Researching:

# Security

Alliance of
Scientific Organizations

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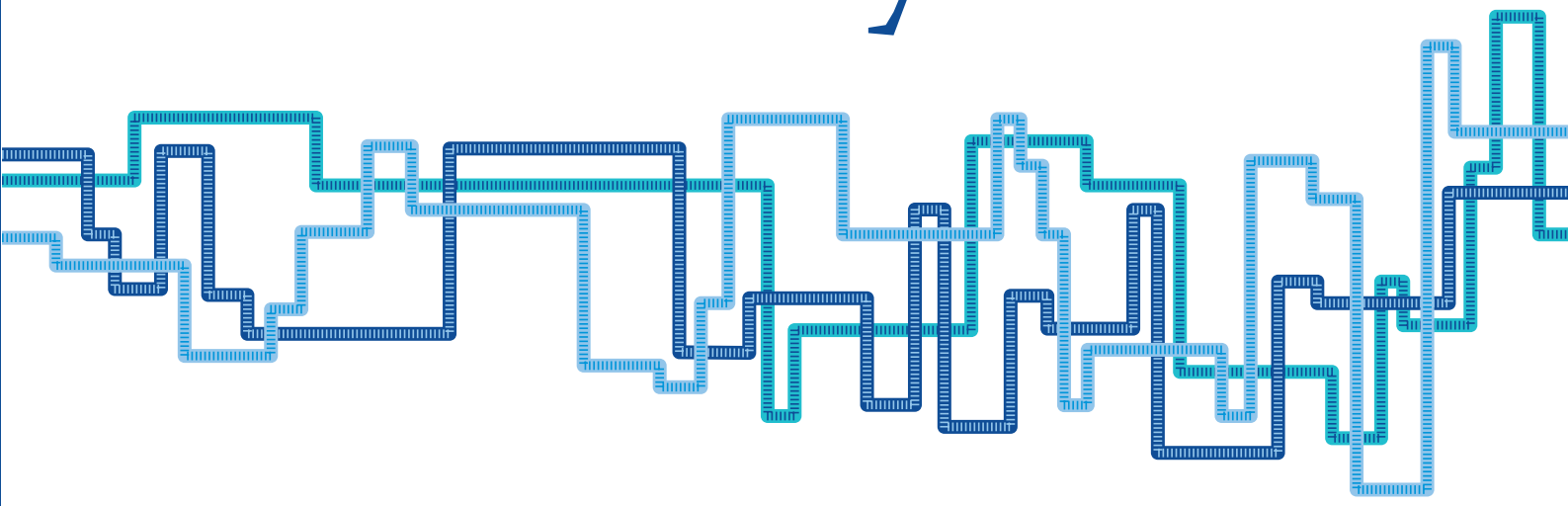
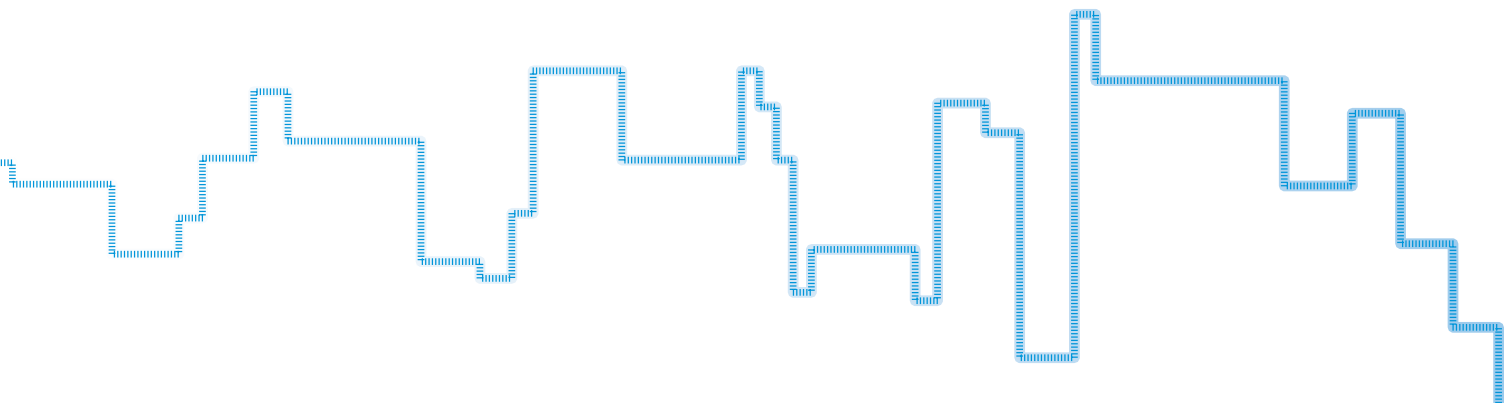
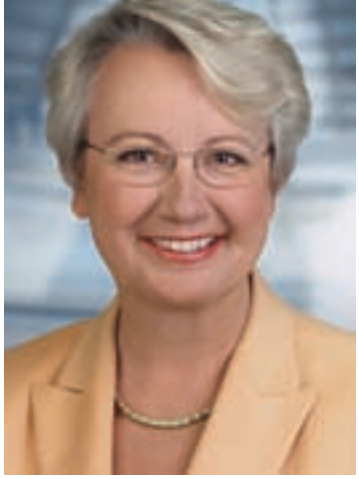
# Security







# Message of Greeting

In recent years the processes of innovation have gained significant dynamic force. The “High-Tech Strategy for Germany” has been a major factor in this. Introduced in the last legislative period, it constituted the first national all-embracing concept for the research sector and has led to a new quality of cooperation between the scientific, business and political communities. In developing the High-Tech Strategy further, proven measures will be continued, but new points of emphasis are also being accentuated. The “High-Tech Strategy 2020” focuses on five major areas: climate and energy, health and nutrition, mobility, security, and communication. The aim is to make Germany a leader in the solution of urgent global problems by giving impetus to new technologies and innovations and by pooling the resources of science and industry.

The members of the Alliance of Scientific Organizations have a key role to play in the successful implementation of the High-Tech Strategy. So that science can perform its central task in research and development, in technology transfer and in the innovation process, the federal and state governments have agreed to continue with the Pact for Research and Innovation, and to support the Excellence Initiative and the Higher Education Pact. Together, these initiatives represent the biggest investment in research, science, innovation and education ever seen in Germany.

The scientific organizations are successfully addressing issues of the future and are advancing into new areas of research. The current series of brochures shows how well German research is placed to deal with the major future challenges. Each brochure is devoted to one of the main subjects identified in the High-Tech Strategy and uses engaging examples to illustrate the work conducted in Germany’s research institutes. With their easy-to-understand descriptions of advanced research, these publications support the broad dialogue with the public on the pressing questions of our time.

Prof. Dr. Annette Schavan, MdB
German Federal Minister of Education and Research

# Preface

Ladies and gentlemen,

People need security. We instinctively avoid hazardous situations and seek protection from danger. The only risks we find appealing are those that are calculable, that we take on voluntarily and that may open up opportunities for us. By contrast, no one is looking for the sort of danger caused by natural catastrophes, violent attacks, crime or major accidents.

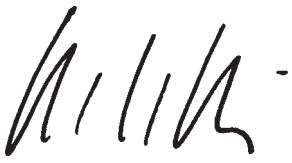
The desire for security thus represents a truly fundamental need. The confidence to tackle future challenges can only arise on a basis of security. Society can engender this confidence if people experience security and are convinced that everything is being done to protect them.

With their complex infrastructure, modern industrialized societies are more exposed to threats because even relatively minor events can have a serious impact. In view of this growing vulnerability, it is the task of science to bring about decisive improvements in the tools used to prevent, avert and mitigate risks. Precisely where the researchers and technicians set about this task depends on the individual risks involved.

It goes without saying that science has its limits. We cannot prevent natural catastrophes such as earthquakes, volcanic eruptions or tornados; the most we can hope to do is predict when they will occur. That is why research into safety and security in this area focuses on early warning systems and on mitigating the consequences. Anthropogenic risks, on the other hand, such as those that arise through large-scale public events or through crime, call for surveillance technologies, access control, logistical systems or methods for securing evidence. To ensure proper handling of hazardous substances requires rapid diagnostic techniques, protection measures, alarm systems and evacuation procedures. Disaster relief workers not only need to have the right tools for their work – such as sensors, detection equipment or communication devices – they also require adequate protection and support themselves. Last but not least, infrastructure such as traffic and information networks and water/power supply lines has to be planned and constructed in such a way that the impact of even major disturbances to whole systems can be neutralized and problems eliminated as quickly as possible.

By showcasing selected examples, we aim in this publication to give you an impression of the expertise and diversity that researchers in Germany are bringing to bear in their efforts to enhance our safety and security. Their commitment is crucial – both for each of us as individuals and for society as a whole.

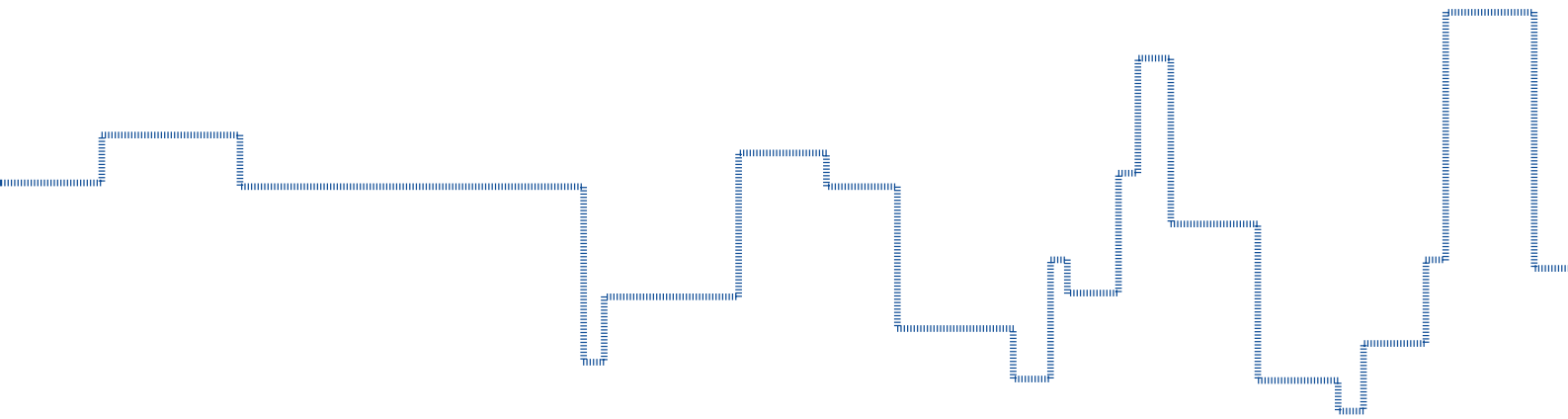
Sincerely,



Hans-Jörg Bullinger
President of the Fraunhofer-Gesellschaft

Contents





1 Robust infrastructure

# Secure mobility and utility supplies

More and more people are living and working in urban conurbations. They are highly dependent on the infrastructure that secures their mobility, energy supplies, communications and healthcare. The ongoing process of global networking and the increasing number of links in the chain of service provision are causing these supply structures to become ever more complex. What is more, air, rail and road traffic is growing rapidly – both locally and globally. Society's vulnerability to violent attacks, terrorism and natural catastrophes is rising, as is the public's desire for greater protection against everyday crime.

**More and more people are living in urban conurbations, a trend to which security research must respond.**

## Urban life

In order to improve safety in urban areas and minimize the damage caused by security incidents, we need to recognize vulnerabilities and take appropriate precautions. In order to maintain the attractiveness of city living and make a lasting improvement to urban environments, we need to take a medium- to long-term view of security. Security measures can be of a structural or organizational nature or may be needed at the level of urban planning; security research addresses this whole spectrum.

When it comes to building protection, research comprises the analysis and assessment of the security and safety solutions in place, with a view to making more efficient use of them. Building materials and construction methods are being developed and refined for use in buildings and along traffic routes that are particularly exposed to risk. These include prestigious buildings, buildings used for political purposes, those belonging to the utility infrastructure and, in particular, tunnels and bridges. One research goal is to create a solid ba-

Security for critical infrastructure
**Helping with decisions in crisis situations**

Critical infrastructure – of the kind involved, for instance, in the supply of drinking water, energy and food, and in telecommunications – is indispensable for the functioning of a modern society. Owing to its complexity and wide geographic reach, such infrastructure is highly sensitive to disturbances such as extreme weather phenomena or violent attacks. As mutual dependencies exist between the infrastructures of different systems, disturbances can spread out in cascades. That is why government authorities and industry are so interested in having support systems that they can turn to in crisis situations. The main objective of the CEDIM project at the Karlsruhe Institute of Technology is to develop a fundamental and comprehensive concept for a decision-making support system.

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Crisis simulator
**Maintaining mobility is a must**

In crisis situations it is imperative that rescue workers be able to reach the scene by road. In the German Aerospace Center's VABENE project, researchers are developing tools for intelligent traffic management in crisis situations. A so-called crisis simulator processes the data available from counting stations along roads, combining it to generate a traffic overview and forecast. This information is supplemented by vehicle motion data from cars on the road and by an airborne surveillance system. The simulation is also used to assess how planned measures will affect the traffic situation; recommendations for action are generated automatically. The system's range of tools is complemented by functions such as a route planner, route monitoring and reachability analyses.

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1 Robust infrastructure

**Aviation safety begins as soon as passengers enter the terminal building.**

sis for taking security aspects into account when critical building infrastructure is still in the design phase.

Above and beyond the measures needed for particularly exposed individual buildings in our urban environment, security packages must also be incorporated in urban planning processes. Optimized urban planning will also take into account medium- to long-term developments and decisively reduce vulnerabilities and potential adverse developments at the system's weakest points.

## Mobility

The strong growth in international passenger traffic and the transport of goods, coupled with growing global threats from terrorism and organized crime, is driving demand for security solutions in the transportation and utilities sectors. Both public mass transit and transport systems such as aviation that are already well protected make especially attractive targets for terrorists, owing to their potential for devastating damage and the wide media coverage they receive (witness the attacks

Secure power supplies

### Information infrastructure that can learn

Power outages are rare in Germany, but when they do occur they take people by surprise and can cause major damage. In such cases, information and communication are decisive factors in quickly restoring power supplies. In its InfoStrom project, Fraunhofer is developing components for an IT-based security platform that connects all the key players – such as power suppliers, crisis management teams, the fire brigade and the police – and supports them in defining the measures that need to be taken and how to structure them. Process support tools are used to gather and present in-depth knowledge of different approaches, and to analyze it for plausibility and consistency.

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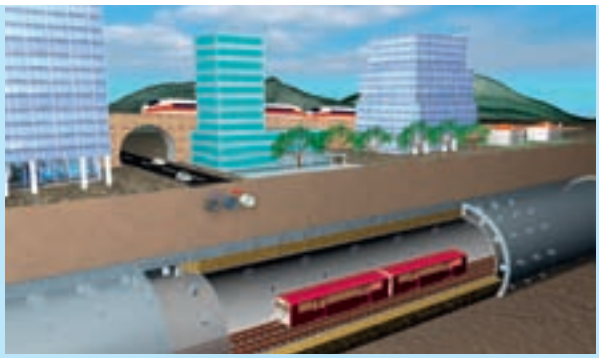

Traffic routes

### Protecting bridges and tunnels

Fully functioning traffic infrastructure is indispensable for mobility and for keeping the population supplied with essentials. In this context, bridges and tunnels are particularly at risk. Scientists participating in the SKRIBT project are identifying threat scenarios and developing appopriate protective measures. Taking an "all-hazard" approach, the scientists first try to take into account all conceivable natural and anthropogenic threat scenarios. The effects of these scenarios on the structures and on their users are determined, and possible protective measures examined in terms of their effectiveness and efficiency. This allows protective measures of a structural, operational and organizational nature to be derived that focus on the safety of both the traffic participants and the structures.

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**Aircraft movements on runways have to be constantly monitored.**

in Madrid, London, Moscow, Detroit and Glasgow). To date, there are still no suitable access portals available that could ensure a workable system of passenger checks for such large numbers of people.

One focus of research lies on enhancing the security of air travel. Although recent attacks were all thwarted, they also led to ever more stringent security checks of passengers, including the inspection of footwear, the banning of liquids in hand luggage and the introduction of full-body scanners. The development of innovative technologies and of new holistic approaches that take into account cost-effectiveness targets will deliver substantial improvements in the security situation.

The secure transportation of goods, which is intimately connected with the protection of traffic routes, is another area on which researchers are focusing. A terrorist attack on a major node in the logistics chain could threaten supplies for the entire population. As security is a key competitiveness factor, such an attack would also damage the economy. To preempt this, effective

Safe building structures

**Environmentally friendly corrosion protection**

The corrosion of load-bearing components or equipment poses a safety problem and can thus prove very costly. Many of the systems used to protect aluminum, steel and magnesium alloys against corrosion contain hexavalent chromium (chromium VI), i.e. highly oxidized chromium. Although these systems provide effective protection for the metals, they are hazardous to both humans and the environment. Material developers at INM – Leibniz Institute for New Materials are carrying out research into protective coatings that employ substitutes for chromium VI. They are developing materials comprising nanometer-sized particles. These nano-structured hybrid materials offer highly effective protection. They are simply sprayed onto the metal in question using the sol-gel process. The result is a thin, uniform and highly effective protective film that is completely free of chromium.

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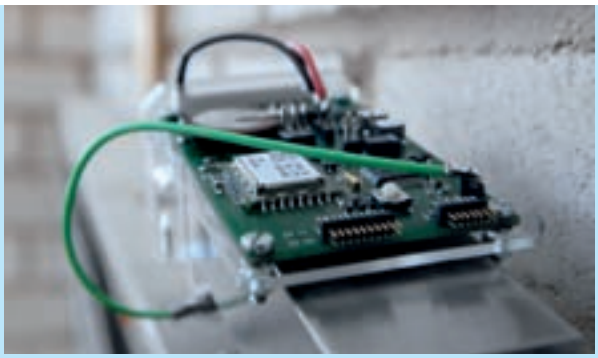

Safety in tunnels

**Robust walls with autonomous sensors**

The AISIS project centers on the potentially enormous damage caused to public rail infrastructure by attacks with explosives. The level of damage to infrastructure caused by such attacks can be so great that rescue workers are prevented from entering the structure. In order to close this gap in security, scientists are developing measures and technologies that are designed to enhance the structural resilience of tunnels. These include a new fire-resistant type of high-performance concrete and a situation assessment system fed with data from a network of mechanically robust radio sensors that are built into the walls of the tunnel and have an autonomous energy supply.

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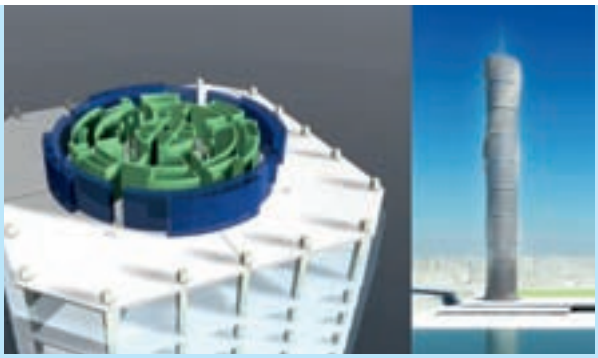
**Car2Car communication: interconnected automotive assistance systems exchange warnings autonomously.**

preventive measures are called for to avert both acts of terrorism and the smuggling of dangerous substances, drugs and weapons.

A further aspect is the changes that are now beginning to come to individual passenger traffic. The plan for the future is for motor vehicles to be capable of autonomous wireless communication – both with each other and with the traffic infrastructure. This means that security components and sensitive data will need to be protected against manipulation, and the goal here is to develop a corresponding on-board network architecture for motor vehicles.

Extreme weather phenomena are having an ever bigger impact on the economy and society as a whole, not least in terms of security. The impact of such extreme meteorological events on different transportation systems and their associated infrastructure is a decisive factor in efforts to avoid and/or minimize crisis situations and cascade effects, which is why such events warrant more in-depth analysis.



Building security

**Security for tomorrow's skyscrapers**

In cooperation with the German company Schüßler-Plan, researchers at the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI have developed a concept for building safety in skyscrapers over 500 meters in height. The integrated structural security plan comprises vertical escape and emergency access routes that are protected against all manner of mechanical impacts, shock waves, smoke and fire. Their designs feature structural integrity and redundancy to prevent the progressive collapse of the building. The concept also incorporates fire-resistant materials such as ultra-high-performance concrete (UHPC), and is now being implemented with the support of Danish architects Dissing+Weitling.

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Risk analyses

**Danger from earthquakes**

The urbanization of regions with a medium to high exposure to earthquakes has dramatically increased the seismic risk in those places, and innovative risk assessment methods are needed at local and regional level to counter this risk. Researchers at the GFZ German Research Centre for Geosciences have developed processes for quantifying the entire risk chain (seismic earth movements, microzoning, degree of danger, vulnerability), and have determined the seismic risk for Cologne and compared it with the city's storm and flood risk. In addition, they have drawn up the first risk map of Germany and completed detailed preliminary studies for Istanbul. They are currently working on a seismic danger and risk assessment for Central Asia.

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**Power plants and grids are key structures requiring special protection.**

## Energy supplies

The stability of energy supplies is critical to the future economic success not only of Germany, but also of Europe. Complex large-scale systems that are highly integrated and display many interdependencies – such as the electricity supply system – are most at risk from natural catastrophes, attacks or technical failure. Performing vulnerability assessments on the electrical power system and developing a set of practical modeling tools for estimating systemic risks will help to identify critical components and point the way toward designing a less vulnerable system. It is essential to identify and analyze potential cascade effects – both those within the system and those extending beyond it – that could be triggered by a failure of energy-supply infrastructure. In view of the potential consequences, particular attention must be paid to protecting nuclear power plants against catastrophes such as earthquakes or plane crashes.

Engineering seismology
**Earthquake-proof construction**

In view of the growing risks involved, it is becoming ever more important to provide documentary evidence that buildings and facilities can withstand the effect of earthquakes. This applies to buildings, plants – such as those of the chemical industry – or dams, whether they are constructed in Germany or by German firms abroad. Work carried out by the GFZ German Research Centre for Geosciences in this area has formed the seismological basis for all relevant national standards and regulations since 1992. As part of its research work in the field of engineering seismology for practical building applications, the GFZ provides load assumption data for simulating the effects of earthquakes. This data has been used, for instance, to assess the ability of Germany's embassy buildings abroad to withstand earthquakes.

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Risk management
**Mitigating flood damage**

In Germany as elsewhere, floods can cause billions of euros' worth of damage. Compiled at the GFZ German Research Centre for Geosciences, the HOWAS 21 flood damage database provides a solid foundation for researching flood damage. The data aid our understanding of how flood damage occurs and allow us to better assess the effectiveness of precautionary measures. HOWAS 21 is an object-specific database for flood damage in Germany. Scientists at the GFZ German Research Centre for Geosciences constructed the database as part of a program funded by the German Federal Ministry of Education and Research (BMBF) entitled "Risk Management of Extreme Flood Events (RIMAX)."

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# Communication and data protection

Our world is being digitized, and the Internet is becoming its most important and critical infrastructure. The digital world will not prosper and grow unless the security and privacy of users are ensured. Making the Internet secure at all levels is, in particular, one of the toughest challenges facing R&D specialists.

**As computer networks take over more and more key tasks, they need reliable protection.**

## The Internet of the future

Everybody – and nearly everything – will be digitally present and interconnected on the Internet of the future. Trillions of tiny computers will be embedded in the objects of everyday life (e.g. motor vehicles, appliances, electronic devices, clothing, etc.) and will link up with each other to become the "Internet of Things." Large-scale sensor networks will capture the state of the world around us. Intelligent digital assistants will represent the interests of people. Gigantic mainframes will store vast quantities of data and carry out computations that are inconceivable today. Business, too, will take place primarily on the web. Software will control business processes such as production, tenders, negotiations, purchases, sales and delivery. Resources will be available in virtual form via the "cloud," with users utilizing computing power and memory space without knowing where the corresponding computers and storage media are located or who controls them.

Information technology

**A new key for the car key**

Most drivers love the convenience of remote central locking. But the security processes currently used in these systems to transmit the radio signal are not safe, making them child's play for criminal hackers. As radio keys are compact and battery-operated, it has thus far been virtually impossible to deploy the secure, but more complex, security systems available. Researchers at Fraunhofer AISEC in Munich have now become the first scientists to integrate a highly secure encryption process in a radio key without noticeably shortening the life span of the key's battery. The trick is a new efficient protocol developed by the researchers, which minimizes the drain on computing power and the amount of data transferred.

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Reliable communication structures

**Secure sensor nodes**

Wireless sensor networks are a much-discussed solution for applications in which a high level of communication reliability and security is crucial, which include automation technology or the protection of critical infrastructures. Encryption processes are used in communication technology in order to ensure confidentiality, authenticity and data integrity. But such processes require a lot of computing power and are thus often considered to be unsuitable for low-resource wireless sensor nodes. The IHP – Innovations for High Performance Microelectronics developed exceptionally space-saving and energy-efficient hardware accelerators for cryptographic processes. Working on behalf of the German Federal Office for Information Security, the IHP then integrated these so-called ASICs in the trusted sensor node along with a processor.

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**The virtual Logistics Mall is a marketplace for software providers and users as well as for providers of logistics services.**

The Internet of the future will imbue our roads and vehicles with intelligence. It will help to avoid accidents and bring down costs, for instance by averting traffic jams. Once the world is digital, it will be possible to provide high-quality healthcare in the home environment and simultaneously reduce healthcare costs. Intelligent production systems will enable many companies – especially SMEs – to co-develop products and services and market them worldwide. The Internet will provide the platform for this type of collaboration and the undreamed-of business opportunities it promises.

## Security and privacy – a dual challenge

This digital world will only be able to grow – and the Internet develop its full potential – if users' data is secure and their privacy is guaranteed. Under the heading "Protection of Personal Data," Article 8 of the EU Charter of Fundamental Rights states: (1) Everyone has the right to the protection of personal data concerning him or her. (2) Such data must be processed fairly for specified purposes and on the basis of the consent of

Information technology in motor vehicles
**Components that understand each other**

Today's motor vehicles contain up to 70 different electronic control units – mini-computers that exchange data with each other to ensure, for example, that an airbag inflates at precisely the right moment. Unfortunately, these devices often only speak and understand their own language, which hampers innovative developments. In order to speed up the development cycles of such systems, communication between the control units is being switched to the IP protocol used for the Internet. Fraunhofer AISEC is working with carmakers and automotive suppliers to develop innovative security systems. These not only enable reliable communication between control units, they also form the basis for safe driver assistance systems and make new developments possible, for instance to reduce fuel consumption.

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Information technology for road traffic
**Cars that talk to traffic lights**

In order to improve the flow of traffic and enhance road safety, the motor vehicles of the future will increasingly exchange information, for example to warn each other of dangers. A team of researchers at Fraunhofer SIT is working on this task, developing ways of protecting inter-vehicle communication and enabling vehicles to exchange information with infrastructure such as traffic lights. They have come up with a special public-key infrastructure to protect the messages sent between vehicles. This infrastructure manages the cryptographic keys – a task that is so essential to communication. It also prevents messages being smuggled into the system and protects against the manipulation of messages.

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**The security of electronic data is a key pillar of a functioning IT infrastructure.**

the person concerned or some other legitimate basis laid down by law. Everyone has the right of access to data which has been collected concerning him or her, and the right to have it rectified. What has to be protected? The confidentiality of information, for example, when doctors exchange electronic data on their patients. Another important goal is authentication of data: has the operating system update for my laptop or iPhone really been sent by Microsoft or Apple respectively? A malign counterfeit program could quite plausibly affect billions of users.

## The basis: cryptography

Cryptography is of fundamental importance when it comes to achieving data protection goals. Encryption is a guarantee of confidentiality, and electronic signatures ensure authenticity. Although cryptography has been around for centuries, it still faces huge challenges. Nowadays, cryptography must function on tiny new IT components such as RFIDs. But classical cryptography often requires more computing power than these components can provide. Meanwhile, algorithmic and

Cryptography

### Quantum key keeps data secure

Encrypted bank data can only be safely transferred between servers if no one has access to the security key used. In principle, such a key can be transferred with absolute security using the principles of quantum mechanics, because these mean anyone attempting to spy on the data is detected immediately with absolute certainty. Physicists at the Max Planck Institute are testing whether the quantum cryptographic systems already available commercially can implement this process with the required precision. In addition, they are following up new approaches in which the key is exchanged by means of easy-to-handle bright laser pulses through optical fiber cables or along an unobstructed path through the atmosphere, rather than in the customary manner, i.e. using individual light quanta.

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Password security

### The cell phone safe

Whether e-commerce, Web 2.0 or online banking – nowadays, virtually everything requires a password, PIN or TAN. But the more access codes we have to memorize, the harder it gets. Password manager programs make things easier for users, but many of them are also easy prey for hackers – despite employing recognized encryption processes. The Fraunhofer MobileSitter is different. It protects passwords, PINs and TAN lists with the help of an innovative process that offers much greater security than conventional software. Users will be delighted with the ease of use offered by the cell phone software, while hackers will despair at the MobileSitter's ability to parry typical password attacks.

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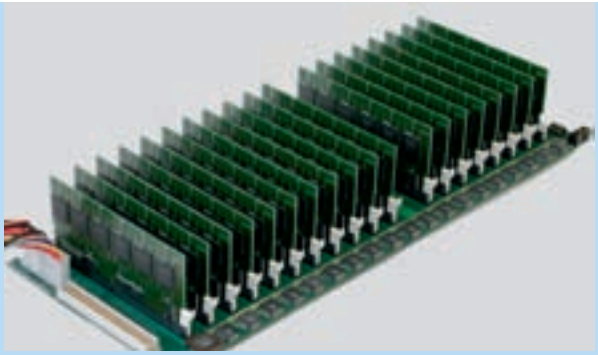
**Quantum cryptography is a field of research that can take data security to a higher plane.**

technological progress is giving rise to new dangers. For instance, it is possible to carry out a so-called side-channel attack on security chips and read the security codes they hold simply by measuring the current flowing through the chip. Quantum computers, which have been under development for several years now, can crack major encryption processes and all the customary electronic signature processes. That is why new cryptographic algorithms are needed that can function on compact Internet devices and are protected against these kinds of attack. Totally new technologies are being developed for this purpose. One example is quantum cryptography, which draws on the validity of the laws of quantum mechanics – guaranteeing an unprecedented level of security. A huge amount of research and development work will be needed to make quantum cryptography truly practicable.

Signatures and encryption processes are the modules from which complex cryptographic protocols can be built. When, for example, customers use their new electronic ID card in an online shop to verify that they are over



Encryption

**Alternative cryptographic processes**

Information technology is playing an ever increasing role in our society, and the security needs of citizens, businesses and government institutions are growing in line with this trend. Cryptographic processes, which are the foundation of all security solutions, need to be available in both the medium and long term. The goal of research is to investigate alternatives to the main class of cryptographic processes, the so-called asymmetric algorithms. The advantage of the new codes is that they are not vulnerable to attacks from tomorrow's quantum computers and also function very quickly. The researchers are looking for ways to implement the alternative cryptographic processes efficiently in software and hardware, thus making them deployable in practice.

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Protection against piracy

**Watermark for online shopping**

Files can be easily copied, which isn't always legal. In order to identify violations of copyright, employees of the Fraunhofer Institute for Secure Information Technology SIT developed a digital watermark. In a special container process, digital "watermarks" unrecognizable to the human eye are added to audio, video and image files virtually in real time. That means the technology can even be used in online shops. Several of Fraunhofer SIT's watermark solutions are already in use. The institute's latest development is a procedure for protecting e-books.

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**A lot of research work went into making the new German ID card a secure proof of identity.**

18, a complex cryptographic protocol is run. The ID first checks to see whether it is connected to a legitimate provider. A secure channel is then established between the buyer and seller so that no one else can intercept or influence communication between the two parties. The seller can recognize whether the buyer's proof of age is valid. But how can the buyer and seller be sure that the protocol is actually doing what it has promised? Cryptographic experts are developing complicated mathematical models to demonstrate that the protocols function in accordance with these models and are thus secure.

## IT security beyond cryptography

Providing secure cryptography for countless IT and Internet applications poses an immense challenge – and is still only one of the many tasks to be solved by IT security researchers. Internet security not only calls for complex infrastructures, but also requires the formulation and enforcement of comprehensive sets of regulations. Firewalls are designed to prevent malware from penetrating sensitive areas. So-called public-key infrastructures, for instance, make confiden-

Digital signatures

**Long-term signature security**

Digital signatures are one of the building blocks of modern IT security solutions, protecting software updates and enabling secure Internet connections. However, the number of practicable processes is quite limited. There is a real danger that just a single new method of attack could render all the signature processes in use today unsafe in one fell swoop. In a project entitled "Efficient and verifiably secure digital signatures for the quantum computer era," researchers at the Technische Universität Darmstadt are examining alternative signature processes so as to be prepared in case this worst-case scenario materializes. The object of their research is to develop processes with minimal security requirements that are able to ensure the authenticity and integrity of data in the long term.

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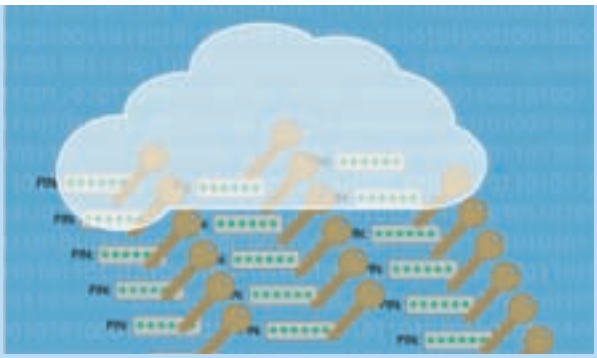

Authentication

**Protection against counterfeit products**

Counterfeit products cost trade and industry billions in losses every year. The Fraunhofer Research Institution for Applied and Integrated Security AISEC helps companies to secure their supply chains and protect their machines and equipment. The institution created a real-time scrambler that disguises digital signal currents and enables ongoing authentication between electronic components and the associated firmware. This makes it difficult for counterfeiters to analyze functions and reconstruct the product. In addition, Fraunhofer AISEC is working to make the design of hardware and software components counterfeit-proof through the use of encryption techniques and physical unclonable functions (PUFs).

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**Internet downloads are a potential source of threat for computer systems.**

tial and authenticated e-mail communication possible – a very desirable goal. But public-key infrastructures and their rules are so complex that communication by e-mail still remains largely unprotected. Finding lean, flexible security infrastructures and rule systems with readily comprehensible user interfaces is one of the key tasks on which both science and industry are focusing their efforts.

IT security processes are implemented in hardware and software systems. Even though the processes themselves are highly secure, new weaknesses can arise if they are implemented incorrectly. Developing methods that make it possible to verify the correctness and security of implementations is an exciting research task in its own right.

E-commerce

**The Internet requires trust**

The Internet is still a long way from realizing its full potential as an all-encompassing electronic marketplace. One of the main things standing in the way of this is a lack of trust in the technologies, with users worrying that their payment details could wind up in the wrong hands. In an interdisciplinary project entitled "TrustCaps" that is funded by the German Research Foundation (DFG), psychologists, computer scientists and lawyers teamed up to investigate the mechanisms and concepts that will grant people the trust they need to participate in virtual worlds. The results of their research were put into practice in a prototype for a secure e-commerce client, which can prove its trustworthiness vis-à-vis users and online traders. The innovative design of the software guarantees reliable and legally binding interaction.

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Software security

**Guaranteeing reliable data protection**

Protecting data during processing is a legitimate concern, but one that is difficult to achieve in technical terms. The distribution of computing functions, the mobility of end-user devices and the expandability of applications create a level of complexity that can lead to weak points in the design of software systems, making them vulnerable to attacks during operation. The DFG's "Reliably Secure Software Systems" program is researching analytical techniques for reliably checking and certifying the security features of programs. It is also developing models that can make the complexity of security issues technically more manageable and render guarantees more comprehensible.

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**Retrofitting security technology is expensive and not always feasible.**

## Security and privacy by design

The dramatic pace of progress in the field of information technology and the rapid growth of the Internet have triggered the development of complex IT security technologies in recent decades, and a number of large-scale projects are still devoted to advancing these technologies. In many applications, however, IT security is merely an add-on. Security technologies are expensive and do not have any readily visible benefit. They are retrofitted when it becomes unavoidable – either because laws or regulations prescribe compliance with security standards or after a lack of security has resulted in damage. Studies show that retrofitting security mechanisms is particularly expensive and does not always result in the desired protection. That is why the guiding principle for IT development in future must be: security and privacy by design. That means that these two aspects must be taken into account from the very outset of the design and development process.


Cybercrime

**Improving international cooperation**

The Internet offers a whole of new possibilities for networking – also for organized crime. As a result, national and international police organizations need to step up their cross-border cooperation by means of coordinated strategies. What is more, the new legislation essential for combating cybercrime presupposes international treaties. This is the field of research of Dr. Tatiana Tropina, who came to Germany in May 2009 as a German Chancellor Fellow of the Alexander von Humboldt Foundation. Her research focus is on issues such as the international harmonization of cybercrime legislation, and she participated in the drafting of joint ICT guidelines for the Caribbean states (ITU-EC HIPCAR Project).

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Criminal law

**Effective protection against banned websites**

The Internet has its dark sides, child pornography being one of them. But blocking access to such websites is not an effective measure, as researchers from the Max Planck Institute point out. Not only does it represent a massive infringement of the privacy rights of Internet users, it also leaves untouched those who increasingly share this sort of pornographic data via peer-to-peer networks. That is why scientists have carried out an international comparison of laws to identify the most effective measures against crimes of this type. And thanks to their advice it is now easier to pursue the perpetrators both at national and international level. The researchers recommend making the possession of child pornography a crime and gaining the cooperation of Internet service providers in tracking down the culprits.

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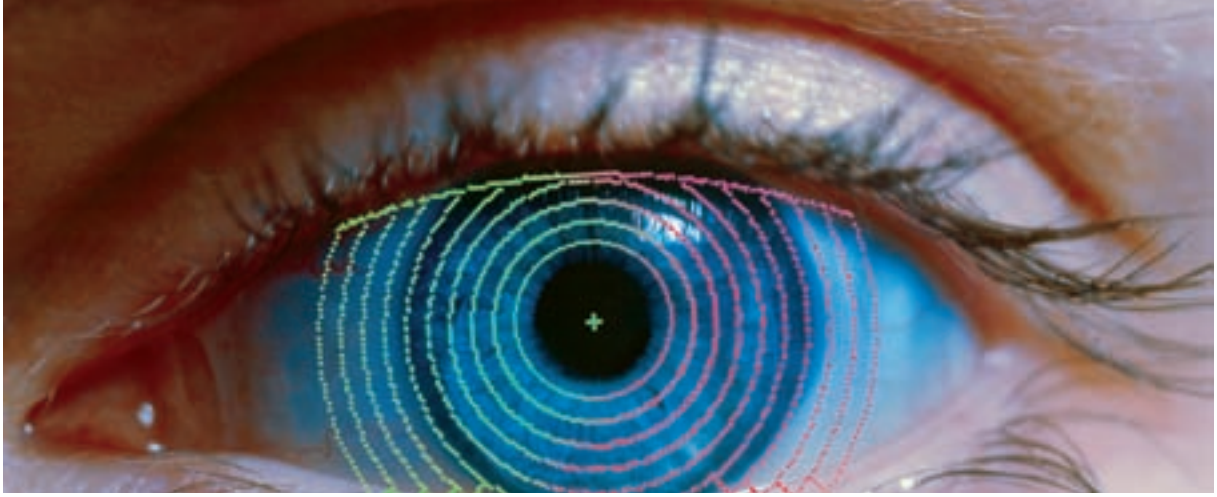
3 Access control and surveillance

# Protecting people and facilities

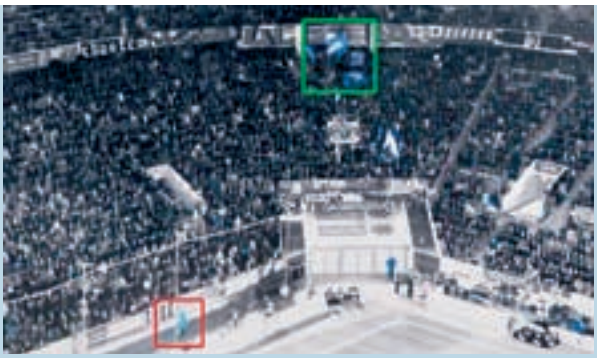
The proper functioning of highly developed societies is dependent on complex systems and infrastructures. One of the key goals of civil security research is therefore to provide these infrastructures – and the people who use them – with reliable and effective protection. Highly sophisticated sensor systems can detect substances and people, while powerful pattern-recognition processes are able to identify them automatically.



**Cutting-edge security technology: scanners reveal the contents of luggage; biometric processes can help to identify people with certainty.**

Nowadays, sensor systems are often more sensitive than humans themselves. New technologies enable image data to be captured even in adverse light and weather conditions, as well as allowing the reliable identification of objects from these data. In addition, as the Gigabit Ethernet (GigE) standard becomes more widespread for CCD and CMOS cameras in security applications, it will make system integration much easier owing to the lower number of complex hardware interfaces.

The combination of biometric processes such as fingerprint, face and hand vein recognition affords a high level of protection against manipulation when authenticating people's identities. Systems based on these processes enable secure access to both premises and data, thus protecting knowledge. When selecting an appropriate technology, it is necessary to weigh up different aspects, including security requirements, costs, complexity and efficiency. The development of pattern-recognition technologies, coupled with the growth in computing power, means that automated recognition



Automatic camera surveillance
**Conspicuous events trigger an alarm**

Automated video surveillance can substantially enhance security in public buildings and outdoor spaces. The Vigilant Eye System teaches itself which events are conspicuous in a video scene, identifies such events in real time and sounds an alarm. The system is also able to recognize people and objects and track them across its field of view. By analyzing movement patterns, the system can detect suspicious situations. Objects left lying around, for instance, are conspicuous because of the fact that they are no longer moving. The system recognizes these as potential dangers and uses movement patterns to identify and pursue whoever left them.

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Tsunami early warning system
**A warning of a giant wave**

GITEWS differs from previous tsunami early warning systems by employing new scientific processes and technologies. The special geological situation in Indonesia, with its extremely short warning times, meant the new early warning system had to incorporate new processes for determining severe earthquakes with speed and certainty, modeling tsunamis and assessing the situation. GITEWS is a project funded by the German government to assist in rebuilding tsunami-devastated regions around the Indian Ocean. It is supported by a consortium of nine research institutes in Germany. The system has been in operation since November 2008 and has provided timely warnings of all the tsunamis that have occurred since then.

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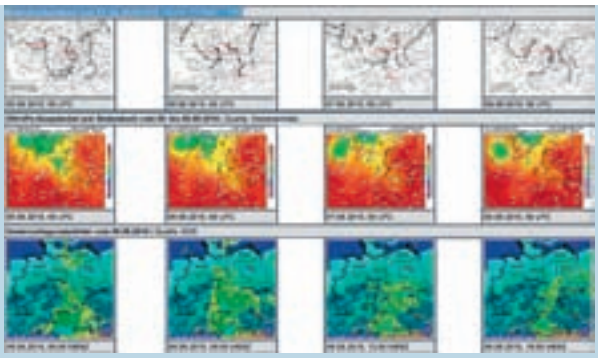
**Cell phones that can read the new German ID card enable holders to clearly identify themselves on the Internet.**

systems are now much faster, more reliable and more robust. Technologies for identifying people and objects are intended to make access to buildings more secure and to control it more efficiently.

Electronic business processes are already part and parcel of everyday life, whether we purchase something on the net or transfer our tax return to the tax office electronically. What these processes have in common is the requirement that the identities of the parties involved be verified in a tamper-proof manner. Secure electronic identities – a feature promised, for example, by the new ID card in Germany – enable both secure and efficient authentication. Efficient identification mechanisms are set to become even more widespread with the growth in mobile systems such as cell phones and smartphones. A person's identity can be used elsewhere for everyday processes, such as gaining access to an automobile and calling up personal seat settings, etc. At the same time, however, the privacy of users must be ensured. This challenge will become even tougher with the introduc-



Internet information service

**Extreme-weather warnings worldwide**

The purpose of the Internet information service "Wettergefahren-Frühwarnung" (Weather Hazards Early Warning), which was developed by the Karlsruhe Institute of Technology (KIT), is to keep its users up to date on imminent or developing meteorological events of an exceptional or extreme nature. The website is accessible at all times and is updated several times a day where necessary. Routine operation of the service began on February 1, 2004 and has been maintained since then without interruption. The website currently registers between 1500 and 2500 hits per day. In addition to the service's warning function, analysis of the weather events makes up a large part of the content; the website's archive already covers more than 600 extreme weather events.

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Air-traffic safety

**Guaranteed clean runways**

To ensure that aircraft can take off and land in safety, ground staff constantly check the runways for objects. In order for this time-consuming job to be handled automatically in future, daylight- and weather-independent sensors are required that can reliably detect even the smallest of objects such as screws. Researchers from the Fraunhofer Institutes for High Frequency Physics and Radar Techniques FHR and for Communication, Information Processing and Ergonomics FKIE have teamed up to develop a new surveillance system. Equipped with high-resolution radar sensors and intelligent data-fusion algorithms, the system learns during operation what a clean runway should look like and also how it changes depending on the weather conditions and time of day.

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**The Internet offers both opportunities and risks, and these have to be weighed up against each other.**

tion of the IPv6 Internet Protocol, as every communication device and every user will be assigned a unique web address.

The assignment of web addresses to objects opens up new opportunities for networking and communication. Smart-grid technologies will enable household appliances to be controlled remotely, for instance to adjust their power consumption to suit the output of renewable energy. Motor vehicles or production facilities will coordinate independently with each other to perform autonomous control tasks. But the Stuxnet worm clearly demonstrated the vulnerability of highly automated and networked systems. The technological know-how contained in the control programs also requires effective protection. In fact, there are already demands to decouple systems from networks in order to reduce both dependencies and complexity.

Protecting know-how and products is of fundamental importance to industry. In Germany alone, counter-

Maritime security

**Averting dangers on board ships**

Nowadays, more stringent security standards are the goal in many areas, and maritime shipping is no exception. Fraunhofer FKIE is developing a new visualization technique for merchant shipping that will support ship crews and harbor personnel avert terrorist attacks and other dangers. The Security Modeling Technique (SMT) enables security procedures to be easily developed and printed out in poster format. As a result, the information contained in security plans is made available in a concise and compact form, enabling the right measures to be taken if the worst comes to the worst.

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Tracking technology

**Enhanced security for large-scale facilities**

Initiated by the Fraunhofer Institute for Integrated Circuits IIS and developed in cooperation with eight other European partners, LocON is a system that uses real-time wireless tracking to determine the position of objects, people and vehicles. This gives airport operators, security managers and other businesses at the airport a way to record situations along with all relevant information. The system's potential is expanded when combined with video surveillance: everything – from suspicious objects and suitcases that have fallen off baggage carts to objects on the runway – can be recognized and recorded. LocON has been installed at Faro airport in Portugal. In future it is also intended to enhance security at building sites, train stations and company premises.

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**RFID tags can be used to protect against product piracy.**

feit products cause economic damage of between 30 and 50 billion euros every year. What is more, fake medicines and safety-relevant products such as brake systems or electrical fuses can endanger human lives. That is why processes aimed at making products unambiguously identifiable are gaining ground. In this area, systems that can clearly verify the path of a product from its manufacture through to delivery will become more widespread. New materials and technologies make counterfeit-proof labeling possible. Researchers are also focusing on capturing the inherent authenticity features of products that result from their surface features, component materials and the way they are processed. They form a kind of "genetic fingerprint" that can be used to recognize fakes.

The latest research work centers not only on highly sensitive detection and secure identification methods, but also on computer-aided interpretation of the data so as to be able, for instance, to recognize critical situations at large-scale events or in mass-transit situations

Holistic security concept
**Protecting airports**

Security is a central concern at airports. With passenger numbers on the rise, airport operators must adapt their security management in order to counter new threats and they must develop efficient, customer-focused process architectures. One of the goals of the "Fluss" project is to develop an integrated security concept for airports that offers an innovative approach to passive structural protection against conventional threats. The approach adds value by taking a holistic view of the problem: various components such as technologies, processes and the organization are optimized and integrated in an overall concept that also takes the airport surroundings into account.

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Biometrics
**Computer-based facial recognition checks**

In future, self-learning computer programs could help to prevent terrorist attacks. An international team that also includes researchers from the Max Planck Institute is teaching computers to locate faces in video recordings. The scientists are using instructive training examples, so-called support vectors, to enable a computer program to detect whether a certain detail from an image is a human face or some other pattern. To this end, they have formalized and reduced the image data to a point where it can be handled by a computer. When the program recognizes a face, it could, for instance, alert security personnel, who could then check whether the person approaching the building or grounds under surveillance has terrorist intentions.

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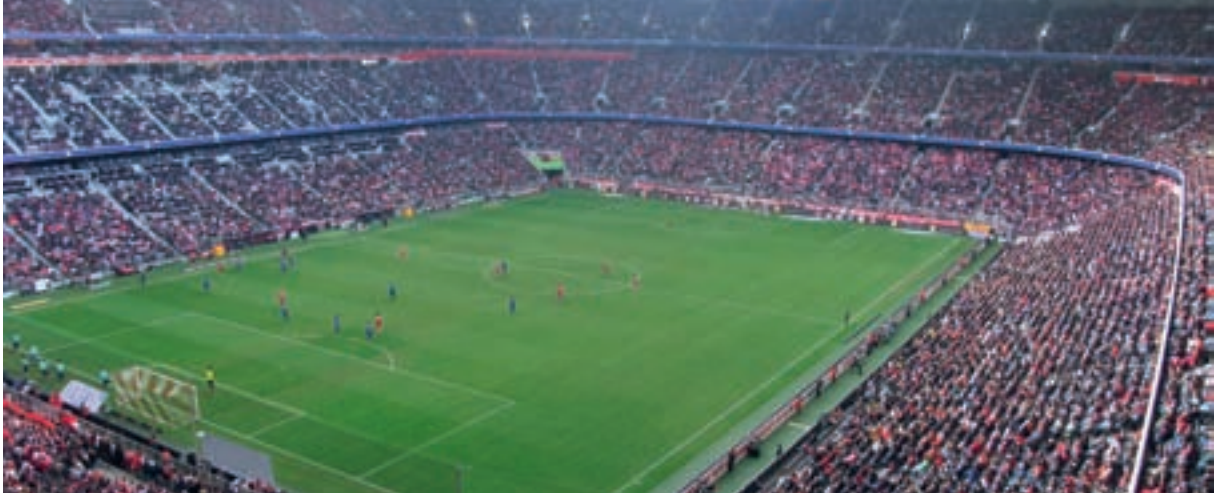

**Electronic systems can help to improve security at large-scale events.**

in good time. To this end, the way machines "learn" must be enhanced so that they are able not only to detect persons and objects, but also to understand how they interact in a complex situation. These new learning methods will allow them to analyze a flood of image data and filter out the relevant information for sounding an alarm.

Since the ongoing networking of complex systems harbors potential for new attacks, absolute security is likely to remain a chimera in future, too. However, these systems need to made more robust to attacks, and it must be made possible to detect deviations from normal behavior quickly and automatically. The challenge is to provide people and facilities with reliable protection using innovative sensor systems and intelligent signal-processing procedures. At the same time, we need to exploit the potential offered by new security technologies in order to make processes more efficient and thus cut costs. In future, the focus will shift more and more towards this combination of security and efficiency.

Biometrics and data protection

**My face belongs to me**

Data protection is a key concern with biometric applications, and so-called template protection methods – which involve transforming biometric information into a secure and irreversible form – are an important way of protecting the biometric reference data used. The methods developed at Fraunhofer IGD function without having to save the biometric data. Instead, they employ various techniques to generate a digital key for the biometric feature that has nothing in common with the original physical characteristics. The protective function can be further enhanced through password- or PIN-based authentication, which promises additional benefits in terms of security, user-friendliness and accuracy.

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Access codes

**Security for smart cards and such**

What do the access keycards of a major north German airport and the payment cards for the canteens at Berlin's universities have in common? Both are contactless smart cards that can be used to safely handle amounts of money or security-critical applications. But because their security mechanisms are inadequate, it is only too easy to tamper with or reproduce them. This can be done by means of a side-channel attack, in which the physical properties of electronic circuits, such as the current rating or voltage, are evaluated. Fraunhofer researchers in Munich are therefore working to find tools and methods for analyzing such flaws and eliminating them prior to series production.

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# Protection against hazardous substances

As the name implies, hazardous substances are those that, either directly or indirectly, pose some sort of hazard or danger to humans. Toxins belong in this category, as do pathogens (germs) and explosives. One of the main tasks of researchers consists in developing sensors and analytical procedures to rapidly and reliably detect hazardous substances so that appropriate precautionary and preventive measures can be taken.

**Hazardous substances must be transported and stored with great care.**

Together with the earthquake and subsequent tsunami on the east coast of Japan, the nuclear accident at Fukushima in March of this year represents a disaster scenario that both Japan and the world will have to cope with for a long time to come. One of the core problems is the question of how to prevent decades-long contamination of the groundwater, soil and inhabitants through the noxious substances generated or released during the catastrophe. And, if this is not possible, how can the effects at least be mitigated?

These questions lead us straight to the heart of an important and multifaceted topic that is of relevance to security: how to handle hazardous substances. By hazardous substances we generally mean chemical substances or compounds that exhibit a high potential risk and possess certain properties, i.e. substances that are, for example, caustic, radioactive, explosion-prone, or harmful to the environment or human health. The term "hazardous substance" covers a bewildering array of substances, and the Hazardous Substanc-

Sensor technology
**Reliable detection of explosives**

Electrochemical sensors can detect even the tiniest amounts of explosive substances, whether they are present in the air, water or soil. The sensors are easy to use and can be deployed anywhere, meaning reliable measurements can be obtained on the spot at airports or train stations. In addition to explosives for commercial and military applications, unconventional types of explosive also exist. Up to now, these so-called home-made explosives have been difficult to track down. Now, Fraunhofer researchers have succeeded in detecting them by electrochemical means. To ensure the sensors function accurately, they have also developed a facility that can produce defined span gases.

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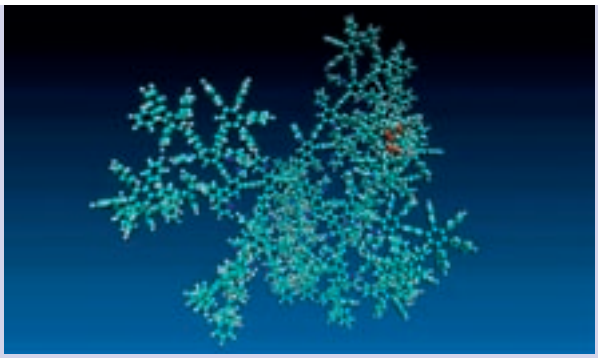

Chemistry
**A nose for explosives**

Help is at hand from the chemistry lab for dogs trained to sniff out explosives. In cooperation with partners from Bonn University (who now work at Mainz University), researchers at the Max Planck Institute for Polymer Research have developed substances that are integrated in reliable, low-cost mobile devices and can function as chemical sensors for explosives. TATP, an explosive that is easy to make and is often used in terrorist attacks, attaches highly selectively to a branch-shaped molecule called a dendrimer. This molecule could form the core of a piezoelectric element. By contrast, TNT and DNT attach to a fluorescent aromatic polymer, causing it to lose its luminosity.

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**Explosives – just one hazardous substance from a list of 940.**

es Database of the German *Länder* (GDL) lists more than 940 solid substances alone. Key hazardous substances include poisons, smoke, dust, explosives and pathogens.

## Recognizing potential risk

But even an ostensibly harmless substance such as salt can be hazardous: in the metalworking industry, for example, the hardening salts used in thermochemical curing processes are toxic and environmentally hazardous. Another example is water. If it penetrates where it does not belong and causes damage – such as corrosion – this life-giving fluid becomes a hazardous substance.

Protecting drinking water

### No worries with water

Drinking water is essential to human life – and it is the only item of food or drink that is piped directly into every home in the developed world. It must be constantly monitored for impurities so as to ensure that it can be consumed at any time without hesitation. The Fraunhofer Institutes for Interfacial Engineering and Biotechnology IGB and for Optronics, System Technologies and Image Exploitation IOSB have developed a sensor system called AquaBioTox that reacts particularly fast to toxic impurities. In the system, Fraunhofer IGB uses living cells whose fluorescence changes when they come into contact with toxins. A highly sensitive camera system that includes an integrated analysis unit – both developed by Fraunhofer IOSB – triggers an alarm as soon as any changes are detected in the quality of the drinking water. The system is currently being tested under real-life conditions.

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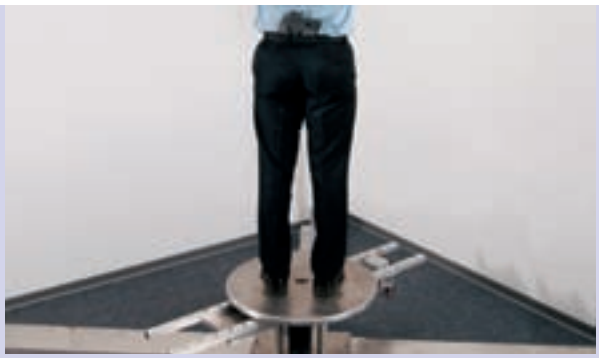

Sensor technology

### Touch-free frisking

A lot could be done to improve security check systems, and researchers in this field are focusing on technologies to check people for hidden objects from a distance. Their goal is to limit manual frisking to those few people whom a sensor check deems suspicious. The diversity of potentially dangerous objects means various different sensor types could be employed. Suitable technologies include active scanners, which emit radar waves and analyze their reflection patterns, and passive scanners, which for instance measure differences in temperature from a distance. By combining such technologies, researchers hope to achieve a high level of security while causing little or no bother to those being checked.

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**A laboratory test to detect liquid explosives.**

When handling hazardous substances, three principles must be observed: prevention – mitigation – protection. As obvious as that may seem, the challenges posed are highly complex, in particular for scientists. That is why researchers whose work focuses on hazardous substances are taking a multi-pronged approach. They are studying technologies that can be used to detect dangerous substances faster and more reliably. One example of such a technology is microelectronic detectors, or chemical sniffer devices. Such devices are capable of responding to certain molecules in a highly specific manner.

Another key point is the investigation of optimal strategies for dealing with catastrophes. In this context, administrative scientists or sociologists can also assist in analyzing and improving information processes. Finally, the scientists are concerned with prevention, i.e. they are looking for ways to stop critical situations occurring at all.

Constant detection

**Hazardous substances in person streams**

The HAMLeT system (Hazardous Material Localization and Person Tracking) makes it possible to identify people carrying explosives or other dangerous substances, while they are moving through a defined security area, e.g. on escalators or in a pedestrian tunnel. Intelligent data fusion techniques combine data from chemical sensors for hazardous substance detection with person tracks derived from laser range scanners. The system operates covertly, and is therefore not noticed by the observed persons; no personal data is gathered. HAMLeT is suitable for anti-terrorism applications, deployment by fire brigades, in disaster prevention and military operations.

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Versatile molecules

**Detecting pollutants with biosensors**

Clean water is taken for granted in Germany. Nevertheless, more and more unwanted substances, such as traces of medicine, are cropping up in the country's drinking water. Scientists from the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) are working on a technology to detect such substances in time and prevent them from entering the water supply and the environment. They are developing tiny biosensors whose nanostructured protein surface reliably detects a variety of pollutants – from medicines and chemicals to heavy metals. As a next step, the scientists want to use the protein's properties for innovative catalysts and filters for recycling metals.

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**Mexico City is one of the largest urban conurbations in the world, and keeping its citizens supplied with food, and other necessities is a correspondingly difficult task.**

Scientists involved in prevention, containment and protection against hazardous substances are faced with an increasingly acute situation throughout the world that is attributable to several factors. Both the frequency and severity of environmental disasters are on the increase – probably in part as a result of climate change. Another aggravating factor is the rise of megacities, many of which are situated in dangerous regions – Istanbul, Mexico City, Tokyo, San Francisco and Lagos are just a few such examples. Population growth is driving forward human settlement of areas such as the slopes of volcanoes, alluvial plains and earthquake zones. Even if the number of natural disasters did not increase in absolute terms, the number of people affected by such disasters and the amount of damage they cause would rise owing to the higher population and building density.

But even in the absence of catastrophes, the risks posed by hazardous substances are growing. The de-

Drug safety

**Knowing what you're swallowing**

Fake drugs cause damage estimated at around 75 billion dollars per year worldwide – not only to the pharmaceutical industry, but also more particularly to patients, who might react adversely to a counterfeit medicine. Counterfeit-proof markings directly on the tablets themselves are not yet available. Researchers at the INM – Leibniz Institute for New Materials are investigating DNA-based composites. This involves transforming harmless DNA in a specific manner and integrating it in a polymer matrix with special optical properties. In this way, they can develop counterfeit-proof holographic markings. Applied to tablets or foodstuffs, such markings make for an edible form of security.

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Security on the waterfront

**Looking through the walls of containers**

Starting in 2012, all seaborne containers bound for the United States must be scanned at their port of departure prior to shipment. The goal of a project being sponsored by the German Federal Ministry of Education and Research (BMBF) is to research a fast process for scanning the contents of containers and detecting radioactivity that takes into account logistic, data-processing and legal constraints. In collaboration with the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI and other partners, the Fraunhofer Development Center for X-ray Technology (EZRT) is working on a scanner level for high-energy 3-D X-ray imaging that will enable contactless inspection of containers at terminals without impinging on the operating procedures in place.

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**In the tropics, stagnant water harbors the potential for infectious diseases.**

mand for clean drinking water, for example, is rising in step with global population growth. In many regions, rivers and open wells are the only source of drinking water, and it is not only the debate surrounding arsenic levels in Bangladesh's groundwater that demonstrates the importance of protection against hazardous substances. What is more, people are traveling much more as a result of globalized business and tourism, leading to an increase in a diverse number of risks, such as the rapid spread of dangerous pathogens. And the threat of terrorist attacks seems to be omnipresent – another problem whose significance is likely to swell rather than fade.

## Researching the right protective measures

The challenges being faced are just as diverse as the current scientific projects dealing with hazardous sub-

Laser-based detection processes

**Recognizing danger from a safe distance**

Chemical, biological or explosive substances can cause wide-scale damage if released into the atmosphere. A reliable remote detection process employing laser beams enables countermeasures to be taken rapidly, thus mitigating the threat both to rescue workers and the public at large. Researchers at the German Aerospace Center (DLR) are developing and validating processes that will make it possible to detect hazardous substances at a distance of several kilometers. The processes are based on a spectral analysis of the laser light scattered or remitted by the hazardous substance. Future laser-based remote detection processes will be able to distinguish between a variety of hazardous substances, will function regardless of prevailing weather conditions and will not damage people's eyesight, thus making them deployable anytime anywhere.

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Diagnostics

**Nano blood test**

When it comes to containing epidemics, time is a decisive factor. Scientists at the Max Planck Institute for Solid State Research are developing miniature sensors that can identify pathogens in the blood much faster than traditional diagnostic procedures. The sensors consist mainly of carbon nanotubes that conduct an electric current. The surface of the nanotubes is equipped with receptors for different characteristic snippets of the genetic material of pathogens, for example those of a particularly aggressive flu virus. As soon as a piece of the pathogen's RNA attaches itself to the corresponding receptor, the electrical resistance of the nanotube changes. Devices that function according to this principle would be very compact and need only tiny blood samples.

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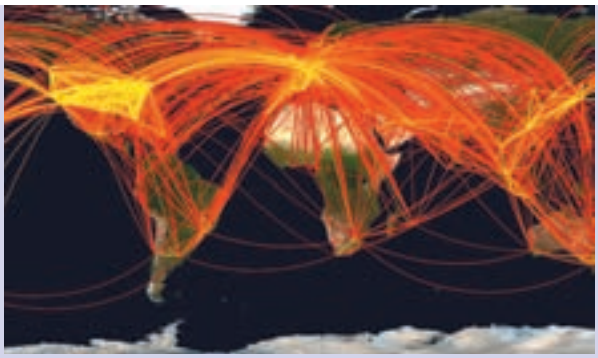
**The technical equipment used to supply drinking water must be kept scrupulously clean.**

stances. In a number of projects, scientists are working out how to make explosives more easily detectable – in the air, water or soil, from long distances, or in groups of people. These detection techniques are designed to replace sniffer dogs, which are not available everywhere at all times. An important aspect of such techniques is also that the systems enhance security without placing an additional burden on people. Only if they achieve this balance can they be deployed on an ongoing basis.

Researchers and scientists working on emergency support solutions are investigating how infrastructure – including overhead power lines, water pipes or tunnels – can be protected against attacks and extreme weather events. The goal of other current research projects is to improve the quality of drinking water by enabling the detection of even tiny amounts of hazardous substances in water supplies. The scientists plan to develop systems that sound the alarm before contaminated water reaches households.



Pandemics

**Predicting propagation paths**

Pandemics such as swine flu can spread across the entire globe within a matter of weeks. Now, Max Planck researchers are using new models to predict the propagation paths of such infectious diseases. Whereas older models assumed that the pathogens spread out evenly from a single source, the researchers are now taking actual travel behavior – from a short stroll to a long-distance flight – into account. They base their predictions on the data provided by a website that tracks the circulation of dollar notes. Working together with fellow scientists from Northwestern University in the United States, they have used these new models to simulate the spread both of SARS and swine flu, thus delivering an important tool in the fight against epidemics.

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Detecting bacteria

**Fast test for blood poisoning**

A bacterial infection of the blood can quickly have fatal consequences as it directly affects the sufferer's entire body. A rapid diagnosis of blood poisoning is thus essential as it enables appropriate countermeasures to be taken in good time. In conjunction with the Fraunhofer spin-off Magna Diagnostics GmbH and with the support of the German Federal Ministry of Education and Research (BMBF), researchers at the Fraunhofer Institute for Cell Therapy and Immunology IZI are working on a solution. MinoLab is a diagnostic system that can provide results within just one hour, making it possible in many cases to start life-saving therapy.

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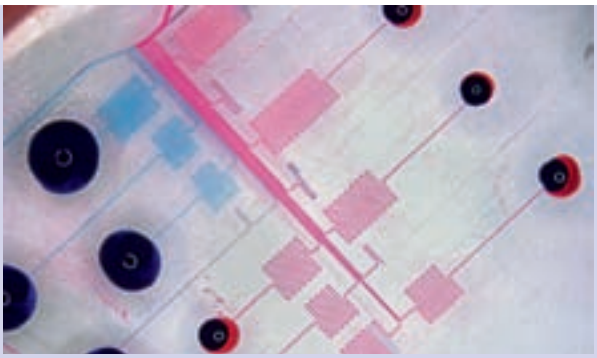
**Tropical wetlands are a breeding ground for malaria.**

Several research projects are devoted to combating pathogens, each in its own particular way. For example, an innovative miniature sensor is being developed that can identify pathogens in the blood much faster than traditional diagnostic procedures. New models predicting how infections will spread can help, for instance, to nip epidemics in the bud. The scope of ongoing research into hazardous substances is, without doubt, broad and varied. And yet we cannot expect scientific progress to result in absolute security. Ultimately, nature can be controlled only to a very limited extent, especially – as was the case in Japan – when it collides with anthropogenic risk technologies. In the interests of their own professional integrity, scientists and researchers must provide a realistic appraisal of which problems they can solve and which they cannot.



Mobile blood diagnosis
**Keeping pathogens at bay**

Even medical products may contain dangerous substances. Ideally, before blood is donated, one should know whether it contains pathogens that make it unsuitable for transfusions. This is a particular problem in developing countries. Scientists at the Fraunhofer Institute for Biomedical Engineering IBMT have developed a mobile diagnosis device that can detect several different pathogens simultaneously in just a few drops of sampled blood, using a new surface plasmon resonance method. The system is being integrated in a mobile blood-testing laboratory that will shortly be deployed during a blood donation campaign in Egypt. It provides a rapid means of excluding donors whose blood is contaminated.

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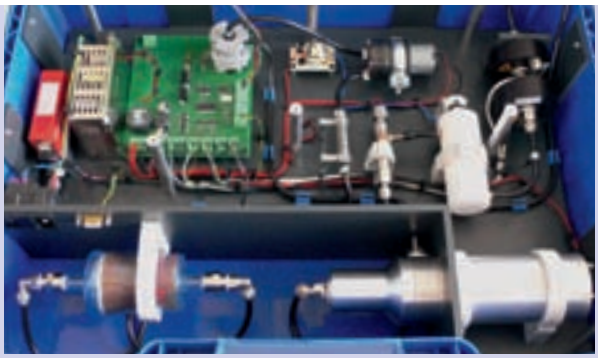

Dangerous substances in the environment
**A sensor for particulates**

Particulates in the air pose a substantial health threat in Germany. In addition to traffic emissions, a growing source of these emissions is the smoke produced by wood-fired furnaces in private homes. The German federal government has therefore set emission limits for such domestic heating furnaces. In cooperation with a partner from industry, experts at the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM in Hanover and the Institute of Particle Technology of the Clausthal University of Technology have together developed a device for measuring the emission of particulates directly at the wood-burning stoves themselves, thus making it possible to take appropriate countermeasures.

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# Tomorrow's emergency helpers

Technical and scientific progress is generally regarded as something positive: people consider secure energy supplies, advances in the medical field, and transport and travel routes that span the globe to be real achievements. But the existential importance of such achievements often does not become apparent until they are disrupted or beset by accidents. Even the highly developed industrialized societies of the 21st century are not immune to crises and catastrophes. "Being prepared" is the watchword.

**Natural catastrophes such as windstorms and floods can never be entirely avoided.**

Although modern technology protects us against many of nature's rigors, the highly developed infrastructure of human society is increasingly exposed to natural hazards and the ever higher amounts of property damage they cause. The main natural hazards to which Germany is exposed are windstorms, thunderstorms, floods, heat, frost and earthquake. Munich Re Group has put at over 34 billion euros the amount of economic damage caused by natural disasters in the period 1970 to 2004. Around half of that figure was attributable to windstorm events and a further 40 percent to flooding. The CEDIM network (Center for Disaster Management and Risk Reduction Technology) has cited more than 600 major loss events during that period, which equates to around 20 events every year. But even geographically remote catastrophes such as the 2004 tsunami in the Indian Ocean, which claimed a total of almost a quarter of a million lives, have quite a direct effect on us: with a death toll of 537 Germans, the tsunami constituted the country's worst natural disaster of the post-war era.

Help with organizing large-scale events

**Evacuations require planning**

Spectacular losses in the past demonstrate the risks involved in large-scale events. The goal of Hermes, a BMBF-sponsored joint project, is to enhance the safety of the people attending such events with the aid of a so-called evacuation assistant. This supports the event organizers, security personnel, police and fire brigade by issuing early forecasts of potential evacuation bottlenecks, thus enabling the optimal deployment of security personnel and rescue workers alike. The assistant's core components are camera- and sensor-based modules that constantly monitor the number and distribution of visitors as well as the state of the buildings. Cutting-edge parallel computers and optimized algorithms make it possible to simulate the evacuation process faster than in real time – even when large groups of people are involved.

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Equipment for firefighters

**Finding your way through thick smoke**

In its "Landmarke" project, Fraunhofer is developing a navigation system for firefighters that will make rescue missions in smoke-filled indoor and outdoor areas less dangerous and increase the chances of saving lives. The rescue workers mark key reference points using interactive components known as "landmarks," which contain sensor and transmission technologies. The firefighters' interactive suits communicate with these sensors, for example exchanging position and temperature data, and this heightens the firefighters' perception of their surroundings. It also improves their common understanding of the situation on the ground and helps them to recognize dangers earlier.

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**Modern technology can minimize the risk of chemical accidents.**

## Recognizing and averting risks

But natural catastrophes are just one of the forms of risk facing society. By its very nature, our technical civilization itself harbors inherent risks. Chemical accidents, oil-rig fires and train accidents are prime examples of technical or human failure. But modern technologies also present an array of possibilities for minimizing risk, for preventing losses and – if an accident does occur – for mitigating the damage caused. Experts agree that prevention is the best option.

Although everyone knows that 100-percent protection against catastrophes is neither possible nor affordable, it is nevertheless difficult to determine the possible and necessary scope of precautionary measures. This is the point at which the efforts of scientists meet those of crisis and disaster management experts. Investigating and recording the potential for natural and technical catastrophes is no trivial task, and neither is estimating their possible consequences.

Surveillance technology
**Detecting and monitoring fires**

Recent decades have seen a huge leap in the number and severity of forest fires. A range of technologies is being developed that can detect fires quickly and determine their position for firefighters. Researchers at Stiftung caesar, an independent non-profit foundation, are taking their lead from the black jewel beetle, which can detect fire at a distance of up to 80 km thanks to pit organs in its body that are sensitive to infrared light. Together with scientists from the Zoological Institute of Bonn University, they have discovered that the infrared radiation warms a liquid in the beetle's pit organs, which measure just a few micrometers in size. The rising pressure stimulates a receptor. Working on this principle, the researchers have designed a fire sensor integrated in a silicon chip and are currently putting it through its paces. As smoke, dust and fog strongly impair infrared radiation, researchers at the Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR are developing a radiometer that can localize and monitor fires even when visibility is limited – because, in the microwave range, dust and smoke particles are practically transparent. The device allows firefighting planes to be directed precisely to the location of fires. In conjunction with a Berlin-based company, researchers at the German Aerospace Center (DLR) developed an automated tower-based system called FireWatch for the early identification of fires. With the aid of an optical sensor system and special image-processing software, the system recognizes smoke up to 30 km away within just a few minutes by analyzing typical movement patterns and structural characteristics, and reports the danger to a control center. The system is already being used to monitor 3.2 million hectares of forest.

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**Rescue workers have to carry out their missions even in the most adverse conditions.**

These consequences include not only fundamental natural perils such as fire, smoke and water, but also the destruction of infrastructure which leads to a lack of aid, resources and means of communication. When disaster strikes, it is important first of all to gain a clear overview of the situation. A wide array of tools and processes is already available for this purpose, ranging from satellites and remote-sensing networks through to individual sensors. Adapting existing technologies and processes to precisely match particular risks and hazard scenarios always involves weighing up what is possible and what is necessary on the basis of the knowledge available. Once the situation has been identified and defined, the danger has to be contained and ultimately eliminated. Methods and technologies can provide support here, too. Quite apart from the crucial aspect of communication among search and rescue workers on the ground, it is especially important that the people in

Finding and freeing people buried under rubble

**Electronic search dogs**

The Leibniz-Institut für Analytische Wissenschaften – ISAS – e.V. (Institute for Analytical Sciences) is carrying out research into the search dogs of the future. In an EU-sponsored project entitled "Second Generation Locator for Urban Search and Rescue Operations" (SGL for USaR), the scientists are developing devices that, one day, will be used not only to locate people buried under rubble, but also even to determine their state of health. This will involve combining several different sensors. The ISAS scientists have specialized in developing a sensor on the basis of an ion-mobility spectrometer (IMS), a technology that allows the characteristic substances exhaled by humans to be analyzed in the ambient air. The scientists have already been able to demonstrate that, after just one hour, a person buried under rubble has exhaled enough metabolic products to be localized using an IMS.

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Crisis management

**Assessing the situation with satellite technology**

Climate change and our ever more complex infrastructure make us more and more vulnerable to catastrophes and technical accidents. In order to respond quickly in emergency situations, rescue workers need to receive precise, comprehensive information on the local situation as quickly as possible. Most of this information is now provided in the form of satellite images. As part of the DLR's DeSecure project, a team of geoscientists, IT experts, surveyors and physicists developed methods for simplifying the evaluation of satellite data. An important aspect of their work was how this data is passed on to the situation centers. DLR data products have already been used to support search and rescue workers in the field, for example after the earthquake in Haiti in January 2010.

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**Universal IT systems help crisis management teams assess the situation and make decisions.**

danger receive rapid assistance. This key task is hampered by the fact that the victims themselves are often unable to move and difficult to locate. This is where technical devices can provide crucial information.

## Crisis management and international cooperation

Major crises in particular often call for coordination of an overarching – even international – nature. Crisis management systems provide a platform for coordination – one that can be adapted to suit different situations, where a variety of resources can be assembled and coordinated, and that enables the efficient deployment of search and rescue workers.

The core component of such systems is often a decision support system (DSS), which provides decision-makers – to a certain extent automatically – with the key parameters for making targeted decisions. As it requires a lot of effort to develop complex systems

Disaster management
**Research reduces risk**

Successfully mitigating the damage caused by natural disasters calls for a combination of risk capture, risk analysis and risk management. The aim of CEDIM, an interdisciplinary research institution of the GFZ German Research Centre for Geosciences and the Karlsruhe Institute of Technology (KIT), is to amass corresponding knowledge of natural hazards and the impact of global changes on them as well as to develop technologies and tools for mitigating risk. For example, the researchers are using high-resolution models to forecast the expected extreme precipitation and flood levels in three catchment areas in Germany for the period 2020 to 2050, as well as estimating the associated uncertainties and analyzing the implications for flood protection systems.

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Self-configuring networks
**Communication during emergencies**

In crisis and disaster situations, rapid and problem-free ad hoc communication is of the essence. That is a particular challenge when the communication infrastructure has been destroyed or badly damaged. The Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE is working on mobile ad-hoc networks (MANETs), which allow information on the situation in the affected area to be gathered more quickly and reliably. For instance, sensors can transmit the vital data of rescue workers, such as their heart rate and temperature, directly to the command center, allowing it to respond quickly to any excess physical strain on the workers.

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**Although it is possible to predict storms shortly before they occur, they cannot be prevented. The task of safety researchers is to mitigate the damage they cause.**

of this type, it is expedient only if the systems' scope covers a wide array of potential hazard scenarios.

But even the best early warning and alert systems are useless if the warnings fail to reach the right people. That is why dissemination systems form the final link in the warning chain. An intelligent information-processing and communication system is essential, especially across large areas that may comprise different linguistic regions. Classic examples are early warning systems for tsunamis or the weather services' storm warning systems. Although sounding the all-clear once the danger has passed is a key component of such systems, it is an aspect that is often overlooked.

In recent years, the systems, technologies and procedures mentioned here have increasingly been taken up as a topic by teachers and researchers at universities and other learning institutions. Courses of study in disaster management as well as international and national training courses for decision-makers and scientists reveal that the idea of taking precautions is gain-

Information systems
**Intelligent deployment planning**

Emergency situations, large-scale events and large transport networks call for reliable planning and the rapid deployment of the required personnel. To accomplish this, a large volume of data – for example from video cameras, telephones, GPS and radio devices as well as sensors – has to be coordinated. To help deployment planners gain a rapid overview of the situation on the ground, Fraunhofer researchers participating in the PRONTO project have developed technologies to compile, automatically tap and independently evaluate this information. The knowledge gained is displayed on a digital map in an interactive, user-friendly manner and can be used to aid decision-making. The system enables deployment planners to organize their resources with the aid of intelligent information management.

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Action planning
**Crisis management after power failures**

As almost all areas of modern life require electricity to function, the supply of power is an essential part of our infrastructure. That is why it is so important to take precautions against large-scale power outages. As part of a research project conducted at the Institute for Industrial Production (IIP), a manual was compiled to support decision-making in the field of operational and strategic crisis management in the event of power failures in the German state of Baden-Württemberg. The manual is intended for use by power utilities and disaster protection authorities as well as by companies and institutions affected by power outages.

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**When catastrophes occur, rescue missions always pose an enormous challenge.**

ing more weight in this arena too. Whether we think of the floods on the Elbe and Oder rivers in Germany, hurricane "Lothar," which swept through the country at Christmas time, the accident at Eschede involving a high-speed ICE train, or the forest fires that ravaged the Lüneburg Heath – all these disasters follow the same formula: hazard x vulnerability = risk. In order to minimize risk, therefore, you must reduce either the vulnerability or the hazard.

## Catastrophes affect us all

All the disasters mentioned above resulted in the development of new risk and catastrophe management processes, which in turn were the product of research and development. The lessons learned were fed back into accident and risk research courses and found their way into crisis and catastrophe management systems, bringing together what belongs together: research and development, teaching, and practical implementation.

Monitoring rescue workers
**Sensor networks save lives**

Fighting fires is a dangerous and strenuous job. In order to reduce the danger to firefighters during their missions, it makes sense to monitor their vital data, such as heart rate and blood oxygen concentration, as well as the air around them, and to transfer these data to the command center. For this very purpose, the IHP's so-called FeuerWhere project, which is funded by the German Federal Ministry of Education and Research (BMBF), has developed a sensor node and middleware for the reliable distributed storage of data. The picture above shows the FeuerWhere node with three radio modules, the graphical user interface for displaying the readings, and a firefighter using the FeuerWhere node during a test in the fire exercise building of the Berlin-Schönefeld airport fire brigade.

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Deployment planning
**Helping rescue workers to make decisions**

Making the right strategic and operational decisions to avert risks can save lives and minimize damage. The Fraunhofer Institute for Transportation and Infrastructure Systems IVI is cooperating with the responsible authorities and ministries as well as with the commanders of fire brigades, rescue services and the police to find practical solutions for preventive planning and the optimization of tactical measures. The focus lies on carrying out a precise assessment of the situation and hazards as well as optimally deploying workers and resources at large-scale events and on routine assignments. The results of the researchers' work are evident in a technology called MobiKat (German acronym for mobile command and tactical), which has been successfully deployed for several years now, and will be subjected to ongoing development together with practitioners.

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**Global tourism means that large-scale natural disasters such as earthquakes, tsunamis or volcanic eruptions almost always have an impact on all countries.**

In our increasingly networked global economy, local catastrophes or natural disasters almost always have international repercussions. That is why there is always an international component inherent in the design and development of tomorrow's emergency helpers. After all, whether it be methods for the early identification of forest fires or earthquake early warning systems, the technologies developed in Germany and the know-how that is their wellspring can be utilized anywhere in the world. This is something that extends far beyond the mere export of technology. It goes without saying that major catastrophes initially have the greatest and most severe impact on the people living in the affected regions. But in the era of the global economy and global tourism, it is ultimately in our own best interests to develop tomorrow's emergency helpers and to make them available to others in an efficient and cost-effective manner.

Intelligent clothing

## Greater safety for rescue workers

Sensprocloth assists firefighters and rescue workers on their missions, and can even trigger support and rescue efforts of its own accord. Protective clothing equipped with sensors automatically assesses the wearer's surroundings and passes data such as temperature, position and presence of hazardous substances on to the command center. The system also measures the wearer's vital data, e.g. heart rate, respiratory rate, blood oxygen concentration, level of activity and body temperature. In developing the localization function for rescue workers, the Fraunhofer Institute for Integrated Circuits IIS has to meet important requirements: the system must not only be low-cost, it must be quick and easy to install, and its location data must also have high availability and reliability. To meet these requirements, the institute is drawing on its wealth of experience in everything related to localization.

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Warning systems

## A new task for car horns

In the past, sirens were used to warn people of catastrophes. But in the 1990s, most of these sirens were dismantled to save on maintenance costs. Now that no reliable, widespread warning system is in place, researchers at the Fraunhofer Institute for Technological Trend Analysis INT are developing a system that will enable the authorities to sound a siren-like warning in emergencies via the horns of parked automobiles. The system makes use of parts of the eCall emergency system, which will be standard equipment in all new vehicles as from 2014. According to estimates, once 14 percent of vehicles are equipped with the system, any warning signal sent out will reach the entire population.

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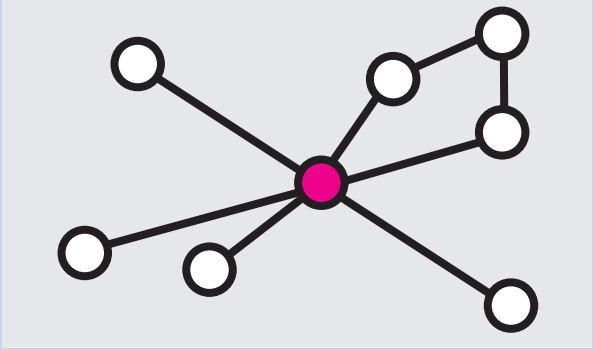
# Setting goals and protecting rights

The topic of security has become a central concern in the political arena. The political discourse reveals a radical narrowing of the topic to “homeland security” and thus to the threat to social stability posed by serious forms of violence. The result is a growing conflict between security policy and personal freedom, a conflict that feeds mainly on the assumption that comprehensive information and covert access to personal data are vital to ensuring security.


**Striking the right balance between public security and the privacy rights of individuals is a task for politicians.**

Security is both a social and personal need – and one that can never be fully met. That is because the demand for security is as unquenchable as the fears and feelings of insecurity triggered by the risks inherent in our modern societies – risks that individuals can no longer comprehend or get a grip on. Paradoxically, as levels of security increase, so does the demand for even greater security. Thus, security is a concept with a persuasive ultimate goal, but little to offer in the way of achievable interim objectives along the path toward that goal. After all, terrorist attacks are extremely rare events in Europe and over the last five decades have occurred in a highly unpredictable manner. And yet, warnings of terrorist attacks loom large in the perception of both the public and politicians. In 2010, Germany registered some 14,000 fatal accidents, 10,000 cases of suicide, 4,000 road deaths and 700 deliberate killings. But not one of these deaths was the result of terrorism.



Web 2.0 data protection

**Personal data requires protection**

Web 2.0 is the term used to describe the new generation of participatory Internet, in which users often blithely reveal a lot of their personal data. The risk of abuse posed by the creation of personality profiles is largely overlooked. Lawyers and IT specialists have teamed up to research the risks and opportunities of Web 2.0, taking the example of BibSonomy, a collaborative social-bookmarking and publication-sharing system. The researchers are devising and testing technically feasible approaches to system design that respect the users' personal rights. The solutions developed can be applied to many different Web 2.0 applications. In this way, legally compliant technology design is making an indispensable contribution to Internet security.

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Digital elections

**Constitutionally acceptable electronic voting**

The modernization of democratic voting procedures through the use of IT promises many advantages. But it also poses substantial risks since the technology opens up new possibilities for manipulating results and entails a loss of control for voters. In order to ensure compliance with election laws – in particular the requirement that the ballots are secret and free of manipulation – it is essential that legal experts make a significant contribution to the process. That is why legal scholars at Kassel University, together with IT experts, are researching the specific opportunities and risks of the use of information technology in the democratic election process, as well as devising specifications for the design of election computers and online voting procedures that comply with the constitution.

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**The fundamental need for security is universal ...**

At the heart of the matter lie feelings and expectations of security. These feelings and expectations depend on a number of different conditions – conditions that change over time, encompass contradictory ideas as regards the content of security, and cannot serve as yardsticks when formulating legitimate security policy objectives.

When people talk about security, they can mean quite different things. The concept can comprise: social security in a jobs market gripped by rapid change and characterized by unstable employment terms; protection against the risks posed by large-scale technologies; security on the Internet; protection against illness and in old age; or protection against the misuse of personal data. People are willing and even happy to take on certain risks, such as those involved in road traffic, while some generate enormous fear among people – and others trigger no special feelings or expectations at all. Attitudes to security are also shaped by our

Conflict research

**The risk of resource abundance**

In recent years, there have been more and more oil finds in Africa, and countries such as Ghana or Sierra Leone can look forward to a considerable boost in national income. But a side effect of these riches could be a greater risk of civil war. In Angola and Nigeria, for instance, oil was the trigger for violent conflicts on a massive scale. In many countries, unfavorable socio-economic conditions serve to aggravate the potential for conflict posed by the extraction of raw materials. These include greater dependence on oil exports, the questionable use of the associated income, and the overlapping of conflicts concerning the distribution of resources with ethnic tensions. Leibniz researchers in Hamburg are investigating the conditions under which an abundance of resources can lead to civil violence and what options Germany and Europe have to respond to this.

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Non-proliferation, armaments control and disarmament

**The birth of a European network of experts**

The proliferation of weapons of mass destruction and the unchecked trade in small arms constitute a threat to international peace. Together with three other European research institutions, the Peace Research Institute Frankfurt has been commissioned by the Council of the European Union to build up a network of experts in this area. The task of the experts is to support the EU in implementing its non-proliferation strategies, provide critical expertise, and formulate policy recommendations. The aim is to stimulate and intensify security policy dialog at the European level under the chair of the EU's High Representative of the Union for Foreign Affairs and Security Policy. The project was launched in 2011 and will be funded by the EU for three years.

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**... as is the desire for freedom and personal rights. Finding a balance between the two is a complex task and must lead to a sustainable consensus acceptable to all sides.**

notions of whether certain risks are evenly distributed within society or whether some social groups are much more exposed to a risk than others.

Thus, future security policy must first and foremost take account of the fact that security is a multidimensional political and social construct, one which not only involves striking a balance between defending personal freedoms against state curtailment on the one hand and protecting individuals against hazards on the other, but also addresses the question of how to deal with people's fears and their expectations of security. A policy that reduces security to the topic of homeland security and focuses on promising protection against extreme forms of violence will in any case miss the target. By contrast, we can expect more of a security policy that aims to achieve widespread social security and avoids simply pandering to fears and feelings of uncertainty.


Risk competence

**Fatal fears**

The terror attacks of September 11, 2001 not only claimed around 3000 direct victims. According to an analysis carried out by researchers of the Max Planck Institute, an additional 1600 US citizens were killed in motor accidents in the months after 9/11 – more than in the corresponding periods before or after – because their fear of a terrorist attack made them travel by car rather than fly. The researchers are investigating the way we generally go about dealing with risks. Their work suggests that we fear situations in which many people could be killed all at once much more than those – such as driving – in which deaths are spread over time, since in earlier times, when people lived in small groups, situations such as the former could potentially wipe out an entire community. The researchers are developing programs to teach even children to realistically assess the risks of modern life by interpreting statistics in an informed manner.

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Retention of telecommunications data

**Databases with doubtful benefits**

Analyzing telephone and Internet data is, it seems, not as helpful in solving crimes as legislators once thought. As Max Planck researchers have discovered, such analysis is performed in less than one in five investigations of serious forms of crime, such as organized crime and terrorism. That runs counter to the premise on which the law allowing such analysis was originally enacted, because the analysis of telecommunications data constitutes a breach of privacy. In another study, the researchers are investigating the benefits of gathering and retaining telecommunications data, a practice which Germany's Constitutional Court put a stop to in March 2010. They are examining cases in which the request for telecommunications data did not result in the criminal's conviction and whether this outcome was due to the fact that the authorities were unable to gather and store such data in advance.

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