that it will be impossible to send up enough provisions with them into space, especially since spaceships always have a dearth of room. Thus the idea is almost automatic that astronauts should also become part-time food producers. Algae can make this especially effective.
Two "photo-bio-reactors" currently make soft blubbering sounds to themselves in the research

An experimental setup at the Institute of Space Systems (IRS)..

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IRS team member Jens Bretschneider at a photo-bioreactor in which living microorganisms flourish with the help of light.

group's laboratory. When this clumsy name is broken down, it turns out to reveal containers in which living microorganisms flourish under the influence of light. In the reactors, which resemble strange-looking bathwater boilers, gas bubbles move about through a dark-green liquid - or to put it more precisely, a mixture of micro-algae and a nutrient culture. "Here is our favorite alga, the Chlorella vulgaris", says Bretschneider. A single-cell green alga, it is very easy to care for and eat, with a high percent of protein. The algae are irradiated in the laboratory with artificial light. How they can receive sufficient photons later on in space to spur them to multiply abundantly has still not been decided. Approaches that include coating the reactor's surfaces with organic light-emitting-diodes (OLEDs) are under discussion.

TESTED UNDER WEIGHTLESSNESS

Currently, however, the researchers have other challenges. As Bretschneider explains, "This kind of test reactor would be far too small to provide a human being with protein." In addition, the test reactor and its spontaneously rising gas bubbles could not function without gravity. For that reason another reactor system in which a pump carefully stirs the nutrient culture was tested in 2014 during about 30 seconds of weightlessness in a parabolic flight. The aim now is to improve the pump's performance to a point where the algae and the nutrient solution (similar to seawater in the case of Chlorella vulgaris) flow uniformly. In addition, the system's footprint must be reduced to a minimum and must run so stably that the astronauts need to check it at most only occasionally.

Other research efforts are underway parallel to this, especially since the photosynthesis upon which algae production is based has welcome side effects: it absorbs carbon dioxide from respiratory air on board and simultaneously generates oxygen. This can not only be added to the respiratory air but can also be converted with hydrogen in fuel cells to electrical energy and heat.

Bretschneider thinks that in a few years these systems could be far enough advanced for a test flight to the International Space Station (ISS). It will be 2025 at the earliest before they are mature enough for use in a long-term flight in space - but in any case there will not be a Mars mission before that time.

Jens Eber

Stuttgart 20-20

Underway to the Energy-Optimized City

"20 - 20 - 20" - a simple formula of the European Union that has consequences for Stuttgart too: greenhouse gas emissions and energy consumption are to drop 20 percent from their 1990 levels by the year 2020, and the share of renewable energy is to rise by 20 percent. How can a city like Stuttgart reach these targets? Scientists from the University of Stuttgart are helping to answer this question.

The 20-20-20 formula sounds simple, but requires many decisions. Decisions that need to be well thought-through. The research project "City with Energy Efficiency - SEE Stuttgart" under the overall direction of the city of Stuttgart intends to make a contribution to this. Five institutes of the University of Stuttgart, along with the Fraunhofer Institute for Building Physics (IBP) and energy provider EnBW, are participating in this project, which will run until next year and is funded by the Federal Ministry of Education and Research (BMBF). SEE is the approach chosen by Stuttgart in the "Energy-Efficient City" competition sponsored by the BMBF. In addition to the regional capital of Stuttgart, four other cities have scored top points in the BMBF competition. Stuttgart has already had success in implementing different energy measures in the past. These include, for example, an energy management system for the city's own properties which led to a significant reduction in their consumption of energy and water. The Fraunhofer IBP and the University of Stuttgart have already made contributions in this area in the past in the form of different studies, for example regarding the potential uses of biomass or geothermal energy. As Dr. Jürgen Görres, Director of the City of Stuttgart's Department of Energy and overall Project Director of SEE says, "With SEE we want to expand our spectrum of approaches and develop a strategy for the whole city." Stuttgart's hands are tied to a certain extent, however, because the city's administration is directly responsible for only four percent of all energy flows within the city limits and has no direct influence over the other 96 percent. "That makes it all the more important for us to get scientific support for a target like the energy revolution," says Görres. "That way we can ensure that latest developments in the energy area are implemented as quickly as possible." Professor Markus Friedrich of the Institute of Road and Transportation Science (ISV) and SEE Coordinator for the institutes of the University of Stuttgart, formulates the target from a scientific point of view: an analysis of how energy is made available and used in Stuttgart, the regional capital. This is done by pursuing the question of what happens "energetically" in the city area and how Stuttgart's inhabitants make use of energy. SEE began by taking inventory: how is total energy consumption in the city of Stuttgart to be allocated to the various sectors? That is, how much is accounted for by households, industry, traffic, the trades, retail, and services? And which sectors rely most on which sources of energy? Traffic, for example, relies primarily on fuel, households above all on gas, and industry takes up an especially high share of electric current. As Friedrich explains, "This data has been input into a macroscopic model balance sheet which serves not only for us in the project but also for the city in future as a basis for our work." Parallel to this the teams recorded the data of all present practices which have an impact on energy use in the city area, along with ideas which could


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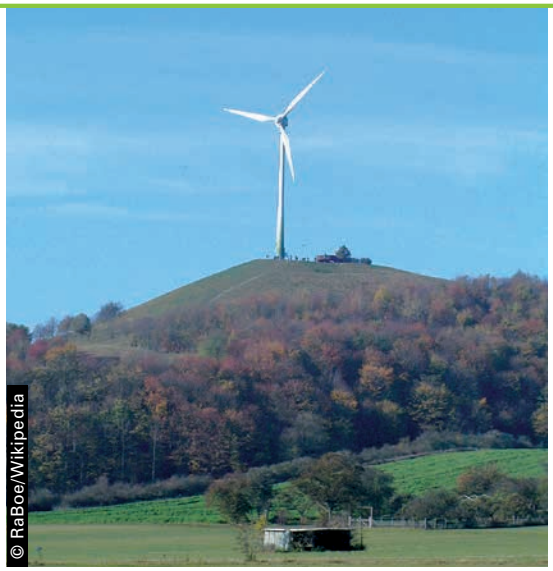
In order to implement Europe's climate targets, the ways in which energy becomes available and is used in Stuttgart is under study as a whole. Traffic is one of the areas involved.

have a positive impact on future energy consumption. The resulting spectrum was huge, ranging from parking space management down in the Stuttgart valley to the uses of waste heat and the subsidized replacement of "electricity gluttons" in private households and on to the idea of gratis public transportation. Some 70 possible courses of action came together in this way and were analyzed. Also taken into consideration were the probable investment costs, the costs of ongoing operation, and the potential for saving energy.

POLITICALLY NEUTRAL

"Estimating the impact of courses of action is a complex task, especially since the actions may be dependent upon one another - quite independently of their political feasibility", says Friedrich. It is no accident that the scientists in the project confine themselves to analysis, since there are "no actions without side effects," as Friedrich puts it. "That is why we researchers view our collaboration in SEE as a scientifically grounded decision-making aid. We voice no recommendations and award no political points." Both are then left up to the political arena in the context of urban discourse.
Friedrich illustrates his meaning by using the example of automotive toll collection and its impact on individual drivers: "Model studies have shown that passenger car travel can be best reduced by large-scale monetary measures," says Friedrich. "But then urban traffic administrators would have the thankless task of proposing measures which would be greeted only with subdued enthusiasm." And the analysis of energy consumption involves not only the macroscopic level but also a microscopic one - the notorious traffic behavior of Stuttgart's inhabitants. During the project, the researchers interviewed 700 households in detail about the energy situation of their property, the existing electrical household appliances, mobility practices, socioeconomic factors, and attitudes regarding saving energy. The interviews went hand-in-hand with detailed advisory services. It was found that although individuals may have a heart for technical or money-saving courses of action, they have a strong distaste for painful measures. "For example," says Friedrich in order to illustrate, "the persons interviewed were well able to envision a more efficient form of ventilation or a lower room temperature, but hardly any of them intended to renovate their buildings in the near future."
ISV scientist Friedrich goes on to say, "We're now using this comprehensive data and Stuttgart building models to develop a model with which we can run different scenarios in detail. We want to take into consideration available household incomes, possible energy price reductions, and different technological courses of development in these scenarios."



This windmill known as "Green Heiner" on Autobahn A81 could be replaced with a higher-performance wind power facility. It is one of the few available sources of renewable energy in Stuttgart.

1,000 RENEWABLE ENERGY GIGAWATT HOURS NEEDED

The goal of Dr. Ludger Eltrop and the University of Stuttgart's Institute of Energy Economics and the Rational Use of Energy (IER) within their part of the SEE project was to increase the share of renewable energy in the urban energy supply to 20 percent. Concretely, this scientist and his colleagues used different scenarios to study how best to reach this target. In 2012, the entire consumption of energy by end users in Stuttgart was 13,000 gigawatt hours per year. 10 percent of this came from renewable energy sources. A good 1,000 gigawatt hours from renewable energy sources will be required in order to reach the renewable energy share targeted for 2020 - together with the parallel target of a 20 percent increase in efficient energy production: whether from photo-voltaic systems, solar-thermal heat, wind, water, biomass, or geothermal energy.

As Eltrop says, "The restriction of remaining within the municipality of Stuttgart means that the city can influence many of these renewable energy sources only to a limited degree." For example, Stuttgart has only a few parcels of land which could be used to generate energy from biomass. That basically leaves wastes as the only possibility, but then wood pellets, for example, would have to come mostly from outside the city limits. The potential sources of wind energy too are only scattered. Eltrop says, "Only one area now remains out of those originally identified by a regional association as potential locations in Stuttgart: the "Tauschwald" area in Stuttgart's northwest. Another option would be to replace the windmill on the "Green Heiner" hill on the municipal border of the suburb of Weilimdorf with an even bigger power plant. Moreover, the potential for hydraulic power within the city's borders is already nearly exhausted. And the expansion of photo-voltaic systems and solar-thermal heat has also slowed considerably, "because surrounding conditions are currently no longer very favorable, and many of the areas of interest are already taken," explains Eltrop. For that reason, and his colleagues came to the conclusion that if Stuttgart wants to reach its target for renewable energy it has almost no choice but to procure green electricity from the region and even beyond, for example by investing in projects for renewable energy generation – "in addition to systematic utilization of the inner-city's remaining potential for renewable energy, the implementation of block heating and power station projects in the city, and the purchase of biomass from the region for operating a wood-burning heating and power plant". But Eltrop knows that this result is not always greeted kindly even by citizens who are all in favor of the energy revolution.

Last December, City Mayor Fritz Kuhn presented the draft of an energy concept for Stuttgart which included many of the SEE insights. Now the trick will be to bring all the relevant key performers under one roof in order to bring the concept down to the grass roots, as Kuhn said at the time. For that reason, the City Fathers will initiate a discussion of the concept on different levels: within the City Council, with the citizens, and with key persons in the worlds of business and research. After undergoing revision, the energy concept will then be adopted by the City Council so that its implementation can begin as soon as possible.

Daniel Vogel /amg

The underground sewerage system of the University of Stuttgart's Teaching and Research Wastewater Treatment Plant, with Professor Heidrun Steinmetz (2nd from right) of the Department of Sanitary Engineering and Water Recycling and (from left) Karen Mouarkech, Anna Bachmann, Dr. Ullrich Dittmer and Dr. Birgit Schlichtig.

Secret Waterways

The City of the Future also calls for underground rethinking

Climate is not the only thing that will change in future. Already today, some cities are struggling with a shrinking and ever-older population. Such changing living conditions will also require adaptation of the underground water supply networks and wastewater lines. On the other hand, underground space is getting tighter all the time. Researchers from the University of Stuttgart are searching for solutions to water use and management in the City of Tomorrow.

It was July 28, 2014. A sudden cloudburst in the city of Münster flooded thousands of basements and apartments. Up to 292 liters of rain per square meter fell within a few hours. The region's local Office of the Environment said this was one of the highest levels ever recorded in Germany. And such extreme downpours as this one in Münster will become ever more frequent in future. As Birgit Schlichtig of the Department of Sanitary Engineering and Water Recycling explains, "In such a case our wastewater systems quickly become helpless because of their limited capacity to absorb water." The rainwater flows into storm drains and on into the sewer system, where in our part of the world it is usually conducted to wastewater treatment plants; there this so-called "mixed water" is purified and then fed into nearby rivers.

However, the capacities of wastewater purification plants are limited. In most cases, therefore, part of the rainwater is stored for the time being in rain overflow basins and sent to the wastewater purification plant only when the rain has stopped. For economic reasons, however, rain overflow basins too cannot be constructed as large as one might like. It is unavoidable that water from the basins overflows during a hard rain and passes untreated into nearby bodies of water. "That is especially a problem for these bodies of water on hot, dry summer days, which will be even more common in future," says Schlichtig, "because then they carry less water." Microorganisms, contaminants or nutrients from the effluents are then present in

the bodies of water into which they are released in higher concentrations. As a result, fish may die and algae may proliferate out of control due to overfertilization.

SOMETIMES TOO BIG, SOMETIMES TOO SMALL

In order to divert every rainfall, wastewater pipes big as tramway tunnels would have to be built, and wastewater treatment plants would also have to be several orders of magnitude larger than now. On the other hand, the population is shrinking and therefore produces less wastewater, which in turn would be inadequate to flush fecal matter into the over-dimensioned pipes. Storm drains would begin to stink and would have to be flushed out with precious drinking water. As Ulrich Dittmer, Director of the Work Group for Urban Water Removal explains, however, it would be prohibitively expensive to adapt the diameter of wastewater pipes to the respective needs. In the greater Stuttgart area alone, the hidden waste water network covers about 1,700 kilometers.

Scientists are now going in a new direction in the collaborative project "Steps Towards Adaptable Management of the Urban Water Supply", or SAMUWA for short. Dittmer is the Director, Schlichtig the Coordinator of this project, funded by the Federal Ministry of Education and Research.

MISTRESS OF RAINFALL

In one part of this project, for example, Anna Bachmann and other scientists are studying the benefits of a water network drainage control system as a means of mastering such massive rainfalls. This system has been operating in Reutlingen since August 2014 and optimizes inflows to the wastewater purification plant. "We are trying to reduce the amount of dirty water guided into Bonlanden Creek, which is so shallow that it reacts very sensitively to waste matter," explains doctoral candidate Bachmann. Even before the nearby rain overflow basin fills to the brim, the control system opens the wastewater locks wider and allows a larger torrent of cleaner, incoming mixed water to flow through. It can then fill a second basin near a larger stream of water. "This second creek is not so badly disadvantaged when we guide dirty water into it," says 27-year-old Bachmann. That, at least, is the theory. Bachmann is now studying the released effluents to see how soiled they are. To do so, she measures the amount of solid matter in the effluents, to which contaminants tend to attach themselves, and the quantity of nitrate, which acts as a plant fertilizer. She also records oxygen requirements, since organic substances such as fecal matter normally "steal" existing oxygen and thus rob water organisms of the air they need for breathing. As Bachmann reports, "During heavy rains the first surge of water does in fact bring with it a burst of dirt from sewage deposits stirred up by eddies, along with dirt flushed from the streets."

In another part of the project, András Bárdossy and his team at the Institute for Modelling Hydraulic and Environmental Systems (IWS) are working to provide support for the work on sewerage systems control. In order to simulate and plan sewerage systems at the computer, the scientists often need to cover a decade in only 5 minutes in order to know how much rain patters down at any chosen location in an area. This kind of high-resolution measurement of past time periods often leaves many gaps and cannot be used for future periods. The team is

Work in a Reutlingen drainage conduit where a sewerage control system optimizes outflows to a wastewater purification plant.

therefore developing a system for generating probable precipitation time series at the computer, and in doing so is also taking the effects of climate change into account. This enables them to predict locations, for example, where flooding is to be expected.

VIEWING INVISIBLE WETNESS

"We're going through a re-thinking process," says Ulrich Dittmer. "For a long time it was standard practice to eliminate water underground - meaning not only effluents, but also rainwater and natural streams," says this expert for urban wastewater drainage. The aim in future will be to integrate such natural streams into the life of the city wherever possible. Localized seepage of soiled rainwater might be reduced, for example, or diverted to a body of surface water.

Landscape architect Antje Stokman is therefore focusing on city development in Wuppertal in the context of the project. As Director of the Institute of Landscape Planning and Ecology (ILPÖ), she and her team are studying the question of where rainfall catchbasins could conceivably be located in green areas like parks or playgrounds and sports areas in order to collect rainwater. But it's no easy task to adapt the existing sewer system to both future weather escapades and a dwindling population.

"What we have now is a 'dinosaur' system: most effluents in the Stuttgart catchment area flow into the three major wastewater purification plants in Mühlhausen, Plieningen and Möhringen", says Ralf Minke, Director of the Task Area for Water Quality and Water Supply. Instead, he is studying decentralized systems of supply and waste disposal for individual households and/or city areas. Because they are smaller, they can be more quickly adapted to climatic and demographic changes. In addition, the scientists can better exploit the presently unused potential of energy, water and nutrients contained in dirty water because of the shorter drainage routes.

WATER'S LIFE CYCLE

To this end, rainwater will be diverted separately from heavily soiled so-called "blackwater" from toilets and less-soiled effluents from bathtubs and sinks, called "graywater". As Minke explains, "For example, we can easily process the graywater on location and use it to flush toilets." This would enable consumers to use much less precious drinking water from the central water supply.

Toilet residues in future could contribute to the energy revolution: they can be fermented together with biological wastes from industry and agriculture into biogas. If this were to be burned in local block heating and power stations, it could provide enough energy to clean up residual effluents. The wastewater purification plant is usually the greatest consumer of electric current in a commune. But even the fermentation remnant contains useable substances: valuable fertilizers like phosphorus and nitrogen. And Minke goes on to report: "The known reserves of phosphorus on earth will probably be exhausted in only a few decades, and extracting nitrogen from air costs much more energy than retrieving it from effluent material."

As part of the collaborative project "Transitional Ways to Water Infrastructure Systems" (TWIST++), like SAMUWA now underway at the Department

Mixed water overflow in a storage space channel.

for Sanitary Engineering and Water Recycling under the Direction of Heidrun Steinmetz, Minke's team is developing the technology for processing blackwater. "Our pilot facility enables us to extract about 70 percent of the energy contained in blackwater in the form of biogas and also isolate up to 90 percent of its phosphorus and nitrogen," says the scientist. Now he aims to show that components of a decentralized system can also function as an overall complex. Currently, he and his team are working with other partners to develop concepts for the city of Lünen, hard-hit by dwindling population, and for a former mine in Germany's Ruhr area and also for two towns in the Thüringen region. In addition, the team of scientists has recreated these three areas virtually, based on a planning support system developed by the project partners themselves, and uses this to simulate the impact of decentralized waste water facilities, for example on costs and the energy balance sheet.

DANGER IN THE DEPTHS

To come back to the beginning of the water cycle: the aim is to continue supplying the population in future with clean drinking water. But things are getting tight for the groundwater streams below. They contribute 70 percent of the drinking water in Germany.
Rainer Helmig explains: "On the one hand we go below ground to find natural sources of geothermal energy or natural gas, but on the other hand we use it for possible storage of nuclear wastes, climatically harmful carbon dioxide, or for interim storage of electric current derived from the sun and wind and converted into gas."
In major cities, underground streets and rail lines are colliding more and more frequently with the drinking water supply. As Helmig, Director of the Department of Hydromechanics and Modeling of Hydrosystems, says, "'S21' is THE hot-button topic in Stuttgart."
Helmig's area is that of basic flow and transportation processes in porous media; these processes apply just as much for underground water flows as for processes in fuel cells or the flow in human blood vessels. His team has carried out computer simulations, for example, for the sole experimental carbon dioxide storage location in Germany. Just as is done at the real pilot location in Ketzin, near Berlin, the Stuttgart scientists injected some 70,000 tons of carbon dioxide into layers of sandstone which conduct salt water 650 meters below ground in the virtual twin and then used the computer model to observe how the gas spread underground and reacted with its surroundings. This enabled them to reproduce measurement results from observation holes drilled with their models and simultaneously to predict pressure developments in the depths.

VIRTUAL UNDERGROUND – THE CHALLENGE FOR SCIENCE

Carbon dioxide under pressure in major industrial storage projects could displace salt water from its underground storage locations into higher soil layers and mineralize the drinking water being tapped there. Moreover, carbon dioxide escaping from its place of storage in the form of carbonic acid could also dissolve poisonous heavy metals from surrounding layers of stone and flush them into the groundwater. Helmig's team is currently studying the question of whether leaks in such storage locations could be sealed with biofilms engendered when microorganisms settle into pores. "We cannot afford to start such projects without studying in advance what impact they will have on groundwater and how they affect each other reciprocally," says Helmig. But creating a virtual simulation of reality is sometimes extremely difficult: "We have a cocktail of different interactions between carbon dioxide, water, and heavy metals, all dependent on temperatures and other conditions in the surroundings, all going on at different locations and lasting for weeks or decades," says Helmig. "Were we to take all interactions in detail into consideration, we could only calculate 'Mickey Mouse-type' examples," says this native of Germany's Westfalia. On the other hand, the simulations become too imprecise if the researchers oversimplify their mathematics in order to carry on any calculations at all for a complex problem or to shorten computational times.

Thus a compromise: Helmig's task force develops different complex models and couples them with each other if necessary, instead of using only a single overall complex model for calculations. What that means is: they carry out complex calculations which take as many physical processes into account as possible, even microscopic ones, for locations where a leak may be present in the subterranean storage area. On the other hand, simple, less computationally intensive models which provide only a rough calculation of water flows, may suffice for the environment or for a different point in time. And some phenomena still cannot be simulated at all, even with supercomputers - for example the manner in which cracks proliferate in layers of stone. "We need to carry out faster, more efficient and more robust calculations," says Helmig. Then the scientists will be able to reveal step by step how the underground part of the City of Tomorrow would have to look in order to ensure clean drinking water in future, along with a reliable system of wastewater disposal.

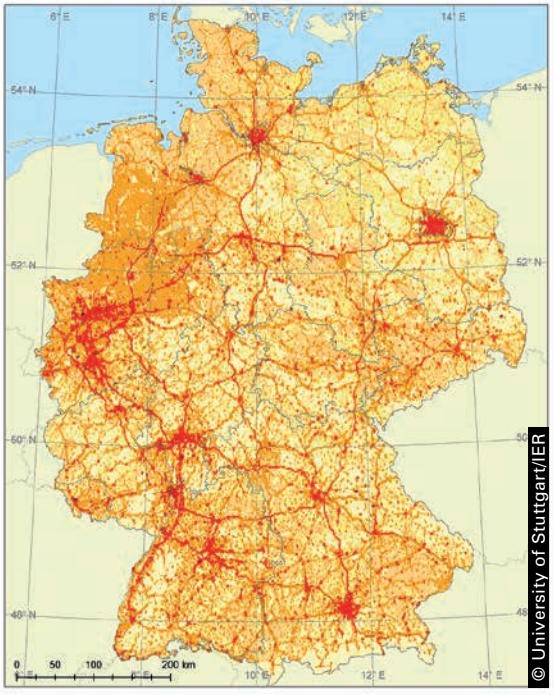
Helmine Braitmaier

Professor Rainer Helmig's team has simulated the geological structures which most likely constitute the Berlin area's carbon dioxide storage location. This in turn permits conclusions to be drawn about flow and transportation processes in the soil.

Fine Dust: Thinking Beyond the Exhaust Pipe

Technical estimates of consequences bring surprises

Meeting the EU's dust particle guidelines means focusing on more than automotive traffic as the culprit. The problem is more complex, and in some ways no isolated solution is to be found for cities. Model calculations at the University of Stuttgart show this.



Luftqualität 2020/2030: APS Szenario 2005
PM10 Emissionen in 1 min x 1 min [t/Jahr]

0,0 - 0,3 | 0,4 - 0,5 | 0,6 - 0,8 | 0,9 - 1,7 | 1,8 - 4,0 | 4,1 - 9,9 | 10,0 - 25,1 | 25,2 - 64,3 | 64,4 - 165,7 | 165,8 - 427,4 | 427,5 - 1103,0 | 1103,1 - 2847,3

Discussions about reducing air pollutants quickly home in on fine dust particles. If anyone can complain about this, Stuttgart can: only last November, the EU Commission again criticized the city for inadequately protecting its citizens against the menace of particulate matter. Now there are even threats of a process before the European Court. Prof. Rainer Friedrich, Director of the Department for Technology Assessment and Environment at the University of Stuttgart's Institute of Energy Economics and the Rational Use of Energy (IER) has carried out intensive research on the impact of different courses of action as part of a German and European project to find out how particulate matter can be reduced. "In the European project we focused specifically on traffic as a source, but in the German project on all sources," says Friedrich. In addition to the IER, the University's Institute of Road and Transportation Science is studying the issue of particulate matter from the viewpoint of traffic technology and planning. Public discussions often lose sight of the fact that city traffic is responsible for only part of the fine dust particles, since 30 to 50 percent of particulate matter is formed in the atmosphere from gases like ammonia or nitric oxides, and often has an impact elsewhere than its point of origin. The other 50 to 70 percent of the particulate matter in Stuttgart is then equally divided between traffic and the wood-burning systems found more and more often in private households. As Friedrich points out, "Thanks to catalytic converters and filters, vehicle exhaust bases are actually the lesser evil - more comes today from tire friction, brake linings, and road surfaces."

In his scientific work at the IERS, Friedrich and his colleagues have carried out thorough analyses of different courses of action in environmental policy. For this purpose they used model reference

® University of Stuttgart/IER

Even presumedly clean-burning wood heating systems, along with construction machines and agriculture, make major contributions to the problem of fine dust particles.

scenarios to simulate the health damage done by particulate matter with and without these actions. Says Friedrich, "in the traffic project we also distinguish between the most effective courses of action - those which best reduce detriments to health - and those which are most efficient because they also take costs, greenhouse gas emissions and public acceptance into account." The result: the two most important steps to minimize health damage are to continue reducing exhaust gases - for instance with the Euro7 Standard and stricter ordinances regarding environmental zones - and a speed limit of 80 on regional roads.

MORE HELP FROM BETTER INFRASTRUCTURES - AND LESS MEAT

The rankings change when efficiency is taken as a criterion for courses of action: improved urban infrastructures in favor of bicycles are then in first place, followed by uniformization of traffic flows with "green waves" of traffic lights. As Friedrich says, "That makes traffic flow more smoothly, thus reducing emissions caused by tire friction and frequent stop-and-go behavior."
Yet another, fully different picture emerged when the scientists no longer confined their risk evaluation to traffic but expanded it to include all sources of fine dust particles in Germany. Friedrich says, "Above all, in view of what is being done to reduce traffic-produced particulate matter, the most effective step would be to reduce meat consumption because then less plant feed would need to be cultivated. It would also make sense to optimize fertilization, since the tendency today is to overfertilize farmland." Fertilizer releases ammonia, which reacts in the atmosphere to form particulate matter. Other effective steps follow, ranked 3 and 4 in the list: a reduction of emissions from wood-burning systems and from construction machinery. The reason: during busy construction in a city the latter emit about as many contaminants as all diesel traffic there, because construction machines are subject to more lax emission standards.

Michael Vogel

Cities At Risk

Climate change is one danger, society's vulnerability another

It sounds like a truism to say that rich countries with functional infrastructures and administrations can more easily absorb natural catastrophes than poor ones. But the World Risk Index, which includes not only environmental data but also many social factors, documents just how dangerously human beings are in fact living. It was put together by Professor Jörn Birkmann, Director of the University of Stuttgart's Institute of Regional Development Planning (IREUS) and his team. In 2014 the group of scientists also determined for the first time the risk of catastrophes in urban areas.

The earthquake that leveled the south of Haiti in the year 2010 measured 7.0 on the Richter scale. According to various estimates it was responsible for the deaths of 200,000 to 300,000 victims and rendered about two million persons homeless. The poverty-stricken nation in the Antilles is still wrestling with the consequences today. Only a short time later, a series of comparably strong quakes shook the population center of Wellington in New Zealand. Although building damage climbed into the billions, the number of deaths remained below 200.

© Karin Desmarowitz/Brot für die Welt

High rates of migration into the cities and low overall levels of urbanization make urban areas especially vulnerable. The picture shows a slum next to train tracks in Bangladesh.

The destruction left behind by Cyclone Pam in March on the underdeveloped Pacific island of Vanuatu also makes it clear: whether extreme weather events can lead to catastrophe for human beings depends on more than their intensity. Jörn Birkmann sums it up: "It's also determined by the vulnerability of the society which they hit and how well it can adapt to current and/or future danger scenarios. The risk potential of countries is quantified in an index published annually since 2001 by the "Development Works" Alliance and the United Nations University. Birkmann, who before coming to Stuttgart in the autumn of 2014 was a researcher at the Bonn Institute for Environment and Human Security, a branch of this "world university", is the scientific director of the study. In addition to the total of 28 indicators incorporated into the World Risk Index, Birkmann focuses not only on potential dangers to a country from earthquakes, cyclones, flooding, drought, and a possible rise in the sea level (exposition), but also on vulnerability, that is, on a society's lack of safeguards. It is especially present when the respective country is highly susceptible to the havoc wreaked by natural threats because of structural circumstances, as when the people are poor and live in slums, or when the infrastructure is either absent or dilapidated. Yet another factor is represented by the power of a country to cope with the consequences of a catastrophe immediately after

© World Risk Report/Pablo Lopez

Natural threats and extreme events have an especially drastic impact on megacities with high rates of growth.

it occurs, for example because public authorities and medical facilities remain functional, important infrastructures can quickly be restored, or the victims are insured against damage. Last but not least, long-term adaptability to ongoing processes like climate change, and thus "soft" factors like education or environmental protection, are also included in the Index. Its figures show at a glance why the earthquake aftereffects in Haiti were so much more devastating than in New Zealand: coupled with the number of inhabitants who might be hard-hit, the risk of heavy earthquake damage on both islands is only moderate. New Zealand, however, was prepared for the catastrophe and was able to deal with the consequences. Haiti's society, on the other hand, is extremely vulnerable: occupying half of an island, Haiti stands globally in second place after Chad on the Vulnerability Index and is thus ahead of crisis regions like Afghanistan or the Central African Republic.

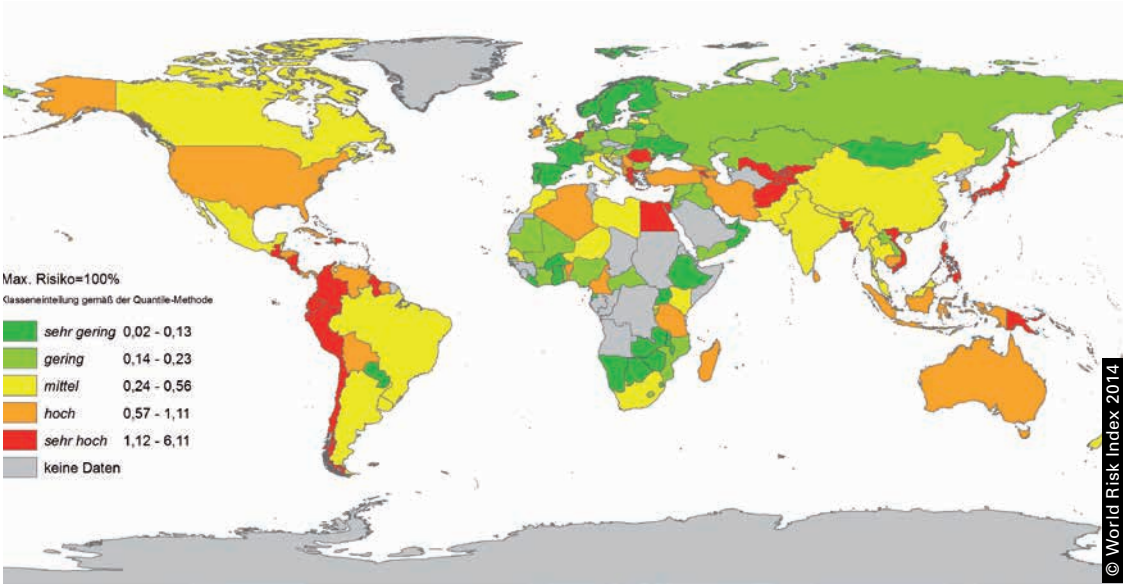
URBAN HOTSPOTS

Threats from nature and extreme events have an especially drastic impact on cities and megacities, where ever more human beings are packed tightly together due to high migration rates; this often taxes the infrastructure to its limits. In addition, cities have a key role in a country's politics and its business world. Should they fail, the entire country is often affected. For that reason, the World Risk Index in 2014 evaluated for the first time the risk of catastrophe for urban areas - and came to surprising results. Well-to-do countries like the U.S.A., Australia or Great Britain are regarded in the overall view as quite safe. In the World Risk Index analysis of urban areas, however, they land in a much higher risk class than rural regions because their developed metropolitan regions are highly exposed to natural hazards and the potential impact of climate change.

However, urbanization is not the only reason for susceptibility to catastrophes. Birkmann explains: "Urban areas with a high level of vulnerability are found more often in countries with a low rate of urbanization but very high growth rates in the cities." This is the case, for example in Nigeria, with cities like Lagos, but also in Middle Eastern and Asian countries like Iraq, Iran, Pakistan, Afghanistan, India or Bangladesh. On the whole, urban risk is particularly high in the Caribbean, in parts of Central America, and in the Pacific nations of South America, like Peru and Chile. Parts of Southeastern Europe and Southeastern Asia also have a high risk potential.

Based on these key factors, initial recommendations for action which take the entire spectrum of social and environmental risk factors into account can be formulated. For cities in industrially developed countries with relatively low growth, the focus of attention is on protecting existing population

Urban risk is derived as the product of a region's level of endangerment and its vulnerability.



areas. In regions with high rates of immigration, on the other hand, new settlements should be created in less exposed areas, and the proportion of especially vulnerable inhabitants - in slums, for example - should be reduced. Actions involving urban construction and the infrastructure are inadequate here. In most cases, improvements are needed in the work situation, the educational system, the role of women, or environmental protection. Questions of governance also have an important role, that is, the government and the administrative system. Birkmann sums the problem up as follows: "Top-quality weather satellites and early-warning systems are useless if the management of cities and workplaces is non-functional."

EXTREME EVENTS AS CATALYZERS

A further step will be to refine the Risk Index in order to permit conclusions about concretely existing cities. The target will be to calculate the hotspots and improve their ability to withstand extreme events. "Such an extreme event often turns out to be a catalyzer for new strategies", says Birkmann, and points to New York as an example. "Major changes have been made in planning and infrastructural policies since Hurricane Sandy hit there in October of 2012: hospitals and airports have been made safer, and the ramshackle electric mains have been stabilized." Concepts for concrete action are currently being worked out with the inhabitants and companies under the motto "Rebuild by Styling".

But the direction in which a city will develop can be estimated only with an understanding of all social cause-and-effect relationships and regional development trends. For that reason, Birkmann is also working in yet another project together with an international and interdisciplinary team

to study the adaptability and resilience of selected cities like New York, London and Tokyo. At issue here are the influencing factors and the future impact of global and local change processes in the context of environmental and social transformation factors. The heart of the matter is the question of what trends and indicators might influence urban development in future. Factors like migration, social gaps, environmental degradation and governance play a central role here. On the basis of past trends, the teams formulate and calculate scenarios and paths of development for the City of the Future.

LOOKING OVER THE POLITICAL SHOULDER

The example of Ho Chi Minh City in the south of Vietnam shows how complex the interrelationships are. Once a worker city, it is now reinventing itself as a high-tech center. But this image template requires critical scrutiny because many poorly-qualified people are moving in from urban areas. In addition, this metropolis of seven million people near the Mekong Delta would be very hard-hit in its development if the sea level were to rise due to climate change. And immigration will probably rise in such a scenario since the quality of life in the countryside would greatly deteriorate due to a rise in the sea level.
Politicians tend to turn a blind eye on such reflections. For that reason too, it is important that discussions of these research results will take place this year and the next at numerous influential conferences, including the Conference for Living and Sustainable Urban Development (HABITAT III). A presentation before Germany's standing representation at the United Nations in New York in January served as a kickoff event for this international dialogue.

Also important in order for the recommendations even to have a chance at implementation, however, says Birkmann, is that local scientists be involved: "Then we have a chance to generate reflection and sustainability."

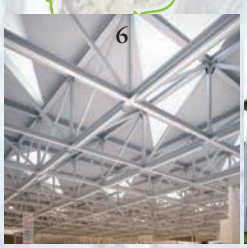
Andrea Mayer-Grenu

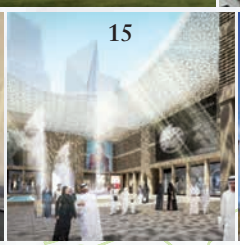
STUTTGART FINGERPRINTS

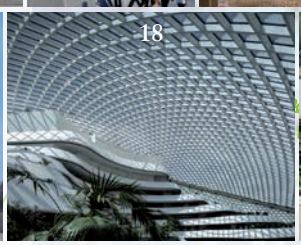
Architecture and Civil Engineering at the University of Stuttgart are among the most important degree programs in all of Germany, with a total of some 2,500 students. Many professors on the faculty have left their mark on world-famous buildings. Our world map shows a few:

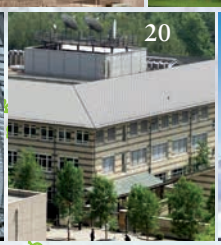
amg

1. **Frei Otto** · Olympia stadium roof, Munich
2. **Fritz Leonhardt** · Stuttgart TV Tower
3. **Paul Schmitthenner** · German War Dead Memorial in Bourdon
4. **Achim Menges** · HygroScope Installation, Paris
5. **Stefan Behling (with Norman Foster)** · City Hall, London
6. **Jan Knippers** · Trade Show Center, Kirchberg
7. **Karla Szyszkowitz-Kowalski** · St. Ulrich House of Culture, Greith
8. **Rolf Gutbrod** · German Embassy, Vienna
9. **Boris Podrecca** · Millenium Tower, Vienna
10. **Walter Förderer** · Technical University, Saint Gall
11. **Paul Bonatz** · Ankara State Opera
12. **Martin Elsaesser** · Sümerbank, Ankara
13. **Jan Knippers** · D1 Tower wooden projecting roof, Dubai
14. **Stefan Behling** · Kuwait City International Airport
15. **Michael Trieb** · Ta'if, Saudi Arabia
16. **Rolf Gutbrod** · Conference Center, Mecca
17. **Werner Sobek** · Baku Flame Towers
18. **Jan Knippers** · Astana Library, Kazakhstan
19. **Michael Trieb** · Chengqiao New Town
20. **Hans Kammerer** · German Embassy, Peking
21. **Werner Sobek** · Maritime Museum, Lingang

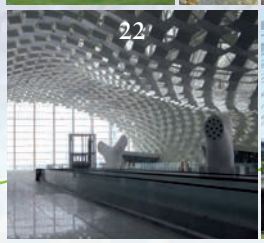


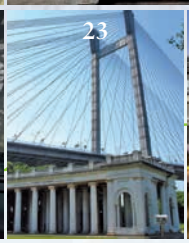


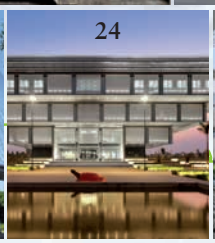


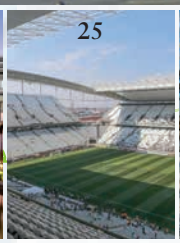


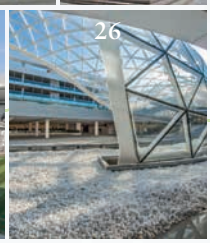
22. **Jan Knippers** · Shenzen International Airport
23. **Jörg Schlaich** · Vidyasagar Setu, Calcutta
24. **Werner Sobek** · City Museum, Hanoi
25. **Werner Sobek** · Corinthian Stadium, Sao Paulo
26. **Jan Knippers** · Casa Shopping Carioca Wave, Rio de Janeiro
27. **Achim Menges** · Patagonia Viewing
28. **Werner Sobek** · Interbank, Lima
29. **Stefan Behling** · Apple Campus, California
30. **Rolf Gutbrod / Frei Otto** · Pavilion of the Federal Republic of Germany, Montreal

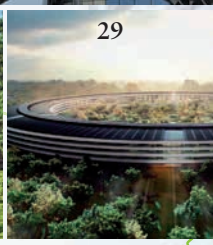












Structures of History

American Erik W. Herrmann feels inspired

Erik W. Herrmann has traveled far on his journey into the past: not only in his own field of research, but also in one closely connected with Stuttgart: computer-based design. Currently the American architect is a guest researcher at Professor Achim Menges' Institute for Computational Design (ICD).

Computational design involves the simulation and/or generation of architectonic structures by means of an algorithm. As Herrmann explains, a few institutes began in the 1960s to use computers for more than accelerating styling processes and lightening their work loads. The new methods also changed designing behavior: the machine became a partner. At first, however, only to a limited degree; except for Stuttgart, this branch of study is represented only in Zürich, London and at a few well-known U.S. universities. That can only be changed by making the story better known, is Erik W. Herrmann's conviction. This young architect came to Stuttgart in November with a Chancellor's Stipendium from the Humboldt Foundation in order to spend a year devoting himself "very fundamentally" to the development of this academic area and to do wide-ranging research in historic literature. "It really opens up a person's eyes to be on location where it all took place." After all, not only did Max Bense teach for many years in Stuttgart, but there are also architectonic highlights here like the State Gallery ("very memorable, above all the connection with the street and the city") and the Mercedes Benz Museum, which he visited right at the beginning of his stay. Likewise the inner city of Constance, where a great-uncles lives whom he had not seen for years. During the course of the month more and more were added, like the Weißenhof Settlement, the City Library, and the Porsche Museum, along with cities like Heidelberg and Tübingen. "I've got a huge list of buildings in Germany which I want to see." Now and then he also interjected a few sightseeing attractions in Zagreb, where Herrmann landed for the entire month of February with the support of the Humboldt Foundation and the "Muzej suvremene umjetnosti Zagreb Documentation and Information Department". In the Croatian capital he retraced the paths of some important artists who contributed to the "New Tendencies" Conference Series and absolved courses of study in Stuttgart. Outstanding philosophers, artists and scientists from the area of early computer art, he reports, also came to Zagreb in the 1960s, inspired like him by the writings of Max Bense.

AN INTERNATIONAL NETWORK OF COMPUTER ARTISTS

The former Yugoslavia played an important part because it belonged to neither of the two east-west blocks during the Cold War. Interested persons from Eastern Europe and the West were able to come there together without visas, he was told by Darko Fritz, one of the pioneers of the discipline, in an interview. For Herrmann it is also very striking to see what an unbelievably large network emerged in this period within the extremely specialized group of computer artists, whose members used every type of communication media available. It also helped that almost all publications were translated into three or four languages - in addition to Serbo-Croatian. It's also surprising, he says, how briefly it all lasted: the first events took place in the mid-1960s, and the movement had almost completely disappeared by the mid-1970s.

© Erik W. Herrmann

Precisely here, at the end, but also at the beginning is where Herrmann is focusing his research. At the end of his planned one-year stay, he intends to present the results of his research to a broader audience by means of articles in technical journals as well as at conferences. “Up to now I’ve only scratched the surface,“ he says.


© Uli Regenscheit

ARCHITECTURE AS A DREAM CAREER

Architecture became his dream career at a very early age, reminisces Herrmann. “I liked art, math, and the sciences and wanted to combine them.“ Like many others, he first thought that architects design only buildings. “But they also make a contribution to culture and the environment.“ He finds it important that there is a collaboration of different disciplines - with the help of computer platforms, on which he is also at work.

Precisely in Stuttgart there are also many possibilities for collaboration. For one thing, many industrial designers are located in the region. And then there are the projects of the University institutes, which he is observing and following intensively. The design of a wood pavilion, for example, in which architects and engineers of the University of Stuttgart as well as biologists from Tübingen are involved. A team of Master’s Degree students will work on this project together with biologists for the next two years and develop ideas regarding the topic of wood and its life cycle. He gets a little bit jealous, he says jokingly, when he sees much of the work done by Master’s students. “There’s so much creativity here, and above all so many options!“ he says enthusiastically. So it was only logical for him to apply for a stipendium and a place at the Institute. Especially since Professor Achim Menges has long been a “major inspiration“ for him through his critical essays. And so Herrmann came to Stuttgart, following a year in the Ukraine after completing his Master’s Degree course at Yale and then working for a U.S. company. His reason for this change of venue, however, was not so much the sightseeing attractions there but rather that his wife had received a Fulbright Stipendium to do research in the area of architecture - precisely at the moment when war broke out in the Ukraine.

One of the sources used by Erik W. Herrmann for his archive research is the ROT publication series which appeared in Stuttgart.

But his travels have not come to an end with his return from Zagreb. His April schedule included a sightseeing tour through Germany with other Humboldt Stipendium recipients. He and the others also visited the Airbus plant at the beginning of his stay in Germany, together with some VW buildings in Wolfsburg, which he describes as architectonically very attractive. The June schedule includes a visit for this stipendium recipient to the stipendium's top sponsor, Germany's chancellor. "That will be wonderful," and his eyes light up even now - thinking especially of the buildings he will see in Berlin.

Julia Schweizer

The City of Dreams

Sustainable, smart, multicultural, energy-optimized, full of flexible buildings, urban gardened, and social - it should be all of that, the City of the Future, and all that is now being researched, at the University of Stuttgart as well.

But one thing has been left out: cloudland, a castle in the clouds.

A research oversight! Rather strange, to be honest. After all, castles in the clouds have a certain tradition.

One architectural magazine even calls itself "Cloud Castle". Which immediately raises the question (prompted by the way, by Stuttgart Professor Gerd de Bruyn), whether architecture is a science at all. So it's clear that critical discourse is certainly going on.

But in other respects the Castle in the Clouds is pretty much a blank page. Speaking scientifically, at any rate.

Out in the world there has been more progress. Aristophanes, the progenitor of all Castles in the Clouds, dedicated his comedy "The Birds" to it. Philosopher Arthur Schopenhauer took it up in his most important work. Writer Karl Krauss used it for a book title, and Adrian Plass, another author, turned it into a refuge for chaotic believers.

The German Duden Dictionary defines it ("A completely unreal phantasy world in which one loses oneself"), pop culture uses it to describe a world full of strange sights and eccentric characters. But the cake is taken (sic!) by toymaker Lego: its Cloud Castle – a castle made of colorful plastic building blocks - is advertised as "the happiest, most carefree, and most creative place in the entire universe!"

A place for dreaming, full of happiness and creativity - that would be nice for the City of the Future. And worthy of every research effort ...

Andrea Mayer-Grenu

Impressum

Published by: Universität Stuttgart

Address: The University of Stuttgart, Keplerstraße 7, 70174 Stuttgart
Telephone 0711 685-82211, Telefax 0711 685-82188
hkom@uni-stuttgart.de, www.uni-stuttgart.de

Editorial Board: Dr. Hans-Herwig Geyer, Andrea Mayer-Grenu

Concept: Tempus Corporate
www.tempuscorporate.zeitverlag.de

Design and realization: Zimmermann Visuelle Kommunikation
www.zimmermann-visuelle-kommunikation.de

Advertisements: ALPHA Informationsgesellschaft mbH
info@alphapublic.de, www.alphapublic.de

Print: W. Kohlhammer Druckerei, Stuttgart

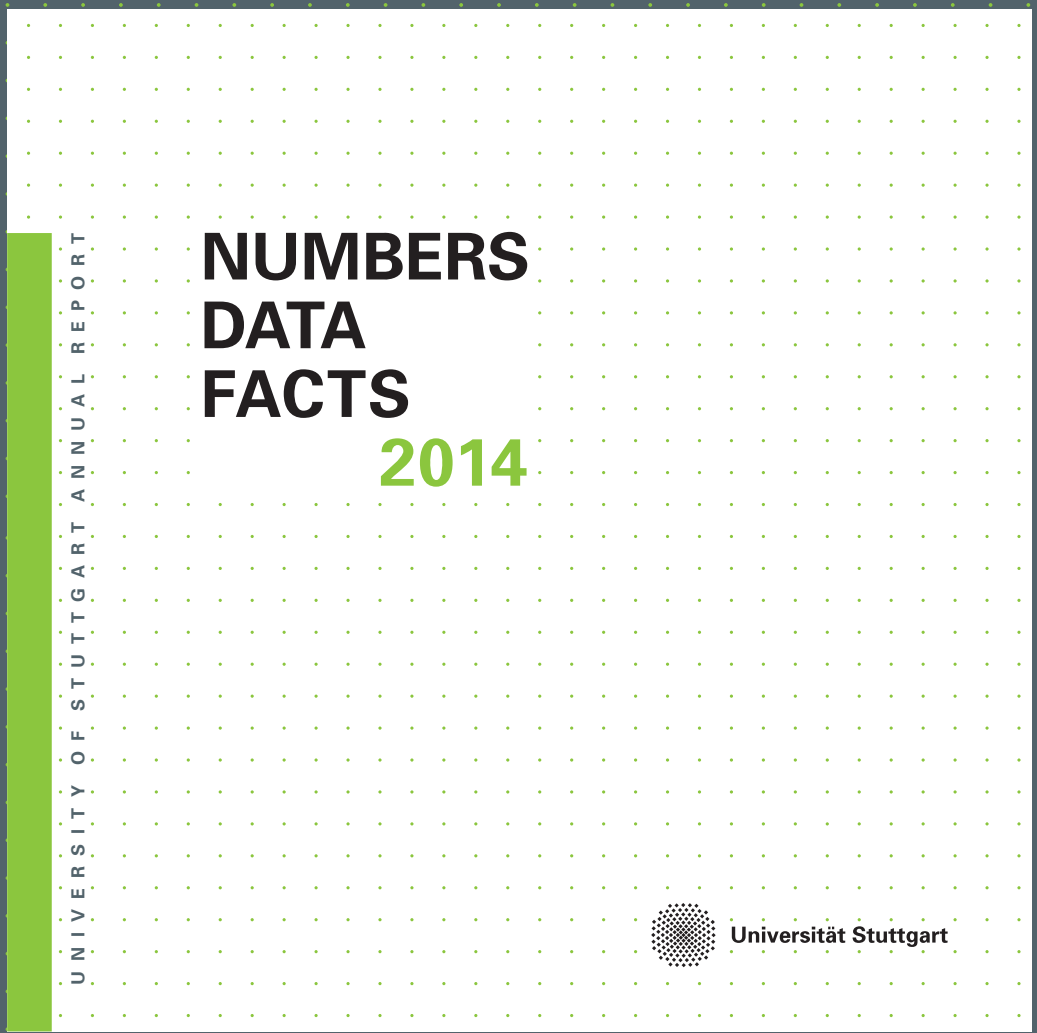
Printed copies (German version): 8.000

ISSN: 2198-2848

Internet: www.uni-stuttgart.de/forschung-leben/

The University of Stuttgart

Annual Report 2014



The University of Stuttgart's Annual Report contains a compact, clearly arranged balance sheet of its work in the year 2014.

Those interested can order the report from the University of Stuttgart Communications Office, E-Mail: *hkomuni-stuttgart.de*, or download it in PDF format at the following Weblink: *www.uni-stuttgart.de/hkom/publikationen/*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